XTC
Thin Film Thickness and Rate Monitor Technical Manual

April 1990

LEYBOLD INFICON

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LEYBOLD INFICON

INTRODUCING THE XTC

A remarkable, affordable instrument that is less expensive than the crystal monitor it may replace, and is invaluable in any single layer vacuum deposition, sputtering process, or linked together in co- deposited vacuum or sputtering processes.

Our Liquid Crystal Display keeps you continuously informed with complete deposition data including rate, thickness, and elapsed time as well as special messages like Crystal Fail. Complete, continuous real-time information reduces the possibility of costly mistakes.

The XTC unites with Inficon's field-proven sensor heads and 6 MHz plano-convex quartz crystals. The two provide superior sensitivity to measure your low rate applications and the precision you need for demanding process repeatability specifications.

The XTC has four special control functions. First is rate ramp which gives you complete control over a requested rate change during deposition. Next is our shutter delay feature which allows you to establish the desired deposition rate before the source shutter opens. Third on our standard feature list is the XTC's ability to let you complete a run on time-power in the event of an unexpected crystal failure. Fourth is RateWatcher. RateWatcher automatically opens the shutter exposing the sensor to the deposition source, adjusts the power so the actual rate will precisely equal your desired rate within the programmed accuracy, and then automatically closes the sensor shutter holding the power at the adjusted level.

Features such as Memory Saver, a rate or thickness analog output, a pair of relay control outputs and shutter assemblies for all sensor heads are available.

RS-232C is standard or you may choose the IEEE-488 computer interface to link your computer with our XTC thin film controller. Inficon also offers an 8 input/8 output (I/O) module, and you can have your XTC in space-saving half rack configurations.

PREFACE

The XTC Manual is written for those of you who install, operate, and maintain the XTC Thin Film Thickness and Rate Monitor. The purpose and contents of each manual section are listed below. Additional details are at the beginning of each individually numbered section.

INTRODUCTION
FRONT PANEL DESCRIPTION
WARRANTY
TABLE OF CONTENTS
ILLUSTRATION AND DIAGRAM LISTING
SECTION 1 - GENERAL INFORMATION
SECTION 2 - PROGRAMMING, OPERATION, AND VERIFICATION
SECTION 3 - INSTALLATION AND REAR PANEL COMPONENTS
SECTION 4 - CALIBRATION AND MEASUREMENT THEORY
SECTION 5 - MAINTENANCE AND REPAIR
SECTION 6 - SCHEMATICS AND MODULE THEORY
SECTION 7 - OPTIONS

USE OF THIS MANUAL

A table of contents and list of illustrations and tables located in the front of this manual provide easy access to any portion of the manual. Abbreviations and panel markings are referenced in the text exactly as they appear on the equipment.

When reading the XTC Manual, please pay particular attention to the NOTES, CAUTIONS, and WARNINGS found throughout this text. For our purposes they are defined as follows:

NOTES: Pertinent information useful in achieving maximum instrument efficiency when followed.

CAUTIONS: Failure to heed these messages could result in damage to your instrument.

WARNINGS: The most important messages. Failure to heed could result in personal injury and/or serious damage to your instrument.

We invite you to comment on the usefulness and accuracy of this manual by filling out the reply card and returning it to us.

