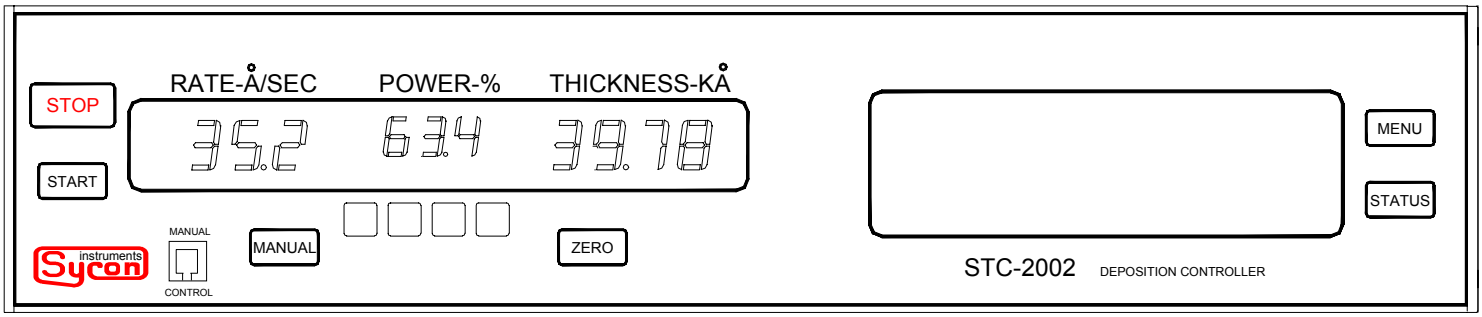
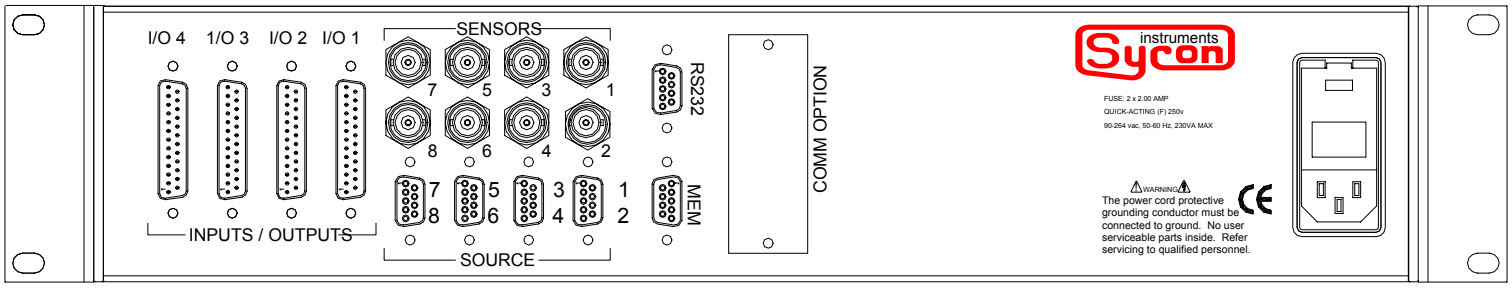
Sycon Instruments
STC-2002
Thin Film
Thickness and Rate Controller



Users Manual

June 7 2003,

518-029 Preliminary



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Sycon
Made in the U.S.A

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USERS MANUAL 518-029

Rev <preliminary> June 7, 2003

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Sycon STC-2002 Deposition Controller

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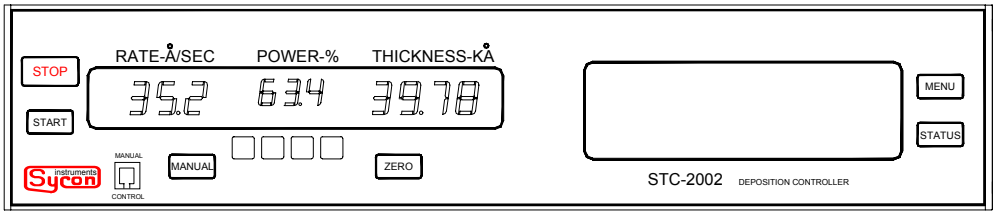

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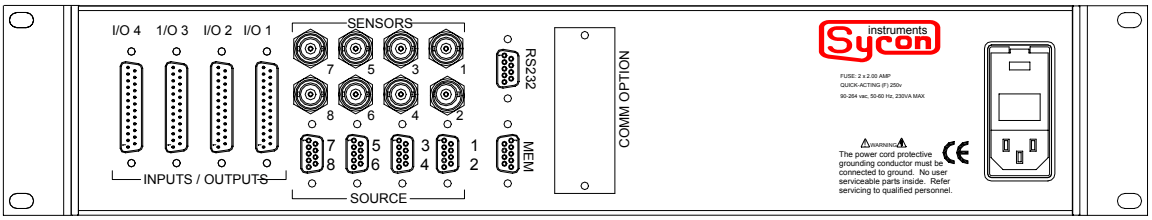

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< Sycon reserves the right to change any information contained in this manual without notice

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Warranty.

Sycon Instruments, Inc. (Sycon) warrants that all electronic instrumentation equipment manufactured by Sycon shall be free from defects in materials and workmanship for a period of **2 years** from date of shipment. Mechanical vacuum components such as feedthroughs, sensors, cables, and shutters shall be warranted for a period of six months from the date of shipment. For the duration of the warranty period Sycon will, at its option, either repair or replace any part which is defective in materials or workmanship without charge to the purchaser. The foregoing shall constitute the exclusive and sole remedy of the purchaser for any breach by Sycon of this warranty.

This warranty does not apply to any equipment which has not been used in accordance with the specifications recommended by Sycon for the proper and normal use of the equipment. Sycon shall not be liable under any circumstances for consequential or incidental damages in connection with, or arising out of the sale, performance, or use of, the equipment covered by this warranty.

This warranty is in lieu of all other warranties by Sycon, expressed or implied, including the implied warranty of merchantability, the implied warranty of fitness for a particular purpose, and warranty against infringement of any patent.

This warranty shall not apply if repair has been performed or an alteration made by anyone other than an authorized Sycon representative or if a malfunction occurs through abuse, misuse, negligence, or accident. No charge will be made for repairs made under warranty at Sycon's facilities.

Equipment Return

Before returning any equipment to Sycon contact the Product Service Department in your area for instructions. You must obtain a **RA** (Return Authorization) number from Sycon Instruments and indicate this number on all shipping cartons and correspondence. Failure to do so will delay the processing of your returned unit. Ship all items in suitable containers with adequate protection from outside damage. Also include a short description of the problem or condition to facilitate processing.

Sycon Instruments, Inc.
6757 Kinne Street
Syracuse, New York
13057-1215

Phone (315) 463-5297
Fax (315) 463-5298
service@sycon.com

User Responsibility

The user is responsible for proper operation an ordinary maintenance of the equipment, following procedures described in this manual. Proper operation includes timely replacement of parts that are missing, broken, or plainly worn. If the user has a reasonable doubt about understanding the use or installation of a component, Sycon be called.

Safety Warning

General Precautions: Human contact with the voltages present within and around a vacuum system can be fatal. Make sure that the input power is turned off before opening the doors or removing panels. Short all HV feedthrough connections with a grounding hook before accessing the controller main body.

SECTION 1.0 Introduction

Unpacking

The STC-2002 comes with a power cord and connectors for the RS-232 interface, the I/O interfaces and analog outputs (see the following *spare parts included* list). If the essential OSC-100A oscillator or crystals were ordered at the same time, they will also be included. The unit operates from 90 to 264 VAC with no adjustments required. If it is ever necessary to return the unit to Sycon, for any reason, call and obtain a Return Authorization number **(RA#)**.

Description

The STC-2002 provides both automatic control of single or multi-layer film deposition in either a production or development environment and improved predictability and repeatability of deposited film characteristics through dependable digital control of the deposition process. It runs unattended in the fully automatic mode and provides a wide number of benefits including performance limit access and setting by the end user.

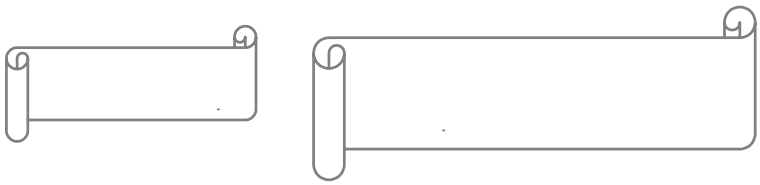
SECTION 1.1 MANUAL DESCRIPTION

Please read and understand the contents of this manual before proceeding with equipment useage in a working system. This manual will take the reader through the appropriate setup and example steps, providing along the way, an understanding of how the STC-2002 instrument is used. A test mode is available from the SERVICE menu for simulated *out of system* experiments. Crystal sensor head information is simulated (actually rate info is simulated for the film) allowing setup of various parameters/programming elements without crystal failure halting the simulated process. The power supply control voltage output is, however, active while in the test mode. All these terms will be described shortly.

This manual is organized into a number of **main sections**: specifications, generalized overview, menu programming specifics and setup, hardware setup, detailed host communications, microbalance theory and maintenance. If any further assistance is needed, please contact Sycon (see section 1.6).

The ***specifications*** section describes STC-2002 product specifics, both hardware and software, along with related necessary and optional product specifics. The software specifics include programmable parameter lists. The ***generalized overview*** section answers the *what*, the *how is it used* and the *how does it work* questions about the STC-2002, that is, the solutions this product can provide. This section is intended to discuss the concepts of main functions and elements with only enough detail to make the conceptualization clear. In addition, rudimentary specifics are given in a number of other areas as an introduction or a primer for the next section. This is information you typically only need to look at once. Experienced users (those familiar with deposition controllers) should at least thumb through this section to take an inventory of what is available. The ***menu programming specifics and operational details*** section provides detailed information about product programming. Experienced users (those familiar with deposition controllers) may decide to start here. If some elements are unclear, check back to the previous section. The *table of contents* and *index* are helpful in this pursuit. This section provides descriptions for the programming of film parameters and process steps, descriptions of menu navigation, descriptions of screens, descriptions of fixed front panel keys, descriptions of run modes, parameter details, memory defaults, programming summaries, etc. The ***hardware setup*** section describes and illustrates connectors, interconnections, peripherals, mechanical connections, and the STC-2002 as a component in a larger system. Detailed ***host communications*** are found in the following section *x6*. See section *x7* for

Microbalance theory and thickness reading calibration with its attendant density, z factor (a material reference table of elements is included) and tooling determination. Each section builds on the previous sections such that no new elements are used that haven't been defined.



SECTION 1.2 DESCRIPTION OF SYMBOLS

Please familiarize yourself with the following warning/safety/caution symbols found within this manual and their general meaning:


Note

Note: Highlights an important fact or condition.


Caution

Caution: Warns of a condition that could cause damage to deposition controller, connected or associated equipment. Also warns if some action taken could result with an undesireable and/or unexpected outcome.


Static Sensitive

or 

! : Warns of a condition that will likely cause damage to the deposition controller, connected or associated equipment. Also warns of a possible unsafe situation for the user. Examples are static sensitivities, maximum component ratings, broken fuses, etc.


Hazardous Voltages Present

or 

ϟ: Warns of a condition that is hazardous to user, deposition controller, connected or associated equipment.

SECTION 1.3 TABLE OF CONTENTS

FIGURES

TABLES

SECTION 1.4

STC-2002 Spare Parts (included with STC-2002)

ASSEMBLY	PART NUMBER
POWER CORD [120 VAC] (1)	600-004
FUSES (2 x 2.00A 250VAC F-type)	356-014
OPTOCOUPLED INPUTS 25 PIN MALE CONNECTOR (1)	402-222
RELAY OUTPUTS 25 PIN FEMALE CONNECTOR (1)	404-020
EMI HOOD FOR 25 PIN CONNECTORS (2)	404-021
RS-232 9 PIN MALE CONNECTOR (1)	404-011
EMI HOOD FOR 9 PIN CONNECTOR (1)	404-009
RACK MOUNT EARS (2)	016-012
RACK MOUNT HDWR (4)	094-006
MANUAL (this manual)	518-029
CONNECTOR KIT / PARTS	516-017
HAND CONTROLLER (1)	500-198
COMMUNICATIONS SOFTWARE TOOLS DISK (1)	500-046

Optional STC-2002 Hardware / Software

MEMORY MODULE/STRIP CHART INTERFACE PCB	500-212
TRANSPORTABLE MEMORY MODULE (32K)	500-210
TRANSP. MEMORY MODULE SOFTWARE FOR PC	500-TBD
TRANSP. MEMORY MODULE CABLE FOR PC	500-TBD

SECTION 1.5

Optional Sensor Parts

Description	Sycon Part Number
Sensor Body (Low Profile)	550-222
Sensor Cap (Low Profile)	550-223
30 inch In-Vacuum Coax Cable	500-024
10 inch In-Vacuum Coax Cable	500-023
Crystals (box of 10)	500-117

Standard Feedthroughs

1" BOLT STANDARD	500-016
2 3/4" ConFlat STANDARD	500-017

Standard Sensors

LOW PROFILE	500-042
RIGHT ANGLE	500-088

Cables

10' OSC TO CONTROL UNIT CABLE 500-026
30' OSC TO CONTROL UNIT CABLE 500-027
6" OSC TO FEEDTHROUGH COAX CABLE 500-025

Crystal / Oscillator Package (includes the following 4 item numbers) 500-109

6" OSC TO FEEDTHROUGH COAX CABLE 500-025
10' OSC TO CONTROL UNIT CABLE 500-026
OSCILLATOR UNIT OSC-100A
10 CRYSTALS 500-117

SECTION 1.6 Contact Information

STC-2002

STC-2002 DEPOSITION RATE CONTROLLER
Sensor Package and Feedthrough Not Included

All prices FOB East Syracuse, New York Terms: Net 30 days

Sycon Instruments, Inc.
6757 Kinne Street
East Syracuse, New York 13057-1215
Telephone (315) 463-5297
Fax (315) 463-5298
Website WWW.SYCON.COM

SECTION 1.7 PRODUCT SPECIFICATIONS

STC-2002 Thin-Film Thickness and Rate Controller Specifications

High Resolution	±0.02Hz(5-6MHz), 0.0088 Angstroms/Measurement (for Aluminum)
High Accuracy	±0.5% thickness + 1 count
High Speed	Ten measurements/second
Measurement Range	500KA Aluminum Equivalent
Standard Sensor Crystal	6 MHz AT cut, Plano/Convex
Sensor Capacity	2 per sensor PCB card [4 PCB cards max.]
Displays	240 x 64 pixel monochrome LCD with Backlight 12 digit LED display (7 segments each digit) 4 discrete indicator LEDs
Operation	Menu driven "Windowing Type" LCD Touch Panel (12 x 4 key matrix) with 6 fixed function membrane keys and 4 user programmable fixed membrane keys
Film Storage (Standard)	1 Active Film Program 98 Alternate Film Programs (with 30 Sensor maps) 9 Sequence recipes, 99 steps per recipe, system total is 250 steps
External Storage (Optional)	Film Parameters for films 1-99 and System Parameters I/O programs, and Process Accounting Can be stored in Transportable Data Module (Optional)
Hardware I/O (Standard)	per card: 8 SPDT Relays, 1.0 Amp @ 24 VDC Maximum per card: 8 Optocoupled Inputs (Electrically Isolated), 5-24VDC [4 slots for input and/or output cards]
Computer Interface Protocols	RS-232C (Sycon Format or ASCII)
Communication Options	DeviceNet, PROFIBUS, CANopen, others
Analog Outputs:	12 bit resolution (2 per sensor card, each for use as control or recorder)
As Control Outputs	2.5, 5, 10 volt @10ma. isolated output with range menu programmable (maximum 2 control outputs per sensor card)
As Recorder Outputs	0 to 10 volt @ 10ma, isolated, function programmable (rate, thickness, power, deviation, computer remote) (maximum 1 recorder output per sensor card and per system)
Power Control:	
Automatic	Three Mode Closed Loop Control (PID)
Manual	Hand Controller
Rack Mount	full width rack mount (std.). 3 1/2" H, 8 5/8" D
Power Requirements	90-264VAC, 50-60Hz (1.4A rms@120VAC, 0.7A rms@230VAC)
Weight (without options)	6 lbs. [with: 1 Sensor card, 1 Input Card, 1 Output Card] Sensor card=0.216 lbs., Input card=0.135 lbs., Output card=0.14 lbs.
Operating Range	0 to 50°C ambient (power supply/LCD display)
Humidity	non-condensing: 5% - 85% RH

SECTION 1.8 Programmable Parameter Lists

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key examples:

Full Parameter Name	⇒	Abbreviated Menu Name
Parameter Name	⇒	Param N

(text) ⇒ implied parameter text in parenthesis

Film Parameter List:

Review Film (Edit Film) [Menu end point: Review Film Menu path: Main/Review Film]

(Material) Density	0.40 to 99.99 gm/cc
(Material) Z-Factor	0.100 to 9.999
Setpoint Thickness Limit	0.000 to 999.999 KÅ
Final Thickness Limit (Trigger)	0.000 to 999.999 KÅ (non-sequencing only)
Setpoint Time Limit	0:00 to 99:59 MM:SS
Soak 1 Power level Value	0.0 to 100.0%
Power Ramp 1 Time (to pwr level)	0 to 99:59 MM:SS
Power Soak 1 Time (@ pwr level)	0 to 99:59 MM:SS
Soak 2 Power level Value	0.0 to 100.0%
Power Ramp 2 Time (to pwr level)	0 to 99:59 MM:SS
Power Soak 2 Time (@ pwr level)	0 to 99:59 MM:SS
Soak 3 Power level Value	0.0 to 100.0%
Power Ramp 3 Time (to pwr level)	0 to 99:59 MM:SS
Deposit Rate (requested)	0.0 to 999.9 A/S
Rate Ramp Mode	OFF / ON
New Deposit Rate (Value)	0.0 to 999.9 A/S
Rate Ramp Time (Duration)	0:00 to 99:59 MM:SS
Rate Ramp (Thickn) Trigger Point	0 to 999.999 KÅ
Control Loop –Proportional term-	1 to 9999
Control Loop –Integral term-	0.0 to 99.9 sec
Control Loop –Derivative term-	0.0 to 99.9 sec
Max Power Limit	0.0 to 100.0%
Abort Max Power SWitch	OFF/ON
Max Power Dwell	0:01-99:59 MM:SS
Shutter Delay Mode	OFF, ON
Shutter Delay TIMEOUT	0:01-99:59 MM:SS
Shutter Delay QUALITY	1-50%
(XTAL) RATE SAMPLING	OFF,TIMED,INTELL.
(XTAL) SAMPLE INTERVAL	0:01-99:59 MM:SS
(XTAL) SAMPLE DWELL TIME	0:01-99:59 MM:SS
(XTAL) SAMPLE QUAL	1-50%
(XTAL) SAMPLE ALARM TIME	0:01-99:59 MM:SS
FILM Fail Mode	ABORT IF FAIL, TIME POWER
Control Loop Qual Limits	0 to 9
XTAL Stability S (Limits)	0 to 9
XTAL Life Bounds	0.0-100.0%
Plot Vert Scale Volts	1, 5, 10, 50, 100
Plot Horiz Scale H	1 to 600 samples
Data Plot Type	Rate /Rate Deviation /Power

Source Sensor MAP SELECT	1 - 30
POCKET SELECT	0 – 63 Pockets
ETCHING MODE	OFF/ON

Process Step elements:

[Menu end point: Review Processes Menu path: Main/Review Processes]

Review Processes (Edit Process)	(Edit Process Steps [1-99]) Mode (Skip, Stop, Auto, End, Wait), Film# (1-99), Thickness (0.0 - 999.999 KÅ)

Main Menu values:

[Menu end point: Main Menu Menu path: fixed front panel MENU key/ Main Menu]

Next Active Process (Select)*	1 of 9 processes [sequencing mode only]
Next Active Film (Select)*	1 of 99 films [non-sequencing mode only]

[*NOTE: press *touch key* enclosing digit to select 1 of the 9 processes or 99 films (press digits + ENTer on invoked submenu)]

RunTime Screen parameters:

[Menu end point: RunTime screen Menu path: programming Menu/ fixed front panel STATUS key/RunTime screen]

(Crystal Quality Indicator Select)	L/Q, Loop *x*, Qual *xx*
(Crystal Sample Select)	(not selected [blank]), SMPL, SMPL+Time, HOLD+Time
START key sequence (fixed front panel)	(Note **PROCess *X*: *message*** change after each START process key press)[2]
STOP key (fixed front panel)	Stops the running process (non-seq mode: stops the 1 inherent process [film])
MANUAL key (fixed front panel)	Switches to manual mode from a running process only. Toggle action.
ZERO key (fixed front panel)	Zeroes the thickness value
MENU key (fixed front panel)	Switches from RunTime screen to MAIN menu screen
STATUS key (fixed front panel)	Switches to RunTime screen from any menu screen, to detailed power and crystal info screens from RunTime screen
Zero Power [non-active process]	zero channel 1-8, zero all [1st STATUS key press from RunTime]
Zero Thickness[1]	zero channel 1-8, zero all, re-verify [2nd STATUS key press from RunTime]
Force Fail [non-active process]	fail channel 1-8, fail all, re-verify [2nd STATUS key press from RunTime]

[1]Zero thickness does not affect film thickness value, only Source Sensor card value (use to set tooling factor, diagnose problems, etc.)

[2]If the PROCess *X*: *status message* does not change when the START key is pressed, check for "STOP: INValid *XXX* " message or check the OPT/INF menu, page 2 for cards not installed which are enabled in software (MIA). Cycle AC power OFF⇨ON to re-sync.

System Configuration values:

[Menu end point: System Config Menu path: Main/Executive menu/System Configuration]

LCD Contrast / Bias	LOW, MEDIUM, HIGH
Password Lock #	0 - 9999
(Process) Run Number	0 to 9999
Recorder Function	Absolute Rate, Rate Deviation, Power, Thickness, Computer Remote, I/O Control, Off
Recorder Out Channel	1 – 8 selects an analog output channel for use (if not *off* and not used as a *source*)
Real Clock Time	HH/MM
Real Clock Date	MM/DD/YY
Need Source/Sensor Card 1	OFF/ON
Need Source/Sensor Card 2	OFF/ON
Need Source/Sensor Card 3	OFF/ON
Need Source/Sensor Card 4	OFF/ON
I/O Slot 1 Type	UNUSED (DISABLED) / INPUT / OUTPUT
I/O Slot 2 Type	UNUSED (DISABLED) / INPUT / OUTPUT
I/O Slot 3 Type	UNUSED (DISABLED) / INPUT / OUTPUT
I/O Slot 4 Type	UNUSED (DISABLED) / INPUT / OUTPUT
Memory Module IFC	OFF/ON

Communication values:

[Menu end point: Comm. Setup Menu path: Main/Executive menu/Communications Setup]

COM/IO Lock Code	0 - 9999
Keyboard Beep	OFF / ON
RS232 Baud Rate	300, 1200, 2400, 9600
RS232 Protocol	Sycon, ASCII

Source Sensor Map elements: [Menu end point: Review SS Map Menu path: Main/Review SS Map]

Source Sensor Full Power Volts	2.5, 5, 10 full scale volts
Source Sensor Max Power Value	0.0% - 100.0%
Source Sensor Analog Output Chnl	1 – 8 Channel Selection
Master Tooling Value	10.0% - 400.0%
Minimum Start Xtal Channels	1 – 8 minimum channels
Minimum Backup Xtal Channels	0 – 7 minimum channels
Minumum Active Xtal Channels	1 – 8 minimum channels
(Xtal) Channel Drop Filter	NONE, BALANCE [Mask dropped Xtal channel Failure] **averaging mode only**
Indexer Synchronization Mode	NONE, DELAY, FEEDBACK
Indexer Synchronization Time	2 – 999 seconds
Channel 1 Start Mode	OFF, ACTIVE, STANDBY
Channel 1 Fail Action (Mode)	NONE, ABORT FILM
Channel 1 Backup List	X – XXXXXXXX (1 item list to 8 item list), [where X = 1 to 8 (in each position w/o redundancies, list extends to 0-8 for a 1 item list)]
Channel 1 Tooling Value	10.0% - 400.0%
Channel 1 Weight	10.0% - 400.0%
Channel 2 Start Mode	OFF, ACTIVE, STANDBY
Channel 2 Fail Action (Mode)	NONE, ABORT FILM
Channel 2 Backup List	X – XXXXXXXX, [X = 1 to 8 (in each position w/o redundancies)] see CH1
Channel 2 Tooling Value	10.0% - 400.0%
Channel 2 Weight	10.0% - 400.0%
Channel 3 Start Mode	OFF, ACTIVE, STANDBY [need 2nd Source Sensor Card for Channels 3 & 4]
Channel 3 Fail Action (Mode)	NONE, ABORT FILM
Channel 3 Backup List	X – XXXXXXXX, [X = 1 to 8 (in each position w/o redundancies)] see CH1
Channel 3 Tooling Value	10.0% - 400.0%
Channel 3 Weight	10.0% - 400.0%
Channel 4 Start Mode	OFF, ACTIVE, STANDBY
Channel 4 Fail Action (Mode)	NONE, ABORT FILM
Channel 4 Backup List	X – XXXXXXXX, [X = 1 to 8 (in each position w/o redundancies)] see CH1
Channel 4 Tooling Value	10.0% - 400.0%
Channel 4 Weight	10.0% - 400.0%
Channel 5 Start Mode	OFF, ACTIVE, STANDBY [need 3rd Source Sensor Card for Channels 5 & 6]
Channel 5 Fail Action (Mode)	NONE, ABORT FILM
Channel 5 Backup List	X – XXXXXXXX, [X = 1 to 8 (in each position w/o redundancies)] see CH1
Channel 5 Tooling Value	10.0% - 400.0%
Channel 5 Weight	10.0% - 400.0%
Channel 6 Start Mode	OFF, ACTIVE, STANDBY
Channel 6 Fail Action (Mode)	NONE, ABORT FILM
Channel 6 Backup List	X – XXXXXXXX, [X = 1 to 8 (in each position w/o redundancies)] see CH1
Channel 6 Tooling Value	10.0% - 400.0%
Channel 6 Weight	10.0% - 400.0%
Channel 7 Start Mode	OFF, ACTIVE, STANDBY [need 4th Source Sensor Card for Channels 7 & 8]
Channel 7 Fail Action (Mode)	NONE, ABORT FILM
Channel 7 Backup List	X – XXXXXXXX, [X = 1 to 8 (in each position w/o redundancies)] see CH1
Channel 7 Tooling Value	10.0% - 400.0%
Channel 7 Weight	10.0% - 400.0%
Channel 8 Start Mode	OFF, ACTIVE, STANDBY
Channel 8 Fail Action (Mode)	NONE, ABORT FILM
Channel 8 Backup List	X – XXXXXXXX, [X = 1 to 8 (in each position w/o redundancies)] see CH1
Channel 8 Tooling Value	10.0% - 400.0%
Channel 8 Weight	10.0% - 400.0%

I/O Function elements:

[Menu end point: I/O Setup Menu path: Main/Executive menu/ I/O Setup]

I/O Relay Functions	user I/O program (8 Form C Relays per card [4 slots available for I or O cards])
I/O Input Functions	user I/O program + PCB jumpers (8 Inputs per card [4 slots for I or O cards])
I/O Setup	Memory: save/swap, Operate: run/stop
I/O Programming	Edit (Program): **IN**, **NOT**, **AND**, **OR**, **XOR**, **POS**itive, **NEG**ative, **OUT**, **TRiP**, **SET**, **CLeaR**, **ARM**, **DRoP,** (events/states/logical operators), (softnodes) and (numeric elements). Arithmetic operators/elements: **KON#** (to input constants), **ADD, SUB**tract, **MUL**tiply, **DIV**ide, **MOD**ulus, **EQU**als, **GREaTer** than, **LESs** than, and **SELect**. Editing: backspace, left/right arrows (to move cursor), delete, undo, insert/delete line.
(Front Panel LEDs [4 discrete])	I/O programming elements (see table x in section 5xx and Section 2.2)
(User Front Panel Keys [4])	I/O programming elements (see table x in section 5xx and Section 2.2)
Pendent Keys	(beyond specified Manual Mode use: I/O programming elements [see table xxx in section 5xx])

Service Menu values:

[Menu end point: Service Menu path: Main/Service]

(Test Mode Select)	Test Off, Test On [Test Mode won't remain in effect if power is cycled)
(Seq/Non-seq Mode Select)	Seq(uencing Mode Select en)able, Non-seq(uencing Select enabled)
(Memory Contents)	as is (no modification), purged, factory (defaults) [see section x.2.2xx]
(Reset)	Arm reset, reset armed [Provide a product reset when back panel power switch is not accessible. Also, use to generate ACCEPT key if not present (e.g. to end the Test mode when in the Test mode).]

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[*Prerequisite states that must be in effect for the following parameters to be fully functional*]

Film Parameter Dependency List:

Material Density	Not Applicable
Material Z-Factor	N.A.
Setpoint Thickness Limit	N.A.
Final Thickness Limit (Trigger)	Service Menu Parameter: Non Seq / Accept
Setpoint Time Limit	N.A.
Soak 1 Power level Value	N.A.
Power Ramp 1 Time (to pwr level)	N.A.
Power Soak 1 Time (@ pwr level)	N.A.
Soak 2 Power level Value	N.A.
Power Ramp 2 Time (to pwr level)	N.A.
Power Soak 2 Time (@ pwr level)	N.A.
Soak 3 Power level Value	N.A.
Power Ramp 3 Time (to pwr level)	N.A.
Deposit Rate (requested)	N.A.
Rate Ramp Mode	N.A.
New Deposit Rate Value	Film Parameter: Rate Ramp Mode = ON
Rate Ramp Time Duration	Film Parameter: Rate Ramp Mode = ON
Rate Ramp (Thickn) Trigger Point	Film Parameter: Rate Ramp Mode = ON
Control Loop –Proportional term-	N.A.
Control Loop –Integral term-	N.A.
Control Loop –Derivative term-	N.A.
Max Power Limit	N.A.
Abort Max Power SW	N.A.
Max Power Dwell	Film Parameter: Abort Max Power SW = ON

Shutter Delay Mode	N.A.
Shutter Delay TIMEOUT	Film Parameter: Shutter Delay Mode = ON
Shutter Delay QUALITY	Film Parameter: Shutter Delay Mode = ON
(XTAL) RATE SAMPLING	N.A.
(XTAL) SAMPLE INTERVAL	(Film Parameter: (XTAL) RATE SAMPLING = Timed or Film Parameter: (XTAL) RATE SAMPLING = Inteli)
(XTAL) SAMPLE DWELL TIME	Film Parameter: (XTAL) RATE SAMPLING = Timed
(XTAL) SAMPLE QUAL	Film Parameter: (XTAL) RATE SAMPLING = Inteli
(XTAL) SAMPLE ALARM TIME	Film Parameter: (XTAL) RATE SAMPLING = Inteli
FILM Fail Mode	N.A.
Control Loop Qual Limits	N.A.
XTAL Stability S Limits	N.A.
XTAL Life Bounds	N.A.
Plot Vert Scale Volts	N.A.
Plot Horiz Scale H	N.A.
Data Plot Type	N.A.
Source Sensor MAP SELECT	N.A.
POCKET SELECT	N.A.
ETCHING MODE	N.A.

Main Menu value Dependency List:

Next Active Process (Select)[1]	Service Menu: Sequence Able + Accept keys (for Sequencing Mode)[2] If *N/A*, must use *START* + *Reset / Start Proc* keys to start a process.
Next Active Film (Select)[1]	Service Menu: Non-Sequence + Accept keys (Non-Sequencing Mode)[2]
Review Process (Select)	Service Menu: Sequence Able + Accept keys (for Sequencing Mode)[2]
Review Film (Select)	N.A.
Review Source/Sensor Map (Sel)	N.A.

[NOTE[1]: press to invoke number entry submenu, sequence of 1 or 2 digits is entered or discarded]

Note[2]: [the *Seq Able / Non Seq* key shows the current mode upon entry into the Service menu, changing the mode toggles key text and generates the *Accept* key that in turn needs to be pressed to accept new mode described on the key in text]

RunTime Screen parameter Dependency List:

(Crystal Quality Indicator Select)	L/Q, Loop *x*, Qual *xx* Film Parameters
(Crystal Sample Select)	Film Parameter: (XTAL) Rate Sampling = Timed or Intelligent? Running in deposit mode
(Crystal Select)	System Config Parameter: Need Source/Sensor Card *X* Review Source Sensor Map Element Parameters: Minimum Start Xtal Channels Minumum Active Xtal Channels Channel *X* Start Mode
(Process *X*)	Main Menu Parameter: [Next Process] Digit Fixed Front Panel START key: *sequence* from N/A to 1 Service Menu: SEQuence enABLE [sequencing mode]
Layer *X* (layer = step)	Review Processes *X*: EDIT: CHANGE, INSERT, DELETE Layers/steps Service Menu: SEQuence enABLE [sequencing mode]
FILM	Review Processes *X*: EDIT: CHANGE, INSERT, DELETE films [sequencing mode] Review Film *X*: [non-sequencing mode]
(Manual mode)	Running Process + Pressing fixed front panel MANUAL key + attached Pendent

MAP#	Film Parameter: Review Source/Sensor Map Select
SRC *x*	Review Source/Sensor Map Parameter: Source Analog Output Channel Film Parameter: Source/Sensor Map Select (select the map that contains the above selected *Source Analog Output Channel*) **NOTE:** If SRC is zero, this is an indication that a *source analog output control voltage* has been assigned to a source sensor card that is not present, not working, etc. Remember that the System Configuration parameters: Need Source/Sensor Card X and I/O Slot X type are only evaluated on power up or on reset. Check the OPTions/INFo menu, page 2 and 3 to see what is currently in effect. To work correctly, the **S/S *x*: line** should end with OK. If it ends with EMPTY, the card is not present or not communicating. If the line ends with INCOMPATable!, the software versions in at least some of the various PCB cards is not compatible- check for field changed PCB cards. If the line ends with MIA, that sensor card is configured but is not present. [See OPTions/INFo menu]
RUN, PHASE	automatic up/down timers. Function when process/film is started (START key sequence). Effected by film parameters that control film phases within the deposition cycle.
RUN *x*	System Configuration Parameter: Run Number
TIME/Day of Week/DATE	System Configuration Parameters: Clock Time, Clock Date
Graph	Film Parameters: Plot Vert Scale Volts, Plot Horiz Scale H, Data Plot Type
(process start)	Carry out the following 2 key sequence up to 3 times. Press the fixed front panel START key + 1 of 4 touch panel keys: Break Wait, Next Layer, Restart Layer, Reset / Start Process (see figure in end of section 3.0). Use the appropriate touch key for the task at hand. If unsure, use *Reset / Start Process* key in all 3 sequences. *Please read and understand this manual before starting a live process.*
(Test mode) [*to enter*]	Service Menu: Test Off ⇒ Test On (text toggles) + Accept
(Test mode) [*to exit*]	Service Menu: Arm Reset ⇒ Reset Armed (text toggles) + Accept

Password Dependencies:

(Communications values)	Main Menu/ Executive Menu/ Communications Setup: Com/IO Lock Code [non-zero value enables the password dependency and is itself the password.]**
(I/O parameters)	Main Menu/ Executive Menu/ Communications Setup: Com/IO Lock Code [non-zero value enables the password dependency and is itself the password.]**
(all other parameters)	Main Menu/ Executive Menu/ System Configuration: Password Lock # [non-zero value enables the password dependency and is itself the password.]**

**Note: If password is forgotten and programming has not been saved in some other media, call factory to eliminate passwords without purging memory.

SECTION 1.9

Sensor Specifications

Low Profile P/N 500-042 Right Angle P/N 500-088

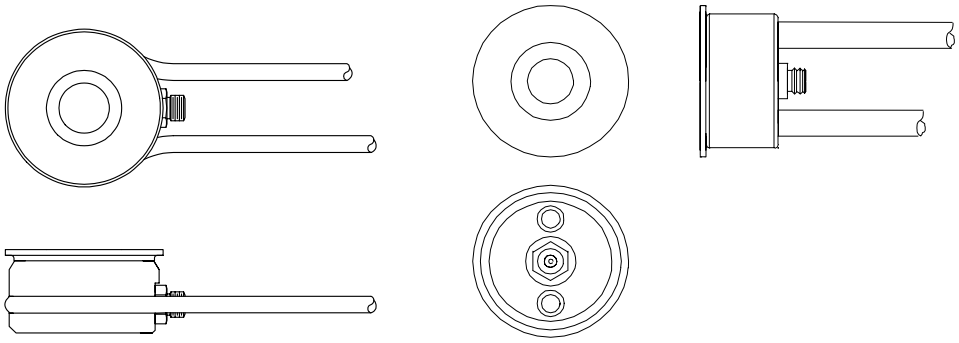

Figure 1.1: Standard Sensors.

Operation

Maximum Temperature ..... 200 °C
Water Line and Coax Length ..... 30 inches
Sensor Mounting ..... Rear of Body, #4-40 Tapped

Feedthrough Installation

Water

Connections ..... Two Required
Type ..... 1/8 inch OD. Stainless Tubing
Flow Rate ..... 0.2 to 0.3 gal/min.
Water Temp..... 50 °C max.

Electrical

Connections ..... One Coaxial Line
Type ..... MicroDot Miniature

Materials (in VAC)

Body and Water Lines ..... 304 Stainless
Insulators ..... Alumina
Coax Insulator ..... Teflon
Coax Conductor and Shields ..... Copper/Silver
Braze Material ..... High VAC Ni/CR/Cu Alloy
Crystal Quartz with Gold Electrodes

SIMPLE QUICK GENERALIZED OVERVIEW

SECTION 2.0

for what is the STC-2002 used ? . . [the problem, the solution]

The STC-2002 addresses the needs of thin film deposition within the vacuum coating industry.
The main function of the STC-2002 is to provide the means for a controlled and repeatable process, which is the deposition of material on a target surface. [process in which material is deposited on a target surface] [process that deposits material on a target surface]
(PVD)
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Without such control, the power [supplies] used to start (or stop) the generation of deposits could be switched on (or off) at human reaction speeds. Once on, the power [supply] outputs could be altered to vary the deposit rate, again at human reaction speeds. From the human perspective, the relatively brief time intervals typically required would be unwieldy at best for accurate control of even a slow process. This kind of direct human control also assumes that a time versus deposition rate and final thickness is known for the various deposited materials. Factor in the many physical elements that effect deposition and the system user, with only time based control, would find it extremely difficult at best for even slowly accumulating thick depositions, and, for thin depositions, impossible to obtain the desired results, much less the consistent desired results. The first need is to at least monitor the deposition and know the thickness (and rate) at any point in time. The next is to be able to control the process based on the monitored information in real time such that the reaction time between monitor and control is at the needed speeds. Fortunately, the needed *monitor/calculation/control* speed is easily within the range of a moderately priced microprocessor.

The STC-2002 has a microprocessor: on each sensor card, on the user interface board (includes interconnected displays, keys, touchscreens, etc.) and on the communications/control/database board. This multiprocessor approach provides greater bandwidth and dedication to specialized functions with obvious benefits: speed, control, etc. The microprocessors used are actually microcontrollers, which can include A/D, D/A, communications, etc. thus providing cost savings and greater reliability because of the higher degree of integration. .

Along with an oscillator and crystal sensor(s), the STC-2002 instrument is the basis of process control and repeatability within a material deposition system. The STC-2002 can be used to monitor and control the process manually, or to monitor and control the process automatically. Utilizing the inherent flexibility of the STC-2002, there are many possible levels of manual control (requiring human intervention at user determined points in the process). This is also true of the automatic process mode. During an automated process, for example, an input state or some other condition can be made to pause the process for user inspection. If satisfactory, the automated process can be resumed by another preprogrammed user input. In addition, reactions between monitor and control (response time, overshoot control, etching vs. depositing, etc.) can be tailored to meet various requirements by user programmable parameters (discussed in PID control section).

The material deposited on the target may be from a single element or a compound (alloy) to create single or multilayered metal deposits, lens coatings, the creation of an alloy combination that has special properties, metalized plastic, etc. The products range from sunglasses, jewelry, automotive decoration, CDs at the low end to optical lenses, mirrors, filters, semiconductors, superconductors, metallurgical research, etc. at the high end.

SECTION 2.1

how is it used ?

First, a few terms and their definitions are needed.

The material to be deposited shall be alternately and henceforth referred to in this manual as an **evaporant source**.

The target surface shall be alternately and henceforth referred to as a **substrate**.

The material is known as an **evaporant** when it has reached sufficient temperature/excitation to leave the surface of the source material supply prior to deposition. The STC-2002 automatically, as it monitors material deposition rate and thickness, controls the power that generates the evaporant within the bounds of the user-defined parameters and other programming. The STC-2002 is programmed through an LCD screen with a touch panel overlay. [ ]
All choices are made within groups of predetermined menu selection alternatives or, as in the case of some data entries, bounded by a *screen specified* range with software enforcing the range of entry acceptance.

With the crystal sensor[s] in the same space as, but not necessarily in relative close proximity to, the substrate, the crystal sensor[s] should accumulate the same amount (or a ratio) of deposited material as the substrate. As the crystal frequency is proportionally related to a deposited mass (within specific bounds), thickness on a substrate can be inferred and deposition rate can be calculated based on thickness values through the progression of time. [For additional information, search the web using "quartz crystal microbalances".]
Other dependent factors such as the type of material deposited (as reflected in *material density* and *z factor*) and the physical positioning of the crystal sensor[s] (see *tooling factor discussion*) are also part of the deposition calculations and are included among the user programmable parameters of the STC-2002.

In a typical case of evaporant stream generation, a high current (or high voltage) power supply is used to heat the material in a boat, crucible or coiled filament. This power supply is controlled by the control output voltage of the STC-2002 sensor card. This power supply can thus be controlled through the STC-2002 either manually or automatically. Manual mode can be used to setup the system before the auto mode is employed. The power supply, in this case, is manually controlled while the deposition is monitored. In non-sequencing mode (defined shortly), the final thickness parameter can be set to terminate the process when reached (evaporant source shutter closure). The power could be switched off via an output relay (a poor man's controller). In the auto mode (sequencing mode), a user programmable PID loop can be used for *process monitor/power supply control* with a relatively high degree of precision based on needed system speed elements. All methods of evaporant stream generation need power supply control. A power supply that is controlled by the STC-2002 typically provides thermal excitation of the target material by laser, electron beam (accurate control), resistance heating (low cost/complexity) or sputter (large area) deposition, each process type having favorable attributes for specific process goals.

Regarding higher level system control, the STC-2002 can be programmed to function in this capacity (keeping in mind failsafe measures).
Using one of the four user programmable fixed front panel keys and output relays, gates/valves could be closed and pumps could be activated as a prelude to the previously described automated process. A pressure monitoring device would signal the STC-2002 through an opto-input when the pressure was correct and the automated deposition would begin. One of the user programmable front panel indicators could be used to show this and that of other points during the process had been reached.

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Returning to STC-2002 specifics, some additional STC-2002 terminology definitions must now be given. Beyond sensor information and power supply control voltage, the STC-2002 also allows the user to define the other parameters that are critical in the deposition process.

In STC-2002 terminology, a **film** is defined as a list of user programmable deposition related parameters (see XXX). Typically, one material deposition is accomplished per film (describes specific: material, mechanical setup, timing, etc.). The STC-2002 can store up to 99 films (referred to as a film recipe library). A **process** is a list of film implementations. Each film implementation is referred to as a **layer** (or step in the process). Process layers can use the same film many times or use any combination of different films (insert figure / see fig. xx).

The STC-2002 has 2 basic process control modes: **sequencing mode** and **non-sequencing mode**. While in either one of these modes, **manual mode** (manual control of power) may be invoked. In addition, a **test mode** can be employed to simulate (w/ simulated rate information) a crystal sensor input while in any combination of the modes just described. Simply put, the sequencing / non-sequencing mode difference is that of having or not having a process. Non-sequencing mode does not have a process (or at least nothing named as such). Non-sequencing mode uses 1 implicit process which can run 1 film. The non-sequencing mode is easiest to configure (user programs an active film). The sequencing mode is more complicated only by the additional programming of a process[es] that calls out a film or films.

The STC-2002 retains the non-sequencing mode for historical compatibility and for simple depositions.

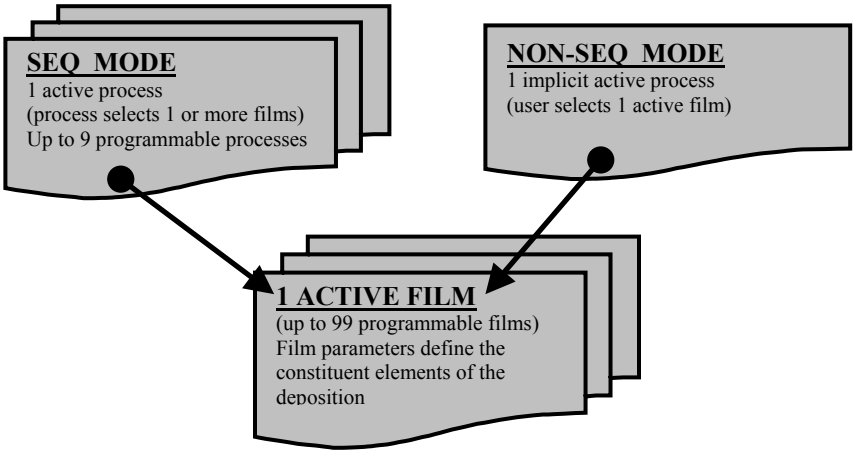
On the subject of films and processes, that which is referred to as *active* is that which is queued to be run when the start sequence is initiated. In other words, except for a co-deposition process, only one film is being deposited at one time and one process (the active process) is calling out that one film in one of its steps. When a process is run (start key sequence), it uses the single process that was selected as the active process (on the Main Menu). Likewise, the film that was selected by the active process as the active film will become the running film. [The non-sequencing mode has only one inherent unspecified process and films are manually selected to be active. Only the film selected as active will be run (Main Menu in *non seq* mode).] Regardless of mode selection, an active process or active film can be edited (modified) while a process or film is running but only in a **limited** manner. This prevents potentially dangerous situations from occurring. The limitations, that is, the parameters that are not changeable while a process (or film) is running include the following:

Film parameters: SS Map Select, Pocket Select, Etching Mode.

Map parameters: CH x Start Mode, Source full power, Source out channel, Indexer Sync Mode.

Min ~~~ XTALS [3 parameters] (evaluated at start only except for RE-VERIFY key usage).

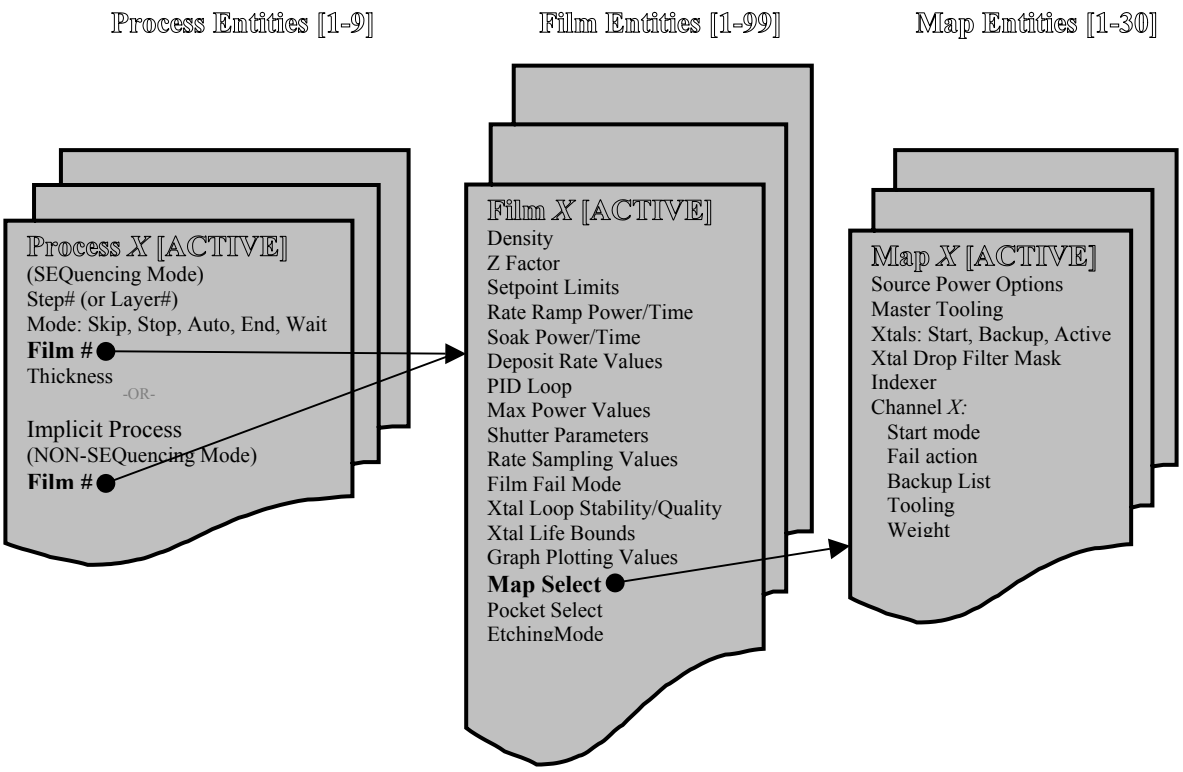
Process: Film# of current running step, Process length (no step insertion/deletion).<<<move?>>>



In terms of STC-2002 usage, the **simplest configurations** would be either in **sequencing mode** with: 1 crystal, 1 oscillator, 1 process, 1 film, 1 material, and 1 deposit or in **non-sequencing mode** with: 1 crystal, 1 oscillator, 1 film, 1 material, and 1 deposit. Also for these simplest configurations, in either sequencing or non-sequencing mode, a **single sensor** input would be employed along with a **single control voltage** output (controls power to that which is generating the evaporant). The simplest means of evaporant stream generation would be resistive heating.

In terms of unit hardware, this translates into an STC-2002 with 1 sensor card, 1 output card and 1 input card.

In terms of unit software (menu programming), a specific film is either called by a process (in sequencing mode) or called directly (in non-sequencing mode). The film, in turn, calls out a specific sensor map. Except for co-deposition applications, which will be explained elsewhere, only 1 process, only 1 film, only 1 map can be active (running) at a single point in time. A process can call a different film at each of its steps (or layers) up to 99 steps.



The typical usage would not be much beyond the simplest case as described above. This would include more films (implying more materials), multiple deposits of the same or different materials or more processes. In addition, a multiple crystal head with an integral *either/or* shutter is sometimes used as an input to 2 sensor inputs. Although these configurations represent most systems, the capabilities of the STC-2002 are far beyond these necessities. [A multiple crystal head that is used as an input to a **single** sensor input is not supported with this product (no switching with zeroing on a single input, etc.).]

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Examples of added usage complications would be using (or using more) digital inputs, relays, more crystals, more sensor channels, external I/O voltages, strip chart recorders, communication terminals, e-beam source indexer (model: SRT-400), etc.
A pendent is supplied for some remote front panel functions and manual mode usage. The pendent plugs into the front panel of the STC-2002 and has a 6 foot coiled cord.
A sensor card has 2 identical sensor inputs and 2 identical analog outputs. The 2 analog outputs, in a single sensor card system, are typically used as 1 control output voltage and 1 strip chart output voltage. When multiple sensor cards are used, the strip chart recorder output can be set up on any of the analog outputs but only one strip chart recorder function per system is programmatically allowed. Each of the two analog outputs arrive at the external connector in 2 polarities: isolated and a negative version of the isolated output. A less expensive non-isolated version of the card is TBD? There are slots for 4 sensor cards (1 sensor card is standard in the STC-2002). Crystal sensor and control voltage output usage has been described above. If one of the analog outputs is programmed for strip chart recorder output, a software menu change can convert the strip chart output into a second isolated control voltage output.
There is another group of 4 slots for either input cards and/or output cards (1 of each type in the first 2 slots are standard in the STC-2002). Input cards have 8 opto-coupled inputs. Output cards have 8 form C (SPDT) relays. Inputs are typically used to trigger events at some meaningful point in the process or to

indicate to the system user that some point has been reached. Outputs (relays) are typically used to open/close shutters on material sources and crystal sensors, but are also used to control many other valves, relays, solenoids, etc. The card IDs (software addresses) of the PCBs (sensor, input, output cards) are not unique within their types nor are they programmed by hardware or software. It is the location into which they are connected that gives them their unique identity (software address).
A communication port is used to interrogate the STC-2002. By using a set of commands, various information can be downloaded or uploaded, front panel control can be simulated, process control can be modified/stopped/started/driven, etc.

There are also other useages and subuseages. Some other useages would be test mode and rate sample/hold mode.
Multiple material co-deposition are also possible with additional hardware and different software described in a different manual.

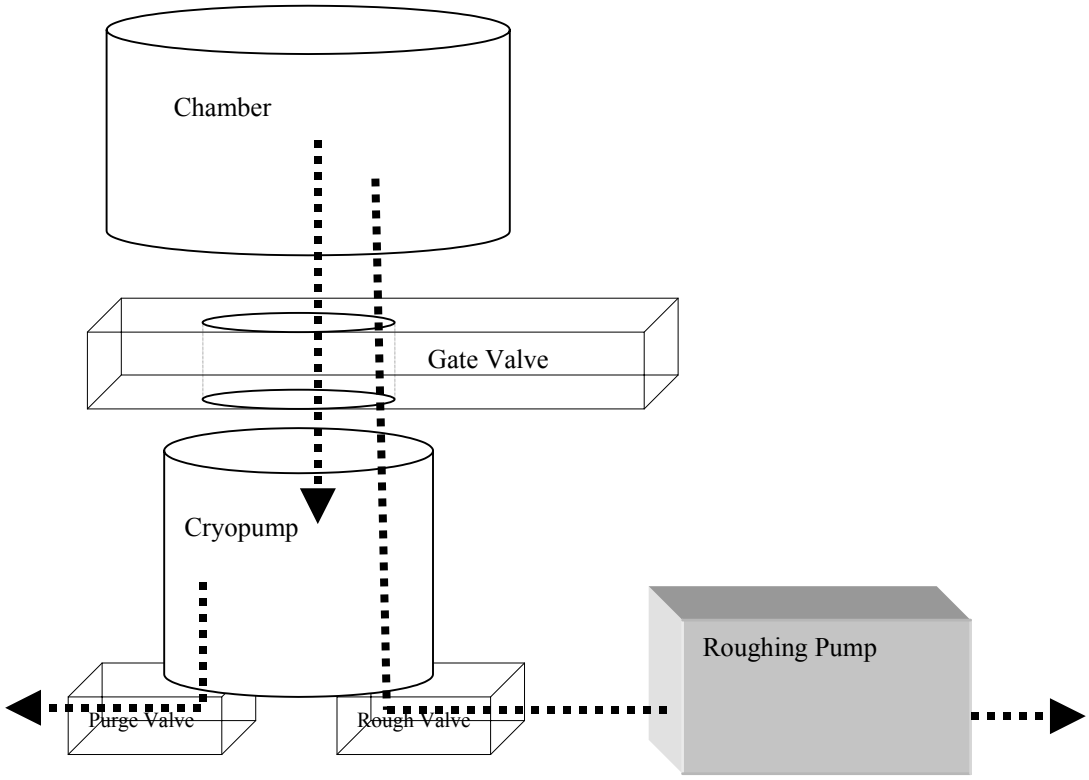
SECTION 2.2

how does it work ?

Be forewarned that the general information contained herein is meant only as an overview of the system. The information presented here does not adequately describe the many hazardous situations that could occur brought about by the incorrect constellation of valve states, temperatures, pressures and voltages. The system needs to have safety provisions should inadvertent human intervention cause changes or should a power failure of any or all parts of the system occur. Safety concerns include electrocution and explosion.

A generalized, simple, thin film vacuum deposition system (using physical vapor deposition techniques) needs a number of components. A vacuum chamber provides the space and environment in which the deposition process will occur. A vacuum is necessary to provide a decreased potential for atomic collisions and contamination (better dispersion with less impurities). Vacuum pumps are needed: roughing pump (starts vacuum), cryogenic pump (provides final high vacuum), etc. Relays, valves and solenoids to control the pumps, pump valves and seal/vent the chamber are needed. A vacuum gauge is needed to monitor the chamber vacuum. Additional vacuum gauges may be used to monitor other points in the vacuum system. At the appropriate pressures, the system user can close/open valves, start the deposition process, etc. A heat/excitation source (electron beam, resistive filament, etc.) to react with the source material to be deposited, the source material itself, a boat, coil or crucible, etc. into which the source material is placed, a power supply for the heat/excitation source, and the target (substrate) material are all needed. A source of water for cooling various components is also needed. An air compressor is necessary to activate solenoid controlled valves, shutters, etc. Various traps can be used to keep gases clean. Crystal sensor[s] and attendant oscillator need to be connected to the STC_2002. Shutters are usually placed to shield the crystal sensors or the source material's evaporant stream, at least during process startup. The STC-2002 typically acts to tie most, or all, of these elements together to control the deposition process. For e-beam use, a sweeper control unit may also be needed. In multipocket e-beam gun systems, a pocket indexer or rotator would also be needed.

The roughing pump creates a low vacuum in the chamber first through the open gate valve, the cryopump and the open rough valve with the purge valve closed. When the desired level of low vacuum is attained, the roughing pump is powered off as the rough valve between the cryopump and roughing pump is closed. The cryopump begins to pump the chamber to a higher vacuum (by condensing gas molecules on an extremely cold surface of a container). When the cryopump reaches saturation, the gate valve is closed and the purge valve is opened so that the cryopump can be regenerated (a heater may be needed). After cryopump regeneration is complete (condensed gases have been dissipated), the purge valve is closed, the gate valve is opened and the pump-down to a higher vacuum using the cryopump continues.



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When the chamber is appropriately pumped down, the source material is heated/excited such that molecules become the evaporant stream and are dispersed.

To reiterate, the source material is known as an evaporant when it has reached sufficient temperature/excitation to leave the surface of the source material supply prior to deposition. A vacuum is necessary to provide a decreased potential for atomic collisions and contamination (better dispersion with less impurities). The STC-2002 automatically, as it monitors material deposition rate and thickness, controls the power that generates the evaporant within the bounds of the user-defined parameters and other programming. The STC-2002 is programmed through an LCD screen with a touch panel overlay. All choices are deterministic or bounded by a screen-specified range with software enforcing the range of entry acceptance. The STC-2002 can also be programmed through the communication port.
The STC-2002 monitors material deposition rate and thickness by means of the crystal sensor, which occupies the same space as the substrate.

As the deposition process is transpiring within a vacuum chamber, the resonant frequency of a quartz crystal sensor, also exposed to the same evaporant as the substrate within the chamber, accumulates deposited film[s] on its surface. The equation in section x7 describes the relationship between the mass of such a film deposition and the measured frequency of the sensor crystal. Knowing the frequency change due to accumulated mass, the **film thickness** can be determined. The **rate of accumulated material thickness** can be calculated using the film thickness along with other elements and progression through time. Contributing factors include crystal sensor placement, material characteristics, etc. The STC-2002 numerically displays rate, thickness and power. It graphically displays rate, power or rate deviation.

As the STC-2002 measures the rate of material deposition (in auto deposit mode), it compares this measured value to a user programmed rate setting. If there is a difference between the actual rate and the user programmed rate, the **control voltage** (from the sensor card) is used to generate a feedback to adjust the deposition source power supply keeping it in compliance with the user programmed rate setpoint value. This method of STC-2002 control has automatic compensation for changing source conditions.

Since there are many different types of deposition power supplies and sources in use today, the deposition **control voltage** provided by the STC-2002 has been made user configurable: can be wired positive isolated or negative isolated and menu scaled for 2.5, 5 or 10 volts full scale. The sense of the control loop can also be set for either deposition or etching applications by menu programming.

To accommodate the extremely wide range of control loop responses required for the diverse deposition sources available today, a **P-I-D** type of **control loop** has been implemented. With this type of control loop available to the user, it should be possible to achieve very good control of any deposition source (see section X3X).

All the control loop parameters interact to some degree in the overall response of the control loop resulting in many combinations of settings that will give equally satisfactory results. Also, the control loop that is optimized for steady state control will have quite different settings from one requiring fast control acquisition with minimal overshoot. By supplying real time rate, rate deviation, or control power to the graph on the STC-2002 RunTime display, determination of control loop settings and performance can be made. By introducing a change into the control system and observing the graphical display responses, it is quite easy to "tune" the control loop. Source response is another contributing control consideration. Sources can be categorized as fast responding (electron beam), medium responding (resistive type boats, baskets, or filaments), or slow responding (Knudsen or induction heated types). User programmable shutter delay can also be used to achieve good deposition rate control before exposing substrates to the evaporant stream. Refer to the I/O programming information later in this section and in section x5x of this manual for a guide on selecting or implementing the logic used to control the substrate and/or sensor shutter[s].

There are several **phases** during a deposition layer of the STC-2002 related to the source and deposition rate control. There are three main parts to a **deposition layer**: pre-deposition, deposition control, and post-deposition. The pre-deposition parameters control the source and material conditioning prior to the film deposition. The STC-2002 can control a variety of different types of **deposition sources**. The typical **run cycle phases** *(rise/soak/rise/soak/shutter delay/deposit/rate ramp/deposit/idle ramp/idle)* are for an electron-beam, resistive element or other thermal source. There are also several **film parameters** (such as DENSITY and Z FACTOR) and associated **map parameters** (TOOLING, WEIGHT) which relate to the deposition material and sensor calibration. All of these issues will be described in greater detail later in this manual.

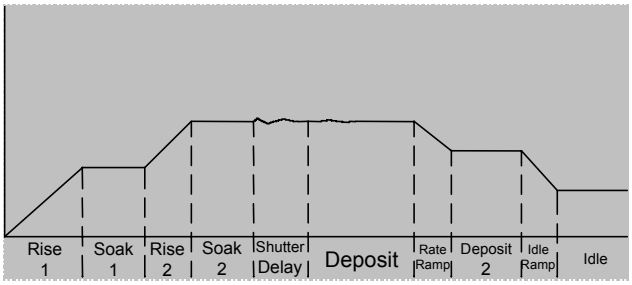
Co-deposition is the running of 2 process layers simultaneously (2 materials, 2 evaporants, 1 or more crystals for each of the 2 co-deposition processes). One of the 2 co-deposition processes will be designated as the one with a final thickness parameter that will terminate the entire co-deposition process. The co-deposition process without the final thickness parameter designation will have a parameter specifying its percentage of the thickness rate of the other process. Another parameter unique to co-deposition is co-deposition interaction which specifies quantitatively [by] how much each process contributes (is seen by) to the other process (the other crystal sensor). Multiple material co-deposition is possible with additional hardware (2nd set of LED/LCD displays) and different software that is described in a different manual.

In addition to the typical configuration of 1 crystal sensor, 1 oscillator, 1 control voltage output, the STC-2002 can utilize (by means of the 2nd sensor channel and optional sensor cards) multiple sensors to acquire evaporant stream data at various locations, insuring greater repeatability of process control as well as better process control (compensating for the vicissitudes of the evaporant stream in location and in time). A number of user programmable parameters effect multiple sensor depositions. *Review Source Sensor Map*

chooses the sensors that are part of the multiple sensor group. Since each sensor has a unique parameter group, programming 2 or more crystals as active automatically invokes an **averaging** mode. Lost channels during averaging are handled by menu programmed alternatives (Main Menu/Review SS Maps/Channel Drop Filter Mask). TBD multiple sensor deposition: *averaging multiple*, *averaging weight*, *interaction calibration* (among the crystal sensors) . [additive]

Although the STC-2002 cannot ***control*** multiple depositions (multiple sources as is the case with co-deposition), but it can maintain other multiple sources (depending on installed and available sensor cards) such that one source output is ***controlled*** while other source outputs can be ***maintained*** at a non-zero power level. This would provide the ability to precondition other materials that could become activated (controlled) when the currently controlled source reaches its preset conditions. In other words, multiple source outputs can be providing some level of output to multiple power supplies while deposition ***control*** can be focused on a single source output (moved) among these. The preconditioning mentioned above would include the soak phases of the deposition process cycle. The soak phase is (or soak phases are) characterized by power being maintained at a constant level.

Note soak power levels in deposition cycle ▷



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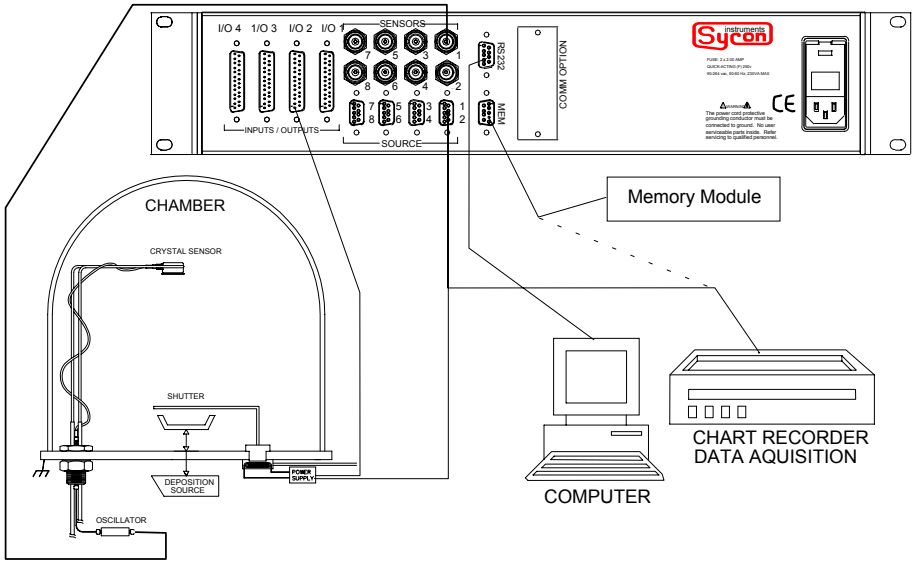
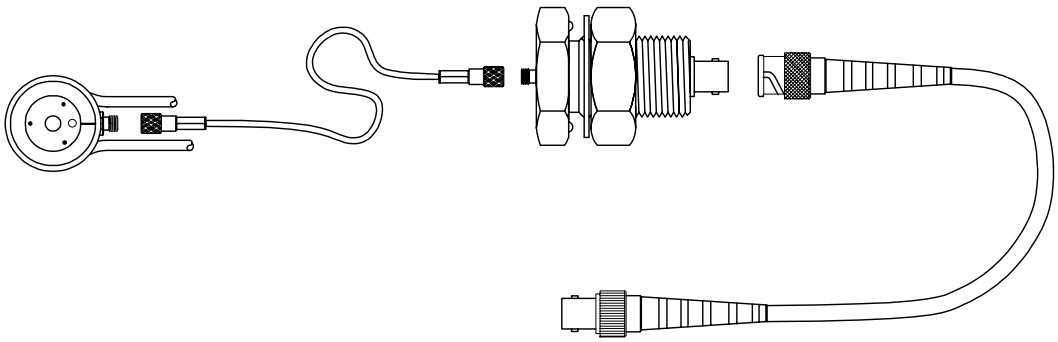
hardware setup discussion (for actual installation details see Sections x3 & 4 but please read this section first)

Following is a diagram of a typical evaporator installation. This diagram is repeated and described further in Section 3 (see fig. 3.7).

NOTE: Chart recorder function through memory module connection uses optional hardware and TBD software.

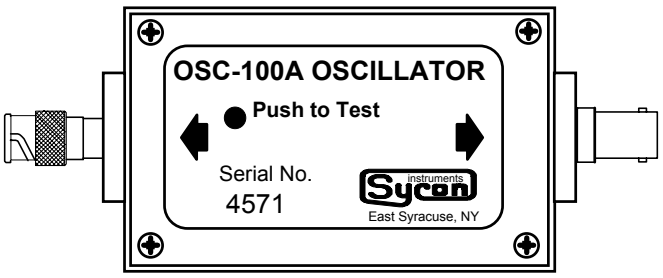


Sensor head hardware generalizations (see Section X4 for actual installation details): [discussion]
A vacuum chamber usually has a number of ports with flanges allowing access to the chamber interior. A typical vacuum **feedthrough** is a threaded cylindrical piece of metal that fits into a chamber's flange (has the appearance of a large bolt with nut and washer). A vacuum feedthrough can provide for the passage of water pipes, compressed air and the electrical connection to the crystal through the chamber wall (or floor) without leaking under vacuum. The vacuum feedthrough typically has relatively short lengths of pipes passing through it from end to end, an electrical passthrough consisting of a microdot connector on the interior side (for the crystal connection) and a BNC connector on the exterior side (for the remote oscillator connection). Feedthrough placement defines the sensor to feedthrough cable length. Lengths over 30 inches negatively effect crystal stability and usable life. Another pipe may also be provided for compressed air (for shutter activation).



Electrical connections from crystal sensor through feedthrough to remote oscillator cable.

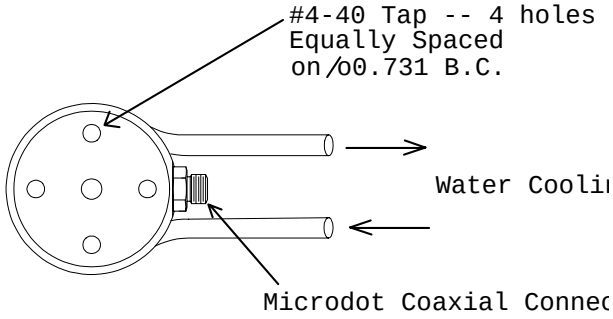
The typical crystal sensor has a microdot coaxial connector located on the perimeter of its body for electrical connection to the enclosed crystal. A teflon cable brings this connection to the chamber wall flange through which it proceeds to the exterior of the chamber via a vacuum feedthrough. The electrical cable from the sensor head to the vacuum feedthrough should be wrapped around the water lines [securing] using up all excess length in the process. The chamber, the sensor body, the outer conductor of the microdot connector and the outer conductor of the BNC connector are electrically interconnected and must be at earth ground for proper use with the remote oscillator and the STC-2002. Grounding also provides safety benefits and lessens signal noise. The remote oscillator can be connected directly to the exterior of the feedthrough BNC if room permits. A 6 inch cable is used if there is not enough room. The cable from the remote oscillator to the STC-2002 sensor card can be as long as 100 feet. These interconnects are 50 ohm coaxial cables. Each STC-2002 sensor card has 2 crystal sensor inputs (BNC males) that, when installed in the STC-2002, are labeled on the back panel as: 1 and 2 (for sensor card 1), 3 and 4 (for sensor card 2), 5 and 6 (for sensor card 3), and 7 and 8 (for sensor card 4). The text SENSORS also appears on the back panel to generally describe the connectors in this area.



Sensor side STC-2002 side

The crystal sensor has an opening which presents an area of the crystal surface to the accumulating deposition material. During setup and initial evaporant material heating/outgassing, this opening on the

sensor should be covered to prevent deposition on its surface. Typically a metal shutter (that can be controlled by an STC-2002 output card and solenoid) is moved remotely to cover or expose the crystal surface and/or the evaporant source. The STC-2002 also has a user programmable shutter delay. Tapped holes are provided on the sensor body for mounting the shutter assembly and/or a mounting bracket to secure the sensor from movement. The sensor body can be opened so that the crystal can be replaced. A "solenoid assembly" is used to provide the compressed air to the shutter and can be electrically controlled by one of the STC-2002 output relays. There are available manual shutters activated through a feedthrough.
The sensor head has a minimum distance to the evaporant source of 10 inches to preclude being struck by larger droplets that which in turn results in incorrect or no readings. These droplets are not part of the evaporant stream and are therefore meaningless to the deposition process measurement. The maximum distance is that which keeps [maintains] the crystal sensor within the evaporant stream. The crystal sensor's deposition surface should be perpendicular to the evaporation source. The sensor mounting must not be free to move or vibrate. If the rigidity of the pipes is not sufficient, secure the sensor with a mounting bracket and screws into the sensor's mounting holes. The evaporant stream needs a clear path (line of sight) to the crystal sensor's deposition surface otherwise intervening physical elements could cast a shadow in the evaporant stream.



The crystal sensor has a pipe bent around most of its circumference for the purpose of transferring heat away from the crystal. Water is sent through the pipe at a specified minimum flow rate to ensure proper cooling. The water lines are typically cut and bent to suit the needs of the chamber interior. The pipes, as previously noted, also provide mechanical support for the sensor. Sensor pipes can be TIG welded or silver soldered to feedthrough pipes. Swagelok compression fittings are an alternative to welding or soldering that allow the easy connect/disconnect of pipes (the long pipes attached to the crystal sensor pass through the Swagelok equipped feedthrough pipes). Covering the pipes and sensor cable as a group with fresh clean aluminum (or other metal) foil helps dissipate heat from the cable thus allowing higher temperature usage while minimizing cable movement. This also keeps deposition materials off the pipes and cable for a cleaner environment when the foil is changed frequently.


Caution

CAUTION Ensure that the water lines are clear of obstructions and restricting bends before operating the sensor above room temperature. (water flow rate details are in section X?.)

Crystal Sensor Variations: The so called **"right angle"** crystal sensor has the microdot connector emerging from the bottom flat surface along with the water cooling pipes (there are no shutter mounting holes on this unit). The so-called **"Bakeable"** crystal sensor has fixed length water pipes between the sensor body and a thick metal disc, which fits into a flange. Also between the sensor body and the thick metal disc, is a rigid fixed length tubing that houses the electrical connection to the crystal (this allows

higher temperatures than the teflon cable of the standard configuration). The ends of the water pipes and crystal connection are on the other side of the thick metal disc (places the 3 terminations outside the chamber). The electrical connection is terminated with a standard male BNC connector. The "bakeable" unit, therefore, presents itself on the outside of the flange like the standard crystal sensor. The so-called **"Dual Shuttered Head"** has 2 crystal sensors in tandem on a single assembly. As part of the assembly, a shutter always covers one crystal while exposing the other. When the shutter moves it exposes the formerly covered crystal and covers the formerly exposed crystal. The installation of a dual shuttered sensing head is similar to that of the single head. A second sensing input (Sensor 2) is used on the second crystal channel. (If other Sensor cards are installed, a second sensing input could be selected on these.) Automatic crystal switching by shutter is accomplished by I/O programming. The primary crystal sensor channel (Channel 1 in this example) has an associated shutter control bit weight value accessed through I/O programming (ID#81). The primary crystal sensor channel (Channel 1 in this example) and the secondary crystal sensor channel (CHannel 2 in this example) are set to the active state by menu programming. By opening or closing the shutter associated with the primary crystal sensor channel (Channel 1 in this example), the I/O programming performs the necessary functions for controlling the shutter of the dual sensor. Proper phasing between the sensor inputs and shutter control can easily be checked by installing a sensing crystal in only sensor 1 and observing the good and "failed" (absent) sensing crystal when switching manually between sensor 1 (good) and sensor 2 (failed).

Of course this mechanical method can be supplemented by using 2 sensors without shutters. The primary crystal sensor channel (Channel 1 in this example) and the secondary crystal sensor channel (CHannel 2 in this example) can also be selected by I/O programming commands or the active sensor can have a backup crystal sensor channel list that names channel 2 (or the secondary sensor channel) as the automatic replacement for the failed primary channel. (Sequence would be: fail primary [by command or 3rd STATUS menu], backup list provides secondary, re-verify [by command or 3rd STATUS menu] reinstates the primary.)

Power Supply Connection: This refers to the high current (or voltage) power supply that provides the energy to create the evaporant stream. The power supply connection on the STC-2002 has the control voltage that controls the high current (or voltage) power supply. From the STC-2002 point of view, this is known as the source control voltage. The word *source* describing the source material of the deposition process in the form of an evaporant stream. Along the bottom of the back panel, in the area where sensor cards may reside, is the text label SOURCE. This is meant to indicate the 9 pin D-sub connector that is part of the sensor card. The text labels ½, ¾, 5/6, 7/8 refer to control voltage outputs. In the first sensor card slot, this indicates control voltage 1 and control voltage 2. Control voltage 1 is meant to control the high current (or voltage) power supply just described. The 2nd control voltage is typically used for the strip chart recorder control. These identical analog outputs can be interchanged. In fact, their function is assigned by means of menu programming. If the two functions (control voltage and recorder) are assigned by menu programming on the same analog channel, the control voltage will have precedence and the recorder function will be lost. After these programmed outputs are used in a film, a conflicting recorder function having been lost in this way would require a reboot to recognize a correcting change. The analog output used for the control voltage output has a number of programmable parameters associated with it. One in the MAIN/ REVIEW FILMS menu path is: *SS MAP SELECT*. Another one in the MAIN/ REVIEW MAPS menu path is: *source out channel*. Don't overlook the ground connection (connector shell). Shielding goes a long way toward noise reduction and ultimately contributes to a stable system. [Section 4.6X has more details]

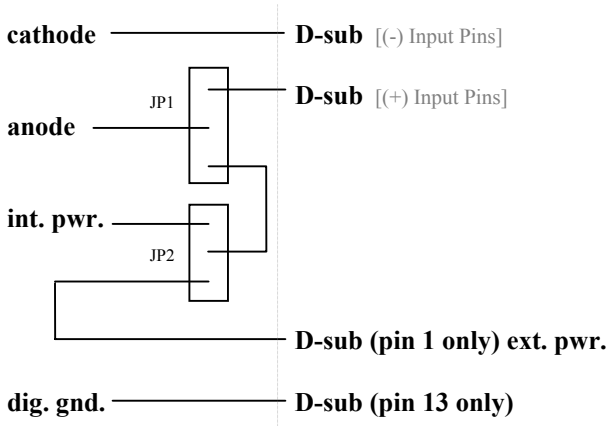
Strip Chart Recorder Connection: This refers to the STC-2002 output from the 9 pin D-sub on a sensor card that can provide the proper analog signal for a strip chart recorder. Along with the hardware connection, the analog output used for the strip chart recorder has a number of programmable parameters associated with it. Two in the MAIN/ EXEC/ SYSTEM CONFIG menu path are: *recorder function I/O control* and *recorder out channel*. Don't overlook the ground connection (connector shell). Shielding goes a long way toward noise reduction and ultimately contributes to a stable system. (See **Power Supply Connection** above) [Section 4.7X has more details]

RS232 Communications Connection: Located in the approximate center of the back panel and labeled with the text RS232 is a male 9 pin D-sub connector for the purpose of communications with a PC or

laptop computer. A straight through cable (that is, pin 1 at one end is connected to pin 1 at the other end, pin 2 to pin2, etc.) **cannot** be used. A cable configuration known as a *null modem* cable needs to be used. A diagram of the connections is shown in section 4.11XX. Operations (start/stop) and menu programming normally done through the front panel controls can be accomplished remotely by means of the interface. Software downloads that become the product firmware can also be accomplished through this port. Menu programming needs to be set for the proper baud rate and communication protocol (Main/Executive/Comm. Setup menus) [Section 3.15X and 3.16Y has more details]

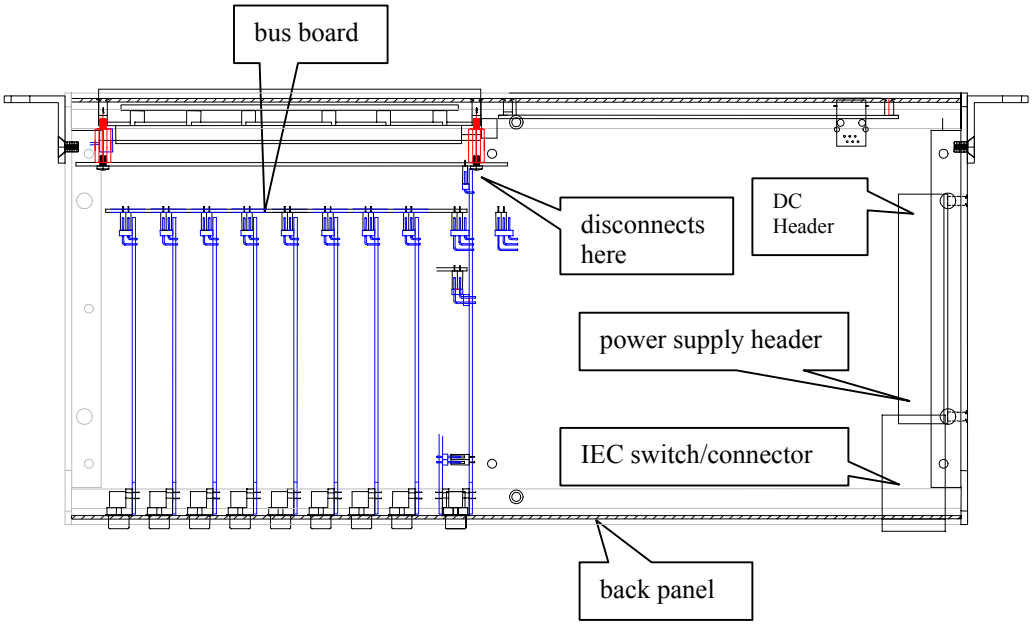
Grounding Stud: Located on the back panel near the AC power connector/switch, the ground stud is a threaded screw embedded in the back panel providing an electrical connection to the chassis ground of the STC-2002 as well as to the ground connection of the AC plug. This should be used to maintain the system equipment grounds, including the chamber, at the same potential as earth ground. As there are many potential sources of high-energy noise that are part of a deposition system, implementation of this ground system can substantially reduce noise resulting in improved system stability. [Section 4.XX has more details]

Input Card Options: An opto-isolated input card can be configured in a number of ways. Inputs can be isolated or non-isolated, internally powered or externally powered (individually or as a group). Jumpers on the input card are used to make the selections. All of the opto-coupler LED cathodes are brought out to the 25 pin D-sub female (i.e. pins 3,6,9,12,14,17,20,23 [(-) Input Pins]). The opto-coupler LED anodes are brought into a jumper header (JP1) where each of the anodes can either be routed to a voltage source or sent out to the 25 pin D-sub female (i.e. pins 2,5,8,11,16,19,22,25 [(+) Input Pins]). The voltage source itself is further selectable on a separate 3 pin jumper header (JP2) such that an internal voltage (+5VDC) can be selected or an external voltage can be selected (comes in on pin 1 of the 25 pin D-sub female). The voltage source, regardless of the JP2 selection, can therefore be applied to all of the anodes when JP1 selects the voltage source. Any one or more of the anodes can be alternately routed through JP1 to keep them isolated from the other anodes and the voltage source. Jumpers can short from the center to one of the ends. Since there are 8 anodes, there are also 8 JP1 sections. The depiction below is a generalization of a single LED input (1 of 8). [Section 4.8 has more details]



Installation/Removal of Sensor Cards, Input Cards, Output Cards: Although other combinations are possible, the following procedure is recommended for field installations and removals. There are **human safety** issues and **component damage** issues that are addressed by this procedure. Please read this procedure in its entirety first before commencing the actual work. Return of the unit is preferred.

1. Disconnect all electrical connections to the STC-2002. This includes all I/O connections, Sensor card connections, RS232 connections, other communications connections, pendent, memory card connections, ground wires and especially the power cord connection. Ensure that the power cord is removed from the back panel IEC 320 connector and that the STC-2002 unit is on a properly grounded rubber mat (or equivalent). The person doing this work should also be properly grounded by wearing a grounding strap.
2. Remove the six screws that secure the top cover. Remove the top cover. Store these items together in anticipation of reassembly.
3. With the top removed, look inside the STC-2002. Disconnect the power connection between the IEC 320 connector/switch assembly (mounted on the back panel) and power supply. This will be a 3 position Molex® type connector housing plugged onto a mating header that is part of the power supply. This will allow for the removal of the back panel. Next, disconnect the DC power wiring harness from the other end of the power supply. This will be a 6 position Molex® type polarized connector housing. Finally, disconnect the 2 pin connector from the LED display board. The wiring harness is now free to move with the bus board. Refrain from flexing the wiring harness at the solder points on the bus board.
4. Locate the two screws on each of the side panels that hold the back panel in place. These are located on the side panels near the back panel (the screws go through the side panels and into the back panel).
5. The back panel/PCB assembly can be pulled straight back away from the STC_2002. The back panel assembly will include the power switch/receptacle/wire harness assembly, the PCB cards secured to the back panel, and the bus PCB that interconnects the other ends of the secured PCB cards. Before pulling the back panel away from the main unit, please note that the PCB that provides the RS232 connection on the back panel will disconnect from a PCB on standoffs running parallel to the front panel. This connection will obviously need to be reconnected upon reassembly. This is why the back panel / PCB assembly must be pulled out straight away from the unit: the header pins may be bent otherwise.
6. With the back panel / printed circuit board assembly on the grounded mat, remove the interconnecting bus PCB from the secured back panel mounted PCB cards taking care to pull the bus board straight out to avoid bending header pins. Place the bus PCB on the grounded mat.
7. PCB cards may be added or removed from the back panel at this time. PCB mounting hardware is removed or added. Securing the PCB cards to the back panel is accomplished by use of the connector mounting hardware.
8. Carefully align all back panel secured PCB connector headers with the mating socket headers on the bus PCB. Start alignment at one end of the bus board, holding each back panel secured PCB lightly in place until all are aligned then press on the bus board such that all bus board connectors are fully engaged with the mating back panel secured PCBs.
9. Introduce the back panel assembly back into the unit moving it horizontally across the table while maintaining its orientation such that the back panel remains parallel to the front panel. Ensure that the power connector harness wires are not pinched or that the insulation on the wires is not damaged. As the PCB (that provides the RS232 connection on the back panel) nears its mating connection, align the assemblies such that the header pins correctly engage and insert straight.
10. Secure the back panel assembly to the side panels with the 4 screws previously removed.
11. Check PCB interconnections for bent pins or misalignments. If there are problems, reverse process to the point needed to correct the problem.
12. Reconnect the switch/IEC wiring assembly connector housing to the power supply header. Reconnect the DC connector housings to the power supply header (6 positions) and LED display board (2 positions). The connectors are polarized.
13. Replace the top cover and secure it with the 6 screws.
14. Reconnect the power cord into the IEC connector.
15. Power on the unit.



Pendent: Also called a hand controller, may be connected by means of the front panel jack labeled Manual Control when certain front panel functions need to be duplicated remotely or when intending to utilize the Manual mode. When not in use, the pendent may be left plugged into the STC-2002 unit or it may be removed. The pendent does not contain any active electronics nor is it polled to check for its presence.

LCD contrast/bias: The optimal viewing is designed for perpendicular to about 45° up and about 45° from perpendicular to either side. Within a few minutes of powering the unit on, there will be some thermal drift effecting color but this should be relatively unnoticeable. If, however, the unit will be in an environment having elevated ambient temperatures (above 30° Celsius), the LCD contrast/bias should be set to *low* through menu programming (Main/Executive/System Configuration menus).