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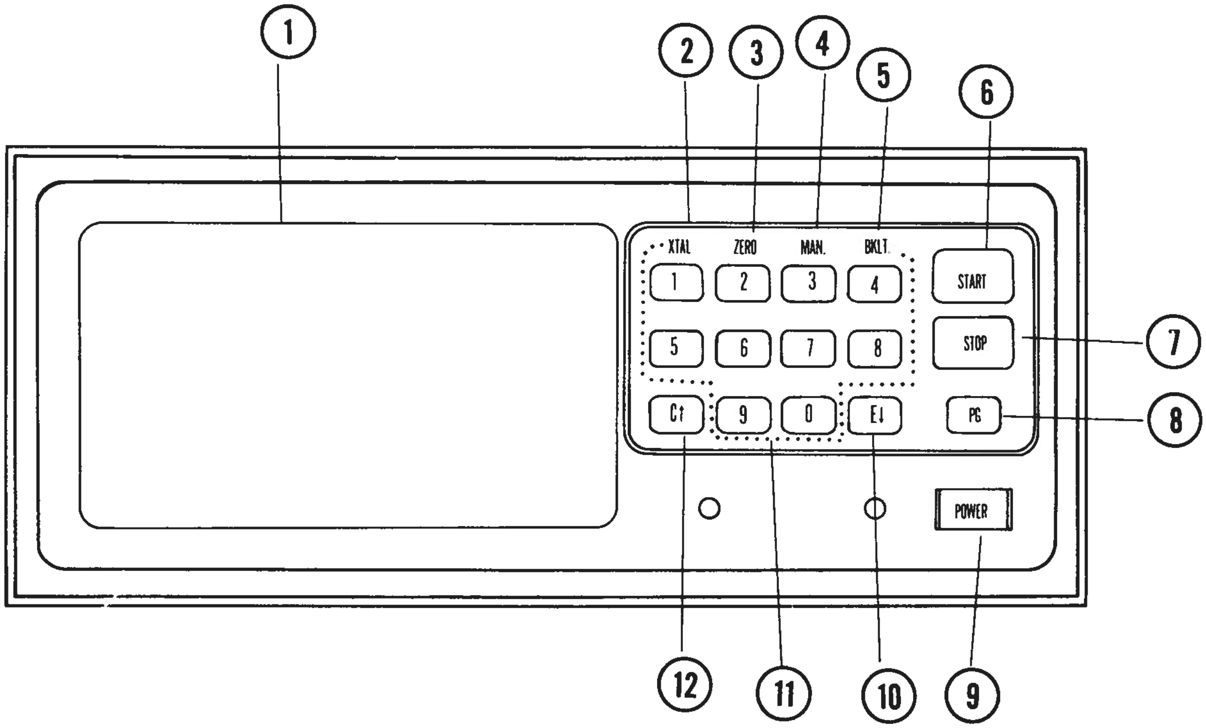
XTC FRONT PANEL DESCRIPTION



1.	**SCREEN**	Highly visible with scaled displays.
2.	**XTAL**	Crystal. Provides momentary display of the percent of crystal life used.
3.	**ZERO**	Zeros accumulated thickness display.
4.	**MAN**	Manual. Places the XTC in manual power control mode.
5.	**BKLT**	Backlight. Activates or deactivates backlight for the LCD display.
6.	**START**	Initiates any one of 3 functions.
7.	**STOP**	Stops the system.
8.	**PG**	Program. Selects the program mode.
9.	**POWER**	Controls power to the XTC.
10.	**E↓**	Enter and cursor down. Two function switch.
11.	**Numeric Key Pad**	Calculator type. Number is entered on screen at the cursor location.
12.	**C↑**	Clear and cursor up. Two function switch.

Section 1 of the XTC Manual contains specifications and performance standards for the XTC and the sensors. This section also includes a front panel diagram and basic reference description of key functions along with general information on unpacking and initial inspection and the inventory listing. Information in Section 1 is found in the following order:

Once you have inspected and inventoried the shipping cartons, follow the test procedures outlined in Section 2.

CAUTION: **Do not make the rear panel connections until you complete the checkout procedure and have read and understood the programming and operating section of this manual.**

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■ XTC SPECIFICATIONS

SPECIFICATIONS:

Thickness Display Range	0 to 999.9 kÅ
Thickness Display Resolution (3 automatic ranges)	1Å from 0 to 9.999 kÅ 10Å from 10 to 99.99 kÅ 100Å from 100 to 999.9 kÅ
Rate Display and Control Range	0.0 to 999Å/sec
Rate Display Resolution	0.1Å/sec when set point < 25Å/sec; 1.0Å/sec when set point ≥ 25Å/sec
Measurement and Control Update Period	0.25 sec
Time Display	00:00 to 99.59 min:sec
Power Display	0 to 99%
Crystal Life Display	0 to 99%
Program Functions	
Density	0.80 to 99.99 gm/cc
Z Ratio	0.100 to 3.999
Tooling Factor	10 to 399%
Thickness Limits (2 set points)	0.000 to 999.9 kÅ
Soak Power (2 set points)	0 to 99%
Soak Times (2 set points)	0 to 99:99 min:sec
Rise Times (2 set points)	0 to 99:99 min:sec
Rate (2 set points)	0 to 999Å/sec
Rate Ramp Time	0 to 99:99 min:sec
Idle Power	0 to 99%
RateWatcher™	
Sample Accuracy	0 to 99%
Hold Time	0 to 99:99 min:sec
Maximum Power	0 to 99%
Gain	1 to 99
Approach	0 to 99
Special Functions	
Crystal Fail	Stop or Complete on Time/Power
Maximum Power	Stop or Continue
Shutter Delay	Delay until actual rate = ±5% of rate set point
Test	Simulates deposition and used for unit test
Control Inputs/Outputs (standard)	
Sensor Input	From remote oscillator
Source Control	0 to ±10 volts or 0 to ±5 volts
Relay Outputs	Source shutter and crystal shutter
Rate/Thickness	Analog output 0 to 10 volts
Manual Power Control	Hand held controller for manual source control
Inputs/Outputs (optional)	
8/8 I/O Module	
Inputs 8, Contact closure or DC sink Start Stop End Deposit Zero Thickness Soak 2 Hold Sensor Sample Initiate Sensor Sample Inhibit Crystal Fail Inhibit	Outputs 8, N.O. Relay 120V/100 VA maximum Final Thickness Thickness Limit In Process Soak Time 2 (Feed Time) Stop End of Process Crystal Fail Alarms
RS-232C	Computer interface (serial)
IEEE-488	Computer interface (parallel)
Power Requirements	120/240V (+5, -25%), 50-60 Hz, 50 VA
Operating Temperature	0 to 50°C
Size	8.97 cm H (3.5") x 21.5 cm W (8.37") x 30.8 cm D (12")
Weight	2.61 kg. (6 lbs.)

SPECIFICATIONS FOR THE STANDARD SENSOR [IPN 007-216]

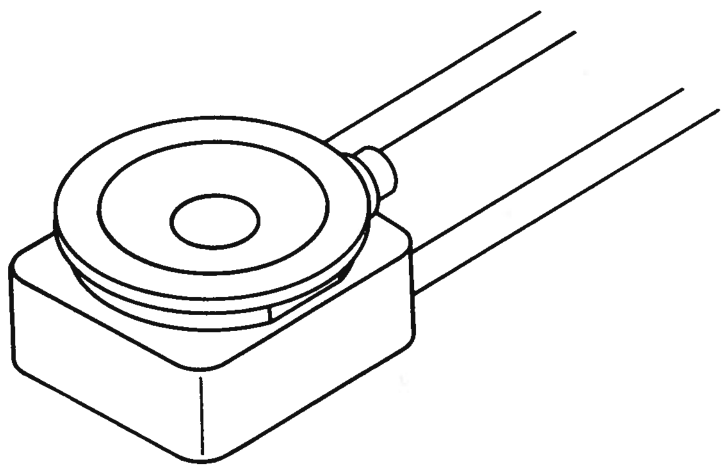

Figure 1.1 Standard Sensor

Maximum temperature	105°C
Size (maximum envelope)	1.063" (2.7 cm) x 2.35" (6 cm) x 0.60" (1.5cm) high
Water line and coax length	Standard 30" (76 cm), 1/8" O.D. seamless stainless
Crystal exchange	Front-loading, self-contained package for ease of exchange
Mounting	Two #4-40 tapped holes on the back of the sensor body

INSTALLATION

A. Feedthrough	a) 2 pass water with Microdot coax connector, 3/16" O.D. tubing
B. Other	b) (1) Customer to provide vacuum-tight braze joints or connectors for the water lines (2) Oscillator [IPN 013-001] designed to interface with the XTC or IC6000® deposition controllers.
C. Utilities	c) Water 150-200 cc/min, 30°C max

MATERIALS

A. Body and Holder	a) 304 type stainless steel
B. Springs	b) Au plated Be-Cu
C. Water lines	c) S-304, 0.125" (.32 cm) OD
D. Connector (Microdot)	d) Ni plated steel, teflon insulated
E. Insulators	e) > 99% Al_2O_3
F. Wire	f) Teflon insulated copper
G. Braze	g) Vacuum process high temperature Ni-Cr alloy
H. Crystal	h) 6.0 MHz, AT-cut plano-convex with Au overcoat

■ SPECIFICATIONS FOR THE COMPACT (VERTICAL) SENSOR [IPN 750-040-G1]