Graphical Display: Although no hardware other than the LCD display is associated with this item, it needs to be setup. Three film parameters need to be programmed: Plot Vert Scale Volts, Plot Horiz Scale H, Data Plot Type. The graphical display, as the name implies, displays, in graph form: rate deviation, rate or power.

Rack Mounting: Rack mounting ears and screws are supplied with the STC-2002 for the purpose of mounting the unit in a standard rack.

Rubber Feet: Rubber feet are not supplied with the STC-2002. The anticipated usage of the product is within a rack. If, however, in the unlikely case where the usage will be on a shelf, table or some other flat surface, rubber feet should be used to prevent sliding with the possible resultant **damage**. They should be of the type that *sticks on* the bottom of the unit. These can be purchased cheaply at many retail outlets. The waxed paper is first removed from each foot. The foot is then applied to the bottom of the STC-2002 such that they are placed in each corner an inch from the 2 corner surfaces. Subsequently, if the unit will be rack mounted, remove the rubber feet.

System Hardware Connections: Except for the generalized previous descriptions, complete system hardware setup is beyond the scope of this manual. Consult the manuals for each of the components in the system. The sum of the manuals is less than the whole: Be forewarned that the general information contained herein is meant as an overview of the system only, an overview to describe how the STC-2002 integrates with the other components in the system and some of its' typical usage's. The information

presented here does not adequately describe the many hazardous situations that could occur brought about by the incorrect constellation of valve states, temperatures, pressures and voltages. The system needs to have safety provisions should inadvertent human intervention cause changes or should a power failure of any or all parts of the system occur. Safety concerns include electrocution and explosion. .

programmable hardware setup discussion (for detailed setup see Section x3 but please read this overview section first)

Synopsis:

Select mode: sequencing/runtime, sequencing/test, non-sequencing/runtime, non-sequencing/test. Optional selects: manual mode and test mode. Select memory configuration: factory, purged, as-is. Program system parameters. Program film parameters (for a single film or multiple films) and process steps. Set active process. Select crystal. Start process.

The versatility of the STC-2002 translates into many modes, parameters and configurations all of which arrive from the factory in default states. Except for the Input card hardware configurations (uses jumpers), all modes, parameters and configurations are menu programmable. The VAR or end user must tailor the unit to work with specific hardware for the desired deposition process.

Run time mode is the general name for the mode used for the deposition process whose screen can always be brought forth from any menu screen by pressing the fixed front panel key labeled STATUS. [A second press of the STATUS key while the Run Time screen is displayed will invoke a screen showing, among other elements, active control output channel[s], pocket number[s] and power % expended on each. A third press of the STATUS key beginning when the Run Time screen was displayed will invoke a screen showing, among other elements, active sensor channels and their states, rates, thickness', stability's and crystal lives. This second screen can be used to fail or reinstate (re-verify) a crystal. **Zero thick**ness at this level is used for tooling setup or diagnostics and has no effect on the deposition thickness.]

The specific **functional run time mode** must be chosen: sequencing or non-sequencing. Either of these modes can be further switched between the normal run mode and the test mode. This results in 4 mode choices: sequencing/run, sequencing/test, non-sequencing/run, non-sequencing/test. Manual mode (manual control of power) can be selected while a process is running by pressing the fixed front panel MANUAL key with the pendent connected.

At the same time that these choices are being made, the **programmable memory** can be kept as it is, purged or set to factory defaults. A memory change can effect film parameters, process steps, run time mode, system configuration, I/O programming, process accounting, and communication parameters. Elsewhere in this manual (appears section 3.21) are tables and lists depicting memory element values after purge and after factory [settings] are invoked. This memory information by itself is also listed later in this section.

A **film** is programmed by selecting the film number (on the main menu), moving through the associated parameter list, and changing the values as needed. Some of the film parameters are not accessible or viable when another related film parameter predicates their availability. Up to 99 films can be programmed. In non-sequencing mode, only 1 film can be run at a time, as there is only one implicit process. In sequencing mode, a **process** can call for a film in a process step. There can be up to 99 steps in a process and up to 9 processes. A process is menu programmed by building each line (step) with a mode value, film number and thickness value.

In the non-sequencing mode, an active *film* must be menu selected (1 of 99). In the sequencing mode, an active *process* must be menu selected (1 of 9). In either case, ***active*** indicates that this is the film or process that will become active when the process starts (initiated by the front panel START key). In addition, neither a film nor a process may be altered by editing when either is being used in a running deposition (for safety reasons).

Some **system configuration** parameters also determine the status of some film and map parameters. Example configuration parameters that fall into this category are: **need s/s card *x*** and **I/O slot *x* type**. Check the *film parameter dependency* list in section X1.8X to find the parameter of interest (all parameters are listed there). Finally, set the status of the controlling parameter such that it allows the

parameter of interest to be accessible and appropriately set. Dependencies are also listed later in this section.

There are some basic parameters that need to be setup. The **Density** and **Z-Factor** can be obtained from table x4.1, in section x4.3 [Review Films menu]. Tooling [Review Source Sensor Map menu] for crystals can be determined empirically by running a trial deposition and using the equation (this will be found in section x4.2):

Tooling = 100 X (Substrate Thickness / Displayed Thickness).

Generally, Tooling is greater than 100% when the sensor *sees* less deposited material than the substrate (e.g. the sensor is further from the evaporant source than the crystal sensor). Generally, Tooling is less than 100% when the sensor *sees* more deposited material than the substrate (e.g. the sensor is closer to the evaporant source than the crystal sensor). If 2 crystal sensors are used (assuming a single sensor card is installed), Start Xtal (crystal) must match the hardware and positioning used. Obviously, the two crystal sensors cannot occupy the same space. Therefore each crystal sensor will have a different tooling factor. Crystal sensor tooling is coordinated by the sensor map menu that selects the sensor along with other sensor properties. The channel specific applicable Review SS Map menu parameter is ***CHx Tooling***. There is also a ***Master Tooling*** parameter (Review SS Map Menu) that can be used change the ratio of all the crystal sensors simultaneously in addition to the individual channel tooling. This can be thought of as a global offset or multiplier used to alter the tooling of all active crystal sensors. In any case, the Tooling factor is the attempt to describe the ratio of deposited material between the crystal sensor and the substrate.

Max Power Limit, Deposit Rate, Soak Power Value, Power Ramp Time, Power Soak Time, Setpoint thickness and time limits need to be described. With these parameters entered, the Test mode could be utilized to check the process behavior. The Max Power indicators show when the Max Power parameter has been exceeded (LED blinks, LCD alternates with MAX!). To reiterate, the TEST mode only effects the crystal sensor information being processed, it does not effect anything else (this includes the control output voltages). This is not the point at which to begin experiments with a live system. This section is meant to provide a discussion of the issues to familiarize the user with functional themes. Please read further.

[no external connections especially unconnected]

When the STC-2002 sensor card control voltage output is connected to the evaporant power supply, Review Source Sensor Map parameters need to be selected for a proper interface (SOURCE OUT CHaNneL, SOURCE FULL PoWeR, SOURCE MAX PoWeR) and the Map itself needs to be selected by a Film parameter (SS MAP SELECT). Following this, other power supply related parameters must also be contemplated. Some thermal excitation alternatives include: electron beam: wire fed electron beam source, high vacuum e-beam w/ small (~2cc) crucible, fixed pocket (large and small), rotary pocket indexers; resistive heater sources: metal filament boats, coils, oxide crucibles (all for organic material deposition). Crucible capacities can range from a fraction of a cc to over 500cc. The input control requirements of the high current (or voltage) power supply should be found in the power supply documentation. Don't assume there is a standard. With the STC-2002 control voltage output controlling the power supply for these thermal sources (the 2nd control output voltage used for power supply control is typically employed for the recorder function), the film parameters effecting power (processes depend upon films) are:

Soak 1 Power level Value	0.0 to 100.0%
Power Ramp 1 Time (to pwr level)	0 to 99:59 MM:SS

Power Soak 1 Time (@ pwr level)	0 to 99:59 MM:SS
Soak 2 Power level Value	0.0 to 100.0%
Power Ramp 2 Time (to pwr level)	0 to 99:59 MM:SS
Power Soak 2 Time (@ pwr level)	0 to 99:59 MM:SS
Soak 3 Power level Value	0.0 to 100.0%
Power Ramp 3 Time (to pwr level)	0 to 99:59 MM:SS
Control Loop –P-roportional term	1 to 9999
Control Loop –I-ntegral term	0.0 to 99.9 sec
Control Loop –D-erivative term	0.0 to 99.9 sec
Max Power Limit	0.0 to 100.0%
Abort Max Power SW	OFF/ON
Max Power Dwell	0:01-99:59 MM:SS
Control Loop Qual Limits	0 to 9
Plot Vert Scale Volts	1, 5, 10, 50, 100 ⇐ Graphical display function
Plot Horiz Scale H	1 to 600 samples ⇐ Graphical display function
Data Plot Type	Rate /Power /Rate Deviation ⇐ Graphical display function
Source Sensor Map Select	1 to 9 (Selects the Map that contains Source Sensor analog output parameters)
Etching Mode	Off / On (Rate Direction can be Positive or Negative)

These parameters are presented here for the purpose of name familiarization and categorization of power related parameters across menu and screen boundaries.

The Power Related **RunTime Screen** parameters are:

(Crystal Quality Indicator Select)	L/Q, Loop *x*, Qual *xx*
(Manual mode)	(fixed front panel key)
(Manual mode)	(pendant arrow keys [increase / decrease power manually])
(Manual mode)	(2nd STATUS screen arrows: ↑↓ [increase/decrease power manually])
(Manual mode)	(1st STATUS screen: zero power key [LCD] on non-active channels)
(Manual mode)	(2nd STATUS screen: zero thick key [LCD] no effect on material thickness)
(Manual mode)	(2nd STATUS screen: force fail key [LCD] fail/verify crystal channels)

The Power Related **System Configuration** values are: Menu path: Main/Executive menu/System Configuration]

Recorder Functions	Rate, Rate Deviation, Power, Thickness, Computer Remote, I/O, Off
Recorder Analog Output ChaNneL	1 to 8 Channels (select 1 only) [note possible conflict w/ Source Analog Output]
Need Source / Sensor Card *x*	on/off

The Power Related **Review Source Sensor Map** values are: Menu path: Main/Review SS Map]

Source FS Voltage Scaling PoWeR*	2.5/5/10 Full Scale VOLTS ⇐ **see Power Supply input requirement**
Source Max PoWeR	0.0 – 100.0%
Source Analog Output CHaNneL	1 to 8 Channels (select 1 only)

The Power Related **Service Menu** values are: Menu path: Main/Service]

(Memory Contents)	as is (no modification), purged, factory (defaults) [see section x3.21x] note film parameter changes
(Reset)	Arm reset, reset armed [Provide a product reset when back panel power switch is not accessible. Also, use to generate ACCEPT key if not present (e.g. to end the Test mode when in the Test mode).]

***NOTE: Of primary concern when connecting evaporant power supply to the sensor card.**

Dependencies

[*Prerequisite states that must be in effect for the following parameters to be fully functional*]

The Power Related **Film Parameter** Dependency List is:

Max Power Dwell	Film Parameter: Abort Max Power SW = ON

The Power Related **RunTime Screen** parameter Dependency List is:

(Crystal Quality Indicator Select)	L/Q, Loop *x*, Qual *xx* Film Parameters
(Manual mode)	Running Process + Pressing fixed front panel MANUAL key + attached Pendent (or on 1st STATUS screen: ↑, ↓, zero CH *x*)
(process start)	. Carry out the following 2 key sequence up to 3 times. Press the fixed front panel START key + 1 of 4 touch panel keys: Break Wait, Next Layer, Restart Layer, Reset / Start Process (see figure in end of section 2.7). Use the appropriate touch key for the task at hand. If unsure, use *Reset / Start Process* key in all 3 sequences. *Please read and understand this manual before starting a live process.*

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Initial Programming Setups (menu parameters)

system configuration programming (factory/ default settings, stand alone / computer controlled)

If the STC-2002 has: arrived directly from the factory or the *factory settings* key has been menu selected or the *purged settings* key has been menu selected, the following specifies the parameter values in effect. The following information will be repeated in later sections in greater detail along with additional related information. The intent here is to introduce the reader to baseline values and consequently what must be altered for the intended use. *Purge* values are listed first, followed by the *factory* differences.

Film Parameter values after purge:

[non-SEQ adds "Final Thick Limit=0.0 KÅ"]

Material Density	1.00 gm/cc
Material Z-Factor	1.000
Setpoint thick limit	0.000 KÅ
Setpoint time limit	0:00 MM:SS
Soak 1 Power Value	0.0%
Power Ramp 1 Time	0:00 MM:SS
Power Soak 1 Time	0:00 MM:SS
Soak 2 Power Value	0.0%
Power Ramp 2 Time	0:00 MM:SS
Power Soak 2 Time	0:00 MM:SS
Soak 3 Power Value	0.0%
Power Ramp 3 Time	0:00 MM:SS
Deposit Rate	0.0 A/S
Rate Ramp Mode	OFF
New Deposit Rate	0.0 A/S
Rate Ramp Time	0:00 MM:SS
Rate Ramp Trigger	0.000 KÅ
Control Loop P	100
Control Loop I	1.0 secs
Control Loop D	1.0 secs
Max Power Limit	0.0%
Abort Max Power SW	ON
Max Power Dwell	0:30 MM:SS
Shutter Delay Mode	Off
Shutter Delay Timeout	0:30 MM:SS
Shutter Delay Quality	10
Rate Sampling	Off
Sample Interval	0:30 MM:SS
Sample Dwell Time	0:30 MM:SS
Sample Quality	10
Sample Alarm Time	0:30 MM:SS
Film Fail Mode	Time Power
Control Loop Quality L	0
XTAL Stability S	0
XTAL Life Bounds	0.0%
Plot Vert Scale Volts	100
Plot Horiz Scale H	1
Data Plot Type	RATE DEV
SS Map Select	1
Pocket Select	0
Etching Mode	Off (pos/neg)

Communication values after purge:

COM/IO Lock Code	0
Keyboard Beep	ON
RS232 Baud Rate	9600
RS232 Protocol	Sycon

System Configuration values after purge:

LCD Contrast	MEDIUM
Password Lock #	0
Run Number	0
Recorder Functions	Off
Recorder Output Channel	1 (note conflict: Source Sensor Out is also1)
Clock Time	no change (HH/MM/SS) (w/o battery: 00/01/00)
Clock Date	no change (MM/DD/YY) (w/o battery: 01/01/01)
Need SS Card 1	ON
Need SS Card 2-4	Off
I/O Slot *x* Type	Disabled (where *x* = 1 to 4)
Memory Module IFC	OFF/ON (optional)

Run Time Screen after PURGE:

PROCess	1 note1
Layer	# note1
FILM (film in use)	1
SRC (Source Control Volts Channel)	1
XTAL	(blank)
MAP#	1
RUN time	0:00
PHASE time	0:00
RUN#	0
(Graph parameter)	Rate Deviation
Crystal Quality	L/Q (Sample/Hold = blank)

MAIN MENU Screen after PURGE:

Review Film	(film 1 will be reviewed)
Review SS Map	(Map 1 will be reviewed)
Next Process	1
Review Processes	(Process 1 will be reviewed)

note1: non-sequencing mode does not have this function (non-SEQ: ACTIVE FILM is 1).

Review SS Map values after purge:

Source Sensor Full Power Volts	10 volts
Source Sensor Max Power Value	0.0%
Source Sensor Analog Output Chnl	1 (Channel Select)
Master Tooling Value	100.0%
Minimum Start Xtal Channels	1 channel
Minimum Backup Xtal Channels	0 channels
Minumum Active Xtal Channels	1 channel
Xtal Channel Drop Filter	NONE
Indexer Synchronization Mode	NONE
Indexer Synchronization Time	2 seconds
Channel 1 Start Mode	OFF
Channel 1 Fail Action Mode	NONE
Channel 1 Backup List	0
Channel 1 Tooling Value	100.0%
Channel 1 Weight	100.0%
Channel 2 Start Mode	OFF
Channel 2 Fail Action Mode	NONE
Channel 2 Backup List	0
Channel 2 Tooling Value	100.0%
Channel 2 Weight	100.0%
[need 2nd Source Sensor Card for Channels 3 & 4]	
Channel 3 Start Mode	OFF
Channel 3 Fail Action Mode	NONE
Channel 3 Backup List	0
Channel 3 Tooling Value	100.0%
Channel 3 Weight	100.0%
Channel 4 Start Mode	OFF
Channel 4 Fail Action Mode	NONE
Channel 4 Backup List	0
Channel 4 Tooling Value	100.0%
Channel 4 Weight	100.0%
[need 3rd Source Sensor Card for Channels 5 & 6]	
Channel 5 Start Mode	OFF
Channel 5 Fail Action Mode	NONE
Channel 5 Backup List	0
Channel 5 Tooling Value	100.0%
Channel 5 Weight	100.0%
Channel 6 Start Mode	OFF
Channel 6 Fail Action Mode	NONE
Channel 6 Backup List	0
Channel 6 Tooling Value	100.0%
Channel 6 Weight	100.0%
[need 4th Source Sensor Card for Channels 7 & 8]	
Channel 7 Start Mode	OFF
Channel 7 Fail Action Mode	NONE
Channel 7 Backup List	0
Channel 7 Tooling Value	100.0%
Channel 7 Weight	100.0%
Channel 8 Start Mode	OFF
Channel 8 Fail Action Mode	NONE
Channel 8 Backup List	0
Channel 8 Tooling Value	100.0%
Channel 8 Weight	100.0%

I/O SETUP values /programs after PURGE:

I/O Programs A & B	Cleared
Memory Menu	A
Operate Menu	Running

Film parameter differences: *factory* restore has: *max power limit* set to 50% (purge = 0%).

Processes Step differences: As an example, the following is the difference between a *factory* setting and a *purged* setting for PROCESS# 3. The *factory* setting has, for the first and only step (step 01): MODE=AUTO, FILM#=3, and THICK(KÅ)=0.300. The *purged* setting has an END line as the first and only step (considered *cleared*). If process 3 were run with *factory* settings, AUTO mode would be invoked using film #3 and running until a final thickness of .300 KÅ was achieved.
If process 3 were run with *purged* settings, the END command would be encountered immediately thus stopping the process. The table below shows this information as well as information for the other processes.

Factory Settings table for All Process Numbers:

	Proc# 1	Proc#2	Proc#3	Proc# 4	Proc#5	Proc#6	Proc#7	Proc#8	Proc#9
STEP	01	01	01	01	01	01	01	01	01
MODE	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO
FILM#	1	2	3	4	5	6	7	8	9
THICK	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900

All *factory* Processes have END as STEP 02.

I/O programs are not *factory* restored because of the danger involved. *Factory restore* will not, therefore, clear or restore the factory I/O program[s] (it leaves them unchanged). *Purge* will, however, clear **I/O programs**. These selections will cause the unit to **REBOOT** with the new configuration in effect. The section describing the SERVICE menu will describe these elements in detail. As seen in the above lists, there are groups of settings (Film parameters, System configuration, Communications, Processes, I/O programs, etc.) that will be included in these configurations. **Valuable process programming could be lost.** The **BYE** key can be pressed to leave the SERVICE menu without changing anything.

If the password is forgotten and programming has not been saved in some other media, call the factory to eliminate passwords without purging memory.

I/O programming Introduction

The **I/O programming** is what controls the opto-isolated inputs on the Input card and the isolated relay contacts on the Output card. Similarly controlled, the front panel has 4 LEDs that are intended as user controlled outputs, 4 user programmable fixed keys that are intended as user controlled inputs and the pendent whose alternate function is user I/O programmable inputs. This I/O programming control extends to input acquisition of front panel key presses, elements of film deposition run cycle states (i.e. rise, soak, deposit, idle, etc.), various process state conditions, process switching, various crystal states or events, setpoint conditions, etc. I/O programming also controls by means of general variables, events and states.~ The I/O programming can discern *whether* an input has changed state and *when* it has changed state. When an input has both state information and temporal information, it is known as an **edge** event condition. When an input has only the state information, it is known as a steady **state** condition. Outputs also have analogous *edge event* and/ *steady state* conditionality. The output result is, correspondingly, either a pulse or a steady state.

To reiterate, Run time mode is the general name for the mode used to run the deposition process whose screen can always be brought forth from any menu screen by pressing the fixed front panel key labeled STATUS. The Run time mode of the STC-2002 has 2 basic process control modes: **sequencing mode** and **non-sequencing mode**. While in either one of these modes, **manual mode** (manual control of power) may be invoked. The specific **functional run time mode** must be chosen by menu selection: sequencing or non-sequencing.

In addition, a **test mode** can be employed to simulate a crystal sensor input (w/ simulated rate information) while in any combination of the modes just described. Simply put, the sequencing / non-sequencing mode difference is that of having or not having a process. Non-sequencing mode does not have a process (or at least nothing named as such). Non-sequencing mode uses 1 implicit process which can run 1 film. The non-sequencing mode is easiest to configure (user programs an active film). The sequencing mode is more complicated only by the additional programming of a process[es] that calls out a film or films.

Inputs, outputs and all the other states and events have a numeric representation called an ID number. An ID number is used to numerically represent: inputs, outputs and all the other states and events. They can be named by their description and classified by state/event condition. A table containing all I/O programming events and states can be found in this manual. After locating an event or state that the user needs as a pivotal point in their process, the identifying ID is found. Next, consideration of the needed I/O programming function type is assessed. The available **function types** are: Input, Output, Trip, Arm, Drop, Set and Clear. The combination of function type and ID number produces (in STC-2002 terminology) a **token**. For the sake of LCD screen limitation imposed brevity, only the first letter of the function type is used to describe the function. Token constituent elements can also include other elements such as a single Boolean operator. Incorrect function type / ID pairings are identified for the user and not allowed as an entry.
Although film parameters provide time, power and thickness based control, I/O programming provides not only these but added dimensions to the kind of control that is achievable. The number of conditional elements is increased dramatically.

I/O programs are constructed using the LCD/touch panel menus. Programs are written in **R**everse **P**olish **N**otation (RPN) by constructing one (or more) line entities that are called rungs. If a single I/O programming task of the total work to be accomplished takes more than one line, an intermediate variable called a softnode can be used to carry the partial result of the task from one line into another line that completes the work.

Example illustrating softnodes:

(where *x* and *y* are used like softnodes in the following 3 generalizations)

$2 + 3 + 5 = x$ ← assignment of the *x* softnode, one program line (or rung) in Algebraic Notation

$2 + 5 = y$ ← assignment of the *y* softnode, another program line (or rung) in Algebraic Notation

$x + y - 3$ ← combining the softnodes, another program line (or rung) in Algebraic Notation

Example illustrating notations:

Algebraic Notation (2 + 3 x 5) vs RPN (2 3 5 x +) answer (in either notation): 17

Algebraic Notation ((2 + 3) x 5) vs RPN (5 3 2 + x) answer (in either notation): 25

[RPN is used to eliminate abiguous and error prone precedence rules determining the order of evaluation and because of the stack oriented nature of RPN that is conducive to the I/O programming structures.]

The line length limitation is purely a result of LCD screen size limitations. **Each program line** (or rung) has an input statement, an output and a consecutive line number (for line identification). A softnode can be used as the output of the line (or rung).

Aside from states and events, there are arithmetic, relational, selectional and logical (Boolean) operators used for I/O programming. The logical operators are AND, OR, XOR and NOT. A Boolean value can have only 2 states. There are many alternate names for these 2 states (respectively): true/false, on/off, 1/0, high/low, closed switch/open switch, system voltage/zero voltage, positive voltage/negative voltage, even negative voltage/positive voltage, etc. Logic levels conform to the following table:

Where logic level 0 = zero volts, logic level 1 = system high volts, Boolean value T = true and Boolean value F = false.

Logic Levels In	Boolean Value In	AND [&] result	OR [¦] result	XOR [^] result	NOT [!] result
0	F	(2 or more inputs only)	(2 or more inputs only)	(2 or more inputs only)	T
1	T	(2 or more inputs only)	(2 or more inputs only)	(2 or more inputs only)	F
00	FF	F	F	F	(uses 1 input only)
01	FT	F	T	T	(uses 1 input only)
10	TF	F	T	T	(uses 1 input only)
11	TT	T	T	F	(uses 1 input only)
(with 3 inputs ↓)		(using 2 AND operators ↓)	(using 2 OR operators ↓)	(using 2 XOR operators ↓)	(uses 1 input only)
000	FFF	F	F	F	(uses 1 input only)
001	FFT	F	T	T	(uses 1 input only)
010	FTF	F	T	T	(uses 1 input only)
011	FTT	F	T	F	(uses 1 input only)
100	TFF	F	T	T	(uses 1 input only)
101	TFT	F	T	F	(uses 1 input only)
110	TTF	F	T	F	(uses 1 input only)
111	TTT	T	T	T	(uses 1 input only)

Although the above table ends with three inputs, this does not imply an I/O programming input limitation as many elements can be OR'ed, XOR'ed or AND'ed together but there is a **syntactical limit** of 2 elements only per each OR, XOR or AND operator. These can be cascaded to the limit of the line length and, beyond that, using softnodes, to the limit of the program maximum length.

The constituent parts of a program line (or rung) consist of logical operators and elements that are logically combined or altered by them. These elements involve what was previously described as a token.

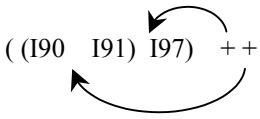
Incorrect function type / ID pairings are identified for the user by an error message and not allowed as an entry.

Examples:

(*where* I *represents an input, the number an ID representing various system input states*)

I90 I91 ¦	(this ORs inputs 90 and 91 together)
I90 I91 I97 ¦ ¦	(this ORs inputs 91 and 97 together and ORs the result with 90)
I90 I91 + I97 ¦	(this ORs inputs 90 and 91 together and ORs the result with I97 [this has the same result as the 2nd example, an alternate way of writing it])
I90 I91 I97 I100 ¦ ¦ ¦	(this ORs inputs 90, 91, 97 and 100 together)
I90 I91 I97 I100 & & &	(this ANDs inputs 90, 91, 97 and 100 together)

For those expecting something like I90 ⊕ I91 ⊕ I97 ⊕ I100 notation, the ID tokens are written first (at least 2) followed by the logical operator token for each pair of Or'ed elements.



⇐**1st two tokens are OR'ed, their result OR'ed with the last token**

[parenthesis are not part of program, they indicate grouping only]

I/O Functions include: INput, OUTput, SET, CLeaR, ARM, DRoP and TRiP (KON may also be considered as a numerical input).
Logical operators include: AND, OR, XOR, NOT, POSitive and NEGative.
Arithmetic Functions include: ADD, SUBtract, MULtiply, DIVide, MODulus, EQUality, GREaTer than, LESs than, SELect, KON (numeric constant).
Navigational/Editing functions are also included in the I/O programming menus: ←, → (cursor move), ENTer (line ENTer [on 5/5] and value ENTer), UNDO, DELete, BAcKSPace, BAcK (1 menu position), MORe (menu screens), BAcK (leave edit w/o save).

On the LCD screen, the line (rung) number always appears above the token string for which the line has been constructed.

001:	⇐ the first line of the I/O program, the line number part
[token string]	⇐ the first line of the I/O program, the token string part
002:	⇐ the second line of the I/O program, the line number part
[token string]	⇐ the second line of the I/O program, the token string part
003:	⇐ the third line of the I/O program, the line number part
END	⇐ the third line of the I/O program, the token string part

The shortest possible (though not useful) I/O program: [has 1 *line*, *line* is not a screen line but a program line]

001:
END

The following is an I/O program that inputs a user programmable front panel key and outputs the logical state of the input to a user programmable front panel LED. The ID numbers specify the rightmost key and LED. The TRIP function is used as an output; therefore the output will be pulsed. (Function types will be described in section 5X.) With this I/O program running, a press of the rightmost user key will result in the momentary (~1 second) illumination of the rightmost user LED. [An I/O program is running when the menu key *run* is selected from the choice pair RUN / STOP.] The duration is based on the speed at which the lines of the I/O program are processed (by an I/O program *"clock"* [approximately 1 second]).

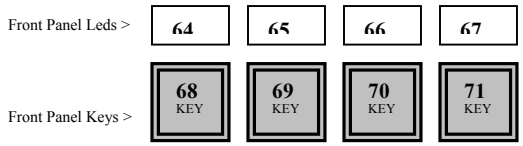
```
001:
I71  T67
002:
END
```

Starting with the above I/O program, the TRIP function is replaced with the OUTPUT function, and the Boolean NOT operator is inserted between the Input and the Output tokens. With this I/O program running, the LED is immediately illuminated. Pressing the rightmost key causes the rightmost LED to extinguish. The key is considered a logical False (low) when not pressed. The logical False (low) is converted to a logical True (high) by the Boolean NOT operator which is in turn sent to the LED output thus illuminating it. Pressing the key is considered a logical True (high). The logical True (high) is converted to a logical False (low) by the Boolean NOT operator which is in turn sent to the LED output thus extinguishing it.

```
001:
I71  !  O67
002:
END
```

The following is an I/O program that uses elements of the previous two programs to demonstrate the difference between the **T**rip and **O**utput functions. Again, the I/O program inputs a user programmable front panel key and outputs the logical state of the input to a user programmable front panel LED. The **T**rip function will be pulsed whereas the **O**utput function is not. If the 70 key is pressed and held, the 66 LED is illuminated for about a second, it must be released and pressed again to illuminate the 66 LED once more. If the 65 key is pressed and held, the 65 LED is illuminated for at least as long as the 65 key is held.

```
001:
I70  T66        ⇦Trip
002:
I69  O65        ⇦Output
003:
END
```



The following program provides indications of 2 Stopped Mode conditions. The first should be activated upon pressing the front panel STOP key (leftmost LED). The second LED is illuminated when a process stops due to failed crystal when running a deposition (LED 2nd from the left). Please note that once the leftmost LED is illuminated, it will not be off until the deposition process is run again. The next LED will not be off until the deposition process is run again with the crystal replaced and re-verified (menu invoked at the 2nd press of the STATUS Key). Input 73 is not a simple Boolean value as was 71 in the above example but a scalar numeric value. In the first case (line 001), the Stopped Mode (73) is input and compared to the constant numeric value of 4 by the EQUality operator. If the input is equal to the value of 4 then it will be passed on to the Output at 64 as a Boolean True. If it is not equal to 4, then it will be passed on to the Output at 64 as a Boolean False. The LED will, in turn, indicate the result. Line 002 is similar except that the input is checked against the constant numeric value of 2 and the result is output to a different LED.

```
001:
I73  #4 = O64        ⇐ inputs status of Stopped Mode from Front Panel. When true, LED = on
002:
I73  #2 = O65        ⇐ inputs status of Stopped Mode-Crystal Bad. When true, LED = on
003:
END
```

Note: If these entries are added to the above examples in one program (by using higher rung #s), an error message will be displayed: **ERROR: 065 PHASE ERROR→ OK**. This indicates that the 065 output has already been used and the STC-2002 software will not allow the rung to be entered as it is. If multiple sources could use the same output, the effect would be difficult to trace back to all of the causes. The preferred way is to use intermediate elements to combine logic before the single output. As programs are developed, editing over existing lines with the intent of complete replacement is possible but there may be outputs used on lines beyond current edit line that may prevent the entry. Delete entire lines by using the higher level menu key "DELete" to avoid this problem.

The following I/O program activates relay 2 (if relay card is installed in slot 2) when leftmost user programmable front panel key is pressed (relay activation can be heard).

001:
I68 O9 ⇐ inputs status of leftmost user key, outputs to Relay 2
002:
END

The following I/O program uses a modulo 100 counter (ID 401) to activate user programmable LEDs on the front panel. Starting with line (rung) **001**, when leftmost user programmable front panel key is pressed, the counter is advanced on the positive edge (function type *set*). Line (rung) **002** inputs the value of the counter and compares this to the constant **#0**. The logical result of this compare (if it's equal or not) produces a True/False value output. This logic value is output to the rightmost front panel LED. If the logical value is true, this LED will be illuminated. Line (rung) **003** inputs the value of the counter, compares this to the constant **#1**, if it's equal (401 contents = 1) the result will be True. Whatever the result, this logic value is output to the next front panel LED[66]. If the logical value is true, the LED will be illuminated. Line (rung) **004** inputs the value of the counter, compares this to the constant **#2**, if it's equal (401 contents = 2) the result will be True. Whatever the result, this logic value is output to the next front panel LED[65]. If the logical value is true, the LED will be illuminated. Line (rung) **005** inputs the value of the counter, compares this to the constant **#3**, if it's equal (401 contents = 3) the result will be True. Whatever the result, this logic value is output to the leftmost front panel LED[64]. If the logical value is true, the LED will be illuminated. Line (rung) **006** inputs the value of the counter, compares this to the constant **#6**, if it's equal (401 contents = 6) the result will be True. If the result is True, the contents of address 401 is cleared (set to zero). If the result is False, the Clear is not performed and the contents of address 401 is not changed. The STC-2002 schedules the entire I/O program to run every 100ms. Extremes of bandwidth availability, program length, line length and complication may limit this. There is space enough in each memory (A and B) for a 1000 tokens (2 kbytes each). As the leftmost user programmable key is repeatedly pressed, the user programmable front panel LEDs illuminate one at a time starting with the rightmost LED, proceeding to the leftmost with each key press. Two key presses after the leftmost LED is illuminated (and extinguished), the count gets cleared and the sequence cycles through again.

Since this is a longer I/O program, now is a good time to discuss the program checksum. When the above program is entered correctly, the checksum should be A04241 (that is, if it's in the 'A' memory [the MEMORY key of the I/O programming menu will be described in Section 5X]). There are 2 non-volatile memory areas in which I/O programs can be constructed and reside. One memory area is called 'A' and the other is called 'B'. Only one memory area can be run / edited at a time. By means of a menu key labeled SWAP, one memory is placed in the active edit/run position while the other memory is placed into the unused state. The checksum should be B04241 if it's in the 'B' memory.

Stopping and restarting the I/O program does not clear the counter value (I/O menu: RUN/STOP selections). Switching to the alternate memory and back again (from A to B to A or from B to A to B) will reinitialize the I/O program.

An alternate for line 001 that will automatically advance the counter once a second (see table 5.XX, ID # 224) is: **I224 S401** [w/ program ID = A05027]. In cases where the count may have changed by the time a line is encountered and evaluated (and would need to wait for the counter to cycle around through the maximum count and return to the checked value), the *greater than* would ensure an immediate function as in: **I401 #5 > C401**.

```
001:
I68 S401              ⇐ inputs status of leftmost user key, outputs to counter on positive edge (Set to increment counter)
002:
I401 #0 = O67         ⇐ inputs value of counter location, outputs logical evaluation of count (=0?) to rightmost LED
003:
I401 #1 = O66         ⇐ inputs value of counter location, outputs logical evaluation of numeric count (=1?) to next LED
004:
I401 #2 = O65         ⇐ inputs value of counter location, outputs logical evaluation of numeric count (=2?) to next LED
005:
I401 #3 = O64         ⇐ inputs value of counter location, outputs logical evaluation of count (=3?) to leftmost LED
006:
I401 #6 = C401        ⇐ inputs value of counter location, outputs logical evaluation of count clearing counter when true
007:
END
```

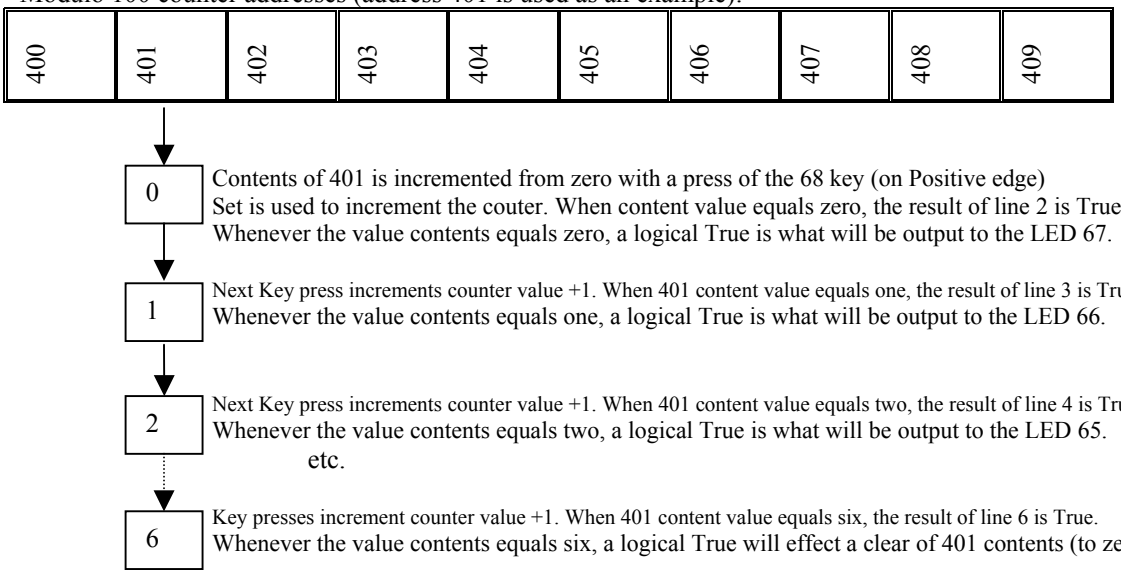
As can be seen by the above program, the counter at address location 401 can be used as an input or an output. The counter can contain a number from 0 to 99. In line 001, it is used as an ouput (set) access point to advance the count (+1) of this specific counter. When the count increments, the result of some relational evaluation of the sequential count at the 401 address will be a logic value. In these example cases, evaluating true is based on that count value and to what it is compared by the equals function. The count that is needed (to trigger some process element) is selected by comparing it with the needed constant value to make the selection. For example, to count 50 *things* using the first Counter (see table X5.6), input the logic value from count *address* location 400, and evaluate it using some combination of arithmetic or logical elements.

Some ways to count 50 things...

```
I400 #50 =      [contents = 50?]
I400 #49 >      [contents > 49?]
I400 #50 < !    [[contents < 50] Not ]
```

To do the same with the 8th Counter: I407.

Modulo 100 counter addresses (address 401 is used as an example):



How to Develop I/O Programs:

This discussion may seem like a lot to absorb for unknown benefits. However, this short introduction is needed to provide the user with the general I/O programming capabilities of the STC-2002. Once this is known, the system user need only run (or setup) their process until specific needs become apparent. With a specific need in mind, a perusal of the Event and State ID List (Table x5.3) will match your need to one or more of the many possible solutions within the expansive repertoire of the STC-2002.

There has also been provided some example I/O programming segments with accompanying explanations in section x5. These can be used to construct larger programs that fulfill the overall process goal. Included with the STC-2002 is a CD containing communications programs that allow the construction of I/O programs on a P.C. Writing I/O programs in this way is further enhanced as comments can be added using a comma as a delimiter and not having to use line numbers. The Windows® program running on the P.C. will strip the comma and all that follows on each line and add the line numbers as the I/O program is downloaded into the STC-2002. I/O programs constructed on the STC-2002 may also be uploaded to a P.C. using the same communication program. The following is an example of such a program constructed on a P.C. and from the P.C. view (this example [w/ checksum of 41779] is repeated with an explanation in a later chapter).

```
I73 #2 = S8,          Stopped Xtal bad sets relay 1 slot 2.
I228 C8,              Begin Job/Film Event, clears relay 1 slot 2.
I79 #1 = O9,          Source 1 shutter connects to relay 2 slot 2.
I81 #2 & O10,         Sensor 2 shutter connects to relay 3 slot 2.
I221 S11,             Setpoint thickness trigger sets relay 4 slot 2.
I228 C11,             Begin Job/Film Event, clears relay 4 slot 2.
I0 T216,              Input 1 slot 1 is start unconditional.
I0 T202,
I1 T200,              Input 2 slot 1 is stop.
I2 T217,              Input 3 slot 1 is final thickness trigger input.
I3 T219,              Input 4 slot 1 is zero substrate thickness trigger.
I68 O64,              Input function key 1 to front panel LED 1.
```

SECTION 3.0 Menu Programming and Operation Details

Overview

To reiterate, the STC-2002 is an extremely flexible and versatile deposition process controller. Through its soft key menus on the LCD display screen it can be configured to do almost any deposition process and conform to almost all system requirements. (Soft key refers to the LCD overlay touch keys whose definition, at any point, is software dependent.)

It would be advantageous, while reading this manual, to take an STC-2002 without connections, add the AC power cord and switch the STC-2002 to the power on position. With the unit unconnected from the system and powered-on, try (as far as possible) what is being read from this manual using the STC-2002 hardware. The RunTime screen will always appear at power up after a correct initialization.

Pressing the fixed front panel MENU key while the RunTime screen is displayed, provides access to these menus. The programming menus, which concern the deposition process, are the FILM parameters and the PROCESS listing. Film parameter menus along with an associated source sensor map contain material and source dependent parameters. Parameters for 99 material/source combinations can be stored in the STC-2002. In the STC-2002 these 99 films can be arranged to form a process of up to 99 layers, with each layer having an independent final thickness. Nine different processes can be stored. Only one film within one process can be actively controlling at a given time (non-active sources can be maintained at non-zero levels). The STATUS key returns the RunTime screen from any menu screen. In addition, the STATUS key provides detailed source information in two screens when pressed with the RunTime screen displayed.

The unit utilizes the extremely sensitive and time proven 6 MHz quartz crystal as the sensor device. The STC-2002 can operate from 90VAC to 264VAC (50-60Hz, 1.4A rms@120VAC, 0.7A rms@230VAC). Units are shipped from the factory with a 120V nominal line voltage cordset. Before attempting to operate the unit with other than this cordset (voltages beyond the 120V nominal range), proper IEC-320 cordset must be selected as appropriate for the line voltage and mating receptacle configuration. See section 4.XX.

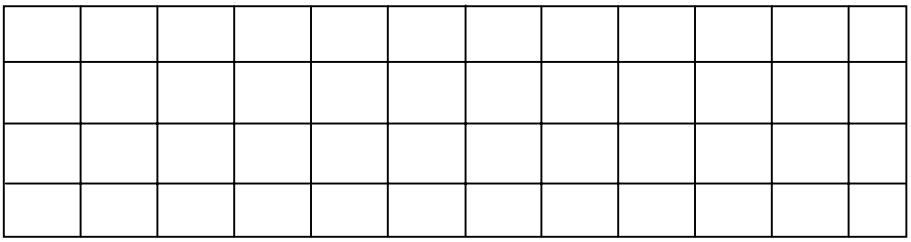
Deposition Programming

The STC-2002 is a Deposition Rate Controller with LCD/LED displays. It uses keys along with menus for programming. Programming choices are defined or valid ranges are given. Invalid entries are ignored. There are three general categories of menu operations performed on the STC-2002 that can be classified as programming of the instrument. There are a few interdependencies that cross group lines.

1) Deposition Programming *2) Input/Output Programming* *3) System Configuration Programming*

The I/O and System Configuration programming generally occur only at the initial installation or when the coating system is physically altered. The first part of Section's Group 3.XX of the manual describes the Deposition Programming and general operation of the STC-2002. The later part of this section's group covers system configuration. If the STC-2002 arrives installed in a system, Section 3.XX may be the only section of the manual that is required to be read. Section 4.XX covers the physical installation of the sensor and unit . Section 5.XX of this manual describes the operation and use of the programmable I/O which allows the STC-2002 to be easily interfaced to most systems.

All of these programming functions are performed through the front panel keys of the STC-2002 or alternately through one of the computer interfaces described in Section Group 6.XX Software controlled **touch key areas** on the LCD display are shown below. If anything is unclear, return to section group 2.XX.



LCD display has a 12 X 4 key touch panel overlay.

STC-2002 Front Panel

There are several areas of interest on the Front Panel. These are illustrated in Fig. 3.1.

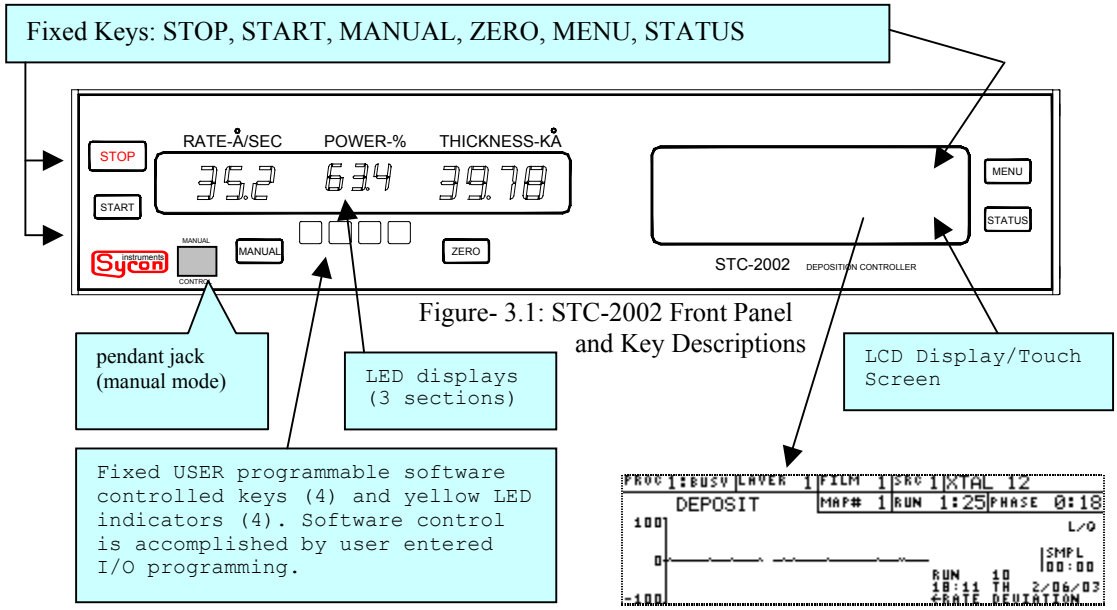
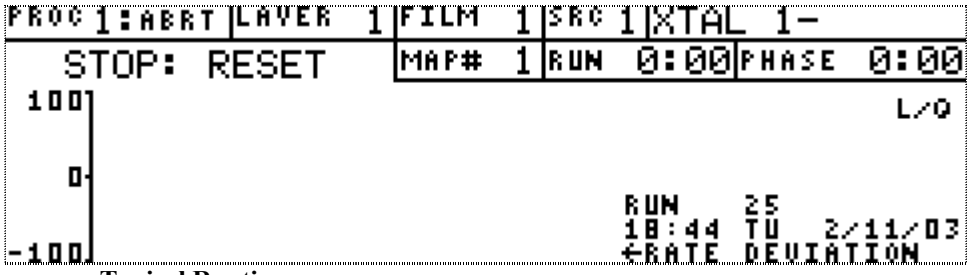


Figure- 3.1: STC-2002 Front Panel and Key Descriptions

Fixed Keys and Software Controlled Keys (Touch Screen)

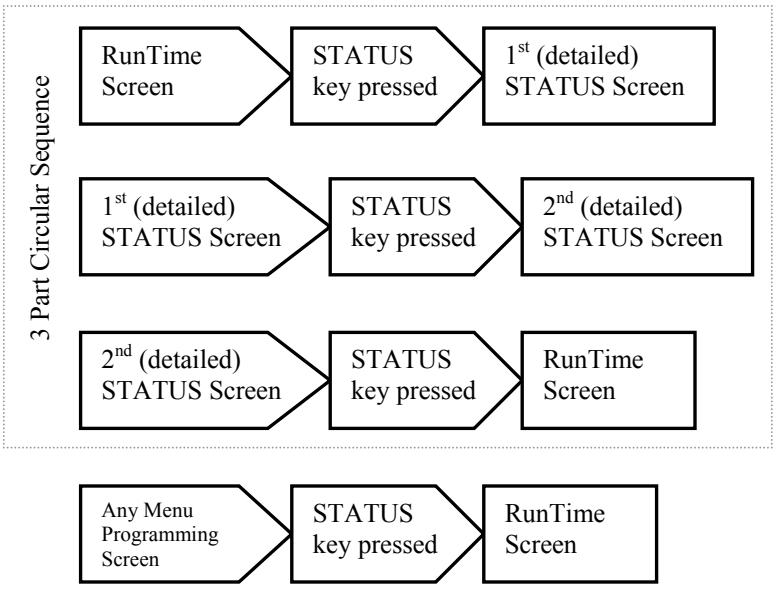
The **software controlled touch keys** and the **fixed MENU key** are used for programming entries, numeric and otherwise, and to navigate through the programming menus of the STC-2002. When the STC-2002 is initially turned on or generally when it is in operation, the display on the screen will be similar to the display shown in Figure 3.1. This is called the **RunTime screen**. It shows most of the vital parameters of the deposition process and is described more fully in Section x2.3. When the fixed **MENU key** is pressed the unit enters its programming menu tree. The touch keys select the menus and/or program the parameters. **When the RunTime screen is displayed, some touch keys are active** such as the area containing the text "L/Q". Pressing this area on the RunTime screen brings forth sequential text for the various control loop quality factors (crystal stability modes) (see Section. x2.10). This allows selection of the alternate modes (1-4). Forcing a sample, if crystal sample and hold is implemented, can also be selected by pressing the text "SMPL" (see Section. x2.10).



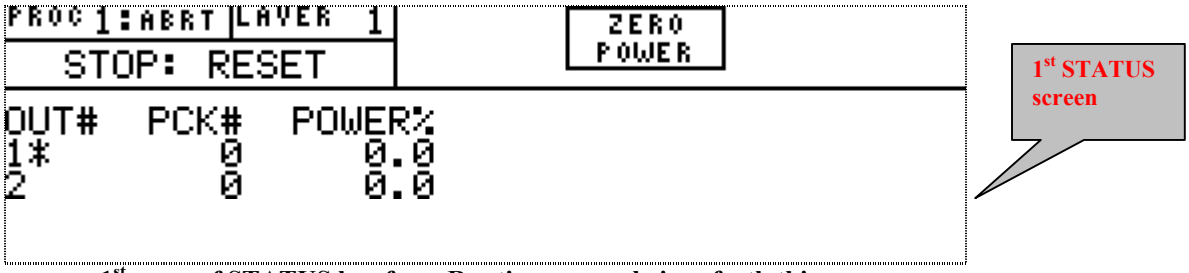
Typical Runtime screen.

The fixed **STATUS** key returns the Run Time Screen from any menu screen, when the Run Time screen is displayed, the STATUS key brings forth 2 consecutive screens: the first showing *source control output/ pocket/ power* and the next *sensor channel contribution and status* before returning to the RunTime screen. **To reiterate, the fixed front panel STATUS key is a multifunction key. The different navigational functions are based on the screen (or category of screen) that is displayed when the STATUS key is**

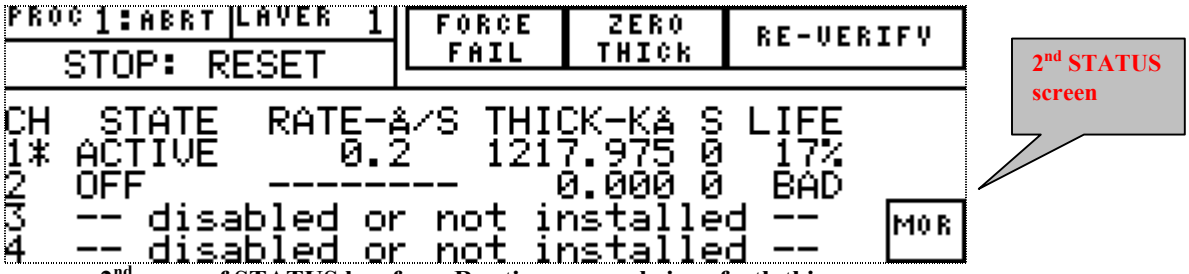
pressed. The following illustrates the 4 possibilities. Three are part of a sequence that begins with the RunTime screen and returns to the RunTime screen.



The following 2 LCD screen depictions show the second and third parts of the above 3 part sequence. The following 2 screens will be called the *1st STATUS screen* and the *2nd STATUS* screen respectively.

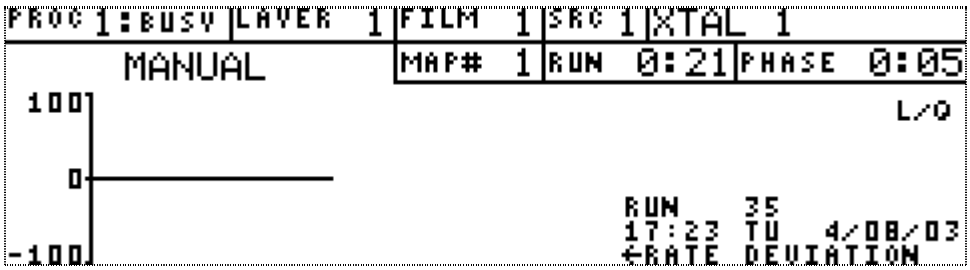


1st press of STATUS key from Runtime screen brings forth this screen.

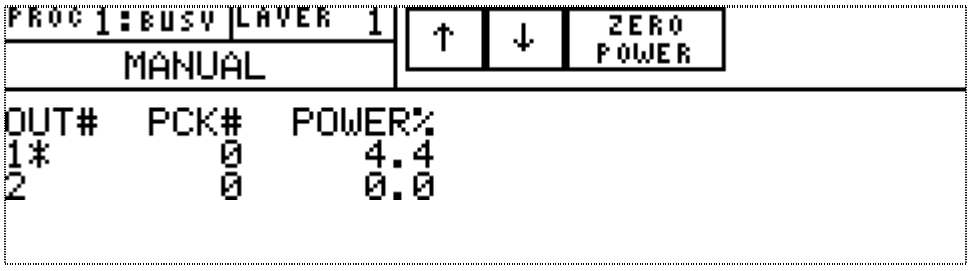


2nd press of STATUS key from Runtime screen brings forth this screen.

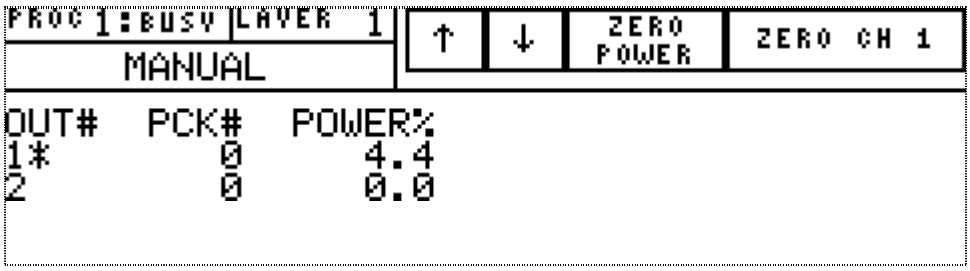
The following shows a RunTime screen that was put into manual mode by pressing the fixed front panel MANUAL key while running a deposition cycle. The text MANUAL appears on the screen in place of the text messages: rise 1, soak 1, rise 2, soak 2, deposit, etc.



If manual mode is entered while in the rise, soak or deposit phases of a deposition, the following arrow key additions will appear on the 1st STATUS screen. They can be pressed to change the power% value. The Up arrow increases power. The Down arrow decreases power. If the pendant is connected, pendant arrow keys can be used in conjunction with the LCD arrow keys. If an LCD arrow key and a pendant arrow key are held depressed simultaneously, the last key pressed and held gets the attention. [Manual mode can be entered by pressing the fixed front panel MANUAL key while in rise, soak or deposit phases of a deposition.]



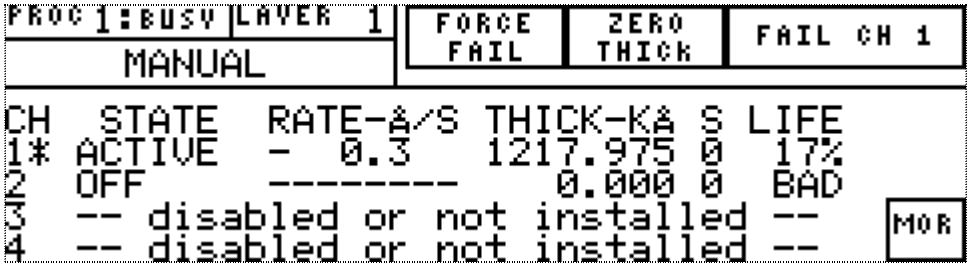
The ZERO POWER key is used to zero the power on non-active source outputs only. It has no effect on the *active* source output. Pressing the key (box) labeled *ZERO POWER* brings forth a key to the right of it that can have 3 possibilities (w/ 1 sensor card): ZERO CHannel 1, ZERO CHannel 2 and ZERO ALL. After the 3rd key in the sequence, the area to the right of the zero power key reverts to blank. The ZERO POWER key is used to select the desired function and the key to the right, which indicates the function, is pressed to make the selection. If more sensor cards are installed and they are ON (in SYS CONFIG menu), pressing the key (box) labeled *ZERO POWER* brings forth the key to the right with up to 9 possibilities (w/ 4 sensor cards): ZERO CHannel 1 through ZERO CHannel 8 and ZERO ALL. Again, after the ZERO ALL key in the sequence, the area to the right of the zero power key reverts to blank.



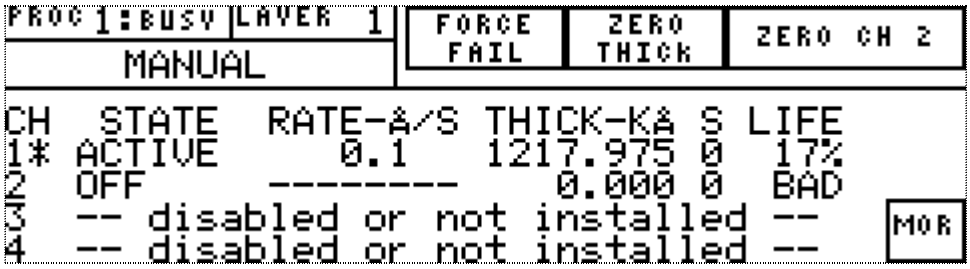
The ZERO THICK key is used for diagnostics and tooling set up only. It has no effect on the deposition thickness as seen on the LED display. What is zeroed is the raw value that comes from the sensor card[s]. For either FORCE FAIL or ZERO THICK selector keys, the selections appear to the right in the form of a key, that when pressed, will effect the named channel[s] with that function. Also, in either case, and depending upon how many sensor cards are installed and ON (in SYS CONFIG menu), pressing the key labeled FORCE FAIL or ZERO THICK brings forth the key to the right. The ZERO THICK key yields up to 9 possibilities (w/ 4 sensor cards): ZERO CHannel 1 through ZERO CHannel 8 and ZERO ALL and FAIL CHannel 1 through FAIL CHannel 8, FAIL ALL and RE-VERIFY (for FORCE FAIL key). The FORCE FAIL key yields up to 10 possibilities (w/ 4 sensor cards): FAIL CHannel 1 through FAIL CHannel 8, FAIL ALL and RE-VERIFY. The FORCE FAIL function can fail any crystal, including the active crystal[s]. When a crystal is failed, the system will look for a backup crystal or crystals. To re-

evaluate/reinstate a *failed* crystal sensor, by *force fail* key or otherwise, the RE-VERIFY key is used. The RE-VERIFY key checks all potentially active crystals and *re-verifies* their status as good or bad. This is useful when a nearly loaded crystal is replaced as in the following example scenario.

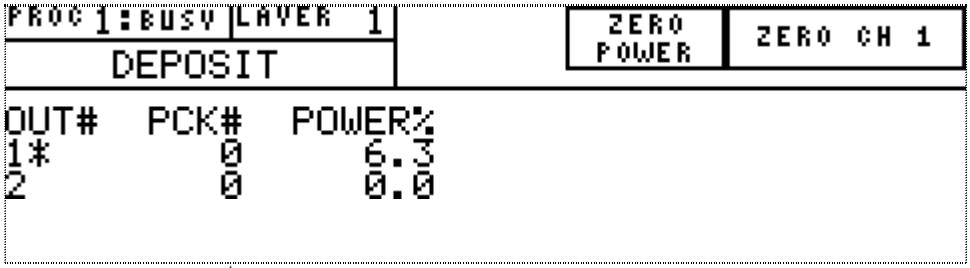
Starting with 3 crystal sensors mounted in a chamber, each having external electrical connections and oscillators in place, one crystal sensor is connected to sensor channel 1, and one crystal sensor is connected to sensor channel 2. If channel 2 is programmed as its backup, automatic switching to the second crystal sensor on the second channel is accomplished when the crystal sensor on channel 1 is force failed. Replacing the broken/loaded crystal on the first channel (with the 3rd unconnected crystal sensor) and *re-verifying* allows the first channel to be used again. This example, meant as glimpse into some possibilities, presents only the effected topics here but there are other elements such as shutters, thickness values, etc. to be considered.



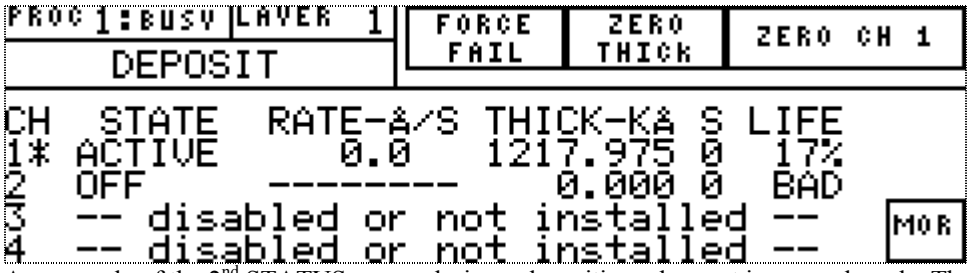
An example of a *force fail* selection appearing to the right.



An example of a zero thick selection appearing to the right.

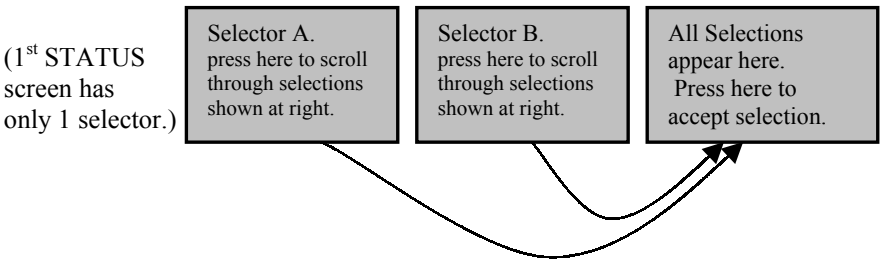


An example of the 1st STATUS screen during a deposition when not in manual mode. Note the absence of arrow keys.



An example of the 2nd STATUS screen during a deposition when not in manual mode. The MORe key reveals channels 5 through 8.

The general function of the selector/result/select keys is illustrated below.



Fixed Keys:

Start and Stop Keys

The following 2 fixed keys are used to start and stop a deposition run.

STOP -The fixed STOP key always terminates the automatic operation of the STC-2002 and brings the source control voltage to 0 volts (0% Power). The STOP key is always active.

START - The fixed START key in the STC-2002 is multifunctional. It is used to Reset and recover from abnormal Stop conditions (max. power conditions, sensor failure or manual stop button pushes) along with STARTing or proceeding through the multi-film process sequencing. When the START key is pushed a menu which defines all the functions of the START key is displayed. The START key is active during Run Time screen only. See Figure 3.2 for start menu, which appears in what is typically the graph display area. The START menu is automatically **canceled** after 15 seconds without user activity.

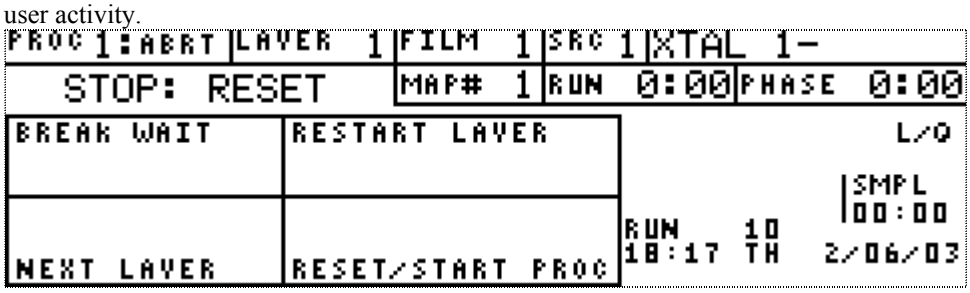


Figure- 3.2: Start Key Menu.

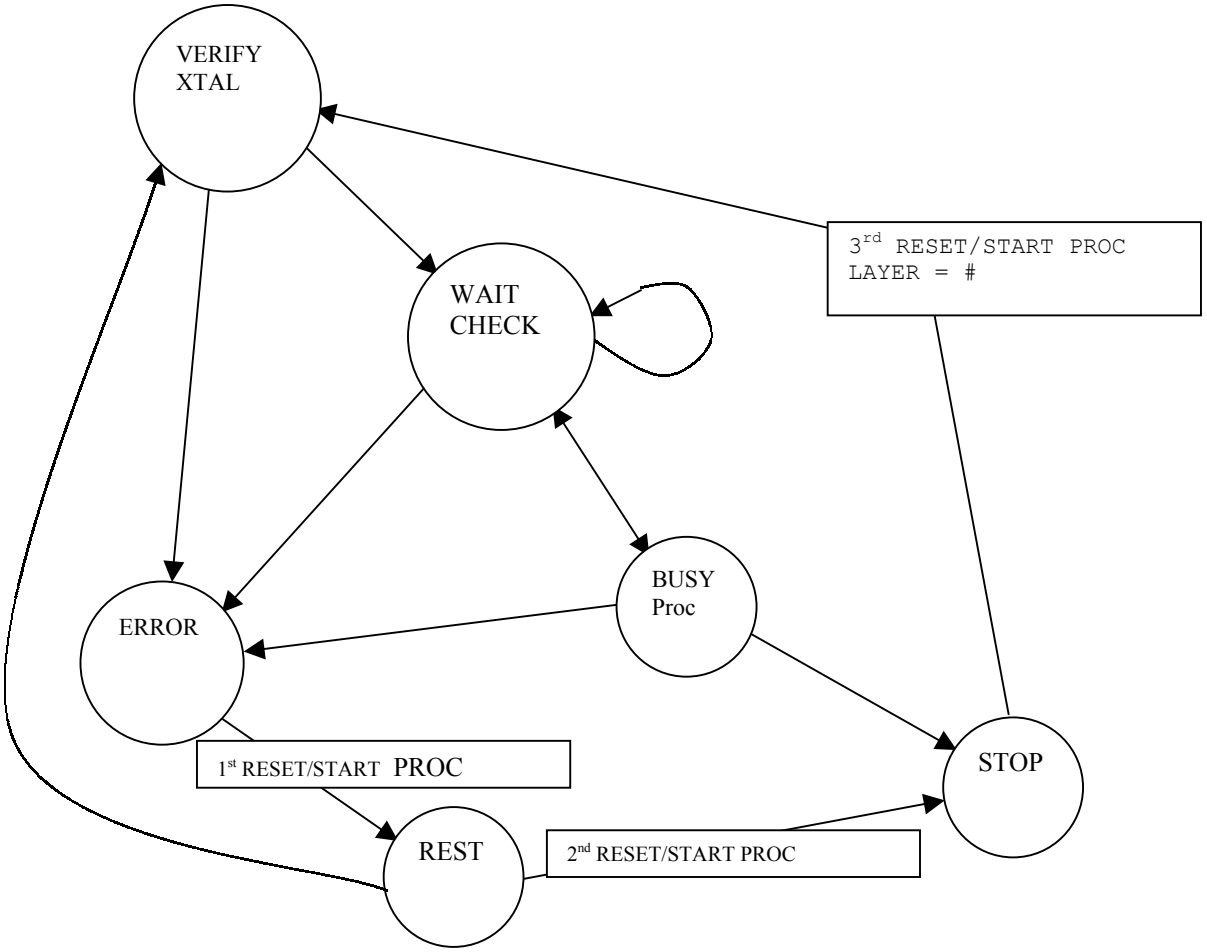
Note

[Non-SEQuencing configuration: the boxes now containing "PROC 1: ABRT" and "LAYER #" in Fig. 3.3 will not exist. There will not be a START key menu. See Non-SEQuencing Section 2.20.]

When the START menu is displayed, press the text box required to select the desired operation of the start function. Not all selections on this menu are valid at all times. Whether a selection is valid depends on the state of the STC-2002. For example, when the unit is first turned on or has experienced an abnormal stop the STC-2002 is in an error state. The START key is first used to ***reset*** the error condition (**RESET/START PROC**). This brings the unit to a Process Resting state, at this point the operator has the option to restart the process from the beginning of the current film (**RESTART FILM**); to restart the process at the next layer (**NEXT LAYER**); or to reset the process to the beginning layer by pushing a START followed by pressing **RESET/START PROC**. Once the process is reset to its beginning (which is indicated by Layer = '#') the process can be started by pushing the START key followed by pressing **RESET/START PROC**. Take note of the changing **PROC 1: xxxx** messages as the start menu is used.

The **BREAK WAIT** is valid when the layer sequencing has encountered a WAIT in its process layer list in the Process menu. (See Section 2.6). Under this condition pushing **BREAK WAIT** releases the wait and begins the sequence step. The wait can also be released via I/O or computer interface (see sections 5 & 6).

Flow chart depicting the steps of a START process.



First press of START key + RESET/START PROC key: to **REST** location.

Second press of START key + RESET/START PROC key: to **STOP** location.

Third press of START key + RESET/START PROC key: to **VERIFY CRYSTAL** location.

This sequence was presented to help provide an understanding of a start. Other sequences are possible.

Fixed Key: Zero Key - Active during run time screen only.

ZERO - This fixed key zeros the thickness number used and displayed by the STC-2002. Pushing the ZERO key stores a new zero reference for the sensing crystal. Any mass from previously deposited materials is subtracted from the new thickness calculations. *Zero thick* on 2nd STATUS key press does not zero the calculated thickness, but is used as a setup/diagnostic to zero the value from the sensor card.

Fixed Key: Manual Key

MANUAL - Used to enable/disable the manual control of power. (See Section x2.8) This fixed key toggles the use of the manual power pendent. When in manual phase, the Automatic rate control of the STC-2002 is inactive, the control voltage to the deposition source can be increased, decreased or set to '0' (STOP) with the pendent buttons. Pressing the pendent up and down buttons simultaneously will zero the control voltage without aborting the run. The MANUAL key is only active after a film has been started and during Run Time screen and other screens available through the STATUS key only. When you leave MANUAL power control by pressing the MANUAL key a second time, the STC-2002 goes to the Deposit phase of the film program without zeroing the thickness reading (see Section x2.8). The pendent STOP button is functional only in the MANUAL mode.

SECTION 3.1 NAVIGATING THROUGH STC-2002 MENUS

Menu Tree

An overview of the main programming menus and screens is shown in Figure 3.3. The keys to navigate from menu to menu are shown in *screenlike* boxes with arrows to a general function category. **[These boxes are not meant to be true LCD depictions.]** For example, to display the *Main Menu* while on the *Run Time* screen, the fixed front panel MENU key is pressed, to display the *Review Film Menu* while on the *Main menu* screen, the *Review Film* key is pressed. Refer to Figure 3.3. on the next page.

In the next section, the RunTime Screen and the information and data that appears on it will be described. The STATUS key returns the Run Time screen from any programming menu location (1st key press). When the RunTime screen is displayed, pressing the STATUS key will invoke two other consecutive screens as described in the previous section.

The Sequencing mode is fully described in the menu tree whereas only the non-sequencing mode *differences* are shown.

Please note that the text boxes of the following menu tree are not meant to be true LCD screen depictions.

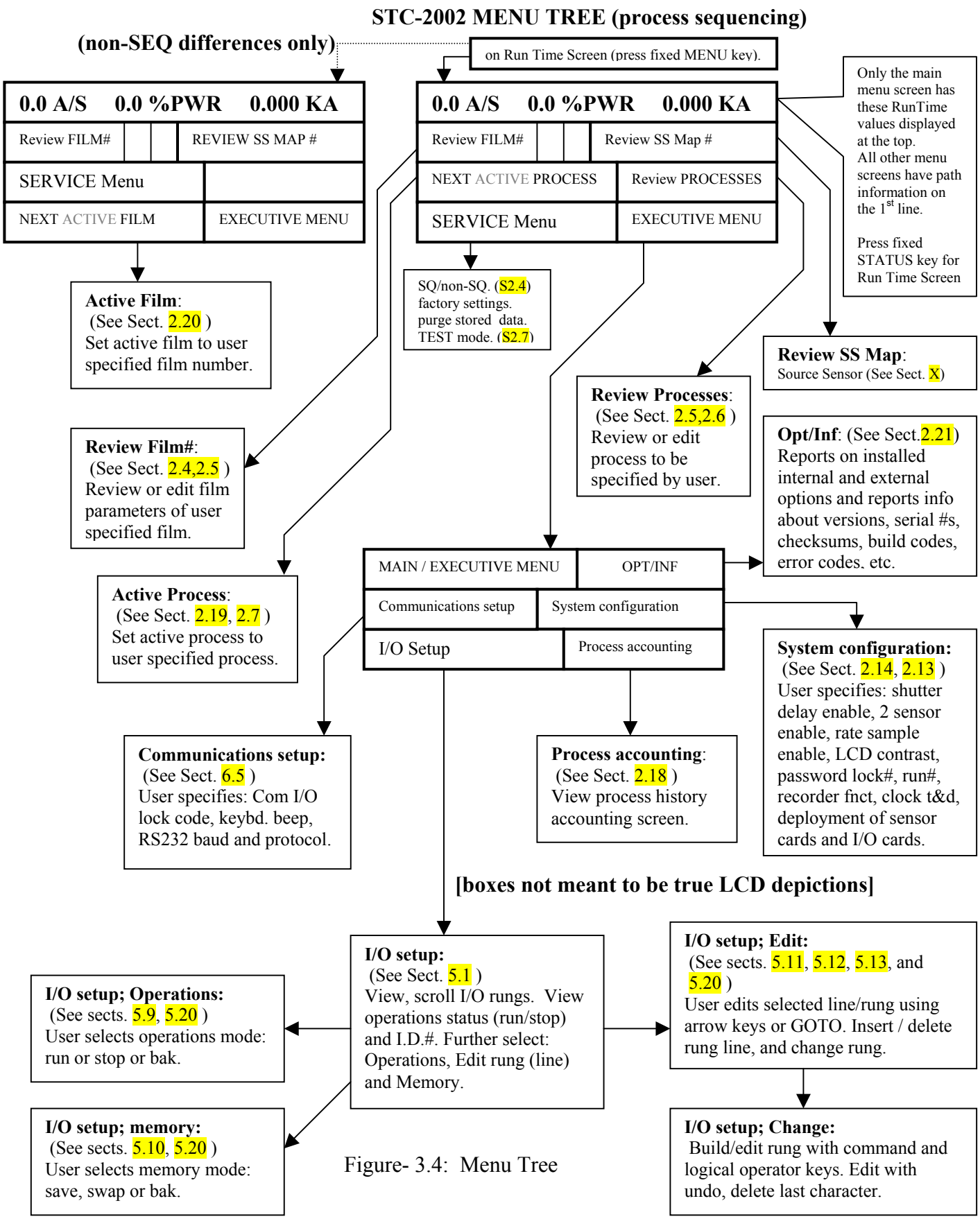


Figure- 3.4: Menu Tree

SECTION 3.2 RunTime Screen

SEE SECTION x2.21 for proper initialization sequence.

When the instrument powers up and has fully initialized, you are presented with the RunTime Screen. When this display is present, you can start, stop, and view the operation of the STC-2002. Figures 3.1 and 3.5, show typical RunTime Screens. While the RunTime screen is displayed, the 2nd and 3rd press of the STATUS key will bring forth 2 screens showing detailed sensor channel information and live keys.

Note → The fixed **STOP** Key is active on any screen.

There are several areas of interest on the RunTime screen.

RunTime Display Description

Area # 1: Rate, Power and Thickness

1. **Rate, Power,** and **Thickness Values.** These are the current values of the three most important process data and their units. These values are displayed on the LED displays in large format. They are also shown on the first line of the main menu screen. If you choose to review any data items on other screens, this information will always be present on the LED displays. When max power is reached: the text PWR% will alternate with **[MAX!]** (on MAIN menu) and the LED display section showing power will blink.

Area # 2: Current Phase

2. **Current Phase.** This tells you what phase or stage of your process that you are currently in. After you power up the STC-2002 or you return from a power loss, it is in a STOPPED RESET state. Other main states are MANUAL, plus all of the phases associated with source conditioning and DEPOSITION.

Area # 3: Data Area

3. **Data Area.** This shows a real-time view of your deposition process (an X/Y graph). Both the vertical and horizontal scale of this display area can be changed to make this display the most meaningful for your process. The data shown in this area during the DEPOSIT phase can be one of three types; rate deviation, rate, or power. The data type and scale are programmable as film parameters. This area is overwritten by the START menu options when the fixed start key is pressed (shown below).

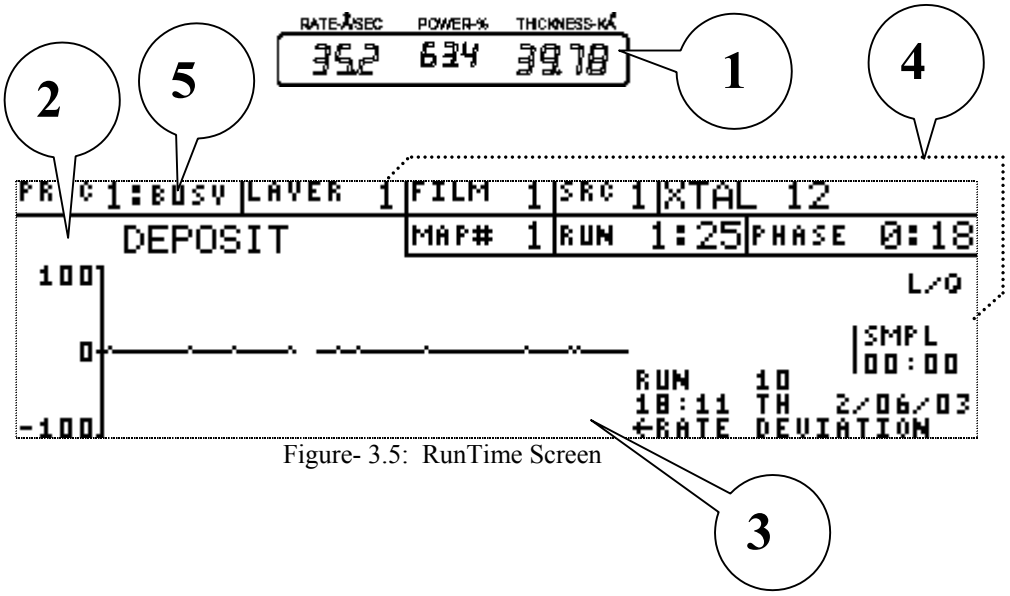


Figure- 3.5: RunTime Screen

Area # 4: Miscellaneous

4. **Miscellaneous Area.** This has several pieces of data in it. These are:

FILM - Shows film program that you are currently running (1 of 99).

SRC # - Indicates the Source Sensor Analog Output voltage channel. An SRC of zero indicates that a *source analog output control voltage* has been assigned to a source sensor card that is not present, not working, etc.

XTAL 1 to 8 - Shows which sensors are currently active or standby. Active crystals are indicated by their numeric name. Standby crystals are indicated by their numeric name alternating on the screen with a dash at a ~1Hz. rate. Percentage of potential crystal life left can be viewed by pressing the STATUS key twice. When a new sensing crystal is installed it will indicate 99 to 95% of crystal life remaining. A sensing crystal will show 0% remaining when the mass deposited on the surface of the crystal has caused the sensing crystal to shift by 1 MHz. About 500,000 KÅ of aluminum causes a frequency shift of 1 MHz. Depending on the material being deposited, a sensor may fail considerably before showing 0% remaining life. This is due mainly to the high film stress generated by some materials or other characteristics of the deposition material which causes the sensing crystal and circuit to cease oscillation prior to the full MHz shift generally possible with deposition materials such as Al, or Cu .

MAP # - Each sensor has various parameters. A map is an associative list of these source sensors with their parameters along with source power parameters, tooling, etc. This list can structure the sequence of which crystals start active, which are backups, etc. A unique map can be identified by its map number. Only one map can be active at a time. A Map is used when it is called out by the film parameter *SS Map Select*.

RUN TIME - Shows minutes and seconds into the film.

PHASE TIME - Shows minutes and seconds remaining in the current timed phase, or elapsed for indefinite duration phases (such as DEPOSIT).

RUN # - A user programmable number that increments at the start of every Process.

Area # 5: Process Status Line

5. **Process Status Line** - These two in-line text boxes running horizontally in the top left section of the screen indicate: the process being used, the current layer number, and the process status when the unit is configured for SEQuencing (non-SEQuencing configuration blanks these 3 boxes). The process status has one of the five following messages displayed:

a) PROCESS STOP - This message is displayed when the last layer of the process has been completed or the process has been reset (by using the (START-Reset/Start Proc) from a PROCESS RESTING. A process must be in this state to start a process from layer 1.

b) PROCESS WAITING- This message displayed when a WAIT has been encountered in the layer sequence. A (START-Break Wait) or a programmed I/O input can release the wait. (START-Reset/Start Proc) takes the process to RESTING.

c) PROCESS RESTING - This message occurs during the reset (START- Reset/Start Proc) of a PROCESS ERROR or PROCESS WAIT condition. While in this condition the user can reset (START-Reset/Start Proc) to PROCESS STOP, Restart the current layer (START-Restart Film) or start the next layer (START-Next Layer). These options allow the user to select the error recovery method.

d) PROCESS **BUSY** - This message occurs during an operation phase of a deposition process.

e) ERROR IN RECIPE - This message occurs when a process is started which has no layer information programmed.

f) ERROR-FILM ABORT - This message occurs when an abnormal event occurs during the running of a film. Anything which stops or aborts a film program causes this message to occur (i.e. crystal failure, max. power abort, Front Panel STOP key, power loss, etc.). A reset (START- Reset/Start Proc) takes the process to the PROCESS RESTING phase where the user can select the path of error recovery desired.

SECTION 3.3 Main Menu Description

From the RunTime Mode, you navigate into other parts of the STC-2002 by using the **fixed MENU key**. After pressing it, the Main Menu screen will appear and the display will look like Figure 3.6. Pressing the fixed STATUS key while navigating menus (including the MAIN MENU) restores the Run Time screen. Pressing the **BYE key** while navigating on other menus (highest level) will restore the MAIN MENU.

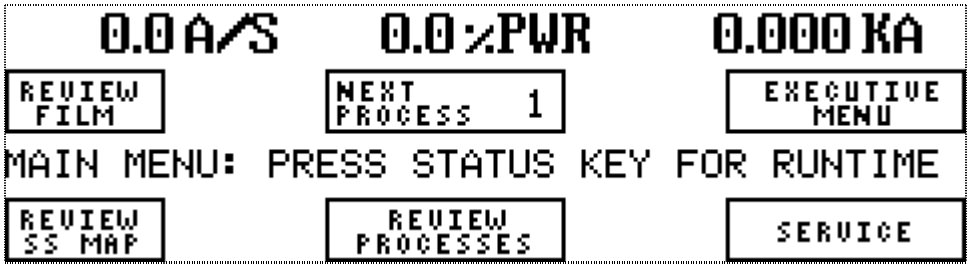


Figure- 3.6: Main Menu Screen.

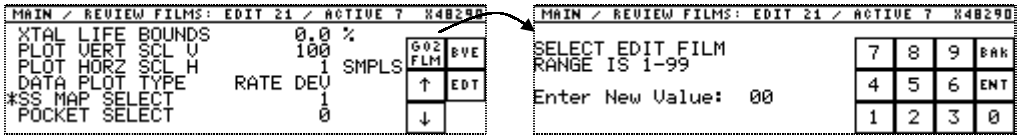
Main menu *or* **1st Menu**

Main Menu Selections

There are several options at this point. The **keys** that are used here are:

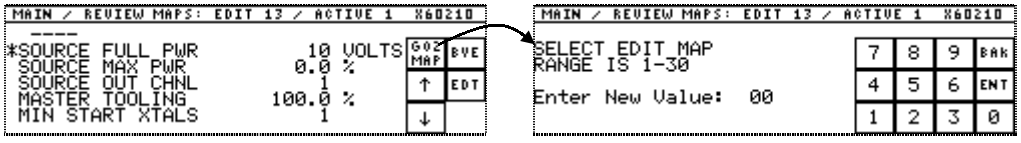
Choice: REVIEW FILM#

REVIEW FILM# -Goes into the review/edit film mode to the last film selected. Note that the film selected for view/edit can be different than the active film. Pressing the Review Film key invokes the 1st of the following 2 displays. Note on this display that film number 21 is specified. To select a different film for review/edit, press the *GO2 FLM* (go to film) key. When the numeric entry screen appears, enter the film number to edit or review by pressing the **digit** key[s] that represent the desired number (tens value first followed by units value or just the units value) and press ENTer to accept or BAcK to discard. See Section 3.4 for a detailed explanation of the review/edit capabilities. The current active film is also allowed for review/edit selection.



Choice: REVIEW SS MAP

REVIEW SS MAP - Allows viewing/editing of Source Sensor Maps. Goes into the review mode to the last map selected. Note that the selected map can be different than the active map. Pressing the Review SS MAP key invokes the 1st of the following 2 displays. Note on this display that map number 2 is specified. To select a different Map for review/edit, press the *GO2 MAP* (go to map) key. When the numeric entry screen appears, enter the map number to edit or review by pressing the **digit** key[s] that represent the desired number (tens value first followed by units value or just the units value) and press ENTer to accept or BAcK to discard. See Section x3.4x for a detailed explanation of the review/edit capabilities. The current active map is also allowed for review/edit selection.

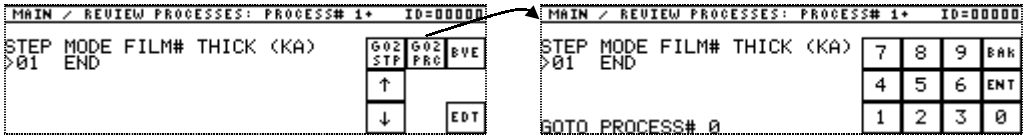


Choice: Next Process

NEXT ACTIVE PROCESS - This key choice allows the user to change the active process. There is storage in the STC-2002 for 9 different processes. (See Sections x.x, x.x and x.x) (figure x.x). The box containing the text *NEXT PROCESS* is a key used to indirectly input a new active process number. Pressing the *NEXT PROCESS* key invokes the following display. Note on the main menu display above that the active process number specified is 1. To select a different active process, press the *NEXT PROCESS* key. When the numeric entry screen appears, enter the active process number needed by pressing the **digit** key that represents the desired number and press ENTer to accept or BAcK to discard. The number last entered immediately becomes the *specified* active process. At times during certain phases of normal product use, the number digit will be temporarily replaced with the text **NA** (not applicable) indicating that it would not be desirable to change the ACTIVE PROCESS at a time when it is running. Also, NA appears when beginning with a memory purged unit. The active process is the process that will begin with the next start. To change an active process, the STC-2002 must be reset to the PROCESS STOP condition (Any error condition must be cleared and no process can be running). See Sections 3.6-x3.7x for full description.