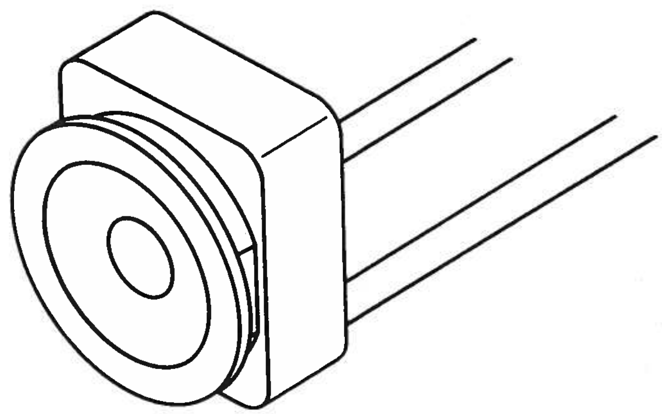

Figure 1.2 Compact (Vertical) Sensor

Maximum temperature	105°C
Size (maximum envelope)	1.15″ (2.7 cm) x 1.00″ (6 cm) x 1.00″ (1.5 cm) high
Water line and coax length	Standard 30" (76 cm)
Crystal exchange	Front-loading, self-contained package for ease of exchange
Mounting	Two #4-40 tapped holes on the back of the sensor body

INSTALLATION

A. Feedthrough	a) 2 pass water with Microdot coax connector
B. Other	b) (1) Customer to provide vacuum-tight braze joints or connectors for the water lines (2) Oscillator [IPN 013-001] designed to interface with the XTC or IC6000® deposition controllers.
C. Utilities	c) Water 150-200 cc/min, 30°C max

MATERIALS

A. Body and Holder	a) 304 type stainless steel
B. Springs	b) Au plated Be-Cu
C. Water lines	c) S-304, 0.125" (.32 cm) OD
D. Connector (Microdot)	d) Ni plated steel, teflon insulated
E. Insulators	e) > 99% Al_2O_3
F. Wire	f) Teflon insulated copper
G. Braze	g) Vacuum process high temperature Ni-Cr alloy
H. Crystal	h) 6.0 MHz, AT-cut plano-convex with Au overcoat

SPECIFICATIONS FOR THE SPUTTERING SENSOR [IPN 007-031]

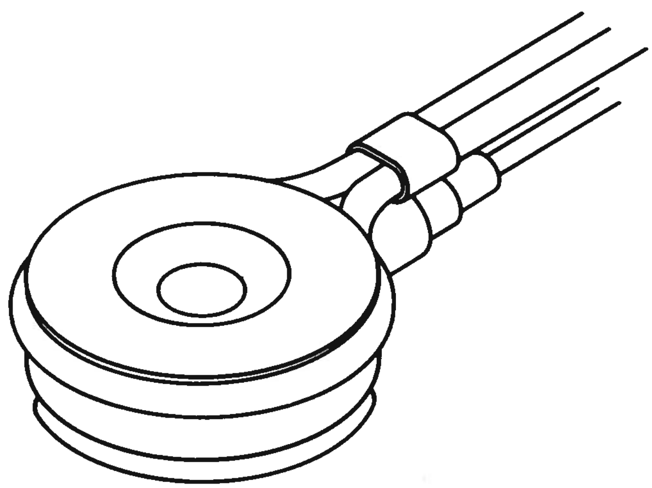

Figure 1.3 Sputtering Sensor

Maximum temperature	105°C
Size (maximum envelope)	1.36" (3.45 cm)ϕ x 0.47" (1.18 cm) high
Water line and coax length	Standard 30" (76 cm)
Crystal exchange	Rear-loading
Mounting	Customer supplied

INSTALLATION

A. Feedthrough — a) 2 pass water with Microdot coax connector
2¾" - (IPN 002-043)
1" - (IPN 002-042)

B. Other — b) (1) Customer to provide vacuum-tight braze joints or connectors for the water lines
(2) Oscillator [IPN 013-001] designed to interface with the XTC or IC6000® deposition controllers.

C. Utilities — c) Water 750 cc/min, 30°C max

MATERIALS

A. Body and Holder	a) Au plated Be-Cu
B. Springs	b) Au plated Be-Cu
C. Water lines	c) Au plated Cu, 0.125" (.32 cm) OD
D. Connector (Microdot)	d) Ni plated steel, teflon insulated
E. Insulators	e) 99% Al_2O_3
F. Wire	f) Teflon insulated copper
G. Solder	g) Cadmium free silver and indium alloys
H. Crystal	h) 6.0 MHz, AT-cut plano-convex with Ag overcoat
I. Magnet	i) ALNICO 5

■ SPECIFICATIONS FOR THE BAKEABLE SENSOR [IPN 007-219, 220 or 221]

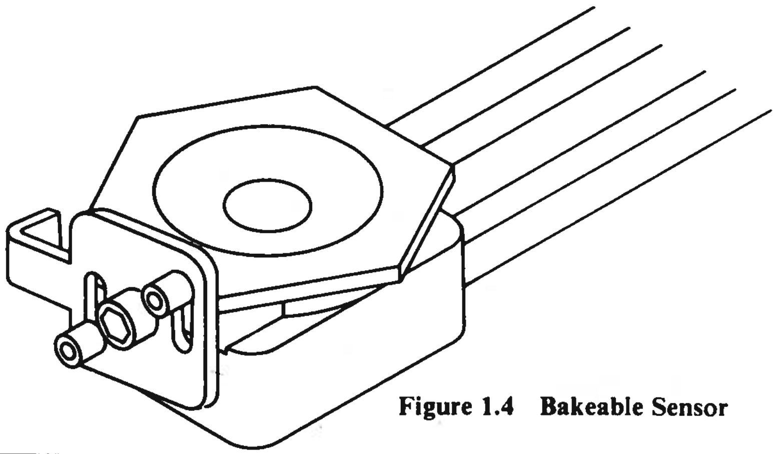

Figure 1.4 Bakeable Sensor

Maximum temperature	405°C continuous (for bake only; waterflow recommended for actual deposition monitoring)
Size (maximum envelope)	1.35" (3.4 cm) x 1.38" (3.5 cm) x 0.94" (2.4 cm) high
Water line and coax length (from face of feedthrough to center of crystal)	a) standard (1) 30" (76 cm) IPN 007-209 (2) 20" (50.8 cm) IPN 007-208 (3) 12" (30.5 cm) IPN 007-207
Crystal exchange	Front-loading, self-contained package for ease of exchange. CAM type locking handle allows easy removal and good thermal contact.
Mounting	a) Standard - four #4-40 tapped holes on the back of body b) Optional - right angle bracket

INSTALLATION

A. Feedthrough	a) 2¾" ConFlat®, integral with sensor head
B. Other	b) (1) Oscillator [IPN 013-001] designed to interface with the XTC or IC6000® deposition controllers. (2) Water and coax lines are semi-ridged, but easily formed.
C. Utilities	c) Water 150-200 cc/min, 30°C max (Customer should provide means of easily disconnecting the ½" water lines during bakeout.

MATERIALS

A. Body and Holder	a) 304 type stainless steel
B. Springs	b) Molybdenum & Inconel X-750
C. Water and coax lines	c) S-304, 0.125" (.3 cm) O.D. water 0.188" (.5 cm) O.D. coax
D. Other mechanical parts	d) 18-8 or 304 stainless
E. Insulators	e) > 99% Al_2O_3 in vacuum; other high density ceramics used elsewhere
F. Wire	f) (1) Ni (in vacuum) (2) Ni plated Cu (elsewhere)
G. Braze	g) Vacuum process high temperature Ni-Cr alloy
H. Crystal	h) 6.0 MHz, AT-cut plano-convex with Au overcoat