Choice: Review Processes

REVIEW PROCESSES - This choice allows the product user to review and edit the process layer list (recipe) of the selected process (1 through 9). Select the process number by pressing the REVIEW PROCESSES key (See Sections x.x and x.x). The process that was last edited is shown in the menu path (top line). associated digit key (see section 3.x). Pressing the *REVIEW PROCESSES* key invokes the 1st of the following 2 displays. To select a process for edit/review, press the *GO2 PRC* key. When the numeric entry screen appears, enter the number of the process to be edited/reviewed by pressing the **digit** key that represents the desired number and press ENTer to accept or BAcK to discard. Note that the process you are editing does not have to be the active process. The active process is indicated by a "+" on the menu path line of the REVIEW PROCESS menu.



Choice: Executive Menu

EXECUTIVE MENU - Changes how the STC-2002 is configured (communications, system configuration and I/O setups) and allows access to Process Accounting screen and OPTions/INFo. (See Section x.x). A menu as shown in Figure 3.16 will appear. These are mainly system operations that involve setups/configurations that are infrequently used. I/O setup is described in Section x, Communications Setup and computer interfacing in Section x, Process Accounting in Section x.x, and System Configuration/Communications setup in Section x.x. OPTions/INFo is described in section x.x.

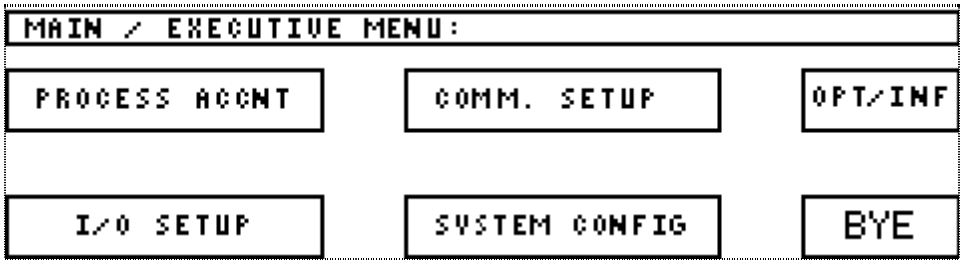


Figure- 3.7: Executive Menu.

fixed STATUS Key

Fixed STATUS key removes Main Menu (or any other menu screen) and returns the RunTime Screen. A second and third press of the STATUS key after the Runtime screen appears will invoke detailed power and crystal information by channel.

Service Menu

SERVICE menu – This choice brings up the **Service MENU** which provides selection of : **SEQ** vs. **non-SEQ** product function, return to **factory settings**, **purge ALL** stored data, and **test** mode entry. Keys toggle functions and key labels alternate between **TEST on** / **TEST off**, **SEQ / non-SEQ**, etc. To initiate any of the Service MENU personalities, any or all four of the choices are toggled **on** or **off** as needed *and* the **Accept/Restart Product** key is pressed. The product will restart with the selected personalities in effect. Only the user selected SEQ/non-SEQ personality will remain in effect upon subsequent product power cycles. AS IS, PURGED and FACTORY is a three way select. Optional ***Memory Card*** key allows saving or restoring all parameters, films, processes, and I/O programs in memory locations A and B to the memory card. ARM RESET allows restarting with same features selected. The service menu was not included for the casual user. If you are uncertain about these functions and their effects, do not proceed. See sections: x.x (factory settings), x.x (test mode) and x.x (password purge).

SECTION 3.4 Films and Processes

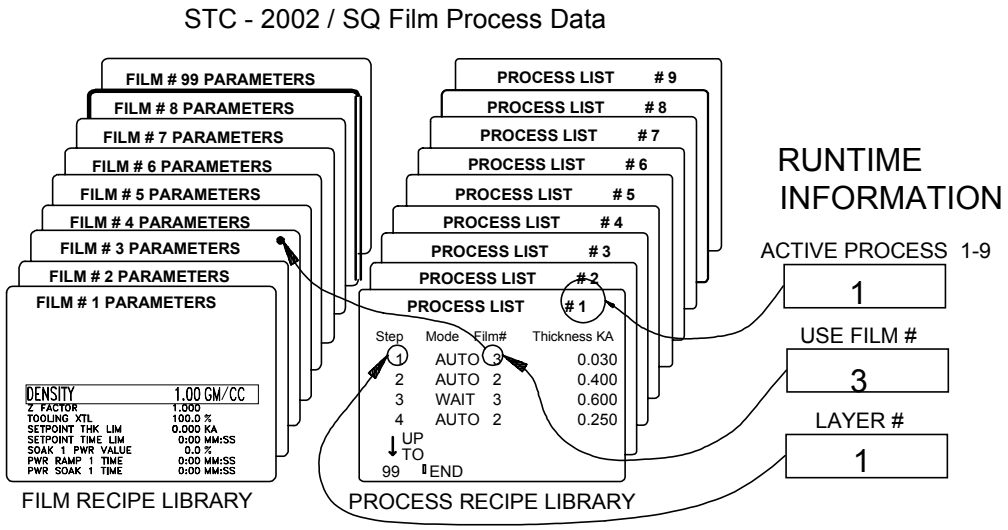


Figure- 3.8: Film & Process Storage.

Films & Processes Description

A deposition process is controlled by the parameters programmed by the user in the film parameter and process sequencing lists. Figure 3.8, illustrates the film parameter and process data storage and the relationship to the RunTime mode. The figure shows a process (Process 1) sequencing through the layers (currently on layer 1) using the parameters of Film 3. The ending thickness for this layer is determined by the final thickness for step 1 (layer 1) programmed in the process list. Each of the nine processes can have a different set or arrangement of any or all of the nine films. A process list can repetitively use a film program for different layers as in the case for layer 1 & 3 of Process 1. The ending thickness for each layer is independent of the film parameters and determined by the value programmed in the process list.

SECTION 3.5 Film Edit/Review Mode

Editing Films

The STC-2002 has storage for 99 sets of film parameters (99 films). Depending on the system and hardware configurations, up to 42 parameters per film can be stored. On the MAIN MENU, the *Review Film* key provides entry into the menu area containing all film edit/review menus. An unprogrammed unit will start with film 1 selected. When is the *REVIEW FILM* key pressed, this brings into view the film parameter list which was last selected as the film to review or edit on the last numeric entry screen. The film number that is currently being viewed and can potentially be edited, is indicated on the top line of the display (menu path/status/ID line) in the form **EDIT *x,*** where *x* is the film now open for viewing/editing. If the film number that is displayed when is the *REVIEW FILM* key pressed is not the film needed for viewing/editing, press the *GO2 FLM* (go to film) key to bring forth the numeric entry screen. This is simply a vehicle used to *go to the film number* as indicated by the entered number. This may or may not be the active film, that is, the current film that is in use. The Active Film number value can be seen, as was the edit film number, on the top line of the *REVIEW FILM menu* screen in the form **ACTIVE *x,*** where *x* is the film now active for a starting process. The Active Film number value is also indicated on the *RunTIme* screen [FILM __]. To edit or review a different film while on the REVIEW FILMS menu , press the *GO2 FLM* key again and change digit[s] as required. The alternate film number will be selected whereupon editing/reviewing can commence on the subsequent menu screens as well as on the *REVIEW FILM menu*. The *GO2 FLM* key thus provides lateral navigation from film to film on that menu level. To reiterate,

Selection of the edit film is indicated at this menu level by the text *edit* appearing in the path line. The value following the text ***edit*** is the current film for review/edit. Selection of the active film is indicated at this menu level by the text ***active*** appearing near the end of the path line. The value following the text *active* is the current active film. [note: active film selection will be discussed in detail later. An active film is selected by a process step in sequencing mode and by the NEXT FILM key in non-sequencing mode.] For each film there are up to 42 parameters that can be programmed. The film parameters are in the format of a long list, where you have a viewing window which shows 6 parameters at a time and a cursor (*) within the viewing window that moves from line to line. The cursor indicates the parameter that is currently changeable. The **UP**↑ and **DOWN**↓ keys are used to scroll the screen and select the different parameters. When the cursor is forced beyond the limit of the 6 line window, the page scrolls up/down by five lines plus the line on which the cursor was last. The **BYE** key returns the MAIN menu screen.

Changing Parameters

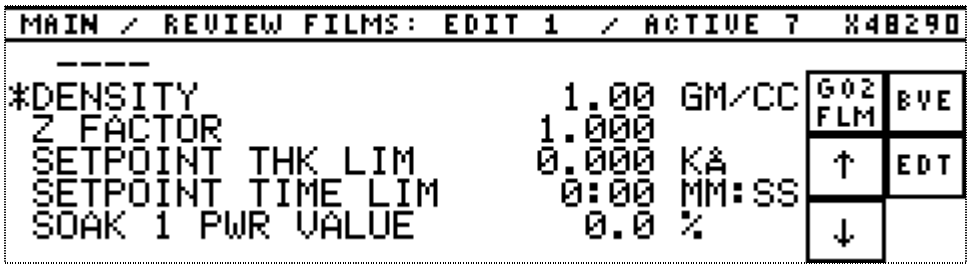


Figure- 3.9: Review Film Menu.

The EDIT (**EDT**) key brings forth the REVIEW FILM **edit** screen where the parameter selected by the cursor is shown by itself. The specific parameter name, its current value, unit value name and value range appear. On this menu level, scrolling with the arrow keys traverses the list one parameter at a time. If a screen is **password locked**, a "LOCK CODE NEEDED" message screen will insert itself when an EDT entry is attempted (passwords will be discussed shortly).

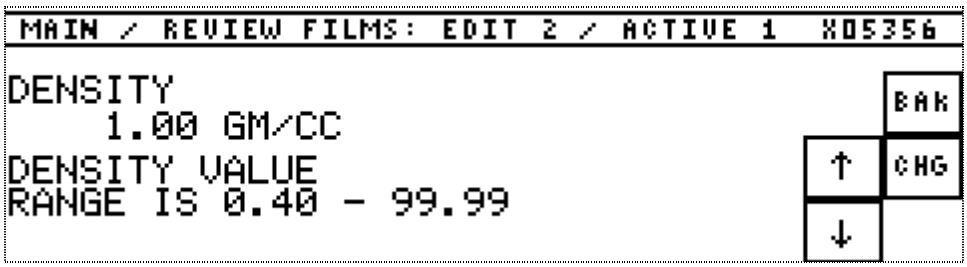
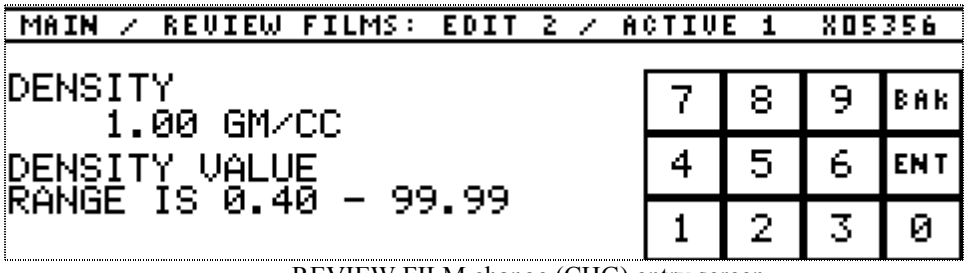


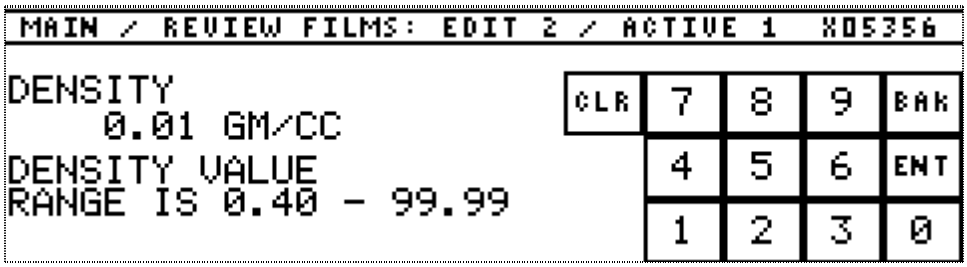
Figure- 3.10: REVIEW FILM edit screen

Pressing the Change (**CHG**) key invokes a numeric keypad on which direct number or representative numeric values are entered. Scrolling at this hierarchical menu level traverses the list one parameter at a time with one notable exception which is the non-presentation of the list items prefixed with the "-".



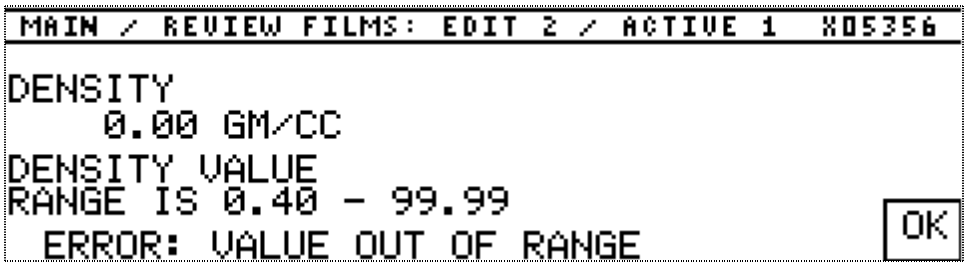
REVIEW FILM change (CHG) entry screen

Pressing the **BAK** key on the above menus cancels the current menu (or keypad) and moves back to the previous menu. Pressing the BAK key will also discard any edit value while pressing the ENTER (**ENT**) key accepts the entered edit value. Numeric keys can be pressed indefinitely and are shifted in from the right until either BAK or ENT are pressed. The entered value appears under the parameter name. In the above example, the value "1.00" is replaced by zeroes and the first number pressed becomes the rightmost digit (in the following case, a "1" was pressed). Also, as the first digit is pressed, a clear (**CLR**) key appears. Pressing the clear (CLR) key restores the original value. The fixed STATUS key returns the Run Time screen from any menu point.



REVIEW FILM change (CHG) entry screen after first entry

The next digit that is pressed appears in the rightmost position while the previous digit is shifted to the left. In other words, as key digits are pressed the numeric representations are built from the right and the entries can continue indefinitely (to make corrections). INVALID will appear if a numerical representation is incorrect.
If an illegal value is ENTered, an error message will appear on the bottom of the screen: "ERROR: VALUE OUT OF RANGE". The legal range of values message is presented, as previously described, as a help guide.

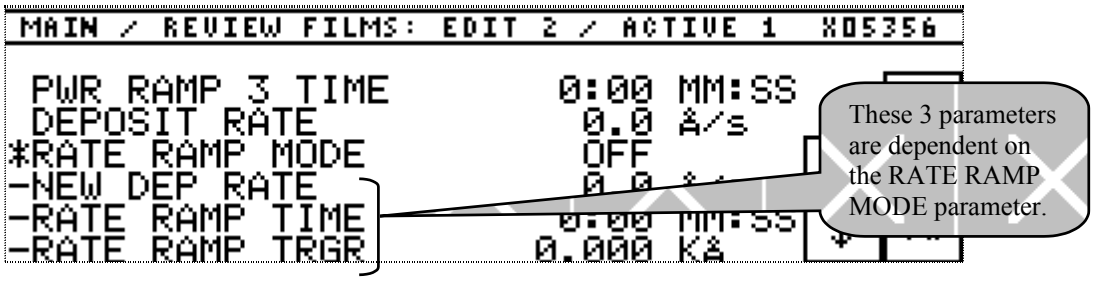


When an out of range value has been entered for a parameter, the ERROR message can be cleared by pressing the **OK** key. Clear also restores the original parameter value. With the error message cleared, value entry can be resumed (or BAK can be used to abandon the change).

MENU/STATUS Key Descriptions

In order to get back to the RunTime Mode at any time, press the fixed STATUS key (a discussion about other menu options is found in Section x3.9?x). Because the most frequent menu activity is to change a parameter and see its effect on the RunTime Screen, pressing the fixed MENU and STATUS keys will become almost automatic to get back and forth between these two screens. Notice on returning back to the Review Films Screen that the same parameter appears that was last viewed.

As you proceed through the parameter list, you may notice that some lines begin with a dash (-), this means that the parameter is dependent upon another parameter that is itself not used or not enabled. The parameters following RATE RAMP MODE are an example of this. Find this parameter in the Review Mode and set it to OFF. The 3 following parameters are all associated with RATE RAMP MODE. If it is set to OFF, then these 3 will have a "-" indicator. Rate Ramp is used to change the desired rate to a new setting during deposition. As the parameter list is traversed, note that the cursor will skip over the unused parameters (marked with a "-") but they can still be viewed. These "-" prefixed parameters will not be presented if scrolling is accomplished when the single parameter screens are viewed



System Related Parameters

The number of film parameters displayed will not vary but the number of accessible elements may vary with the way the STC-2002 is configured [e.g. SEQ / NON-SEQ mode differences]. The STC-2002 determines that if it is configured for certain types of hardware (example) there are parameters that do not make any sense. The STC-2002 provides conflict information and only allows running with correct parameters depending on its configuration.

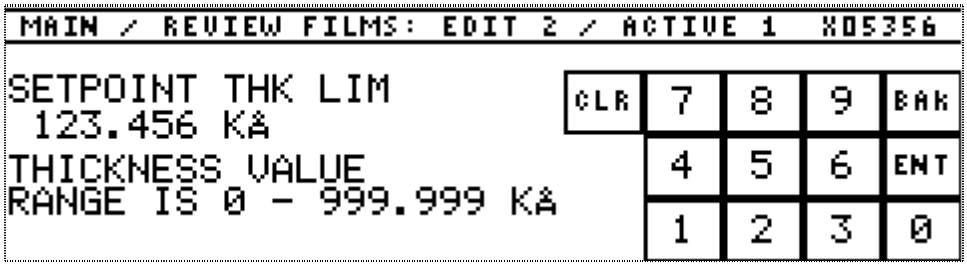
General description

To reiterate, there are 42 programmable parameters. There may be less parameters available at times due to parameter mode choices which preclude the availability of other related dependent parameters. The fixed MENU key is pressed to show the MAIN MENU. The REVIEW FILM key is pressed to enter the Review(/Edit) Films menu. Different films can be viewed/edited by pressing the GO2 FLM key. In Sequencing mode, the active film is set by the film value on the programmed lines (steps) of a process program. In non-sequencing mode, the active film is set by pressing the NEXT FILM key on the main menu.

The first line of the *Review(/Edit) Films menu* shows the menu path to the current menu in hierarchical form. On the same line, the film now being viewed is named after the text "EDIT". Likewise, the film that is now active is named after the text "ACTIVE". The first parameter on the list will appear first (density) as this is a *factory* default setting. Thereafter, the last viewed parameter on which the cursor is left when exiting the menu, returns with the same cursor placement along with its adjacent list parameters as the point of interest when returning to the list.

If the fixed STATUS key were pressed to leave the REVIEW FILM menu while individual parameters were being scrolled, a return to the REVIEW FILM menu would return the parameter list not the individual parameter view.

The following shows the result of entering a number (123.456) into the temporary workspace. This was accomplished by pressing "1", "2", "3", "4", "5" and then "6". If a mistake were made, the sequence could begin again at any point in the sequence.

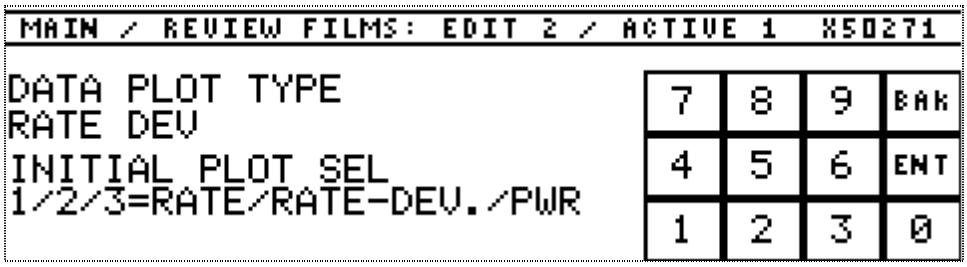


After the complete desired number is entered, pressing ENT will transfer the value from the **temporary workspace** to the saved parameter list value. Range boundaries will be enforced by software when not already enforced by available digits.

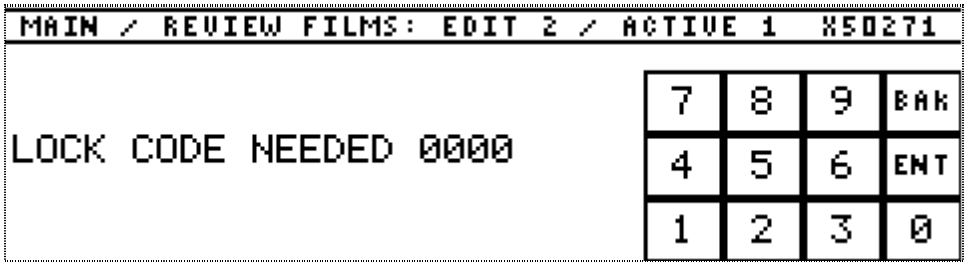
Pressing the **BAK** or **CLR** keys will result in the abandonment of any values entered in the current temporary workspace. Clear maintains the screen and resets the workspace to zeroes. BAK returns the parameter list screen.

Note → X12345 CHECKSUM
NOTE: observe the changing checksum of the parameter list as new parameter values are ENTered (designated by the X prefix). This checksum is an aid to identifying a parameter list (all parameter values together) as unique. This allows tracking of film numbers to obtain specific results and repeatability. When system problems occur, film numbers can be checked for integrity by use of this checksum. See section x3.19x, *Checksum Validation*.

For parameters whose values are not numeric, numerically represented values are selected per their descriptions on the help line. In the following example, there are three choices to be made: RATE, RATE DEVIATION, and POWER. The RATE choice is made by pressing the "1" key. The RATE DEVIATION choice is made by pressing the "2" key. The POWER (PWR) choice is made by pressing the "3" key.



Scrolling up beyond the first parameter wraps to the end of the parameter list. Similarly, scrolling down beyond the end of the parameter list wraps to the beginning of the parameter list. The beginning and end of the parameter list is demarcated with a list line having the following " ----".
When starting from the main REVIEW FILM MENU screen (see Figure x3.9), pressing the EDiT key may generate the following screen if the PASSWORD LOCK# under the SYSTEM CONFIG. key on the EXECUTIVE menu has a value other than zero (a non-zero value enables the password and is itself the password). The EXECUTIVE menu key is on the MAIN menu.



Using PASSWORD LOCK, enter up to a four digit lock code as the password. Enter a zero to disable password entry. Unfortunately, when a password is in force, the password must be used to change it to zero, that is, to disable it.

MENU KEY DEFINITIONS
BYE: pressing BYE cancels the review film process and returns to the MAIN MENU screen. The fixed STATUS key returns the RunTime screen.
BAK: cancels the current menu level and returns the previous menu and/or screen.
GO2 FLM: changes review/edit from current film to named film number via the numeric keypad.

SEQ/non-SEQ product differences (see sections x2.1 and x.x for additional information):
SQ: active film# is always selected by a process.
non-SQ: active film# is selected in place of active process# (MAIN menu key label change is apparent along with non-appearance of the REVIEW PROCESSES key and the associated digit key [see below]).

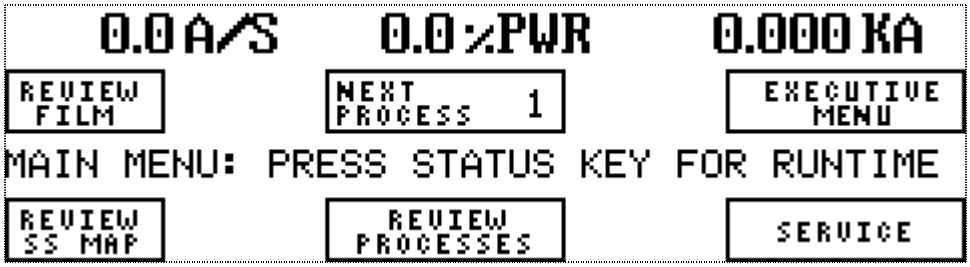
The following reiterates information providing a starting place for parameter values when the STC-2002 is received directly from the factory or the unit has had the memory purged or set to factory defaults. Section X.X describes the Service menu and memory configuration. Section x.x (end of next section) will also discuss how memory is changed. While viewing the LCD screen, some parameters are not accessible until other related parameters are in an appropriate state. These parameters are thus **dependent** upon the condition of other parameters. A list of these dependent parameters is given along with their controlling parameter (see section 1.7).

Film Parameter: Source Sensor Map Select

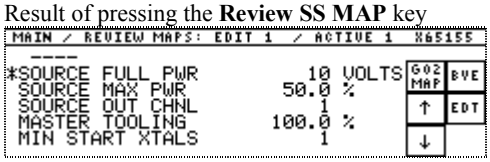
Source Sensor Map Select is a film parameter and as such a sensor map may be thought of as an extension of the film parameters. Each film calls out a specific map. Many different films can reuse a single map. Maps define many elements including the analog control output voltage and associated parameters, crystal activity and associated parameters, sensor channel activity and associated parameters.

To Program a sensor map, start with the film parameter Source Sensor Map Select. Select the map number that will be edited (or has been edited). Press ENTer to accept the value or BAcK to discard the enrty, if any. This will select a map as the ***active*** map when the calling film is itself active and running. See section 2.1. The MAP# in use is shown on the Runtime screen along with the calling Film.

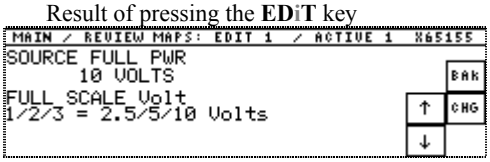
From the Main Menu, select the source sensor map named by the film parameter. This is initiated by pressing the **REVIEW S S MAP** key. See section 1.8 for all Map parameters.



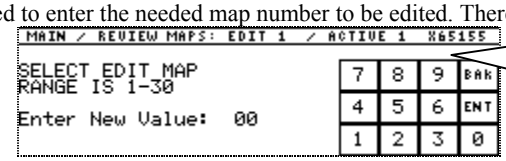
Result of pressing the **Review SS MAP** key



Result of pressing the **EDiT** key

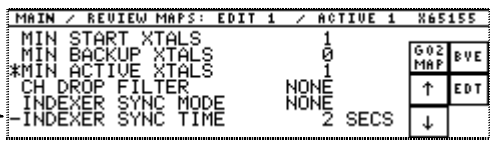


To select a different map than the current map, press the **GO2 MAP** key. A numeric entry screen will appear that is used to enter the needed map number to be edited. There are 30 maps available.



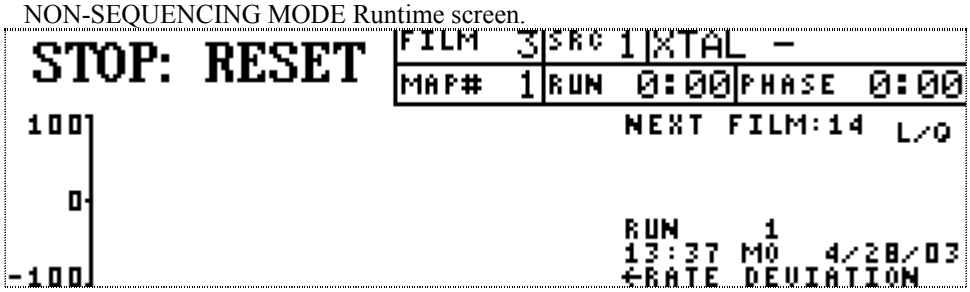
Result of pressing GO2 MAP key.

As was the case with Film parameters, there are also Map parameters that are dependent upon other parameters for accessibility. Note the "-" Prefix.

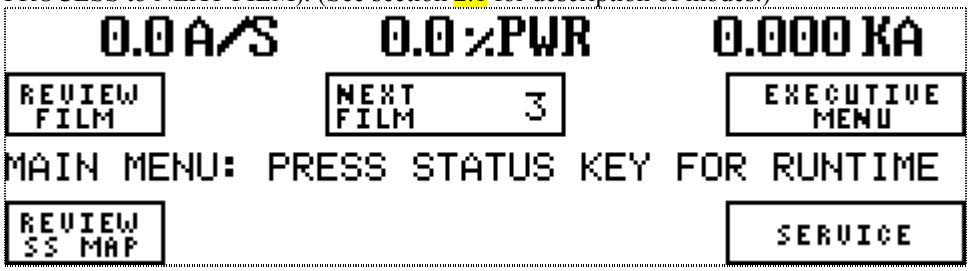


NON-SEQUENCING MODE: SELECTING THE ACTIVE FILM

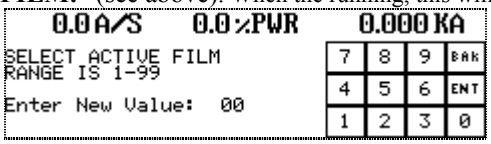
NON-SEQUENCING MODE Runtime screen.



NON-SEQUENCING MODE Main Menu (note missing REVIEW PROCESSES and change from NEXT PROCESS to NEXT FILM). (See section 2.1 for description of modes.)



To select the next active film in non-sequencing mode, begin by pressing the NEXT FILM key on the Main Menu above. This action will result in the following numeric entry screen. The entry made here will become the active film following the next START sequence. The BAcK key returns to the Main Menu without change. The ENTer key accepts the entry and returns to the Main Menu. The numeric entry, if made, will show itself within the "NEXT FILM" key legend and on the runtime screen following the text "**NEXT FILM:**" (see above). When the running, this will become the active film and appear after the text "FILM".



Film Parameter values after memory *purge*: [non-SEQ adds "Final Thick Limit=0.0 KÅ"]

See Section 1.8 for *Programmable Parameter Lists* and *Programmable Parameter Dependency Lists*.
See Section 2.2 for ***Menu Parameter Values & Programming After Memory Purge*** and ***...After Factory Restored Memory***.

Film parameter difference (from *purge*) with a *factory* restore:
max power limit set to 50% (purge = 0%).

Related System Configuration values after memory *purge*:

LCD Contrast	Medium
Password Lock #	0
Run number	0
⋮	
Recorder Functions	Rate
Recorder Output Channel	1
⋮	
Need Source Sensor Card *X*	Off
⋮	
I/O Slot *X* Type	Unused

Related System Config differences (from *purge*) with *factory* restore has:
recorder function set to show POWER.

Detailed Film Parameter Descriptions

Parameter **DENSITY**
DENSITY VALUE RANGE IS 0.40 - 99.99
Units gm/CC

Material Density

The Density parameter refers to the measured material in gm/CC. This constant is normally the bulk material value but is sometimes different due to deposition and film growth conditions. This value is utilized in the thickness equation to convert measured mass to a thickness value. See Table x4.1 in Section x4.3 for an extensive value list. See Section x4.2 for calibration information.

Parameter **Z FACTOR**
Z FACTOR VALUE RANGE IS 0.100 - 9.999
Units None

Material Z-Factor

The Z-Factor parameter refers to the elastic properties of the measured material. This value is utilized in the thickness equation to match the acoustical properties of the film being measured to the acoustic properties of the base quartz material of the sensor crystal. This correction is necessary to insure accurate measurements when sensor crystal shifts of greater than 10% are realized. See Table 4.1 for an extensive material value list. See Section 4.2 for calibration information.

Parameter **SETPOINT THK LIM**
THICKNESS VALUE RANGE IS 0 - 999.999 KA
Units Kilo Angstroms

Setpoint Thickness Limit

The SETPOINT THICKNESS parameter is used to provide a comparison point for the STC-2002 Thickness Setpoint Event. This event will be triggered whenever the thickness display equals or exceeds the setpoint value. The final or end thickness of a layer is layer dependent and is determined by the value programmed in the process, it should not be confused with this parameter which is film associated.

Parameter Final Thickness Limit (Trigger) **non-sequencing only**
THICKNESS VALUE RANGE IS 0.000 to 999.999 KÅ
Units Kilo Angstroms

Final Thickness Limit

The FINAL THICKNESS LIMIT parameter is only present in the non-sequencing mode. It is used to provide an end thickness value whose counterpart in the sequencing mode is the thickness value in a process program. This value determines the end of the deposit for the active film.

Parameter **SETPOINT TIME LIM**
ELAPSED TIME RANGE IS 0:00 - 99:59
Units Min:Sec

Setpoint Time Limit

The SETPOINT TIME LIMIT parameter is used to provide a comparison point for the STC-2002 Timer Setpoint Event status. The timer relay status is set when this time is exceeded.

Parameter **SOAK 1 PWR VALUE**
Percentage Value: Range is 0.0 - 100.0
Units Percent

Soak 1 Power Value

This parameter sets the deposition source power value to be used as the first level of soak power in the pre-deposition cycle. This power level will be maintained for the duration of the soak 1 timer. This

level is typically used to out gas and condition the source material. A value of 0.0% causes the RISE/SOAK 1 phases to be skipped.

Parameter **PWR RAMP 1 TIME**
Elapsed Time; Range is 0:00 - 99:59
Units Min:Sec

Ramp Time To Soak 1

This parameter sets the duration of the power ramp from zero power to the power level set by the soak 1 power value parameter. The source is typically heated slowly enough to permit outgassing and melt conditioning without causing actual deposition to take place.

Parameter **PWR SOAK 1 TIME**
Elapsed Time; Range is 0:00 - 99:59
Units Min:Sec

Soak 1 Time

This parameter sets the time that the source will remain at the soak 1 power level following the completion of the ramp to this level.

Soak 2 Power Value
Parameter **SOAK 2 PWR VALUE**
Percentage Value; Range is 0.0 - 100.0
Units Percent

This parameter sets the deposition source power value to be used as the second level of soak power in the pre-deposition cycle. This power level will be maintained for the duration of the soak 2 timer. This level is typically used to further out gas and condition the source material and actually begin depositing material at a low rate. A value of 0.0% causes the RISE/SOAK 2 Phases to be skipped.

Parameter **PWR RAMP 2 TIME**
Elapsed Time; Range is 0:00 - 99:59
Units Min:Sec

Ramp Time to Soak 2

This parameter sets the duration of the power ramp from the soak 1 power value or the idle power value to the value set by the soak 2 power parameter. The source is typically heated slowly enough to permit further outgassing and melt conditioning and actual deposition may begin during this time period.

Parameter **PWR SOAK 2 TIME**
Elapsed Time; Range is 0:00 - 99:59
Units Min:Sec

Soak 2 Time

This parameter sets the time that the source will remain at the soak 2 power level following the completion of the ramp to this level. At the end of this time the deposition phase begins. An external input can be programmed using the programmable I/O to hold the film at soak until released (Soak Hold).

Parameter **SOAK 3 PWR VALUE (IDLE PWR)**
Percentage Value; Range is 0.0 - 100.0
Units Percent

Idle Power Value

This parameter determines the final (idle) power setting at the completion of the entire deposition profile. If this power level is zero, a START command will begin a new power profile at rise 1, an idle power setting other than zero will cause the power profile to begin at rise 2 after a START.

Parameter **PWR RAMP 3 TIME (IDLE RAMP TIME)**
Elapsed Time; Range is 0:00 - 99:59
Units Min:Sec

Idle Ramp Time

This parameter sets the duration of the power ramp from the power level at the time that final thickness was reached until the power reaches the value set by the soak 3 power value parameter.

Parameter **DEPOSIT RATE**
Rate Value; Range is 0.0 - 999.9
Units Å/s (10^{-8} cm/s)

Deposition Rate

This parameter determines the material deposition rate that the closed loop control system will try to establish and maintain at the time that closed loop operation begins.

Parameter **RATE RAMP MODE**
On/Off
Units None

Enabling Rate Ramp Mode

This parameter is an enable/disable switch for the rate ramp function and associated film parameters. When set to Off the programming cursor window will skip over the associated parameters. When set to On all associated parameters are accessible and it will be possible to alter the deposition control rate profile during closed loop control. **[The following 3 parameters are dependent upon this parameter.]**

Parameter **NEW DEP RATE**
Rate Value; Range is 0.0 - 999.9
Units Å/s

New Deposition Rate

This parameter sets the new deposition rate value that is to be reached at the end of the rate ramp operation.

Parameter **RATE RAMP TIME**
Elapsed Time; Range is 0:00 - 99:59
Units Min:Sec

Rate Ramp Time

This parameter sets the duration of the rate ramp. The rate ramp starts at the rate control value at the time that the rate ramp trigger is reached and ends at the value set by the new deposition rate parameter.

Parameter **RATE RAMP TRGR**
Thickness Value; Range is 0 - 999.999
Units Kilo Angstroms

Rate Ramp Trigger Point Thickness

This parameter sets the trigger point for a rate ramp to begin during the deposit phase.

Parameter **CTL LOOP -P-**
Ctrl Loop Gain; Range is 1 - 9999
Units None

Control Loop Gain Term

This parameter sets the closed loop rate control proportional gain.

Parameter **CTL LOOP -I-**
Control Loop Time Constant; 0.0 - 99.9
Units Seconds

Control Loop Integral Term

This parameter sets the closed loop rate control integral term time constant.

Parameter **CTL LOOP -D-**
Control Loop Time Constant; 0.0 - 99.9
Units Seconds

Control Loop Differential Term

This parameter sets the closed loop rate control derivative term time constant.

Parameter **MAX POWER LIMIT**
Percentage Value; Range is 0.0 - 100.0
Units Percent

Max. Power Limit

This parameter sets the absolute maximum power level that will be allowed to occur at any time from the instrument (for the current film in use).
Specifically, this parameter selects the maximum percent of power that will be allowed out of the controlled power supply (named by the SOURCE OUTPUT CHANNEL parameter). This parameter and the Map parameter *Source Max Power* are redundant but not without good reason. When a process is running, the lesser value of these two parameters will be used as the limiting value. Maps are intended to be more closely associated with the source supply in terms of their definition at setup. One map may be called by many Films and, as a consequence, a Film may inadvertently set the power at a level beyond what is desirable for the power supply, wiring, etc. This is a fail safe way to limit a power supply configuration in a place close to the hardware, that is, in a map configuration.

Parameter **ABORT MAX PWR SW**
On/Off Value
Units None

Abort On Max. Power Switch

This parameter is a switch value. When set to Off it has no effect on the deposition sequence and the programming data window will not access the associated max. power dwell parameter. When set to On a maximum power condition will be allowed for the time duration set by the now accessible max. power dwell parameter and then the STC-2002 will abort the deposition sequence and power will be set to zero.

Parameter **MAX POWER DWELL**
Elapsed Time; Range is 0:0 - 99:59
Units Min:Sec

Max. Power Dwell

This parameter is associated with the max. power abort switch parameter and sets the allowable duration of a maximum power condition before an abort will occur.

Shutter Delay (has 2 dependent parameters)

This operating mode, if enabled, allows precise rate control to be established before substrates are exposed. For this capability the sensor must be located on the source side of the substrate shutter. A sensor shutter may also be used if desired.

Parameter **SHTR DELAY MODE**
On/Off
Units None

Enabling Shutter Delay Mode

This switch type parameter will allow the shutter delay parameters to become active and the mode functional on an individual film basis. If set to Off, the parameter window cursor will not access the associated parameters. If set to On, the delayed shutter operation will be performed as specified by the following parameters. **[The following 2 parameters are dependent upon this parameter.]**

Parameter **SHTR DLY TIMEOUT**
Process Timer; Range 0:01 - 99:59
Units Min:Sec

Shutter Delay Timeout

This parameter sets a time limit for the delayed shutter operation to be completed. The time period begins at the beginning of the shutter delay cycle. The sensor is exposed to evaporant with the substrates remaining shielded. When rate control is established to the programmed accuracy, three things happen.

The substrate shutter is opened, accumulated thickness set to zero, and the programmed deposition profile is then started. If the specified rate control accuracy cannot be met within this time limit, the deposition will be aborted.

Parameter **SHTR DLY QUALITY**
Range is 1 - 50
Units Percent

Shutter Delay Quality

This parameter sets the rate control accuracy that must be established for a period of five seconds in order to complete the delayed shutter sequence. The maximum accuracy settable is 1 percent of the desired setpoint. However, this is internally limited to 1 angstrom per second for noise and resolution restrictions.

Rate Sampling (has 4 dependent parameters)

This operating mode, when enabled, allows the user to expose the crystal sensor for short periods of time to the evaporant stream, establish rate control, and then shutter the sensor maintaining the power setting established during exposure. For relatively stable deposition sources or systems that must maintain vacuum integrity for long periods of time, crystal sensor life can be greatly extended. Two sampling modes are available. One has the exposure time strictly time controlled, the other will expose the sensor only long enough to establish the required accuracy. The exposure period for either mode is also triggerable externally.

Sample and Hold

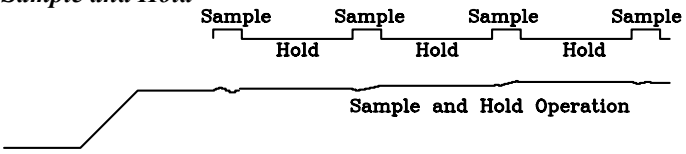


Figure- 3.11: Rate Sampling, Sample and Hold Operation.

Parameter **RATE SAMPLING**
Rate Sample choices (1 of 3):
OFF
TIMED MODE
INTELLIGENT MODE
Units None

Enabling Rate Sampling

This switch type parameter will allow the rate sampling parameters to become active and the mode functional on an individual film basis. If set to Off the parameter window cursor will not access the associated parameters. If Timed Mode is selected, the crystal sensor will be exposed to evaporant for the time specified by the sample dwell parameter, and will sample at the interval specified by the sample interval parameter. If Intelligent Mode is selected, then the duration of the sample will only be long enough to establish the desired accuracy. **[The following 4 parameters are dependent upon this parameter.]**

Parameter **RATE SAMPLE**
On/Off Value: Off or On
Units On/Off

Enabling Rate Sampling

This parameter assumes there is a shuttered head connected and that Rate Sampling can be used if the film parameters are programmed for such. (Without the shutter, deposit would be continuous and negate the advantage of this feature.) This feature extends the apparent life of the sensing crystal. It is used for thick coatings or in systems where it is not possible to break vacuum to change the sensing crystal. Depending on various factors in your particular system, the apparent crystal life can be extended up to 50

times by using the rate sampling feature of the STC-2002. Five film parameters which pertain to this feature are described in (Section 2.13).

Parameter **SAMPLE INTERVAL**
Process Time; Range is 0:01 - 99:59
Units Min:Sec

Sample Interval Time

For either mode of operation this parameter will select the sampling interval of the sensor.

Parameter **SAMPLE DWELL TIME**
Process Time; Range is 0:01 - 99:59
Units Min:Sec

Sample Dwell Time

For the Timed Mode selection this parameter sets the duration of sensor exposure.

Parameter **SAMPLE QUALITY**
Quality Value; Range is 1 - 50
Units Percent

Sample Quality

In the Intelligent Mode this parameter sets the control quality required to terminate the exposure period of the sensor.

Parameter **SAMPLE ALARM TIME**
Process Time; Range is 0:0 - 99:59
Units Min:Sec

Sample Alarm Time

In the Intelligent Mode this parameter sets the maximum allowable time allowed to complete the sensor exposure and control operation. The STC-2002 will treat this as a crystal failure when this limit is exceeded.

Parameter **FILM FAIL MODE**
Meas. Processing: select 1 of 2 choices;
Abort If Fail
Complete On Time Power
Units: None

Enabling Measurement Fail Processing

This parameter allows the user to select the system execution path if it is no longer possible to get reliable measurement information from the sensor system. This is the last resort choice that will be made after all other system configuration options have been exhausted. Choice 1) **Abort If Fail**, will abort the deposition and set the output power to zero. Choice 2) **Complete On Time Power**, will set the unit into a time power completion mode. In this mode the last reliable control power level will be maintained and thickness accumulation will occur in a simulated fashion until the final thickness setpoint is reached. Post deposition processing then will occur as programmed.

Parameter **CTL LOOP QUAL L**
Select Value; Range is 0 - 9
Units None

Control Loop Quality Limit

This parameter is used to set a threshold on acceptable control loop quality. When the threshold is exceeded a sensor fail condition is assumed and the system will process this condition as configured. A programmed value of 0 disables this test. A value of one gives the tightest limits (5%).

Parameter **XTL STABILITY**
Select Value; Range 0 - 9
Units None

Crystal Stability Limit

This parameter is used to set a threshold on acceptable sensing crystal performance. When the threshold is exceeded a sensor fail condition is assumed and the system will process this condition as configured. A programmed value of 0 disables this test. A value of one gives the tightest limits.

Parameter **XTAL LIFE BOUNDS**
Percentage Value; Range is 0.0 - 100.0
Units Percent

Crystal Life Limit

This parameter is used to provide a setpoint on the allowable sensing crystal usage. This setpoint may be utilized through the I/O system as a warning or interlock that sensing crystals need attention.

The following three parameters are used to select the data type and scale factors for the RunTime screen graphics area. These parameter values are always reinstated when a film is started.

Parameter **PLOT VERT SCALE**
Vertical Scale;
Select Specific Values 1/5/10/50/100
Units Å/s or % Power as selected

Vertical Scale RunTime Display

This parameter sets the vertical scale factor of the graphics display on the RunTime Screen. If Rate deviation is the type of data being displayed, generally setting this value to 10 will give a good display of the deposition control.

Parameter **PLOT HORIZ SCALE**
Horizontal Samples; Range is 1-600
Units Samples Per Display Point

Horizontal Scale RunTime Display

This parameter sets the horizontal sweep rate of the graphics display on the RunTime screen. Samples are taken at a rate of 4 per second. A programmed value of 1 will display every sample. The X-axis is 200 samples wide on the RunTime display. By increasing the sample number the sweep rate is slowed down. Proper selection of this number allows an entire deposition cycle to be displayed on one sweep of the screen, if desired.

Parameter **DATA PLOT TYPE**
Initial Plot, Select 1 of 3 choices:
Rate
Rate Deviation
Power
Units Å/S or % Power as selected

Data Plot Type

This parameter selects the type of information to be displayed in the graphics area of the RunTime screen.

Parameter **Source Sensor MAP SELECT**
Select Value; Range is 1 – 30
Units maps

Source Sensor Map Select

This parameter is used to associate a specific sensor map to a specific film. When a film becomes active, it will invoke the map number named by this parameter. The map itself is edited/changed within the REVIEW SS MAP menu.

Parameter **POCKET SELECT**
Select Value; Range is 0 – 63
Units Pockets

Pocket Select

This parameter is used to provide pocket information from a specific film in conjunction with the *ss map* parameter: *indexer sync mode*. If *indexer sync mode* is set for either *delay* or *feedback*, then following an XTAL verify, the indexer activity will commence before arriving at the RISE1 phase. Either a 1 of N or a binary (3 digit) value issued through output relays by I/O programming will select the correct pocket. If *indexer sync mode* is set to *none*, then the POCKET SELECT parameter has no effect.

Parameter **ETCHING MODE**
Polarity Value: OFF/ON
Units None

Etching Mode

This parameter sets the STC-2002 for either a deposit mode (positive rate) when set to OFF or an etch mode (negative rate) when set to ON.

Detailed Map Parameter Descriptions

Parameter **SOURCE FULL POWER**
Full Scale Volts: [enter representative values 1,2,3 respectively] 2.5, 5, 10
Units Volts

Source full power Control Voltage Scale Select

This scales the control voltage of the STC-2002 to match your power supply. Provides versatility to match supplies whose full power settings are one of these 3 selections. This allows 100% power from the STC-2002 to be any of 2.5, 5, or 10 volts. (see section 3.9)

Parameter **SOURCE MAX POWER**
Percentage Value: 0.0 – 100.0%
Units power %

Source max power Select

This parameter selects the maximum percent of power that will be allowed out of the controlled power supply (named by the SOURCE OUTPUT CHANNEL parameter). This parameter and the Film parameter *Max Power Limit* are redundant but not without good reason. When a process is running, the lesser value of these two parameters will be used as the limiting value. Maps are intended to be more closely associated with the source supply in terms of their definition at setup. One map may be called by many Films and, as a consequence, a Film may inadvertently set the power at a level beyond what is desirable for the power supply, wiring, etc. This is a fail safe way to limit a power supply configuration in a place close to the hardware, that is, in a map configuration.

Parameter **SOURCE OUTPUT CHANNEL**
Analog Output Channel Selection: 1 - 8
Units Channels

Source Output Channel Select

This parameter selects the channel that will be used as the control voltage output, that is the analog output from the STC-2002 that controls the power supply that generates the evaporant stream. There are 2 identical analog outputs on each source sensor card with up to four source sensor cards possible. A source output channel (1-8) can be selected for use here and the other source output channel (per card) can be used for the strip chart recorder (defined by a System Configuration parameter: *recorder out chnl*). If the source output channel parameter and the recorder output channel are set to the same channel, the source output channel will be used and the recorder function will be lost. If this situation should occur, a reboot will be necessary to reassign the recorder output.

Parameter **MASTER TOOLING**
TOOLING VALUE RANGE IS 10.0 - 400.0
Units Percent

Master Tooling

The TOOLING parameter is used as a correction factor to compensate for geometric position differences between the location of the sensor and the target substrate. Each of the 8 possible sensors has its own tooling factor. If no correction is required, both the substrate and sensor see the material source in an identical manner and the Tooling Parameter is set to 100%. Generally, if the sensor is farther from the source than the substrate, the tooling will be set to >100%. If the sensor is closer to the source, the tooling will be set to < 100%. Master tooling is used in conjunction with the individual tooling for each channel. The master tooling can be used as a global offset value for individual channel tooling or as a base tooling value upon which individual channel tooling is added. This is a parameter with global scope.

Parameter **MINIMUM START XTALS**
Minimum Number of Start Crystal Channels: 1 - 8
Units Channels

Selecting the minimum number crystal channels with which to start process

This parameter indicates the minimum number of crystals in the starting group when a process is begun. To reiterate, this is a START value. The intent is to provide a qualification minimum for run acceptability. If more than 1, averaging is assumed in conjunction with *Channel x Start Mode* map parameter programming to more than 1 active sensor. This is a parameter with global scope.

Parameter **MINIMUM BACKUP XTALS**
Minimum Number of Backup Crystal Channels: 0 - 7
Units Channels

Selecting the minimum number crystal channels for possible use as backup crystals

This parameter indicates the minimum number of crystals to be used as backup crystals. This is a parameter with global scope.

Parameter **MINIMUM ACTIVE XTALS**
Minimum Number of Active Crystal Channels: 1 - 8
Units Channels

Selecting the minimum number crystal channels that are active

This parameter indicates the minimum number of crystals that will be active when a process is started. The intent is to provide a guard for the minimum constellation of averaging crystal sensors the user decides are necessary. For a process to run, this value cannot be greater than that of the *minimum start xtals* map parameter value. This is a parameter with global scope.

Parameter **CHANNEL DROP FILTER**
Channel Drop Filter Mask Status: none / balance
Units None

Channel Drop Filter

This parameter enables/disables a filter mask for use during multi-sensor averaging. Each crystal sensor has a unique map parameter group. Programming 2 or more crystal sensor channels as active automatically invokes an averaging mode. Lost channels during averaging are handled by this Channel Drop Filter Mask parameter when enabled. An example of a crystal sensor/channel loss is crystal life failure. This parameter in the BALANCE setting, provides bumpless rate info if, for example, 3 channels are averaged and one channel fails and has no assigned backup crystal sensor/channel for the failing channel. This is done by keeping an historical buffer of the rate info stream for each of the 3 channels in this example case. When a channel fails (without backup), the historical rate info from each of the 3 channels is used to produce a composite multiplier based on the 3 channels when they were all working that will be used to fill in for the missing channel's contribution. This is, of course, a simplification for the purposes of discussion. When averaging, the preferred setting should be BALANCE. The setting of NONE allows the composite rate to jump when a channel is lost (without a backup). This parameter has no effect unless in averaging mode. This is a parameter with global scope.

Parameter **INDEXER SYNCHRONIZATION MODE**
Indexer Synchronization: NONE, DELAY, FEEDBACK
Units None

Indexer Synchronization Mode

This parameter is used to provide pocket information in conjunction with the *Film* parameters: ***Pocket Select*** and ***SS MAP SELECT***. If *indexer sync mode* is set for either *delay* or *feedback*, then following an XTAL verify, the indexer activity will commence before arriving at the RISE1 phase. Either a 1 of N or a binary (3 digit) value issued through output relays by I/O programming will select the correct pocket. If *indexer sync mode* is set to *none*, then the POCKET SELECT parameter has no effect. This is a parameter with global scope.

Parameter **INDEXER SYNCHRONIZATION TIME**
Indexer Synchronization Time: 2 – 999 seconds
Units Seconds:

Indexer Synchronization Time

This parameter provides the time value when the map parameter *Indexer Synchronization Mode* is set to DELAY. The indexer allowed a predetermined pocket search time. This is a parameter with global scope.???

Parameter **CHANNEL x START MODE** **[where x = any of 1 through 8]**
Channel Start Mode: Off, Active, Standby
Units None

Channel x Start Mode

This indicates which of the crystal sensor channels will be *active* when a deposition run starts. Unless the crystal fails, or an I/O program processing event causes a configuration change, this crystal state will remain in effect throughout the process.

Parameter **CHANNEL x FAIL ACTION** **[where x = any of 1 through 8]**
Channel Fail Action: None, Abort Film
Units None

Channel x Fail Action

This indicates what will occur when a channel fails for whatever reason. NONE provides no fail action. Abort Film provides a film abort when a failure occurs on this channel.

Parameter **CHANNEL x BACKUP LIST** **[where x = any of 1 through 8]**
Channel Backup List: Z – ZZZZZZZZ (1 item list to 8 item list)
[where Z = 1 to 8 (in each position w/o redundancies, list extends to 0-8 for a 1 item list)]
Units None

Channel x Fail Action

This parameter provides a list of potential backup crystal sensors should this channel fail for whatever reason. The crystal sensor channel switching is automatic when there is a sensor failure. Thickness and rate control is maintained during the switching operation. Also, for those multiple material depositions requiring extreme accuracy of measurement that mixing of materials on one sensor could degrade, it is possible to use a specific sensor for each material type.

Example backup lists:	comments:
0	(zero) no backups are defined
3	channel 3 is the one and only backup channel
237	backup channels are 2 then 3 then 7
2345678	backup channels are sequentially: 2345678
235637	incorrect list: 3 is repeated

Parameter **CHANNEL x TOOLING** **[where x = any of 1 through 8]**
Tooling Value: RANGE IS 10.0 - 400.0
Units Percent

Channel x Tooling

This TOOLING parameter is used in conjunction with the MASTER TOOLING parameter as a correction factor to compensate for geometric position differences between the location of the sensor and the target substrate. All of the 8 possible sensors have their own tooling factor. If no correction is required, both the substrate and sensor see the material source in an identical manner and the Tooling Parameter is set to 100%. Generally, if the sensor is farther from the source than the substrate, the tooling will be set to >100%. If the sensor is closer to the source, the tooling will be set to < 100%. See Section x4.2 for calibration information.

Parameter **CHANNEL x WEIGHT** **[where x = any of 1 through 8]**
Weight Value: RANGE IS 10.0 - 400.0
Units Percent

Channel x Weight

This parameter is used during a multi-sensor averaging process. Programming 2 or more crystal sensor channels as active automatically invokes an averaging mode. Weight provides the user with a method to assign each of the sensors a contribution percentage of the total used to determine thickness. When not in averaging mode, this parameter has no effect.

There are programmable Film and Map parameters that are only viable for particular hardware configurations. Unless the hardware that is needed to support the programmable parameters is physically installed and configured appropriately (on the **SYSTEM CONFIGURATION** menu), the process will not run and will display various error messages indicating the cause. The **SYSTEM CONFIGURATION** menu is accessed through the **EXECUTIVE** menu which is located on the **MAIN** menu.

Examples:

- Repaired crystal channels (or channels failed by user programming) must be RE-VERIFY'd on the 2nd STATUS screen before they can be recognized as good again.
- If the typical **PROCess *X*:** *status message* does not change when the **START** key is pressed, check for **"STOP: INValid *XXX*"** message and check the **OPT/INF** menu, page 2 for cards not installed that are enabled in software **(MIA).** AC Power must be recycled **OFF⇨ON** to re-sync.
- If SRC is zero, this is an indication that a *source analog output control voltage* has been assigned to a source sensor card that is not present, not working, etc. Remember that the System Configuration parameters: **Need Source/Sensor Card X** and **I/O Slot X type** are only evaluated on power up or on reset. Check the OPTions/INFo menu, page 2 and 3 to see what is currently in effect. To work correctly, the **S/S *x*: line** should end with **OK**. If it ends with **EMPTY**, the card is not present or not communicating. If the line ends with **INCOMPATable!**, the software versions in at least some of the various PCB cards is not compatible- check for field changed PCB cards. If the line ends with **MIA**, that sensor card is configured but is not physically present. [See OPTions/INFo menu]

Review or Edit Processes

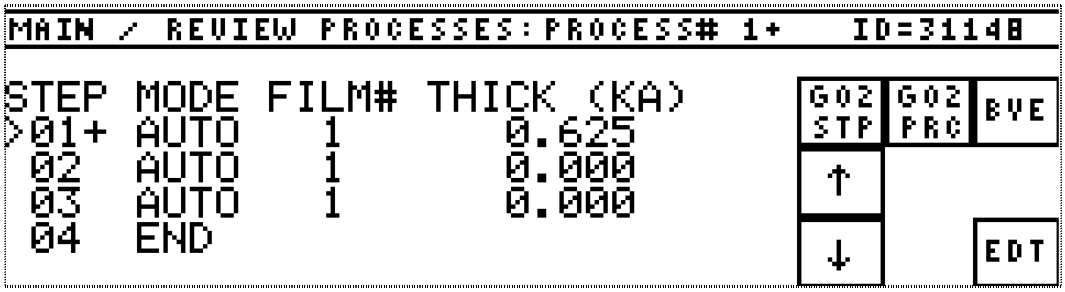


Figure- 3.12: Main Process Review/Edit Screen.

SECTION 3.6 Editing Processes

The STC-2002 has the capability of sequencing through many layers of film. The sequential arrangement of films is called a process. The STC-2002 has the capability of storing 9 processes. The maximum length of a single process is 99 layers. The total number of layers in use by the 9 processes is 250 layers. The following are equivalent: a layer, a process step, a line of process programming.

To operate the STC-2002, a process of at least one layer must be programmed. If a process is started with no layer information programmed, the message **ERROR IN RECIPE** will occur in the process status area of the screen. This also assumes the STC-2002 is in Sequencing mode (See section 2.1). **[**Memory *Purge* reduces all process programming to a 1 line process with an END command as the only function (program starts and ends itself). *Factory* defaulted memory yields 9 process programs each with an auto mode, a film number = process number, a thickness = 0.1 multiplied by the process number.**]**

To edit or review a process, press the REVIEW PROCESSES key on the Main Menu. The screen appears initially as shown in Figure 3.11. Other sub-menu keys appear as needed. See below for a detailed description of menu keys. To select a different process for review/edit, press the GO2 PRC (go to process) key. This will bring forth a numeric entry screen whose number entry will select the needed process by its number name.

Each process step (also called layer) has 3 programmable parameters associated with it and is a line in the process program. The steps range from 1 to 99. The programmable parameters available are: Start Mode, Film#, and Thickness. Pressing the EDT (EDIT) key invokes the Process Edit screen that allows line insertion, deletion and passage into the change/edit menu to modify and build steps using the CHG (change) key as the entry point. The change/edit menu provides entry of Mode, Film number and Thickness. The two editing selections that are available for inserting or deleting layers are intended for use in an existing process or a new process.

When the mode key is pressed, there are five selections as to how the starting of the film will be handled by the layer sequencing of the STC-2002. The mode choices appear as key legends after the mode key is pressed.

The five choices for modes which control the layer starting are: **END, AUTO, WAIT, SKIP, STOP**. By selecting the appropriate start mode, a layer can be sequenced automatically or designed to wait for a Front Panel break-wait or remote break-wait to proceed to the next step or layer. Generally, in an actual process, only the first three start modes would be used.

Process Start Mode Edit Key Descriptions

Mode Choice: End

The **End** mode would terminate the process. It is always inserted as the last step of a process.


Caution

CAUTION If the END statement is entered in the middle of an existing process, all steps or layers that originally followed will be deleted.

Mode Choice: Auto

If **AUTO** is programmed to be the layer start mode, then this layer begins immediately upon completion of the previous layer. If layer 1 has AUTO programmed as its start mode then the first appropriate start command generated begins this layer. Key legend is **AUT**.


Note

Note The unit must be reset of any **ERROR** conditions, and not in the process RESTING mode but in the PROCESS STOP phase before a start command will be accepted. The fixed START key is also used to reset any process error conditions and initiate a process reset under some conditions. (See Section 3.0, START process)

Mode Choice: Wait

If **WAIT** is programmed to be the layer start mode, upon completion of the previous layer, the STC-2002 enters a wait state. This is useful when some mechanical event such as rotation of a source pocket, or some process change like gas composition occurs between layers. The appropriate start command (START-Break Wait) breaks the wait state and starts the layer. The break-wait command can be issued from either a Front Panel function, a remote input or through one of the computer interfaces. Key legend is **WAI**.

Mode Choice: Skip

If **SKIP** is entered as the start mode, the layer is skipped over (key legend is **SKP**).

Mode Choice: Stop

If **STOP** is entered as the start mode, the process will continue until the stop is encountered. The **STOP** is similar to an **END** with the exception that if it is installed in the middle of a process list, the steps following are not erased.

The **SKIP** and **STOP** mode are normally not used in a process recipe. They can be useful during the development of a process or to recover a process which has been aborted. Key legend is **STP**.

INSERT and **DELETE**.

Two list editing choices also become available when the **EDT** (edit) key is pressed.

Mode Choice: INSERT

INSERT inserts a step in an existing list (key legend is **INS**) after the line with the cursor. [If END is at line 1, cannot use INSERT. Use MODE to change END to another mode choice and END will be auto advanced to position 2.]

Mode Choice: DELETE

DELETE removes a step from the process program list (key legend is **DEL**) indicated by the cursor.

The mode for a step or layer can be edited while the process is running if the change is not on the active layer or the change does not alter the length of the process list. (**END, INSERT,** and **DELETE** generally changes the list length).

FILM# key legend is: FLM.

MODE key legend is: MOD.

THICK key legend is: THK.

ENTER key legend is: ENT.

After the mode is entered, the FILM# key (FLM) can be pressed. (Note that the MODE, FILM# and THICK keys can be pressed in any order.) After pressing the FILM# key, one of the ninety-nine stored films can be selected by pressing the digit key[s] followed by the ENTER key (ENT). This associates a layer or step in a process with a film program. The film program stores the material related parameters and calls out a sensor map that contains source, tooling and crystal related parameters . The same film can be assigned to multiple steps within a process. After entering the film number, the THICK key (THK) can be pressed. The desired final thickness for that layer is entered/edited by pressing the necessary digit keys followed by the ENTer key. The number is built by shifting in digits from right to left and can continue indefinitely until either ENTer or BAK is pressed. This allows entry correction by repeating the number sequence until correct.

While constructing/editing the elements of a line (MODE, FILM#, THICKNESS), an *edit line* will appear at the bottom of the LCD screen to indicate that an edit is in progress. The *edit line* consists of a prompt naming the edit type followed by the value being entered. The edit can either be accepted by pressing **ENT**er or abandoned by pressing **BAK**.

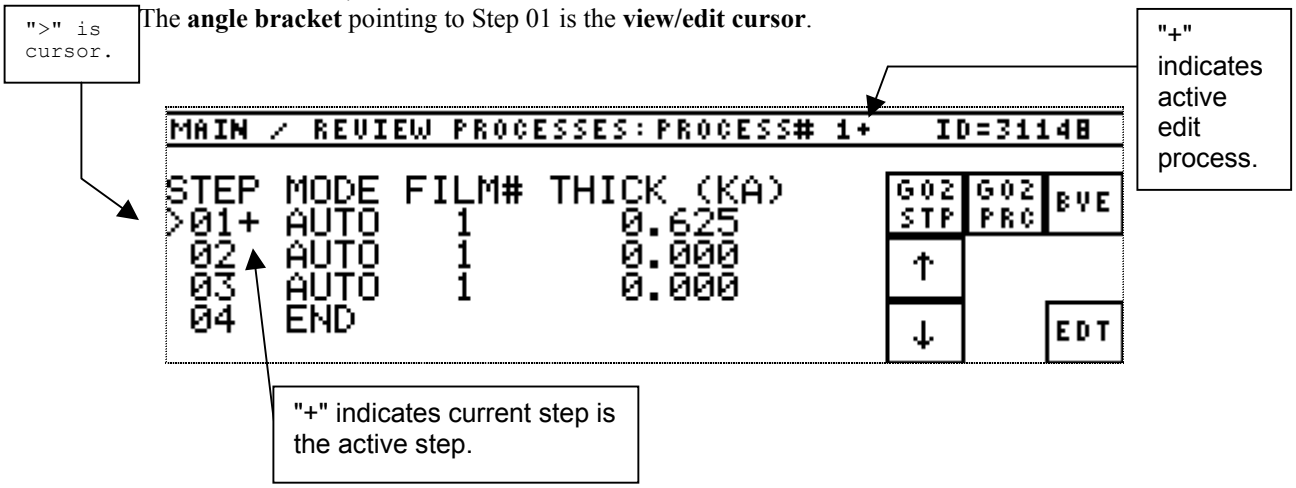
Additional steps can be added to the process by repeating the above procedure. A step or steps can be added to an existing process by positioning the cursor (>) at the step where the new step will be inserted. The new line will be inserted after the line with the cursor. The former line step occupant and all subsequent line steps are advanced in their list positions as the new step is added. Press the **INS**ert key and then a new step will be inserted. When this is done, the default parameters of **SKIP**, film 1, and thickness 0.000 are entered for the inserted layer. These can then be edited to the desired values.

In multi-layer deposition the same deposition material and source combination are sometimes used in different film programs. Generally at least two film programs are associated with one material source combination. One of the film programs contains source parameters (rise and soak time and power levels) for the initial conditioning of the source or first layer or material usage, the other film program parameters would be for subsequent layers of the same material.

Review / Edit Process Specifics.

The following shows the review processes screen. The top line contains the menu path to the current screen/menu followed by the process# currently being viewed. The **Process#** is selected by pressing the **GO2 PRC** (go to process number) key and the digit key[s] on the subsequent numeric entry screen. A "+" appears near the end of the top line (after path information) to indicate when the **active process** is being viewed. The recipe ID number is also on this line (use to determine process program integrity). The ID is a checksum of the entire program. The ID with only the END at step 01 is 00000. The second line contains the column headers, which remain fixed as the list is scrolled.

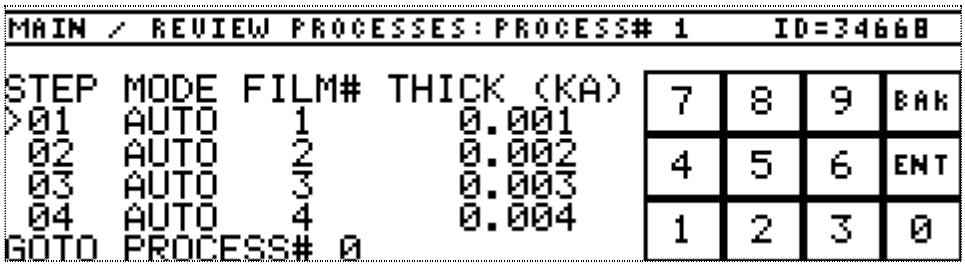
The **angle bracket** pointing to Step 01 is the **view/edit cursor**.



BYE: pressing this key causes a return to the MAIN MENU. The fixed STATUS key returns the RunTime screen.

GO2 STP: press this key to move *cursor/list segment* to indicate and display step number entered by numeric keys that appear after GO2 STP is pressed (GOTO Step).

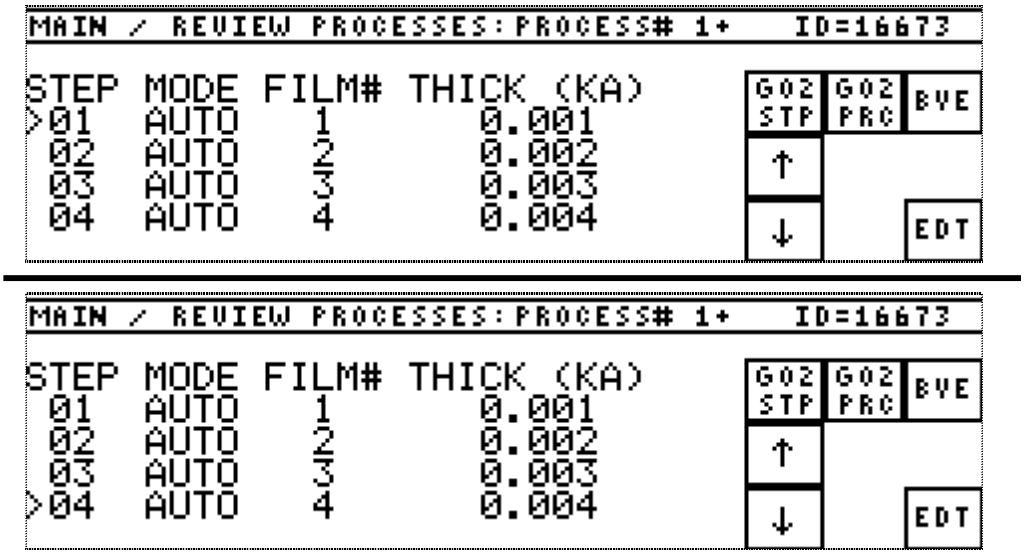
GO2 PRC: press this key to bring up a numeric keypad that allows changing the Process number (GOTO PROCESS). Enter PROCESS# and press **ENT**er to accept or **BAK** to abandon.



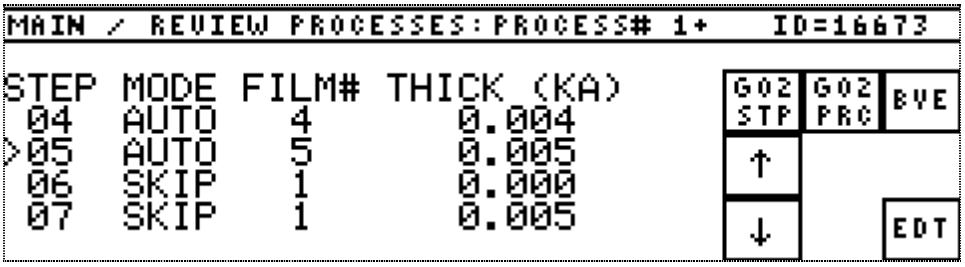
↑: pressing the UP ↑ key moves the edit cursor toward the first of the four list lines currently on the screen. When the edit cursor is on the first list line displayed (somewhere in the middle of a 20 line list, for example) subsequent UP ↑ presses result in moving the line at the top of the displayed section of the list to the last (4th) position of the displayed section. What were the last three list items are no longer seen and three consecutively lower, previously unseen, numbers are now occupying the first three of the four displayed lines. The cursor is always moved to a lesser numbered step number (list line) with each press of the UP ↑ key (except at step 1). When the edit cursor is coincidental with step number 1 and UP ↑ is pressed, no action is taken other than to beep the audio indicator. In other words, the UP/DN keys move the edit cursor up or down on the four list lines displayed and if UP/DN exceeds those list lines shown, the list lines will be advanced or receded by three lines except at the beginning and end of the list lines.

↓ **(down)**: pressing the DN ↓ key moves the edit cursor toward the last of the four list lines currently displayed on the screen. When the edit cursor is on the last list line displayed, subsequent DOWN ↓ presses result in moving the line at the bottom of the displayed section of the list to the top (1st) position of the displayed section. What were the first three list items are no longer seen and three consecutively higher,

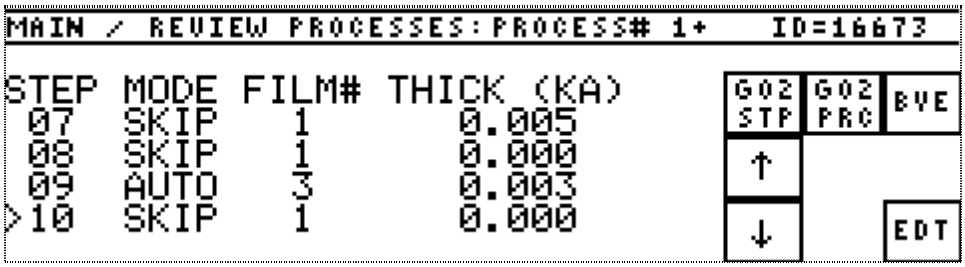
previously unseen, numbers are now occupying the last three of the four displayed lines. The cursor is always moved to a higher numbered step number (list line) with each press of the DOWN ↓ key (except at the last step). When the edit cursor is coincidental with the last step and DOWN ↓ is pressed, no action is taken other than activation of the beep annunciator.
Starting with the cursor at step 01, pressing down ↓ three times moves the edit cursor alone. Scrolling has the same behavior in all places/menu levels.



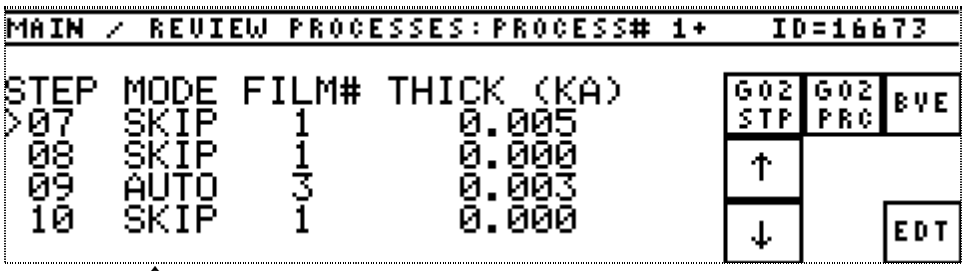
Pressing the down ↓ key once again causes the *four-line* window into the list to be shifted ahead by three lines as shown below. The edit cursor moves to the newly appearing, next consecutive list line. At this point, the UP↑ key could be pressed one time and the down ↓ key could be pressed three times with only the edit cursor moving, that is, before the list lines in the *four-line* window would change.



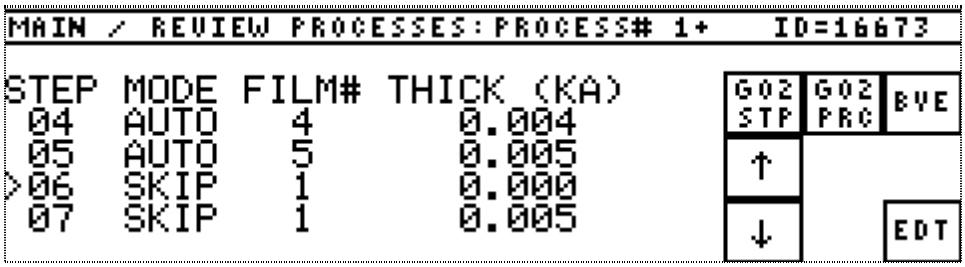
The following sequence shows the scrolling behavior using the UP ↑ key. Again, scrolling has the same behavior in all places/menu levels.



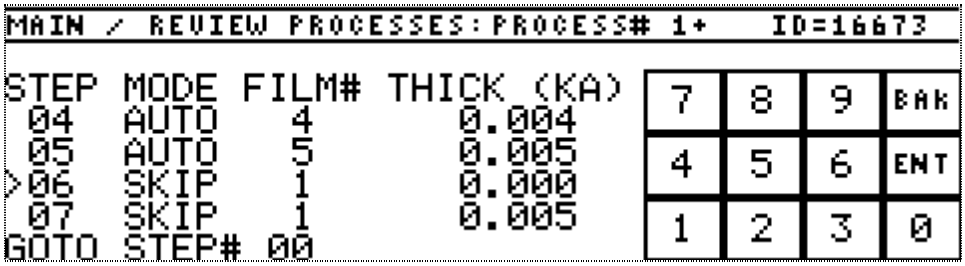
Press the UP ↑ key three times for the following result.



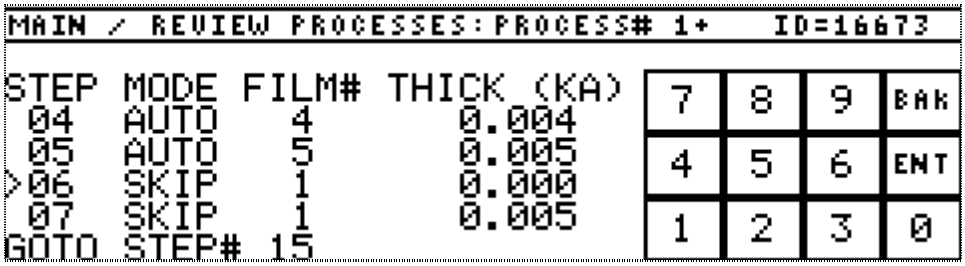
Press the UP ↑ key one more time for the following.



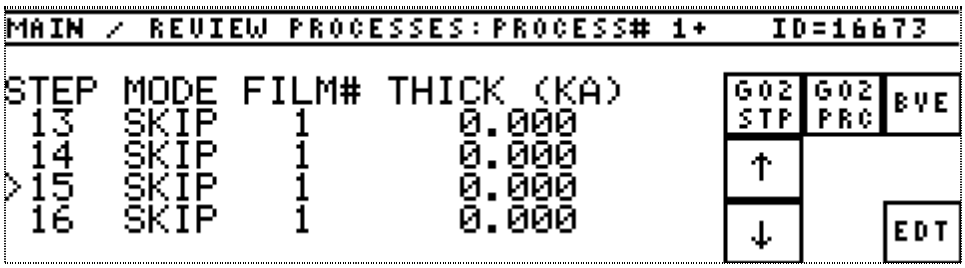
GO2 STP: pressing the GO2 STP (GOTO STEP) key takes you to the step/line whose number you enter and accept by pressing ENT on the **number entry key** menu. The following screen is the result of pressing the GO2STP key. If a number is entered that is greater than the last (END) line, the cursor would move to the last (END) line.



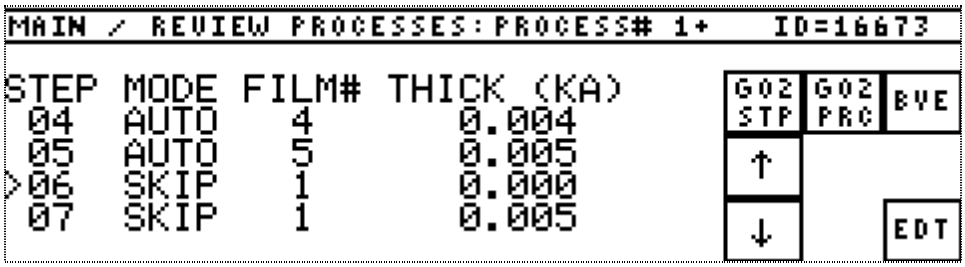
The following screen shows the result of pressing the "1" key followed by pressing the "5" key. This value can be accepted by pressing the ENT key, abandoned by pressing the BAK key or continued by pressing more number keys (shifting more digits into the two digit GOTO prompt area at the end of the last line).



the following screen shows the result of pressing GO2STP and entering 15 as the destination (the "1" key, the "5" key and the ENT key)...

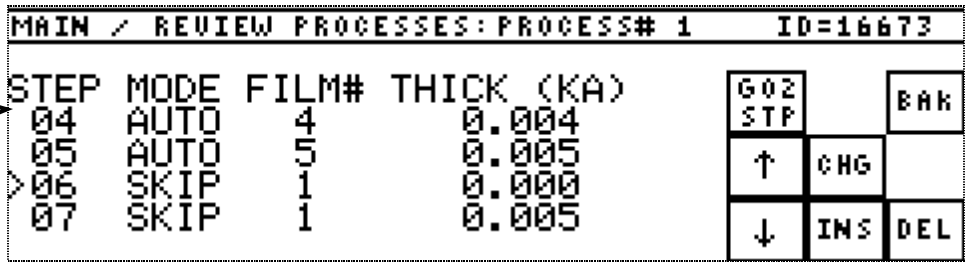


When the destination is greater than 2, the line list will appear with the <u>destination as the **third line**</u> of the four displayed lines with the edit cursor on this line. This gives a *two previous and one succeeding line* perspective for reference and relational purposes. Near the end of the list this display preference is not in effect.



Pressing the **EDT** (edit) key generates the following screen. If a password has been used (a non-zero value), an intermediate password entry screen will appear. See the end of this section for more details.

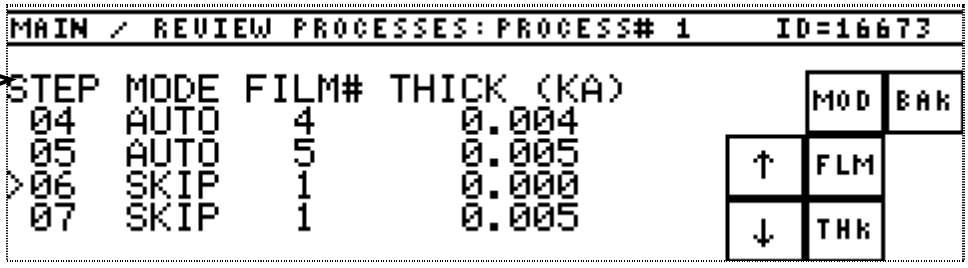
Process Edit menu



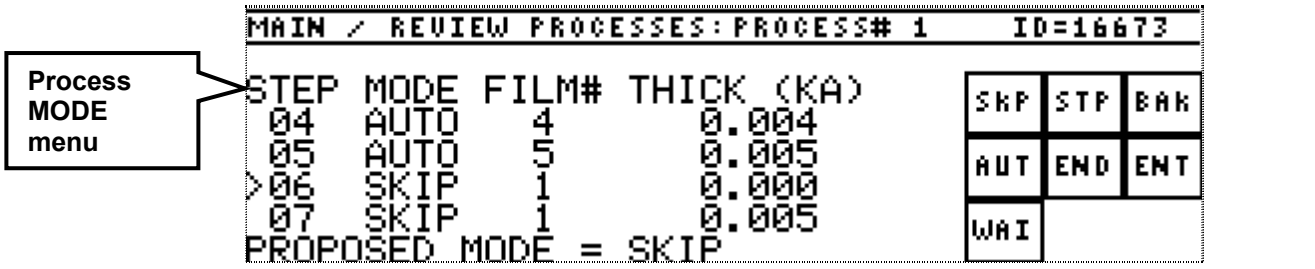
Navigation remains as previously described. Three new edit related choices are now possible: change line (**CHG**), insert line (**INS**), and delete line (**DEL**). DEL deletes the line with cursor. INS inserts a new line *after* the line with the cursor. The following screens will help describe the change (CHG) line (that is, the edited line elements). **BAK** (back) always returns to the previous screen, discarding entries, if any were made.

Pressing the **CHG** (change) key produces the next screen. Take note of the current values on the edited line (line with the cursor ">"). This screen is the <u>starting point</u> for modification of mode, film# and thickness. When a line element is edited(changed), an edit line appears at the bottom of the screen and shows the value in the temporary workspace.

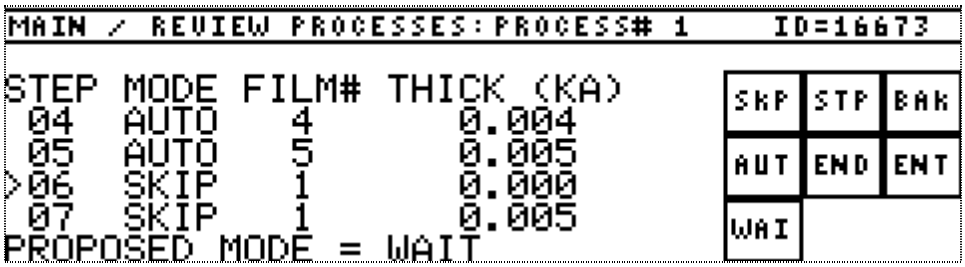
Process Edit/Change menu



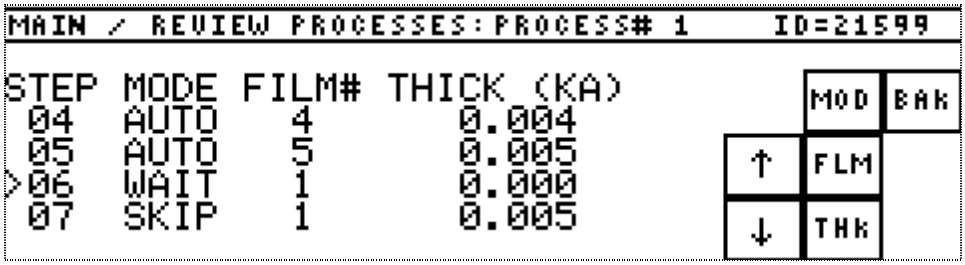
Pressing the MOD (mode) key brings forth the mode select menu as follows. SKIP is the default mode value used when the INSert key creates a new line.



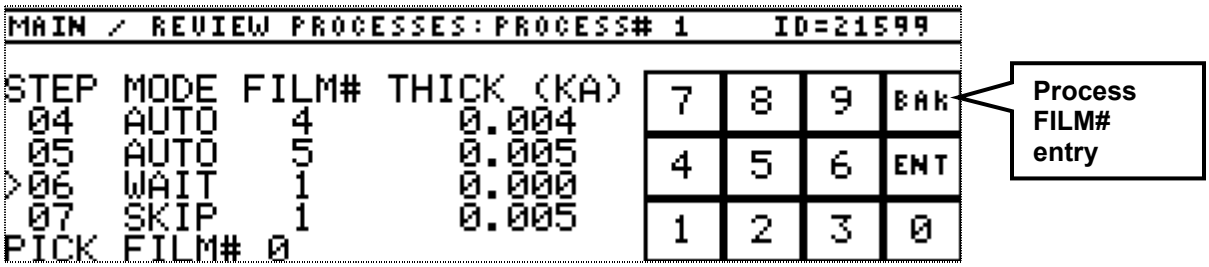
Pressing the **WAI** (wait) key changes the proposed mode value as seen next on the edit line.



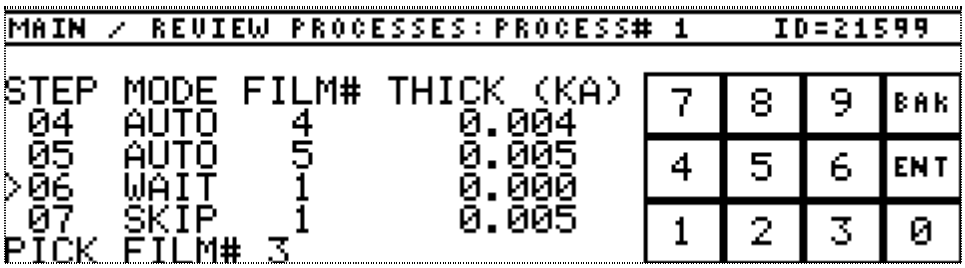
Now press ENT (enter) to accept WAIT.



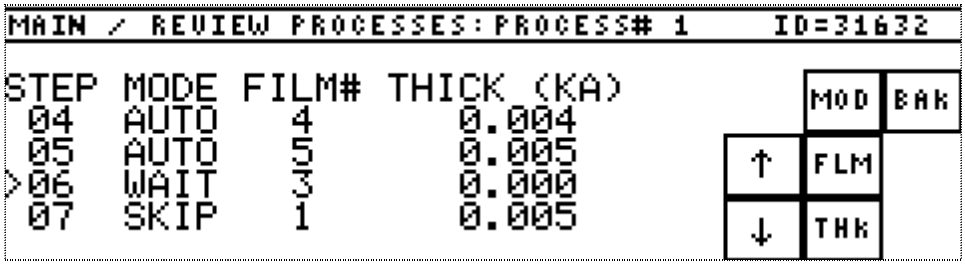
Notice that WAIT replaces SKIP on the edited line. MOD (Mode) could be pressed again or FLM (Film) or THK (thick) could be pressed. The following screen shows the result of pressing the FLM (Film) key.



Enter a "3" for film number 3 by pressing the "3" key. Note change in edit line on the following screen. Up to 2 digits can be entered here as there can be up to 99 films.

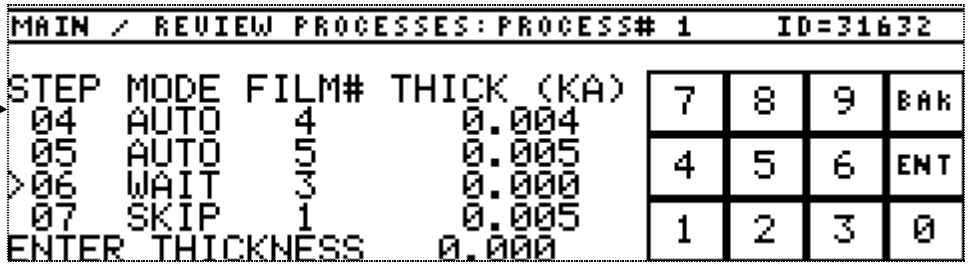


Press BAK (back) to abandon FILM# value edit. Press ENT (enter) to accept entered film number value as seen next. Note that the FILM# on the edited line has been displaced by the new value of "3".

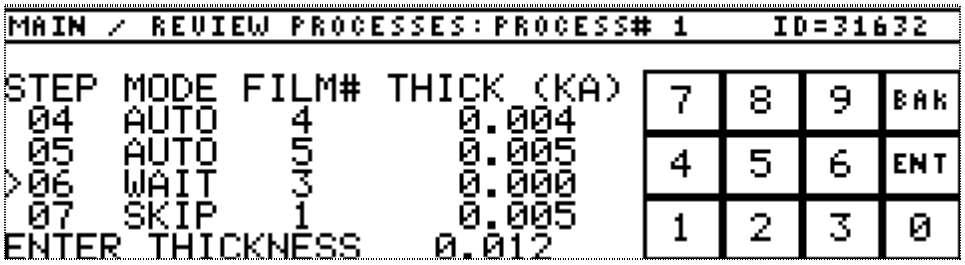


Once again, the change screen reappears from which any of the three choices could be made. The next screen depicts the result of pressing the THK (thick) key.

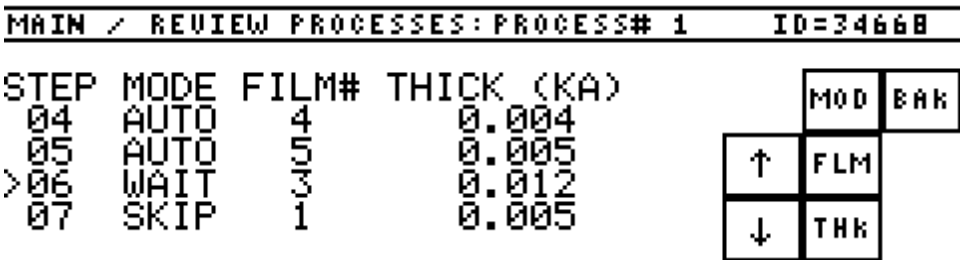
Process Thickness entry menu



Pressing the "1" key and then the "2" key produces the following screen. Numbers can be entered indefinitely until either the BAK or the ENT (enter) key is pressed.

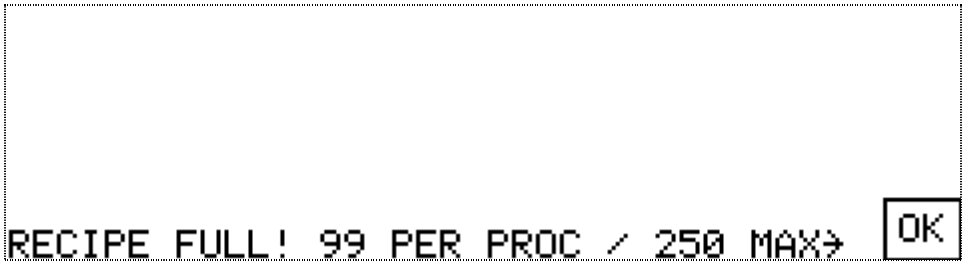


Pressing the ENT (enter) key returns the change screen. Please note that the decimal point is fixed and that leading zeroes are suppressed.

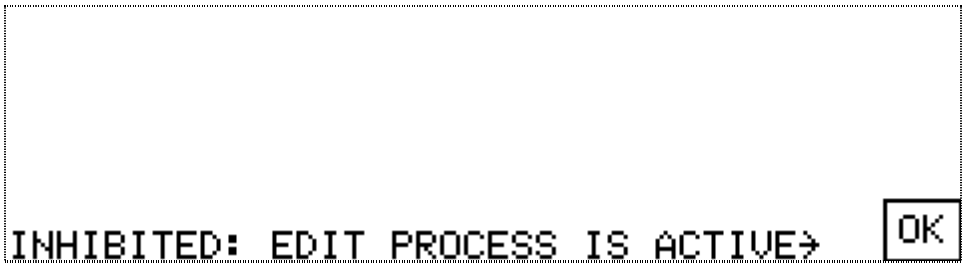


By using the arrow up/down keys, the order of entry could be to change the modes of lines 5, 6 and 7, then change the FILM#s of lines 5, 6, and 7 and then change the thickness of lines 5, 6, and 7.
Once in the edit/change mode, different parameters can be changed without leaving the edit mode.

Special Cases
The following screen appears when all of the total unit memory has been used. As the message relates, recipe memory is used in its entirety. Although there can be up to 99 layers (steps) per process recipe and up to 9 recipes, there is not enough unit memory to have 99 layers for each of all nine recipes. Press the OK key to clear the message screen.



The following screen appears when an active process is running and someone is attempting to edit the process while it is running. Press the OK key to clear the message screen.

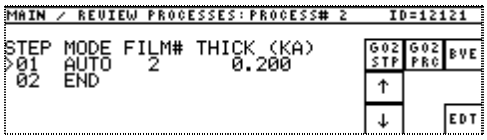


If the PASSWORD LOCK# under the SYSTEM CONFIG. key on the EXECUTIVE menu has a value other than zero (a non-zero value enables password and is itself the password) the following screen will appear when the EDT (edit) key is pressed. The EXECUTIVE menu key is on the MAIN menu.

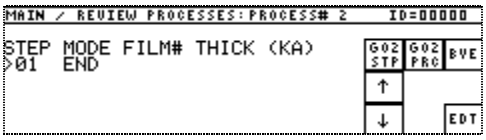
Enter the lockcode number value in the same way as previously described for other number entries.

Processes: Factory settings vs. purged settings.

The following example LCD displays show the difference between factory settings and purged settings for PROCESS# 2. The first screen is the factory setting and has, for step 01, MODE=AUTO, FILM#=2, and THICK(KA)=0.200. The second screen is the purged setting and has only the END line.



Typical Factory Setting



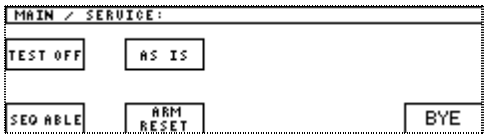
Purged Setting

Factory (defaulted) Settings table for All Process Numbers:

	Proc# 1	Proc#2	Proc#3	Proc# 4	Proc#5	Proc#6	Proc#7	Proc#8	Proc#9
STEP	01	01	01	01	01	01	01	01	01
MODE	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO
FILM#	1	2	3	4	5	6	7	8	9
THICK	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900

All factory Processes have END as STEP 02.

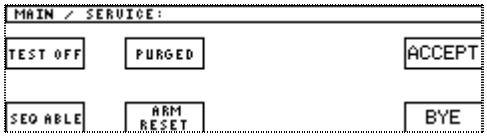
To restore factory settings or to purge settings, press the SERVICE key on the MAIN menu. This brings forth the SERVICE menu as shown below.

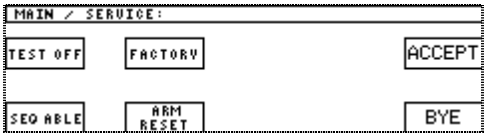


Caution

Please be aware that changing the memory contents by this means changes more than just the process values. See section X for a complete description.

Press the **AS IS** key once for **PURGED**, twice for **FACTORY**, thrice to return to **AS IS**.





[See section x3.21, *Check sum validation*. See section x7.3, *battery and memory loss*.]
Press the **ACCEPT** (/ restart) key to accept the configuration as described by all of the key labels. This will also cause the unit to **REBOOT** with the new configuration in effect. Please see the section describing the SERVICE menu as there are groups of settings other than those which are PROCESS# related (Film parameters, I/O programs, etc.) that will be included in this configuration. **Valuable process programming could be lost.** No **I/O programs** are *factory* restored because of the danger involved. *Purge* will, however, clear **I/O programs**. See section x5.15 (table 5.4) for I/O program entry.

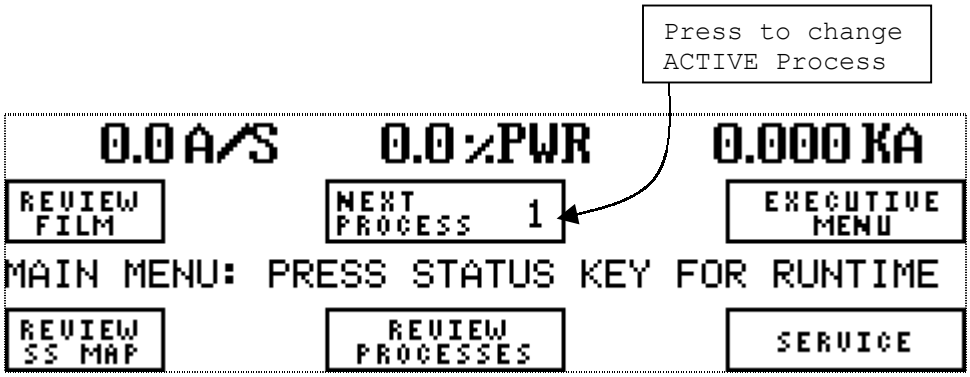
Press **BYE** to leave the SERVICE menu without accepting anything changed.

If the password is forgotten and programming has not been saved in some other media, call factory to eliminate passwords without purging memory.

SECTION 3.7 Set Active Process

General Description: (See Section moved here2.9 and figure 2.12) To change the active process (only allowed when the instrument is in IDLE and the LAYER value is "#" indicating an at rest condition [observe the runtime screen]), press the fixed MENU key, which will produce the MAIN menu

screen as shown in the following figure. Next, press the key area that is labeled on the MAIN menu as '**NEXT PROCESS**' and sometimes referred to as the '**NEXT** ACTIVE **PROCESS**' selection. The numeric entry screen will then appear at which time pressing the needed digit will select the next active process. Pressing the numeric digit keys allows any value from '1' through '9' to be entered as the next active process. ENTer accepts the entry, BAK discards the entry, if made, key needs to be pressed. The active process will be the value at which the digit value is left when ENTer is pressed. The next process started will use this process number. Press the fixed STATUS key to return to the Run Time screen. If an attempt to change the active process is made with the instrument in a non-idle condition either a temporary error message will appear saying ; "**INHIBITED: UNIT MUST BE IDLED**" or the text UNIT BUSY NA will appear in the key instead of NEXT PROCESS. When the text "NA" appears on the key, the product is not allowing the alteration because it would not be desirable to change the process while it is running. The result of pressing the key when UNIT BUSY NA appears will be an acknowledgement beep only. The process must be stopped. See *START: Reset/Start Process* diagram below.

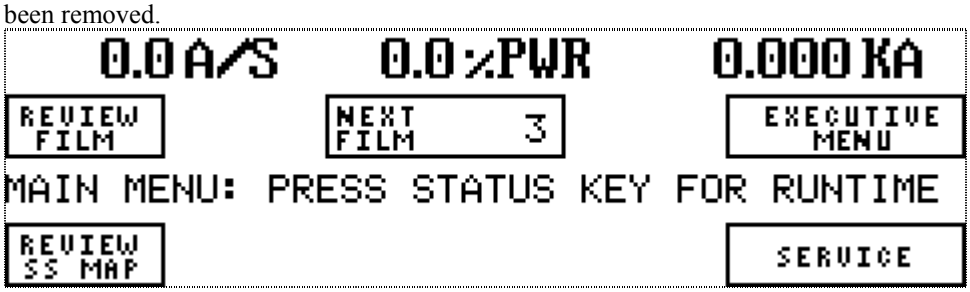


SECTION 3.8 Non-Sequencing Differences

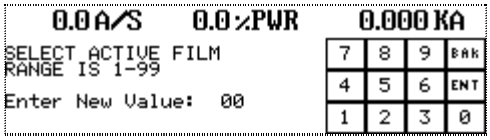
Non-sequencing mode does not use processes but treats one of the ninety-nine possible films selected as active in a single implicit process.

Note that *process* related information is not shown on the Run Time screen.

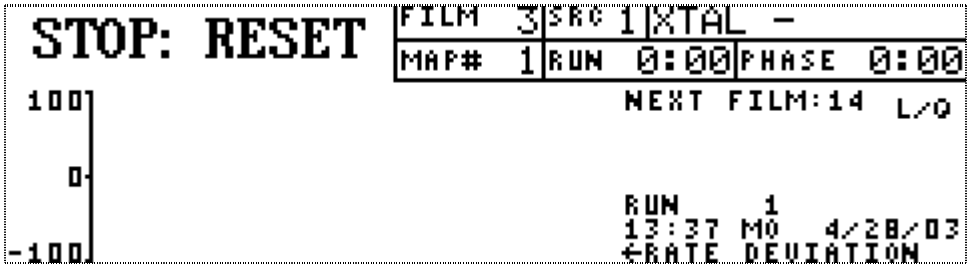
Note that the "**Next Process**" label has changed to "**Next Film**" and that the **Review Processes** key have been removed.



Pressing the NEXT FILM key brings forth the numeric entry screen that is used to select the next active film. BAcK returns the previous screen and discards the entry, if any. ENTer accepts the digit[s] entered as the next active film and returns to the previous screen.



If 14 were entered, upon return to the runtime screen, the message "Next Film: 14" would appear as shown below.



Programming the unit for non-sequencing involves the same type of communications and I/O setups, system configuration, and film parameter modifications.
Process programming does not exist for non-sequencing product use.
An added parameter is added to the film parameter list: **Final Thick Limit**.
The final thickness, no longer part of process programming, becomes a parameter.

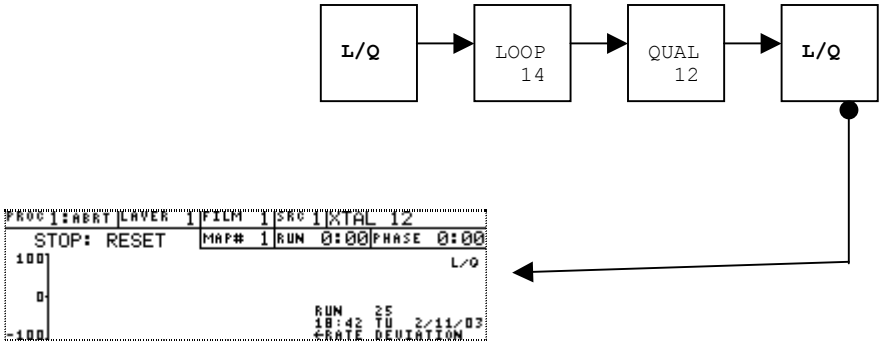
SEQ: active film# is always selected by a process.

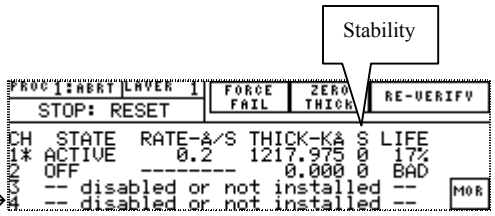
non-**SEQ**: active film# is selected in place of active process# (MAIN menu key label change is apparent along with non-appearance of the REVIEW PROCESSES key).

SECTION 3.9 Software Controlled *RunTime Screen* Keys

There are several software controlled keys that are active in the RunTime Mode.

Crystal Quality Display.
L/Q Key
The rightmost single key area on the second row of the Run Time screen labeled "**L/Q**" is used to sequence through the crystal quality indicators displayed on the RunTime screen (as depicted below). The parameters that can be displayed are LOOP and QUAL. These are described in Section x2.17 under STC-2002 Crystal Switch. Each press of the L/Q key, advances through the possibilities as shown. For those that are familiar with previous deposition control products, STABility is no longer presented by this method due to the increased complexity because of the added crystal possibilities. The STABility information can now be found on the 2nd STATUS screen under the column header "S".

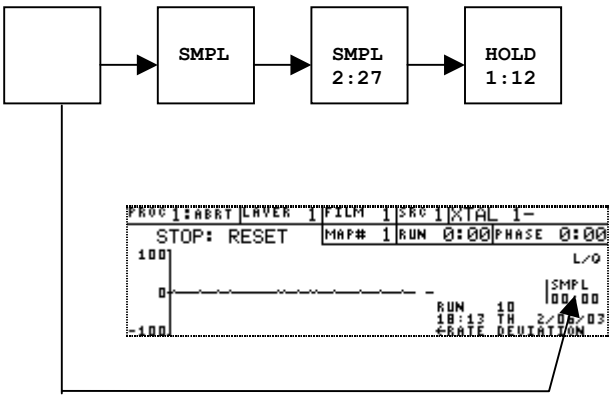




STABility now displayed on the 2nd STATUS screen →

Related Film parameters: **Control Loop Qual Limits** **0 to 9**
XTAL Stability S (Limits) **0 to 9**

Sample and Hold.
SMPL Key
Using the single key area below the L/Q key, the STC-2002 will force a Sample to be taken and restart the toggling sequence of the Sample and Hold Phases when in a Sample and Hold mode. When in the Sample and Hold mode, this area will not be empty as is normally the case and will contain text and values appropriate to the activity which is running. See Section x2.13 for a description of Sample and Hold operation and the associated parameters (MAIN/REVIEW FILM).



Related Film Parameters:		
	(XTAL) RATE SAMPLING	OFF,TIMED,INTELL.
	(XTAL) SAMPLE INTERVAL	0:01-99:59 MM:SS
	(XTAL) SAMPLE DWELL TIME	0:01-99:59 MM:SS
	(XTAL) SAMPLE QUAL	1-50%
	(XTAL) SAMPLE ALARM TIME	0:01-99:59 MM:SS

SECTION 3.10 Manual Power Control

The Manual Power Mode is a method of controlling the source power manually. It is useful to initially determine the operating point for the soak and deposition levels. The Manual Power Mode can be entered from the RunTime Screen or either of the 2 STATUS screens (see section 3.0). In addition, a film and process must be running (not stopped) to enter the Manual Power mode. Section 3.20 defines and describes a test program. With this test program is running, all of these functions can be exercised and their effects observed.

Hand Controller / Manual Power Mode

Although familiarization with the operation of the manual power control can be accomplished by reading alone, with the multilayered test deposition program mentioned above running and used as an aid, familiarization with the operation of the manual power control can be enhanced. By pressing the fixed front panel **MANUAL** key, the STC-2002 is placed in a phase similar to **DEPOSIT**. MANUAL is shown as the current phase displayed on the RunTime screen. The I/O event status designated as source shutter will indicate open and the rate control loop is disabled during the Manual Power Mode (with test program running). When in the MANUAL mode, a means of power adjustment using either one of two **vertical ARROW** keys on the pendent becomes available. After entering the MANUAL mode, press one of the two **vertical ARROW** keys (see figure 3.12) and observe the Run Time screen. The power value indication shown by the middle LED display section (front panel is labeled with POWER-%) will increase or decrease depending on the arrow key pressed. You can also use the hand controller (pendent) to put the unit in a STOPPED state by pressing the pendent STOP button. Pressing both of the pendent arrow keys simultaneously, zeroes the power value. The twelve foot coiled cord of the hand controller (pendent) plugs into the jack in the lower left corner of the front panel labeled MANUAL CONTROL.

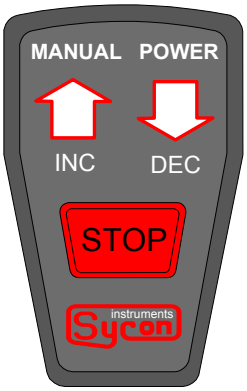


Figure- 3.13: Hand Controller (pendent).

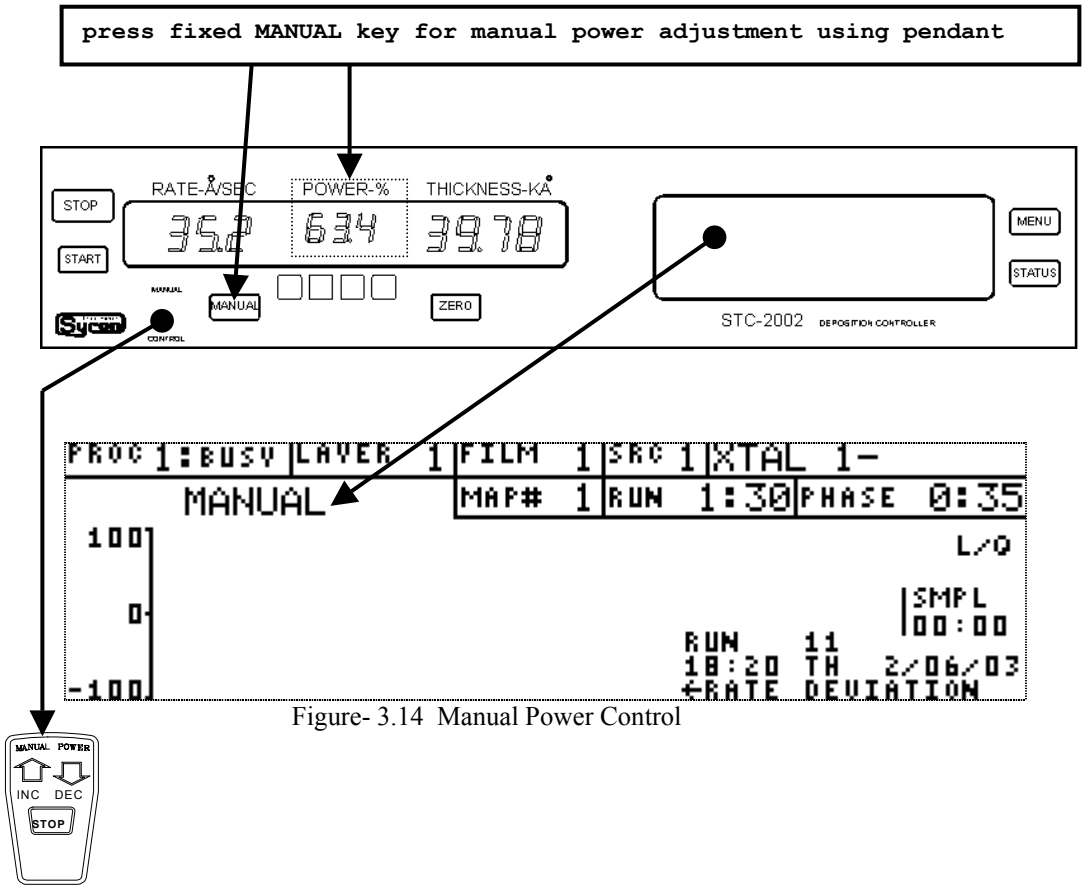


Figure- 3.14 Manual Power Control

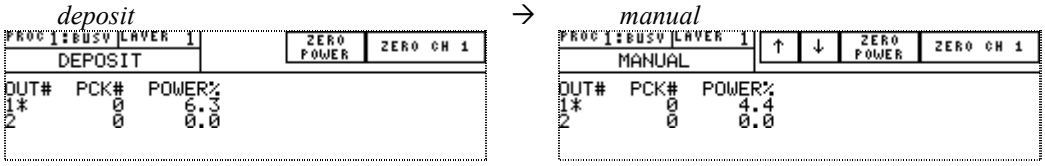
When you leave the Manual Power Mode (by pressing the fixed **MANUAL** key again), the STC-2002 will enter the **DEPOSIT** phase of the film in use. The control loop will be active at this point. If the Thickness number is greater than the programmed Final Thickness value when you leave MANUAL, the STC-2002 will go to the next process step.

[The push buttons on the pendent hand controller can be used for other functions when the STC-2002 is not in the Manual Power Mode. By using the programmable I/O, these keys can control internal I/O events or output to relays. One common use example is to assign one of these buttons as an I/O program input to manually trip the final thickness limit. An example of using these buttons for these functions is given in Example 5 of Section 5 of this manual.]

Manual Power Control (LCD keys)

If the pendent is missing or if the pendent's key functions have been re-programmed (reassigned functionality) by an I/O program, there are available arrow keys that accomplish the identical functions. These have already been discussed in section 3.0. To reiterate briefly, switching between DEPOSIT and MANUAL can be accomplished on the Runtime screen, 1st STATUS screen and 2nd STATUS screen. On the 1st STATUS screen, two arrow keys appear when switching into MANUAL mode. Press the UP arrow key to increase power % value. Press the DOWN arrow key to decrease power % value.

deposit → *manual*



SECTION 3.11 STC-2002 Shutter Delay *(Setting Up Shutter Delay Mode)*

Shutter Delay Operation

Shutter delay operation is desirable when it is necessary to bring the deposition rate into good control before exposing substrates to the evaporant stream. When this mode of operation is required it must be enabled in the **Review Film** menu parameter list. This is **not** a global enable and will allow the following associated film parameters of only this specific film to become active and programmable. These parameters are:

Parameter 1 Shutter Delay Mode

(On/Off) This parameter enables the mode of operation for this specific film program and also allows the following parameters to be accessed when ON.

Parameter 2 Shutter Delay Time Out

Time-Out (Accuracy) 1 To 99:59 M/S

This parameter determines how long the system will keep trying to obtain the control accuracy value before giving up and aborting the run (process time).

When the desired control accuracy is maintained for a period of 3 seconds before the time-out limit, the thickness display is set to zero and the substrate shutter relay is energized. All associated crystal switch, crystal backup, or active sensor selections and operations remain valid in this mode. Proper control loop P-I-D settings should be previously determined. This will insure minimum delay times and will also optimize film consistency. Refer to the I/O programming in Section X5 of this manual for a guide on selecting the logic for use as the substrate and sensor shutter controls.

Parameter 3 Shutter Delay Quality

Control Quality (Accuracy) 1 To 50% Of Setpoint

This parameter sets the desired accuracy of the control loop before the substrate shutter is opened. The maximum accuracy available is 1% of the deposit rate setpoint or 1 angstrom per second; whichever is greater. The control accuracy must be maintained for a period of 3 seconds.

Film Parameters (/menu):	**Shutter Delay Mode**	**OFF, ON**
	Shutter Delay TIMEOUT	**0:01-99:59 MM:SS**
	Shutter Delay QUALITY	**1-50%**

SECTION 3.12 Deposition Source Control Loop Description

The STC-2002 instrument is designed to measure the rate of material deposition and compare this measured value to a programmed rate setting, the difference between the actual and programmed rate is used to generate a feedback control signal to the deposition source power supply. The power supply is then adjusted by this control signal to achieve the programmed rate setpoint value. This method of control allows the STC-2002 to compensate automatically for source condition changes.

Control Output Voltage

Since there are many different types of deposition power supplies and sources in use today, the deposition control voltage provided by the STC-2002 has been made user configurable. This control voltage can be wired to be either positive or negative from chassis ground and scaled for either 2.5, 5 ,or 10 volts full scale. Full scale corresponds to 100% on the LCD power digits. The control voltage has 12 bit resolution and 10 milliampere source or sink capability. The sense of the control loop can also be set for etching applications where it must operate in an inverted fashion. This configuration is done on the *Review Films* parameter list menu (Etching Mode: Off/On).

P-I-D Control Loop

To accommodate the extremely wide range of control loop responses required for the diverse deposition sources available today, a P-I-D type of control loop has been implemented. With this type of control loop available to the user, it should be possible to achieve very good control of any deposition source. The **P** or **proportional gain term** provides a fast response to any system rate control error and sets

the overall control loop gain. The **I** or **integral term** forces the rate control error to reach a zero value and is typically set to equal the slowest time constant in the control loop. The **D** or **Derivative term** helps to anticipate control loop overshoot and negates some of the slowing down effect of the Integral term. This term is seldom required for systems with time constants faster than 10 seconds. Too much D term can actually contribute to loop drift and instability.

Determining Control Loop Settings

Using Data Display For Tuning

All the control loop parameters interact to some degree in the overall response of the control loop. Therefore, there are many combinations of settings that will give equally satisfactory results. Also, the control loop that is optimized for steady state control will have quite different settings from one requiring fast control acquisition with minimal overshoot. The graphics available on the RunTime display can greatly aid the user in determining the control loop settings and performance. The user can observe real time rate, rate deviation, or control power on this display. By introducing a step response into the control system and observing the graphical display responses it is quite easy to "tune" the control loop. There are several ways to introduce a step change. The first is by programming a different deposition rate number while in control. Another way is to go into Manual Power and ramp the power either up or down, then come out of manual and go back into control.

Setting The P-I-D Terms

The basic philosophy of tuning a control loop is to isolate each of the P, I, and D parameters as much as possible. Start off by disabling the I and D terms. The I parameter should be set to 0.0 secs and the D term to its lowest value (0.0 secs). This isolates just the gain term (P). Start off with a low value of P and increase it until your system starts to oscillate in response to a step input. Make a note of this number. Reduce it by 50% as a starting point. You will notice that your desired control point will not be reached by using this number, (the actual rate will always be below the desired rate). This offset can be eliminated by setting (to non 0.0) the integral term (I). If you know the time constant of your system, use this number (or slightly longer) as a starting point. Smaller values of the I term will make the system respond faster, but may cause oscillations. At this point, you can go back and re-adjust (lower) the P term. Keep in mind that there is interaction between the P term and the I and D terms.

For most systems, these 2 terms (P and I) will be enough to stabilize your system. If you have a very slow system, you will want to use the D parameter also. This term can be helpful in controlling the amount of overshoot you have in your system. If you know what the lag of your system is, set the D term to it. The D term puts lead into the control loop to compensate for lag in your system. Remember that a P-I-D control loop is much more difficult to tune than just a P-I loop.

Typical Settings

Typical Sources

Fast responding sources such as electron beam types generally can operate at high gain settings (20 to 200), fast integration times (.1 to .5 sec), and minimal or no derivative term (0 sec). This is somewhat material sensitive and also is affected by the use or non-use of source liners. These settings are also typical of most sputtering applications.

Medium response sources such as resistive type boats, baskets, or filaments typically require lower gain settings (10 to 100), longer integration times (.5 to 10 sec) and some derivative term (0 to 1 sec).

Slow sources such as Knudsen or induction heated types may require lower gains (1 to 50), longer integration times (5 to 30 sec), and a derivative term approximately 20% of the integral term (1 to 10 sec).

SECTION 3.13 Film Phases and Parameter Groups

There are several phases during a deposition layer of the STC-2002 related to the source and deposition rate control. There are three main parts to a deposition layer. These are pre-deposition, deposition control, and post-deposition. The pre-deposition parameters control the source and material conditioning prior to the film deposition. The STC-2002 can control a variety of different types of deposition sources. The typical run cycle shown in Figure 3.15 is for an E-B or thermal source.

Typical Film Deposition Cycle

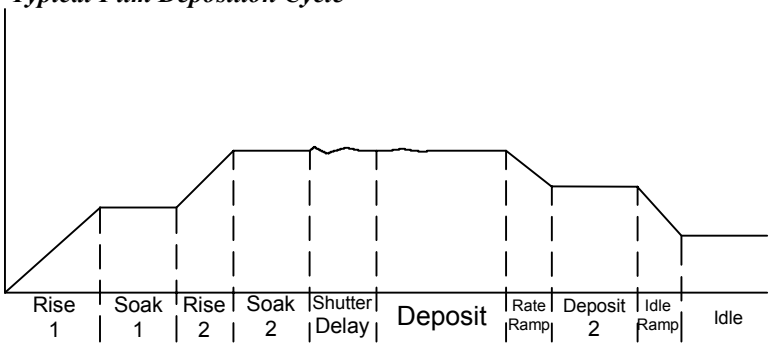


Figure- 3.15: Typical Run Cycle.

Table 3.1 which follows provides a list of phases and their associated parameters for all phases of the deposition. There are also several film parameters which relate to the deposition material and sensor calibration . Among these are DENSITY, Z FACTOR and TOOLING. A detailed description of each film and map parameter is given in section 3.5. Indexing, if used, follows XTAL verify and precedes Rise 1.

Phase	Parameters	Group
RISE 1	SOAK 1 PWR VALUE PWR RAMP 1 TIME	Pre-Deposit
SOAK 1	PWR SOAK 1 TIME	
RISE 2	SOAK 2 PWR VALUE PWR RAMP 2 TIME	
SOAK 2	PWR SOAK 2 TIME	
SHUTTER DELAY	SHTR DELAY MODE SHTR DLY TIMEOUT SHTR DLY QUALITY	
DEPOSIT	DEPOSIT RATE CTL LOOP P CTL LOOP I CTL LOOP D MAX POWER LIMIT ABORT MAX PWR SW MAX POWER DWELL	Deposition
RATE RAMP	RATE RAMP MODE RATE RAMP TRGR RATE RAMP TIME NEW DEP RATE	Control
DEPOSIT 2	NEW DEP RATE	
IDLE RAMP IDLE	PWR RAMP 3 TIME SOAK 3 PWR VALUE	Post-Deposit

Table 3.1: STC-2002 Phases and Parameters.

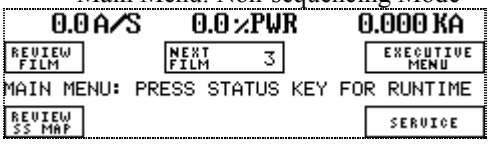
SECTION 3.14 System Configuration

System configuration is a category that generally includes parameters that are not deposition process related, but it has also been the recipient of other miscellaneous parameters that are not strictly *system* related. If the STC-2002 is moved among systems, these system configuration parameters need to be checked for the appropriate system environment. Program checksums can be used to verify integrity each of the parameter groups.

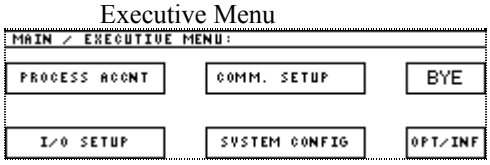
In order to access this parameter group, start at the RunTime display. Press the **fixed MENU** key and the **MAIN** menu will appear. With the MAIN menu displayed, press the **EXECUTIVE MENU** key. When the EXECUTIVE MENU appears, press the **SYSTEM CONFIGURATION** key and the SYSTEM CONFIGURATION menu will be displayed. There are 12 parameters that have to do with system type parameters that are programmable. The **fixed STATUS** key returns the Run Time Screen.

Main Menu: Sequencing Mode

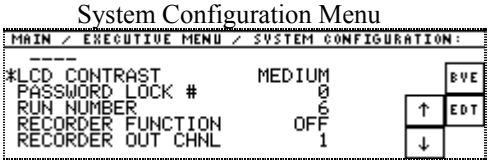
Main Menu: Non-sequencing Mode



Executive Menu

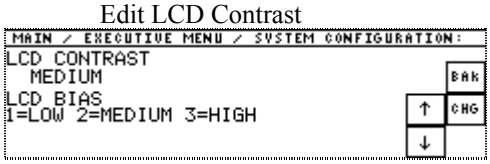


System Configuration Menu



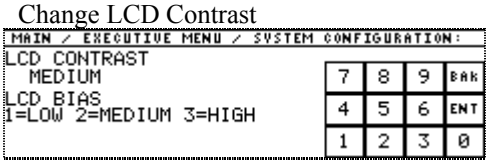
press EDIT

Edit LCD Contrast

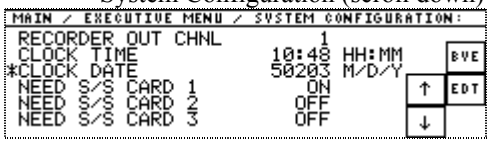


press CHANGE

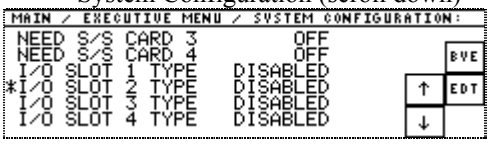
Change LCD Contrast



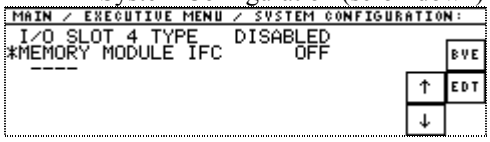
System Configuration (scroll down)



System Configuration (scroll down)



System Configuration (scroll down)



SECTION 3.15 Detailed System Configuration Related Parameters

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Parameter **LCD CONTRAST**
Low/Medium/High Value: Low or Medium or High
Units Low/Medium/High

LCD Contrast

This parameter tells the STC-2002 how to control the bias voltage to the LCD. Adjust for best viewing: brightest with the most contrast at the desired viewing angle. Between 45° above and perpendicular to the LCD viewing surface is best (@25°c±5°).

Parameter **PASSWORD LOCK #**
Lock Code Value Range is 0 - 9999
Units None

Setting The Passwords

This allows changes of STC-2002 program parameters to be restricted to only those people knowing this 4 digit password code. If password lock is programmed with a non-zero value, whenever you access a menu that can change a parameter or try to change a parameter, the STC-2002 will ask you for the password. The exceptions are the I/O Programming menus and the Communications Setup menu that are password locked by a *Lock Code* parameter found on the Communication Setup menu (see Communications Setup Configurations in the following section).


Caution

CAUTION If this password is entered inadvertently or forgotten it can be removed by purging the unit of all its stored parameters. When this is done all program parameters including I/O programming, System Configuration, Process Lists and Film Parameters **will be lost** and require reprogramming. This could be several hundred items of data. All this data should be recorded prior to purging the memory of the STC-2002. Recording methods include downloading to a PC from the HOST port, information written down by making a paper copy of the various parameter tables and circling the selected element, downloading to the memory module. To purge ALL stored data from the STC-2002, press the fixed MENU key when on the Run Time screen then select the **Service** key on the MAIN menu. Press the **Purge** (All Stored Data) key and the confirming **ACCEPT** key. After doing this the STC-2002 will contain no user programmed information and will have to be completely reprogrammed.

If password is forgotten and programming has not been saved in some other media, call factory to eliminate passwords without purging memory.

Parameter **RUN NUMBER**
Run Number Value: 0 - 9999
Units None

RUN NUMBER

The run number auto-increments with the start of each new process [Sequencing: on process start. Non-sequencing: on Film start.]. The number entered with this parameter should be thought of as a pre-usage offset as the run number increments when the process or film starts. For example, if the run number entered is 2, the next process that is started will have the run number of 3. Run number is used to identify a specific process run. Run results can be compared by viewing the PROCESS ACCOUNTING screens (See PROCESS ACCOUNTING in section x.x).

Run Number

Parameter **RECORDER FUNCTION**
Analog output type: Rate, Deviation, Power, Thickness, Remote
Units None

Selecting Recorder Output Type

There are 2 identical analog outputs on each Sensor card in the STC-2002. The 9 pin female D-SUB connectors labeled SOURCE x/x contain these analog outputs (see section x3.10), either of which is used for the recorder output. You may program one of five variables to appear on this output. They are absolute rate, rate deviation, power, thickness or remote. The Remote setting allows a voltage level to be determined by an external computer to appear at this output. (See T command of computer interfacing, Section x6)

Selecting Recorder Output Type

Parameter **RECORDER OUT CHANNEL**
Analog output Channel: 1 - 8
Units Channels

Selecting Recorder Output Channel

There are 2 identical analog outputs on each Sensor card in the STC-2002. The 9 pin female D-SUB connectors labeled SOURCE x/x contain these analog outputs (see section x3.10), either of which can be used for the recorder output. A source output channel (1-8) can be selected for use here and the other source output channel (per card) can be used for the strip chart recorder (defined by an SS MAPS parameter: *source output chnl*). If the source output channel parameter and the recorder output channel are set to the same channel, the source output channel will be used and the recorder function will be lost. If this situation should occur, a reboot will be necessary to reassign the recorder output.

Recorder Output Channel

Parameter **CLOCK TIME**
Real Time HH:MM Range is 00:00 - 23:59
Units Hours:Minutes
Parameter **CLOCK DATE**
Real Time Data MMDDYY Range is 010100 to 123199
Units Month Day Year

Setting The Clock

These 2 parameters program the clock of the STC-2002. These are used in the process accounting mode. The format for the time is 24 hour time. One o'clock in the afternoon is 13:00. The date is programmed in month-day-year format without any separators. You need to enter any zeros in the day (March 5th is 05, not just 5) and year fields. The range of dates is from 01/01/1989 through 12/31/2088. That is to say, 89..99 years are interpreted as 1989..1999. 00 through 88 are interpreted as 2000..2088. This date is year 2000 compliant, as far as the STC-2002 is concerned. Use of the two digit year numbers outside of the STC-2002 require proper recognition of the century digits (19 or 20) which are implied but not included in the exported (via RS232) information.

SECTION 3.16 Communications Configuration Related Parameters

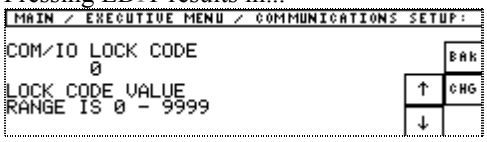
Communications setup

The Communications setup menu can be located by pressing the fixed MENU key while on the Run Time screen. Press the EXECUTIVE MENU key on the MAIN menu. Finally, press the COMM. SETUP key on the EXECUTIVE MENU (the fixed STATUS key returns the Runtime screen).

The following screens illustrate the communications setup programming from general list to specific list item change. Its programming steps are like those of other programmed elements previously described. Cursor to the list item using the arrow keys, press the EDT (edit) key, press the CHG (change) key, press numeric or numeric representation of needed value, and press ENT (enter). Scrolling can take place when individual elements are displayed or when the list is displayed. The BAK (back) key returns to the previous menu keys. The BYE key leaves the Communications setup. The STATUS key returns the Runtime screen.

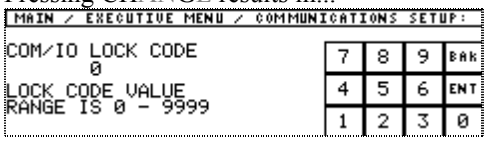
The Communications setup menu. The asterisk represents the arrow key controlled cursor.

Pressing EDIT results in...



The edit menu screen presents the current value and the permitted value range.

Pressing CHANGE results in...



The edit/change menu provides the new entry capability. BACK allows return to the previous screen without change.

Detailed Communications Configuration Related Parameters

Parameter **COM/IO LOCK CODE**
Lock Code Value Range is 0 - 9999
Units None

Setting The I/O Lock Code

COM/IO LOCK CODE

This allows changes of STC-2002 program parameters to be restricted to only those people knowing this 4 digit password code. A non-zero number in the range of 1-9999 enables this feature and becomes the lock code. If the lock code is programmed with a non-zero value, whenever you access an I/O Program menu that can change a parameter or try to change a Communications Configuration parameter, the STC-2002 will ask you for this lock code.


Caution

CAUTION If this lock code is entered inadvertently or forgotten it can be removed by purging the unit of all its stored parameters. When this is done all program parameters including I/O programming, System Configuration, Process Lists and Film Parameters **will be lost** and require reprogramming. This could be several hundred items of data. All this data should be recorded prior to purging the memory of the STC-2002. Recording methods include downloading to a PC from the HOST port, information written down by making a paper copy of the various parameter tables and circling the selected element (see end of manual), downloading to the memory module. To purge ALL stored data from the STC-2002, press the fixed MENU key when on the Run Time screen then select the **Service** key on the MAIN menu. Press the **Purge** (All Stored Data) key and the confirming **ACCEPT** key. After doing this the STC-2002 will contain no user programmed information and will have to be completely reprogrammed. Default values will be in effect elsewhere.

If lock code is forgotten and programming has not been saved in some other media, call factory to eliminate passwords without purging memory.

Parameter **KEYBOARD BEEP**
OFF / ON
Units None

KEYBOARD BEEP

KEYBOARD BEEP

This parameter tells the STC-2002 whether touch screen activity or fixed front panel key activity will result in an audible sound upon key press. Key release is never annunciated. Various frequencies are employed to convey different meanings. For example, a low frequency beep indicates an incorrect entry or a non-existent key area. The STC-2002 audio system has a frequency range of approximately 330 Hz to 10 KHz.

Parameter	**RS 232 BAUD RATE**
	RS 232 BAUD Values: 300, 1200, 2400, 9600
Units	BAUD

RS 232 BAUD RATE

RS 232 BAUD RATE

This parameter sets the host port communications baud rate. The higher the baud rate, the more data bit transfer is increased which, generally speaking, results in faster communications. In an electrically noisy environment, lower baud rates can be tried if communications fail at higher baud rates. In an electrically noisy environment, the communications may not appear any faster using the higher baud rates due to the increased number of message retries (corrupted messages are requested by the receiver to be re-sent). Noise has a greater effect at higher baud rates because the duration of a noise pulse occupies a higher ratio of time when compared with the duration of a signal pulse. Please ensure proper system grounding is maintained as well as proper cable grounds and shields.

Parameter	**RS 232 PROTOCOL**
	Protocol types: Sycon, ASCII
Units	None

RS 232 PROTOCOL TYPE

RS 232 PROTOCOL

This parameter sets the host port communications protocol type. The Sycon protocol has a higher degree of integrity but is a proprietary protocol and will work with Sycon software only. The ASCII protocol has lower integrity but is universally accepted. There is included with the STC-2002 a CD that contains various software programs using both protocols.

SECTION 3.17 STC-2002 Crystal Failure Processing

The STC-2002 instrument gives the user many options in the event of a crystal or sensor failure. This failure may be a hard sensor failure or caused by tripping over the crystal **stability(S)** or the control loop **quality(Q)** thresholds. Improper setting of the **S & Q film parameters** may trigger an apparent early sensor failure. It is possible to switch to other sensors and/or continue operation in a time power fashion, or abort the process. These options are available on a per film basis and are programmable in each film parameter list. The REVIEW SS MAP menu parameters specify starting crystal[s], backup crystal[s], active crystal[s], channel [1-8] start mode, channel [1-8] fail action and channel [1-8] backup list. The specific ss map that defines these parameters is called out by a Film parameter, thus providing the linkage between the film and its associated ss map. In addition to being physically installed, the utilized source sensor cards must be enabled on the **SYSTEM CONFIGURATION** menu (set to ON) before its sensors can be used as an option in a film program. This is a global system enable and indicates that proper hardware is installed on the system.

Measurement Fail Parameter

Time Power Mode

The SS Map parameter, **Channel [1-8] Fail Action**, can provide *no action* or *abort film*. The Film parameter, **Film Fail Mode**, determines what the instrument will do when all crystal processing options have been exhausted and there is still no valid sensor data available for processing. The options are **1**: to abort the run or **2**: to complete the run in a Time Power Mode. If option 1 is selected, the unit will stop with the last valid thickness showing on the display and the control power will be set to zero. If option 2 is selected, the unit will continue to run using the average deposition power for the 5 second period previous to the sensor failure, and will *simulate* the continued accumulation of material on the sensor using the present rate setpoint value. **Simulated** accumulation will continue until the final thickness setpoint is reached. The unit will then do the post deposition sequence as programmed and indicate to the user that a time power completion was achieved.

Using Crystal Switching

If a crystal sensor has been provided with a backup capability by menu programming with the Film and Map parameters, a sensor failure on the primary sensor will cause a switch to a backup sensor. Each crystal in succession that fails can have a backup or follow processing as programmed otherwise.

Crystal Switching Function Description

The crystal switching function within the STC-2002 allows for either manual or automatic switching from one sensor crystal to an alternate sensor crystal. This switch over is done without introducing rate control transients into the system and also will maintain all valid thickness information accumulated. The availability of this function can provide an extra measure of safety in insuring proper deposition completion if the primary sensing crystal should fail or become erratic for some reason.

Crystal Stability Terms

Crystal **failures** can be of **three** types. During a hard failure the crystal just stops oscillating. The other modes of failure are types of erratic operation. When sensor crystals begin to approach the end of their useful life, they begin to exhibit small positive frequency jumps. These positive jumps can cause large instantaneous rate error signals to be seen by the control loop. The loop tries to correct for these false signals and significant short-term rate control errors may occur. These positive frequency jumps also cause an apparent loss of accumulated thickness on the sensor. Therefore, the final thickness setpoint may be reached with more material deposited on the substrates than desired. By internally monitoring these frequency jumps along with the control loop deviation from the desired control value, an automatic switch over to a new or fresh sensor crystal can be made to occur. This is done by placing setpoint limits on sustained control deviation error and the number and magnitude of positive frequency jumps allowed.

Forcing A Crystal Switch

Manual Crystal Switching can be accomplished from the **front panel** while in the **RunTime** display by pressing in the fixed front panel STATUS key twice. This will display the 2nd STATUS screen. On the 2nd STATUS screen, is the FORCE FAIL key. Crystal channel switching is accomplished by manually failing the primary active channel and allowing its designated backup to automatically take control. Pressing the FORCE FAIL key will change the key legend of the key to the far right to Fail Channel 1. Subsequent presses will step through all of the installed and enabled channels ending with the FAIL ALL selection. When the channel that needs to be failed appears, press the key on the far right to accept. (See section x.x) The FORCE FAIL key is the selector and the key to the far right accepts the selection. After FAIL ALL, the selection returns to RE-VERIFY.
After the **FAIL CH *X*** is selected, the crystal designated as its backup is now displayed as the active crystal number with its life values indicated on the appropriate channel line. Press MORE to view channels 5 through 8. Switching can also be done through the remote hardware inputs or computer interfaces. To move back to the crystal sensor that was failed, use FORCE FAIL to select RE-VERIFY and press to accept. If the crystal still has acceptable life, etc. it will be reinstated as active and the other sensor channel will return to standby. The crystal sensor channel designated as backup must be set to standby with the SS MAP parameter, CH*x* START MODE, as well as the crystal sensor channel designated as primary being set to active with the SS MAP parameter, CH*x* START MODE. There can be as many backups as there are installed and enabled supporting sensor cards (up to 7).

Once configured for serial multi sensor operation (one active at a time), **Automatic crystal switching** for hard failures is enabled in the same way as it was for manual switching: by setting the primary channel parameter CH x BACKUP LIST = [select desired 1-8 backup channel], the secondary (backup) channel parameters to CH *x* START MODE = standby and CH x FAIL ACTION = none in the individual ss map programs. A hard crystal failure of any kind will now automatically switch to the backup sensor[s]. Imminent failures predicted by the CRYSTAL STABILITY and CONTROL QUALITY algorithms will also cause switching to the backup sensor. Setting a setpoint value other than zero for each type enables the S&Q. Smaller numeric settings cause smaller errors to be tolerated and will typically cause crystals to be switched sooner than large numbers. Initially these parameters should be set to a high value or disabled (set to 0). For initial process evaluation a value of 6 is good for both parameters. These parameters can be tightened as process history is obtained.

The **CRYSTAL STABILITY** parameter sets a limit on the amount and magnitude of positive frequency jumps allowed during a deposition control phase. The smaller the setpoint number the fewer jumps allowed. Due to differing stress values exhibited by different film materials optimum settings are material dependent and may require experimental derivation. A good starting point for most applications is a value of 6.

Hardware Requirements

To utilize the Crystal Switch function, one of the following is required: either a dual sensor head with shutter or two single sensor heads with shutters. Both primary and backup sensors are operational at all times and are connected to the appropriate STC-2002 Sensor *x* BNC connectors through their respective oscillator units. When a switch over is desired, one of the I/O relays provided within the STC-2002 can be programmed to activate. These contacts should be utilized to operate an air type solenoid valve that in turn activates the air operated shutter mechanism on the sensor heads. The primary crystal then becomes shielded and the backup crystal is exposed to the deposition stream.

It should be noted that there are **separate TOOLING FACTOR** parameters for each sensor. This parameter is designed for geometric position correction within the vacuum vessel and is set in the individual film programs.

Crystal Stability

The STC-2002 will display the crystal stability value detected during the deposition run on the 2nd STATUS screen (from the RunTime screen press the STATUS key twice). The data will appear below the **S** (stability) header between the thickness column and the Life column. The display may read as follows:

Stability	indicates crystal stability
3	indicates that the 3 threshold setting was exceeded
9	indicates that the system was within 90% of exceeding the 4 Threshold

If these are typical run values, a setpoint value of 5 is a reasonable setting. If the readings are much higher or lower, the setpoint should be scaled accordingly.

Control Quality

The control quality parameter sets a limit on the amount of sustained control loop deviation error. Due to differing source and material characteristics optimum settings may need to be arrived at experimentally. Control loop quality can be effected by EB gun or sputtering target arcs as well the PID control loop parameters. These areas should be made to operate properly before attempting to set tight switching threshold on control quality (press **L/Q** key area twice on RunTime screen).

The parameter values correspond to an allowable sustained deviation in the following manner.

Setpoint	*% Deviation*	*Setpoint*	*% Deviation*
1	5	6	20
2	7.5	7	25
3	10	8	30
4	12.5	9	40
5	15	0	Off

The setpoint values detected and accumulated by these algorithms may be observed on the RunTime display by pressing the **L/Q** key. The data will appear below the text label "loop" in the key graphics area. After several deposition runs the typical values found here may be used for determining the proper setpoint values. The display may read as follows:

Loop	indicates control loop quality
2	indicates that the 2 threshold setting was exceeded
7	indicates that the system was within 70% of exceeding the 3 threshold

If these are typical run values a setpoint value of 4 is a reasonable setting. If the readings are much higher or lower, the setpoint should be scaled accordingly.

Use for Multi Layer Depositions

Using Separate Crystals For Multi Layer Depositions

Where the ultimate in accuracy is required in a two material deposition, it is desirable to use separate crystal sensors for each material. This would prevent any errors in Z-Factor correction due to the layering of different materials to be reduced to the minimum. This mode of operation can be accomplished, as described above, by programming the starting sensor parameters in the first film/map combination to sensor 1, for example, and set the second film/map combination to start on sensor 2, for example. The CH x backup parameter should be set to off in each layer or to a crystal channel other than 1 or 2 as in this example. However, it may be set to ON even when using only 2 crystal channel sensors to allow for a possible crystal failure recovery using the alternate crystal sensor. A recovery could possibly give a small thickness error due to the mixing of materials but may be preferred over an aborted or time power completed run. The tooling factors may also be optimized for differing source geometry's as each sensor has its own tooling factor value in each map parameter program.

Averaging with Multiple Active Crystal Sensors and Averaging For Multi Layer Depositions

This adds another level of complexity to the serial multi sensor description above. Instead of a single sensor being active, the map parameter CH x START MODE defines 2 or more channels as active, the MIN START XTALS parameter reflects this same number or less but at least 2, the MIN ACTIVE XTALS =< MIN START XTALS (BACKUP channels are optional). By selecting more than 1 active sensor channel, averaging is automatically assumed. Multi layer would use, as previously described, separate film/map combinations for each layer except in this case, more than 1 channel is active for each of the multiple layers. The intent here is toward increased accuracy in a multiple layer material deposition.

The following parameters are described in greater detail in sections 3.5 and 3.15.

Related Conf. Parameters:	Need Source/Sensor Card 1	OFF/ON
	Need Source/Sensor Card 2	OFF/ON
	Need Source/Sensor Card 3	OFF/ON
	Need Source/Sensor Card 4	OFF/ON
Related Film Parameters:	FILM Fail Mode	TIME POWER, ABORT IF FAIL
	Control Loop Qual Limits	0 to 9
	XTAL Stability S (Limits)	0 to 9
	XTAL Life Bounds	0.0-100.0%
	Source Sensor MAP SELECT	1 - 30
Related Map Parameters:	Master Tooling Value	10.0% - 400.0%
	Minimum Start Xtal Channels	1 – 8 minimum channels
	Minimum Backup Xtal Channels	0 – 7 minimum channels
	Minumum Active Xtal Channels	1 – 8 minimum channels
	Xtal Channel Drop Filter*	NONE, BALANCE [dropped Xtal ch Failure]
	Channel *x* Start Mode	OFF, ACTIVE, STANDBY
	Channel *x* Fail Action Mode	NONE, ABORT FILM
	Channel *x* Backup List	X – XXXXXXXX (1 item list to 8 item list), [where X = 1 to 8 (in each position w/o redundancies, list extends to 0-8 for a 1 item list)]
	Channel *x* Tooling Value	10.0% - 400.0%
	Channel *x* Weight	10.0% - 400.0%

*averaging only

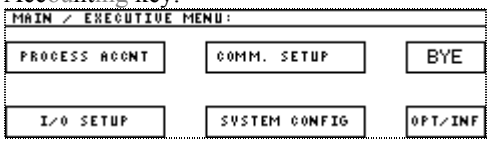
SECTION 3.18 Process Accounting

The process accounting screen displays a summary of the vital parameters of the last four previous deposition films. It is useful to review this screen at the completion of a deposition run and compare the results to the previous similar runs. Trends which show changes in source conditions, deposition material supply or pending crystal failure can sometimes be determined by the comparison of the vital parameters shown on the process accounting screen.

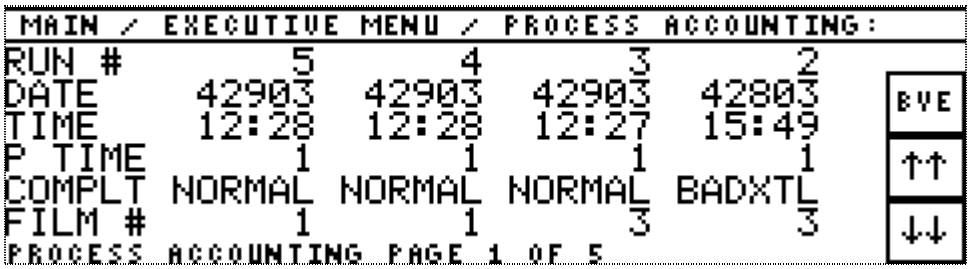
All the data displayed on this screen can also be 'read' through the computer interface for longer-term storage (more than four runs) or hard copy data logging. Starting at the Runtime screen...

Press the fixed front panel Menu key to invoke the main menu.

On the Executive menu, press the Process Accounting key.

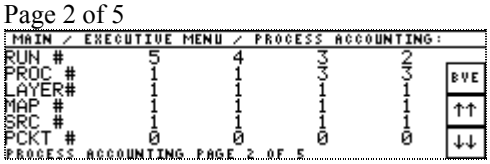


The following is the initial screen when process accounting is selected (page 1 of 5). The first line of the list is RUN# and it remains stationary as the list is scrolled in order to maintain a fixed frame of reference. The double arrow down moves the list a section at a time so that the list is displayed in 5 line sections in 5 pages (a 5 line window moving down the list). The double up arrow moves the viewed section of the list in the same way but the direction is up the list. The scrolling function will wrap. After the 5th page, the view will revert to the 1st page when the double down arrow key is pressed. After the 1st page, the view will revert to the 5th page when the double up arrow key is pressed.

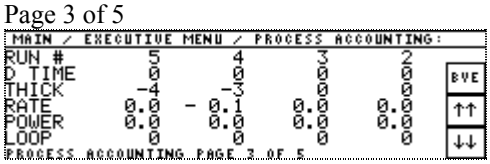


The following screens show the progression through the list using the double down arrows.

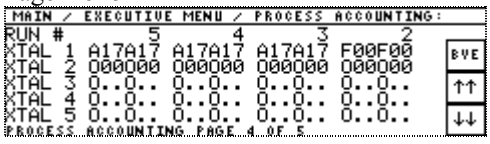
Page 2 of 5



Page 3 of 5



Page 4 of 5



Page 5 of 5

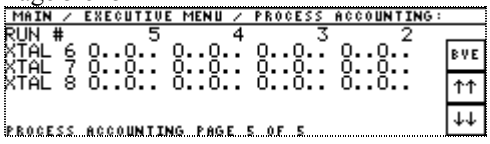


Figure- 3.16: Process Accounting Screens

Please note screens *4 of 5* and *5 of 5*. The XTAL % life is reported for the start condition in the first 3 characters (e.g. A17, F00, O00, O..) and for the ending condition in the next 3 characters (e.g. A17, F00, O00, O..). The first of the 3 characters is a letter code that is explained in the table below and the next 2 characters are a numeric value, which is the XTAL % life. The O letter code has an additional

differentiation in that if it is followed by two periods, this means that there is no sensor card installed for this crystal channel, otherwise the presence of 2 zeroes indicates that the sensor card is installed and enabled (by menu parameter) and in an OFF condition.

general form: **XYYXZZ** **where X=Letter Code, YY= starting XTAL%, ZZ= ending XTAL%**

starting group ending group

XTAL 1 A91A89	**= Crystal 1 started a process as active at 91% life and ended a process as active at 89% life.**
XTAL 3 A97F71	**= Crystal 3 started a process as active at 97% life and ended a process as failed at 71% life.**
XTAL 5 O00O00	**= Crystal 5 started a process as OFF at zero% life and ended a process as OFF at zero% life (00 usually indicates that no crystal is connected).**
XTAL 7 O21O021	**= Crystal 7 started a process as OFF at 21% life and ended a process as OFF at 21% life.**
XTAL 8 O..O..	**= Crystal 8 is OFF and has no supporting sensor card installed.**

The vital parameters stored and displayed are:

RUN: Run number - increments at the start of each process cycle (beginning at layer #1).**

DATE: MMDDYY representation of date the film was started.

TIME: The time of the start of the run (from the 24 hour clock of the STC-2002).

P TIME: Process time - the time from a Start initiation to end of the Film Process.

COMPLT: Mode of completion of the deposition.

- **NORMAL-** Normal completion of run
- **TMPWR-** Xtal failure occurred, run completed on time-power *
- **BADXTL-** Bad Xtal terminated run
- **REMOTE-** External input terminated run
- **KEYBRD-** Front keypad STOP BUTTON terminated run
- **MAXPWR-** MAX POWER limit exceeded, run terminated *
- **PENDNT-** STOP button on Hand Controller terminated run

FILM# Film # used

PROC# Process# used

LAYER# Layer # used

MAP# Map# used

SRC# Source channel # used

POCKET# Pocket # (of indexer) used

D TIME: Deposition time - the time the source shutter is open in Minutes:Seconds format.

THICK: Thickness at end of deposition in Angstroms.

RATE: Deposition rate at end of deposition in Å/Sec.

POWER: Deposition power for last three seconds of deposition in %.

LOOP: Accumulated counts in the control quality accumulator. See Section x2.17 for a description of this value.

XTAL 1: The start and ending crystal percent life is shown. See letter code table below.

XTAL 2: Same as above.

XTAL 3: Same as above.

XTAL 4: Same as above.

XTAL 5: Same as above.

XTAL 6: Same as above.

XTAL 7: Same as above.

XTAL 8: Same as above.

Crystal % Life Letter Code Table

O = Off	**M** = Missing
A = Active	**B** = Standby
D = Dropped	**S** = Switched
F = Failed	

* programmable feature ** The letter **T** appears after the run# when the **TEST mode** was used.

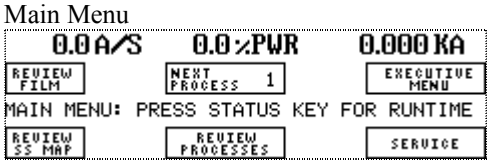
Note: [STAB: Accumulated counts in the crystal stability accumulator not reported here. See 2nd STATUS screen.**]**

Purge will clear Process Accounting contents (see section x2.6x, *Factory Settings vs...* and section x2.21, *Check Sum Validation*).

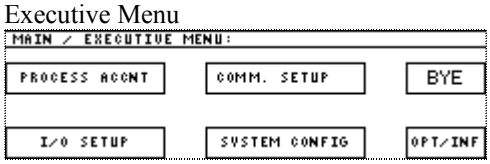
SECTION 3.19
OPTions/INFo: product identification, diagnostics, etc.

OPTIONS/INFO: From the Run Time screen, press the fixed MENU key. Press the EXECUTIVE MENU key on the MAIN menu. (Press the BYE key to return to the MAIN menu or press the fixed STATUS key to return to the Run Time screen.) **OPT/INF** is a selection on the EXECUTIVE menu. The information is intended to be relayed to the factory for the purpose of identification and diagnostics. The information strings contain: software Version #s, checksums, serial#s, build codes, installed option cards, option codes, error codes, PCB he**x** code identifiers, frequency. There can be up to six lines of info per page, **MOR**E shows next page.

Main Menu

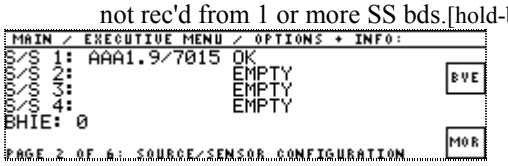


Executive Menu

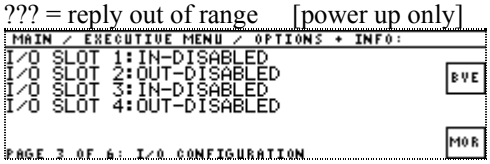


Options/Info, page 1 of 6 (user interface bd.)
S/W Version, Build/CRC, SCUP COV
Serial **n**umber / **B**uild **t**ype
Bootloader Build: CRC of BTLR code
UBAS min. ver of UIFC/SBAS min. ver of SCUP intercommunications
Error Code (Sys Trap)
[power up only]

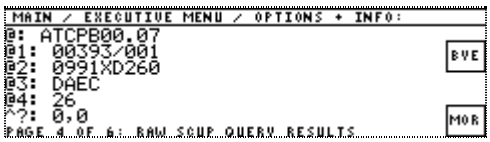
Options/Info, page 2 of 6 (source sensor bd.)
S/W code version / CRC each bd.
OK = present, enabled, working. OK-Unused = not enabled
MIA! = enabled but not physically present
Incompatible! = beyond s/w family compatibility
Failed = source sensor board has failed
BHIE: if not zero, cycle power off/on, (interrupt not rec'd from 1 or more SS bds.[hold-bus])



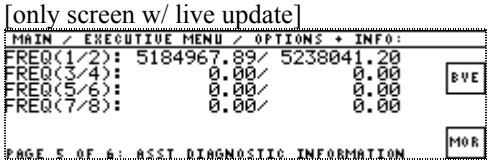
Options/Info, page 3 of 6 (input/output bds.)
Empty = no module detected, config'd empty
In-Disabled = disabled input card in this slot
Out-Disabled = disabled output card in this slot
Input = input card detected in this slot
Output = output card detected in this slot
In-Mia = missing card, enabled as if input present
Conflict-I = have output card where input bd called
Out-Mia = missing card, enabled as if output present
Conflict-O = have input card where output bd called
??? = reply out of range [power up only]



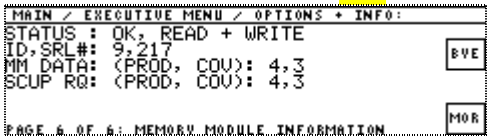
Options/Info, page 4 of 6
SN / Build type
S/W version
Configuration X CRC
Bootloader CRC
Covenant
Error Code (Sys Trap)
[power up only]



Options/Info, page 5 of 6
Displays live frequency measurements from the installed/enabled source sensor cards.
If no crystal/oscillator w/installed/enabled, freq. = zero
[only screen w/ live update]



Options/Info, page 6 of 6
Displays Memory Module information if the optional memory module interface bd. and the memory module are installed and the memory module is enabled. See section 3.20 for details.



This information can be useful to the factory if there is a problem. Information also appears after product power-on during initialization. The initialization process (for diagnostic purposes) is as follows (with typical LCD screen information):

1. LED displays: non-illuminated.
   LCD display: screen: clear
   backlight: on
2. LCD display:

```
APP LOADER V01.02(BUILD 5C24)
---------------------------------------------
>APP FOUND:SECTOR E BUILD 3754
>VERIFY APP IN PROGRESS
.............................................
>APP OK
>LAUNCHING APPLICATION...
```

3. LCD display: screen clear
   LED displays: all segments on (test)
   Beeper: 2 Lo/Hi beeps
4. LCD display:

```
UIFC: VERSION AUIFA01.01
SYNCING WITH SCUP...60
```

5. LCD display: typical Run Time Screen
   LED displays: typical information

check sum validation
Check sums are used to validate the integrity of the user programmable functions for the STC-2002. Of the programs that use check sums, there are three categorical types: one for the film parameters (Main Menu: Review Film key), another for the process steps (Main Menu: Review Processes key), and finally one for

the I/O rungs (Main Menu: Executive Menu: I/O Setup). See sections x2.5, x2.7, x5.10 and x5.13 for related details. See the end of section x2.6, *Processes: Factory settings vs. purged settings*.
Each of the three program types have check sums that can be used to check the integrity of a program which is a part of a system that has a problem or check the integrity of a program that may have been inadvertently changed or verify a program that is reentered in its entirety. A group of check sums from the different programs can be used to uniquely identify an entire deposition process. The programs along with their check sums should be stored both electronically and on paper. Different processes can be identified by a text description coupled with constituent programs and their check sums. When a program is known to be correct, write the check sum number down in a journal of software entries/programs, having method or recipe attributes being integral to objectives.
Please note that as changes, additions or deletions are edited, the commensurate check sum change will not become apparent until the modification is accepted (saved) into the program from the temporary workspace.

The check sum is a five digit hexadecimal number (e.g. 4A6F6, 5204D). The number is prefixed by the label "ID=" (except for the film parameters check sum, which is prefixed by an "X"). In addition, the I/O program has, following the "ID=", a letter designator indicating the memory sector in which the program resides (either an A or B). Using the SWP (swap) key accessed through the MEM key reverses this.

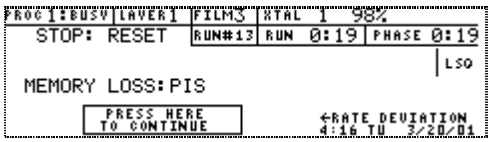
Check sums and paramters after a PURGE or a FACTORY RESTORE are as follows:

	After PURGE	**After FACTORY RESTORE**
Review films 1-9:	X17523	X61037
Review Process 1:	ID=00000	ID=55274
Review Process 2:	ID=00000	ID=12121
Review Process 3:	ID=00000	ID=30944
Review Process 4:	ID=00000	ID=24150
Review Process 5:	ID=00000	ID=02503
Review Process 6:	ID=00000	ID=61768
Review Process 7:	ID=00000	ID=09958
Review Process 8:	ID=00000	ID=48200
Review Process 9:	ID=00000	ID=60411
I/O Program A:	ID=A24490	ID=A24490
I/O Program B:	ID=B24490	ID=B24490
Run Time Mode:	Sequencing	not changed (remains SEQ or NON-SEQ)
Film parameter:		
MAX POWER LIMIT	0%	50%
System configuration:		
RECORDER FUNCTN:	RATE	POWER
CLOCK TIME:	not changed	not changed
CLOCK DATE:	not changed	not changed
I/O Programs:	cleared	not changed
PROCESS ACCT'ING:	cleared	cleared

See **section 2.2**, ***Initial Programming Setups (Menu Parameters)***, for complete listings of parameter states after factory default memory configuration and purged memory configuration. See next section for optional external memory save / restore functions.

<update screens>

The following screens are examples of what may appear after a PURGE/REBOOT sequence:



The letter designators are:

P	Film Parameters
I	I/O Programs
A	Process Accounting
S	Process Sequences

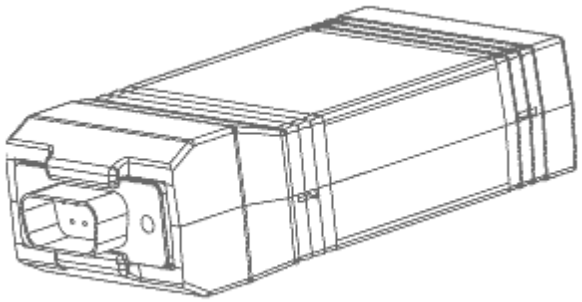
Press the area indicated to acknowledge memory loss in the memory sectors represented by the designators. The memory loss message is meant to alert the user that a change in memory contents has occurred in the areas represented by the letter designators and that parameter/program dependent processes need to be evaluated and the unit reprogrammed accordingly.

SECTION 3.20 Memory Module Programming & Usage

The Memory Module (or Memory Card) option allows saving or restoring all parameters, configurations, films, processes, and I/O programs in both memory locations A and B to the memory card. The real time and date informations are the exceptions. The memory card function needs a memory interface board installed in the unit. If there is a high density 15 pin D-sub on the back panel (labeled MEM), the memory interface board is installed. The memory card has a write protect switch (green indicates memory card is ready to accept new data as well as be read, red indicates that the write protect is on and that no new data can be written to the memory card but it can be read).

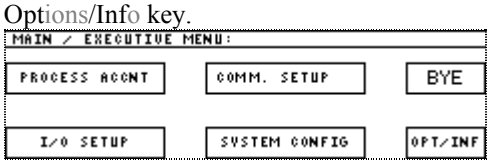
In the menu path *main / executive menu / options + info*, page 6 of 6 will indicate whether the memory module has been recognized. The memory module can be plugged into a powered STC-2002. The *options/info* screen interrogation is not dynamic (a snapshot of how things are when the snapshot is taken) and the 6th screen must be displayed afresh to capture the new status of the memory module.

The memory module has 1 programmable parameter associated with its usage and that is the *Memory Module IFC* parameter on the System Configuration menu. This must be set to ON. Please note that save/restore functions to and from the memory module necessitate a unit reboot, which will be initiated automatically when directed to save or restore on the service menu. This reboot save/restore process takes about a minute to complete. If there is a problem, from whatever cause, an error message will be displayed indicating that the save or restore had failed. This message can be cleared using the fixed front panel MANUAL key.

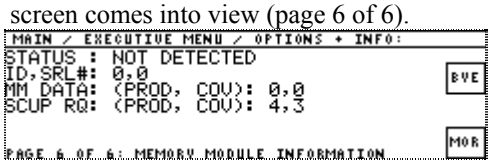


Memory Module

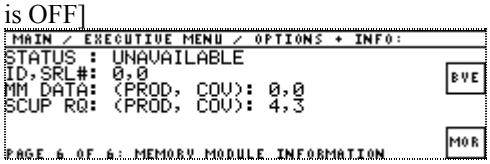
On the Executive menu press the Options/Info key.



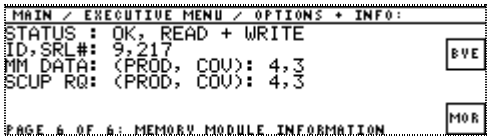
Press the More key until the Memory Module info screen comes into view (page 6 of 6).



STATUS: *Unavailable* [when the System Configuration parameter *Memory Module IFC* is OFF]



Note serial number 217



Here are typical Options/Info screen messages [note STATUS line]:

Not detected means that the STC-2002 could not communicate with the memory module. This could indicate a failure with the memory device within the memory module or a failure along the communications path to the module. As previously stated, the memory module needs the optional memory module interface board installed. This board contains isolation circuitry to protect the STC-2002 from external electrical damage both on power lines and communication lines. The LED on the memory module should be illuminated green with the write protect off and red with the write protect on. If the LED is not illuminated in either switch position, there is a power problem.

OK, Read + Write indicates that the memory module has been properly accessed and is capable of being read from and written to by the STC-2002 (the Write Protect switch should be in the WP-OFF position).

OK, Write protected indicates that the memory module has been properly accessed and is capable of being read from by the STC-2002 (the Write Protect switch should be in the WP-ON position).

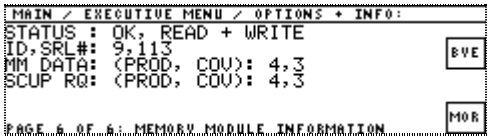
Unformatted indicates that the memory module has been properly accessed but has not yet been used. The first write process automatically formats the memory module (the Write Protect switch must be in the WP-OFF to format/write and this message indicates that it is in the OFF position).

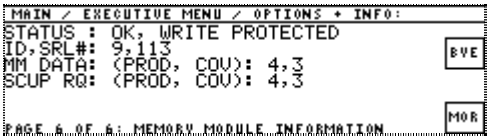
Unformatted, Write Protected indicates that the memory module has been properly accessed but has not yet been used. The first write process automatically formats the memory module (the Write Protect switch must be in the WP-OFF position to format/write but this message indicates that the WP switch is in the ON position).

Unavailable indicates that the memory module function has not been properly enabled through the *Memory Module IFC* parameter on the System Configuration menu. This must be set to ON to recognize the memory module. The act of changing this parameter is not recognized for this function (memory module) unless the STC-2002 is reboot or power cycled (it checks this parameter only at initialization.

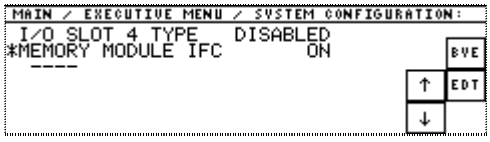
The STATUS line will change as the WP switch is changed but in order for the info screen to be updated, it must be refreshed by scrolling off and then back on it by using the MORE key. In other words, the info screen contents are not dynamically displayed. The act of calling forth the info screen causes the STC-2002 to recheck the data upon which the information is based.

Note serial number 113.

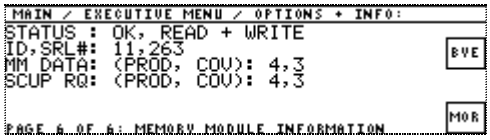




Returning to the Executive menu, press the System Config key. Using the arrow key[s], scroll to the Memory Module IFC parameter. Press EDIT to bring forth the Edit/Change menu and press Change to bring forth a numeric entry screen. Pressing the digit 2 will change the value to ON.

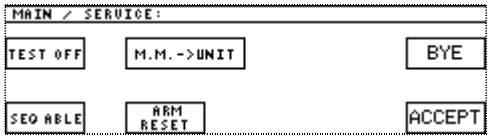


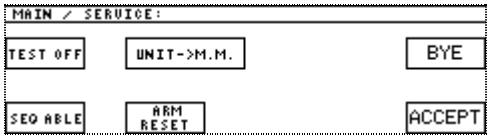
Has ID type 11 indicating 96kbyte module.



DATA TRANSFER

From the main menu, press the service key to bring forth the service menu. On the service menu, press the key labeled AS IS. This will eventually, with the 3rd and 4th presses, reveal the memory module transaction related keys. M.M.→ UNIT takes what is stored in the memory module and transfers it to the STC-2002, which is overwritten. UNIT → M.M. takes what is in the STC-2002 and stores it into the memory module. Please note that in both cases, the recipient of the data is overwritten. Pressing the Accept key finalizes the data transfer directive. Pressing the BYE key leaves the service screen without any effect. If other keys are pressed on the service screen, whatever is indicated on the key legends will become implemented along with the memory module data transfer.





Other lines from the memory module Options Info screen

ID,SRL#: The ID identifies the amount of memory in the module.

9 = 32 kbytes
10 = 64 kbytes
11 = 96 kbytes

The STC-2002 memory usage, at this time, will not exceed 32 kbytes.

The SRL# is a randomly generated serial number when formatted in the field (between 1 and 1000). It is generated and assigned by the STC-2002 to the memory module when it is formatted. The numbers 217 and 113 can be found as serial numbers among the above screen depictions. Factory formatted modules are assigned numbers to match a bar-coded label placed on the exterior of the module.

MM DATA: This is a number code that identifies the product with which this memory module has been used, if formatted. The code "4,3" identifies the STC-2002 deposition controller.

SCUP RQ: This is the number code that the STC-2002 will write to a memory module when formatted. [The intent is to first identify the memory module in terms of its former usage, if any, and to check whether it was a deposition controller type (the MM DATA is compared with SCUP RQ). A memory module used with another type of product will be reformatted as it is used with an STC-2002. These 2 number codes are merely an identification aid for the user.]

PROBLEM INDICATIONS

If the memory module LED is not illuminated in either or both of the WP switch positions or if the LED is amber in either or both WP switch positions, the memory module is not connected properly, or the memory module itself (500-210) is malfunctioning or the memory module interface PCB (500-212) is malfunctioning. In any of these cases, neither the memory integrity of the module nor the integrity of data transactions with the module should be considered valid.

MEMORY MODULE PLACEMENT

The picture below shows the Memory Module plugged into the STC-2002 back panel. If this placement is inconvenient, a standard VGA/SVGA monitor extension cable can be used to bring the Memory Module to a more accessible location.

BELKIN model F2N025-06-E is an example of this type of cable. It has the following characteristics: high density 15 pin D-sub female at one end, high density 15 pin D-sub male at the other end, 6 ft. shielded cable w/ 28 AWG stranded wires, pin for pin connections (pin 1 to pin1, pin 2 to pin 2, etc. except for pin 9 which is a no connect)

SECTION 3.21 Programming Example

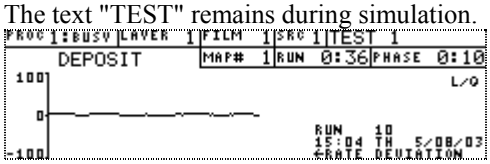
Perhaps the best way to become familiar with the STC-2002 operation and programming is to program a simple 6 layer process of two alternating materials and then exercise the process using the test mode of the STC-2002. The Test Mode simulates sensor input information (actually rate info is simulated for the film) to the unit and allows the STC-2002 to "run" a process. The source control output voltage is, however, still fully functional. If the evaporant generating power supply is not needed for the "test"/simulation, disconnect it. With the power supply connected, there could be some dangerous conditions.

Entering the Test Mode

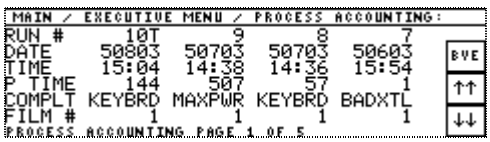
To activate the **Test Mode**: from the Run Time screen, press the fixed MENU key then press the key area labeled **SERVICE** when the MAIN MENU is displayed. This brings up the **SERVICE MENU** which provides selection of : SQ vs. non-SQ product function, return to factory settings, purge ALL stored data, memory module functions and the test mode entry. A key labeled either "**TEST OFF**" or **"TEST ON**" is for entry into the test mode. When in the test mode, you will notice in the crystal status area on the upper right corner of the RunTime screen that the text, **XTAL**, has been replaced with the text, **TEST**. The word, **TEST**, also appears on the 2nd STATUS screen in the LIFE column when a reporting sensor channel is without a crystal/oscillator. This 'test' mode remains in effect until the unit is turned off and back on normally. On the Service Menu, the TEST mode key has a toggle function (ON/OFF) and the key label alternates between **TEST ON** and **TEST OFF**. To initiate any of the Service MENU personalities, any or all three of the key choices are toggled/selected as needed *and* the **Accept/Restart Product** key is pressed. The product will restart with the selected personalities in effect. Only the user selected *SQ/non-SQ* personality will remain in effect upon subsequent product power cycles. To enter the TEST mode, press the TEST OFF key so that it reads TEST ON and then press the ACCEPT key. The other keys are not used.

TEST mode: "TEST" replaces "XTAL".

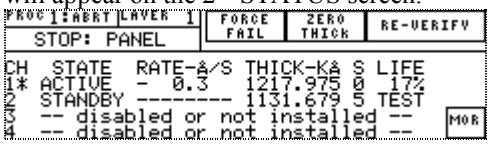
The text "TEST" remains during simulation.



After a simulation, *process accounting* will show the results and add the letter "T" to overwritten
indicate that this run# was in TEST mode.

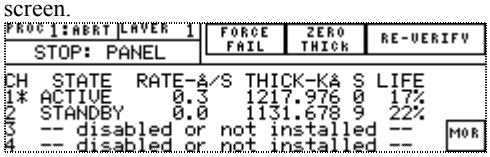


If no crystal/oscillator is connected, the text "TEST" will appear on the 2nd STATUS screen.



If a crystal sensor/oscillator is connected while in the test mode, the text "TEST" will be

with life info. "TEST" will remain on the runtime screen.



Programming Process 1 - (Example)

Process Programming Example

If the STC-2002 is already interfaced to a system (hardware configured and I/O programmed) the following example covers the majority of what a user needs to know to program a multilayered process.

Defining the Process

For the example, we would like Process 1 to be 6 layers of two alternating materials (Films 1 & 3). To show the use of independent end thicknesses we will specify the first film to be 200Å thick, with each succeeding layer being 50Å thicker then the previous layer. Three entities have to be programmed to implement this process, Film 1, Film 3 and Process 1. Maps invoked by the films must also be defined. The order of programming is not important. For this example we will start by programming Process 1.