SPECIFICATIONS FOR THE SHUTTER ASSEMBLY

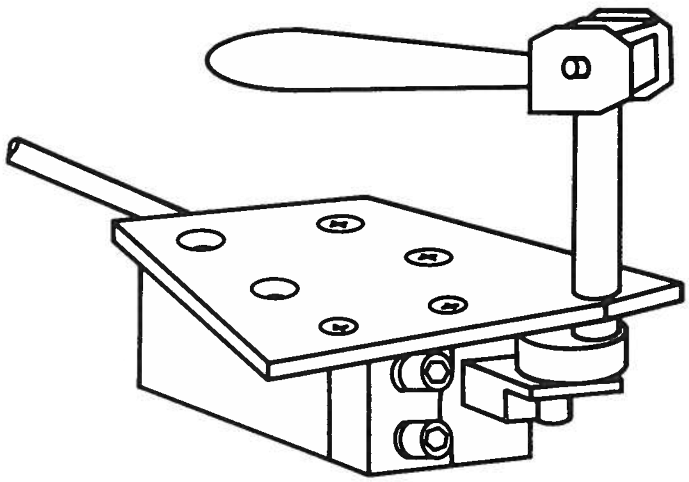

Figure 1.5 Shutter Assembly

Temperature	120°C
Materials	300 series Stainless Steel
Pressure	60-80 psi operation 100 psi max
Shutter	Pneumatically operated. Swings with piston activated cam, spring returned. Shutter swings out of way for easy crystal exchange.
Braze	Vacuum process hi temp. Ni-Cr Alloy

UNPACKING, INITIAL INSPECTION, AND INVENTORY

Unpacking and Inspection Procedures

1. If you haven't removed the XTC from its shipping containers, do so now.

2. Carefully examine the unit for damage that may have occurred during shipping. This is especially important if you notice signs of obvious rough handling on the outside of the cartons. REPORT ANY DAMAGE TO THE CARRIER AND TO INFICON, IMMEDIATELY.

3. DO NOT discard any packing materials until you have taken inventory and completed the check procedures.

4. Store the spare crystals in their shipping containers for convenience and cleanliness.

Inventory

Make sure you have received all of the necessary equipment by checking the contents of the shipping containers with the parts list below.

PARTS LISTING

Qty	Part	IPN #
	CONTROLLER PACKAGE	
(1)	XTC Single Film Monitor/Controller	751-001-G1
	or	
(1)	XTC Single Film Monitor/Controller (with RS232)	751-001-G2
(1)	15 Pin Receptacle	051-484
(1)	15 Pin Standard Cable Clamp Assembly Kit	051-477
(1)	Power Cord	068-002
(1)	Instrument Manual	074-062
(1)	Hand Power Control	006-016
(1)	1/8 Amp Slo Blo Fuse	062-017
(1)	1/4 Amp Slo Blo Fuse	062-019
	FEEDTHROUGHS (Optional)	
	1" Bolt Standard	002-042
	1" Bolt (Shutter Assembly Model)	750-030-G1
	2 3/4" ConFlat® (Copper)	002-043
	2 3/4" ConFlat® (With Viton® Gasket)	002-044
	2 3/4" ConFlat® (Shutter Assembly Model)	002-080

Qty Part	IPN #
OPTIONS	
Relay I/O	751-112-G1
IEEE-488 Interface	751-122-G1
Rack Adapter	751-028-G1
Remote Oscillator	007-251
CRYSTALS (Optional)	
Silver Sensor Crystals	008-009
Gold Sensor Crystals	008-010
SENSORS (Optional)	
Standard	007-216
Compact	750-040-G1
Sputtering	007-031
Bakeable (12" Crystal to Feedthrough)	007-219
Bakeable (20" Crystal to Feedthrough)	007-220
Bakeable (30" Crystal to Feedthrough)	007-221
Shuttered Bakeable (12" Crystal to Feedthrough)	750-028-G1
Shuttered Bakeable (20" Crystal to Feedthrough)	750-028-G2
Shuttered Bakeable (30" Crystal to Feedthrough)	750-028-G3
Shuttered Bakeable (Special length)	750-028-G4
SENSOR SHUTTERS (Optional)	
Pneumatic Shutter Assembly (Standard/Compact)	750-001-G3
Pneumatic Shutter Assembly (Sputtering)	750-005-G1
Pneumatic Shutter Actuator Control Valve	007-199
ACCESSORIES	
30" In-Vacuum Coax Cable	007-044
Sensor Cover (Fits 007-216 and 750-040)	007-083
Sensor Cover (Fits 007-219, 220, 221)	007-097
Ceramic Retainer (Fits all except 007-219, 220, 221)	007-023
Ceramic Retainer (Fits 007-219, 220, 221)	007-064
Crystal Snatcher	008-007

INITIAL CHECK PROCEDURES

NOTE: Prior to performing the Initial Check Procedure you should check the inventory of your system to be sure that you have received all of the components which were ordered with the instrument. For the Initial Check Procedure you will need only the instrument and the power cord. Do not connect any other cables or devices to the unit for this check.