With the RunTime screen displayed, pushing the fixed MENU key brings up the MAIN MENU. Press the REVIEW PROCESSES key to bring forth the process view/edit menus. Press the GO2 PROCESS key, press the 1 digit and accept the entry by pressing the ENTER key. This activity will place the focus of the review/edit on process 1. The first line of a process layer list, for the process # indicated, is shown on the screen and is identified as Step 01 at the **">"** cursor. The **">"** cursor points to the line that can be edited. The cursor can be moved by the GO2STEP, (UP)↑, and (DOWN)↓ keys. [Note: pressing the GO2PRC key at this point would allow you to select an alternative process# to be reviewed/edited. Pressing the fixed STATUS key would return to the Run Time screen.] If it is not already the case, program layer 1 (step 1) as shown in Figure 3.18.

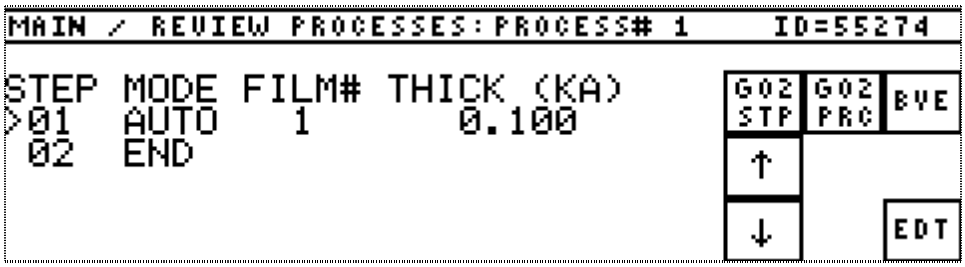


Figure- 3.17: Process Review Screen

Figure 3.17 depicts the initial programming of the product as it leaves the factory. If this is the current product condition, then *just read* the following 2 steps and perform the 3rd. If Process# 1 has been programmed in some other way and can be overwritten, *perform* the activities in steps 1 through 3. If END is STEP 01, perform activities in items 2 and 3.

1. Using UP/DOWN arrow keys, move edit cursor to STEP 01. Press keys: edit (EDT), change (CHG) and mode (MOD) then press the END key. This action will delete all lines except the STEP 01 line which now represents the minimum list, that with the END as the single line list.
2. With the edit cursor on STEP 01, press the MODE key (if necessary press the edit (EDT) and change (CHG) keys first) and then press the AUTO (AUT) key and the enter (ENT) key. On step 01, the END will change to AUTO. This action inserts a new line and increments the END line to reflect its new list position. As END assumes its new position, it is given a new consecutive step number (02). The Film# is, by default, set to film 1. Whether the Film# is entered by default or user entered, the 01 Film# will associate film program 1 with layer 1.The Thickness is, by default, set to zero.
3. With the edit cursor on STEP 01, press the thickness (THK) key to edit the **THICK**ness_**KA** column. As the menu keys change to allow numeric entry, the thickness edit line appears at the bottom of the screen where the desired end thickness for the first layer is entered (200Å). Press digits as needed in the previously described manner. Note number to decimal point relationship. When digits are correct press enter (ENT) on the numeric entry menu to accept these digits. After entering the thickness value, the menu reverts to its EDT/CHG menu. Film# and Mode could have been included in this edit sequence. Press BAK to return to the edit menu.

1.) Beginning from the factory setting (see fig. 3.17), press the edit (EDT) key to bring forth the process edit menu.
2.) Move the cursor to step 01.
3.) Press the insert (INS) key until the END is on step 07. This action inserts 5 lines with default values.
4.) Move the cursor back to step 01.
5.) Press the change (CHG) key to bring forth the process edit/change menu.
6.) Press the thickness (THK) key and enter the thickness value found in fig. 2.11: 2, 0, 0, ENT.
7.) Press the down arrow ↓ key to cursor to step 02.
8.) a.) Press the mode (MOD) key and enter the mode found in fig. 2.11.
b.) Press the film (FLM) key and enter the film# found in fig. 2.11.
c.) Press the thickness (THK) key and enter the thickness value in fig. 2.11.

In a similar fashion, program the next four layers of process 1 to look like the display shown in Figure 3.11. Press the **arrow down** key to edit the each consecutive line. The most expedient strategy would be to follow procedure# 8 above. Some of the steps will not require a film entry as the default value will be correct. Use BAK and BYE to return to the MAIN menu (press fixed STATUS key to return immediately to Run Time screen.

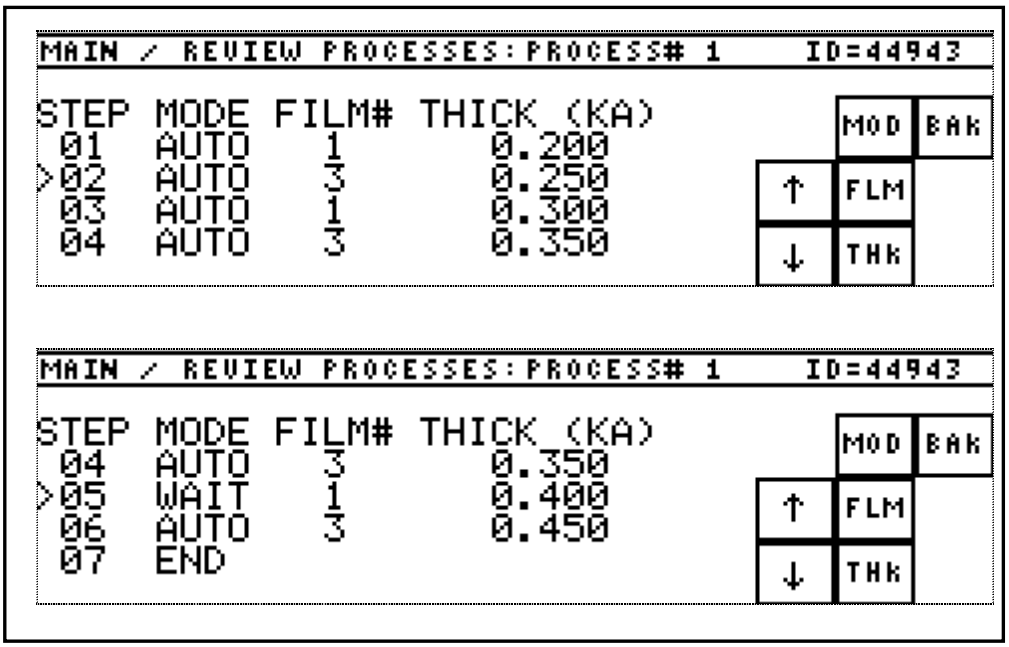


Figure- 3.18: Six Layer Test Process.

After programming the above process, note the five digit number that appears in the upper right area of the screen labeled **ID** (a checksum for the seven step process sequence). This is a unique checksum determined by the numbers and terms programmed into the process. If you have programmed the process identical to the above example the checksum number will be 44943. After programming an actual process, it is useful to record this number. If you ever have to duplicate a process program all of the data entry can be verified by comparing this number to original process checksum. See section 2.21: check sum validation.
Feel free to repeat the above procedural elements with variations that still complete the desired goal as many alternative paths are possible.

Programming Film 1 & Film 3

Film Programming

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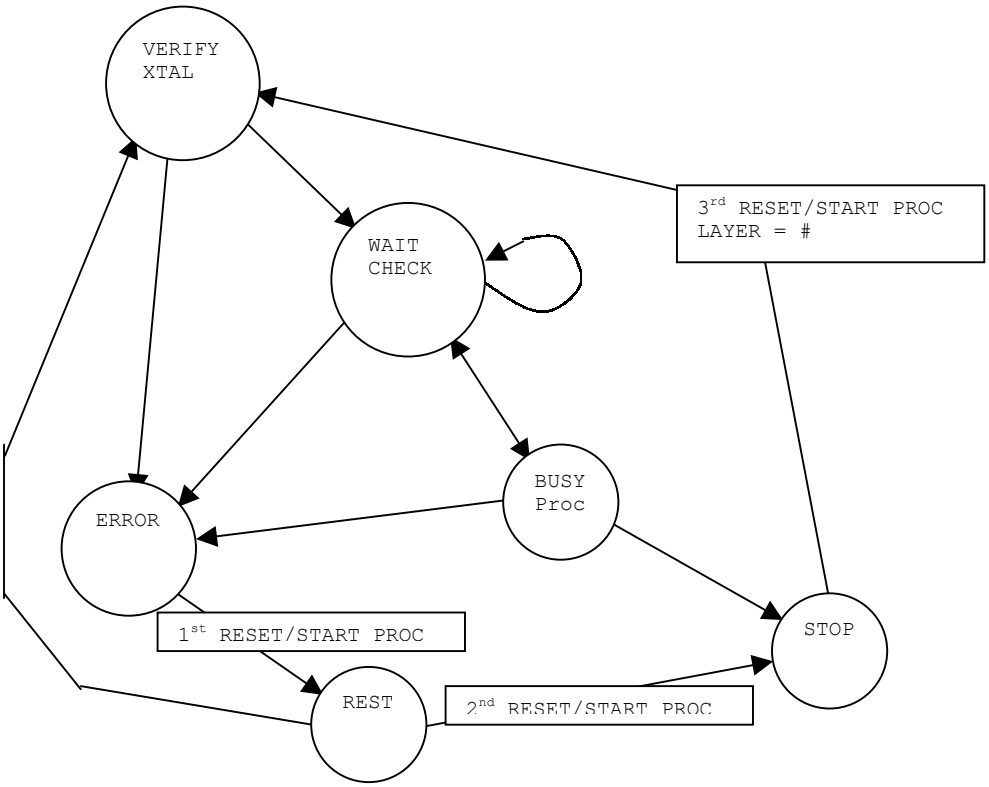
2.12

2.13

5

5



Process START: RESET / START PROCESS diagram

Some ERROR conditions may need 3 RESET/START's to return to a running process. See "Process START: RESET/START PROCESS diagram"↑

Product programming summary

SECTION 3.22 Summary

In all of the following cases, use **BAK**s and/or **BYE**s for a return path. The **fixed STATUS** key can be used at any time or point to return to the Run Time screen.

To program for **PROCESS NON-SEQUENCING**...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	SERVICE
Service menu	SEQ [en]ABLE to NON SEQ + ACCEPT

To program for **PROCESS SEQUENCING**...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	SERVICE
Service menu	NON SEQ to SEQ [en]ABLE + ACCEPT

To put the STC-2002 into **TEST MODE**...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	SERVICE
Service menu	TEST OFF to TEST ON + ACCEPT

Subsequent power cycling automatically sets TEST MODE to OFF.

To **PURGE** programmed memory...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	SERVICE
Service menu	AS IS to PURGE + ACCEPT

Exercise CAUTION PLEASE! See cautions in sections 1.8 and 3.19.

To return to **FACTORY** settings (programmable elements)...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	SERVICE
Service menu	AS IS to PURGE to FACTORY + ACCEPT

Communications setup includes:
COM/IO lock code
KEYBOARD BEEP
RS232 Baud rate
RS232 Protocol

To view / program one of these...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	EXECUTIVE MENU
EXECUTIVE MENU	COMM. SETUP
COMMUNICATIONS SETUP MENU	arrow[s] ; EDT (edit)
(Lock Code, if enabled [see Comm Setup]	numeric entry + ENT (enter))
COMMUNICATIONS SETUP EDIT MENU	arrow[s] ; CHG (change)
COMMUNICATIONS SETUP EDIT/CHG MENU	numeric entry[s] + ENT (enter)

System Configuration includes:
LCD Contrast / Bias
Password Lock #
(Process) Run Number
Recorder Function
Recorder Out Channel
Real Clock Time
Real Clock Date
Need Source/Sensor Card 1
Need Source/Sensor Card 2
Need Source/Sensor Card 3
Need Source/Sensor Card 4
I/O Slot 1 Type
I/O Slot 2 Type
I/O Slot 3 Type
I/O Slot 4 Type
Memory Module IFC

To view / program one of these...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	EXECUTIVE MENU
EXECUTIVE MENU	SYSTEM CONFIG
System Configuration menu	arrow[s] + EDT (edit)
(Lock Code, if enabled [see Sys Config]	numeric entry + ENT (enter))
System Configuration Edit menu	arrow[s] + CHG (change)
System Configuration Edit/Change menu	numeric entry + ENT (enter)

To view / program **film parameters**...

Screen	Key{s] to press
Run Time	fixed MENU
MAIN MENU	REVIEW FILM
REVIEW FILMS menu	GO2 FILM (to select different film, if needed)
REVIEW FILMS menu	arrow[s] + EDT (edit)
(Lock Code, if enabled [see Sys Config]	numeric entry + ENT (enter))
Review Films Edit menu	arrow[s] + CHG (change)
Review Films Edit/Change Numeric Entry	numeric entry + ENT (enter)

See Section 1.8 for Programmable Parameter List.

To set the **NEXT ACTIVE PROCESS** (sequencing mode only)...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	NEXT ACTIVE PROCESS
NUMERIC ENTRY MENU	Digit (1-9) + ENTER

To view / program **PROCESS steps** (sequencing mode only)...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	REVIEW PROCESSES
Review Processes menu	GO2 PROCESS (to select a different process, if needed [process selected on numeric entry screen by digit + ENTER])
Review Processes menu	arrow[s] ; EDT (edit)
(Lock Code, if enabled [see Sys Config]	numeric entry + ENT (enter))
Review Processes Edit menu	arrow[s] ; INS (insert) ; DEL (delete) ; CHG (change) step line
Review Processes Edit/Change menu	arrow[s] ; MOD (**mode**) ; FLM (**film**) ; THK (**thickness**)
Review Processes Edit/Change **Mode** menu	SKP (skip) ; STP (stop) ; AUT (auto) ; END ; WAI (wait) ; ENT (enter)
Review Processes Edit/Change **Film** menu	numeric entry + ENT (enter)
Review Processes Edit/Change **Thickness** menu	numeric entry + ENT (enter)

To view **Process Accounting History** (sequencing mode only)...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	EXECUTIVE MENU
EXECUTIVE MENU	PROCESS ACCNT
Process Accounting History menu	arrow[s]

To view / program **I/O Setup**...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	EXECUTIVE MENU
EXECUTIVE MENU	I/O SETUP
I/O Setup MENU	arrow[s] ; MEM (**memory A or B**) ; OPR (**operating status**) ; EDT (**edit**)
(Lock Code, if enabled [see Comm Setup]	numeric entry + ENT (enter))
I/O Setup **Memory** menu	SAV (save) ; SWP (swap A↔B)
I/O Setup **Operating Status** menu	RUN ; STP (stop)
I/O Setup **Edit** menu	arrow[s] ; INS (insert) ; DEL (delete) ; CHG (change)
I/O Setup **Edit**/Change menu	arrow[s] ; IN (input) ; NOT ; AND ; OR ; UNDO ; MOR (more) ; POS (positive edge) ; NEG (negative edge) ; BAK SP (back space) ; DEL (delete) ; OUT (output) ; TRP (trip) ; SET ; CLR (clear) ; ARM ; DRP (drop) ; ENT (enter)
I/O Setup **Edit**/Change menu (numeric entry)	100 (most significant digit, hundreds digit) + 10 (tens digit) + 1 (least significant digit, units place) ; ENT (enter)

To select **Crystal Sensor** (set secondary crystal[s] as backup, fail primary, re-verify to reinstate primary)...

Screen	Key[s] to press
(Setup parameters on FILM REVIEW menu and REVIEW SS MAP menu)	(Film Review: SS MAP SELECT *x*, Review SS MAP: XTALS and CH *x* related parameters)
Run Time	STATUS (press twice)
2nd STATUS screen	Use FORCE FAIL to select fail channel and re-verify

To adjust **Power** level % manually (first 2 lines using LCD, second 2 lines using pendent)...

Screen	Key[s] to press
Run Time (with deposition running)	fixed MANUAL, fixed STATUS
1st STATUS (with deposition running)	↑ (up arrow) increase, ↓ (down arrow) decrease
Run Time (with deposition running)	fixed MANUAL
Run Time (with deposition running)	(Pendent Hand Controller) **UP ↑ ; DOWN ↓**

To select Crystal Stability Indicators "**L/Q**"...

Screen	Key[s] to press
Run Time	L/Q
Run Time	LOOP
Run Time	QUAL

To select/use **Sample and Hold** (see System Configuration parameter)...

Screen	Key[s] to press
Run Time	[area below L/Q]
Run Time	SMPL
Run Time	HOLD

To view **Control Options**...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	CONTROL OPTIONS <not available>

To view **OPT/INF (options / info)**...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	EXECUTIVE MENU
EXECUTIVE MENU	OPT/INF
OPT/INF	MORE (more pages)

To select **ACTIVE FILM** (non-sequencing mode only)...

Screen	Key[s] to press
Run Time	fixed MENU
MAIN MENU	NEXT ACTIVE FILM
Numeric entry	Digit[s] + ENTER

In SEQUENCING mode, the active film is set by the active process.

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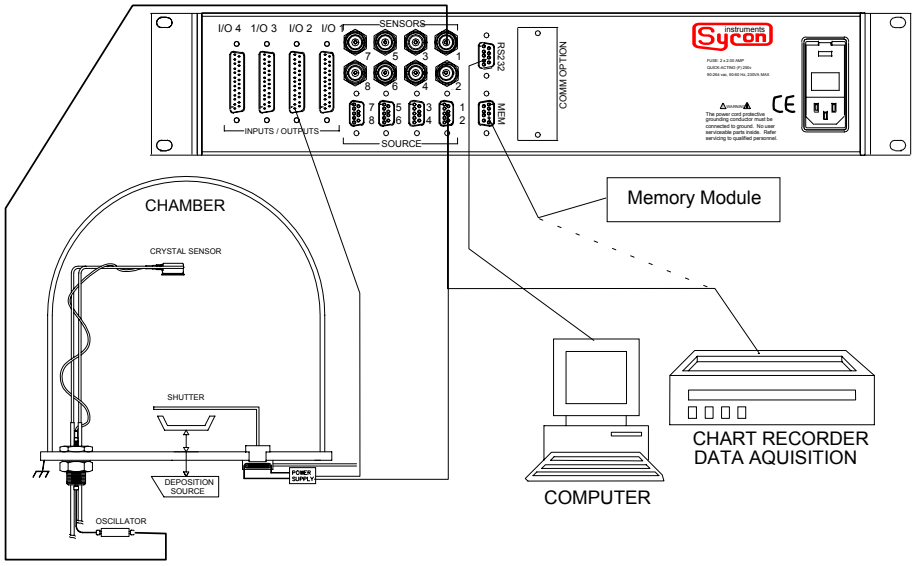
Electrical Connections And Descriptions

SECTION 4.0 Sensor Head Installation

Following is a diagram of a typical evaporator installation. This diagram is repeated and described further in Section x3 (see fig. 3.7).



Sensor Installation

As a general rule the sensor head should not be installed closer than 10 inches to the evaporation source. This minimum distance will generally provide adequate measurement sensitivity while reducing the possibility of the source spattering small particles onto the sensor. Even small particles hitting the crystal surface may cause the crystal to become unstable or stop oscillating completely.

The sensor should be shielded from the evaporant source by a shutter or other means when evaporant material is being initially conditioned or outgassed.

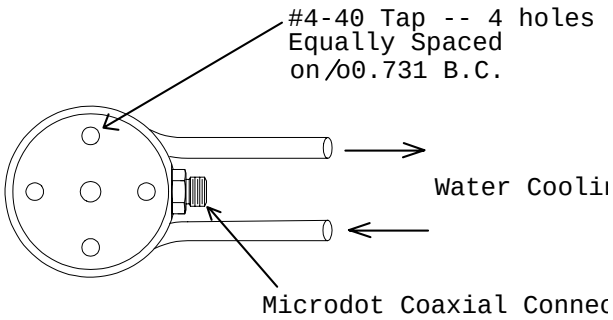


Figure- : 4.1 Head Mounting Dimensions.

Install the sensor so that the crystal opening is in a direct line with the evaporation source and well within the evaporant stream. Ensure that the sensor is not shadowed by mechanical structures within the vacuum system. The sensor should be held mechanically stable by attaching it to a mounting bracket via the rear #4-40 tapped holes.

Water Lines

Bend the two sensor water lines into the desired position for connection to the vacuum feedthrough. Take care not to crimp the lines. There are two methods for attaching the water lines to the feedthrough. The first is to silver solder or TIG weld the sensor and water lines together. To do this first locate the final position of the sensing head and feedthrough. Trim the 1/4" water lines on the feedthrough to the desired length. Bend and fit the sensor water lines as required. Cut the 1/8" water lines to length allowing 1/4" to 1/2" of extra length to be inserted into the 1/4" feedthrough water lines. Then braze, silver solder, or TIG weld.

The second is to use Swagelok compression fittings. These are available from Sycon as part number 022-001. These can also be purchased from Swagelok as part number SS-300-6-2.

Installing Compression Fittings

Swagelok® Compression Fittings

Swagelok® Tube fittings are installed in three easy steps:
Step 1-simply insert the tubing into the Swagelok® tube fitting. Make sure that the tubing rests firmly on the shoulder of the fitting and that the nut is finger tight.
Step 2-before tightening the Swagelok ® nut, scribe the nut at the 6 o'clock position.
Step 3-now, while holding the fitting body steady with a backup wrench, tighten the nut 3/4 of a turn. Watch the scribe mark, and make 3/4 revolution to the 3 o'clock position.
By scribing the nut at the 6 o'clock position as it appears to you, there will be no doubt as to the starting position. When tightened 3/4 of a turn to the 3 o'clock position you can easily see that the fitting has been properly installed.

Re-Tightening Instructions

Re-Tightening Water Line Fittings

Connections can be disconnected and re-tightened many times. The same reliable, leak-proof seal can be obtained every time the connection is remade. First tighten the nut by hand. Then rotate the nut to the original position (scribe mark at 3 o'clock) with a wrench. An increase in resistance will be felt near this point. Now tighten an additional 1/8 turn.

Vacuum Feedthrough

The vacuum feedthrough should be installed as close as practically possible to the sensor head. This allows the shortest length of sensor-to-feedthrough coax cable to be used. Cable lengths greater than 30 inches may reduce crystal life and stability. Install the feedthrough using proper gaskets and vacuum grease if needed. The small electrical coax connector should be on the vacuum side of the installation.

Water Line Caution:


Caution

CAUTION Ensure that the water lines are clear of obstructions before operating the sensor above room temperature. A **water flow rate** of 0.2 to 0.3 gpm is adequate for most applications.

Electrical In-Vacuum Cable

Vacuum Electrical Connections

The electrical cable from the sensor head to the vacuum feedthrough should be wrapped around the water lines using up all excess length in the process. Firmly tighten the connectors at both the sensor and feedthrough ends. The water lines and sensor cable should then be wrapped with clean tin foil or other shielding material to prevent evaporant build-up and also to aid cable cooling and mechanical stability.

The sensor head must always be operated at "ground" potential and this connection is carried through the sensor feedthrough coaxial connectors and shields. The remote oscillator is attached to the vacuum feedthrough via the six-inch male/female coax cable. The long coax cable connects the remote oscillator to the display unit. This cable must be a coaxial 50-ohm type and can be up to 100 feet in length.

For safety purposes and electrical noise immunity, a ground wire should always be installed between the vacuum vessel and earth ground. Refer to Figure 4.3.

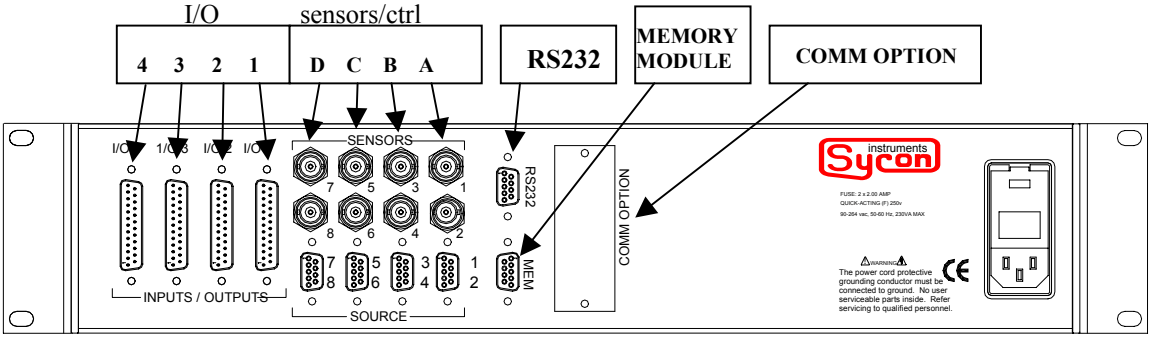
Dual Shuttered Head

The installation of a dual shuttered sensing head is similar to that of the single head. A second sensing input (Sensor 2) is used for the second crystal channel. If the STC-2002 is configured in the executive mode for automatic crystal switching the XTAL 2 SELECT output performs the necessary functions for controlling the shutter of the dual sensor. Proper phasing between the sensor inputs and shutter control can easily be checked by installing a sensing crystal in only sensor 1 and observing the good and "failed" (absent) sensing crystal when switching manually between sensor 1 (good) and sensor 2 (failed).

Electrical Connections and Descriptions

SECTION 4.1

All electrical connections to the STC-2002, with the exception of the remote hand held power controller, are made at the rear panel of the instrument. Care should be exercised in routing all cables as far as practically possible from any other cables or wires that may be generating noise. These may include other line voltage cables, wires to heaters that are SCR-controlled, and wires or cables to source power supplies that may conduct high transient currents during arc over conditions.



4.2: Rear Panel

SECTION 4.2

Line Power

Line Power and Fuses

WARNING

Replace broken or blown fuses only with the ratings specified. Failure to do so may result in unsafe operation and may cause damage to the unit. See back panel for fuse specifications. Fuses are located in IEC power connector. (See section 7.1)

The STC-2002 operates from 90 to 264VAC, 50/60Hz (1.4A rms@120VAC, 0.7A rms@230VAC). No adjustments are required. A correct IEC or Sycon power cord should be used.

SECTION 4.3

Installation of STC-2002 in a 19" Rack

To install a single STC-2002 in a 19" rack it is recommended that the included mounting ears be used.

SECTION 4.4

Vacuum System Grounding

GROUND

A ground post is provided on the rear panel. This point should be connected to the deposition system ground with the shortest convenient length of heavy gauge wire or flat braided cable. This connection is not required for normal operation but will make the unit less susceptible to transient noise and **it is highly recommended that it be installed**. Refer to figure below for an example of proper installation.

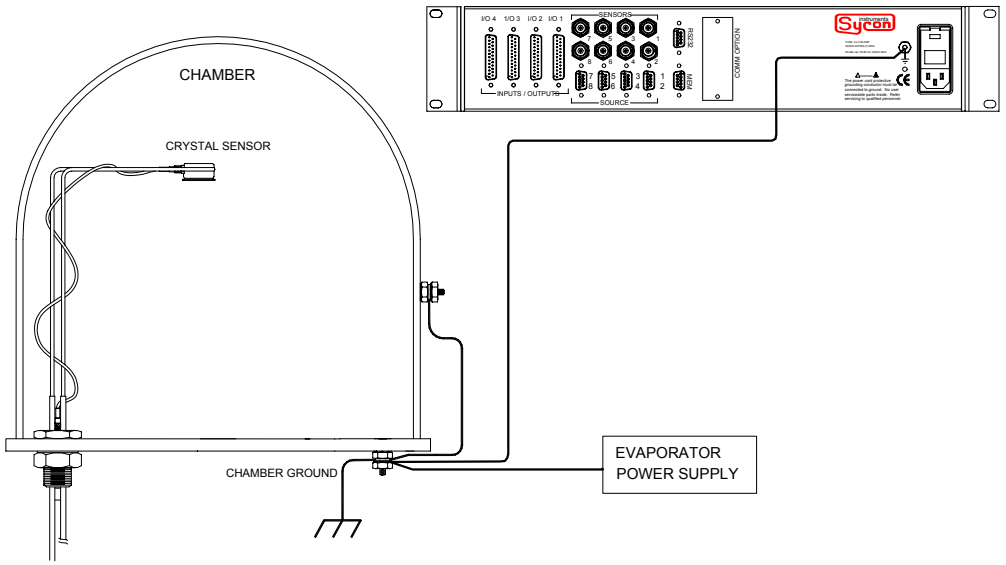


Figure- 4.3: Recommended Grounding

CONNECTOR INSTALLATION

Connector Shielding

In systems with a high electrical noise environment, attention needs to be given when wiring connectors. A little extra time spent here can save hours of frustration later. Sycon provides mating connectors with each instrument. For best results, use a shielded multi-conductor cable. On the D-subminiature connectors that are supplied with the units, the metal shells each come with a set of four grommets. Pick the grommet for the size cable you are using. After making the desired electrical connections, remove an additional 3/4 inch of the outer insulation of the cable to expose the cable shield to the grommet. Because the grommet is conductive, just clamping it between the metal shell is sufficient to complete the shielding of the cable.

Figure 4.2 shows the Input/Output card card slots (labeled 1, 2, 3 and 4). The typical installation has slot 1 filled with an input card and slot 2 filled with an output card. Figure 4.2 also shows the Sensor card slots (labeled in the figure as: A, B, C, D). The standard installation has slot 1 filled. Each sensor card has 2 crystal inputs and 2 identical control voltage outputs. Each of these control voltage outputs are both isolated and single ended. In a standard STC-2002 (with 1 sensor card), the control voltage outputs may be configured such that one output is programmed and intended as a process control voltage while the other control voltage output is programmed and intended for use on a strip chart recorder. Back panel designations for slot 1 are: **"1"** and **"2"** for sensors 1 and 2 in the area labeled "**SENSORS**" while in the area labeled **"SOURCE"**, **"1/2"** indicates source control voltages 1 and 2 on one 9 pin D-sub female. Back panel designations for slot 2 are: **"3"** and **"4"** for sensors 1 and 2 on the second sensor card in the area labeled "**SENSORS**" while in the area labeled **"SOURCE"**, **"3/4"** indicates source control voltages 3 and 4 (1 and 2 on the second sensor card). There are 4 slots for Input and/or Output cards. There are 4 slots for Sensor cards.

SECTION 4.5 Sensor Connections

Connector Type -- BNC

Crystal Sensor Inputs

These connectors are the remote sensor oscillator's interface to the STC-2002. These connections are both the signal and power path to the oscillator. The supplied power is 5 volts at 50 mA. The input impedance is 50 ohms and the signal level is 1 volt peak to peak. This connection should always be made with coaxial cable. Type RG58 or RG59 is recommended. Cable lengths up to 100 feet are acceptable. These cables in 10 and 30-foot lengths are available as standard parts from Sycon.

SECTION 4.6 Analog Control Voltage Connections

There are 2 identical analog output voltages available from each sensor card on a single connector.

Power Supply Connection: This refers to the high current (or voltage) power supply that provides the energy to create the evaporant stream. The power supply connection on the STC-2002 has the control voltage that controls the high current (or voltage) power supply. From the STC-2002 point of view, this is known as the source control voltage. The word *source* describing the source material of the deposition process in the form of an evaporant stream. Along the bottom of the back panel, in the area where sensor cards may reside, is the text label SOURCE. This is meant to indicate the 9 pin D-sub that is part of the sensor card. The text labels ½, ¾, 5/6, 7/8 refer to control voltage outputs. In the first sensor card slot, this indicates control voltage 1 and control voltage 2. Given the standard hardware configuration, that with 1 sensor card, one of the control voltages is meant to control the high current (or voltage) power supply just described and the other control voltage is normally meant for the strip chart recorder control. These identical analog outputs can be interchanged. In fact, their function is assigned by means of menu programming. If the two functions (control voltage and recorder) are assigned by menu programming on the same analog channel, the control voltage will have precedence and the recorder function will be lost. After these programmed outputs are used in a film, a conflicting recorder function having been lost in this way would require a reboot to recognize a correcting change. The analog output used for the control voltage output has a number of programmable parameters associated with it. One in the MAIN/ REVIEW FILMS menu path is: *SS MAP SELECT*. Another one in the MAIN/ REVIEW MAPS menu path is: *source out channel*. Don't overlook the ground connection (connector shell). Shielding goes a long way toward noise reduction and ultimately contributes to a stable system.

Strip Chart Recorder Connection: This refers to the STC-2002 output from the 9 pin D-sub on a sensor card that can provide the proper analog signal for a strip chart recorder. Along with the hardware connection, the analog output used for the strip chart recorder has a number of programmable parameters associated with it. Two in the MAIN/ EXEC/ SYSTEM CONFIG menu path are: *recorder function I/O control* and *recorder out channel*. Don't overlook the ground connection (connector shell). Shielding goes a long way toward noise reduction and ultimately contributes to a stable system.

Control Voltage Output Connection

Except for the possible single output per unit used for the strip chart recorder, the other outputs are intended to provide the rate control voltage for the deposition source power supply. The voltage is programmable in range through the review maps menu as described previously. The isolated single ended output provides up to 10 ma at 2.5, 5, and 10 volts, both positive and negative relative to the channel common. The control output voltage connections for outputs 1 and 2 (per each sensor card) are as follows:

[for optimum noise immunity, it is recommended that a shielded, twisted pair cable be used to make the connection from the STC-2002 to the power supply control input or strip chart recoder of the deposition system]

Control Signal 1	Pin No.
+Output	9
-Output	4
Analog Ground (common)	5
Shield	SHLD

Connector Type – 9 PIN D-SUBMINIATURE female

Control Signal 2	Pin No.
+Output	2
-Output	6
Analog Ground (common)	1
Shield	SHLD

Connector Type -- 9 PIN D-SUBMINIATURE (ON THE SAME CONNECTOR DESCRIBED ABOVE)

SECTION 4.7 Analog Recorder Output Connection/Usage

As previously discussed, the analog outputs are identical and interchangeable. One output per STC-2002 may be used for a strip chart recorder regardless of the number of sensor cards enabled. A standard unit having one sensor card may use the second channel for strip chart recording as discussed here. In this example, the second output provides an analog output voltage proportional to either displayed rate, rate deviation, power, or thickness. The channel and status value are selected using the system configuration menu. The names of the related system configuration menu items are *recorder function*, *recorder output channel* and *need SS card*.

The second analog output, here described for possible use as the analog recorder output voltage, has the connections as described above for Control Signal 2, that is pins 2, 6, 1 and shield. It is recommended that a shielded, twisted pair cable be used to make the connection from the STC-2002 to the chart recorder input.

Analog Recorder Output Specifications (any analog output)

Resolution	12 Bits
Accuracy	0.3 % Fs
Loading Capacity	5 mA
Full Scale Output	10 Volts

Analog Recorder Output Calibration / Interpretation

Recorder Output Types

Thickness Mode - The analog recorder output in the thickness mode is always scaled for plus or minus 999 angstroms full-scale (9.99V). Resolution is always one (1) angstrom. Display readings above 999 angstroms will be sent to the recorder output as the remainder of the displayed value divided by 1000.

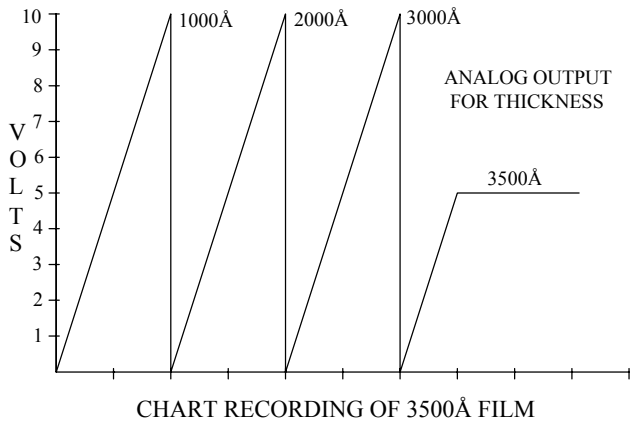


Figure- 4.4: Example of Thickness Mode Recorder Output.

Rate Mode - The analog recorder output for the rate mode is scaled for a full scale (999.9 Å/s) reading of 10 volts. Readings up to 100.0 Å/s will be output with a resolution of 0.1 Angstrom and values above 100.0 Angstroms will be output with a resolution of 1.0 Å/s. This method allows a continuous recorder accuracy of at least 0.3% and also provides a unique output voltage for any rate value within the displayable range of values. This output is unipolar with negative rates clamped at zero volts.

Rate Deviation Mode - linear from 0 to ±999.9 A°/S and 0 to 10 Volts. 0 to 999.9 A°/S generated by voltages between (and including) 5 and 10 volts. 0 to -999.9 A°/S generated by voltages between (and including) 5 and 0 volts. In other words, zero rate deviation is midscale at 5 volts.

Power Mode - The analog recorder output for the power mode is scaled for a full-scale (100%) reading of 10 volts.

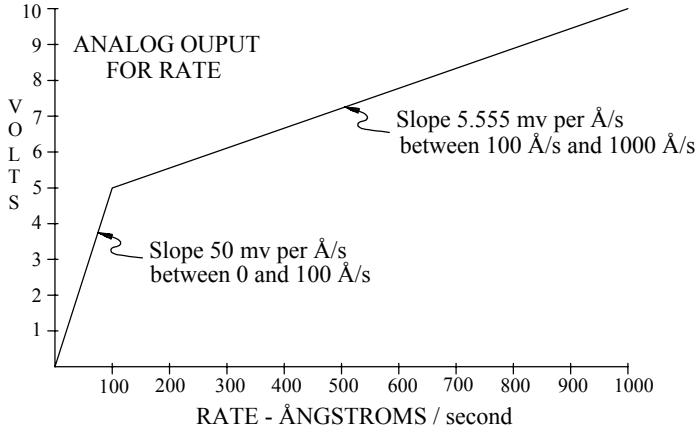
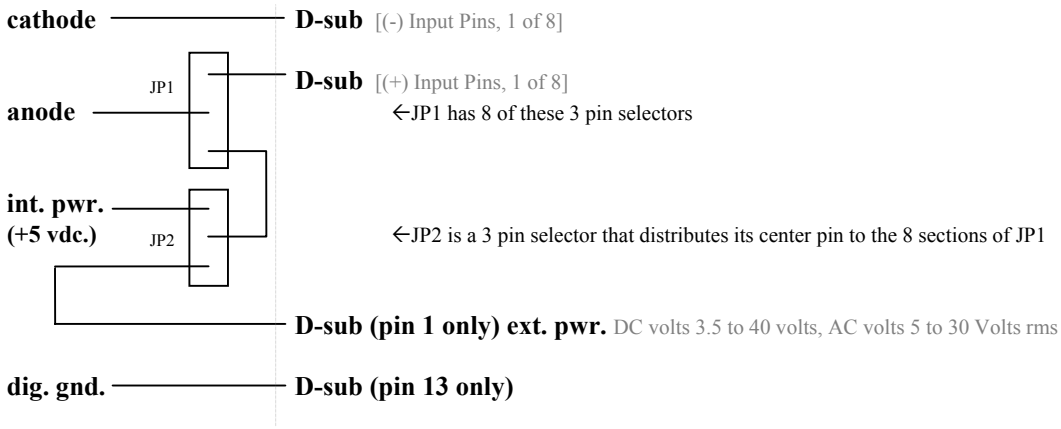


Figure- 4.5: Example of Rate Mode Recorder Output.

SECTION 4.8 I/O Interface

Input Card Options: An opto-isolated input card can be configured in a number of ways. Inputs can be isolated or non-isolated, internally powered or externally powered (individually or as a group). Jumpers on the input card are used to make the selections. All of the opto-coupler LED cathodes are brought out to the 25 pin D-sub female (i.e. pins 3,6,9,12,14,17,20,23 [(-) Input Pins]). The opto-coupler LED anodes are brought into a jumper header (JP1) where each of the anodes can either be routed to a voltage source or sent out to the 25 pin D-sub female (i.e. pins 2,5,8,11,16,19,22,25 [(+) Input Pins]). The voltage source itself is further selectable on a separate 3 pin jumper header (JP2) such that an internal voltage (+5VDC) can be selected or an external voltage can be selected (connects to pin 1 of the 25 pin D-sub female). The voltage source, regardless of the JP2 selection, can therefore be applied to any or all of the anodes when JP1 selects the voltage source. Any one or more of the anodes can be alternately routed through JP1 to keep them isolated from the other anodes and the voltage source. Jumpers can short from the center pin position to one of the two outer pins (in each of the eight JP1 segments). Since there are 8 anodes, there are also 8 JP1 sections. The depiction below is a generalization of a single LED input (1 of 8). JP2 is a single 3 pin position selector. [Section 4.8 has more details]



The standard I/O INTERFACE of the STC-2002 is comprised of 8 opto-coupled inputs (electrically isolated) on one PCB card and 8 Form C relay outputs on another PCB. The factory default I/O program, which is described in Section 5.15, utilizes the factory programmed defaults which configures the first 4 inputs (1-4) and 4 relay outputs (1-4) to perform functions which suit a majority of deposition requirements. These are described in sections below. The additional 4 inputs (5-8) and 4 outputs (5-8) are not programmed at the factory. If the factory I/O program as shown in Section 5.15 is altered or deleted these functions may not occur as described in the Sections 3.6 and 3.7. A full description of I/O programming is given in Section 5 of this manual.

The **OPTOCOUPLER INPUTS** connector provides the user an isolated interface to 8 inputs from user equipment. These inputs can be activated in several ways, depending on user accessible connection options, the following choices are available; DC voltage between 3.5 and 40 volts, AC voltage from 5 to 30 Volts rms, NPN transistor open collector or contact closure, logic level 3.5 Volts or greater. For non-isolated applications the user can choose to use an internally supplied 5VDC bias voltage for the open collector or contact closure activation method. Isolated open collector operation requires the user to supply a separate 5VDC bias, which is not

~~Input Ratings~~

grounded to the STC-2002 unit. **Do not exceed 45 Volts peak on any inputs or damage may occur. Ensure that the proper polarity is applied to each input.**

Input Connections and Functions

The function of each input is user definable and programmable. However, the first four inputs are pre-programmed at the factory per the following table. Any input may be reprogrammed or deprogrammed as needed. The pin numbers refer to the contact on the 25 pin D-subminiature female *Optocoupler Inputs* connector. (See **Input Card Options** above)

Input No.	(+) Input Pin No. (JP1 commons)	(-) Input Pin No. (cathodes)	Function (preprogrammed in I/O program)
1	2	14	Start
2	16	3	Stop
3	5	17	Final Thickness Trigger
4	19	6	Zero Thickness
5	8	20	User Defined
6	22	9	User Defined
7	11	23	User Defined
8	25	12	User Defined

Digital ground (DG) is on pin 13. External power (User supplied voltage, [Vext]) can be applied to pin 1.

Input PCB Card: Optional External Power Supply Connections

If an optional external isolated power supply is utilized, it can be applied on the *Optocoupler Input* connector, pin 1 with the RETURN either negative for isolated or using pin 13 for non-isolated systems. This supply should be limited to 1.0 Amp total output current.

Hookups to the optocoupler inputs are facilitated with two pin arrays, JP1 and JP2, which are right angle mounted on the edge of the Input Module PC-board and accessible by removal of the top cover. JP1 is a 3 by 8 pin array and JP2 is a 3 pin inline array. Connection choices are made with 2 pin shorting blocks, as determined by the user for a particular application. Figure 3.3 shows examples of shorting pin locations, which are required to accommodate the various activation methods.

Hazardous Voltages Present

Static Sensitive

Input PCB Card jumper installation: See section 7 for shock hazard and ESD sensitivity

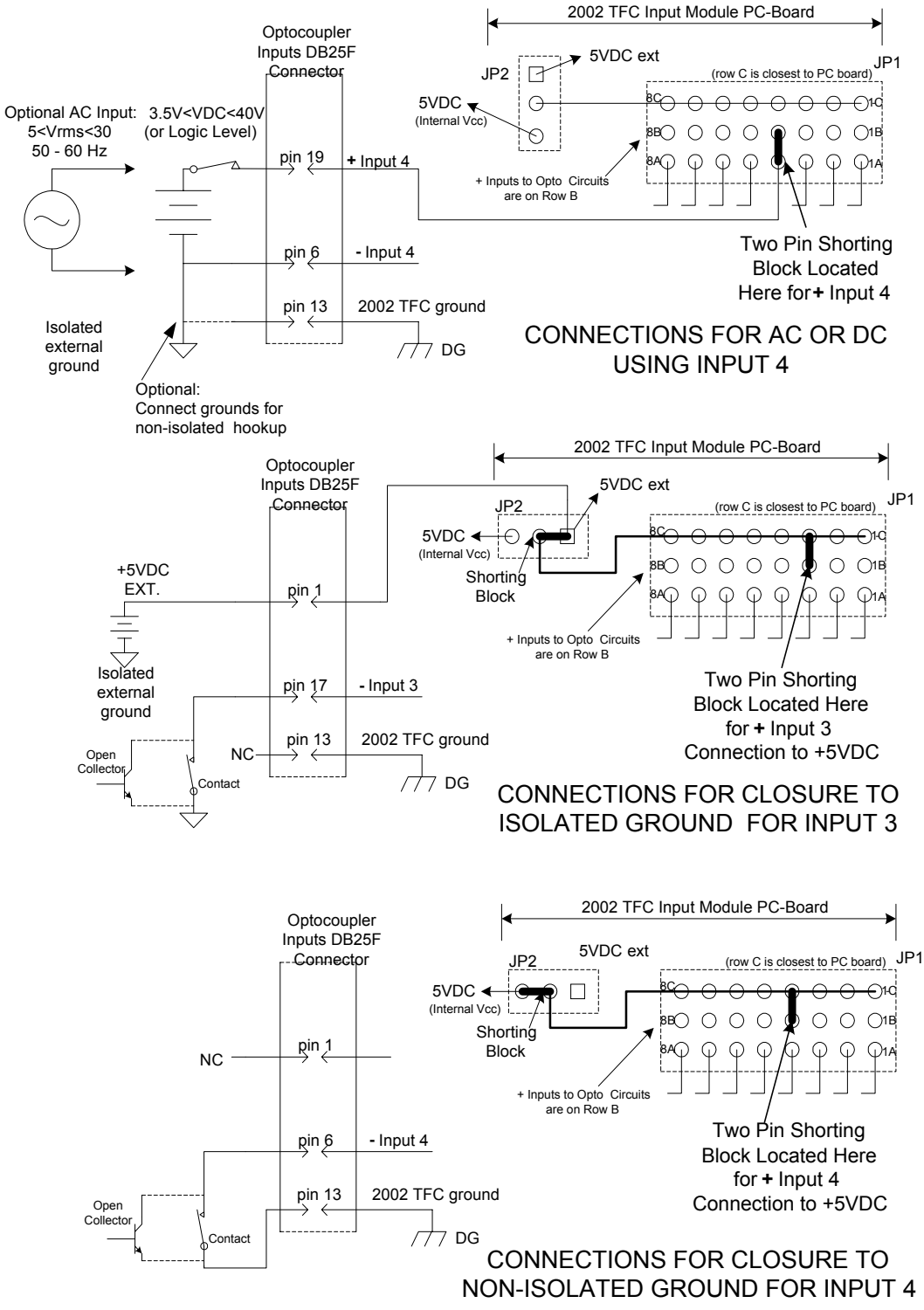


Figure- 4.6: Examples of Shorting Block Locations to Accommodate the Various Optocoupler Input Hookup Options

The RELAY OUTPUTS connector provides the user an interface to 8 Form C (SPDT) relays. The contact rating of these relays is 2A at 30 VDC or 2A at 30 VAC maximum. Do not exceed these ratings or damage will occur.

As with the Optocoupler Inputs, each relay function is definable and programmable. The eight output relays of the STC-2002 can be programmed to respond to logical combination of the following: external events (the eight remote inputs); the state of the deposition process; active layers; or setpoints of the STC-2002. Programmable internal memory elements within the STC-2002 can provide many system control functions, such as cycle counters or sequencers, which previously required external hardware. The first four relay outputs are pre-programmed at the factory per the following table. Any input may be reprogrammed or deprogrammed as needed.

Relay Ratings

Factory Installed Relay Output Program

Relays- Connections and Functions

Relay No.	Function	Common Pin No.	NO Contact Pin No.	NC Contact Pin No.
1	Crystal Fail	13	12	25
2	Source Shutter Relay	24	23	11
3	Xtal 2 Select	10	9	22
4	Thickness Setpoint	21	20	8
5	User Defined	7	6	19
6	User Defined	18	17	5
7	User Defined	4	3	16
8	User Defined	15	14	2

pin 1 is not connected

SECTION 4.9 Relay Outputs for Factory Installed I/O Program

The standard STC-2002 is equipped with eight SPDT relays. These are Form C (SPDT) relays and have normally open and normally closed contacts. The normally open contacts become active when their respective function is true. It is assumed that the OUTPUT card PCB is in slot 2 (see figure 3.1 for I/O slot designations).

Factory Output Relays

The definitions of the factory programmed relay outputs are as follows:

Output 1	Crystal Fail - This Relay provides a contact closure whenever the selected sensor crystal fails to operate properly or has exceeded its operating range. A flashing XTAL BAD message will be displayed on the LCD to alert the user of this condition.
Output 2	Substrate Shutter Relay - This Relay is intended to provide control of the substrate shutter. It is generally activated during the deposition phase.
Output 3	Xtal 2 Select - Relay is closed when sensor 2 is the active sensor.
Output 4	Thickness Setpoint - This Relay provides a contact closure whenever the accumulated thickness display value equals or exceeds the thickness setpoint parameter value of the active film. A zero event (front panel or remote) or thickness setpoint parameter change resets this.

Remote Inputs for Factory Installed I/O Program

SECTION 4.10

The standard STC-2002 is equipped with eight remote input functions. These inputs are intended to be activated in a number of ways depending upon the previously described jumper placement (see figure 3.3). The signal can be continuously applied or be pulsed. The STC-2002 can be programmed to respond to the leading or trailing edge of this pulse. The minimum pulse width required is 15 ms. All eight of the inputs can be programmed by the user to suit the system requirements. It is assumed that the INPUT card PCB is in slot 1 (see figure 3.1 for I/O slot designations). Initially, the first four inputs are pre-programmed at the factory to the following four functions:

Factory Remote Inputs

Input 1	START - Functionally identical to Front Panel START key with the STC-2002 in the ready state. Activating this input with the STC-2002 in either the ready or stopped state will begin the process cycle.
Input 2	STOP -Functionally identical to Front Panel STOP key. Activating this input will terminate the deposition process.
Input 3	Final Thickness Trigger - Activation of this input causes the unit to respond as if the final thickness has been reached.
Input 4	Zero Film Thickness.

Specifications

External P.S. Activation	3.5 to 40 VDC , AC voltage from 5 to 30 Volts rms
Minimum Current	2 mA

SECTION 4.11

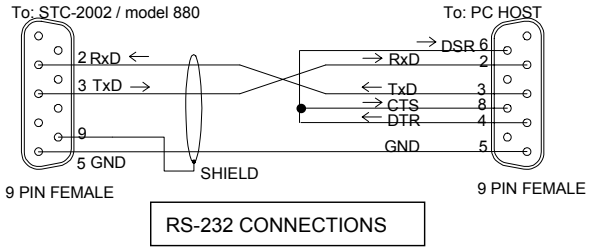
RS-232 Serial Communications Interface

This connection provides a serial data communications link to the STC-2002. Four standard baud rates can be selected: 300, 1200, 2400, and 9600. They are selected via the configuration menu. The serial interface communications protocol is also selectable. The choices are either the Sycon format or ASCII protocol. The electrical specifications correspond to the EIA RS-232 standard.

RS-232 Connections

STC-2002 Type: 9 Pin "D" male
Mating Connector: AMP 205203-1 Or Equivalent (Sycon#s: 404-028, 404-019)

STC-2002 Function	Pin Number
RS-232 Received Data	2
RS-232 Transmitted Data	3
RS-232 Signal Ground	5
Cable Shield	Shield Case



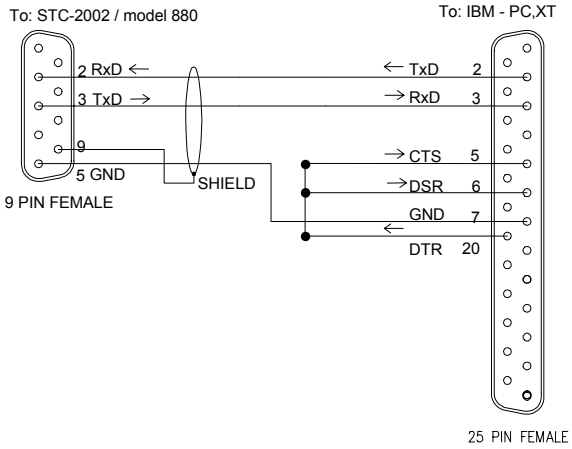


Figure- 4.7: Example Cable to Interface STC-2002 To Host PC

SECTION 4.12 Communications Options

Communications Option

The STC-2002 supports one communications option board. This is for an industrial network. This card uses the rear panel option cutout for external connection. This is a factory-installed option.

SECTION 5 I/O PROGRAMMING

I/O Programming Introduction

SECTION 5.1

The ability of the user to configure the structure of STC-2002's inputs and outputs is one of its most powerful features. The I/O configuration can be customized by the user through the use of the I/O setup menus of the STC-2002. This is accomplished through the LCD display, the fixed front panel MENU key and the software controlled touch panel LCD display overlay (a 12 column by 4 row key matrix). See section 2.1.

In this section, I/O Setup menus will be used to enter, view and maintain I/O programs through the above described LCD menus. Section x.x will describe host port commands that can duplicate these actions.

General Description: The LED display indicates run time values of *rate/power/thickness*. The 1st line of the LCD indicates the menu path down to the current menu. The next line (central part only) indicates operations as running or stopped along with the I/O program checksum (prefixed with the label: ID=). Next, there is an area that shows as many as three I/O Setup list items with the 2nd of 3 list positions allowing edits (edit line always indicated by -↓↓-). Each list item occupies two display lines (line# on 1st, tokens on 2nd). In the area on the right, there are 9 touch key areas that can become active or inactive as appropriate for the various cascading menu usages. The following depicts the main I/O setup menu in its initial state (with no program entered).

There are four general functions that can be utilized: 1) View the I/O program using GOTO and arrow keys, 2) Exchange (swap) or save the I/O program using the MEM (memory) key to access a sub-menu, 3) Run or stop the I/O program using the OPR (operations) key to access a sub-menu, 4) Edit the I/O program (includes adding/deleting/changing lines) using the EDT (edit) key to access a series of sub-menus. See sections 5.9 and beyond for detailed descriptions.

The I/O program is a list of logical combinations of states or events with their desired results. The states and events are related to the inputs, outputs and internal operation of the STC-2002 by **id**entification **numbers** shown in Table 5.4. These ID's along with a function code form tokens which are evaluated along with Boolean operators (AND, OR & NOT) to cause the desired output results. Each line of the I/O program is called a **rung**. The minimal program is shown above, with the END line in the 2nd list position (display lines 5 and 6). Don't confuse program line (rung) number with the physical LCD display line number. The display line number will not be used.

An I/O rung consists of **three segments**: the rung number, the input statement, and the output token. The **rung number** is like a line number in a software program. Rungs can be inserted or deleted by editing an I/O program as described in Sections 5.11 through 5.14. When this is done the rungs are renumbered. The rung number serves as a reference when writing or recording an I/O program.

After the rung number, an **input expression** follows. This can be a single input token or a logical expression of many tokens. When an input expression becomes too complex to fit in the rung, **soft nodes** can be used to store intermediate results. In this case, the soft node forms the output portion of the rung. The soft node used for intermediate storage can then be used as an input in a later I/O rung to complete the desired expression. (See the following table 5.1 under the heading of *Terms and Definitions* for definitions of input, token, soft node, etc.)

There is room in the STC-2002 for a program of more than **100 rungs**. Once installed the I/O configuration is stored in **non-volatile** memory within the STC-2002 and need not be reentered or changed unless the system configuration or requirements change. The STC-2002 is shipped from the factory with a partial I/O configuration installed. In many installations the **factory I/O structure** is sufficient for system use, as it allows for remotely starting and stopping the deposition cycle along with controlling the source shutter. Some systems do require more complex controls. The advanced programmable I/O capabilities of the STC-2002 allows these to be implemented. A description of the factory programmed I/O functions are described in Section x3.5-3.7.

By writing an I/O program for the STC-2002, it can often be used as a controller for a portion or all of your vacuum system. A multi-hearth deposition source may be rotated under the control of the STC-2002 to correspond to the selected film material. With the ability to test and set various internal states of the STC-2002 there is **no need** to connect relay outputs back to inputs externally. There are 8 opto-isolated inputs[1] and 8 relays available for use in a standard STC-2002. Four of the inputs and relays normally have common functions preprogrammed at the factory. These can be redefined by changing the I/O program. The remaining 4 inputs and relays are not committed in any way. We recommend that you use the uncommitted I/O for your system before redefining the factory installed system I/O.

While at a first glance, writing an I/O program may seem overwhelming, knowing the terminology will help a great deal. You will find that by learning a few consistent rules , writing an I/O program will solve many of your system problems.


Note

Note Once the I/O is programmed, it should be recorded and stored for safe keeping (see section 2.21). If a unit is replaced because of a failure, the I/O program will have to be re-installed in the replacement unit in order to perform the same system functions. Factory restore function does not include I/O programs (See section x3.6, *Processes: Factory Settings*…).

Note[1] : Opto anode and cathode are presented to the user through a 25 pin D-sub female typically found in slot1 on the back panel labeled "**I/O 1**" (see figure 3.1). LEDs can be powered in a number of ways depending upon input card PCB jumper setting (see figure 3.3 in section 3.5).

Definition Of Common Terms

The first task is to become familiar with the terms used in writing an I/O program. Refer to Table 5.1, it lists common terms and the manual section where a more complete description of each can be found.

The best way to become familiar with writing an I/O program is to go through the examples with a unit in front of you. In case you make a mistake and want to restore the original I/O program, we have provided you with the ability to **save and recall** an I/O program (See Section 5.10). Factory restore does not include I/O programs.

Terms and Definitions

State

A testable condition of the STC-2002. Examples of states are stopped, deposit, manual, idle, etc. A state does not have anything to do with time (see Edges). **See Section x5.3**

Event

An event can be either triggered or tested. It is normally an internal occurrence in the STC-2002. Examples of events are zeroing, reaching the final thickness limit, etc. An event is triggered by an Edge.
see Section x5.3

Boolean

A Boolean state can take on only one of two values, commonly referred to as True (on) and False (off). **See Section x5.2**

Scalar

A variable with a range of 0...N. Also, a special non-Boolean type of scalar whose set is {0,1}. **See Section x5.2**

Bit Map Scalar (combined bit weights)

A variable whose constituent parts are independent Boolean values combined in a single variable entity. **See Section x5.2**

AND, OR, NOT

These are logical operators. 'AND*ing*' can be thought of as relays in series, 'OR*ing*' as relays in parallel, and 'NOT*ing*' or complementing as using the normally closed contacts instead of the normally open ones. (for complications of, see section x5.4) **See Section x5.2**

Arithmetic

The Arithmetic operators included are: multiply, divide, add and subtract.

Relational

The relational operators included are: *greater than*, *less than* and *equal to*.

Selection

This is a type of *IF... THEN... ELSE* conditional operator. If *something* is true, then use value A, if *something* is not true then use value B. The selection is between two values (values A or B) and is based upon the truth or falsity of the main argument (*something*).

Input Function

This is the manner in which states and events are tested or examined. All states and events are examined or read with the same 'I' input function. **See Section x5.5**

Output Function

Manner in which relays and events are set or triggered. By providing several different types of output functions, counters and shift registers can be implemented. **See Section x5.6**

Table 5.1: Glossary Of Terms continues on following page...

Terms and Definitions **Table 5.1: Glossary Of Terms continues from previous page...**

Edges

A condition that has to do with the instant in time of an event's occurrence. An example is the pushing of the zero key. The action takes place on the edge of pushing the key. Edges are categorized by the direction of change in the associated state. Positive or rising (↑) and negative or falling (↓) (True to False). **See Sections x5.4, 5.5, and 5.6**

ID Number

A code that the STC-2002 uses to refer to a state or event. It can be up to a 3 digit number. **See Sections x5.3 (table 5.6) and 5.7**

Token

Either the combination of an input/output (I/O) function and an ID number, or a Boolean, logical, arithmetic, or relational operator. A token is made up of input or output functions with an ID number. An operator is also a token (not, or, and, etc.). **See Section x5.8**

Rung

A rung is a line of an I/O program. Each rung has a number associated with it. This term is a carryover from programmable logic controllers (PLC). An I/O program is made up of rungs of tokens. Each rung has 1 or more input tokens, may contain operators, and has 1 output token. **See Sections x5.6, 5.7 and 5.8**

Soft Node

A soft node is a special input / output variable in the STC-2002. It is a holding area where intermediate results can be stored. They are not associated with any machine state. By using soft nodes, complex functions can be implemented such as counters and shift registers. Soft nodes can also be scalars. **See Section 5.7**

Stack

The method that the STC-2002 uses to evaluate Boolean expressions. Each Boolean value is placed on a stack when an operator or input expression is encountered and popped off when an output expression is encountered. By using a stack, parenthesis are not needed in writing I/O programs. **See Section 5.8**

Push

Every time the STC-2002 comes across an input function, the associated value (T/F, On/Off) is pushed on the top of the stack. Everything else in the stack moves down one position. **See Section 5.8**

Pop

Every time the STC-2002 comes across an output function or operator, the top value(s) is popped off of the stack (and another pushed back in the case of operators). In the case of an output function, the value that is popped is used to define the specific output behavior performed. **See Section 5.8**

Table 5.2: Glossary Of Terms.

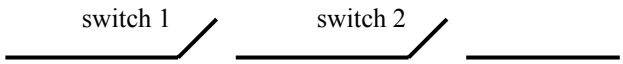
Boolean Operations

SECTION 5.2 Boolean Definition

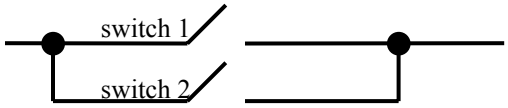
A basic understanding of Boolean operations is needed before you can write an I/O program. A Boolean variable has only 2 states. This can be thought of as *on* and *off*, *closed* and *opened*, *1* and *0*, *active* and *inactive*, or *true* and *false*. Only the terminology is different for these examples. The important thing to keep in mind is that there can be only 2 states.

Boolean Operations

There are 3 basic operations that you can do with Boolean variables. These are 'AND*ing*', 'OR*ing*', and 'Complementing' (complementing is also known as the 'NOT' operator). For the 'AND' operator, both input conditions must be true for the output to be true. If you are familiar with relays, this is like putting 2 relays in series with each other. Both relay switches must be closed for the output to become active.



For the 'OR' operator, either input condition being true will cause the output to become true. In terms of the relay description, either one of the switches (or both of the switches) can be closed to activate the output.



The 'NOT' operator is only used on one input condition. It outputs the reverse state of the input. This is like using the normally closed (instead of the normally open) contacts of a relay, converting *true* to *false*, *on* to *off*, *off* to *on*, etc.

Figure 5.1 illustrates using relays and the way the STC-2002 represents their function. Many people like to first write out their solution using relay notation, then translate each rung for the STC-2002's notation.

Relay Ladder Notation

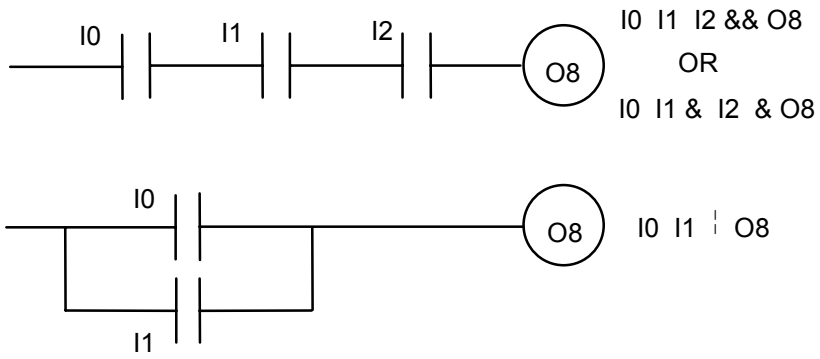


Figure- 5.8: Relay Ladder Notation [top is 'AND'ing, bottom is 'OR'ing]

Truth Table Notation

When using Boolean operators, it is common to use a truth table, (Refer to Table 5.3). This shows all possible combinations of inputs and the resulting outputs. Let's assume that we have 2 input terms called A and B, and the output term is called C. The **operator symbols** for 'AND', 'OR' and 'NOT' are **&**, **¦**, and **!** , respectively. For the following table, we will use TRUE (T) and FALSE (F) to indicate Boolean states.

& (AND)	¦ (OR)	! (NOT)
A & B = C	A ¦ B = C	! A = C
T T T	T T T	T F
T F F	T F T	F T
F T F	F T T	
F F F	F F F	

Table 5.3: Truth Table.

SECTION 5.3 STC-2002 States and Events

You are already familiar with states of the STC-2002. Some of them appear on the RunTime screen and appear as large characters. Common states are STOPPED, DEPOSIT, RISE 1, etc. States are just a period of time in which the STC-2002 does a particular task. There are many internal states into which you have access with the I/O program. It is not necessary to fully understand the internal workings of the STC-2002 in order to write an I/O program, however. By examining the examples later in this section, you can get a good idea of what is needed.

State Diagram Notation

In writing an I/O program, you can test whether a state is active or not. Events cause something to happen in the STC-2002. An example of an event is pushing the START key. In **state diagram notation**, events are the lines connecting states together. The I/O system can force events in the STC-2002. Refer to Table 5.4, a list of all of the **states** and **events** the I/O system can access. You may want to copy this table and keep it handy as you go through the examples. It provides a key to the codes in an I/O program. Four front panel LEDs (output) and four fixed front panel keys (input) have been assigned ID's which allow them to be incorporated into an I/O program (Table 5.6,#64-71).

ID Number	Valid Functions - Type	Class	Description
0 To 7	I - B	I/O	Remote Inputs 1 Through 8 (slot 1)
8 To 15	All - B	I/O	Relay Outputs 1 Through 8 (slot 2)
16 To 23	I - B	I/O	Remote Inputs 1 Through 8 (slot 3)
24 To 31	All - B	I/O	Relay Outputs 1 Through 8 (slot 4)
32 To 39	All - B	I/O	Relay Outputs 1 Through 8 (slot 1) [see ID 0-7, slot 1]
40 To 47	I - B	I/O	Remote Inputs 1 Through 8 (slot 2)
48 To 55	All - B	I/O	Relay Outputs 1 Through 8 (slot 3)
56 To 63	I - B	I/O	Remote Inputs 1 Through 8 (slot 4)
64 To 67	All - B	I/O	leftmost=64, rightmost=67 front panel LED indicators
68 To 71	I - B	I/O	leftmost=68, rightmost=71 fixed front panel function keys
72	I - B	Istate	Manual Mode [true/false]
73	I - V	Istate	Stopped Mode - Power Up [0]
73	I - V	Istate	True If Not In Any Stopped Mode [1]
73	I - V	Istate	Stopped Mode - Crystal Bad [2]
73	I - V	Istate	Stopped Mode - Remote I/O [3]
73	I - V	Istate	Stopped Mode – Front Panel [4]
73	I - V	Istate	Stopped Mode – Max. Power Abort [5]
73	I - V	Istate	Stopped Mode – Hand Controller [6]
73	I - V	Istate	Stopped Mode – User Interface Presence Lost [7]
73	I - V	Istate	Stopped Mode – Measurement Comm. to SS Card Lost [8]
73	I - V	Istate	Stopped Mode – Communication to I/O Card Lost [9]
73	I - V	Istate	Stopped Mode – Bus Hold Integrity Error [10]
73	I - V	Istate	Stopped Mode – Rotator Time-out Failure [11, 12...19]
74	I - V	Istate	Film 1 Through 9 Active [# 1-9] (0 if non-sequencing mode)
75	I - V	Istate	Process 1 Through 9 Active [# 1-9]
76	I - V	Istate	Polling Current Layer Info (0-99)
77	I - B	Istate	Sequencer Running a Process = True / at Rest = False
78	I - M	Istate	True If Power = 0%. Bitmap 8 sources
79	I - M	Istate	True If Source Shutter Open During Deposit Phase
80	I - V	Istate	Phase – Power Up [0]
80	I - V	Istate	Phase – Stopped At Zero Power [1]
80	I - V	Istate	Phase – Begin Crystal Verify [2]
80	I - V	Istate	Phase – Rise 1 [3]
80	I - V	Istate	Phase – Soak 1 [4]
80	I - V	Istate	Phase – Rise 2 [5]
80	I - V	Istate	Phase – Soak 2 [6]
80	I - V	Istate	Phase – Soak Hold [7]
80	I - V	Istate	Phase – Shutter Delay [8]
80	I - V	Istate	Phase – Deposit [9]
80	I - V	Istate	Phase – Rate Ramp [10]
80	I - V	Istate	Phase – Deposit After Rate Ramp [11]
80	I - V	Istate	Phase – Time/Power Recovery Phase [12]
80	I - V	Istate	Phase – Idle Ramp [13]
80	I - V	Istate	Phase – Idle Power After Successful Deposit [14]
80	I - V	Istate	Phase – Idle From Time-Power Mode [15]
80	I - V	Istate	Phase – Manual Control [16]
80	I - V	Istate	Phase – Ready After Stop – Waiting For Start [17]
80	I - V	Istate	Phase – Indexing To Pocket [18]
80	I - V	Istate	Phase – Hold Film Before Rise/Soak [19]
81	I - M	Istate	XTAL Shutter State- All Sensor Shutters Closed [0]
81	I - M	Istate	XTAL Shutter State- Sensor #1 = Shutter Open [1]
81	I - M	Istate	XTAL Shutter State- Sensor #2 = Shutter Open [2]
81	I - M	Istate	XTAL Shutter State- Sensor #3 = Shutter Open [4]
81	I - M	Istate	XTAL Shutter State- Sensor #4 = Shutter Open [8]
81	I - M	Istate	XTAL Shutter State- Sensor #5 = Shutter Open [16]
81	I - M	Istate	XTAL Shutter State- Sensor #6 = Shutter Open [32]
81	I - M	Istate	XTAL Shutter State- Sensor #7 = Shutter Open [64]
81	I - M	Istate	XTAL Shutter State- Sensor #8 = Shutter Open [128]
81	I - M	Istate	XTAL Shutter State- All Sensor Shutters Open [255]
82	I - M	Istate	SRC Being Modified or Designated as Active
83	I - M	Istate	Xtal Used Map- Sensors Making Active Contribution
84	I - M	Istate	Xtal Standby Map- Sensors In Standby Mode

Function Index

I INPUT
O OUTPUT
T TRIP
A ARM
D DROP
S SET
C CLEAR

Type Values

B Boolean
V Scalar
M Bitmap (combined bit weights)
E Event

ID number	Valid Functions – Type	Class	Description
85	I - M	Istate	Xtal Failed Map- Failed Sensors
86	I - V	Istate	Sample / Hold Status- No cycle Activity, State Not Important [0]
86	I - V	Istate	Sample / Hold Status- Sampling, Xtal is Read for Control [1]
86	I - V	Istate	Sample / Hold Status- Holding, Xtal Covered, estimated Rate [2]
87	I - M	Istate	Crystal Life Over Bounds
88	I - M	Istate	Max. Power Condition- SRC @ Max Power = True, Else False
88	I - M	Istate	Max. Power Condition- No Sources @ Max Power Limit [0]
88	I - M	Istate	Max. Power Condition- Source #1 @ Max Power Limit [1]
88	I - M	Istate	Max. Power Condition- Source #2 @ Max Power Limit [2]
88	I - M	Istate	Max. Power Condition- Source #3 @ Max Power Limit [4]
88	I - M	Istate	Max. Power Condition- Source #4 @ Max Power Limit [8]
88	I - M	Istate	Max. Power Condition- Source #5 @ Max Power Limit [16]
88	I - M	Istate	Max. Power Condition- Source #6 @ Max Power Limit [32]
88	I - M	Istate	Max. Power Condition- Source #7 @ Max Power Limit [64]
88	I - M	Istate	Max. Power Condition- Source #8 @ Max Power Limit [128]
88	I - M	Istate	Max. Power Condition- All Sources @ Max Power Limit [255]
89	I - B	Istate	Increment Key - Hand Controller
90	I - B	Istate	Decrement Key - Hand Controller
91	I - B	Istate	Stop Key – Hand Controller
92	I - V	Istate	Process Verify Phase [0] (sequencing mode only)
92	I - V	Istate	Process Stopped, Number Displayed [1] (sequencing mode only)
92	I - V	Istate	Process Resting [2] (sequencing mode only)
92	I - V	Istate	Process Busy [3] (sequencing mode only)
92	I - V	Istate	Process Waiting [4] (sequencing mode only)
92	I - V	Istate	Process Error [5]
93	I - V	Istate	Process Not Failed [0]
93	I - V	Istate	Bad Recipe [1]
93	I - V	Istate	Process Aborted [2]
94	I - B	Istate	True if front panel is communicating
95	I - B	Istate	true when Sensor card failure occurs
96	I - B	Istate	T=front panel PCB (UIFC) not communicating (w/o STOP key)
97	I - B	Istate	True = Crystal Test / Simulate Mode Activated
98	I - M	Istate	Rotator Sync Map- Synchronization needed, 1 per each Source
99	I - V	Istate	Active Source Being Controlled [1 To 8]
100	I - B	Istate	True = Non-Sequencing Mode Active
101	I - V	Istate	Active Map of Source Sensor usage
102	I - M	Istate	Available Modules (in bit map pairs)
103	I - V	Istate	Source 1: Pocket Code [0-63] (in Film Program)
104	I - V	Istate	Source 2: Pocket Code [0-63] (in Film Program)
105	I - V	Istate	Source 3: Pocket Code [0-63] (in Film Program)
106	I - V	Istate	Source 4: Pocket Code [0-63] (in Film Program)
107	I - V	Istate	Source 5: Pocket Code [0-63] (in Film Program)
108	I - V	Istate	Source 6: Pocket Code [0-63] (in Film Program)
109	I - V	Istate	Source 7: Pocket Code [0-63] (in Film Program)
110	I - V	Istate	Source 8: Pocket Code [0-63] (in Film Program)
111	I - V	Istate	I/O Slot 1: PCB Status: Not Established Yet [0]
111	I - V	Istate	I/O Slot 1: PCB Status: Not Detected, Config = Empty [1]
111	I - V	Istate	I/O Slot 1: PCB Status: Disabled Input Card in Slot [2]
111	I - V	Istate	I/O Slot 1: PCB Status: Disabled Output Card in Slot [3]
111	I - V	Istate	I/O Slot 1: PCB Status: Input Card Detected in Slot [4]
111	I - V	Istate	I/O Slot 1: PCB Status: Output Card Detected in Slot [5]
111	I - V	Istate	I/O Slot 1: PCB Status: MIA, Config'd Input on Empty Slot [6]1
111	I - V	Istate	I/O Slot 1: PCB Status: Conflict, have output, need input card [7]
111	I - V	Istate	I/O Slot 1: PCB Status: MIA, Config'd Output on Empty Slot [8]
111	I - V	Istate	I/O Slot 1: PCB Status: Conflict, have input, need output card [9]
112	I - V	Istate	I/O Slot 2: PCB Status (see Slot 1 breakout)
113	I - V	Istate	I/O Slot 3: PCB Status (see Slot 1 breakout)
114	I - V	Istate	I/O Slot 4: PCB Status (see Slot 1 breakout)
115	I - V	Istate	Sensor Slot A Status: Unknown (until PCB is polled) [0]
115	I - V	Istate	Sensor Slot A Status: PCB Located by Communication [1]
115	I - V	Istate	Sensor Slot A Status: PCB Not Located by Communication [2]
115	I - V	Istate	Sensor Slot A Status: PCB exists but incorrect Configuration [3]
115	I - V	Istate	Sensor Slot A Status: No PCB but correct Configuration [4]
115	I - V	Istate	Sensor Slot A Status: PCB has Incompatible Software Rev [5]

ID number	Valid Functions – Type	Class	Description
115	I - V	Istate	Sensor Slot A Status: PCB that was initially OK, now fails [6]
116	I - V	Istate	Sensor Slot B Status: (see Slot A breakout)
117	I - V	Istate	Sensor Slot C Status: (see Slot A breakout)
118	I - V	Istate	Sensor Slot D Status: (see Slot A breakout)
119	I - V	Istate	Source Channel 1 Sensor Head Status: Off, Not Needed [0]
119	I - V	Istate	Source Channel 1 Sensor Head Status: Active, Contributing [1]
119	I - V	Istate	Source Channel 1 Sensor Head Status: Dropped, OK→Failed [2]
119	I - V	Istate	Source Channel 1 Sensor Head Status: Failed, no replacem't [3]
119	I - V	Istate	Source Channel 1 Sensor Head Status: Missing, Config Err [4]
119	I - V	Istate	Source Channel 1 Sensor Head Status: Standby, backup list [5]
119	I - V	Istate	Source Channel 1 Sensor Head Status: Switched, fail to bak [6]
120	I - V	Istate	Source Channel 2 Sensor Head Status: (see Channel 1)
121	I - V	Istate	Source Channel 3 Sensor Head Status: (see Channel 1)
122	I - V	Istate	Source Channel 4 Sensor Head Status: (see Channel 1)
123	I - V	Istate	Source Channel 5 Sensor Head Status: (see Channel 1)
124	I - V	Istate	Source Channel 6 Sensor Head Status: (see Channel 1)
125	I - V	Istate	Source Channel 7 Sensor Head Status: (see Channel 1)
126	I - V	Istate	Source Channel 8 Sensor Head Status: (see Channel 1)
127	I - M	Istate	Verify Memory: Invalid Section: Film Parameters Area [1]
127	I - M	Istate	Verify Memory: Invalid Section: I/O Programming Area [2]
127	I - M	Istate	Verify Memory: Invalid Section: Process Accounting Area [4]
127	I - M	Istate	Verify Memory: Invalid Section: Process Sequence Area [8]
127	I - M	Istate	Verify Memory: Invalid Section: Archive fail (to Mem Mod) [16]
127	I - M	Istate	Verify Memory: Invalid Section: Clone fail (to Dep Contrlr) [32]
127	I - M	Istate	Verify Memory: Invalid Section: Clone OK [64]
128	I - B	Istate	Needs Reboot or Service, fatal error
129-149			Available
150	IO - B	Ustate	Resets / Sets Soak Hold Mode
151	IO - B	Ustate	Sample Off / On When In Sample/Hold Mode
152	IO - B	Ustate	Film Hold Off / On (requires event trig leave)
153	IO - M	Ustate	Set Deposition Power to 'Zero' (Unconditional) [Off = 0, On = 1]
153	IO - M	Ustate	No Sources Overridden, Source is at System Power [0]
153	IO - M	Ustate	Source #1 Overridden to Zero Power [1]
153	IO - M	Ustate	Source #2 Overridden to Zero Power [2]
153	IO - M	Ustate	Source #3 Overridden to Zero Power [4]
153	IO - M	Ustate	Source #4 Overridden to Zero Power [8]
153	IO - M	Ustate	Source #5 Overridden to Zero Power [16]
153	IO - M	Ustate	Source #6 Overridden to Zero Power [32]
153	IO - M	Ustate	Source #7 Overridden to Zero Power [64]
153	IO - M	Ustate	Source #8 Overridden to Zero Power [128]
153	IO - M	Ustate	All Sources Overridden To Zero Power [255]
154	IO - B	Ustate	$M_{easured\ rate\ not\ =\ desired\ Rate.\ (>=),\ set\ true\ when\ Rate\ >\ desired,\ user\ clr}$
155	IO - B	Ustate	Check if Zeroing is allowed on entering deposit (T = Skip)
156	IO - V	Ustate	I/O scalar analog out (0-255) times multiplier changes output
157	IO - V	Ustate	Launch Film number ___
158-169			Available
170-199	IT	Event	Computer Events 00 To 29
200	IT	Event	Stop
201	IT / All	Evnt/Stat	Non-Seq Mode = Proc Start Event Req./ Seq Mode = Soft Node
202	IT / All	Evnt/Stat	Non-Seq Mode = Generic I/O Start / Seq Mode = Soft Node
203	IT	Event	Switch *to Process* 1 and Start it [non-seq mode = *to Film*]
204	IT	Event	Switch *to Process* 2 and Start it [non-seq mode = *to Film*]
205	IT	Event	Switch *to Process* 3 and Start it [non-seq mode = *to Film*]
206	IT	Event	Switch *to Process* 4 and Start it [non-seq mode = *to Film*]
207	IT	Event	Switch *to Process* 5 and Start it [non-seq mode = *to Film*]
208	IT	Event	Switch *to Process* 6 and Start it [non-seq mode = *to Film*]
209	IT	Event	Switch *to Process* 7 and Start it [non-seq mode = *to Film*]
210	IT	Event	Switch *to Process* 8 and Start it [non-seq mode = *to Film*]
211	IT	Event	Switch *to Process* 9 and Start it [non-seq mode = *to Film*]
212	IT	Event	Break Process Wait
213	IT	Event	Restart Film
214	IT	Event	Start Next Layer
215	IT	Event	Process Reset / Start
216	IT	Event	Seq Mode: Unconditional Process Start by I/O or Host Comp.

217	IT	Event	Final Thickness Trigger (from measurement or external)
218	IT	Event	Rate measurement system (from crystal onward) failed
219	IT	Event	Zero Thickness Event Requested / Performed
220	IT	Event	Setpoint Time Triggered Condition
221	IT	Event	Setpoint Thickness Triggered Condition
222	IT	Event	Set Manual Mode Off
223	IT	Event	Set Manual Mode On
224	IT	Event	Metronome Timer Event in Seconds (Once Per Second Event)
225	IT	Event	Metronome Timer Event in Minutes (Once Per Minute Event)
226	IT	Event	Metronome Timer Event in Hours (Once Per Hour Event)
227	IT	Event	Begin Job/Process Event
228	IT	Event	Begin Job/Film Event
229	IT	Event	Begin Job/Deposit Event
230	IT	Event	End Of Job/Deposit Event
231	IT	Event	End Of Job/Film Event
232	IT	Event	End Of Job/Process Event
233	IT	Event	Rate Ramp Trigger (Rate Ramp Starts if Enabled)
234	IT	Event	Gun 1: pocket good
235	IT	Event	Gun 2: pocket good
236	IT	Event	Gun 3: pocket good
237	IT	Event	Gun 4: pocket good
238	IT	Event	Gun 5: pocket good
239	IT	Event	Gun 6: pocket good
240	IT	Event	Gun 7: pocket good
241	IT	Event	Gun 8: pocket good
242	IT	Event	Release Film Hold Event
243	IT	Event	Release Soak Hold Event
244	IT	Event	Trigger Request To Rescan Sensor Map Matrix
245	IT	Event	Channel 1: Thickness Zero
246	IT	Event	Channel 2: Thickness Zero
247	IT	Event	Channel 3: Thickness Zero
248	IT	Event	Channel 4: Thickness Zero
249	IT	Event	Channel 5: Thickness Zero
250	IT	Event	Channel 6: Thickness Zero
251	IT	Event	Channel 7: Thickness Zero
252	IT	Event	Channel 8: Thickness Zero
253	IT	Event	Gun 1: Reset Output Power (only works on non-active sources)
254	IT	Event	Gun 2: Reset Output Power (only works on non-active sources)
255	IT	Event	Gun 3: Reset Output Power (only works on non-active sources)
256	IT	Event	Gun 4: Reset Output Power (only works on non-active sources)
257	IT	Event	Gun 5: Reset Output Power (only works on non-active sources)
258	IT	Event	Gun 6: Reset Output Power (only works on non-active sources)
259	IT	Event	Gun 7: Reset Output Power (only works on non-active sources)
260	IT	Event	Gun 8: Reset Output Power (only works on non-active sources)
261	IT	Event	Channel 1: User Fource Fails Sensor Channel
262	IT	Event	Channel 2: User Fource Fails Sensor Channel
263	IT	Event	Channel 3: User Fource Fails Sensor Channel
264	IT	Event	Channel 4: User Fource Fails Sensor Channel
265	IT	Event	Channel 5: User Fource Fails Sensor Channel
266	IT	Event	Channel 6: User Fource Fails Sensor Channel
267	IT	Event	Channel 7: User Fource Fails Sensor Channel
268	IT	Event	Channel 8: User Fource Fails Sensor Channel
269	IT	Event	Measurement at Rate for 4 Seconds (event 154 function duplicate)
270	IT	Event	I/O Auxiliary Stop 1
271	IT	Event	I/O Auxiliary Stop 2
272	IT	Event	I/O Auxiliary Stop 3
273	IT	Event	I/O Auxiliary Stop 4
274	IT	Event	Start Coupling (for non-sequencing film starts linkage)
275-299			Available
300 - 399	All	State	1st Soft Node To Last Soft Node
400 To 409	ISCAD	Counter	Modulo 100 Counters [10 counters]

Function Index

I	INPUT
O	OUTPUT
T	TRIP
A	ARM
D	DROP
S	SET
C	CLEAR

Type Values

B	Boolean
V	Scalar
M	Bitmap (combined bit weights)
E	Event

Table 5.4: Event And State ID List. […continued from previous 3 pages]

SECTION 5.4 Steady State vs. Edges

In order to fully understand how an I/O program works, we need to look at Edge type events. There is an additional complication using Boolean operators. We need to differentiate not only when a variable is True or False (the steady state condition), but **when** and **if** it changes state. Think of what is involved in zeroing the thickness, for example. When you press the ZERO key, the thickness is actually zeroed when the key was first detected as being pushed, once only, not continuously.

Edge Events

It is because of this transitioning between States (or Edge Event) that the zeroing happens. It is important to understand Edge type events in the STC-2002. If you look at Table 5.4, events that must be triggered using an edge are numbers 170 through 273. If you try to use a **non-edge output** operator on these events, you will get an **error** message.

SECTION 5.5 Input Functions

Input Functions are used to test the condition or state of something. An Input Function is not limited to only remote hardware inputs. You are free to use an Input Function on a relay or any other variable. In this case, you may want to test the condition of something that was set.

Input

*Input (**I**)* is the only type of input function. After the prefix **I**, you will be asked to specify a variable ID number to be used. As an example, if you see **I3** in the I/O program, this means use remote input number 4 (from Table 5.4) as an input. The input function works on steady state types of states to push to the stack the variables current value. That is, if you try to do an input function on an edge type event pushes True once on the first occurrence of the event (transient), you will get an error message.
Note: the KON# (constant) could also be thought of as a means to input.

SECTION 5.6 Output Functions

There are several ways to evaluate the result of a rung in the STC-2002. A rung must have 1 and **only 1** output function. Some Output Functions are for use with edges and others are for use with steady states.

There are several ways of **describing edges** in the I/O program of the STC-2002. The Trip function is used exclusively to force events in the STC-2002. Arm and Drop are the other two output functions that operate when triggered by edges, and operate on I/O outputs, softnodes and counters.

Output

The **Output** function (**O**) is used as a steady state output. It will take the evaluated state of the rung and use the value as an output. It is common to use the output function for relays and softnodes. Not available for events, counters, hardware inputs.

Trip

The **Trip** Function (**T**) can be used for providing a pulse to an output, either of a relay or softnode. It is triggered by a positive Edge transition (something that goes from false to true). The output will stay true for about 1 second, then go back to the false state. This is sometimes known as a 1-shot function. In addition, all of the events of the STC-2002 can only be triggered using this function. This is indicated in Table 5.4, by having a 'T' in the valid function column.

Arm And Drop

There are two other functions that operate by triggering on edge transitions. These are called **arm** and **drop** (**A** and **D**). The identified output will become true when there is a positive edge on the arm input. The output will remain true until something else makes it false. The drop function is the opposite of arm. The output will become false on the positive edge of the drop input. These are different from the trip function because the arm causes the output to go high and stay there. It takes a drop function to cause the output to go back low. The arm and drop functions are to be used together. If you use arm on an output, somewhere in the I/O program you must use a drop or clear on that output, unless the relay or output activates and latches.

Set And Clear

There are 2 functions that may look like edge events, but they are **level** triggers. They are called **set** and **clear** (**S** and **C**). A true condition on the set of an output will cause the output to become true and stay that way even when the input condition later becomes false. This is known as a **latching** function. The clear input will cause the output to become false when the clear becomes true. The clear function is the opposite of the set function. (The set/clear and the arm/drop can be mixed and matched, i.e. set/drop or arm/clear)


Note

Note Remember that only a trip function can cause a trigger to an **internal** event of the STC-2002. If you try to program any other output to events, you will get an error message.

SECTION 5.7 Soft Nodes and Sync Events

Soft nodes in the STC-2002 are a special type of I/O variable. Their **ID** numbers are 300 through 399. They can act as temporary storage areas for intermediate results. If you develop complex I/O rungs, you can use these soft nodes to break these up into several simpler rungs. Devices such as counters and shift registers can be implemented using soft nodes.

Another usage is to re-program some of your relays quickly. Just use the soft nodes as intermediate outputs of your rungs. Then you can have a simple rung that Inputs a Soft Node and Outputs it to a relay. There is an example later in this section of doing this.

Synchronize Events

There are 30 events (ID#s 170 to 199) that have a special use with the computer interface. They can be set with commands through the computer. In this manner, you can synchronize events in the STC-2002 with an external computer via an active I/O program.

SECTION 5.8 Internal Operations

The way the STC-2002 interprets an I/O program is useful to know, especially when writing complicated programs. The way variables and functions are evaluated is by using what is called a **stack**. By using this method, parentheses are not needed to specify order and use of operations. Each item that is entered into your program will either push something on the stack, pop it off, or modify the stack contents. The variables are evaluated to be either true or false (or a scalar value if of M or V types) and that value is used. Let us look at the following rung and see how the stack works. Refer to Table 5.4, for what the ID numbers refer to.

Stack Operation

```
I0 I1 ! ¦ O8
```

Scanning Tokens

The way this is read is: do an input function on ID #0 (remote input #1), do an input function on ID #1 (remote input #2), complement what is on the top of the stack (the state of remote input #2 in this case), do an 'OR' operation, and output the result to ID #8 (relay #1).

Assume That The Variables **`I0`** And **`I1`** Are Both False. As the rung gets evaluated, the stack will look like this.

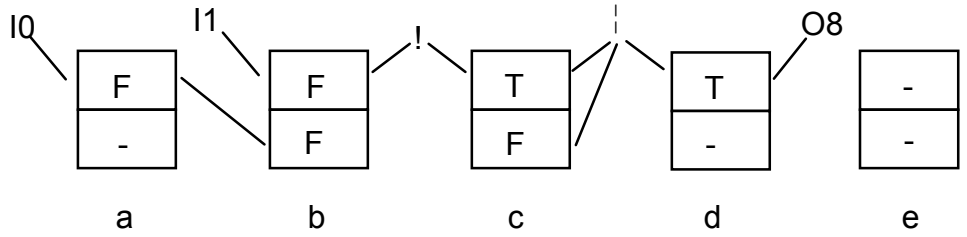


Figure- 5.9: Stack I/O Operations.

The **lines** indicate the movement of the stack. A downward slope of the lines in Figure 5.9 indicates a push operation and an upward slope indicates a pop. Notice that when the rung is completely evaluated, the stack is empty (Figure 5.9e). The stack in this example has a depth of only 2 objects, but the STC-2002 has a much larger stack. Because you cannot enter a rung longer than a line on the display, it is not possible to exceed the depth of the stack.

Each token within the rung is scanned, and each rung is scanned. All of the rungs are scanned 10 times per second. An input function causes the evaluated variable to be pushed on the stack. An output function will cause the stack to be popped. The value that is taken off of the stack is used as the output. The 'AND', 'OR' operators will pop 2 values off of the stack, do the operation, then push the result back on the stack. The 'NOT' operator will pop 1 value off of the stack, reverse the state of it, then push it back on. Likewise, all the other arithmetic, relational and selection operators perform similarly (see chart). The stack is always empty when the STC-2002 starts to evaluate a rung, and must be empty when it finishes

evaluating a rung. These stack rules are checked when the editing of a rung is completed. If the stack operations are not balanced when this happens, the STC-2002 will issue an error message.

SECTION 5.9 Operate Menu

There are **2 options** under the Operate Menu. These are used to suspend/resume the operation of the I/O program. The use of **turning off** the operation of the I/O program is in case something goes **wrong**. You can shut off the program while editing changes so relays are not turning on and off before the program is completely entered.

Stopping The I/O Program

Use **caution** when causing the I/O program to stop running. This should be a temporary condition used for entering or modifying your program only. If someone else does not know the I/O program is stopped and tries to run the instrument, the results can be **serious**. See figure x5.3 and OPR key definition in section 5.11.

SECTION 5.10 Memory Menu

Saving Your Program.

This provides you with the ability to **save** and **recall** your I/O program. If you want to try something new with the I/O system, it is a good idea to save what you have running before making major changes to the program. The **Save option** will take the entire I/O program and store it in an alternative memory sector. The **Swap option** will put the active I/O program into inactive status, and take what was in inactive memory and make it active. Both programs (one in alternate memory and one in active memory) are remembered when power is off. The I/O program check sum (prefixed with the label **ID=**) also reflects which memory section is in use by it's first character: **A** or **B** memory.

(See section 2.21 for checksum validation).
(See section 2.6 for Factory settings...)
(See section 3 for memory module.)

In addition to saving your program in memory, be sure to record it on a piece of **paper** also. If a unit ever needs to be replaced, you will have to reprogram its I/O for your system requirements. See figure 5.10 and MEM key definition in section 5.11.

SECTION 5.11 Editing an I/O Program

In order to get to the I/O screens, you need to navigate through the following sequence. From the Run Time Screen, press the **fixed MENU** key. When the **MAIN MENU** appears, press the **EXECUTIVE MENU** key and then press the **I/O SETUP** key and the unit will display the following screen. Rungs (I/O SETUP Program lines) can range from 001 (END statement only) to 999 (memory constraints aside). 001 and 1 refer to the same rung, etc.

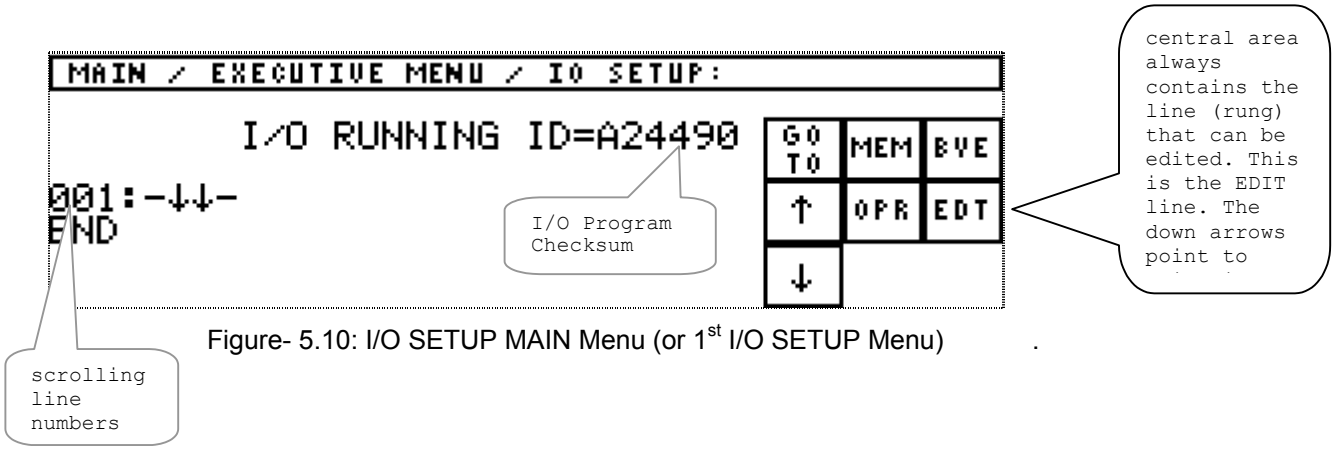
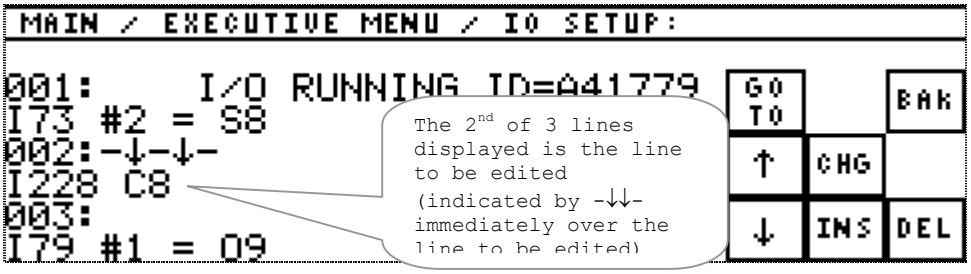


Figure- 5.10: I/O SETUP MAIN Menu (or 1st I/O SETUP Menu) .



Top Level I/O Menu: See Fig. 5.10. Typical I/O Program: (with line # 002 in the edit position) See Fig. 5.11.

Figure- 5.11: EDT (edit) menu with typical I/O Program values.

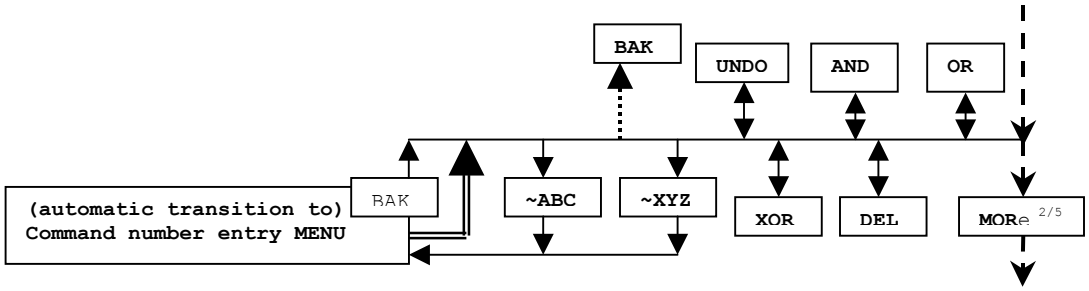
Figure 5.10 is the top level of the I/O menu. Figure 5.12 shows the structure of the various menus. By pressing the **fixed STATUS** key while in this set of menus, you will be taken back to the Run Time screen. The **BAK** key navigates *back* up one level and cancels unfinished EDTs (edits). The **BYE** key returns to the Executive MENU.

A fictitious representative section of the real I/O Programming menu tree on the following page is presented here as an example. This menu segment is a pseudo composite representation of the first and second in a series of 5 menus accessed through the EDIT/CHanGe path of the I/O SETUP menu. The representation is meant to be like a flowchart. The longest horizontal line is the second screen level from which all selections can be made. The dotted line on the right shows the entry point from the previous screen (screens can only be traversed in one direction). The double ended arrows are meant to illustrate that pressing the related key does not remove or modify the current screen (focus remains on the current screen). Keys UNDO, AND, OR, XOR, DEL are examples of this. BAK returns to the CHanGe Key entry point from any of the 5 change/edit screens. MORe x/5 invokes the next screen in the 5 screen sequence. At the 5th screen, MORe 5/5 returns to the 1st of 5 screens.

Note

Note: an unprogrammed unit will have only 1 line showing with the "END" line in the edit window, therefore ↑, ↓, **GOTO** have only one location to which they can *move*, that is list item #1. **DEL** (delete) is similar as the END line cannot be deleted. You must insert lines to have other line locations. **INS** (insert) lines or **CHG** (change) the END line. See figure 5.10 as an example of an unprogrammed unit.

Fictitious commands ~ABC and ~XYZ have an associated number that must be entered before the token is entered on the I/O program line (rung). The completed command entry would be something like "~ABC 121". The ~ABC command flows into the box representing the number entry screen. From the number entry screen, BAK will bring back the second screen level throwing out the entire command while ENTer will accept the command and its associated number and place them on the edited line which is at the second screen level. The BAK on the second screen level, returns to the menu point where the decision to Edit/Change was made (one menu level up from the 5 Edit/Change menus).



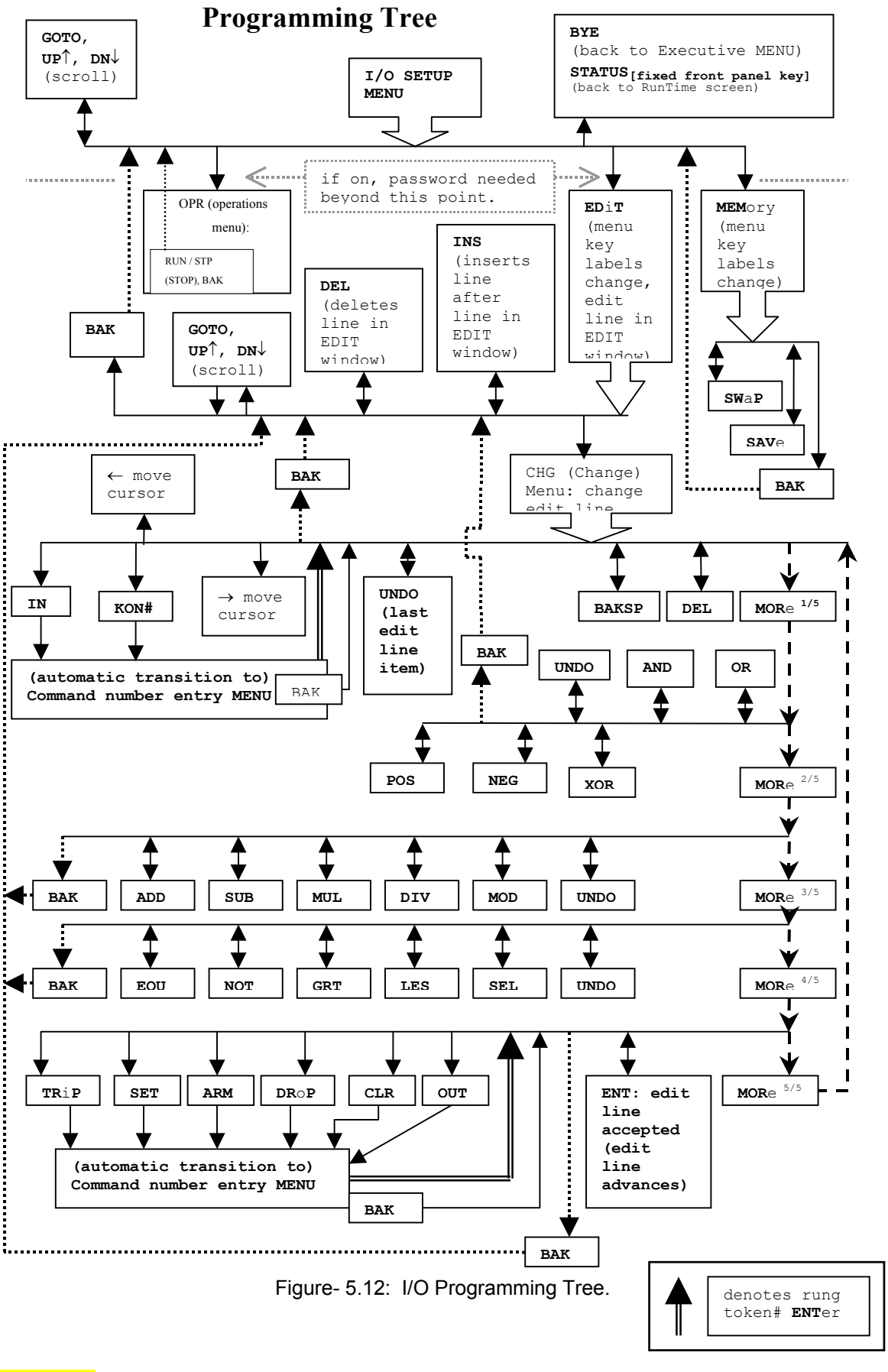
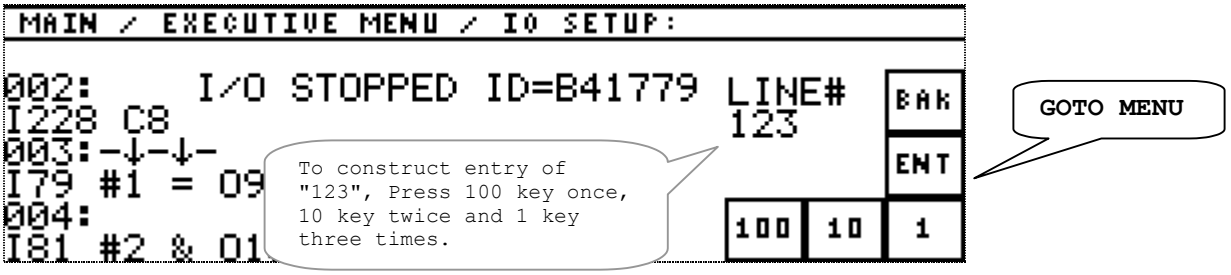


Figure- 5.12: I/O Programming Tree.

General Descriptions of I/O MENUs

GOTO: Press GOTO to move to a specified line (rung) in the I/O program setup list. This gives the capability of jumping to a rung if the rung (line) number is known. This is useful when the I/O program is complicated and there is a need to jump around in it rapidly. When a rung number is entered that exceeds the last existent rung, the GOTO function will move to the last available rung position (zero moves to 001). Having entered the GOTO function, the BAK key may alternately be pressed, instead of entering a line number. This will terminate the GOTO without effect. GOTO appears on the I/O Setup main menu (Fig. 5.10) and on the I/O Setup Edit menu (Fig. 5.11). Pressing the GOTO key on the main I/O menu (See Fig. 5.10) results in the following screen.



Pressing GOTO changes the key labels (as shown) to reflect a new level of functionality, that is, to enter a number that will be the object of the search and locate process. This number entry menu has provision to enter numbers in the range of 0-999. Numbers are entered by pressing any one or all of the three digit keys, which represent the total number. The hundreds digit (**100** key) is on the left, the tens digit (**10** key) is in the middle and the units digit (**1** key) is on the right. Each digit is incremented from zero with each key press. When nine is indicated, the subsequent key press will cause that digit alone to revert to a zero. Digits are independent of each other (no carryover). A key press of a digit effects only the digit pressed. After the desired number is completely entered, the ENT key may be pressed to accept the entry.

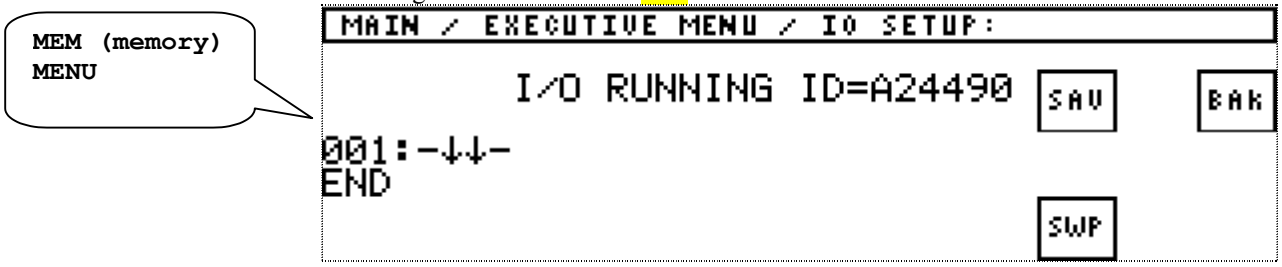
(UP)↑: Navigates up the rung list. The displayed section of the rung list moves toward the beginning of the rung list. (UP)↑ appears on the I/O Setup main menu (Fig. 5.10) and on the I/O Setup Edit menu (Fig. 5.11).

(DOWN)↓: Navigates down the rung list. The displayed section of the rung list moves toward the end of the rung list. (DOWN)↓ appears on the I/O Setup main menu (Fig. 5.10) and on the I/O Setup Edit menu (Fig. 5.11).

MENU: Press fixed **MENU** key to enter the menu system. When the fixed **STATUS** key is pressed from any place in the menus, the Run Time screen is returned.

BYE: Returns to the Executive Menu or one level back. See Fig. 5.10.

MEM: This allows you to save and exchange (swap) the I/O program that is in memory. A sub-menu selects among 3 choices: **SWP** (SWAP), **SAV** (SAVE), and **BAK** (BACK 1 level). Pressing the MEM (memory) key on the main menu (See Fig. 5.3) results in the following screen. See section 5.10.

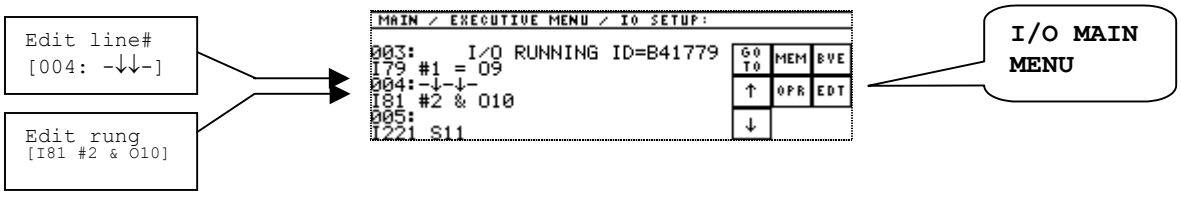


OPR: This key (OPeRations) will start and stop the I/O program by means of a sub-menu selection. Note: display changes to RUNNING when the RUN key is pressed and STOPPED when the STP (stop) key is pressed. There are times when the OPR function is locked out during the I/O setup. Pressing the OPR (operations) key on the main I/O menu (Fig. 5.10) results in the following.

See section 5.9.

EDT: The EDT (edit) key is used to insert rungs, delete rungs and go on to enter or change tokens/operators within a rung. This is the key that initiates the EDIT mode. The Edit sub-menu offers: arrow cursors, GOTO, CHG (change), INS (insert line), DEL (delete line) and BAK. Pressing the EDT (edit) key on the I/O Setup main menu (See Fig. 5.10) results in the appearance of the I/O Setup Edit menu (see Fig. 5.11).

At this point, there are 3 selection keys available (navigation aside): one for an editing sub-menu (**EDT**), another for an I/O program related memory option sub-menu (**MEM**), and a third for the operations control sub-menu (**OPR**). (See Fig. 5.10 and screen immediately below)
Also at this point, the display will contain an EDIT(view) window into the I/O program. Specifically, three consecutive rungs of the I/O program are displayed with the middle rung as the EDIT line (see figures 5.10 and screen immediately below). Each line of the I/O program is called a rung. Rung 004 is in the line edit position with contents of "I81 #2 & O10" indicated by -↓↓-. Rungs 003 and 005 are now view only. By pressing the **UP**↑ and **DOWN**↓ arrow keys on the LCD touch Panel, you can move through the I/O program rung list bringing different rungs into view with middle line ready to edit. **GOTO** also navigates by going directly to the entered rung number, making it the current rung in the EDIT window. **BYE** returns to the EXECUTIVE MENU. The fixed **STATUS** key returns to the Run Time screen.



SECTION 5.12 I/O SETUP Edit Menu

Pressing the **EDT** (edit) key produces the I/O Setup Edit menu as seen in figure 5.4. At this menu level, there are 3 edit options (navigation aside): **CHG** (change line currently in the 2nd [editing position] of the displayed rung list section), **INS** (insert a new [empty rung] line before the line in the editing [2nd] position of the displayed rung list section), and **DEL** (delete line currently in the 2nd, editing position of displayed rung list section).

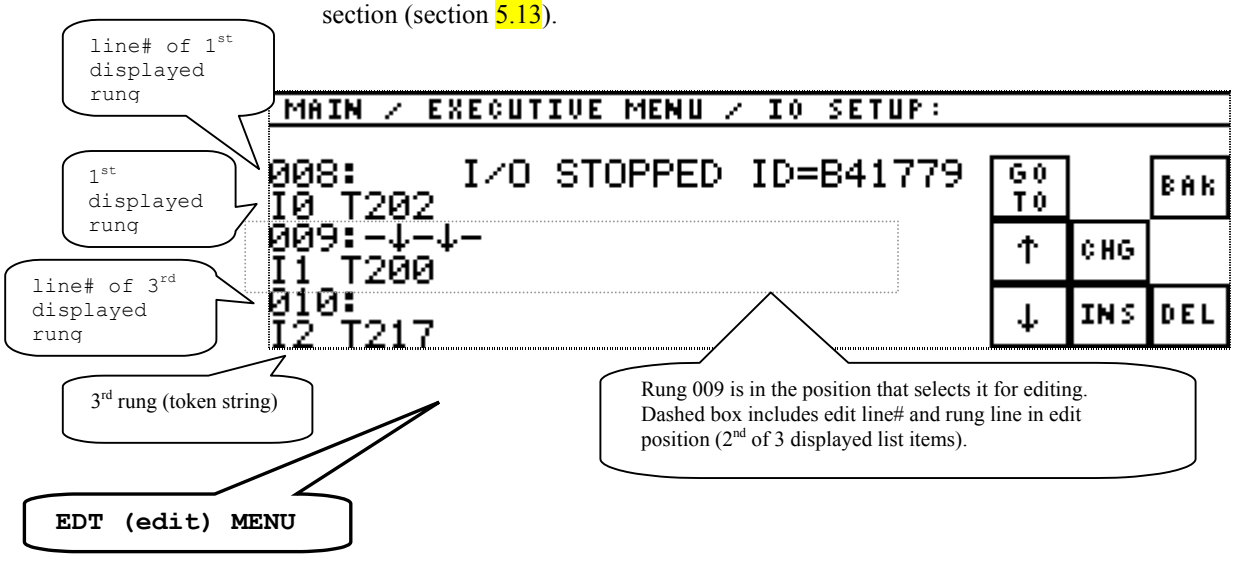
DEL This key deletes the rung (line) that currently appears in the EDIT position (centered rung with -↓↓- above it, see figure 5.10 or 5.11). The END rung cannot be deleted. The next consecutive rung assumes the place and line number of the rung (line) now vacated by the deletion. All subsequent rungs (lines), if any, are also moved up with the line number values decremented by 1.

INS This key inserts an empty rung (line) into the I/O setup program list with each key press. The new rung (line) is inserted just ahead of the rung (line) that is in the current edit position (see figure 5.11). The new rung assumes the EDIT position while previous EDIT position contents are advanced by one: in screen position, line number value and I/O list position.

In other words, the INS key inserts an empty rung just before the rung in the current EDIT position. After pressing the INS key, the new empty rung will occupy the EDIT position (2nd line) while the former rung is moved to the bottom (3rd) line with the line number incremented by 1. After a rung is inserted, use the CHG (change) key to alter the empty rung contents.

BAK: Quits the I/O SETUP Edit menu and returns to the I/O Setup main menu.

CHG: Can be used to modify (change) the contents of the rung (line) currently in the edit position (2nd line of displayed rung list section). Used for entering or changing function commands/operators within the rung. The CHG (Edit/Change) mode is the mode in which you will write your programs. You can construct rungs by adding/subtracting tokens (see table 5.1). The CHG (Change) key sub-menus are discussed in the next section (section 5.13).



The format of each rung as it appears in the edit/view window is as follows:

Rung (Line) # :
Token string of Rung

The format for the middle rung, which is the edit/change position, has the same format except for dashes and down arrows:

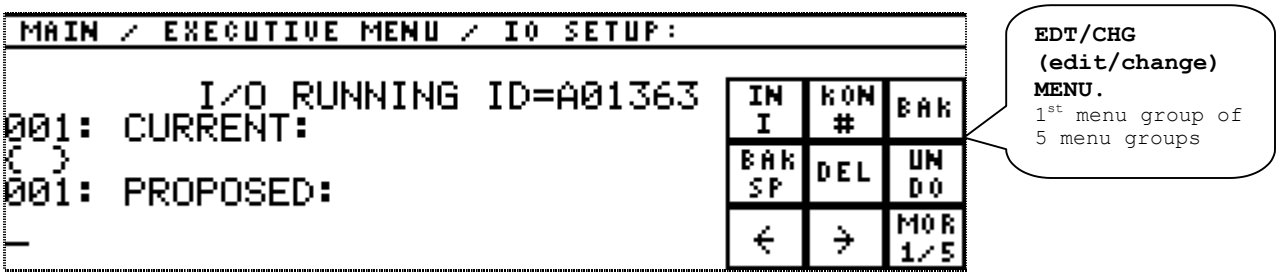
Rung (Line) # : -↓↓-
Token string of Rung

Note If an incorrect token string is entered on a rung, an error message will result when the rung ENT (enter) key is pressed. See section 5.19 for error message description.

Note

SECTION 5.13 Edit/Change Menu

Pressing the **CHG** (change) key on the **I/O Setup Edit menu** opens the **I/O Setup Edit/Change menu** as shown below. The CHG (change) key begins the sequence of menu keys by which the program is actually entered. Figure 5.12 shows the options under this menu key.



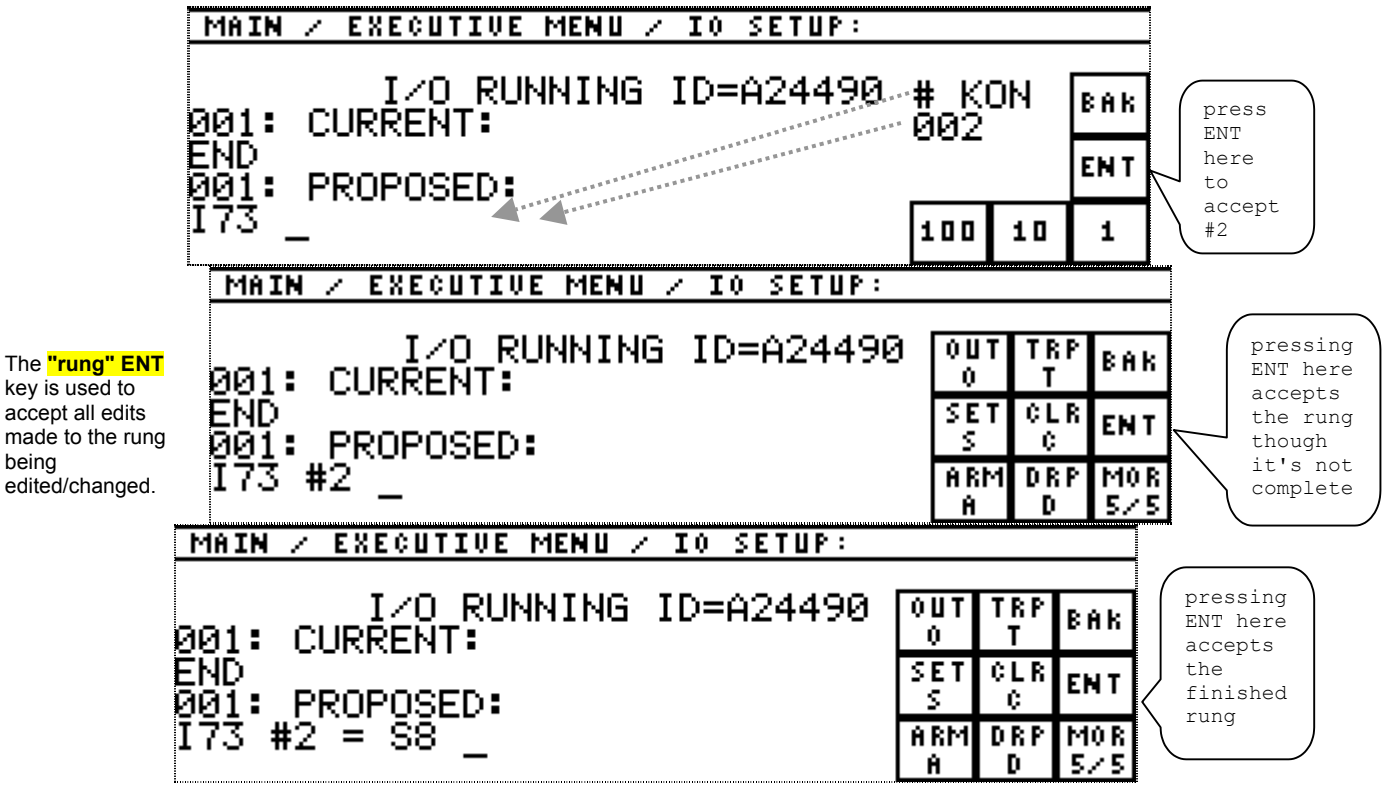
There are 5 sets of menu keys for the **I/O Setup Edit/Change menu.** They can be navigated and always appear in the same order by pressing the **MOR**e key.

The rung that was in the edit position on the displayed rung list, is now shown by itself on the **I/O Setup Edit/Change menu** screen. In the depiction below, the rung is in the process of being changed from an END rung to a typical control rung. Three tokens have been added. The cursor position now follows the I47 entry. This is the 1st of 5 key menus navigated by the **MOR**e key.

←: The rung line that is being edited (following *PROPOSED:*) has a **cursor,** which is represented by an underscore "_". The cursor indicates the point at which entries will be inserted or removed. Normally, this will be at the end of a new construction and at the beginning of a previously constructed rung that is being edited. The ← **key** moves the line cursor to the left within the range of the existing elements (tokens) on a single rung. Works like the cursor of a text editor using arrow keys.

→: As the ← , but moves the line cursor to the right.

ENT: There are two menu levels within the **I/O Setup Edit/Change menu** that use an **ENT** (enter) key**.** On one level, this key accepts all of the current rung edit[s] into the I/O program. On another level, the **ENT** (enter) key accepts the ID# of the *command/ID#* combination (each of the function commands entered has an associated ID number that forms a token). A rung is often built with multiple entries during an Edit/Change where *function command/ID#* combinations and logical operators form the constituent parts of a rung. A single press of the **ENT** key at the end of a string of edit/change additions will *accept* all of the rung edits. Of course, the **ENT** key must also be pressed after each function command element combination is added to the rung. The different menus and context should eliminate any confusion.



The **"rung" ENT** key is used to accept all edits made to the rung being edited/changed.

UNDO: Cancels in reverse order insertions and deletions up to 6 changes.

DEL: This editing command will erase the item that the erase/insert cursor is on. The UNDO key will restore something that was just erased. Specifically, DEL deletes the token that is above the line cursor. Can be used repeatedly to clear a whole rung (line) when the cursor is under the first token. This action is possible because the space left by the deleted token is automatically filled by a token moving in from the right portion of the line. All tokens to the right of a deleted token move 1 place to the left.

BAKSP: Deletes the token to the left of the line cursor position. Can be used repeatedly to clear a whole rung (line) when the line cursor is beyond the rightmost token. All tokens to the right of a deleted token move 1 place to the left to fill the void.

BAK: Quits the I/O SETUP Edit/Change menu without saving EDITs that were not accepted (saved) by pressing the rung **ENT** key. Returns to the I/O Setup Edit menu (see fig. 5.11). This key has both navigational and editorial consequences (see second definition for this same key below).

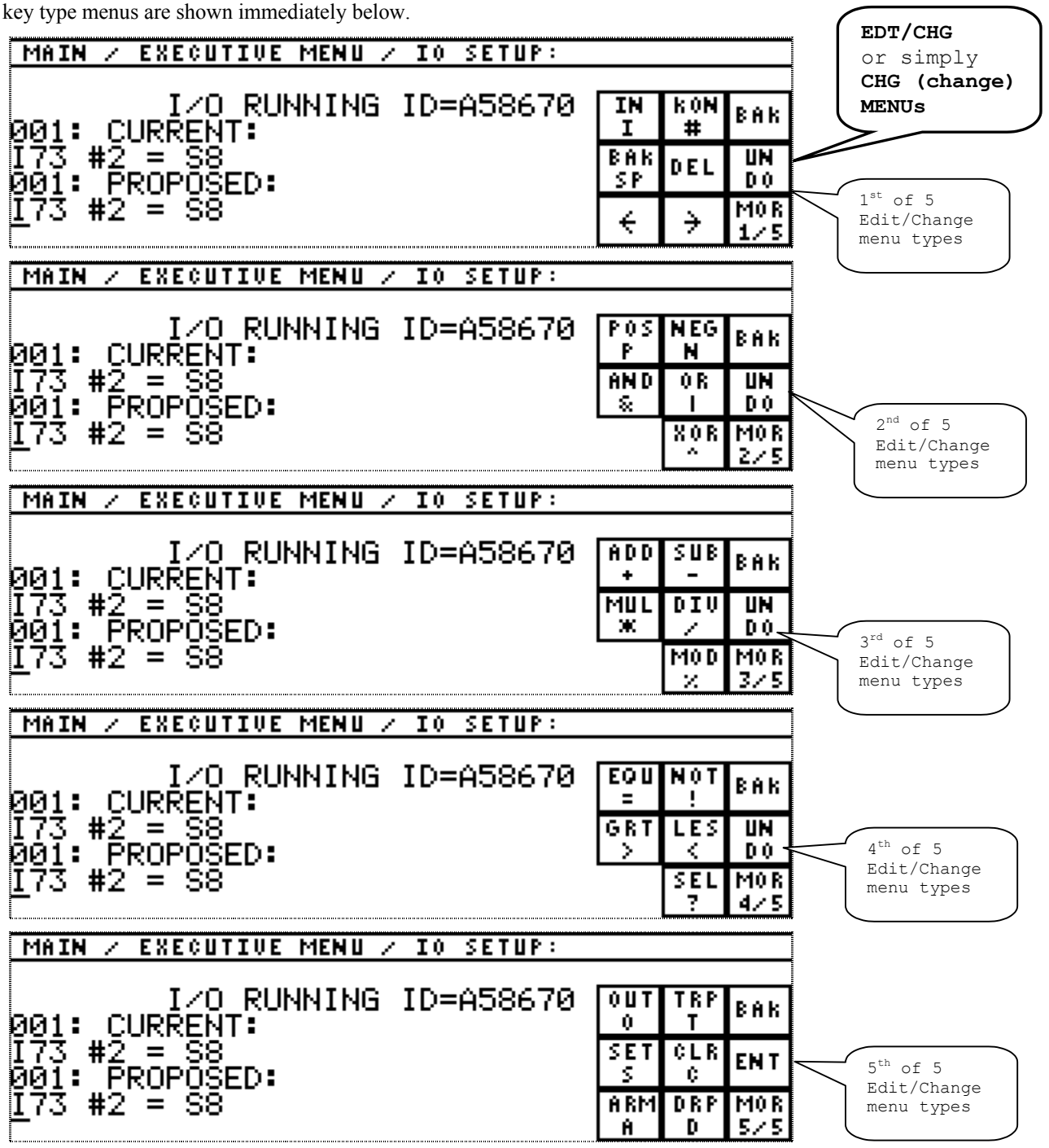
The menu keys just described are the keys used to edit, quit or accept the PROPOSED rung. These are distributed among 5 key type menus all within the scope of the I/O Setup Edit/Change menu.

Navigation within the I/O Setup Edit/Change menu:

MOR: The **MOR**e key changes the menu key selection groups in ascending sequence from first through to the fifth group of token, navigation and edit keys whereupon the sequence is repeated as the fifth group is followed by the first group. The 1/5 indicates group 1 of 5, etc.

BAK: Return 1 menu level back. In this case, returns to the I/O Setup Edit menu. The only way to leave Edit/Change (except for the fixed STATUS key).

The 5 key type menus are shown immediately below.



Token keys (logical operators, command function/ID# combinations)

IN: Used to input a variable. This can be used on any of the states. The current state of the variable will be pushed on the stack when the term is processed or scanned. When inputing from scalar (as in softnode use) the stack result is scalar. When inputing from Boolean or event, the result on the stack is Boolean.

OUT: Used to output to an output or user definable soft node. If an Out is specified to a read only state (an Input for example), an error message will appear on the display. The term being scanned causes the top of the stack to be popped and sent to the output. When going to scalar

(as in softnode use) the stack value result is scalar. When going from scalar to Boolean the result on the stack is interpreted as Boolean (i.e. 0 = False, non-zero = True).

AND: This is the AND operator. It will take the top 2 variables from the stack, perform an AND operation, and push the single result back on the stack. This is a bitwise entity and the stack result is a scalar.

OR: This is the OR operator. It will take the top 2 variables from the stack, perform an OR operation, and push the single result back on the stack. This is a bitwise entity and the stack result is a scalar.

XOR: This is the XOR operator. It will take the top 2 variables from the stack, perform an XOR operation, and push the single result back on the stack. This is a bitwise entity and the stack result is a scalar.

NOT: This is the NOT (or complement) operator. It will take the top variable from the stack, perform a NOT operation, and return it to the top of the stack. This is a logical (Boolean) entity, that is, if the current top of stack is zero, it is replaced with a 1, otherwise, it is replaced with a zero.

POS: A pos function is mainly used for sensing events, and it becomes true only during a positive edge of the sensed variable. This can be a scalar entity but is assessed as a Boolean (zero vs non-zero number) and the stack result is a Boolean.

NEG: A neg function is the opposite of pos, and it becomes true only during a negative edge of the sensed variable. This can be a scalar entity but is assessed as a Boolean (zero vs non-zero number) and the stack result is a Boolean.

I/O Functions

SET: A set can be performed on an output or a soft node (numbers 300 through 399). It will continue to force the variable to an on state as long as the set condition remains on. When the set goes back off, the output will remain set (or on) until an overriding clear or drop is encountered.

CLR: A clear is the opposite of set, it will continue to force the variable to an off state as long as the clear condition remains on. **NOTE**: if during a pass both set and clear are true at the same time, the last one in the rung order prevails.

ARM: An arm condition is similar to a set. The difference is that for an arm, the variable is forced to an on state only during the positive **edge** of the arm condition.

DRP: A drop condition is similar to a clear. The difference is that for a drop, the variable is forced to an off state only during the positive **edge** of the drop condition.

TRP: TRP (**trip**) is an edge driven output function. The output will become true for one second after the trip goes from false to true (a positive edge). These are used to trigger internal events of the STC-2002, change internal status, or cause 1 second delay pulses.

Arithmetic/Logical Functions

ADD: Arithmetic addition as in I5 + I6 (I5 I6 +) will add input 5 to input 6. Positionality is not important for this commutative function.

SUB: Arithmetic subtraction as in I5 - I6 (I5 I6 -) will subtract input 6 from input 5. Positionality is important for this function.

MUL: Arithmetic multiplication, as in I5 ✶ I6 (I5 I6 ✶), will multiply input 6 by input 5. Positionality is not important for this function.

DIV: Arithmetic division as in I5 / I6 (I5 I6 /) will divide input 5 by input 6. Positionality is important for this function.

MOD: Arithmetic modulus function as in I5 % I6 (I5 I6 %) will divide input 5 by input 6 and generate the remainder only. Positionality is important for this function.

EQU: A comparison function as in I5 = I6 (I5 I6 =). This can be a scalar entity but the stack result will be a Boolean. Positionality is not important for this function.

GRT: A comparison function as in I5 > I6 (I5 I6 >). This can be a scalar entity but the stack result will be a Boolean. Positionality is important for this function. This will result in True if I5 > I6.

LES: A comparison function as in I5 < I6 (I5 I6 <). This can be a scalar entity but the stack result will be a Boolean. This can be a scalar entity but the stack result will be a Boolean. Positionality is important for this function.

SEL: Selects which node of the stack that will produce the result, a multiplex function as in I5 < I6. (Example: I5 I6 I7? [If I7 is True, I6 will result. If I7 is False, I5 is result]) Positionality is important for this function. I5 or I6 can be Boolean or scalar. I7 is interpreted Boolean and the result is a scalar.

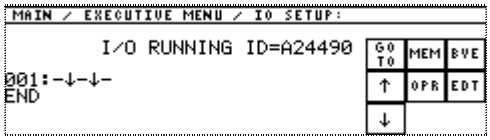
KON: Used to input a constant value of scalar type.

Example 1: Entering a very simple I/O program.

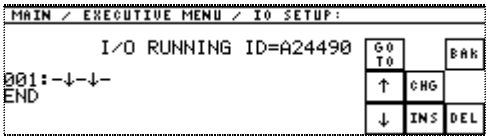
The following screen sequence illustrates the programming of the first I/O program introduced in Section 2 under the heading of *I/O Programming Introduction*. See page 41. To reiterate, the I/O program is as follows:

001:
I71 T67
002:
END

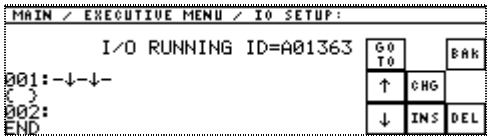
Navigational path is: fixed front panel **MENU** key, **EXECUTIVE MENU** key and **I/O SETUP** key. The result is the first screen below. This screen depiction assumes that there is no I/O program already written in the A memory. If there is, switch to the B memory. Memory areas are selected by pressing the SwaP key which appears after pressing the MEM key on the first screen shown below. Note that ID# starts with either an A or B designating the memory shown. Use EDIT/DEL to delete rungs (steps) until empty. Make sure the factory I/O program has been saved first. There will be a need for it later.



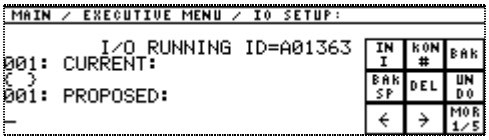
I/O program has only END line. Press EDiT key.



Result of pressing EDiT. Press INSert key*.



Result of pressing INSert. Press ChanGe key.



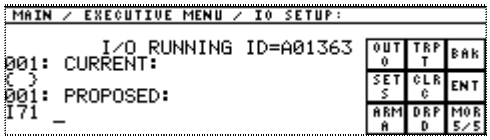
Result of pressing ChanGe key. Press IN key.

Result of pressing IN. Enter 71 by pressing the 10 key 7 times and 1 key once. Result is shown above.

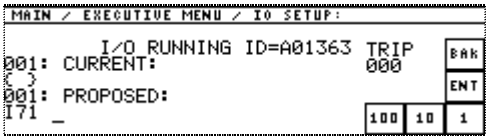
Result of pressing ENTer key. Press MORe key.

Result of pressing MORe. Press MORe again.

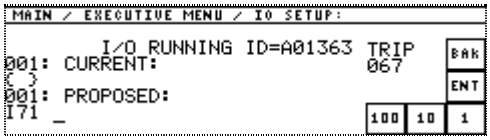
Press MORe again. Note menu selection changes and numeric changes on MORe key. Press MORe again.



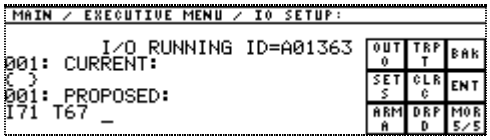
Press TriP key.



Result of pressing TriP. Enter 67: press 10 six times,

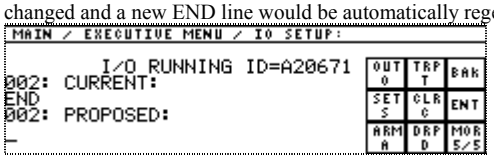


press 1 seven times. Press ENTer key to accept.

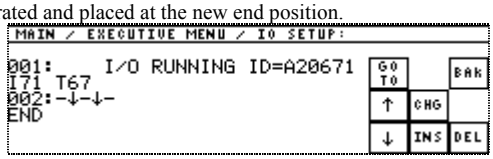


Press ENTer to accept entire line (rung).

* Although the INSert key was used here, this step could be eliminated by pressing the CHanGe key. The END line would get changed and a new END line would be automatically regenerated and placed at the new end position.



The result: still in edit mode, automatically advanced to next line, press BAK to exit edit.



Result of pressing BAK. Press BAK again.

Result of pressing BAK. Compare this screen to the initial screen in this sequence. It is the entry point for I/O Programming. Press ↑.

Demonstrating how up arrow ↑ has changed the focus of the line edit function. Press BYE or the fixed front panel STATUS key to leave.

If the second printed line on the LCD is I/O STOPPED instead of I/O RUNNING, return to the first screen in the sequence and press the OPeRations key followed by the RUN key on the subsequent menu. BAK is used to return to the first screen. This has already been discussed earlier in this section under *General Descriptions of I/O MENUs*. It is included here for those who thumb through the manual looking for pictures of what they want to accomplish instead of reading it straight through.

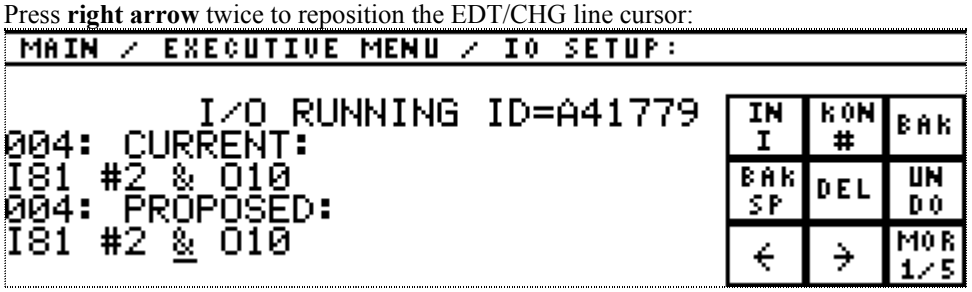
With the I/O program running, pressing the rightmost user programmable fixed front panel key (1 of 4) should result in the momentary illumination of the rightmost user programmable front panel LED (1 of 4).

The program will work while in the I/O programming menus or by pressing the fixed front panel STATUS key, work while the runtime screen is displayed.

Example 2: Editing of a rung

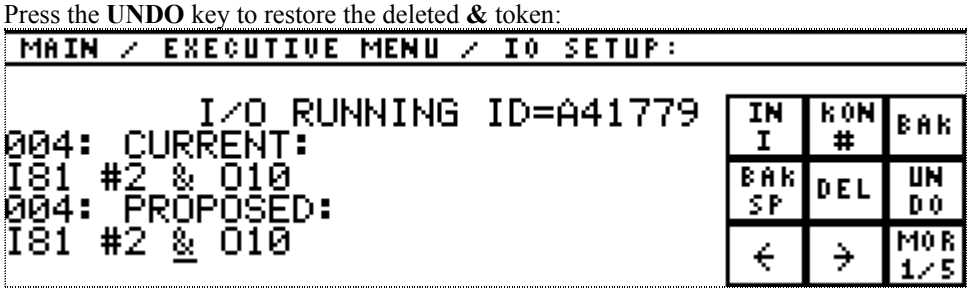
Following is the result of pressing CHG with rung # 004 in the edit/change position:

Press **right arrow** twice to reposition the EDT/CHG line cursor:



Press the **DEL** (delete) key to remove the **&** token:

Press the **UNDO** key to restore the deleted **&** token:



Now insert a **KON#** in between #2 and & by pressing the KON# key with the EDT/CHG line cursor positioned as shown. On the right side of the screen, the temporary KON appears with zero default zero value. Press the 1 key and ENT key to accept the constant value:

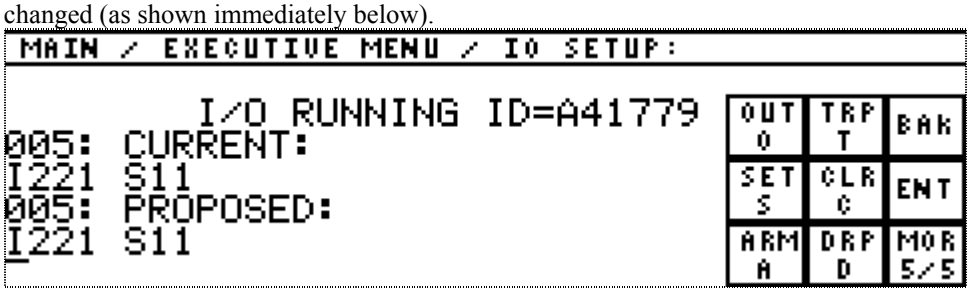
Using the **BAKSP** key, the newly entered **#1** can be eliminated:

#1 has been removed.

Next, move the **cursor** back to the end of the edit line (press → twice):

Using the **MOR** (more) key, repeatedly navigate to the mor 5/5 where the ENTER key is found. Press the ENTER key to accept the entire rung. The rung is unchanged and this is reflected in the checksum, which is also unchanged (A41779).

Pressing the **ENT** key accepts (saves) the rung and as a programming convenience, the next rung is automatically advanced into the edit/change position. In this case, it is the 5th line. If a new program were being constructed, new rungs could be continuously built in this fashion from the END line. A new END line is automatically placed as the last rung with each new conversion of the current END line.
If a rung is being edited in the middle of an existing program, the next rung will be a rung that will not be changed (as shown immediately below).



In either case, the **BAK** key must be used to exit the CHG (change) menu process (the MENU and STATUS keys can also be used).
The following is the result of pressing the **BAK** key (follows from above screen).

Please note that as rungs are added to, deleted from or edited in the I/O program, the number prefixed by the label "ID=" will change. As rungs are being edited (before they are accepted by pressing the rung ENT

key), the ID number will remain unchanged. This number (with hex digits such as A4F656) is a check sum of the entire I/O program and can be used to uniquely identify an I/O program. This can be used as an integrity check for this part of a system with a problem or as a means to check that entries have been correctly made when entering in a program, for example. When an I/O program is known to be correct, write the ID number down in a journal of software entries / programs, having method or recipe attributes being integral to objective. The first character of the ID# will be either an A or B, indicating in which memory section the program resides. Using the SWP (swap) key accessed through the MEM key reverses this. [See section x2.21, *Check Sum Validation* for checksum discussion. See section x3.6, *Factory Settings*... for saving programs. See section x.x, memory module.)

SECTION 5.14 Example 2 - Power On Relay

Defining The Problem

At this point, a few examples might be helpful. This program is almost trivial, but it will demonstrate what is needed to write an I/O program. Its job is to close relay number 8 when the STC-2002 is powered up. While there are several ways to do this, we will pick the method shown in Figure 5.13.

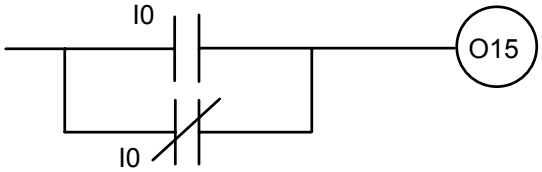


Figure- 5.13: Power On Relay.

Implementing The Solution

The rung to implement this function is:

```
013:  I0 I0! ¦ O15
```

At a first glance, this may seem like a roundabout way of implementing the desired function. If you look through the event and state ID list (Refer to Table 5.4,), you will not see a state that exists for indicating that power is on. This is not a problem for us however, as we can use a logical identity to implement the desired function.

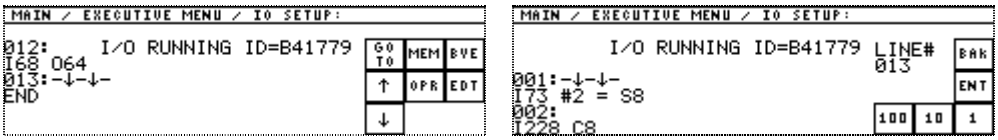
What this program does is take remote input 1 and its complemented term, then ORs them together. One of these terms is always false and the other always true. ORing 2 terms together with one of them always true will result in the output always being true. You could pick any state as an input, we just picked input 1 arbitrarily (the **I0** term). Keep in mind that this input is not "used up". We can still use it for its default use of a remote start, we just needed an input term. The reason for using rung 13 is that the factory installed program uses rungs 1 through 12. We want to keep our example isolated from the factory installed I/O program so we can delete it easily later. Remember that the factory installed I/O program is what is shipped from the factory and defines the first four remote inputs and relays. Let's go through programming this step by step.

Step 1 Get to the Run Time screen. This is the power-on default display for the STC-2002, otherwise, press the fixed STATUS key. (See figures 2.1, 2.4)

Step 2 Get to the I/O SETUP menu. This is done by pressing the fixed MENU key, then the EXECUTIVE Menu key and finally the I/O SETUP key. The display will look like Figure 5.3 (except for the rung information). Pressing the fixed MENU key within other menus invokes the MAIN menu.

Using The Goto Function

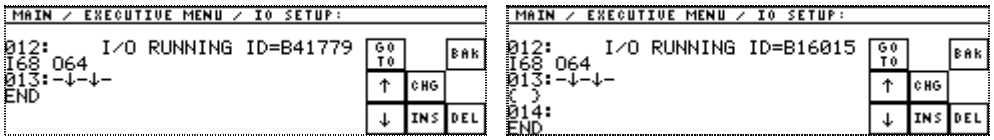
Step 3 Get to the rung that is to be changed. There are two ways to do this. The first is to press the ↓ (down arrow) key 12 times (because we want to get to rung 13). The other way is to press the GOTO key. This is the GOTO command. You will be prompted for the rung number that you want as a destination. In this case, enter the number 13 by pressing the 10 key once (for the 1) and the 1 key thrice (for the 3). Press ENT to accept the digits entered. The thirteenth line of the I/O program will now appear in the EDIT window being the 2nd of 3 consecutive rungs from the I/O program. Since END is the last rung, an empty line appears as the 3rd consecutive line.



(a) Figure- 5.7: Goto Examples. (b)

Step 4 Enter the edit mode by pressing the EDIT key. Insert an empty rung. First, press INS key. This will place an empty rung in the list position formerly occupied by the END statement. The END statement is advanced on the list by one and its line value is changed to reflect it's new position. The display will look like Figure 5.8 a&b. Notice the ID (checksum) change from (a) to (b).

Inserting An Empty Rung



(a) Figure- 5.8: Empty Rung Display. (b)

Step 5 Put the program in the rung. Press the CHG key to begin the edit/change process. The line (rung) list area on the LCD display will change. The line (rung) that occupied the edit position (in this case, rung#012) will appear by itself but in two manifestations. The first will be the current state of the rung (labeled CURRENT). The second is the edit/change line that will accumulate the user entries that will become the constituent parts forming the entire rung (labeled PROPOSED). (See Figure 5.9). [The rung could also have been entered by edit/chg'ing the END line as described in section 5.13, example 1.]

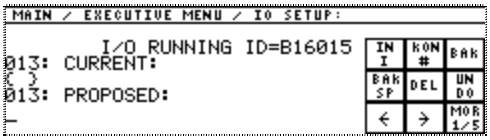
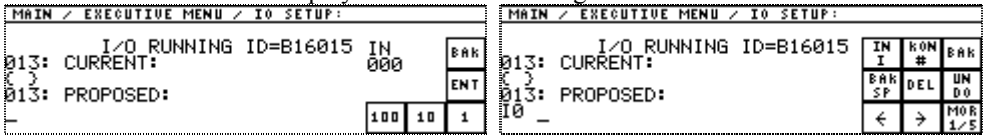


Figure- 5.9: Changing The Rung.

Programming The Rung

We are now ready to enter the program in. The first element to enter is **IO**. Pressing the **IN** key tells the STC-2002 that an input function is wanted. After the IN key is pressed, you will be automatically prompted for the ID number. A temporary token construction area appears on the upper right of the LCD display. As the digits are zeroes by default, no digit entries are needed, press ENT (enter). The *PROPOSED: line* of the display will reflect the change.



We will do the same thing again, press the IN key again and enter an **I0**. The display will now look like the 1st screen in Figure 5.10

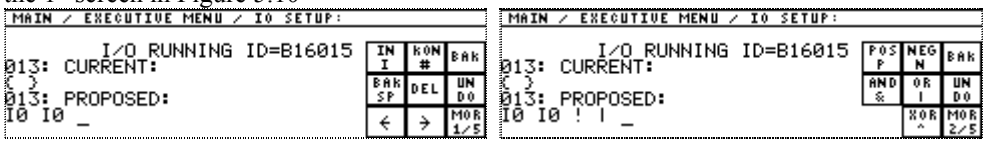


Figure- 5.10: Entering Input Functions and Starting Output Function.

Entering The Program

We now want to complement the second **I0**. This is done by selecting the NOT function by pressing the **NOT** key (! appears). Now we want to OR these two terms together. Select OR by pressing the **OR** key (¦ appears). See the 2nd screen in figure 5.10 for these two entries (the MORE key navigates). The last function to enter is the output to which the result is sent. Because we have defined relay 8 for this, we want to enter an **O15**. See Table 5.4, for a list of all States and Events. Press the **OUT** key to select an Output function. You will be prompted for the ID number. Enter a 15 for the ID#. Press the 10 key once for the 1, and the 1 key five times for the 5 (See the 2nd screen in figure 5.10). Follow the digit entries with the **ENT** key to accept the digit entries. The display will look like figure 5.11.

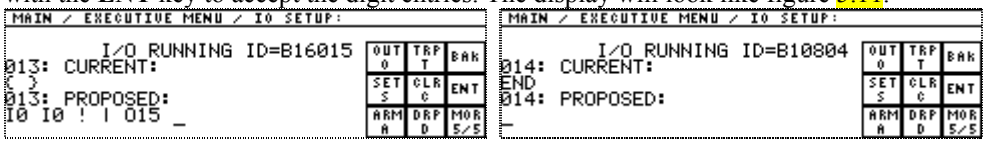


Figure- 5.11: Finishing the Output Function Entry.

Entering Tokens

Press (rung) ENT to accept complete rung. Result is in screen 2 of figure 5.11. Rung 012 is now finished and saved as part of the I/O Setup program. Use BAK to leave the CHG/EDT line process. The relay number 8 will close at this point (you can probably hear it click on). The **ID** (I/O program checksum) should be: **B07587**. This finishes entering this I/O program. Return to the Run Time screen by pressing the fixed STATUS key.

>>>>>>>>>>>>>>>>>>>>>>>>>>

SECTION 5.15 Example 2 - Factory Installed I/O Program

This I/O program is the one that is shipped standard with the STC-2002. Its functions are:

Factory Set Outputs

Output 1 Crystal Fail - This relay provides a contact closure whenever the film program stops because of mapped (selected) sensors failing to operate properly (or sensors exceeding the user defined operating range). A STOP: XTAL message will be displayed on the LCD display to alert the user of this condition.

Output 2 Source #1 Shutter Relay - This relay is intended to provide control of the source shutter. It is generally activated during the deposition phase when source #1 is active.

Output 3 Xtal 2 Select - Output 3 is enabled when sensor 2 is an active sensor.

Output 4 Thickness Setpoint - This relay provides a contact closure whenever the accumulated thickness display value equals or exceeds the thickness setpoint parameter value.

Factory Set Inputs

Input 1 Start Process Film – In sequencing mode, functionally identical to the fixed Front Panel START key followed by the RESET/START PROC key with the STC-2002 in the process stop state. Activating this input with the STC-2002 in any state except *busy* and *wait* will begin the active process. In non-sequencing mode, starts current active film unconditionally.

Input 2 Stop -Functionally identical to fixed Front Panel STOP key. Activating this input will terminate the deposition process. Displays STOP: REMOTE in the Runtime status area on the LCD screen.

Input 3 Final Thickness Trigger - Activation of this input causes the unit to respond as if the final thickness has been reached.

Input 4 Substrate thickness zero trigger – Activating this input (active true edge) causes the accumulated thickness to be reset to zero.

Factory Installed I/O Program with checksum ID=B41779
(if SWP key reversed locations, ID=X41779, where X is either memory section A or B)

The listing of the program to implement this is below in Table 5.5. (non-sequencing mode is addressed in line 8) Each rung of the program is described following the program listing.

```
1:    I73 #2 = S8        (Cobra ship pgm 2003/5/22 CRC 41779)
2:    I228 C8            (Xtal Fail Stop to Relay 1)
3:    I79 #1 = O9
4:    I81 #2 & O10
5:    I221 S11
6:    I228 C11
7:    I0 T216
8:    I0 T202
9:    I1 T200
10:   I2 T217
11:   I3 T219
12:   I68 O64
```

Table 5.5: Factory Installed I/O Program [in B memory].

Rung 001: This line along with rung 2 is used to control the crystal failure relay (Output 1, ID# 8). This line examines the STOPPED status condition (I73) and compares it for a value of 2 (XBAD). When the unit is aborted or stopped for a Xtal failure condition (related to sensor failure during deposition), the relay is set (S8). It remains set until cleared in rung 2 (see below).

Rung 002: This line is used to reset or clear relay 1 (ID# 8). A detection of the Begin of Job/Film event (I228) causes the clearing of the state of the resource #8 (Relay 1). Since this rung follows the previous rung #1, even if the stopped condition (I73 equals 2) continued to persist, the clear behavior would override the earlier set behavior, causing the relay to be cleared or reset. The Begin Job/Film event is triggered or tripped at the start of every active film (leaving stop or idle and entering the Begin/XtalVerify state). At this time the health of the sensors configured in the Active Film/Active Map programming is re-evaluated. This is the point at which the earlier state of a bad crystal is 'thrown out' and new condition ascertained. Of course, if the sensors are still bad, the film will abort again, and the relay will close again due to rung #1 above.

Rung 003: This rung controls the Source shutter relay (Output 2, ID# 9). It does this by examining the state of resource ID #79 (the Source Shutter bitmap value), which is the combined value of eight

different bit weights. This combined map value encodes the state of each of the possible eight source's active deposition state. When a source is being used for an active deposit (manual, deposit, rate-ramp, time-power, etc) phase, the associated bit weight for that source will be true. For the case of source #1 (first of two sources on the first Source/Sensor card), the least significant bit weight (value of 1) is used. This bit is detected via the #1 = test. Since only one source can be active at a time (non-codeposition mode), the test for which source is in use can be a simple equality comparison. If source two were desired, the bit weight/value would be 2. Source three would be a value of 4, with a doubling to 8, 16, 32, 64, 128 for each higher numbered source's shutter.

Rung 004: This rung controls a relay that can be used to operate a dual shuttered head. When sensor two is contributing to a measurement (active mode), its bit-weight (#2) will be true in the bitmap I/O resource #81 (XTLSHUT, or crystal shutter). Rung 4 examines the value of resource 81 (I81), placing the combined state of all 8 sensors as a scalar value on the I/O program stack. The constant value 2 is then stacked, and the bitwise AND operator (&) is performed, leaving either a 0 or 2 value remaining on the stack. The O10 output token evaluates the top of stack (TOS) value, and if non-zero (in this case, 2), results in a TRUE state to resource 10 (Relay 3). If sensor two is not being used (and most likely # 1 is), then the result will be 0 or FALSE, and the relay will not be activated. In this way the exclusive (one or the other) use of the standard two sensor channels can control an electrical/pneumatic/mechanical shutter to cover/expose the appropriate crystal.

Rung 005: This rung, in combination with rung #6, controls relay 4 (resource ID #11) to indicate when a film's setpoint thickness threshold has been reached. This rung examines the event 221 (I221 for setpoint thickness event) and when the instrument signals/triggers the internal event which indicates the accumulated thickness has exceeded the programmed threshold, sets the relay via the S11 token. It remains set until a subsequent clear operation is caused in rung #6 (see below), which is at the start of a new film job. In this way the signal is a steady state throughout the deposit phase in which it is detected and occurs. Such a relay could be used to turn on a process variable such as heat, gas flow, etc..

Rung 006: This rung examines the occurrence of the 228 (Begin Job/Film) event via the I228 token, and on occurrence of the event (starting up a film execution) places a TRUE value to the stack (TOS) for one evaluation of the logic program. This single occurrence of the TRUE is used to activate the C11 token, which clears or reset relay 4. The combined behavior of rungs 5 and 6 produce a relay closure which lasts from the time when a deposit thickness accumulation exceeds the programmed thickness setpoint threshold until the next film is started. Alternatively the EndJobDeposit or EndJobFilm (230 or 231) events could be used to cancel the relay at the end of the deposit, so the relay would be active only during the deposit cycle which closed it. Exactly what is needed is up to the end user's requirements.

Rung 007: This rung connects (logically, cause and effect wise) the external input 1 to event 216, the sequencing mode Start/Unconditional event. Triggering this event has the effect, if the unit is operating in the sequencing mode, of starting the currently selected ActiveProcess. In this way a stopped unit will start at layer 0 whether at an idle resting state or stopped in an error condition, without the need for multiple starts as would be needed from the front panel. If the unit is in the NON-sequencing mode, triggering this event has no effect, and this rung is harmless. It is included in this program so the program is generic and works whether in sequencing or non-sequencing mode. The transition of the input from FALSE to TRUE creates the edge which triggers the event. Continued persistence in the TRUE state does nothing, and the signal must go FALSE long enough to be sensed FALSE (minimally 1/4 second to be sure), before going TRUE again can cause another process start. Only a process at rest can respond to the process start. Process starts that occur while a process is already running are ignored, not queued up. Once the process stops, the next occurring new trigger of a start event causes the process to restart.

Rung 008: This rung connects (logically, cause and effect-wise) the external input 1 to event 202, the NON-sequencing mode Generic Start Film event. Triggering this event has the effect, if the unit is

operating in the NON-sequencing mode, of starting the currently selected ActiveFilm. In this way a stopped unit will start a film up whether at an idle resting state or stopped in an error condition, without the possible need for multiple starts as would be needed from the front panel (STOP to READY, then READY to Running Film). If the unit is in the Sequencing mode, the resource 202 is treated as a softnode, rather than as an event, and triggering it will cause the softnode behavior at 202 (a one-second TRUE state which reverts back to FALSE). This re-mapping of unused events between sequencing and non-sequencing modes insures that a working program for one mode will not produce a syntax error if the mode of the instrument is changed. That is because a softnode has universal usage (In/Out/Trip/Set/Clear/etc.) and if legal in the intended mode (sequencing or non-sequencing), it will still be legal ,although non-functional, in the alternate mode. It is NOT recommended, however, to use the alternative function softnode as a softnode intentionally. Under such conditions a program could be written which uses other than the T (trip) token, and then if the unit is alterred to from a sequencing to a non-sequencing unit, or vice versa, the I/O program would be a syntactically invalid program. This rung is included in this program so the program is generic and works when in non-sequencing mode. The transition of the input from FALSE to TRUE creates the edge which triggers the event. Continued persistence in the TRUE state does nothing, and the signal must go FALSE long enough to be sensed FALSE (minimally 1/4 second to be sure), before going TRUE again can cause another Active film start. Only a film at rest can respond to the film start. Film starts which occur while a film is already running are ignored, not queued up. Once the film stops, the next occurring new trigger of a start event causes the film to restart.

Rung 009: This rung connects (logically, cause and effect wise) the external input 2 (I1) to event 200, the abort/stop event. This event is the same event which is used by all internal systems logic to stop the running film/processes, and will have the same behavior. The uniqueness of this stop is that, along with a computer communications caused stop, it will display STOP: REMOTE on screen, and the stop type (resource #73) will be a value of 3. The transition of the input from FALSE to TRUE creates the edge which triggers the event. Continued persistence in the TRUE state does nothing, and the signal must go FALSE long enough to be sensed FALSE (minimally 1/4 second to be sure), before going TRUE again can cause another STOP. Only an actively running film can respond to the STOP. Film stops which occur while a film is already stopped are ignored, not queued up, since the automatic process is already stopped. Once the film is running, the next occurring new trigger of a stop event causes the running film to abort/stop.

Rung 010: This rung connects (logically, cause and effect wise) the external input 3 (I2) to event 217, the final thickness trigger event. When the change of input edge event of the external input 3 occurs, it triggers the final thickness trigger event. This event is used in the process automation logic to terminate a deposit phase (deposit, rate-ramp, post rate ramp deposit, time power, etc). It is automatically generated internally when the measured accumulated thickness exceeds the final thickness as programmed in the film (for non-sequencing) or process (for sequencing). By triggering the same event remotely, the deposition ends (prematurely) and the film enters the post deposit idle phases and eventually terminates. To use this, the external termination signal from some other form of endpoint determination (optical monitor, resistance monitor, etc..) is wired into this input, and the film or process layer thickness is set to a high value such that the measured accumulated thickness would not normally trip the final thickness event. Then when the external system determines sufficient coating has occurred, it triggers the event via a hardware input signal long enough to be seen and coupled into the processing.

Rung 011: This rung connects (logically, cause and effect wise) the external input 4 (I3) to event 219, the zero substrate thickness event. When the change of input edge event of the external input 4 occurs, it triggers a zero thickness event which is the same one that is used to zero thickness when the front panel button is pressed. In this way the accumulated thickness value can be reset to zero from a remote input.

Rung 012: This rung connects (logically, cause and effect wise) the user definable front panel function key F1 (leftmost membrane switch under the yellow user-LEDs) (I68) to the leftmost yellow user LED

(O64). This rung serves no useful purpose other than to demonstrate the use of one of the four soft-switch inputs and one of the uncommitted LED indicators. When the unit is running, pressing the leftmost membrane key will light the LED for the duration of the depression. A slight lag between activation and deactivation of switch and the tracking of the LED illumination is normal. Pressing and releasing the front panel switch quickly enough will result in no LED lighting, demonstrating the need to have inputs persist long enough to be sampled and recognized.

Replace incorrect drawing.

Figure- 5.12: Factory Installed I/O Relay Ladder Notation.

SECTION 5.16 Modulo 100 Counters ID# 400-409

Ten Modulo 100 counters are incorporated into the STC-2002 I/O structure. Each counter is represented by a unique ID number. The status of these counter states can be used as inputs with the I/O

programming statements. The counters can alternately be named with letters in consecutive order based on their numeric sequence (eg. 400=A, 401=B, etc.).

Counters

Counter A Is represented by the ID 400. Using the 400 **id**entification, the counter when used as an output can have current count, count advancement (increment) and count reset to zero (clear). Similarly, using the 400 **id**entification, the counter as an input can have values written to the counter. The function code I is valid to test a state. The I/O term I400 would be true at the positive transition to count 44 of the counter. The I/O term I344 is true while counter A exists at count 44.

Outputs

Outputs of logical I/O expressions can clear or advance the count within a counter. These are of the form s400 (set), c400 (clear), a400 (arm), or d400 (drop). Set and arm act identically when used with counters. Each positive edge of these terms advances the counter one count, incrementing the counter in a 00..01..02..03.....98..99..00..01 sequence.

Resetting

Clear (C400) and drop (D400) are two ways to reset the counter to its 00 count. Clear is a level sensitive clear which sets the counter to its 00 state and keeps it there as long as it is true. Any attempts to advance the count (S400 or A400) while C400 is active will be ignored. The drop (D400) input is positive edge sensitive and thus sets the counter to its 00 state on the positive occurrence of the drop event (D400). The fact that D400 remains true does not affect the ability of the counter to be advanced by either S400 or A400 commands. If during a single I/O program evaluation pass, both a set (or arm) and clear (or drop) are active, the clear has priority and count will go to zero and the advance count event will be lost.

Example 3 - A Modulo 6 Counter

A Modulo 6 counter will be implemented which closes output relay 8 for 1 second on every fifth push of the INC push key on the hand controller (not really too useful but demonstrates some fundamentals and can be easily tested). Also, each press alternates the illumination state of the LED#2 between *off* and *on*.

The Program

The following program implements this modulo 6 counter.

```
1:    I89 P 0350
2:    I350 S400
3:    I400 #5 = I350 & D400
4:    I400 #5 = N T15
5:    I400 #1 & O65
```

Table 5.6: Modulo 6 Counter Program

Rung By Rung

rung 1: Examines the INC push key (I89) and produces an event on the positive edge to softnode 350.
rung 2: The occurrence of the positive edge of the soft node is used to advance the counter.
rung 3: When the counter is in the state 05, and the soft node then goes True, the counter is cleared to zero rather than advancing to 6.
rung 4: Generates a one second (trip) pulse on relay 8 (ID#15) when the counter has been incremented from the 5 state to the 00 state, each 5th press of the INC hand controller key.
rung 5: Masks the least significant bit of counter 400 and displays it to LED#2.

Entering The Program

For a little practice with counters or using the I/O, this program can be entered at the end of an existing I/O program or in the alternate I/O memory and tested. Once installed, listen for the one second click of relay 8 after every sixth push of the INC key on the hand control, and observe LED#2 either toggle ON or OFF with each press of the INC key.

Example 4 - Fixed Delay & Pulse Width

The internal modulo 100 counters of the STC's I/O can easily be used along with the Time events (ID# 1224 - once per second, ID# 225 - once per minute, ID# 226 once per hour) to generate a desired pulse width after a fixed time delay after the occurrence of some internal or external event.

The Program

The following program implements a five second pulse on an output relay 50 seconds after the occurrence of an external input to the STC-2002.

```
1:    I224 I400 #0 > & I68 P ¦ S400
2:    I400 #50 > O15
3:    I400 #55 > C400
4:    I15 O65
```

Table 5.6: Fixed Delay & Pulse Width I/O Program

Rung By Rung

rung 1: is the rung which advances the ID# 400 counter. The first advance occurs on the positive edge of the external input applied to remote Input 8 (ID# 07), once the counter is 'started' the once per second event ID# 224 continues to advance the counter. [Change I68 to I7 to use an opto-input instead of the programmable front panel key for input triggering method]

rung 2: Approximately 50 seconds later, when the counter reaches the value of 51, the second rung causes Output Relay 8 to close (ID# 15).

rung 3: value of the comparison ">55" becomes True when the counter value exceeds 55, then the "C400" resets the counter to the zero value state.

rung 4: copies the relay 8 state to LED#2.

STC-2002/SRT-400 Interconnect Cable:

Example 5 - I/O Program for Four Pocket Source

Input/Output assignments are as follows:

012 Relay 5, Pins 6(NO)&7(COM) of the RELAY OUTPUTS connector.

013 Relay 6, Pins 17(NO)&18(COM) of the RELAY OUTPUTS connector.

I7 Input 8, Pin 12(cathode) of the OPTOCOUPLER INPUTS connector (assumes LED anode is pulled high via jumper headers JP1, JP2 and/or Pin 25 [see figure x4.3]).

This I/O assignment matches the Sycon cable between the Input and Output card connectors of the STC-2002 program and the SRT-400 rotator cable (501-053 is correct for STC-200 but is not compatible with STC-2002). The 25 pin connectors (M&F) go to the STC-2002 and the 9 pin (F) connector to the SRT-400.

```
I104 #1 - #1 & O12,                NEW4POCK.IO 2003-5-20 Relay 5
for LSB CRC=58129
```

to: STC-2002 relay pins(F)	to: SRT-400 pins(F)
6	1
17	2
3	7
14	3
7,18,4,15	6
input pins(M)	
12	5
13	6

[see figure x4.3]

```
I104 #1 - #2 & O13,                RELAY 6 for MSB of Source 2/ 1..4 is 0..3
I68 I7 | O300,                     External input 8 or F.P. Func1 is pocket good to softnode 300
I98 #2 / #1 & O301,                Bit D1 of RTRSYNC shifted/masked to LSB SN301
I301 I300 & T235,                  When PocketGood signal TRUE and Source 2 syncing/ trig PG2
I12 O67,                           Copy state of relay 5 to LED D (rightmost)
I13 O66,                           Copy state of relay 6 to LED C (for MSB weight)
I104 #4 > I104 #1 < | O302,        Test valid range of pocket source 2 as 1..4
I80 #18 = P O303,                  When enter INDEXER state generate event to SN303
I303 N I302 & T270,                After delay of SN303/ if SN302 TRUE/invalid range/stop270
I301 O65,                          Map SN301 state when looking for pocket good to LED B (2nd)
```

Four softnodes are used: 300, 301, 302, 303.

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SECTION 5.18 Hand Controller Push Buttons / Front Panel LEDs and Function Keys

The Hand Controller, see Figure 5.13, was designed to increase, decrease, or terminate the control voltage to the deposition power source while in manual operation. When the STC-2002 is not in the manual mode the three keys can be used for other functions. The keys INC, DEC, and STOP have been assigned ID's which allow them to be incorporated into an I/O program.

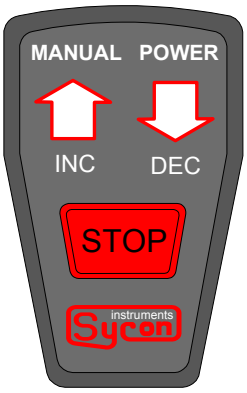


Figure- 5.13: Hand Controller (also called a Pendant).

One common usage of a remote stop key is when the STC-2002 is used in conjunction with an optical monitor. An I/O rung is added which triggers an external final thickness. Thus an operator viewing the optical monitor results can manually terminate the deposition remotely by adding a single I/O rung, which provides this function.

1: I91 I72 ! & T217

The input portion of this statement tests the status of the STOP key on the Hand Controller (I91) and logically 'ANDs' it with the complement of the manual mode state (I72!). The output portion of this statement triggers the final thickness when the input conditions are met. With this I/O statement installed, pushing the STOP key on the Hand Controller while in non-manual deposition will cause the deposition to be terminated as if the set point final thickness had been achieved. In practice, the set point is set slightly above the predicted desired thickness and then the deposition terminates either manually by the operator or automatically at some safety thickness if the operator misjudges his optical results. Likewise the INC and DEC keys could be programmed to raise and lower the vacuum chamber or do some other useful tasks by adding an additional I/O rung or two.

Four front panel LED indicators (for output) and four fixed front panel function keys (for input) have been assigned ID's which allow them to be incorporated into an I/O program as are the pendent keys (See Table 5.3, ID#s: 64 through 71). The leftmost LED has an ID# of 64 and the following LED ID#s increment consecutively to the rightmost LED whose ID# is 67. The leftmost function key has an ID# of 68 and the key ID#s increment consecutively to the rightmost function key whose ID# is 71. The LEDs can be used to indicate progression through a process, a single event, a series of unrelated single events, indicate that a function key has accomplished its programmed function, etc. The function keys can be used to trigger events, provide or release a pause in a process, provide a decision capability by waiting for the press of one of two (or three) keys at some point in a process, etc.

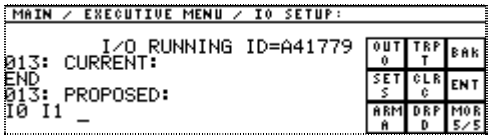
SECTION 5.19 I/O ERROR MESSAGES

When entering or editing an I/O program several Error Messages might occur. These messages indicate that the rung which was changed contains an error in form or content. The following error messages may appear during the process of entering an I/O rung or trying to leave an I/O program which has been altered.

ERROR	**Probable Cause**
Phase Error	Multiple use of an output ID code somewhere in the I/O program. The following I/O program will cause a Phase Error message: 1: I1 O7 2: I2 O7 It is desired to have both Remote input 2 & 3 (ID#'s 1 & 2) close Output Relay 1 (ID# 7). The proper way to do this is to logically combine the input portion of the I/O statements as follows: 1: I1 I2 ¦ O7
Nest Too deep	The I/O rung contains an extra input or is missing a logical operator or output term.

Stack under flow	Extra logical operator or output term or missing an input term
Bad node ID	Using an unassigned ID # (Reserved)
Invalid Operation	A non-valid function assigned to an ID#. Example: Trying to assign the output function to an Remote Input ID by forming output token (O3) would give this error.
Out of I/O Memory	I/O program too long to fit available memory

Typical error sequence example: two input tokens are created, ENT (enter) is pressed, the CHG (change) screen appears with an error message on the last line. Press the **OK** key to acknowledge error message and return to 1st screen pictured below. Use editing facilities (eg. BAKSP, DEL, etc.) to make corrections.



SECTION 5.20 I/O SETUP Menu Summary

See chapter 3, section x3.22, *Product Programming Summary* for I/O Menu summary.

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SECTION 6.0 Computer Interfacing

The STC-2002 can be connected to a computer in a variety of ways. An RS-232 interface is standard and an industrial bus interface <not yet software implemented> such as DeviceNet, PROFIBUS-x or CANopen can be factory added as an option. There is room for only one optional card. There is also another hardware option for an external I^2C connection <not yet software implemented>.
For the RS-232 interface, either a Sycon protocol or a simple ASCII protocol can be selected. This section will describe the hardware with each interface, and give an example of how to interface to a PC host.

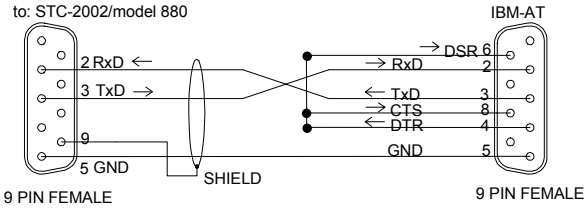
RS-232 Interface Description

RS-232 is an electrical specification for the transmission of data in a serial format. What this means is that the mechanism for transmitting data is defined by RS-232. The particular set of commands is defined by each vendor as they see fit. There is no computer program that will "communicate with all RS-232 devices". Different sets of commands and miscellaneous overhead must be handled differently. The Sycon protocol incorporates message length and checksum characters which insure the integrity of the data transmission.

Baud Rates And Cabling

No matter what protocol you are using, the first order of business is to get the STC-2002 connected to the host computer and set up the baud rates. Figure 6.1 shows how to connect to an IBM-PC and IBM-AT. Note that the connectors are different for each end, label similar ends accordingly.

Making An RS-232 Cable



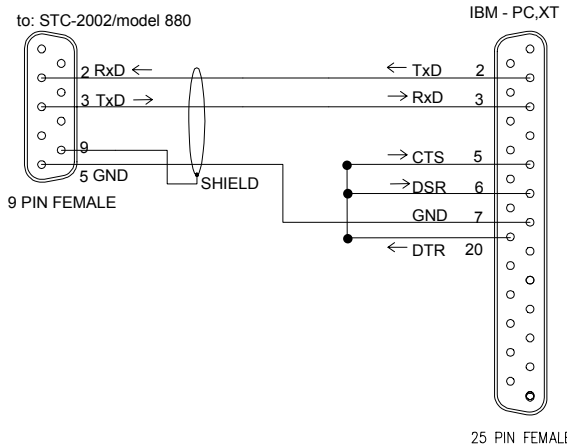


Figure- 6.14: Example Cable: Connections From STC-2002 To MS-DOS Computer.