Correct Operating Voltage

Before you connect the power cord, check the line voltage selector card which is part of the power cord socket at the rear of the unit. To check this connection remove the power cord from the rear of the unit, slide the protective cover to the left, and pull the tab marked "FUSE" out to swing the fuse holder open (see Figure 1.6).

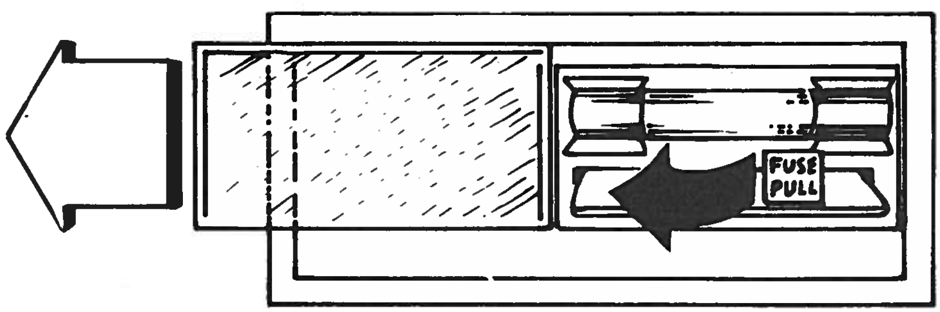

Figure 1.6 Fuse Tab

If the required voltage is not showing on the small circuit card, it must be changed prior to power up. Use needle nose pliers to remove the card. Select the required voltage (from the four voltages marked on the card) and reinsert the card with the proper voltage selection on the left side facing upward (see Figure 1.7).

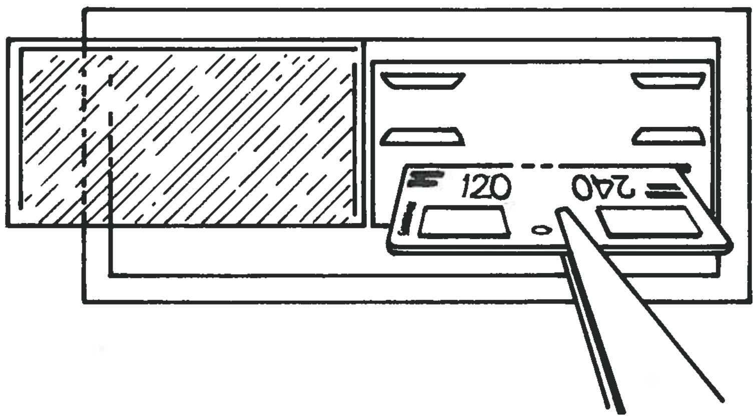

Figure 1.7 Circuit Card

Check the line fuse at this time. On 100 or 120 volt units it should be 1/4 amp; on 220 and 240 volt units it should be 1/8 amp. Swing the fuseholder back into place, slide the protective cover to the right and plug the line power cord into the back of the unit. Make sure that the power switch is OFF (extended outward) and plug the power cord into an outlet of appropriate voltage.

WARNING:	**Voltages may exist in rear panel connectors. Do NOT touch the exposed connectors when power is connected to the instrument.**

■INITIAL DISPLAY

For this procedure you should set the TEST switch to ON. To do this refer to page 2-14, OPTION SELECT and set switch number 3 to ON. Turn the POWER on by pressing the power switch until it locks. The power on indicator should light instantly and one of the following LCD displays should appear.