After the proper cable is made or purchased, make sure the baud rate of the computer and STC-2002 are the same. This is done by going into the Executive Menu (by pressing the fixed MENU key, followed by the EXECUTIVE MENU key) and selecting the ***comm**unications **setup*** option. You will see a screen with the current baud rate on it. Section 6.4 describes programming these parameters in detail.

Setting The Baud Rate

Make sure that the baud rate on your computer is set to the same baud rate. The STC-2002 is shipped from the factory set at 9600 baud. To set an IBM-PC to the same baud rate, at a DOS prompt type in:

Mode Com1:9600,N,8,1 <Enter>

This will set the IBM for 9600 baud, 8 data bits, no parity, and 1 stop bit on its COM1 port. It is important to use 8 data bits because the protocols use all of them.

SECTION 6.1 Sycon Protocol

The STC-2002 does not initiate any messages on its own. It responds only when "spoken" to. In order for error-free communications to occur, several safeguards are built into the Sycon protocol for checking data integrity. The general format for sending and receiving commands is:

(STX) (Data Length) (Data(Data..Data)) (Checksum)

RS-232 Message Format

The STX character (hex 02) indicates a start of message sequence. The STC-2002 uses this as a synchronization point. It just sits in a loop waiting for the STX character. If a different character is received, it is discarded. When the STX character is received, the STC-2002 looks at the rest of the characters in the command.

The data length is a ASCII character from SOH (1 decimal) through CR (13 decimal) and indicates the number of data characters in the message. The data is defined in the protocol below. The STC-2002 uses this number to determine where the end of the command is. If there is a mismatch between this number and the actual number of data characters in the message, one of two things can happen. If the data length number is low, the STC-2002 will terminate the command prematurely. The checksum will not match and an error will be recognized by the STC-2002. It will not respond in any way.

Message Length

If the data length number is high, the STC-2002 will be waiting for more characters than actually contained in the message. In order to recover from either kind of error, the host computer must have a time-out/retry capability built into the software. There is a maximum of 13 data characters allowed in any communications message. This does not include any packet formatting characters.

Checksum - Error Recovery

The checksum is the sum (modulo 256) of only the data bytes. If this does not match the actual checksum of the data, an error condition is recognized by the STC-2002. It will not respond to the command.

Table 6.2 is a basic program that will run on an IBM-PC. It prompts you for a command to send to the STC-2002 and will print the response on the display. It is written in BASICA program, but will also run under Microsoft GWBASIC. This program prompts the user for the STC-2002 command; then adds the STX, data length and checksum before it transmits the message to the STC-2002.

SECTION 6.2 ASCII Protocol

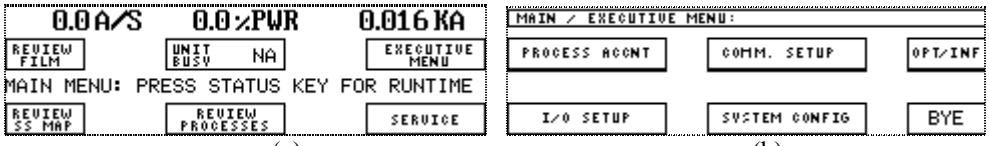
While the ASCII protocol is the simplest to use it doesn't provide for any error checking of the data transmission. The format of the ASCII protocol is as follows:

('$')((data)(data.....Data)) CR(LF)

The '$' is the start of a message. A single command is contained in the data fields. A CR(LF) terminates the message. The line feed is optional, the CR must terminate the command immediately after the final character of data.

SECTION 6.3 Communications Setup

Before you can communicate with the STC-2002, there are several communications oriented parameters that you need to program. While the RunTime screen is displayed, the MAIN menu can be accessed by pressing the fixed MENU key. After the fixed MENU key is pressed, you will see the screen as in Figure x6.15(a) which is the MAIN menu.



(a) (b)

Figure- 6.15: **Fixed Menu**, **Executive Menu** and **Comm. Setup** keys

Getting Into The Communications Setup Mode

From the MAIN menu, the Executive Menu can be selected. This is done by pressing the EXECUTIVE MENU key, the results of which are shown in figure 6.15(b). From this point, we can select communications setup by pressing the COMM. SETUP key. Figure 6.16 will then be on the display.

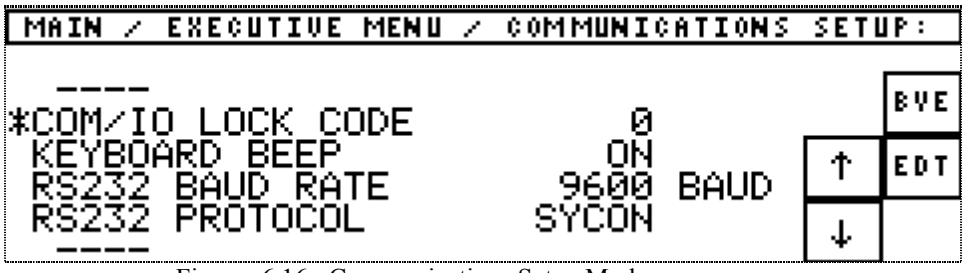


Figure- 6.16: Communications Setup Mode.

Communications Setup Parameters

There are 4 parameters that can be programmed from this screen.

Comm./IO Lock Code

The **Comm. / IO Lock Code** parameter provides safeguarding against tampering with either the I/O program or the communications parameters. You can enter any 4 digit number for a lock code. A code of 0 disables this feature. If you use it, whenever you enter into this menu or try to change the I/O program, you will be prompted for the lock code. Make sure that you don't forget what you set it to, as there is no way to disable this feature unless you know the code.

Keyboard Beep

The **Keyboard Beep** parameter, which controls the audible feedback when pressing keys, can be disabled if desired. A value of 1 will turn the beeper Off and a value of 2 will turn it on.

RS-232 Baud Rate

The **RS-232 Baud Rate** parameter sets the baud rate for the RS-232 interface. It can be programmed to one of 4 values. A value of 1 is 300 baud, 2 is 1200 baud, 3 is 2400 baud, and 4 is 9600 baud.

RS-232 Protocol

The **RS232 protocol** parameter selects one of the two RS-232 protocols available. A 0 will select the Sycon protocol and a 1 will select the ASCII protocol.

Optional: Addresses

<not implemented> If you use an optional communications card, you will need to assign bus addresses.

Optional: Checksum Mode

<not implemented> If the optional communications card is installed, this parameter allows an optional checksum character to be used with the message packets.

SECTION 6.4 Industrial Interface Option

<not implemented>

SECTION 6.5 Response Format

All commands received by the STC-2002 will return a response. The minimum response (not including protocol dependent characters) is a single ASCII character. This character indicates two things.

First the success or failure of the command which was sent. One of six result types is returned, to indicate success (AOK), illegal command token (Groups 1..16), illegal data value (number out of range for command), illegal syntax (something other than required = sent after command token), inhibited operation (changing the film number while depositing for instance) and I/O sequencing error.

Second, the returned response character reports the power on reset status of the STC-2002. Each of the four response codes (see below) is modified after a reset until the ? command resets the power failure flag. In this way each response message informs the host as to the occurrence of an instrument reset since the last exchange. The reason this is done is so that in every communication exchange a power on reset can be detected and the correct exception processing be performed via host software, without special polling overhead.

Response character	Power Lost	No Reset
Message AOK	B	A
Illegal Command	G	F
Illegal Data Value	I	H
Illegal Syntax	K	J
Inhibited Operation	M	L
I/O Sequencing Error	O	N

Table 6.7: Response Character Table.

SECTION 6.6

Result Codes Returned: The first letter of the reply message sent from the STC-2002 to the host computer is from the set of result codes detailed below. For each type of result one of two reply characters is returned depending on the nature of the power up acknowledge flag of the instrument. The second letter of the two for each type of result is returned after any previous power failures or resets (such as when the unit is first powered up). Once this condition is recognized and handled (bringing the host and the STC-2002 into synchronization) and the host sends the '?' command to the STC-2002, then the power loss/reset is acknowledged by the host and replies from the STC-2002 are then prefixed with the first letter of the particular response type.

Returned values following ACK and Reset, their meanings and their searchable mnemonic tags (searchable in the electronic form of this document).

The response letters, mnemonic tag types and meanings are as follows:

Returned Value (following ACK/RESET)		Mnemonic Tag	Meaning
A	B	RZCD_AOK	Result returned as expected
F	G	RZCD_ILCD	Illegal Command Token
H	I	RZCD_ILDV	Illegal Data Value
J	K	RZCD_ILSN	Illegal Syntax, # of args, delimiters, etc.
L	M	RZCD_INHB	inhibited operation, unable to process now
N	O	RZCD_IOSQ	sequence error when downloading rung data
R	S	RZCD_OBSOI	Old obsolete command received, command ignored. This occurs when old commands to write to obsolete parameters are encountered.

Note: A delimiter is either a single comma, one or more spaces, or zero or more spaces preceding a comma followed by zero or more spaces. An assignment operator ('=') is the equals sign preceded or followed by 0 or more space characters.

Delimiter Examples: (ignore verticle lines || as they are used to define the area surrounding the delimiter text)

|| is a delimiter.
|,| is a delimiter.
|, | is a delimiter.
| , | is a delimiter.
| , | is a delimiter.
|,,| is illegal as a single delimiter.
| , , | is illegal as a single delimiter.

SECTION 6.7 Communication Commands

While there are 2 protocols for RS-232, the command set for both of these is the same. The only things that change between the two RS-232 protocols are the prefix before the command and the suffix after. All commands and data are in printable ASCII form. Only the prefix and suffix characters that make up the protocol-dependent data are allowed to be possibly non-printable. There are 16 types or groups of commands. These 16 group types are: Initialization commands; Read, Write Film Parameters; Read, Write System Parameters; Read RunTime Data; Read, Set Status Information; Read, Trigger Events; I/O Status Commands; Read Process Accounting; Read, Load I/O Program; I/O Program Editing; Set Analog Output(T); Process Sequencing – Process Size, Memory; Process Sequencing – Read, Write, Edit Processes; Measurement Substitution Group; Purge All I/O Programs; External Memory Module Status. **Please note that there is a difference between menu programming numerically represented selections and communication commanding numerically represented selections. Menu selections using menu programming might be 1, 2, 3 while communication commands for the same group might be 0, 1, 2. Therefore, menu selection 1 is equivalant to command selection 0, menu selection 2 is equivalant to command selection 1, menu selection 3 is equivalant to command selection 2. For example, using communication command selection for BAUD rate: 0 is 300, 1 is 1200, 2 is 2400, and 3 is 9600 Baud while using menu programming selection: 1 is 300, 2 is 1200, 3 is 2400, And 4 is 9600 Baud.**

INITIALIZATION COMMANDS

Initialization Commands Group 1-- Commands @ & ?

Initialize communications and read version. There are 2 commands that are typically used to initiate communications with the STC-2002. The @ command will request the software version and is a good command to start off with. The ? command resets a power fail condition. This is used after any power lost condition to reset the power lost status of the STC-2002.

Detailed Command Description:

Initialization Commands - Initialization (@),(?)

There are only 2 commands in this group, and they have no arguments.

Initialize -@- Get Software Version

This is used to get the current version of software back from the STC-2002.

Command: @
Mnemonic: EXCT_whatv (what version)
Parameters: None or numeric 0..16,30..33 to retrieve platform configuration and manufacturing information.
Description: Returns the current software version or other information as shown in chart below.

Returns:

For @ or @0
[RZCD_AOK]ASTCXMM.NN
Where XMM.NN is version identifier, such as B01.01, RZCD_AOK is either the letter A or B, depending on power failure or reset history. X is A or B for non-sequencing or sequencing variety, MM.NN is version identity.

For @1
[RZCD_AOK]SERIAL/BTYPE

For @2
[RZCD_AOK]OPTIONS/FWSIG

For @3
[RZCD_AOK]BTLSIG

For @4
[RZCD_AOK]UIF_COVEN

For @5..@8
[RZCD_AOK]AAAN.M/xxxx
S4 module software revision information for each of the four modules (1..4 respectively). The N.M is the revision code, the xxxx is the checksum for the firmware, and the AAA field identifies generic module identity.

For @9
[RZCD_AOK]UIFBASE_NUM
UIFBASE_NUM is a decimal number which defines the minimum UIFC version base desired for use with SCUP. Returns decimal number, encoded version 02.12 would return 212. This insures that the proper version compatibility exists between the SCUP and UIFC boards.

For @10..@16
[RZCD_AOK]{reply from UIFC to its @0..@6 commands}
@10 = response from SCUP UIFC vrsn string info.
@11 = UIFC Code signature.
@12 = UIFC Bootloader signature.
@13 = UIFC serial/build.
@14 = Base SCUP version for UIFC.
@15 = UIFC Glossary covenant.

@16 = UIFC sys_trap codes. In nnnn,nnnn form.
Read at power up, can be refreshed for recent reading from UIFC via ^U? command. Reset from SCUP via ^U! command. Note, the ^U? command requests a new sys_trap code from UIFC, but requires a separate @16 to interrogate the reading if changed. Once a sys_trap code is non-zero, it will not change or be overwritten until cleared from the UIFC front panel or via the YH command passthru or the ^U! command.
@17..@29 reserved for future UIFC codes.
@30 = ReadBack SCUP Memory Module status. Returns CRDSTAT_class integer.
0 CRDSTAT_uninst Uninstalled option.
1 CRDSTAT_error Unavailable or unpresent when spoken to.
2 CRDSTAT_unfmtRO Present but format not recognized.
3 CRDSTAT_unfmt Present but format not recognized.
4 CRDSTAT_wrprot Present but write-protected.
5 CRDSTAT_readwrite Totally available.
@31 = Readback MemModule ProdID & Serial# returns integer, integer where first integer is 9/10/11 for FRAM memory module w/1/2/3 chips. If chip's status is not above unformatted, then returns 0,0. Serial number in range of 1..1000 is one which was formatted automatically on SCUP system. Factory registered ones start at serial # 2001 and up. This leaves an additional area from 1001..2000 for future special purpose.
@32 = Readback Data Compatibility code returns number,number where 1st number is product code (such as COBRASCUP #4) and second number is a dialect/data representation covenant code which determines whether the data saved to file is expected to be interpreted for read/write of params/accounting/sequences/ and RLLE steps. If chip's status is not above unfmt, then returns 0,0 . This information pertains to the portable data on the CARD.
@33 = Readback Data Compatibility code returns number,number where 1st number is product code (such as COBRASCUP #4) and second number is a dialect/data representation covenant code which determines whether the data saved to file is expected to be interpreted. This information pertains to the SCUP firmware's desired/expected information profile. It must MATCH EXACTLY the card in order to load/clone.

Initialization Commands Example

Command @
Response ASTC200/B15
Description The version request message. Where the 'A' might be a 'B' if the instrument was reset since the last power loss acknowledgment message.

Reset Power Lost Status

This is used to reset the power lost status of the STC-2002. See Section x3 for a complete description.

Command: ?
Mnemonic: EXCT ackpl (acknowledge power loss)
Parameters: None
Description: Acknowledge Power Loss status.
Returns: [RZCD AOK] (an A or B)

Initialization Commands Example

Command ?
Response A
Description The reset power loss status message. Always an A since the message resets the 'B' status

condition.

Table 6.8: Initialization Commands Examples

Read, Write Film Parameters Group 2--

Commands A & B

(A) Read film parameters. These commands are used to read all of the film parameters. The group command is the letter A followed by the film number, which can be from 1 through 99, followed by a parameter number. Either a comma or white space needs to separate the arguments. Each film parameter has a number associated with it.

(B) Write film parameters. These commands are used to set the film parameters of the STC-2002. Its format is similar to the read commands above. The command is the letter B followed by the film number (1 through 99), the film parameter number, the character =, and the data value (as returned with a matching *A* query).

Command: **A**
Mnemonic: **EXCT_rdfp (read film parameters)**
Parameters: **[1..99] [delimiter] [1 .. 46]**
corresponding to film # 1..99 and parameter types DENS .. FRATDR .
Description: **Requests a read back from the selected film of the selected parameter value. See the list of parameters and the corresponding ID code below.**
Returns:
[RZCD_AOK][param_value]
if proper film # (1..99) and parameter id were sent. Exact format of [param_value] depends on the particular parameter for which the data was requested.
[RZCD_ILDV] (H or I) if improper value for parameter arguments.
[RZCD_ILSN] (J or K) if too many arguments, wrong delimiters, etc.

Command: **B**
Mnemonic: **EXCT_wrfp (write film parameters)**
Parameters: **[1..99] [delimiter] [1 .. 46] [assign_delim] [desired_value] corresponding to film # 1..99 and parameter types DENS .. FRATDR as in A command above. The assign_delim is zero or more spaces preceding the '=' sign followed by zero or more spaces. The desired_value is a numeric data item of proper range and representation (# of decimals points, etc..) used to update or change the value of the parameter to. This value is expressed in the same manner as returned to the host when an A type command is issued. Therefore the data return from an 'A [FILM#] [PARAM#]' query command can be appended to a 'B [FILM#] [PARAM#] =' command, forming a legal B command which will download the same value to a parameter as was uploaded with the 'A' command. This makes it easy to save and restore the STC-2002 instrument's parameters via a host computer.**
Description: **Command to set or store a new parameter value into one of the film programs.**
Returns:
[RZCD_AOK] (A or B) if correctly processed.
[RZCD_ILDV] (H or I) if film #, parameter #, or new value is of improper value.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

Film parameter access values:

Parameter 1 **Density**
access: DENS
Value Range 0.40 - 99.99
Units gm/cc
Reads Or Sets The Density Parameter depending which prefix letter A or B is used.

Parameter 2 **Z Factor**
access: ZRATio
Value Range 0.100 - 9.999
Units None
Reads Or Sets The Z Factor Parameter depending which prefix letter A or B is used.

(Obsolete)
Parameter 3 **Tooling Xtal 1**
access: OBSOLETE Was sensor 1 tool
Value Range 10.0 - 400.0
Units Percent

(Obsolete)
Parameter 4 **Tooling Xtal 2**
access: OBSOLETE Was sensor 2 tool
Value Range 10.0 - 400.0
Units Percent
Reads or sets depending which prefix letter A or B is used, the tooling factor parameters. These correspond to the two sensors available on the STC-2002.

(Obsolete)
Parameter 5 Start Xtal #
access: OBSOLETE Was initial channel
Value Range 0,1
Units 0 is Sensor 1, 1 is Sensor 2
This indicates which of the 2 sensor crystals will be used for a deposition run.

Parameter 6 **Setpoint Thk Lim**
access: STHK Setpoint Thickness Limit
Value Range 0.000 - 999.999
Units Kilo Angstroms
The setpoint thickness parameter is used to provide a comparison point for the STC-2002 thickness setpoint event. This event will be triggered whenever the thickness display equals or exceeds the setpoint value.

(non-sequencing mode only)
Parameter 7 Final Thickness Limit (Trigger)
access: FTHK final thickness, end of run trigger
Value Range 0.000 - 999.999
Units Kilo Angstroms
Used to stop the deposition process in non-sequencing mode. Non-sequencing mode does not use a process program but rather a film, which is invoked by making it the next active film and pressing the START key sequence to begin the deposition process. It has, therefore, one implicit process. The Final Thickness Limit Trigger stops the selected film deposition when the thickness reaches this user entered thickness value. This value is analgous to the thickness value in a process program when in sequencing mode.

Parameter 8 **Setpoint Time Limit**
access: SPTM
Value Range 0:00 - 99:59
Units Min:Sec
The setpoint time limit parameter is used to provide a comparison point for the STC-2002 timer setpoint event status.

Parameter 9 **Soak 1 Power Value**
access: PWR1 power condition power level 1
Value Range 0.0 - 100.0
Units Percent
This parameter sets the deposition source power value to be used as the first level of soak power in the pre-deposition cycle. This power level will be maintained for the duration of the soak 1 timer. This level is typically used to out gas and condition the source material. A value of 0.0% causes the rise/soak 1 phase to be skipped.

Parameter 10 **Power Ramp 1 Time**
access: RMP1 ramp time to power level 1
Value Range 0:00 - 99:59
Units Min:Sec
This parameter sets the duration of the power ramp from zero power to the power level set by the soak 1 power value parameter.

Parameter 11 **Power Soak 1 Time**
access: SKT1 soak time at power level 1
Value Range 0:00 - 99:59
Units Min:Sec
This parameter sets the time that the source will remain at the soak 1 power level following the completion of the ramp to this level.

Parameter 12 **Soak 2 Power Value**
access: PWR2 power condition power level 2
Value Range 0.0 - 100.0
Units Percent
This parameter sets the deposition source power value to be used as the second level of soak power in the pre-deposition cycle. This power level will be maintained for the duration of the soak 2 timer. A value of 0.0% skips the rise/soak 2 phases.

Parameter 13 **Power Ramp 2 Time**
access: RMP2 ramp time to power level 2
Value Range 0:00 - 99:59
Units Min:Sec
This parameter sets the duration of the power ramp from the soak 1 power value or the idle power value to the value set by the soak 2 power parameter.

Parameter 14 **Power Soak 2 Time**
access: SKT2 soak time at power level 2

Value Range 0:00 - 99:59
Units Min:Sec
This parameter sets the time that the source will remain at the soak 2 power level following the completion of the ramp to this level.

Parameter 15 Idle Power
access: PWR3 power condition power level 3
Value Range 0.0 - 100.0
Units Percent
This parameter determines the final (idle) power setting at the completion of the entire deposition profile. If this power level is zero a start command will begin a new power profile at rise 1. An idle power setting other than zero will cause the power profile to begin at rise 2 after a start.

Parameter 16 Idle Ramp Time
access: RMP3 ramp time to power level 3
Value Range 0:00 - 99:59
Units Min:Sec
This parameter sets the duration of the power ramp from the power level at the time that final thickness was reached until the power reaches the value set by the idle power parameter.

Parameter 17 Deposit Rate
access: RATE requested rate for deposition
Value Range 0.0 - 999.9
Units Å/s (10^{-8} cm/s)
This parameter determines the material deposition rate that the closed loop control system will try to establish and maintain at the time that closed loop operation begins.

Parameter 18 Rate Ramp Mode
access: RRMD rate ramp mode, on/off
Value Range 0,1
Units 0 is Off, 1 is On
This parameter is a disable/enable switch for the rate ramp function and associated film parameters. When set to Off the programming cursor window will skip over the associated parameters. When set to on all associated parameters are accessible and it will be possible to alter the deposition control rate profile during closed loop control.

Parameter 19 New Deposite Rate
access: NRAT new rate to ramp to
Value Range 0.0 - 999.9
Units Å/s
This parameter sets the new deposition rate value that is to be reached at the end of the rate ramp operation.

Parameter 20 Rate Ramp Time
access: RRTM rate ramp time
Value Range 0:00 - 99:59
Units Min:Sec

This parameter sets the duration of the rate ramp. The rate ramp starts at the rate control value at the time that the rate ramp trigger is reached and ends at the value set by the new Dep rate parameter.

Parameter 21 **Rate Ramp Trigger**
access: RRTG rate ramp thickness trigger
Value Range 0 - 999.999
Units Kilo angstroms
This parameter sets the trigger point for a rate ramp to begin during deposit.

Parameter 22 **Ctl Loop -P-**
access: PROP control loop proportional term gain
Value Range 1 - 9999
Units None
This parameter sets the closed loop rate control proportional gain.

Parameter 23 **Ctl Loop -I-**
access: INTG control loop integral term
Value Range 0.0 - 99.9
Units Seconds
This parameter sets the closed loop rate control integral term time constant.

Parameter 24 **Ctl Loop -D-**
access: DRIV control loop derivative term
Value Range 0.0 - 99.9
Units Seconds
This parameter sets the closed loop rate control derivative term time constant.

Parameter 25 **Max. Power Limit**
access: MAXP max power limit
Value Range 0.0 - 100.0
Units Percent
This parameter sets the absolute maximum power level that will be allowed to occur at any time from the instrument (film dependent).

Parameter 26 **Abort Max. Pwr Switch**
access: ABMP abort on max power on/off
Value Range 0,1
Units 0 is Off, 1 is On
This parameter is a switch value. When set to Off it has no effect on the deposition sequence and the programming data window will not access the associated max. power dwell parameter. When set to on a maximum power condition will be allowed for the time duration set by the now accessible max. power dwell parameter and then the STC-2002 will abort the deposition sequence and power will be set to zero.

Parameter 27 **Max. Power Dwell**
access: MPTM max power time interval
Value Range 0:0 - 99:59
Units Min:Sec

This parameter is associated with the max. power abort switch parameter and sets the allowable duration of a maximum power condition before an abort will occur.

Parameter 28 **Shutter Delay Mode** Enable
access: SDMD shutter delay mode, on/off
Value Range 0,1
Units 0 is Off, 1 is On
This switch type parameter will allow the shutter delay parameters to become active and the mode functional on a individual film basis. If set to Off, the parameter window cursor will not access the associated parameters. If set to On, the delayed shutter operation will be performed as specified by the following parameters.

Parameter 29 **Shutter Delay Time-Out**
access: SDTM time to achieve control without alarm
Value Range 0:01 - 99:59
Units Min:Sec
This parameter sets a time limit for the delayed shutter operation to be completed. The time period begins at the beginning of the shutter delay cycle. The sensor is exposed to evaporant with the substrates remaining shielded. When rate control is established to the programmed accuracy, three things happen. The substrate shutter is opened, accumulated thickness set to zero, and the programmed deposition profile is then started. If the specified rate control accuracy cannot be met within this time limit, the deposition will be aborted.

Parameter 30 **Shutter Delay Quality**
access: SDAC shutter delay accuracy factor
Value Range 1 - 50
Units Percent
This parameter sets the rate control accuracy that must be established for a period of five seconds in order to complete the delayed shutter sequence. The maximum accuracy set able is 1 percent of the desired setpoint. However, this is internally limited to 1 Å/s.

Parameter 31 **Rate Sampling**
access: XSMD crystal sample mode, off/timed/intel
Value Range 0 To 2
Units 0 is Off, 1 is Timed Mode, 2 is Intelligent Mode
This switch type parameter will allow the rate sampling parameters to become active and the mode functional on an individual film basis. If set to Off the parameter window cursor will not access the associated parameters. If timed mode is selected, the crystal sensor will be exposed to evaporant for the time specified by the sample dwell parameter, and will sample at the interval specified by the sample interval parameter. If intelligent mode is selected, then the duration of the sample will only be long enough to establish the desired accuracy.

Parameter 32 **Sample Interval**
access: XSTI crystal sample time interval
Value Range 0:01 - 99:59
Units Min:Sec
For either mode of operation this parameter will select the sampling interval of the sensor.

Parameter 33 **Sample Dwell Time**
access: XSDW xtal sample dwell time for timed mode
Value Range 0:01 - 99:59
Units Min:Sec
For the timed mode selection this parameter sets the duration of sensor exposure.

Parameter 34 **Sample Quality**
access: XSAC xtal sample accuracy for intel mode
Value Range 1 - 50
Units Percent
In the intelligent mode of rate sampling this parameter sets the control quality required to terminate the exposure period of the sensor.

Parameter 35 **Sample Alarm Time**
access: XSTM xtal sample alarm time for accuracy monitor
Value Range 0:0 - 99:59
Units Min:Sec
In the intelligent mode this parameter sets the maximum allowable time allowed to complete the sensor exposure and control operation. The STC-2002 will go into time-power when outside the time limit.

Parameter 36 **Measurement Fail Proc**
access: XFMD xtal fail mode, stop or complete on time power
Value Range 0,1
Units 0 is Abort On Fail, 1 is Complete On Time Power
This parameter allows the user to select the system execution path if it is no longer possible to get reliable measurement information from the sensor system. This is the last resort choice that will be made after all other system configuration options have been exhausted. A choice of zero (0) will abort the deposition and set the output power to zero. A choice of one (1) will set the unit into a time power completion mode. In this mode the last reliable control power level will be maintained and thickness accumulation will occur in a simulated fashion until the final thickness setpoint is reached. Post deposition processing then will occur as programmed.

(Obsolete)
Parameter 37 **Xtal Backup Mode**
access: OBSO Was crystal backup switch desired yes/no
Value Range 0,1
Units 0 is Off, 1 is On
This parameter allows crystal sensor switching to automatically take place if a sensor failure of any type is determined. Thickness and rate control is maintained during the operation.

Parameter 38 **Ctl Loop Qual**
access: CLQU control loop quality limit
Value Range 0 - 9
Units None
This parameter is used to set a threshold on acceptable control loop quality. When the threshold is exceeded a sensor fail condition is assumed and the system will process this

condition as configured. A programmed value of 0 disables this test. A value of one gives the tightest limits (5%).

Parameter 39 **Xtal Stability**
access: XLQU crystal oscillation quality limit
Value Range 0 - 9
Units None
This parameter is used to set a threshold on acceptable sensing crystal performance. When the threshold is exceeded a sensor fail condition is assumed and the system will process this condition as configured. A programmed value of 0 disables this test. A value of one gives the tightest limits.

Parameter 40 **Xtal Life Bounds**
access: LIFB life bounds for I/O event
Value Range 0.0 - 100.0
Units Percent
This parameter is used to provide a setpoint on the allowable sensing crystal usage. This setpoint may be utilized through the I/O system as a warning or interlock that sensing crystals need attention.

Parameter 41 **Plot Vertical Scale**
access: VSCL vertical scale units, 1..5..10..etc.
Value Range 0-4
Units 1,5,10,50,100 Å/s Or % Power As Selected
This parameter sets the vertical scale factor of the graphics display on the RunTime screen.

Parameter 42 **Plot Horizontal Scale**
access: HSPL horizontal sampling, 1,2,3.. samples per point
Value Range 1-600
Units Samples Per Display Point
This parameter sets the horizontal sweep rate of the graphics display on the RunTime screen. Samples are taken at a rate of 4 per second. A programmed value of 1 will display every sample. The x-axis is 200 samples wide on the RunTime display.

Parameter 43 **Data Plot Type**
access: IPLT initial plot variable, chosen at start time
Value Range 0-2
Units 0 is Rate, 1 is Rate Deviation, 2 is Power
This parameter selects the type of information to be displayed on the RunTime graphics screen.

Parameter 44 **Source Sensor MAP SELECT**
access: SMAP Source/Sensor map associated, 1..30
Value Range 1 - 30
Units map#
This parameter selects the map that is to be associated with film that invokes it.

Parameter 45 **POCKET SELECT**

access: PSEL Pocket select 0..63
Value Range 0 – 63
Units Pockets
This parameter selects the type of information to be displayed on the RunTime graphics screen.

Parameter 46 ETCHING MODE
access: FRATDR Film Rate Direction/EtchMode if true, otherwise deposit.
Value Range OFF/ON
Units None
When ON, this parameter selects the deposition controller perspective such that a negative (etching) process will be indicated with positive values and that setpoints, etc. will trigger based on these values. When OFF deposition will be indicated with positive values.

Read, Write Film Parameters Examples

Command Examples

Command	A1 25 or A 1,25 or A 1 25
Response	A0.0
Description	To Request Film 1, Parameter 25 The Max. Power Limit Parameter. The Current Parameter Setting, In This Case 0.0 %.
Command	A9 18
Response	A0
Description	To Request Film 9, Parameter 18, Rate Ramp Mode. Rate Ramp Mode is Off.
Command	B1 25=50.2 or B 1,25 = 50.2
Response	A
Description	To Set Film 1, Parameter 25 (The Max. Power Limit Parameter) To 50.2 %. Message Understood And Accepted.
Command	B1 25=100.4
Response	H
Description	To Set The Parameter To A Value Exceeding 100%, Which is Illegal! Response is Signifying An Illegal Data Value Being Used, command ignored.

Table 6.9: Group 2 Examples.

SECTION 6.8
Read, Write System Parameters Group 3-- Commands C & D

(C) Read system parameters. These commands read the system oriented commands, that is those not associated with any film. The group command is the letter C followed by a system parameter number.

(D) Write System Parameters. These commands are used to set the system parameters. The group command is the letter D followed by the system parameter number, the character "=", and the data value.

Command: **C**
Mnemonic: **EXCT_rdsp (read system parameters)**
Parameters: **[2..32] corresponding to system parameter types AFILM..REQMEMMOD .**
Description: **Requests a read back from the selected system parameter value. See the list of parameters and the corresponding ident code below.**
Returns:
[RZCD_AOK][param_value] if proper parameter id was sent. Exact format of [param_value] depends on the particular parameter for which the data was requested.
[RZCD_ILDV] if improper value for parameter argument.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

Command: **D**
Mnemonic: **EXCT_wrsp (write system parameters)**
Parameters: **[2 .. 32] [assign_delim] [desired_value] corresponding to parameter types AFILM..REQMEMMOD as in C command above. The desired_value is a numeric data item of proper range and representation (# of decimals points, etc..) used to update or change the value of the parameter to. This value is expressed in the same manner as returned to the host when a C type command is issued (See A and B commands above).**
Description: **Command to set or store a new parameter value into one of the system parameter variables.**
Returns:
[RZCD_AOK] (A or B) if correctly processed.
[RZCD_ILDV] if improper value for parameter argument.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..
[RZCD_INHB] if chosen parameter can not be programmed at this time. This applies to run number, active film or process, system configuration, etc..

Commands C and D, System Parameters

Parameter 1	Rate sample able, dual sensor able, shutter delay able
access value:	OBSO Was CNFG, no longer used.
Value Range	0 - 1
Units	On / Off

Parameter 2 **Active Process Number**
access value: AFILM active film / or active process, depending on sequencing
Value Range 1 To 9
Units None
Read or set the process number that is currently active. The set command is inhibited if a process is running.

Parameter 3 Process **Run Number**
access value: RUNNO run number
Value Range 0 To 9999
Units None
Read or set the run number. The set command is inhibited if a film is running.

Parameter 4 **Password Lock #** - Parameters And Executive
access value: LOCKN param & exec lock number
Value Range 0 To 9999
Units None
This allows certain areas of the STC-2002 to be restricted to those people knowing the password code. If this is programmed with a non-zero value the value enables the password function and is itself the password. Whenever accessing a menu that can change a parameter, the STC-2002 will ask for the password.

Parameter 5 **Password Lock #** - I/O And Communications
access value: COMLOK I/O and communications lock code
Value Range 0 To 9999
Units None
This allows certain areas of the STC-2002 to be restricted to those people knowing the password code. If this is programmed with a non-zero value the value enables the password function and is itself the password. Whenever accessing a menu that can change an I/O programming parameter or a communications parameter, the STC-2002 will ask for the password.

Parameter 6 NA access value: OBSO Was control loop polarity

Parameter 7 **Control F.S. Volt** Control Loop Full Scale Voltage
access value: OBSO Was control loop full scale volts choice
Value Range 0 , 1 or 2
Units 0 = 2 Volts, 1 = 5 Volts, 2 = 10 Volts
This scales the control voltage of the STC-2002 to match your power supply. While most supplies are set to -10 volts for full power, not all are. This allows 100% power from the STC-2002 to be either 2, 5, or 10 volts.

Parameter 8 **Rate Direction**
access value: OBSO Was rate direction, positive, negative
Value Range 0,1
Units 0 = Positive, 1 = Negative
This parameter sets the STC-2002 for either a deposit mode (positive) or an etch mode (negative).

Parameter 9 **Recorder Function**
access value: ARFNC analog recorder function select, ARFC_class RATE/RDEV/PWRL THIK/REMOTE/IOACC/NONE
Value Range 0 To 6
Units 0=Rate, 1=Rate Deviation, 2=Power, 3=Thickness, 4=Computer Remote, 5=I/O Control, 6=Off
There are 2 analog outputs on the STC-2002. One analog output per STC-2002 can be used as a recorder output (with 1 or more sensor cards). You may program one of seven variables to appear on this output. These are absolute rate, rate deviation, power, thickness, remote computer or off.

Parameter 10 **Clock Time**
access value: RTHST real time hours:minutes set param access id.
Value Range 00:00 - 23:59
Units Hours:Minutes

Parameter 11 **Clock Date**
access value: RTCLS real time date set MMDDYY 010100 .. 123199. param access id.
Value Range 010189 To 123188
Units Month Day Year
These 2 parameters program the clock of the STC-2002. These are used in the process accounting mode. The format for the time is 24 hour time. One O'clock in the afternoon is 13:00. The date is programmed in month-day-year format without any separators. You need to enter any zeros in the day (March 5th is '05', not just '5'). The range of dates is from 01/01/1989 through 12/31/2088

Parameter 12 **LCD Contrast/Bias Control**
access value: CRTL crt control, 1 of 3, 0=dim, 1=medium, 2=bright.
Value Range 1,2,3
Units LOW, MEDIUM, HIGH
This parameter adjusts the contrast/bias of the LCD.

Parameter 13 **Beeper Control** Enabling The Beeper
access value: BEEP beep, on/off type 0=off, 1=on.
Value Range 0 To 1
Units 0 is Off, 1 is On
This parameter controls if the beeper of the STC-2002 is turned On or Off.

Parameter 14 **Baud Rate**
access value: BAUD baud , 1 of 4, 0=300, 1=1200, 2=2400, 3=9600. Takes effect immediately. This will most likely break current communication
Value Range 0 To 3
Units 0 is 300, 1 is 1200, 2 is 2400, And 3 is 9600 Baud
This parameter controls the baud rate of the STC-2002. It takes effect immediately. This likely means future communications will fail until the host is set to the new value.

Parameter 15 **Protocol Selection** Communications Protocol Selection
access value: PROT protocol, selection, SYCON(0)/SECS(1), requires reset.
Value Range 0,1,2
Units 0,1 is Sycon Protocol, 2 is ASCII Protocol
This parameter selects which RS-232 protocol will be used, either Sycon or simple ASCII. It takes effect only during a power up condition.

Parameter 16 NA access value: OBSO Was secs address.

Parameter 17 NA access value: OBSO Was link mode.

Parameter 18 NA access value: OBSO Was ieee-488 address.

Parameter 19 NA access value: OBSO Was bit bus address.

Parameter 20 NA access value: OBSO Was gpib checksum control param code.

Parameter 21 NA access value: OBSO Was line frequency param code.

Parameter 22 **Sequence Inhibit** Inhibit Sequence Mode
access value: SQINH sequence inhibit, set true when cant sequence, Needs reset.
Value Range 0,1
Units None
This parameter (when set to 1) allows a STC-2002 to operate like a non SQ. This can be polled/set via RS232 or changed on the SERVICE menu (see Section 2).

Parameter 23 **Recorder Out Channel**
access value: ROUTS Analog output channel select, when ARFNC not off, then active datalogging value output to analog channel 1..8 providing no conflict with process control.
Units None
1 – 8 selects an analog output channel for use (if not *off* and not used as a *source*)

Parameter 24 **Need Source/Sensor Card 1**
access value: REQSS1 Require Source/Sensor 1 in system, boolean 0/1
Value Range OFF/ON
Units None

Parameter 25 **Need Source/Sensor Card 2**
access value: REQSS2 Require Source/Sensor 2 in system, boolean 0/1
Value Range OFF/ON
Units None

Parameter 26 **Need Source/Sensor Card 3**
access value: REQSS3 Require Source/Sensor 3 in system, boolean 0/1
Value Range OFF/ON
Units None

Parameter 27 **Need Source/Sensor Card 4**
access value: REQSS4 Require Source/Sensor 4 in system, boolean 0/1
Value Range OFF/ON
Units None

Parameter 28 **I/O Slot 1 Type**
access value: REQIO1 Require Input/Output 1 in system, CFGIOS_class DSBL/Inp/Outp
Value Range UNUSED (DISABLED) / INPUT / OUTPUT
Units None

Parameter 29 **I/O Slot 2 Type**
access value: REQIO2 Require Input/Output 2 in system, CFGIOS_class

Value Range UNUSED (DISABLED) / INPUT / OUTPUT
Units None

Parameter 30 **I/O Slot 3 Type**
access value: REQIO3 Require Input/Output 3 in system, CFGIOS_class
Value Range UNUSED (DISABLED) / INPUT / OUTPUT
Units None

Parameter 31 **I/O Slot 4 Type**
access value: REQIO4 Require Input/Output 4 in system, CFGIOS_class
Value Range UNUSED (DISABLED) / INPUT / OUTPUT
Units None

Parameter 32 **Memory Module IFC**
access value: REQMEMMOD Require memory module option installation. Not auto detectable Boolean 1/0 True/False.
Value Range OFF/ON
Units None

Read, Write System Parameters Command Examples

Command C10 or C 10
Response A15:33
Description Read system parameter # 10, system clock time. Result is 15:33 hrs:mins, 3:33 p.m. time.

Command C18
Response A5
Description Read system parameter # 18, NA.

Command D11 = 70689
Response A
Description Set system parameter 11, calendar date to July 6, 1989. Command received and accepted.

Command D 14= 1
Response A (Possible missed due baud change)
Description Set baud rate 1200 baud.

Table 6.10: Group 3 Examples.

Read RunTime Data

Read RunTime Data Group 4 -- Command E

(E) Read RunTime Data. These commands are used for reading back real time numerical information from STC-2002. This includes information such as rate, thickness, power, etc. The group command is the letter E followed by a parameter number.

Command: **E**
Mnemonic: **EXCT_rdata (read runtime data)**
Parameters: **[1..61] corresponding to real time data types PWRLVL..XSTAB8 .**
Description: **Requests a read back of real time (not fixed parameters) system data. See the list of data and the corresponding ident code below.**
Returns:

[RZCD_AOK][data_value] if proper data # (1..13) id was sent. Exact format of [data_value] depends on the particular parameter for which the data was requested.
[RZCD_ILDV] if improper value for parameter argument.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

Command E, Read RunTime Data Parameters

Parameter 1 **Power Level Output**
access index: PWRLVL power level, in units of .1 percent, 0.. 1000, of active source.
Value Range 0 To 1000
Units 10 X Percent
This parameter reads the current power being supplied to the **active** control output. It is in percent of full scale x 10. If the number 123 is returned, this represents 12.3%.

Parameter 2 **Deposition Rate**
access index: RATEVL rate value, +- 0 .. 999.9 A/s, as 0 .. 9999
Value Range 0 To 9999
Units 10 X Å/s
This is the current deposition rate as is displayed on the RunTime display. If the number 123 is returned, this represents 12.3 Å/s.

Parameter 3 **Thickness**
access index: THKVL thickness value, angstroms, 0 .. +- 999999
Value Range 0 To 999999
Units Angstroms
This is the current thickness value as is displayed on the RunTime display. The units that are displayed are in KÅ, but the units sent across the computer interface are in angstroms. A number returned of 1234 means 1.234 KÅ.

Parameter 4 **Phase Timer**
access index: PHSTMR phase timer, counts up or down
Value Range 0 To 5999
Units Seconds
This returns the time into the current phase (such as deposit). This is similar to the number on the RunTime display, except that the time is in seconds instead of minutes:seconds.

Parameter 5 **Running Timer**
access index: RUNTMR running timer, counts up
Value Range 0 To 5999
Units Seconds
This returns a general timer function that is always running during a process. It pegs at 5999 and resets when you start a new process.

Parameter 6 **Rate Deviation**
access index: RDEVTN rate deviation value, +- 0 .. 999.9 A/s, as 0 .. 9999
Value Range 0 To ±9999
Units 10 X Å/s
This parameter returns the current deviation from the programmed rate setpoint. A negative number indicates the actual value is below the programmed one. A returned number of -123 indicates that the rate is 12.3 Å/s below whatever the programmed value is.

Parameter 7 **Crystal Life (primary sensor)**
access index: XLIFE crystal life value, 0..99 percent., primary crystal.
Value Range 0 To 99
Units Percent
This parameter returns the percentage of the crystal life that is left on the primary crystal sensor. It is the same number as on the RunTime display.

Parameter 8 **Sensor Channel And Status (active channel)**
access index: XCHNL crystal channel in use.
Value Range 0 To 5
Units None
This is a composite number where the lsb is 0 for sensor 1 selected, 1 for sensor 2 selected; bit 1 is 0 if the sensor is not good, 1 if it is good; and bit 2 is 0 if the sensor has not failed, and 1 if the sensor has failed. If bits 1 and 2 are both 0, this indicates that the sensor status is unknown.

Parameter 9 **Crystal Stability Value**
access index: XSTAB crystal stability value
Value Range 0 To 99
Units None
The tens digit of this number is incremented when the stability level is violated. The units digit indicates 10 x of range violated to get to the next stability level.

Parameter 10 **Process Quality Value**
access index: PQUAL process quality value
Value Range 0 To 99
Units None
The tens digit of this number is incremented when the quality level is violated. The units digit indicates 10 x of range violated to get to the next quality level.

Parameter 11 **Control Quality Value**
access index: CQUAL control quality, instantaneous
Value Range 0 To 99
Units Percent
This parameter indicates how good the control loop is. It is the deviation expressed as a percentage of the setpoint.

Parameter 12 **Sample Hold Time**
access index: SHTIME sample hold time
Value Range 0 To 5999
Units Seconds

This is the time remaining in the current sample/hold phase.

Parameter 13 Crystal Frequency
access index: FREQ Crystal Frequency 5 Mhz to 6 Mhz to .1 hertz, 0 if bad. from primary (when not averaging) sensor crystal.
Value Range 5000000.0…6000000.0, 0.0 if bad crystal
Units Hz
This is the measured frequency of the **active** sensing crystal.

The following parameters (14-61) are the values as reported by physically present and enabled source sensor card[s].

Parameter 14 Crystal frequency from Sensor 1
access index: FREQ1 Crystal frequency from Sensor 1 in centiHz (0.01Hz) resolution.
Value Range 500,000,000-600,000,000
Units centiHz (0.01Hz)
Crystal frequency from Sensor 1 in centiHz (0.01Hz) resolution [6 MHz looks like 600,000,000].
Associated card needs to be physically installed and enabled before a reboot.

Parameter 15 Crystal frequency from Sensor 2
access index: FREQ2 Crystal frequency from Sensor 2 in centiHz (0.01Hz) resolution.
Value Range 500,000,000-600,000,000
Units centiHz (0.01Hz)
Crystal frequency from Sensor 2 in centiHz (0.01Hz) resolution [6 MHz looks like 600,000,000].
Associated card needs to be physically installed and enabled before a reboot.

Parameter 16 Crystal frequency from Sensor 3
access index: FREQ3 Crystal frequency from Sensor 3 in centiHz (0.01Hz) resolution.
Value Range 500,000,000-600,000,000
Units centiHz (0.01Hz)
Crystal frequency from Sensor 3 in centiHz (0.01Hz) resolution [6 MHz looks like 600,000,000].
Associated card needs to be physically installed and enabled before a reboot.

Parameter 17 Crystal frequency from Sensor 4
access index: FREQ4 Crystal frequency from Sensor 4 in centiHz (0.01Hz) resolution.
Value Range 500,000,000-600,000,000
Units centiHz (0.01Hz)
Crystal frequency from Sensor 4 in centiHz (0.01Hz) resolution [6 MHz looks like 600,000,000].
Associated card needs to be physically installed and enabled before a reboot.

Parameter 18 Crystal frequency from Sensor 5
access index: FREQ5 Crystal frequency from Sensor 5 in centiHz (0.01Hz) resolution.
Value Range 500,000,000-600,000,000
Units centiHz (0.01Hz)
Crystal frequency from Sensor 5 in centiHz (0.01Hz) resolution [6 MHz looks like 600,000,000].
Associated card needs to be physically installed and enabled before a reboot.

Parameter 19 Crystal frequency from Sensor 6

access index: FREQ6 Crystal frequency from Sensor 6 in centiHz (0.01Hz) resolution.
Value Range 500,000,000-600,000,000
Units centiHz (0.01Hz)
Crystal frequency from Sensor 6 in centiHz (0.01Hz) resolution [6 MHz looks like 600,000,000]. Associated card needs to be physically installed and enabled before a reboot.

Parameter 20 Crystal frequency from Sensor 7
access index: FREQ7 Crystal frequency from Sensor 7 in centiHz (0.01Hz) resolution.
Value Range 500,000,000-600,000,000
Units centiHz (0.01Hz)
Crystal frequency from Sensor 7 in centiHz (0.01Hz) resolution [6 MHz looks like 600,000,000]. Associated card needs to be physically installed and enabled before a reboot.

Parameter 21 Crystal frequency from Sensor 8
access index: FREQ8 Crystal frequency from Sensor 8 in centiHz (0.01Hz) resolution [6 MHz looks like 600,000,000].
Value Range 500,000,000-600,000,000
Units centiHz (0.01Hz)
Crystal frequency from Sensor 8 in centiHz (0.01Hz) resolution [6 MHz looks like 600,000,000]. Associated card needs to be physically installed and enabled before a reboot.

Parameter 22 source 1 power level
access index: POWR1 power level, in units of .1 percent, 0.. 1000, of source 1.
Value Range 0 to 1000
Units .1 Percent
source 1 power level in units of .1 percent [100% looks like 1000]. Associated card needs to be physically installed and enabled before a reboot.

Parameter 23 source 2 power level
access index: POWR2 power level, in units of .1 percent, 0.. 1000, of source 2.
Value Range 0 to 1000
Units .1 Percent
source 2 power level in units of .1 percent [100% looks like 1000]. Associated card needs to be physically installed and enabled before a reboot.

Parameter 24 source 3 power level
access index: POWR3 power level, in units of .1 percent, 0.. 1000, of source 3.
Value Range 0 to 1000
Units .1 Percent
source 3 power level in units of .1 percent [100% looks like 1000]. Associated card needs to be physically installed and enabled before a reboot.

Parameter 25 source 4 power level
access index: POWR4 power level, in units of .1 percent, 0.. 1000, of source 4.
Value Range 0 to 1000
Units .1 Percent
source 4 power level in units of .1 percent [100% looks like 1000]. Associated card needs to be physically installed and enabled before a reboot.

Parameter 26 source 5 power level
access index: POWR5 power level, in units of .1 percent, 0.. 1000, of source 5.
Value Range 0 to 1000
Units .1 Percent
source 5 power level in units of .1 percent [100% looks like 1000]. Associated card needs to be physically installed and enabled before a reboot.

Parameter 27 source 6 power level
access index: POWR6 power level, in units of .1 percent, 0.. 1000, of source 6.
Value Range 0 to 1000
Units .1 Percent
source 6 power level in units of .1 percent [100% looks like 1000]. Associated card needs to be physically installed and enabled before a reboot.

Parameter 28 source 7 power level
access index: POWR7 power level, in units of .1 percent, 0.. 1000, of source 7.
Value Range 0 to 1000
Units .1 Percent
source 7 power level in units of .1 percent [100% looks like 1000]. Associated card needs to be physically installed and enabled before a reboot.

Parameter 29 source 8 power level
access index: POWR8 power level, in units of .1 percent, 0.. 1000, of source 8.
Value Range 0 to 1000
Units .1 Percent
source 8 power level in units of .1 percent [100% looks like 1000]. Associated card needs to be physically installed and enabled before a reboot.

Parameter 30 Sensor 1 thickness
access index: THICK1 thick from sensor.
Value Range 0 To 999,999
Units Angstroms
Thickness from sensor 1. 1 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 31 Sensor 2 thickness
access index: THICK2 thick from sensor.
Value Range 0 To 999,999
Units Angstroms
Thickness from sensor 2. 2 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 32 Sensor 3 thickness
access index: THICK3 thick from sensor.
Value Range 0 To 999,999
Units Angstroms
Thickness from sensor 3. 3 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 33 Sensor 4 thickness
access index: THICK4 thick from sensor.
Value Range 0 To 999,999
Units Angstroms
Thickness from sensor 4. 4 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 34 Sensor 5 thickness
access index: THICK5 thick from sensor.
Value Range 0 To 999,999
Units Angstroms
Thickness from sensor 5. 5 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 35 Sensor 6 thickness
access index: THICK6 thick from sensor.
Value Range 0 To 999,999
Units Angstroms
Thickness from sensor 6. 6 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 36 Sensor 7 thickness
access index: THICK7 thick from sensor.
Value Range 0 To 999,999
Units Angstroms
Thickness from sensor 7. 7 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 37 Sensor 8 thickness
access index: THICK8 thick from sensor.
Value Range 0 To 999,999
Units Angstroms
Thickness from sensor 8. 8 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 38 rate from sensor 1
access index: RATE1
Value Range 0 To 9999 [integer]
Units Deci-angstroms/sec
The rate reported from sensor 1 with 9999 representing 999.9 Å/S. 1 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 39 rate from sensor 2
access index: RATE2
Value Range 0 To 9999 [integer]
Units Deci-angstroms/sec
The rate reported from sensor 2 with 9999 representing 999.9 Å/S. 2 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 40 rate from sensor 3
access index: RATE3
Value Range 0 To 9999 [integer]
Units Deci-angstroms/sec
The rate reported from sensor 3 with 9999 representing 999.9 Å/S. 3 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 41 rate from sensor 4
access index: RATE4
Value Range 0 To 9999 [integer]
Units Deci-angstroms/sec
The rate reported from sensor 4 with 9999 representing 999.9 Å/S. 4 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 42 rate from sensor 5
access index: RATE5
Value Range 0 To 9999 [integer]
Units Deci-angstroms/sec
The rate reported from sensor 5 with 9999 representing 999.9 Å/S. 5 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 43 rate from sensor 6
access index: RATE6
Value Range 0 To 9999 [integer]
Units Deci-angstroms/sec
The rate reported from sensor 6 with 9999 representing 999.9 Å/S. 6 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 44 rate from sensor 7
access index: RATE7
Value Range 0 To 9999 [integer]
Units Deci-angstroms/sec
The rate reported from sensor 7 with 9999 representing 999.9 Å/S. 7 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 45 rate from sensor 8
access index: RATE8
Value Range 0 To 9999 [integer]
Units Deci-angstroms/sec
The rate reported from sensor 8 with 9999 representing 999.9 Å/S. 8 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 46 xtal life/status from sensor 1
access index: XLIFE1
Value Range 0 To 99
Units Percent
xtal life/status from sensor 1. This parameter along with the following seven parameters form a contiguous block of 8. Associated card needs to be physically installed and enabled before a reboot.

Parameter 47 xtal life/status from sensor 2
access index: XLIFE2
Value Range 0 To 99
Units Percent
xtal life/status from sensor 2. 2nd in a contiguous block of 8. Associated card needs to be physically installed and enabled before a reboot.

Parameter 48 xtal life/status from sensor 3
access index: XLIFE3
Value Range 0 To 99
Units Percent
xtal life/status from sensor 3. 3rd in a contiguous block of 8. Associated card needs to be physically installed and enabled before a reboot.

Parameter 49 xtal life/status from sensor 4
access index: XLIFE4
Value Range 0 To 99
Units Percent
xtal life/status from sensor 4. 4th in a contiguous block of 8. Associated card needs to be physically installed and enabled before a reboot.

Parameter 50 xtal life/status from sensor 5
access index: XLIFE5
Value Range 0 To 99
Units Percent
xtal life/status from sensor 5. 5th in a contiguous block of 8. Associated card needs to be physically installed and enabled before a reboot.

Parameter 51 xtal life/status from sensor 6
access index: XLIFE6
Value Range 0 To 99
Units Percent
xtal life/status from sensor 6. 6th in a contiguous block of 8. Associated card needs to be physically installed and enabled before a reboot.

Parameter 52 xtal life/status from sensor 7
access index: XLIFE7
Value Range 0 To 99
Units Percent
xtal life/status from sensor 7. 7th in a contiguous block of 8. Associated card needs to be physically installed and enabled before a reboot.

Parameter 53 xtal life/status from sensor 8
access index: XLIFE8
Value Range 0 To 99
Units Percent
8th in a contiguous block of 8. xtal life/status from sensor 8. Associated card needs to be physically installed and enabled before a reboot.

Parameter 54 **xtal stability accumulated from sensor 1**
access index: XSTAB1
Value Range 0 To 9
Units None
1 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 55 **xtal stability accumulated from sensor 2**
access index: XSTAB2
Value Range 0 To 9
Units None
2 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 56 **xtal stability accumulated from sensor 3**
access index: XSTAB3
Value Range 0 To 9
Units None
3 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 57 **xtal stability accumulated from sensor 4**
access index: XSTAB4
Value Range 0 To 9
Units None
4 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 58 **xtal stability accumulated from sensor 5**
access index: XSTAB5
Value Range 0 To 9
Units None
5 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 59 **xtal stability accumulated from sensor 6**
access index: XSTAB6
Value Range 0 To 9
Units None
6 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 60 **xtal stability accumulated from sensor 7**
access index: XSTAB7
Value Range 0 To 9
Units None
7 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Parameter 61 **xtal stability accumulated from sensor 8**
access index: XSTAB8
Value Range 0 To 9
Units None
8 of 8 in a contiguous block. Associated card needs to be physically installed and enabled before a reboot.

Read RunTime Data Command Examples

Command E3 or E 3
Response A-1
Description Read Deposition Thickness In Angstroms. Thickness is Minus 1 Angstrom.
Command E4
Response A93
Description Read Phase Timer. Timer is 93 Seconds, Or 1 Minute, 33 Seconds.

Table 6.11: Group 4 Examples.

Read, Set Status Information

Read, Set Status Information Group 5-- Commands F & G

(F) Read Status Information. These commands will read certain status data from the STC-2002. This includes information such as whether the unit is stopped, what film is active, is the unit at max. power, etc. This information is in a more condensed form then available through the I/O system. The command is the letter F followed by a parameter number.

(G) Set Status Information. This forces certain status to occur in the STC-2002. The group command is the letter G followed by {1|2|3|17|21|22|23|24} = {0|1|2|3}. Note: 2,3 only allowed on G3 = form. There are only **8** parameter options in this group.

Command: F
Mnemonic: EXCT_rstat (read status)
Parameters: [1..66] corresponding to system status types SKHLD..LAUNCHFNO
Description: Requests a read back of status information regarding the current operating status of the instrument.

Returns:

[RZCD_AOK][status_value] if proper type # (1..66) id was sent. Exact value of [status_value] depends on the particular parameter for which the data was requested.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc.

Command: G
Mnemonic: EXCT_wstat (write status)
Parameters: [1,2,3,17,21,22,23,40,66] [assign_delim] [status_value] with 1,2,3,...40,60 corresponding to system status types SKHLD..MCTL, FLMHLD, JAMZPR, ATRATE, ZERO, IO_SCALAR_ANALOG and LAUNCHFNO. The status_value is the new intended status value for the status parameter to take on.
Description: Command allowing certain internal status conditions (SKHLD, FORSPL, MCTL, FLMHLD, JAMZPR, ATRATE, ZERO, XTST, IO_SCALAR_ANALOG and LAUNCHFNO) to be set to specific status values via the communications interface. See the F command for status read for valid range of [status_value] argument for a given value of the status variable selection index (SKHLD, FORSPL, MCTL, FLMHLD, JAMZPR, ATRATE, ZERO, IO_SCALAR_ANALOG, LAUNCHFNO).
Returns:

[RZCD_AOK] if proper type # (1..3,17,21,22,23,40,66) id and proper [status_value] was sent. Exact format of [status_value] depends on the particular status variable for which the data is being set to.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc.

Commands F and G, Status Information Parameters

Parameter 1 Soak Hold Status
Value Range 0,1
Units False/True
This parameter indicates if a soak hold state is requested. A value of 1 returned indicates that it is requested. A setting of true means that the soak 2 phase will be held overtime and prevented from entering the deposit phase until the soak-hold is released (made false). This status and others are alterable via G and/or I/O logic.
access: SKHLD soak hold status control variable, false(0)/true(1) status. program will stop at SOAK HOLD state prior to deposition if this status was true(1). Requires an event trigger to break out of film hold (RLSSKHLD event).

0 SKHLD_FALSE
1 SKHLD_TRUE

Parameter 2 Forced Sample
Value Range 0,1
Units Off / On
This parameter indicates if a forced sample state is in progress. A value of 1 returned indicates that a forced sample condition is desired. This state can be changed from the computer interface (G2), I/O logic, or front panel (hold/release '8' key) when on RunTime screen.
access: FORSPL forced sample, false(0)/true(1) status.

0 FORSPL_off
1 FORSPL_on

Parameter 3 Manual Controller Status
Value Range 0 To 3
Units None
This parameter indicates the last status of the manual hand controller according to the following values:
0 At Rest
1 Both Up And Down (zero power without aborting)
2 Up
3 Down
These are for simulating the hand controller through the computer interface only. This parameter does not reflect the physical status of the hand controller.
access: MCTL manual controller status, 0..3 for at rest, Both, Up, Down.

0 MCTL_ATRST
1 MCTL_ZERO
2 MCTL_UP
3 MCTL_DWN

Parameter 4 Manual Mode Active
Value Range 0,1
Units False/True

This parameter indicates if the STC-2002 is in the manual mode. A returned value of 1 indicates that it is in manual. This is a read only parameter, not available for G command.
access: MANL system in manual mode false(0)/true(1).

0 MANL_FALSE
1 MANL_TRUE

Parameter 5 Stopped Mode
Value Range 0 To 6
Units None
This parameter is used to indicate that the STC-2002 is in a stopped state. The following returned values are:

0 Stopped From A Power Up Condition
1 Stopped From A Crystal Bad Condition
2 Stopped From The I/O System Or Computer
3 Stopped From The Front Panel Key
4 Stopped From A Max. Power Condition
5 Stopped From The Hand Controller Button
6 Not Stopped

This is a read only parameter.
access: SMODE Stop mode, set when a stop event declared, set to one of the following STPCD_ types.

0 STPCD_CLEAN stopped at power up, no reason yet.
1 STPCD_GONE when stop condition cleared.
2 STPCD_XBAD crystal head or heads bad.
3 STPCD_RMOTE remote from I/O system.
4 STPCD_FPNL front panel.
5 STPCD_MAXP max power condition persisted too long.
6 STPCD_PEND remote pendant stop.
7 STPCD_UIFLST user interface presence lost.
8 STPCD_MEASCRIT critical measurement failure, comm lost to S4 card required for usage per config.
9 STPCD_IOCRIT critical I/O failure, comm lost to I/O or a detectable/unrecoverable failure.
10 STPCD_BHIE_ERR Bus Hold Integrity error failure caused.
11 STPCD_INDEXER_FAIL Rotator failed to signal done in time.
12 STPCD_INVALID_SRC Invalid source programmed in recipe.
13 STPCD_INVALID_SNS Invalid sensor channel in recipe.
14 STPCD_IO_AX1 Auxiliary I/O stop 1.
15 STPCD_IO_AX2 Auxiliary I/O stop 2.
16 STPCD_IO_AX3 Auxiliary I/O stop 3.
17 STPCD_IO_AX4 Auxiliary I/O stop 4.
18 STPCD_QUALDLY Shutter delay quality failure
19 STPCD_QUALDEP Deposition quality failure.

Parameter 6 Active Film Number
Value Range 1 To 9
Units Film Number
This parameter returns the current active film number. This is a read only parameter.
access: AFPN active film processing # 1..9.

Parameter 7 Running A Process (Process Running Flag)
Value Range 0,1
Units False / True
This parameter indicates that a process is running. A returned value of 1 indicates that a process is running. This is a read only parameter.
access: RNMD true when sequencer running a process, false(0)/true(1) false when at rest.

0 RNMD_FALSE
1 RNMD_TRUE

Parameter 8 Substrate Shutter Status
Value Range 0,1
Units Closed, Open
This parameter indicates if the substrate shutter is open or closed. A returned value of 0 indicates that the shutter is closed and a value of 1 indicates that it is open. This is a read only parameter.
access: SRCSHUT bitmap true(1) when source shutter open, false(0) if closed. One per active source ident (1..8) LSB to MSB. In non-codeposition systems, only one shutter can be open at any one time.

0 ALL SOURCE SHUTTERS CLOSED
1 Source # 1 SRCSHUT OPEN
2 Source # 2 SRCSHUT OPEN
4 Source # 3 SRCSHUT OPEN
8 Source # 4 SRCSHUT OPEN
16 Source # 5 SRCSHUT OPEN
32 Source # 6 SRCSHUT OPEN
64 Source # 7 SRCSHUT OPEN
128 Source # 8 SRCSHUT OPEN
255 ALL SOURCE SHUTTERS OPENED

Parameter 9 Phase Status
Value Range 0 To 17
Units None
This parameter indicates the phase that the STC-2002 is in according to the following Table:

0	Power Up	1	Stopped
2	Crystal Verify	3	Rise 1
4	Soak 1	5	Rise 2
6	Soak 2	7	Soak Hold
8	Shutter Delay	9	Deposit
10	Rate Ramp	11	Deposit After Rate Ramp
12	Time Power Recovery	13	Rise 3
14	Idle	15	Idle After Time Power
16	Manual	17	Ready

Table 6.12: Phase Status.
This is a read only parameter.
access: SQPHS sequencer phase, holds one of PCD_class (process code) data.

0 PCD_pup Power Up.
1 PCD_szp Stopped/Zero power.
2 PCD_bxvfy Crystal Verify.
3 PCD_ris1 Rise 1.
4 PCD_sok1 Soak 1.
5 PCD_ris2 Rise 2.
6 PCD_sok2 Soak 2.
7 PCD_skhl Soak Hold.
8 PCD_sdly Shutter Delay.
9 PCD_dpos Deposit.
10 PCD_rtrp Rate Ramp.
11 PCD_dpo2 Deposit phase after a rate ramp
12 PCD_tpwr Time power recovery phase
13 PCD_ris3 Idle ramp.
14 PCD_idlpr Idle power after successful deposit.
15 PCD_idltp Idle after ending deposit with a time/power phase.
16 PCD_manl Manual phase
17 PCD_rdy Ready phase

18 PCD_index Indexing to pocket
19 PCD_fhold Film Holding before rise/soaks.

Parameter 10 Crystal Shutter Status
Value Range 0,1
Units Open, Closed
This parameter indicates if the crystal shutter is closed. A returned value of 0 indicate that the shutter is open (making measurements) and a value of 1 indicates that it is closed. This is a read only parameter.
access: XTLSHUT xtal shutter state, true(1) when using a xtal, false(0) when ignoring data from crystal, shuttered off. Identical to XTLUSMAP except during sample/hold mode, sensors mapped off to 0 when hiding. One per active sensor ident (1..8) LSB to MSB.

0 ALL SENSOR SHUTTERS CLOSED, SENSORS NOT USED
1 Sensor # 1 XTLSHUT OPEN
2 Sensor # 2 XTLSHUT OPEN
4 Sensor # 3 XTLSHUT OPEN
8 Sensor # 4 XTLSHUT OPEN
16 Sensor # 5 XTLSHUT OPEN
32 Sensor # 6 XTLSHUT OPEN
64 Sensor # 7 XTLSHUT OPEN
128 Sensor # 8 XTLSHUT OPEN
255 ALL SENSOR SHUTTERS OPENED

Parameter 11 Sample/Hold Status
Value Range 0 To 2
Units None
This parameter indicates the status of sample/hold operation according to the following table:

0 Sample/Hold Not Active
1 Sampling
2 Holding

This is a read only parameter.
access: SPLHLD sample hold status, of SPLHLD_class.

0 SPLHLD_NUL not being cycled, so current state not important.
1 SPLHLD_SAM sampling, xtal being read for control.
2 SPLHLD_HOL holding, xtal being covered, pretend rate being used to accumulate thickness.

Parameter 12 Max. Power Limit Status
Value Range 0,1
Units False / True
This parameter indicates if the STC-2002 is at the max. power limit (indicated by a flashing power value on the RunTime display). A value of 0 returned indicates that the STC-2002 is not at the max. power limit. This is a read only parameter.
access: MAXPL true(1)/false(0) if at max power limit now. One per active source ident (1..8) LSB to MSB.

0 No sources at MAX power limit.
1 Source # 1 at Max Power limit.
2 Source # 2 at Max Power limit.
4 Source # 3 at Max Power limit.
8 Source # 4 at Max Power limit.
16 Source # 5 at Max Power limit.
32 Source # 6 at Max Power limit.
64 Source # 7 at Max Power limit.
128 Source # 8 at Max Power limit.
255 ALL sources at MAX power limit.

Parameter 13 Non-Volatile Memory Status
Value Range 0 To 7
Units None
This parameter indicates the status of non-volatile memory according to the following Table:

0	Everything OK
1	Film Parameter Error
2	I/O Program Error
4	Process Accounting Error
8	Process Sequence

The values are added together to form a composite error number. A returned value of 5 would indicate that there was a film parameter error and a process accounting error. This is a read only parameter.
access: VMEMS volatile memory status, bit weight composite which indicates which memory regions have a failed checksum.

0	VMEMS_aok	All good is 0.
1	VMEMS_fpms	Film params defaulted.
2	VMEMS_iopg	IO program defaulted to empty.
4	VMEMS_pact	Process accounting region data lost.
8	VMEMS_sequ	Process sequence region data lost.

Parameter 14 Hand Power Pendant INC Button
Value Range 0,1
Units False, True
This parameter is true while the INC button on the hand power pendant is pressed. This is a read only parameter.
access: PNDUP pendant up power button pushed status, true (1) when pushed.

Parameter 15 Hand Power Pendant DEC Button
Value Range 0,1
Units False, True
This parameter is true while the DEC button on the hand power pendant is pressed. This is a read only parameter.
access: PNDWN pendant down power button pushed status, true (1) when pushed.

Parameter 16 Hand Power Pendant Stop Button
Value Range 0,1
Units False, True
This parameter is true while the STOP button on the hand power pendant is pressed. This is a read only parameter.
access: PNDSP pendant stop button pushed status, true (1) when pushed.

Parameter 17 Film Hold
Value Range 0,1
Units False, True
If this parameter is true prior to start of film, film will remain in crystal verify phase until this parameter is false. Settable via RS232or I/O Logic. This is a read only parameter.
access: FLMHLD film hold, program will stop at FHOLD state when started if this status was true(1). Requires an event trigger to break out of film hold (RLSFHLD event).

Parameter 18 Active Layer
Value Range 0...99
Units Process Layer
This parameter reports the active layer as displayed on the screen. If sequence is reset and "#" is displayed on the screen, this parameter is "0". This is a read only parameter.
access: PROCIP process in process. 0 if # on screen, is layer step # if not. Valid range 0..99.

Parameter 19 Process Fail
Value Range 0,1,2
Units None
This parameter reports if a process has been terminated by other than normal completion. This is a read only parameter.
0 Process Not Failed
1 Bad recipe, generally no layer programmed in process. Occur at process verify phase after a process has been started.
2 Process error- sequence has been aborted due to some failure to complete film or external stop.
access: PRCFAIL PRCFAIL_class value of how process failed if was failed.
0 PRCFAIL_NOFAIL Not failed.
1 PRCFAIL_BADREC Bad recipe, invalid step #/recipe size.
2 PRCFAIL_ABORT Sequence aborted, film stopped.

Parameter 20 Process/Layer State
Range 0....5
Units None
This parameter reports the phase or state of a layer of process. This is a read only parameter.
0 Process verify- checking to see if process is properly programmed. this occurs at the start of a process and is of short duration.
1 Process stopped. Layer 0- this is the normal condition to start a process from its beginning.
2 Layer active, process resting- resetting a process error condition brings the unit to this state. At this point by using different start functions, the unit can be made to restart the layer, start the next layer, or reset to layer 0.
3 Process Busy- Process and layer are busy running a film.
4 Process Waiting- a wait has been encountered during the process sequence. A break wait start command releases this condition.
5 Process Error
access: LYRCD layer state code, LYRCD_class, vfy, stop, etc
0 LYRCD_vfy Verifying recipe.Short lived.
1 LYRCD_stop Process stopped, # displayed.
2 LYRCD_active Process resting.
3 LYRCD_busy Process Busy, running film.
4 LYRCD_waitchk Process Waiting.
5 LYRCD_error Error condition.

Parameter 21 Reset To Zero Power
Value Range 0,1
Units None
This parameter reports if the source control voltage has been set to zero volts by either an I/O or external command. Settable by computer (G21=0|1), or I/O Logic.
0 Not Set To Zero Volts.
1 Source control voltage has been set to zero volts.
access: JAMZPR Jam zero power, JAMZPR_class, off (0), on (1).
One per active source ident (1..8) LSB to MSB.
0 No sources overiden, source is at system power.

1 Source # 1 overiden to zero power.
2 Source # 2 overiden to zero power.
4 Source # 3 overiden to zero power.
8 Source # 4 overiden to zero power.
16 Source # 5 overiden to zero power.
32 Source # 6 overiden to zero power.
64 Source # 7 overiden to zero power.
128 Source # 8 overiden to zero power.
255 ALL sources overiden to zero power.

Parameter 22 At Rate (Deposition is at Desired Rate)
Value Range 0, 1
Units False, True
This parameter is TRUE if the measured rate is equal to the desired rate, else (0) not at desired rate.
access: ATRATE Deposition was at rate, NOT (0), YES (1). Set by measurement once rate is > desired. Only cleared in I/O program if used by customer. Better to use event code for ATRATE.

Parameter 23 Allow Zeroing
Value Range 0, 1
Units False, True
Check if Zeroing allowed when entering deposit. If this parameter is true (1) then Zeroing is inhibited on entering a deposit.
access: ZERO Allow normal zeroing (0=ZERO_NORM) or inhibit it (1=ZERO_SKIP) when entering deposit.

Parameter 24 Crystal Test Mode
Value Range 0, 1
Units False, True
If this parameter is true, a dual sensor configured STC-2002 will successfully start a film with only one sensor operational (the limp along mode).
access: SCUP_SEES_UIFC Set true when UIFC detected.

Parameter 25
access: MEAS_DEAD Set true when measurement system fatal failure detected. This is a hardware problem which is unrecoverable without recycling power and possibly repairing unit.

Parameter 26
access: UIF_DOGDIE Set true when UIFC dog times out and stop occurs.

Parameter 27
access: TEST_MODE Set true when the test/simulate mode is active.

Parameter 28
access: RTRSYNC Rotator Synchronization needed, 1 per source.

Parameter 29
access: ACTSRC Active source being controlled, 1..8.

Parameter 30
access: NON_SEQ Non-sequencing when true.

Parameter 31
access: SA1_POCKET source Channel 1 pocket, 0-63

Parameter 32
access: SA2_POCKET source Channel 2 pocket, 0-63

Parameter 33
access: SB3_POCKET source Channel 3 pocket, 0-63

Parameter 34
access: SB4_POCKET source Channel 4 pocket, 0-63

Parameter 35
access: SC5_POCKET source Channel 5 pocket, 0-63

Parameter 36
access: SC6_POCKET source Channel 6 pocket, 0-63

Parameter 37
access: SD7_POCKET source Channel 7 pocket, 0-63

Parameter 38
access: SD8_POCKET source Channel 8 pocket, 0-63

Parameter 39
access: AMAPID active map, contains 1..9 indicating current active map.

Parameter 40
access: IO_SCALAR_ANALOG, numeric value 0..255 which controls a chart recorder analog output value 0..FullScale if chart recorder option set to IOACC control mode.

Parameter 41
access: LFOVER, xtal life over limit bit map, bits set for xtal channels which are giving valid readings for which the life value is less than the limit value in the active film program.

Parameter 42
access: ZPWRS, bit map of which sources are at 0 power or unused, 1 if source has power or is strip-chart recorder usage.

Parameter 43
access: XTLAVAIL, bit map in pairs, shows what modules are avail.

Parameter 44
access: IO1_MODSTS I/O slot 1 module status.

Parameter 45
access: IO2_MODSTS I/O slot 2 module status.

Parameter 46
access: IO3_MODSTS I/O slot 3 module status.

Parameter 47
access: IO4_MODSTS I/O slot 4 module status.

Parameter 48

access: XTLDEADMAP Bitmap, sensors detected as dead.

Parameter 49
access: XTLSBYMAP Bitmap, sensors in standby.

Parameter 50
access: XTLUSMAP Bitmap, sensors in use contributing.

Parameter 51
access: SA1_HEADSTATE Source Board-A chl1 head status of HSTAT_class

---

Parameter 52
access: SA2_HEADSTATE Source Board-A chl2 head status of HSTAT_class

---

Parameter 53
access: SB3_HEADSTATE Source Board-B chl3 head status of HSTAT_class

---

Parameter 54
access: SB4_HEADSTATE Source Board-B chl4 head status of HSTAT_class

---

Parameter 55
access: SC5_HEADSTATE Source Board-C chl5 head status of HSTAT_class

---

Parameter 56
access: SC6_HEADSTATE Source Board-C chl6 head status of HSTAT_class

---

Parameter 57
access: SD7_HEADSTATE Source Board-D chl7 head status of HSTAT_class

---

Parameter 58
access: SD8_HEADSTATE Source Board-D chl8 head status of HSTAT_class

---

Parameter 59
access: ACPROC Active process.

Parameter 60
access: ACTSRCMAP Active source bitmap.

Parameter 61
access: S4A_BRDSTS Board slot A S4 status

Parameter 62
access: S4B_BRDSTS Board slot B S4 status

Parameter 63
access: S4C_BRDSTS Board slot C S4 status

Parameter 64
access: S4D_BRDSTS Board slot D S4 status

Parameter 65
access: BOX_FATAL_MD Instrument is in fatal unrecoverable mode.

Parameter 66

access: LAUNCHFNO Launch Film number, accessible when Non-sequencing. Can be set to range 1..LastFilm value and is used to augment use of the event code STARTCPL which starts whichever film value is stored in LAUNCHFNO.

Read, Status Information Command Examples

Command F6
Response A1
Description Query The Status Parameter 6, Active Film #. Active Film # is 1.

Command F9
Response A17
Description Query The Status Parameter 9, Phase Status. Process Sequence is At Ready Phase.

Command F 10
Response A0
Description Query The Crystal Shutter Status. Shutter is Non-Eclipsed, Not In Hold Mode.

Table 6.13: Group 5 Examples.

Write Status Information (G)
Only eight parameters are valid (1,2,3,17,21, 22, 23,24). See above for access.

Parameter 1 Soak Hold Status
Value Range 0,1
Units False/True
This parameter sets if a soak hold state is desired. A value of 1 forces it to be scheduled. If soak hold is enabled, this prevents the deposit phase from being entered.

Parameter 2 Forced Sample
Value Range 0,1
Units Off / On
This parameter forces a sample state On or Off. A value of 1 forces a sample.

Parameter 3 Manual Controller Status
Value Range 0 To 3
Units None
This parameter forces the status of the manual hand controller. It is used with a command in the next group called manual pendant update. If you issue either an up or down command, it stays in effect (ramping the power) until you issue an at rest command.

0 At Rest
1 Zero
2 Up
3 Down

Parameter 17 Film Hold
Value Range 0,1
Units False, True
If true, this parameter holds a film at the crystal verify state. The crystal verify state occurs immediately after a film is started.

Parameter 21 Source Voltage Set To Zero
Value Range 0,1
Units False, True
If true, this parameter forces the source control voltage to zero volts. A false value remover this override condition.

Parameter 22 At Rate
Value Range 0, 1
Units False, True
Deposition is at Desired Rate. If this parameter is TRUE the measured rate is equal to the desired rate, else (0) not at desired rate.

Parameter 23 Allow Zeroing
Value Range 0, 1
Units False, True
Zeroing allowed when entering deposit. If this parameter is true (1) then Zeroing is inhibited on entering a deposit, else it is allowed [default].

Parameter 24 Crystal Test Mode
Value Range 0, 1
Units 0 normal (need both working), 1 limp along on 1 crystal.
Normally, a unit configured for dual sensor operation requires both channels to be valid at the start of a deposition. In a multi-film deposition, it is possible to have a crystal failure on one of the channels after successfully finishing several initial layers. By disabling the need for both channels to be valid in later layers, the process can continue automatically with only one remaining crystal.

Command Examples
Command G1=1
Response A
Description Set status parameter 1 (soak hold status) to 1 or true. This will cause the process sequence to hold at the end of soak 2 and wait for the soak hold status to become false. Command understood and accepted.
Table 6.14: More Group 5 Examples.

Group 6-- Read, Trigger Events

Commands H & I

(H,I) Event Commands. These commands read and force certain conditions to occur in the STC-2002. When setting an event, only the parameter number is needed. There is no data associated with the parameter. (See Table 6.15)

Event Commands (H,I)

These commands are used to poll and trigger certain events in the STC-2002. When polling, a value of 0 or 1 is returned indicating not occurred or occurred. The poll status is latching, that is if an event

happens, its poll status remains until read by the computer interface. It is then reset and waiting to be set by that event again.
When triggering an event, no value is required since the action of sending the parameter triggers the event. The following is a Table showing parameter numbers and their equivalent I/O events:

List of computer pollable event codes:

Parameter#	Mnemonic	I/O ID#	Description
1	STOP		Any stop event, internal or external.
2	START		Any simple start event, internal or external.
3	STARTG		General start event, either I/O or computer.
4	START1		Select & Start Film 1, generated via I/O,COMM in non-sequencing option unit, or via sequence logic in sequencing-capable option unit.
5	START2		Same as START1 except for Film 2.
6	START3		Same as START1 except for Film 3.
7	START4		Same as START1 except for Film 4.
8	START5		Same as START1 except for Film 5.
9	START6		Same as START1 except for Film 6.
10	START7		Same as START1 except for Film 7.
11	START8		Same as START1 except for Film 8.
12	START9		Same as START1 except for Film 9.
13	MANLON		A manual on event triggered, possible ignored.
14	MANLOF		A manual off event, possible ignored.
15	MUPDT		A manual pendant update generated, caused by pendant logic or computer interface to control manual power when in manual. Ties into status command G MCTL(3) = 0..3.
16	FTRG		Final thickness trigger event. Caused by measurement logic or I/O or computer interface.
17	XFAIL		Crystal fail event. Caused by measurement logic or I/O or computer interface.
18	MLACK		Memory Loss Acknowledge event. Caused at power up by depressing manual button when prompted, or can be caused through computer interface.
19	ZERO		Thickness zero event, caused through automatic process flow or via computer interface, I/O or front panel.
20	SPTIME		Setpoint time event.
21	SPTHIK		Setpoint thickness event.
22	PHANTOM		Obsolete, no longer used.
23	PHANTOM		Obsolete, no longer used.
24	CILK00		Computer event links, can only be caused by an RS232/command or the I/O logic system. Used to tie the I/O ladder system into the remote host.
25	CILK01		See CILK00.
26	CILK02		See CILK00.
27	CILK03		See CILK00.
28	CILK04		See CILK00.
29	CILK05		See CILK00.
30	CILK06		See CILK00.
31	CILK07		See CILK00.
32	CILK08		See CILK00.
33	CILK09		See CILK00.
34	BRKWT		Break wait event, caused by I/O system, Front Panel Start or host computer in systems with sequencing enabled.
35	FLMRE		Film reset event, caused by I/O system, Front Panel Start or host

			computer in systems with sequencing enabled.
36	LYRADV		Layer Advance, caused by I/O system, Front Panel Start or host computer in systems with sequencing enabled.
37	PRCRE		Process reset, caused by I/O system, Front Panel Start or host computer in systems with sequencing enabled.
38	STRTUNC		Process start unconditional, caused by I/O system or host computer in systems with sequencing enabled.
39	SECTIM		Second metronome timer event, triggered on period of one second. Usefull for establishing timebase in I/O or host interfaces.
40	MINTIM		Minutes metronome timer event, triggered on period of one minute. Usefull for establishing timebase in I/O or host interfaces.
41	HRSTIM		Hours metronome timer event, triggered on period of one hour. Usefull for establishing timebase in I/O or host interfaces.
42	BOJDPOS		Begin of deposit cycle, film being processed has begun the deposit/rate-ramp/deposit-2/manual phase area, after pre-condition/shutter-delay phases, shutter is open.
43	EOJDPOS		End of deposit cycle, film being processed has left the deposit/rate-ramp/deposit-2/manual phase area for idle-ramp/idle or stop phases.
44	EOJFILM		End of Film event, film being processed has reached an idle or stopped phase.
45	EOJPROC		End of process event, last film in a process sequence has completed, process is over.
46	STPROC1		Select & Start Process 1, generated via I/O,COMM in sequencing option unit.
47	STPROC2		Same as STPROC1 except for Process 2.
48	STPROC3		Same as STPROC1 except for Process 3.
49	STPROC4		Same as STPROC1 except for Process 4.
50	STPROC5		Same as STPROC1 except for Process 5.
51	STPROC6		Same as STPROC1 except for Process 6.
52	STPROC7		Same as STPROC1 except for Process 7.
53	STPROC8		Same as STPROC1 except for Process 8.
54	STPROC9		Same as STPROC1 except for Process 9.
55	RRTRIG		Rate Ramp Trigger, causes system to enter the rate ramp on an external request, providing properly program-med.
56	PHANTOM		Obsolete, no longer used. Was LIMPX.
57	BOJPROC		Begin of job/process, new to STC-2002
58	BOJFILM		Begin of job/film, new to STC-2002
59	RLSFHLD		Release from a film hold condition. Trigger of this event releases a film FSM to leave film hold and go on to rise/soaks as needed.
60	CILK10		See CILK00.
61	CILK11		See CILK00.
62	CILK12		See CILK00.
63	CILK13		See CILK00.
64	CILK14		See CILK00.
65	CILK15		See CILK00.
66	CILK16		See CILK00.
67	CILK17		See CILK00.
68	CILK18		See CILK00.
69	CILK19		See CILK00.
70	CILK20		See CILK00.
71	CILK21		See CILK00.

72	CILK22		See CILK00.
73	CILK23		See CILK00.
74	CILK24		See CILK00.
75	CILK25		See CILK00.
76	CILK26		See CILK00.
77	CILK27		See CILK00.
78	CILK28		See CILK00.
79	CILK29		See CILK00.
80	RLSSKHLD		Release from a soak hold condition. Trigger of this event releases a film FSM to leave soak hold and go on to rise/soaks as needed.
81	RSYNC_PG 1		Pocket good, gun1.
82	RSYNC_PG 2		Pocket good, gun2.
83	RSYNC_PG 3		Pocket good, gun3.
84	RSYNC_PG 4		Pocket good, gun4.
85	RSYNC_PG 5		Pocket good, gun5.
86	RSYNC_PG 6		Pocket good, gun6.
87	RSYNC_PG 7		Pocket good, gun7.
88	RSYNC_PG 8		Pocket good, gun8.
89	REVERIFY		Trigger a request for MEAS to re-scan map matrix
90	ZROTK_SS 1		Thickness zero, chnl1.
91	ZROTK_SS 2		Thickness zero, chnl2.
92	ZROTK_SS 3		Thickness zero, chnl3.
93	ZROTK_SS 4		Thickness zero, chnl4.
94	ZROTK_SS 5		Thickness zero, chnl5.
95	ZROTK_SS 6		Thickness zero, chnl6.
96	ZROTK_SS 7		Thickness zero, chnl7.
97	ZROTK_SS 8		Thickness zero, chnl8.
98	CNCLPR_S S1		Reset output power, gun1.
99	CNCLPR_S S2		Reset output power, gun2.
100	CNCLPR_S S3		Reset output power, gun3.
101	CNCLPR_S S4		Reset output power, gun4.
102	CNCLPR_S S5		Reset output power, gun5.
103	CNCLPR_S		Reset output power, gun6.

	S6		
104	CNCLPR_S S7		Reset output power, gun7.
105	CNCLPR_S S8		Reset output power, gun8.
106	FAILSCL_ CHL1		Fail sensor channel, chnl1.
107	FAILSCL_ CHL2		Fail sensor channel, chnl2.
108	FAILSCL_ CHL3		Fail sensor channel, chnl3.
109	FAILSCL_ CHL4		Fail sensor channel, chnl4.
110	FAILSCL_ CHL5		Fail sensor channel, chnl5.
111	FAILSCL_ CHL6		Fail sensor channel, chnl6.
112	FAILSCL_ CHL7		Fail sensor channel, chnl7.
113	FAILSCL_ CHL8		Fail sensor channel, chnl8.
114	ATRATE_ MEZ		At rate during measurement.
115	STP_IO_A X1		I/O auxiliary stop 1.
116	STP_IO_A X2		I/O auxiliary stop 2.
117	STP_IO_A X3		I/O auxiliary stop 3.
118	STP_IO_A X4		I/O auxiliary stop 4.
119	STARTCPL		Event which is only available when non-sequencing. When triggered will request a start of the film which has been written into SSS_LAUNCHFNO via I/O or parser.

Table 6.15: Event Commands.
*Can be polled with 'H' command but not triggered with 'I' command.
Note 1: This command is available only through the computer interface. It updates the status set by parameter 3 of the 'G' command set.
Note 2: This command acknowledges a memory loss condition. Normally, the operator has to push the MANUAL key to continue past where a memory loss is detected (during the power up phase).

Command Examples
Command H21
Response A0
Description Poll whether a setpoint thickness condition has been triggered since the last time polled by the computer interface (computer). A 0, or False, indicating that the event has not yet taken place.

Command H1
Response A1
Description Poll whether the system stop event has occurred since the last time a poll was requested of this event. A 1, or true response, indicating that the event has occurred since the last time polled. Issuing the poll again will result (most likely) in a 0 response, since no new stop has occurred in the time between successive polls.

Command I1
Response A
Description Signal the STC-2002 to trigger a stop event. The STC-2002 will react as though the front panel STOP button was depressed. If the unit was not already stopped (such as at idle or ready) then the screen of the STC-2002 will display "stopped remote". The A response indicates command understood and performed.

Command I18
Response A
Description Trigger the "acknowledge program memory loss" event within the STC-2002. This event is duplicated from the front panel when pushing the manual button during the time that the screen indicates a program data loss. By triggering this event via the computer, and then downloading new information, a program data loss can be recovered fully automatically, without an operator. This can be done if the status poll of the non-volatile memory status ("f13") yields a non-zero result. Response indicates the command was understood and performed.

Command I 5
Response A
Description Start process unconditionally, using film #2. Response indicates command understood and performed.
Table 6.16: Groups 9 And 10 Examples.

Command: H
Mnemonic: EXCT_epoll (event poll)
Parameters: [1..119] corresponding to event selection codes STOP..STARTCPL as listed below:
Description: Requests return of selected event condition history since last poll. If selected event has had an occurrence since last computer poll (RS232 parser, beware of intermingled requests for this information) then will return a true (1) value. If no events at all or since last poll then will return false (0).

Returns:
[RZCD_AOK][0 or 1] if proper event id [1..119] was sent.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..
NOTE: Certain events may be disallowed depending on whether or not sequencing is enabled in the instrument.

Command: I
Mnemonic: EXCT_etrig (event trigger)
Parameters: [1..119] corresponding to event selection codes STOP..STARTCPL as listed above
Description: Causes the selected event to be triggered or made to occur such that any other system logic can detect it and then perform as designed. I/O can respond to events, the auto-matic process sequence system can respond to events, etc.

Returns:
[RZCD_AOK] if proper event id [1..119] was sent.
[RZCD_ILDV] if improper value for parameter argument.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..
NOTE: Certain events may be disallowed depending on whether or not sequencing is enabled in the instrument.

I/O Status Commands

I/O Status Commands Group 7 --
Command J

(J) Read I/O Information. These commands will read the states of the remote inputs and relays, status codes, softnodes, counter values.

Command: J
Mnemonic: EXCT_ioexm (I/O exam)
Parameters: [0..71, 72..128, 150..157, 300..399, 400..409]
Description: Requests a read of state of I/O nodes which correspond to the identifier code (0..128, 150..157, etc..). A return of non-zero indicates TRUE or active. A return of 0 indicates FALSE or inactive. Scalar types can return numeric values between 0 and 255 (such as bit maps, counters,etc). These values are only usable (dynamically updated with new information) if the corresponding node identifier is actually being used within the live (active) I/O program. The state of value which is then being stored into these node areas during program evaluation are what the query (exam) returns. A value of 256 will be returned from nodes which are not being used in an I/O program. If a running I/O program is edited such that a node is no longer referenced in the I/O program, the next query will return a 256 value. This functionality is intended to aid in introspection and debugging of I/O programs by allowing remote determination of I/O node states, especially those which are internal, such as softnodes and counters, for which there is no other independent view. The assignment of the numbers to internal I/O conditions matches the definitions used to program the I/O system. Missing codes of 129 to 149 are reserved for future status pollable nodes. Codes from 158 to 169 are reserved for future settable/pollable status nodes. Codes from 170 to 299 are event type codes and are not pollable by this command but can be looked at via the 'H' command and the appropriate command code (see description above). Note there is no simple correspondence between I/O event codes and 'H' command event id indices.

Returns:
[RZCD_AOK][0..255, 256] if proper I/O node id argument was sent. Returns a logical or scalar value (0,1 for boolean, 0..255 for scalar) for nodes which are being used in I/O program. Returns 256 for nodes which are not in program, information is not representative of system meaning.
[RZCD_ILDV] if improper value for parameter argument.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc.

I/O Status Command (J)

The J set of commands can detect certain states and events in the I/O system. The parameter that is passed is the ID number used by the I/O system. The data returned is either a 0 or 1, depending on the state. The following ID's are always available:

0 To 7	Remote Inputs 1 Through 8
8 To 15	Relays 1 Through 8
16 To 72	IState
81 To 94	UState
141 To 190	Soft Nodes
300 To 899	Counter
900 To 999	Layer Number

Other states and events are available if the I/O program uses them. The ID number that is used as a parameter number is found in Table 5.3. If you ask for something that is not in the above list or in the I/O system, the result will not be valid.

Command Examples
Command J 0
Response A0

Description Read Boolean state of I/O node 0, hardware input number 1. Response of 0, input is not active (is ungrounded).

Command J8
Response A1
Description Read Boolean state of I/O node 8, hardware relay number 1 output contacts. Response of 1, output is active (assuming I/O rungs in program make it so).

Command J141
Response A1
Description Read status of I/O soft node, # 141. Assuming the node is assigned somewhere in the I/O program, this statement will query the current state of it. This aids in debugging complicated I/O programs. Soft Node is Set True.
Table 6.17: Group 7 Examples.

Kill Command

Command: K
Mnemonic: EXCT_kill (KILL, causes equivalent to reset of CPU)
Parameters: =200 literal string with special numeric value to trigger.
Description: Commands STC-2002 to stop satisfying internal watchdog circuit thereby causing a hardware reset within approximately 400 milliseconds. This command should be sent only to cause a remote power up condition similar to a power-off/power-on sequence. This causes a complete hardware reset of the instrument, and can be used to cause certain parameters (such as sequencing/non-sequencing, etc..) to be reloaded after being changed by the host computer interface. =200 will reboot both the UIFC processor and the SCUP processor.

Returns:
May not return anything if watchdog causes a reset before reply message is requested received at host or may return partial message if reset during RS232 reply.

[RZCD_AOK] if proper safety code (=200) was sent.
[RZCD_ILDV] if improper value for parameter argument.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

Read Process Accounting

Read Process Accounting Group 8 --
Command L

(L) Process Accounting. These commands can upload the information in the process accounting display. See Section 2.18 for a description of these parameters.

Command: L
Mnemonic: EXCT_prac (process accounting access)
Parameters: [0..3] [0..23] corresponding to most recent history (0) to oldest (3) account record logged for data items

Description: Requests return of information saved during a process run. The STC-2002 saves information for the last four completed film deposition runs. Each time a new film is completed the information summary (detailed below) for the run is stored away as the latest result (index 0 for first argument) and the previous latest run (old index 3 before this data log operation commenced) data is lost. Data recorded as index 0 through 2 before a new run completion are then accessed by index numbers 1 through 3. Since each log has date/time and run number (and layer number in the case of sequencing) information stamped with it, tracing which data applies to what run is simple. The list of processing accounting data element access indices is below.

Returns:

[RZCD_AOK][param_value] if proper log item ident code argument was sent. Exact format of [param_value] depends on the particular log item for which the data was requested.
[RZCD_ILDV] if improper value for parameter argument.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc.

Read Process Accounting (L)

The set of L commands are used to read the process accounting information from the STC-2002 to the host computer. There are 2 parameters that are passed. The first is a single digit from 0 through 3. This indicates which set of parameters is to be read. The number 0 is the most recent and 3 is the oldest. The second parameter defines what piece of information will be read. Table 6.18 lists the numbers and parameters.

Process Accounting

Index Address / ID	***Mnemonic***	***Description***		
0	PA_date	Date of process run, calendar MM/DD/YY as 6 digits.		
1	PA_time	Time, clock hrs/mins in military HH:MM .		
2	PA_rnno	Run #, 0.9999. Followed by 'T' if a test mode run.		
3	PA_procid	Process #, 1..9 if sequencing, 0 if non-sequencing.		
4	PA_lyrn	Layer number if sequencing, 1..99, # of step in sequence.		
5	PA_flmn	Film # , 1..99.		
6	PA_map	Source-Sensor Map reference number, 1..30.		
7	PA_source	Source channel for power, 1..8 or 0 if invalid source.		
8	PA_pocket	Pocket number associated with film. 0..63.		
9	PA_tdep	Time of shutter open in seconds.		
10	PA_ethk	Ending thickness.		
11	PA_erate	Ending rate.		
12	PA_pwrv	Power value at shutter close.		
13	PA_loop	Loop accum at shutter close, 0..99.		
14	PA_x1use	Life reading for xtal 1 at beginning/end.		
15	PA_x2use	Life reading for xtal 2 at beginning/end.		
16	PA_x3use	Life reading for xtal 3 at beginning/end.		
17	PA_x4use	Life reading for xtal 4 at beginning/end.		
18	PA_x5use	Life reading for xtal 5 at beginning/end.		
19	PA_x6use	Life reading for xtal 6 at beginning/end.		
20	PA_x7use	Life reading for xtal 7 at beginning/end.		
21	PA_x8use	Life reading for xtal 8 at beginning/end		
22	PA_tproc	Time of process, start to idle or stop.		
23	PA_stat	Process run completion status, stopped/why, normal idle, tpwr, etc... from completion status messages below.		
		0	NORMAL	normal completion, reached idle.
		1	TIMPWR	completed to idle, time power during deposit.
		2	BADXTL	crystal bad.
		3	REMOTE	remote from I/O system.

		4	KEYBRD	front panel
		5	MAXPWR	max power condition persisted too long.
		6	PENDNT	remote pendant stop.
		7	SAFE 1	User Interface subsystem failure.
		8	S4 BAD	Measurement module systems failure
		9	IO BAD	I/O module/plugin failure.
		10	0 BHIE	Measurement Bus Hold failure.
		11	INDEXR	Indexer feedback timeout failure
		12	INVSRC	Invalid source associated with Map/Film
		13	INVSNS	Invalid sensor associated with Map.
		14	IO_AX1	I/O auxiliary stop 1
		15	IO_AX2	I/O auxiliary stop 2
		16	IO_AX3	I/O auxiliary stop 3
		17	IO_AX4	I/O auxiliary stop 4
		18	QUALDLY	Failed quality while in shutter delay
		19	QUALDEP	Failed quality while in deposit

Table 6.18: Process Accounting Id List.

Command Examples
Command L0 2
Response A1234
Description Read the 0th (most recent of the four) process log item # 2, the run #. run # 1234 was the run most recently completed.

Command L 3 2
Response A ”BLANK” spelled out
Description Read the 3rd (oldest of the four) process log item # 2, the run #. The log has no information in this entry, fewer than four processes have been logged into the history.

Command L0 14
Response A BADXTL
Description Read the 0th (most recent of the four) process log item # 14, the completion status of the process. A bad crystal caused the stopping or aborting of the run.
Table 6.19: Group 8 Examples.

Read, Load I/O program

Read, Load I/O program Group 9 -- Commands M,N & O

(M) (N) (O) I/O Program Reading And Loading. These commands are used for uploading and downloading the I/O rungs. These commands are not used for controlling the I/O program, just getting it in and out of the STC-2002.
M - read I/O rung
N - select I/O rung for change
O - I/O rung data

Load I/O Program (M, N, O)

These commands Read and Set I/O rung expression contents. Follow **M** with number *n* for which rung is to be read (n can be 1,2 or 3 digits from 1 to 999). If the **M** command is followed immediately by = , it means repeat the transmission of the same information. If it is followed immediately by + , it means advance to the next portion of rung information. This is needed in order to keep the I/O buffers short. It is possible for the rung length to exceed the STC-2002 buffer which is 13 bytes long. In this case it is broken up into several lines of information.

If **n** is beyond the last rung with contents, the STC-2002 will return end and the rung number of the END rung as follows: "A.END nn".

The **N** command is used to change a rung to new data. The N is followed with number *n* to identify which rung to change. After the initial N command, subsequent 'O' commands specify the new rung data.

The **O** command sends an I/O expression to the STC-2002. The O is followed immediately with either a period ('.') or a sequence digit '0' .. '9' and the ASCII rung information. The entire string of the 'O', the '.' or digit, and the following rung symbolic must not exceed 13 characters. Lines longer than this use the sequence number to indicate a continuation is needed, with the final portion (or only portion if small enough) having a '.' where the digit goes.

Command: M
Mnemonic: EXCT_iord (I/O read)
Parameters: [1..LASTRUNG] or [=] or [+]
Description: Requests a read-back of the current active I/O program's symbolic I/O rung data expression. If 1..LASTRUNG (where LASTRUNG is any number greater than or equal to the actual last rung in program storage) then the command will return the reply result (RZCD_AOK, etc..) followed by a sequence code (see description below) followed by symbolic rung expression data. A simple example exchange will clarify this:

SEND:	**Description**	**RECEIVE:**	**Description**
M 1	Request Rung 1		
		A0I18 P109 +	Part of rung sequence code 0 indicates 1st part of line.
M=	Request to resend last data without scanning ahead to remainder of line.		
		A0I18 P109 +	Used if a com link error caused last data to be lost. This way there is no need to start at beginning of rung again.
M+	Request additional information as the previous reply had a sequence code # (0..9) rather than a '.' as terminator.		
		A.S8	Final contents of rung sent in response to the M+ advance command. Un-limited numbers of M= can be sent to request this again until received without data error.

Returns:

[RZCD_AOK][SEQUENCE_CODE][RUNG_SYMBOLIC_DATA] if proper parameters were sent. Exact content of [SEQUENCE_CODE] and [RUNG_SYMBOLIC_DATA] depend on what was programmed into the I/O program. If the rung # parameter is beyond the last rung of the I/O program, then the STC-2002 will return "A.END nn" with nn being one rung beyond the last valid rung number. In this way the length of the program can be ascertained by reading back with a M999 request. This is sure to be longer than the current program (storage allows for a maximum of about 400 rungs) and will respond with the rung number of the last line of the I/O program.

[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

Command: N
Mnemonic: EXCT_iochg (I/O change rung number set)
Parameters: [1..LAST_RUNG] where the parameter number is the number of the rung to be changed or edited.
Description: Designates the rung id to be alterred with a new symbolic rung expression which will follow in subsequent 'O' commands which are described below. If the rung identifier is beyond the end of the program then the command is automatically interpreted to mean alter the end of the program which currently contains END, thereby extending the program.
Returns:
[RZCD_AOK] upon success.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

Command: O
Mnemonic: EXCT_ioexp (I/O expression for changes))
Parameters: [SEQUENCE_CODE][RUNG_SYMBOLIC_DATA]
Description: Sends an I/O logical expression symbolic string to the STC to compose the new rung information for the rung which was set up in the preceding N command. The [SEQUENCE_CODE] and [RUNG_SYMBOLIC_DATA] information complies with the description given above for the M command, such that replies from the STC-2002 can be modified and then downloaded back to the STC-2002. This makes uploading and downloading the I/O program uncomplicated. If the I/O rung data can fit in a single expression then the [SEQUENCE_CODE] is the '.' character, indicating the final (and possibly only) sub-string to compose the desired rung content. If the I/O rung data requires multiple messages, then the [SEQUENCE_CODE] is sent (0,1,etc.) until completed, with the last string having a '.' [SEQUENCE_CODE] token. Should a reply to such a 'O' message be garbled or indicate error (RZCD_AOK not received) then it can be sent again with the [SEQUENCE_CODE] insuring that the STC-2002 does not take the message to contain the next string of data. If the STC-2002 determines redundant repeated [SEQUENCE_CODE] substrings, they are ignored. Should the STC-2002 receive [SEQUENCE_CODE] tokens out of order (not 0,1,2,etc..) then the RZCD_IOSQ code will be returned.
Returns:
[RZCD_AOK] if proper sequence and data were sent.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..
[RZCD_IOSQ] if sequence codes out of sequence.

Command Examples

Command M 1
Response A0I18 P109 +
Description Request upload of rung # 1. The 'A' indicates understood, the '0' indicates the rung information is being blocked in multiple records, this being the 0th, the rest of the packet is the first part of the rung contents, "I18 P109 +".

Command M=
Response A0I18 P109 +

Description Request the same information again as the last response was unintelligible (checksum error, for instance). A duplicate of the above response, to insure reception. The sequence information insures that the assembly of multi-packet rungs is valid.

Command M+
Response A.S8
Description Request additional information on the rung specified in the "M 1" command, since the previous packet had a sequence # associated with it. The '.' where the sequence # goes indicates this is final packet of the rung description. By pasting the "S8" onto the "I18 P109 +" from the first packet, the total rung contents of "I18 P109 + S8" is uploaded. Longer rungs may require more packets. Each packet is numbered, starting at 0, then 1, 2 etc., until the final '.' packet.

Command M999
Response A.END 12
Description Request rung # 999 data (rungs will not go that high since data storage allows for a maximum of 400 rungs). The end information indicates that the rung requested is beyond the last rung which has program information in it. The number 12 after the end word indicates that rung # 12 is the end rung, and rung # 11 is the last rung of the program containing boolean expressions.

Command N23
Response A
Description Signal the desire to change or alter rung # 23. If no rung #23 exists (as is the case with the program shipped with the unit, which stops at rung 11), then the end rung (#12 in this case) will be changed, extending the program. Command understood and performed, future 'O' commands will reference rung 23.

Command O.IO 0141
Response A
Description Send a terminal packet (because of the '.') defining the selected rung as "I0 O141". This sets the rung to input-from-0 output-to-softnode-141. Command understood and performed, rung modified. New 'O' commands will require a new 'N' command prefix in order to specify which rung to modify or change next.

Command N9
Response A
Description Request Change To Rung 9. Command Understood And Performed.

Command O0I45 I46 I47
Response A
Description Enter 0th packet of rung symbolic. Command understood and performed.

Command O1I48+++
Response A
Description Enter 1st packet of rung symbolic. Command understood and performed.

Command O.O141
Response A
Description Enter final packet of rung symbolic. Command understood and performed, rung in place as "I45 I46 I47 I48 + + + O141" .
Table 6.20: Group 9 Examples.

I/O Program Editing Group 10 -- Commands P,Q,R,S

(P) (Q) (R) (S) I/O Editing Commands. This set of commands will do the following editing functions in the I/O program:

P - Delete A Rung
Q - Select The I/O Program (Primary Or Alternate)
R - Insert An Empty Rung
S - Store The I/O Program Into The Alternate Memory

Editing The I/O Program (P, Q, R, S)

The P command is used to delete an I/O rung, followed by a rung number value.

The Q command is used to select the I/O rung bank or query it. Follow the Q by a 1 or 2 to select bank a or b (similar to swap only explicit). If the Q is followed by a 3, the STC-2002 returns a result message of "A*n d* crc" where *n* is an error number from the I/O error codes list below, *d* is a bank code, either 'A' or 'B, and *crc* is the rung program checksum, 1 to 5 digits, 0 to 65535 in value. The error code pertains to the last N/O command series which failed.

The R command will insert a blank rung. It is followed by a rung number *n* and will insert a blank line unless the I/O program has no more room, or n is higher than END rung #.

The S command saves an I/O program from the current bank into the alternate memory bank for safekeeping. Must be followed with the number 200 to activate, so that inadvertent operation is not triggered with a simple single letter command.

I/O Error Codes List:

0	No Error, Command Accepted.
1	Unrecognized Characters Or Format, Missing Spaces, Etc.
2	Unmatched Pushes And Pops.
3	Not Enough Pushes For The Pop Operators.
4	Illegal I/O Node Identifier #. See List Of Legal Ids.
5	Invalid Op code For Selected Node Id.
6	Existing Use Of Node-Id Conflicts With New Use.
9	Nothing On Line At All.
10	Out Of Memory, No Room For Rung Data.

Command: P
Mnemonic: EXCT_iodel (I/O rung delete)
Parameters: [1..MAXRUN] where the parameter value identifies the rung number of the currently active I/O program to delete.
Description: Commands the STC-2002 to remove from the I/O program the rung entry identified by the parameter value.
Returns:

[RZCD_AOK] if proper rung number id was sent and such a rung exists.
[RZCD_INHB] if the requested rung number is beyond the last valid step in the program.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

Command: Q
Mnemonic: EXCT_iosel (I/O select bank)

Parameters: [1,2,3]
Description: If the parameter is 1 or 2 then the STC-2002 is commanded to select the 'A' or 'B' I/O program memory, respectively. This has utility like the SWAP command of the user interface but is explicit as to the desired active program selection. If the parameter is a 3 then the command queries the I/O program and replies with a response indicating the condition of the active I/O program. The condition information includes which bank is active (A or B), what if any errors exist with the I/O program (see error codes below) and what the I/O program space CRC checksum is. The checksum is a code which is derived from the symbolic contents (and order) of the rung information and can be used to identify (via signature value) the I/O program contents. Any changes to the I/O program will result in a modified CRC value. In this way a quick check of the authorized I/O program can be made without a rung by rung comparison with a source document. If the number is the same as recorded for the authorized version then it is safe to assume the program is the intended authorized version.

List of I/O error codes
0 IOERR_GOOD No error, I/O program has acceptible syntax.
1 IOERR_UNREC Unrecognized format for tokens.
2 IOERR_2DEEP Stack nested too deep.
3 IOERR_UNFLW Stack underflow, nothing to pop.
4 IOERR_BADNID Bad node id, wrong # .
5 IOERR_BADMIX Wrong opcode in mix with #.
6 IOERR_PHASE Conflict between usages.
7 IOERR_UNBAL Unbalanced set/clear.
8 IOERR_UNRFI Unreferenced input, being read with nothing to write to it.
9 IOERR_EMPTY Nothing on line at all.
10 IOERR_OUTMM Out of memory.

Returns:
If Q1 or Q2 sent:
[RZCD_AOK]
If Q3 sent:
[RZCD_AOK][err_no] space [bank_code][crc_value]
where err_no is 0..10 (see chart above)
bank_code is either 'A' or 'B'.
crc_value is 1 to 5 digits, ranging from 0 (for blank program) through 65535, depending on result of 16 bit CRC on rung data.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

Command: R
Mnemonic: EXCT_ioins (I/O insert blank rung)
Parameters: [1..LASTRUNG]
Description: Commands the STC to place an empty rung ({ }) into the active I/O program at rung number specified, forcing current occupant of the rung and any others after it to be renumbered one higher. Used to make a gap in rung list so can place useful rung data in proper sequence or location as program maintenance causes changes in rung contents.
Returns:
[RZCD_AOK] if rung number is valid (between 1 and current end rung)
[RZCD_INHB] if rung number is beyond the "END" last rung identifier.
Use the M999 query which returns "[RZCD_AOK].END nn" to identify the last rung available for empty rung insert.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

Command: S
Mnemonic: EXCT_iosav (I/O save active bank to alternate)

Parameters: 200 as a safety value.
Description: Commands the STC to save the current I/O program rung data into the alternate inactive I/O program space, erasing any previous I/O program held there. For instance, if the 'A' bank is active, will save the program in the 'A' bank to the 'B' bank, making them identical.
Returns:

[RZCD_AOK] if safety # (200) was sent.
[RZCD_ILDV] if improper value for parameter argument.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

Command Examples

Command P 3
Response A
Description Delete rung # 3 from the program, just as if the user used the I/O menu screen to do so. Rungs after #3 are renumbered to be one lower. Command understood and performed.

Command P900
Response L
Description Request to delete rung # 900. Error, operation syntactically correct, but inhibited since no rung # 900 exists to delete. This error will return anytime a delete is commanded for a rung at or past the end of the program.

Command Q3
Response A0 B39983
Description Query the I/O program status. The 0 code is the last error result of previous I/O change commands. If an I/O change ('O') command returns an error, then a query of this type will return a # (see above I/O error codes) which will explain the nature of the error. The B code indicates the B memory is the active I/O program. The 39983 is the checksum of the program. This is a CRC algorithmic sum which aids the user in identifying changes to the program. If a known good I/O program is generated by the user, then this number can be recorded and used to insure that the I/O program has not been altered since a change to the program would result in a new and different CRC number. This saves the user from having to scan a long I/O program list to verify program integrity.

Command Q1
Response A
Description Switch to bank A use a 2 to go to bank B. Command understood and performed, if not already using bank A, will switch to it.

Command R2
Response A
Description Insert a blank in rung 2, old rung numbers 2.. the END become 3 .. END+1. Command understood and performed, a new gap is inserted in the program and all subsequent rungs are renumbered one higher.

Command R 99
Response L
Description Insert a blank in rung 99, old rung numbers 99.. The END become 100 .. End+1. Error code, operation inhibited since rung # 99 is beyond the current program. Legal values of the # are from 1 through the last ("end") rung, inclusive. Use the "M999" command to determine the final rung first.

Command R2
Response L
Description Insert a blank in rung 2, old rung numbers 2.. the end become 3 .. End+1. Program memory filled up, no room for another rung.

Command S200
Response A
Description Request a save from current bank to backup. Command understood and performed, both memory banks have the exact same programs in them after execution.
Table 6.21: Group 10 Examples.

Set Analog Output (T)

Set Analog Output (T) Group 11 --
Command T

(T) This command allows the analog output which normally reports either rate, thickness or power information to be controlled by an external computer to a voltage between plus and minus 10 volts. *(note: this option must be selected in the system configuration procedure)*

Command: T
Mnemonic: EXCT_setdac (Set DataLog dac value)
Parameters: [-32767 .. 0 .. 32767]
Description: Sets Analog Data log value from 0 to +10 volts in 12 bit precision. Analog voltage will track this value if the ARFNC system parameter is set to 4, computer control of analog output (either via user menu or computer). Output voltage is linear with respect to parameter value. Range of value is backwards compatible to STC200 (signed 16bit) but STC-2002 generation hardware is single ended and 12 bit, therefore granularity of output is courser, with a single bit change at DAC every 8 counts (3 LSBs of argument are don't cares). Negative values are inverted so output is essentially the absolute value of input argument.
Returns:
[RZCD_AOK] if proper DAC value # (-32767 .. 32767) was sent.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

Set Analog Output (T)
This command sets analog data log value from -10 volts to +10 volts in 16 bit precision. Analog voltage will track this value if the #9 system parameter (Group 3/C/D) is set to 4, computer control of analog output (either via user menu or remote RS232 D9=4 command). The range of numbers is -32767…32767.

Command Examples

Command T=-6556
Response A
Description Sets DAC to -6556 counts, which will produce approximately -2.05 volts at the analog output if the system parameter for analog output function is set to REMOTE.
Table 6.22: Group 11 Examples.

Process Sequencing - Process Size, Memory Group 12 -- Commands U & V

(U,V) These commands determine the number of steps in a process and the amount of process memory storage available.
(U) - Reads Number Of Steps (00 ...99) In A Given Process (1.....9)
(V) - Reads Process Step Memory Storage Still Available

Process Sequencing - Process Size Memory(U,V)

The U command requests a readback of the number of steps in use in the designated process recipe (as per the parameter 1..9). A recipe with only the END layer present uses zero (0) steps.
The V command requests a readback of number of process steps storage still available for use in the STC-2002 instrument. There is a capacity within the instrument for a total of 250 process steps, which may be assigned from 0 to 99 to a process recipe. For example, nine processes each having 27 steps in each would use up 243 steps, leaving a remainder of 7 available. This is the value (7) returned by this query. Any process which has fewer than 99 steps may be extended with more steps providing there is memory available (as indicated by the return of this command). Deletion of steps of some other process may be necessary to free up steps should no steps be available to extend the process which needs extension.

Command: U
Mnemonic: EXCT_plenth (Process Length)
Parameters: [1..9] corresponding to process recipe programs 1..9.
Description: Requests a readback of the number of steps in the designated process recipe.
Returns:
[RZCD_AOK][0..99] if proper process # (1..9) was sent.
[RZCD_ILCD] if unit is non-sequencing instrument.
[RZCD_ILDV] if improper value for parameter argument.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

Command: V
Mnemonic: EXCT_pavail (Process steps available)
Parameters: None
Description: Request readback of number of process steps storage still available for use in STC-2002 instrument. There is capacity within the instrument for a total of 250 process steps, which may be assigned from 0 to 99 to a process recipe. Nine processes each having 27 steps each would use up 243 steps, leaving a remainder of 7 available. This is the value returned by this query. Any process which has fewer than 99 steps may be extended with more steps providing there is memory available (as indicated by the return of this command). Deletion of steps of some other process may be necessary to free up steps should no steps be available to extend the process which needs extension.
Returns:
[RZCD_AOK][0..250] indicating the number of available process steps left to be assigned to a process recipe.
[RZCD_ILCD] if unit is non-sequencing instrument.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

Command Examples

Command U2
Response A17
Description Query of process 2 indicates 17 layers of a possible 99 are programmed.

Command V
Response A250
Description Query of free (unused) steps available indicates 250 are unused. This means none have been used for any processes, therefore, no processes can be run at this time. Once a process sequence is programmed, this number will be reduced to show the remaining free space.
Table 6.23: Group 12 Examples.

Process Sequencing - Read, Write, Edit Processes Group 13 -- Commands W-Z, a-d

Commands W, X, Y, Z, a, b, c, d
These Commands Read, Write, Or Edit The Process Sequencing Steps.

(W) - Erase Process Step
(X) - Insert Process Step
(Y) - Read Layer Mode Setting
(Z) - Set Layer Mode Setting
(a) - Read Layer Film Setting
(b) - Write Layer Film Setting
(c) - Read Layer Final Thickness Setting
(d) - Write Layer Final Thickness Setting

Process Sequencing Read, Write, Edit Processes(W,X,Y,Z,a,b,c,d)
The **W** command requests that the designated step of the selected process be erased, and any steps following will be compacted up.
The **X** command commands the STC-2002 to insert a new step into recipe, with the mode type as specified. Defaults the new step's film number to 1, and its final thickness limit to 0 Angstroms. After insertion of a new step the film and thickness values can be changes with the 'b' & 'd' commands. PROCID ranges 1..9 to select the process to insert the new step into. STEPID ranges from 1..99 and if it exceeds the current length of the process it will be interpreted so as to add a new step at the end.
The **Y** command requests a readback of a process step's mode setting. Returns a numeric value corresponding to a mode per the chart below.

List of valid mode codes for a step:

0. MODE_end	End of recipe, some earlier step last valid step, use 'U' command above.
1. MODE_auto	Auto start, this step will run at the end of previous step automatically.
2. MODE_wait	Wait at this step for a process.
3. MODE_skip	Skip this step and advance to others, if any.
4. MODE_stop	Stop the process run, prepare to reset again.

'Z' commands the STC-2002 to set process step's mode to a new value. This command is similar to the 'X' command except it changes mode of existing step rather than inserting a new one. Changing mode to MODE_end truncates the rest of the process recipe, freeing up step memory to available list (see 'V' command above).

The 'a' command requests a readback of a process step's film number setting. Returns a numeric value (1..99) identifying the film program which the process step will execute when active.
The 'b' command requests the STC-2002 to set a process step's film selection to a new value.
The 'c' command requests a readback of a process step's final thickness limit value setting. It returns a numeric value (0-9999999 angstroms) for the current setting of the target process step.
The 'd' commands the STC-2002 to set a process step's thickness limit to a new value.

Command: W
Mnemonic: EXCT_perase (Process erase)
Parameters: [PROCID] [STEPID] with PROCID ranging from 1..9 to select the recipe to alter. STEPID ranging from 1..99 selecting the step to delete.
Description: Request that the designated step of the selected process be erased, and any steps following will be compacted up.
Returns:

[RZCD_AOK] if proper recipe # and step # sent and able to delete the step.
[RZCD_ILCD] if unit is non-sequencing instrument.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..
[RZCD_INHB] if the requested step number is beyond the last valid step in the program or the instrument is running a process and the selected process is the active process.

Command: X
Mnemonic: EXCT_pinsrt (Process insert)
Parameters: [PROCID] [STEPID] [assign_delim] [MODE_TYPE]
Description: Commands STC-2002 to insert a new step into recipe, with the mode type as specified. Defaults the new step's film number to 1, and the final thickness limit to 0 Angstroms. After insertion of new step the film and thickness values can be changed with the EXCT_pwfilm & EXCT_pwthik commands. PROCID ranges 1..9 to select the process to insert the new step into. STEPID ranges from 1..99 and if exceeds the current length of the process will interpret to add a new step at the end.

List of the Valid modes for a step.

1 MODE_auto Auto-start, this step will run at end of previous automatically.
2 MODE_wait Wait at this step for a process.
3 MODE_skip Skip this step and advance to others, if any, also used for insert.
4 MODE_stop Stop the process run, prepare to reset again.

Returns:

[RZCD_AOK] if proper process, step and mode numbers were sent.
[RZCD_ILCD] if unit is non-sequencing instrument.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..
[RZCD_INHB] if the instrument is running a process and the selected process is the active process.

Command: Y
Mnemonic: EXCT_prmode (Process read mode)
Parameters: [PROCID] [STEPID] where PROCID is 1..9 and STEPID is step selector 1..99.

Description: Request a readback of a process step's mode setting. Returns a numeric value corresponding to a mode per the chart below.

List of the Valid modes for a step readback.
0 MODE_end End of recipe, previous step last valid step.
1 MODE_auto Auto-start, this step will run at end of previous automatically.
2 MODE_wait Wait at this step for a process.
3 MODE_skip Skip this step and advance to others, if any, also used for insert.
4 MODE_stop Stop the process run, prepare to reset again.
Returns:
[RZCD_AOK][mode_value] if proper process and step #s were sent.
[RZCD_ILCD] if unit is non-sequencing instrument.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..
[RZCD_INHB] if step number not valid in specific process program.

Command: Z
Mnemonic: EXCT_pwmode (Process write mode)
Parameters: [PROCID] [STEPID] [assign_delim] [MODE_TYPE] where
PROCID identifies target process,
STEPID identifies target step within process,
MODE_TYPE specifies new mode for step from set of types in list below.
Description: Commands STC to set process step's mode to new value. Command is similar to EXCT_pinsrt 'X' command above except changes mode of existing step rather than inserting new one. Changing mode to MODE_end truncates the rest of process recipe, freeing up step memory to available list (see V command EXCT_pavail above).

List of modes to set step to.
0 MODE_end End of recipe, previous step last valid step.
1 MODE_auto Auto-start, this step will run at end of previous automatically.
2 MODE_wait Wait at this step for a process.
3 MODE_skip Skip this step and advance to others, if any, also used for insert.
4 MODE_stop Stop the process run, prepare to reset again.
Returns:
[RZCD_AOK] if proper process, step and mode numbers were sent.
[RZCD_ILCD] if unit is non-sequencing instrument.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..
[RZCD_INHB] if the requested step number is beyond the last valid step in the program or the instrument is running a process and the selected process is the active process and the step being alterred is the current active layer step. Programming the mode for steps other than the current active step is valid and allowed.

Command: a
Mnemonic: EXCT_prfilm (Process read film)
Parameters: [PROCID] [STEPID] where PROCID is 1..9 and STEPID is step selector 1..99.
Description: Request a readback of a process step's film number setting. Returns a numeric value (1..99) identifying the film program which the process step will execute when active.
Returns:
[RZCD_AOK][film_value 1..99] if proper process and step #s were sent.
[RZCD_ILCD] if unit is non-sequencing instrument.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..
[RZCD_INHB] if step number not valid in specific process program.

Command: b
Mnemonic: EXCT_pwfilm (Process write film)
Parameters: [PROCID] [STEPID] [assign_delim] [FILM_NUMBER] where
PROCID identifies target process,
STEPID identifies target step within process,
FILM_NUMBER specifies new film selection 1-99 for step.
Description: Commands STC to set process step's film selection to new value.
Returns:
[RZCD_AOK] if proper process, step and film numbers were sent.
[RZCD_ILCD] if unit is non-sequencing instrument.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..
[RZCD_INHB] if the requested step number is beyond the last valid step in the program or the instrument is running a process and the selected process is the active process and the step being alterred is the current active layer step. Programming the film for steps other than the current active step is valid and allowed.

Command: c
Mnemonic: EXCT_prthik (Process read thickness)
Parameters: [PROCID] [STEPID] where PROCID is 1..9 and STEPID is step selector 1..99.
Description: Request a readback of a process step's final thickness limit value setting. Returns a numeric value (0-9999999 angstroms) for the current setting of the target process step.
Returns:
[RZCD_AOK][thik_value] if proper process and step #s were sent.
[RZCD_ILCD] if unit is non-sequencing instrument.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..
[RZCD_INHB] if step number not valid in specific process program.

Command: d
Mnemonic: EXCT_pwthik (Process write thickness)
Parameters: [PROCID] [STEPID] [assign_delim] [THIK_VAL] where
PROCID identifies target process,
STEPID identifies target step within process,
THIK_VAL specifies new final thickness value 0..999999 angstroms for step.
Description: Commands STC to set process step's thickness limit to new value.
Returns:
[RZCD_AOK] if proper process, step and thickness numbers were sent.
[RZCD_ILCD] if unit is non-sequencing instrument.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..
[RZCD_INHB] if the requested step number is beyond the last valid step in the program. It is always legal to change the final thickness value in the recipe, even when the program is running the targeted process step layer.

Command Examples

Command W2 57
Response L
Description Command to erase step 57 of process 2 is invalid because no such step exists, or process is currently active.

Command W1 13
Response A
Description Command to erase step 13 of process 1 is successful.

Command X1 89=1
Response A
Description Command to insert a step in a process has succeeded. Any step which were already at or after the 89th step have been renumbered so as to follow step 89. If the last preexisting step was less than 89, the inserted step is placed at the previous last step plus one. For example, if prior to the X1, 89=1 command above the last step was 3, then a new step 4 was created.

Command Y1 13
Response A1
Description Command to query step 13 of process 1 is successful. The 1 value indicates the step is occupied and is an AUTO step.

Command Z1 13=2
Response A
Description Command to reprogram step 13 of process 1 is successful. The new mode of the step is WAIT.

Command a9 3
Response A4
Description Command to query step 3 of process 9 is successful. The numeric return of 4 indicates film 4 is the active film for step 3 of process 9.

Command b4,5=6
Response A4
Description Command to set step 5 of process 4 to film #6 is successful.

Measurement Substitution Group

Measurement Substitution Group Group 14 – Commands e,f,g

These commands substitute or over-ride measurement modes.

(e) - Over-rides thickness measurement.
(f) - Substitutes measurement mode.
(g) - Substitutes rate measurement mode.

Measurement Substitution Group(e,f,g)

The '**e**' command either queries (if parameter is ?) or sets the measurement override system. A setting of 0 disables the override and allows the system to make measurements from the crystal sensor. A value of 1 selects thickness override and the STC-2002 uses thickness values provided via the communications link using the ('**f**') command below. A value of 2 selects rate override mode, where the '**f**' command updates rate information, and this rate is integrated to produce thickness update within the instrument. A value of 3 selects dual override, where both datum are substituted, with the thickness value sent with the '**f**' command, and the rate encoded with the '**g**' command.

The '**f**' command sends a numeric value which has meaning when the instrument is set in a thickness override (1,3) or rate override (2) mode. If instrument is in 0 mod, then the value is ignored. Values from -9999999 to 9999999 allowed. Tenth Angstrom or hundredths A°/sec units.

The '**g**' command sends a numeric value which has meaning when the instrument is set in dual rate/thickness override (3) mode. If the instrument is in modes 0,1,2 then the value is ignored. Values from -999999 to 9999999 hundredths A°/sec allowed

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Purge all I.O Programs

Purge all I.O Programs Group 15 – Command h

This command clears the entire I/O program of the current bank to empty.

Purge all of I/O Program (h)

The 'h' command clears the entire I/O program of it's current bank to empty. Requires =200 to work as a safety.

Command: h
Mnemonic: EXCT_iopurg
Parameters: =200 as a safety.
Description: Clears entire I/O program of current bank to empty.
Returns:

[RZCD_AOK] if proper parameter value was sent.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..

External Memory Module Status

External Memory Module Status Group 16 – Command I

This command queries the STC-2002 for current status of the optional external memory module <not implemented>.

External Memory Module Status (i)

The 'I' command queries the STC-2002 for current status of the External Memory Module. Returns 0,1, or 2 indicating: (0) not installed, (1) installed, or (2) bogus, meaning system hung waiting for clear key to be pressed.

Command: i

Mnemonic: EXCT_mrxstat
Parameters: none.
Description: Queries STC-2002 for current status of Memory Module.
Returns: Numeric value 0, 1 , 2 for not installed, installed, bogus. Bogus means system is menu hung until a clear key is pressed.
[RZCD_AOK] if proper parameter value was sent.
[RZCD_ILDV] if improper value for parameter arguments.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc.

Command i
Response A0
Description Memory Module not installed.

Command: ^
Mnemonic: EXCT_trapinfo
Parameters: ? or ! with no delimiters or U followed by ? or ! for UIFC.
Description: sys_trap information display (?), clear (!).
Returns:
[RZCD_AOK] if proper parameter value was sent. If was a ^? or ^U? query then returns a result of the form:
J,N
where J and N are major and minor sys_trap numbers whose meaning is dependent on the source code. Values of 0,0 indicate no captured error states.
[RZCD_ILDV] if 2nd character (parameter) is other than ? or ! or U ; or if 2nd character is a U and third character is other than ? or !.
[RZCD_ILCD] if command expression too long or too short (more than correct trailing parameters or missing any argument parameter info).
Examples:
^?
query current state of SCUP sys_trap error codes. Returns valid reply per syntax above such as:
A1,2
^! clear sys_trap error codes to 0,0 . Armed to get new error conditions. Replies with just the RZCD_AOK value.
^ missing needed argument, returns RZCD_ILCD.
^ABC More argument than needed, returns RZCD_ILCD.
^4 Argument wrong value, returns RZCD_ILDV.

Command: j
Mnemonic: EXCT_flush
Parameters: =2001
Description: Flush non-vol and reboot as if a Service-Purge performed. The syntax of the j command allows spaces around the '=' operator. The numeric value of 2001 is a security key to insure that the function is only activated intentionally to purge parameter, sequencing, process accounting and I/O memory.
Returns:
[RZCD_AOK] if proper parameter value was sent. Unit will reboot after approximately 2 seconds, and recover to a runtime mode with the system 'hung' in a state which requires user acknowledgement (via front panel or RS232 event) before deposition can occur.

[RZCD_ILSN] if too many arguments, wrong delimiters, etc. such that format is not of the form j=NUMBER.
[RZCD_ILDV] if NUMBER following the = operator is other than the correct value of 2001.

Command: l
Mnemonic: EXCT_CfgManip
Parameters: either ID=VAL or ID
ID is a firmware dependent value which can range from 1 to QUAN_COPTCS, currently 4 (see table below). The value of VAL (when used) can range 0..254, but only legal values will actually be stored into the ID slot. What values are legal for each specific ID are detailed in the table below.
Description: Manipulate configuration items for new reboot. If the 'l' token is followed by just the ID (see table below) then the current value of the service configuration entry is returned. If the parameter is of the form ID=VAL, then the service configuration value is modified to the new value VAL, and the previous value is returned (before modification) as though a simple query was sent. Allows setting of Service mode reboot attributes akin to what the user can do via the Service menu screen, giving remote computer control of the Test mode, Purge, Factory, etc. modes.
Returns:
Table of ID values and VAL values and their meanings.
ID# VAL Range Description
1 0..1 Test mode, set to true (1) if desire test mode. Default is 0, or false. Any non-zero value for VAL when sending the l1=NNN message will be interpreted as TRUE and store a legal 1 value.That value can be later polled with a l1 query. When unit is rebooted, a TRUE setting will be acted upon, and the TEST mode will be in effect until the next reset/reboot. The setting of the configuration values is not 'sticky', meaning they are lost after reboot and need to be re-sent if desired to take action again.
2 0..1 Make the SQ unit type act like Non-SQ (A) after rebooting. Like ID 1 above, any non-zero VAL value is interpreted as TRUE.
3 0..1 Make the non-SQ unit type act as SEQ (B) after rebooting. Like ID 1 above, any non-zero VAL value is interpreted as TRUE. NOTE: no more than one of the two ID 2 and 3 values above should be set to TRUE (1), since they are mutually contradictory. Both can be set to FALSE (the default) since no action would then be taken during the next reboot. If both options are set to TRUE, then the ID # 3 option (act like sequencing) has the priority, and the unit will power up in a SQ capable mode.
4 0..4 Want a power up force of data base to other than remembered nonvolatile state. The three value choices of 0,1 and 2 correspond to the following meanings:
0 PRGMOD_as is : leave memory state as is. The default state, in effect, take no action.
1 PRGMOD_purged : everything set to forgotten default values. safe. The unit will have no usefull program content and will need programming by the customer.
2 PRGMOD_factory: everything set to as if RS232 download, same as purge above, except the I/O program is left alone and certain film and sys. configuration parameters are preloaded to allow the customer to run simple film operations as in instruc. manual.
3 PRGMOD_clone
4 PRGMOD_archive

ID#	VALUE Range	Description
1	0..1	Test mode, set to true (1) if desire test mode. Default is 0, or false. Any non-zero value for VAL when sending the l1=NNN message will be interpreted as TRUE and store a legal 1 value.That value can be later polled with a l1 query. When unit is rebooted, a TRUE setting will be acted upon, and the TEST mode will be in effect until the next reset/reboot. The setting of the configuration values is not 'sticky', meaning they are lost after reboot and need to be re-sent if desired to take action again.
2	0..1	Make the SQ unit type act like Non-SQ (A) after rebooting. Like ID 1

		above, any non-zero VAL value is interpreted as TRUE.		
3	0..1	Make the non-SQ unit type act as SEQ (B) after rebooting. Like ID 1 above, any non-zero VAL value is interpreted as TRUE. NOTE: no more than one of the two ID 2 and 3 values above should be set to TRUE (1), since they are mutually contradictory. Both can be set to FALSE (the default) since no action would then be taken during the next reboot. If both options are set to TRUE, then the ID # 3 option (act like sequencing) has the priority, and the unit will power up in a SQ capable mode.		
4	0..4	Want a power up force of data base to other than remembered nonvolatile state. The five value choices of 0,1, 2, 3 and 4 correspond to the following meanings:		
		Value	Access	Description
		0	PRGMOD_as is	leave memory state as is. The default state, in effect, take no action.
		1	PRGMOD_purged	everything set to forgotten default values. safe. The unit will have no usefull program content and will need programming by the customer.
		2	PRGMOD_factory	everything set to as if RS232 download, same as purge above, except the I/O program is left alone and certain film and sys. configuration parameters are preloaded to allow the customer to run simple film operations as in instruction manual.
		3	PRGMOD_clone	program STC-2002 from memory module contents
		4	PRGMOD_archive	save STC-2002 programming to memory module

---

Command: m
Mnemonic: EXCT_SSMAP_QRY
Parameters: either <SSMAP#>,<SPARM#9..N> or <SSMAP#>,<CHNL#1..8>,<CPARM#1..N>
Description: Command to query the multichannel Source/Sensor map parameters used to configure the measurement process applied to a film. SSMAP# is an integer, 1..9, identifying which map is being interrogated. The second parameter, when in the range of 1..8, indicates a sensor channel (crystal head) configuration is targeted, with the third parameter CPARM# ranging from 1..N (see table of SnsChnlAtrb_class SCA_xxx_G values below). The second parameter, when in the range of 9..N, will associate with the sensor map SPID_OUTFS (FIRST_GENERIC_SENSOR_MAP_P) thru LAST_GENERIC_SENSOR_MAP_P (SPID_SFAILM) value per the SPARM# table below.

Table of Sensor Map non-channel related parameter SPARM#s for second parameter in range of 9..N

SPARM#	Label	Description		
9	OUTFS	Source output full scale volt. Is an enumeration value of CFSV_class		
		0	CFSV_2V	2.5 volts full scale.
		1	CFSV_5V	5 volts F.S.
		2	CFSV_10V	10 volts F.S.

10	SMAXP	Source output max power (additional) percentage. 0.0 to 100.0 percent.
11	SOCHL	Source output analog channel number 1..8
12	MTOOL	Master tooling 10.0-400.0%, like tooling.
13	MINSC	Minimum Starting Contributors, 1..8 .
14	MINRB	Minimum Remaining Backups for good start, 0..7 .
15	PLTUN	Platoon strength, min. # of contrib channels 1..8 .
16	SFAILM	Sensor failure mask, how to recover when averaging mode has a sensor channel failure (FMSK_class) 0 FMSK_NONE No channel-failure rate-glitch correction. Whatever happens with missing contributor occurs. 1 FMSK_FULL_MASK Full substitute via aggreg. multi-plier for rate glitch continuously.
17	RSYN	Rotator synchronization type, none, delayed, feedback
18	RSYNTM	Rotator synchronization time 2..999 secs.

Table of SnsChnlAtrb_class CPARM# values as third parameter

when second parameter for CHNL# channel 1-8.

CPARM#	Label	Description
1	SSMOD	Starting Mode: of SMOD_class 1..3 0 SMOD_OFF channel not active 1 SMOD_ACTIVE channel active at start 2 SMOD_STANDBY channel needed as backup
2	SFOP	Sensor Fail Operation of SFMOD_class 1..2 0 SFMOD_NOTHING no special failure operation 1 SFMOD_FILM_FAIL film failure signalled. 3 SBAKS Sensor Backup list, ordered list of channel numbers which is saved as long integer form of decimal list of 8 digits, from 00000000 (0) to 88888888. Any form not containing the digit 9 and mathematically

between 0..88888888 can be conceptually entered, but data entry process will compress the information into minimum form by removing redundant (subsequent) numbers. Example, the value 1242134, although less than 8 digits, can be minimally expressed as 1243.

4 STOOL Sensor Tooling factor 10.0 to 400.0 percent.

5 SWGHT Sensor averaging weighting factor. 10.0 to 400.0.

Returns: Error codes typical to format or range failure if format is incorrect. Returns [RZCD_AOK] followed by parameter's value as stored in system (enumerations start w/0 values, numbers having numeric meanings stored naturally except floating point values are stored as integer values with implied decimal points of fixed precision). For example, m2,7,4 will query SS Map # 2, Crystal/Sensor channel 7, tooling value from 10.0 to 400.0 percent for internal storage value of 100 to 4000 .

Command: n
Mnemonic: EXCT_SSMAP_UPD
Parameters: either <SSMAP#>,<SPARM#9..N>=<QQ> or
<SSMAP#>,<CHNL#1..8>,<CPARM#1..N>=<QQ>
Description: Command to set/program the multichannel Source/Sensor map parameters used to configure the measurement process applied to a film. SSMAP# is an integer, 1..9, identifying which map is being programmed. The second parameter, when in the range of 1..8, indicates a sensor channel (crystal head) configuration is targeted, with the third parameter CPARM# ranging from 1..N (see table of SnsChnlAtrb_class SCA_xxx_G values in 'm' command above). The second parameter, when in the range of 9..N, will associate with the sensor map SPID_OUTFS (FIRST_GENERIC_SENSOR_MAP_P) thru LAST_GENERIC_SENSOR_MAP_P (SPID_SFAILM) value per the SPARM# table above (see 'm' command above).
Returns:

[RZCD_AOK] (A or B) if correctly processed.
[RZCD_ILDV] if improper value for parameter argument.
[RZCD_ILSN] if too many arguments, wrong delimiters, etc..
[RZCD_INHB] if chosen parameter can not be programmed at this time. This currently does not apply to any sensor map parameters, but could change in future, as needed.

Command:]
Mnemonic: EXCT_echochek
Parameters: Any and all
Description: Special test code to implement test software, will echo back complete string content identical to what was sent in. That is, sending]HELLO returns the result of [RZCD_AOK]]HELLO where [RZCD_AOK] is either an A or B.
Returns:

[RZCD_AOK]]xxxxx where xxxx is whatever was sent in to the parser following the] character.

SECTION 7.0 Theory and Calibration

Measurement Theory

The STC-2002 uses the resonant frequency of an exposed quartz crystal to sense the mass of deposited films attached to its surface. There is a known relationship between the mass of such a film and the measured frequency of the sensor crystal. Knowing the frequency change due to accumulated mass, film thickness is determined by the following equation:

Equation 1:

$$Af = \left[\frac{(Nq \bullet Dq)}{(\Pi \bullet Df \bullet Z \bullet Fc)}\right] \bullet \text{ArcTan}\left[Z \bullet \text{Tan}\left[\frac{\Pi \bullet (Fq - Fc)}{Fq}\right]\right]$$

Where the terms used in the equation are defined as:

Af	Film Thickness, in Angstroms (1a=10^{-10} Meters)
Nq	Frequency Constant for AT Cut Crystal, 1.668 X 10^{13} Hz/Å
Dq	Density of Quartz 2.648 gm/cm^3
Π	The Constant Pi, 3.14159265358979324
Df	Density Of Film Material in gm/cm^3
Z	Z-Factor of material, is the square root of the ratio [(Dq∗uq)/(Df∗uf)]. Dq and Df are the densities as above and uq and uf are the shear moduli of quartz and the film, respectively. These values are available in several materials handbooks.
Fq	Frequency of sensor crystal prior to depositing film material on it. This value is a manufacturing controlled constant.
Fc	Frequency Of Loaded Sensor Crystal.

Measuring Period

By measuring the period of the sensor oscillator signal and using a stable reference clock, an extremely accurate frequency value for Fc is derived using advanced counter technology. Ten times per second, a new value is determined and used to update the above equation. The mathematics is computed using IEEE double precision floating point format, ensuring the most accurate results obtainable from the exact equation, even over wide extremes of the Z-Factor and density parameters used in thin film deposition. Use of the tangent and arctangent functions to compute the film thickness to the resolution of the floating point numeric format (56 bits of resolution) ensures maximum accuracy. Previous solutions incorporated approximations to eq1 or dealt strictly with the period type of measurement solution. The thickness zero function stores as a base or offset the current sensor frequency and film thickness information, which is then continuously subtracted from the later updated readings, yielding a deposited film thickness value based on accumulated material since the latest zero function was performed.

Rate Computation

Rate computation is based on the rate of change of these thickness readings, updated ten times per second, then filtered for display. Also available from the instrument is the raw measured frequency of the sensor crystal.

SECTION 7.1 Thickness Reading Calibration

Thickness

Instrument calibration is affected by three different parameters, material density, material Z-Factor, and tooling. Tooling is a deposition system geometry correction (location of sensor relative to substrates). Density and Z-Factor are material factors.

Density Determination

Use of the material bulk density value will normally provide sufficient film thickness accuracy. If additional accuracy is required, the following procedure may be used:

Density

Using a new sensor crystal (this eliminates Z-Factor errors) place a substrate adjacent to the sensor so that both sensor and substrate see the same evaporant stream. Set the instrument density to the bulk value of the material (see the Material Reference Table in Section 4.3). Set the Z-Factor to 1.000 and the Tooling Factor to 100%. Deposit approximately 5000 Angstroms of material on the sensor and substrate. After deposition remove the substrate and measure the film thickness with a profilometer or multiple beam interferometer. The correct density value may be determined by the formula:

$$\text{Density}\left(\frac{\text{Gm}}{\text{cc}}\right) = \frac{(\text{Density Parameter}) \bullet (\text{Reading})}{(\text{Measured Thickness})}$$

The calculated value may be checked by setting the STC-2002 density parameter to the calculated value and observing that the STC-2002 thickness display shows the corrected reading. Minor value adjustments can be made to make the measurements and calculations exactly equal.

Z-Factor Determination

A list of Z-Factor values may be found in the Material Reference Table in Section 4.3. For other materials Z-Factor may be calculated by the following formula:

Z-Factor

$$\text{Z - Factor} = \left[\frac{D_q \bullet U_q}{D_f \bullet U_f}\right]^{1/2}$$

$\mathbf{D_q}$ = Density Of Quartz
$\mathbf{U_q}$ = Shear Modulus Of Quartz
$\mathbf{D_f}$ = Density Of Film
$\mathbf{U_f}$ = Shear Modulus Of Film

The density and shear modulus values may be found in many material reference handbooks.

Z-Factor values are typically very close to bulk values. High stress materials seem to have values slightly lower than expected.
>

Tooling Determination

Place a substrate in the normal holder location and deposit a film of approximately 5000 Angstroms using either bulk or calibrated density and Z-Factor values. Make sure that when doing this calibration the tooling is set to 100%. Measure the substrate film thickness as in the density calibration method and determine the correct Tooling Factor value by the following formula:

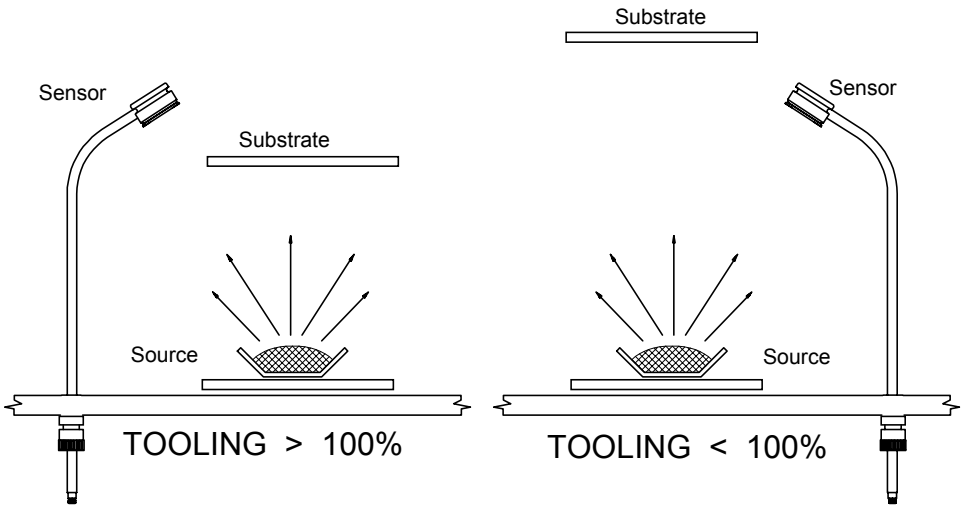

Figure- 7.1: Typical Tooling factors

$$\text{Tooling \%} = 100 \times \frac{(\text{Substrate Thickness})}{(\text{Displayed Thickness})}$$

SECTION 7.2 Material Reference Table

Common Material
Bulk Density And Z-Factor Values

Material	Symbol	Bulk Density gm/cc	Z Factor
Aluminum	Al	2.73	1.080
Aluminum Oxide	Al2O3	3.97	--------
Antimony	Sb	6.62	0.768
Arsenic	As	5.73	0.966
Barium	Ba	3.50	2.100
Beryllium	Be	1.85	0.543
Bismuth	Bi	9.80	0.790
Bismuth Oxide	Bi2O3	8.90	--------
Boron	B	2.54	0.389
Cadmium	Cd	8.64	0.682
Cadmium Selenide	Cdse	5.81	--------
Cadmium Sulfide	Cds	4.83	1.020
Cadmium Telluride	Cdte	5.85	0.980
Calcium	Ca	1.55	2.620
Calcium Fluoride	CaF2	3.18	0.775
Carbon (Diamond)	C	3.52	0.220
Carbon (Graphite)	C	2.25	3.260
Cerium (III) Fluoride	CeF3	6.16	--------
Cerium (IV) Oxide	CeO2	7.13	--------
Chromium	Cr	7.20	0.305
Chromium (III) Oxide	Cr2O3	5.21	--------
Cobalt	Co	8.71	0.343
Copper	Cu	8.93	0.437
Copper (I) Sulfide (A)	Cu2S (A)	5.60	0.690
Copper (I) Sulfide (B)	Cu2S (B)	5.80	0.670
Copper (III) Sulfide	CuS	4.60	0.820
Dysprosium	Dy	8.54	0.600
Erbium	Er	9.05	0.740
Gadolinium	Gd	7.89	0.670
Gallium	Ga	5.93	0.593
Gallium Arsenide	GaAs	5.31	1.590
Germanium	Ge	5.35	0.516
Gold	Au	19.3	0.381
Hafnium	Hf	13.1	0.360
Hafnium Oxide	HfO2	9.63	--------
Holnium	Ho	8.80	0.580
Indium	In	7.30	1.650

Aluminum through Indium

Table 7.1: Material Reference Table. Continued

Material	Symbol	Bulk Density gm/cc	Z Factor
Indium Intimonide	InSb	5.76	0.769
Indium Oxide	In2O3	7.18	--------
Iridium	Ir	22.4	0.129
Iron	Fe	7.86	0.349
Lanthanum	La	6.17	0.920
Lanthanum Fluoride	LaF3	5.94	--------
Lanthanum Oxide	LaO3	6.51	--------
Lead	Pb	11.3	1.130
Lead Sulfide	PbS	7.50	0.566
Lithium	Li	0.53	5.900
Lithium Fluoride	LiF	2.64	0.774
Magnesium	Mg	1.74	1.610
Magnesium Fluoride	MgF2	3.00	--------
Magnesium Oxide	MgO	3.58	0.411
Manganese	Mn	7.20	0.377
Manganese (II) Sulfide	MnS	3.99	0.940
Mercury	Hg	13.46	0.740
Molybdenum	Mo	10.2	0.257
Neodynium Fluoride	NdF3	6.506	--------
Neodynium Oxide	Nd2O3	7.24	--------
Nickel	Ni	8.91	0.331
Niobium	Nb	8.57	0.493
Niobium (V) Oxide	Nb2O5	4.47	--------
Palladium	Pd	12.0	0.357
Platinum	Pt	21.4	0.245
Potasium Chloride	KCl	1.98	2.050
Rhenium	Re	21.04	0.150
Rhodium	Rh	12.41	0.210
Rubidium	Rb	1.53	2.540
Samarium	Sm	7.54	0.890
Scandium	Sc	3.00	0.910
Selenium	Se	4.82	0.864
Silicon	Si	2.32	0.712
Silicon (II) Oxide	SiO	2.13	0.870
Silicon Dioxide	SiO2	2.20	1.070
Silver	Ag	10.5	0.529
Silver Bromide	AgBr	6.47	1.180
Silver Chloride	AgCl	5.56	1.320
Sodium	Na	0.97	4.800
Sodium Chloride	NaCl	2.17	1.570
Sulfur	S	2.07	2.290
Tantalum	Ta	16.6	0.262
Tantalum (IV) Oxide	Ta2O5	8.20	0.300
Tellurium	Te	6.25	0.900
Terbium	Tb	8.27	0.660

Indium Intimonide Through Terbium

Table 7.1: Material Reference Table. Continued.

Material	Symbol	Bulk Density gm/cc	Z Factor
Thallium	Tl	11.85	1.550
Thorium (IV) Fluoride	ThF4	6.32	--------
Tin	Sn	7.30	0.724
Titanium	Ti	4.50	0.628
Titanium (IV) Oxide	TiO2	4.26	0.400
Titanium Oxide	TiO	4.90	--------
Tungsten	W	19.3	0.163
Tungsten Carbide	WC	15.6	0.151
Uranium	U	18.7	0.238
Vanadium	V	5.96	0.530
Ytterbium	Yb	6.98	1.130
Yttrium	Y	4.34	0.835
Yttrium Oxide	Y2O3	5.01	--------
Zinc	Zn	7.04	0.514
Zinc Oxide	ZnO	5.61	0.556
Zinc Selenide	ZnSe	5.26	0.722
Zinc Sulfide	ZnS	4.09	0.775
Zirconium	Zr	6.51	0.600
Zirconium Oxide	ZrO2	5.6	--------

Thallium through Zirconium Oxide

Table 7.1: Material Reference Table.

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Section 8. 0 Maintenance/Problem Solutions

Maintenance of STC-2002 Deposition Controller

Hazardous Voltages Present

WARNING There are potentially lethal voltages present within the STC-2002 control unit with a line cord or an INPUT/OUTPUT cable attached. Service should be attempted by qualified personnel only. Disconnect all cables and power cord when removing, installing, or servicing any component of the STC-2002 instrument.

Static Sensitive

See Section x3.19, "OPTions/INFo" for diagnostics

CAUTION The STC-2002 and remote oscillator contain static sensitive components. Use adequate and appropriate precautions when attempting any service to these devices. Discharge yourself by touching the ground stud on the STC-2002 before disconnecting the power cord. The power cord provides a path back to earth ground through the AC outlet. This will equalize the voltage potential between you and the STC-2002. It is recommended that work be done on a properly grounded mat or table surface.

User Correctable System Problems

SYMPTOM	CAUSE	REMEDY
1. No LED/LCD displays ***(See section 2.21 for additional diagnostic information)***	a. Blown fuse (1 or more of 3) b. Power switch off c. Line cord loose or unplugged	Replace fuse(s) Switch on unit. Tighten cord.
2. Constant crystal fail message	a. Bad or severely oxidized sensor b. Crystal cable connections to oscillator or sensor missing or loose c. Severe material buildup on edges of crystal holder causing a short at the sensor	New crystal. Check cables. Clean sensor.
3. Large thickness jumps during deposition	a. Defective crystal b. Crystal near end of life c. Particles or flakes on crystal seating surface	New crystal. New crystal. Clean sensor.
4. Crystal stops suddenly during deposition before reaching typical source life expectancy.	a. Crystal being hit by small droplets of molten material	Move farther from source.
5. Thermal instability (large change in thickness reading during source warm-up)	a. Poor crystal seating b. Poor or no water flow c. Excessive heating due to secondary electron formation in some sputtering systems	Clean sensor. Correct flow. Increase water flow to sensor.

SYMPTOM	CAUSE	REMEDY
6. Poor thickness reproducibility	a. Poor source emission pattern	Move sensor. Check source.
	b. Material adhesion to sensor poor	New crystal.
7. Computer interface failure	a. Baud rate wrong	Correct configure.
	b. Format wrong	Correct configure.
	c. Device address wrong	Correct configure.
	d. Cable connection bad	Check wiring.

SECTION 8.1 Replacing A Sensor Crystal

The procedure for replacing the 6 MHz sensor crystal is the same for any type sensor head. Use caution in handling the crystals as they are very fragile. Chipped, cracked, dirty or stained crystals should not be used.

CAUTION Crystals should never be handled with bare hands! Always use clean lab gloves and plastic tweezers to handle a crystal. This will avoid surface contamination of the crystal that might lead to poor electrical surface contact and possible poor film adhesion.

Dielectric films sometimes do not adhere strongly to the crystal surface and can cause erratic readings. Some dielectric will peel off the crystal when it is exposed to air. This is caused by gas absorption greatly changing the film stress characteristics. If peeling is observed, change to a new clean crystal.

Follow the procedures outlined below to change a sensor crystal.

1. Grip the sensor cap with a gloved hand and pull to unsnap the cap. The sensor crystal is captured in the cap. Place the sensor cap on a flat surface with the front face up and pop the crystal out by pressing gently down on the coated crystal surface with clean plastic tweezers or a similar type instrument. The crystal should come out easily. Take care not to damage the cap aperture opening to the crystal. Turn the cap over and place a new crystal with the fully coated surface towards the aperture opening (this side receives the evaporate stream) in the sensor cap. Use plastic tweezers to handle the new crystal.
2. *Gently* press the crystal into the finger spring holders using the plastic tweezers. This operation does not require much force. The crystal movement to become held by the finger springs is only about 25 thousandths of an inch. The sensor cap now holds the sensor crystal firmly in place. The cap may now be snapped into the sensor body.
3. Verify that the newly installed crystal is operating by looking at the STC-2002 "XTAL *x* XX%" indicator legend in the upper left of the LCD display. The XTAL *x* XX% should report some percentage of crystal life. If the "XTAL *x* BAD" legend is present check for damaged cables, a cracked or broken crystal, or dirty contact surfaces in the sensor cap.

SECTION 8.2 Persistent Crystal Fail Indication

If you have replaced the sensing crystal and the XTAL *x* BAD indication persists, the problem can either be in the electronics of the STC-2002 or in the sensing head or the cabling and connections to the sensing head. Historically most problems have been found to be somewhere in the electrical connection path. Many mechanical electrical connections exist between the sensing crystal and the oscillator unit and it is therefore sometimes difficult to locate this problem. Remote oscillators have a test feature to help isolate this type of problem, refer to Figure 8.3. A test push-button is provided on the oscillator. This button connects an internal test crystal located inside the remote oscillator in place of the normal sensing head. (By pressing this switch, the electrical path to the sensor from the oscillator is broken and a fixed 5.500MHz crystal inside of the OSC-100 is substituted.) If the STC-2002 and remote oscillator are

functioning correctly the bad crystal indication will go away and the crystal life indication on the STC-2002 should read about 50% while this button is depressed. If this is observed while this button is depressed the problem of the persistent bad crystal indication has been isolated to be in the path between the remote oscillator and the sensing crystal. If the bad crystal indication continues while this button is depressed, then the failure is: in the programming of the sensor selection, in the electronics of the remote oscillator, in the STC-2002 unit itself or in the connecting cable. This push-button can be activated by inserting a small rod or wire, like a straightened paper clip in the 'push to test' hole and depressing the switch.

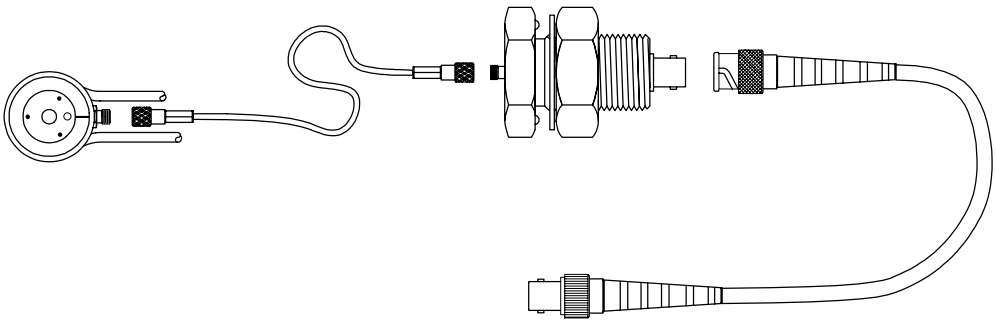

Figure 8.2: Sensor and Feedthrough Connections.

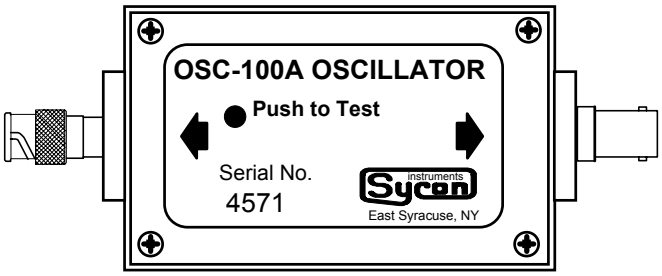

Figure 8.3: Test Oscillator OSC-100A.

The fastest and easiest way to check for a good connection path between the Remote Oscillator and the sensing crystal is to measure the electrical resistance of the cables with a Ohm meter capable of reading 0.10 Ω. Remove the oscillator from the 6" BNC cable, and remove the sensor cover and sensing crystal from the sensing head. Measure the resistance from one of the center push spring contacts inside the sensor unit to the center conductor of the cable normally connected to the oscillator. The reading should be less than 0.20 Ω. The center conductor to the cable shield should be open (greater than 30 MΩ) with respect to the outside ground shield of the cable. This check will verify all the connections from the sensor, the InVac cable, the vacuum feedthrough, and the BNC cable.

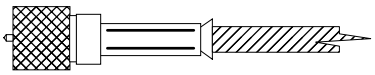

Figure 8.4: SM75, MicroDot® Connector.

If the reading from the continuity test is not as stated, disconnect one part of the chain and repeat the test. Repeat this last step until the bad connection is isolated. From experience, most often, when a problem occurs it has been found that the SM75, MicroDot®, connectors on the InVac cable are not connected securely to the sensor or the feed through. If this is found to be true then the cable should be replaced. Also the center pin on the InVac cable can become damaged and not make contact with the mating connector, Refer to Figure 8.4. The center pin of the connector should extend slightly beyond the end of threaded ferrule. If the pin is damaged the cable should be replaced.

SECTION 8.3 FAQs

Question: Why, when exiting a deposit mode (system shutter closing), does the thickness reading fluctuate greatly?
Answer: There are several possible causes for this phenomenon. First, if the system shutter closing causes any electrical noise in the system and the instrument is not grounded properly, thickness fluctuations may be experienced. There is a #6-32 threaded ground stud near the AC power connector on the back panel of the STC-2002. This stud should be used to make an electrical connection between the STC-2002 and system ground, which should be earth ground as well. This connection should be made with a 16 AWG (or larger) gauge stranded copper wire. Second, a loose cable connection may cause these fluctuations simply from the mechanical vibrations of the system. Check all cable connections to be sure that they are tight. The most likely culprit is the in-vacuum cable (silver braided sheathing) between the feedthrough and sensor head.

Question: When entering deposit and the system shutter opens, why, does the substrate sensor indicate a negative rate?
Answer: This will typically occur in,but is not limited to, a resistive source system that has not been baked out adequately, possibly just pumped down from atmosphere. What causes this is water vapor that has condensed on the surface of the crystal. When the system shutter is opened, the heat from the resistive source causes the water to evaporate from the crystal sensor surface. This evaporation translates to the STC-2002 as a negative rate since the loading on the crystal is decreasing momentarily, rather than increasing (as it would in a deposition).

SECTION 8.4 System Battery and Memory Considerations

The STC-2002 system board contains a 3V Lithium backup battery. This battery maintains the contents of the real time and date memory while the STC-2002 is turned off. Under normal circumstances the battery has an average life of 4+ years.


SHOCK HAZARD

Replacement of the battery toward the end of its life should be performed to eliminate memory loss problems due to battery failure. The battery should be replaced with the same type, 3V Lithium, Rayovac BR1225, Sycon Part Number 360-001.

Replacing the Battery: observe precautions described at the start of this section
The battery is held in a 12mm horizontal 'coin slot' holder on the main CPU board.

WARNING There are potentially lethal voltages present within the STC-2002 control unit with a line cord or an INPUT/OUTPUT cable attached. Service should be attempted by qualified personnel only. Disconnect all cables and power cord when removing, installing, or servicing any component of the STC-2002 instrument.

Remove the bottom cover of the unit, the battery is located on the PCB having the 9 pin D-sub that provides the RS232 connection as indicated on the rear panel. This PCB is labed **502-196**. Remove the old battery and replace it with the new one. Place a label on the inside of the unit case, near the battery, specifying when it was replaced to facilitate future maintenance.

Re-Entering Time and Date Parameters

The Non-Volatile memory will still be intact but the time and date information may not be correct. Re-enter and verify this information before putting the unit back into service (See section x3.x14).

Section 9. 0 Glossary

If a term cannot be found here in the glossary, check the programmable parameter lists as these terms are not repeated here. The index and table of contents can also be checked.

Crystal generally refers to the quartz crystal within a crystal sensor head used in a vacuum chamber whose wired interaction with an oscillator circuit produces an output that is used as an input to an STC-2002 sensor card. The STC-2002 also uses crystals in its own circuitry for microprocessor support, time base/signal comparisons and real time calculations.

Film, in STC-2002 terminology, is defined as a list of user programmable deposition related parameters. Typically, one material deposition is accomplished per film (describes specific: material, mechanical setup, timing, etc.). The STC-2002 can store up to 99 films (referred to as a film recipe library). A list of film implementations can be placed into a **process**. Each film implementation is referred to as a **layer** (or step in the process). Process layers can use the same film many times or use any combination of different films.

manual mode is a possible sub-mode of either non-sequencing mode or sequencing mode. As the name implies, it is intended to provide a means for the manual control of power, that is, the control of the source control voltage output from the source sensor card that, in turn, controls the evaporant generating power supply.

Memory Module (or Memory Card) option allows saving or restoring all parameters, configurations, films, processes, process accounting and I/O programs in both memory locations A and B to the memory card. The memory card function needs a memory interface board installed in the unit. If there is a high density 15 pin female D-sub on the back panel, the memory interface board is installed. The memory card has a write protect switch (LED status: green indicates memory card is ready to accept new data as well as be read, red indicates that the write protect is on and that no new data can be written to the memory card but it can be read). See also Glossary WP (write protect).

Microbalance theory

Non-sequencing mode is one of two basic deposition process control modes that uses a menu programmable process entity called a film. Non-sequencing mode does not have a process (or at least anything named as such). Non-sequencing mode uses 1 implicit process that can run 1 film. The non-sequencing mode is easiest to configure (user programs what will become an active film). The sequencing mode is more complicated only by the additional programming of a process[es] that calls out a film or films. Simply put, the sequencing / non-sequencing mode difference is that of having or not having a process. The STC-2002 retains the non-sequencing mode for historical compatibility and for simple depositions.

OSC-100A oscillator

password is a numeric sequence of up to 4 digits used to limit access to various programming menus. It is intended as a protection device against unauthorized reprogramming of the film, map, process and system configuration parameters (controlled by System Configuration menu's Password Lock # parameter) and key beep, RS-232 interface and I/O programming parameters (controlled by Communication Setup menu's Com I/O Lock Code parameter). A zero value is a non-password. Any password value other than zero is considered a password. Consult factory to undo forgotten passwords.

process is a list of film implementations. Each film implementation is referred to as a **layer** (or step in the process). Process layers can use the same film many times or use any combination of different films.

sequencing mode is one of two basic deposition process control modes that uses a menu programmable process entity called (not coincidentally) a process. Each step of a process invokes a film.

Soft key refers to the LCD overlay touch keys whose definition, at any point, is software dependent.

test mode is a possible sub-mode of either non-sequencing mode or sequencing mode. Test mode is available from the SERVICE menu for simulated *out of system* experiments. Crystal sensor head information is simulated (actually rate info is simulated for the film) allowing setup of various parameters/programming elements without crystal failure halting the simulated process. The power supply control voltage output is, however, active while in the test mode.

Employed to simulate (w/ simulated rate information) a crystal sensor input while in any combination of the modes just described.

WP (Memory Module): WP (write protect) works like the write protect on a floppy disk, that is, when it is in the protect position, writes to the media cannot be made. When a floppy disk is in use, the write protect is not physically accessible. Unfortunately (and for the following reason only), the WP switch on the Memory Module is physically accessible when it is in use. **If the WP is switched while data is being transferred, non-transfer of all data or data corruption will result.** The WP may, however, be switched while the memory module is powered and not having data transferred.

INDEX

[copy this page to record film parameters]

Film Parameters for Film #_____ in Process #_____: date___-___-___

(Material) Density	0.40 to 99.99 gm/cc
(Material) Z-Factor	0.100 to 9.999
Setpoint Thickness Limit	0.000 to 999.999 KÅ
Final Thickness Limit (Trigger)	0.000 to 999.999 KÅ (non-sequencing only)
Setpoint Time Limit	0:00 to 99:59 MM:SS
Soak 1 Power level Value	0.0 to 100.0%
Power Ramp 1 Time (to pwr level)	0 to 99:59 MM:SS
Power Soak 1 Time (@ pwr level)	0 to 99:59 MM:SS
Soak 2 Power level Value	0.0 to 100.0%
Power Ramp 2 Time (to pwr level)	0 to 99:59 MM:SS
Power Soak 2 Time (@ pwr level)	0 to 99:59 MM:SS
Soak 3 Power level Value	0.0 to 100.0%
Power Ramp 3 Time (to pwr level)	0 to 99:59 MM:SS
Deposit Rate (requested)	0.0 to 999.9 A/S
Rate Ramp Mode	OFF / ON
New Deposit Rate (Value)	0.0 to 999.9 A/S
Rate Ramp Time (Duration)	0:00 to 99:59 MM:SS
Rate Ramp (Thickn) Trigger Point	0 to 999.999 KÅ
Control Loop –Proportional term-	1 to 9999
Control Loop –Integral term-	0.0 to 99.9 sec
Control Loop –Derivative term-	0.0 to 99.9 sec
Max Power Limit	0.0 to 100.0%
Abort Max Power SW	OFF/ON
Max Power Dwell	0:01-99:59 MM:SS
Shutter Delay Mode	OFF, ON
Shutter Delay TIMEOUT	0:01-99:59 MM:SS
Shutter Delay QUALITY	1-50%
(XTAL) RATE SAMPLING	OFF,TIMED,INTELL.
(XTAL) SAMPLE INTERVAL	0:01-99:59 MM:SS
(XTAL) SAMPLE DWELL TIME	0:01-99:59 MM:SS
(XTAL) SAMPLE QUAL	1-50%
(XTAL) SAMPLE ALARM TIME	0:01-99:59 MM:SS
FILM Fail Mode	TIME POWER, ABORT IF FAIL
Control Loop Qual Limits	0 to 9
XTAL Stability S (Limits)	0 to 9
XTAL Life Bounds	0.0-100.0%
Plot Vert Scale Volts	1, 5, 10, 50, 100
Plot Horiz Scale H	1 to 600 samples
Data Plot Type	Rate /Power /Rate Deviation
Source Sensor MAP SELECT	1 – 30
POCKET SELECT	0 – 63 Pockets
ETCHING MODE	OFF/ON

date___-___-___ [copy this page to record map parameters]

Source Sensor Map Parameters for Map #_____ in Film #_____ in Process #_____:

Source Sensor Full Power Volts	2.5, 5, 10 full scale volts
Source Sensor Max Power Value	0.0% - 100.0%
Source Sensor Analog Output Chnl	1 – 8 Channel Selection
Master Tooling Value	10.0% - 400.0%
Minimum Start Xtal Channels	1 – 8 minimum channels
Minimum Backup Xtal Channels	0 – 7 minimum channels
Minumum Active Xtal Channels	1 – 8 minimum channels
Xtal Channel Drop Filter	NONE, BALANCE
Indexer Synchronization Mode	NONE, DELAY, FEEDBACK
Indexer Synchronization Time	2 – 999 seconds
Channel 1 Start Mode	OFF, ACTIVE, STANDBY
Channel 1 Fail Action Mode	NONE, ABORT FILM
Channel 1 Backup List	X – XXXXXXXX
Channel 1 Tooling Value	10.0% - 400.0%
Channel 1 Weight	10.0% - 400.0%
Channel 2 Start Mode	OFF, ACTIVE, STANDBY
Channel 2 Fail Action Mode	NONE, ABORT FILM
Channel 2 Backup List	X – XXXXXXXX
Channel 2 Tooling Value	10.0% - 400.0%
Channel 2 Weight	10.0% - 400.0%
Channel 3 Start Mode	OFF, ACTIVE, STANDBY
Channel 3 Fail Action Mode	NONE, ABORT FILM
Channel 3 Backup List	X – XXXXXXXX
Channel 3 Tooling Value	10.0% - 400.0%
Channel 3 Weight	10.0% - 400.0%
Channel 4 Start Mode	OFF, ACTIVE, STANDBY
Channel 4 Fail Action Mode	NONE, ABORT FILM
Channel 4 Backup List	X – XXXXXXXX
Channel 4 Tooling Value	10.0% - 400.0%
Channel 4 Weight	10.0% - 400.0%
Channel 5 Start Mode	OFF, ACTIVE, STANDBY
Channel 5 Fail Action Mode	NONE, ABORT FILM
Channel 5 Backup List	X – XXXXXXXX
Channel 5 Tooling Value	10.0% - 400.0%
Channel 5 Weight	10.0% - 400.0%
Channel 6 Start Mode	OFF, ACTIVE, STANDBY
Channel 6 Fail Action Mode	NONE, ABORT FILM
Channel 6 Backup List	X – XXXXXXXX
Channel 6 Tooling Value	10.0% - 400.0%
Channel 6 Weight	10.0% - 400.0%
Channel 7 Start Mode	OFF, ACTIVE, STANDBY
Channel 7 Fail Action Mode	NONE, ABORT FILM
Channel 7 Backup List	X – XXXXXXXX
Channel 7 Tooling Value	10.0% - 400.0%
Channel 7 Weight	10.0% - 400.0%
Channel 8 Start Mode	OFF, ACTIVE, STANDBY
Channel 8 Fail Action Mode	NONE, ABORT FILM
Channel 8 Backup List	X – XXXXXXXX
Channel 8 Tooling Value	10.0% - 400.0%
Channel 8 Weight	10.0% - 400.0%

[copy this page to record configuration parameters]

System Configuration Parameters for Process #_____: date___-___-___

LCD Contrast / Bias	LOW, MEDIUM, HIGH
Password Lock #	0 – 9999
(Process) Run Number	0 to 9999
Recorder Function	Rate, Rate Deviation, Power, Thickness, Computer Remote, I/O Control, Off
Recorder Out Channel	1 – 8 selects analog output channel
Real Clock Time	HH/MM/SS
Real Clock Date	MM/DD/YY
Need Source/Sensor Card 1	OFF/ON
Need Source/Sensor Card 2	OFF/ON
Need Source/Sensor Card 3	OFF/ON
Need Source/Sensor Card 4	OFF/ON
I/O Slot 1 Type	UNUSED (DISABLED) / INPUT / OUTPUT
I/O Slot 2 Type	UNUSED (DISABLED) / INPUT / OUTPUT
I/O Slot 3 Type	UNUSED (DISABLED) / INPUT / OUTPUT
I/O Slot 4 Type	UNUSED (DISABLED) / INPUT / OUTPUT
Memory Module IFC	OFF/ON

Communication Parameters for Process #_____:

COM/IO Lock Code	0 – 9999
Keyboard Beep	OFF / ON
RS232 Baud Rate	300, 1200, 2400, 9600
RS232 Protocol	Sycon, ASCII