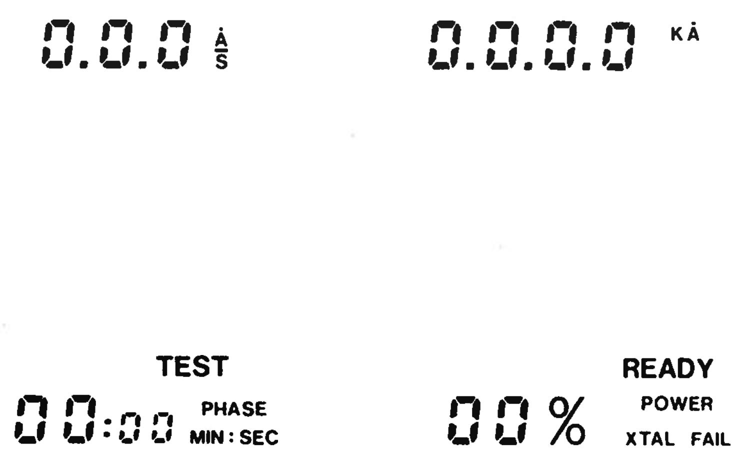

Figure 1.8 Normal Power Up LCD Display

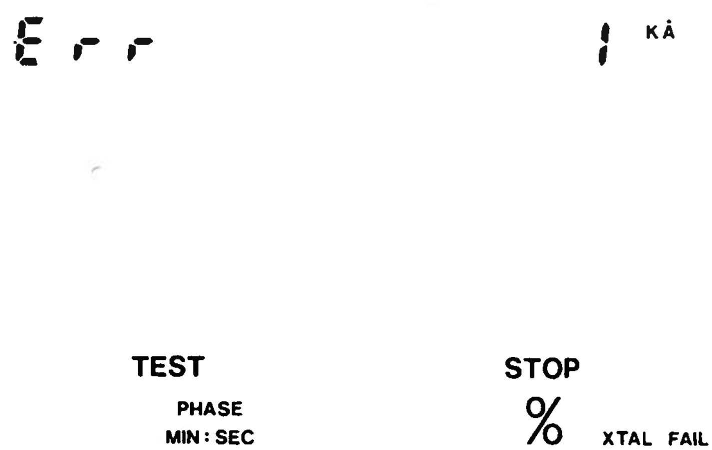

Figure 1.9 Error 1 Display

Figure 1.10 Error 2 Display

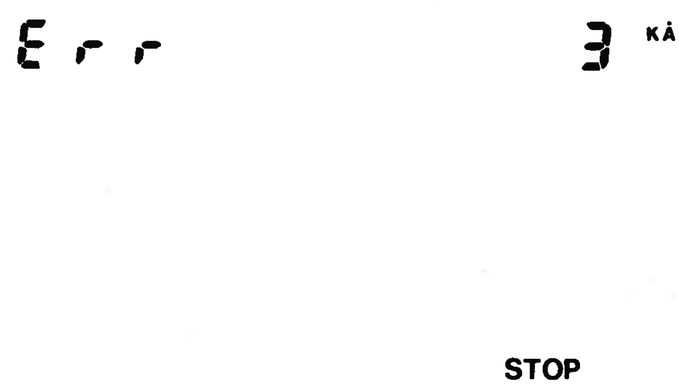

Figure 1.11 Error 3 Display

If the power on indicator does not light, check for proper line voltage connections, blown fuse, etc.

If you encounter an "Err 1" message, press "START" to clear the message and continue with the check. If an "Err 2" through "Err 4" is encountered, turn power OFF to clear the error condition and try the power up again. If the error message returns, contact Inficon Service Department before continuing. An explanation of error messages is provided in Section 5. Briefly the associated faults are:

Err 1 - Program Loss
Err 2 - ROM Fail
Err 3 - RAM Fail
Err 4 - STACK GUARD

Display Modes

The proper display at this time if Figure 1.8 - Normal Power Up LCD Display. Verify that all display information matches the example.

Now press "PG", the display will change to the one shown in Figure 1.12.

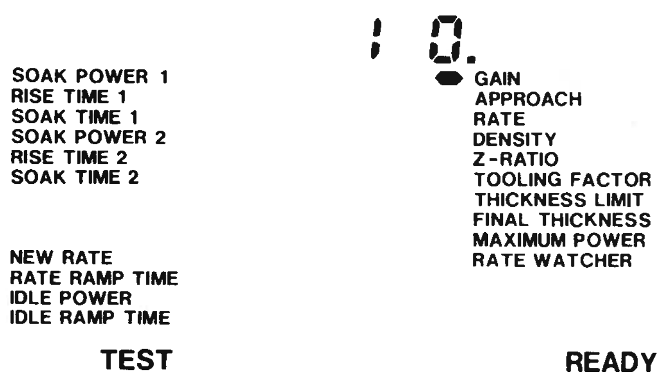

Figure 1.12 Program Mode Test Selected

Press the "E↓" key. Notice the cursor move down the right column of parameters, also notice the associated numeric value change accordingly. The values which appear are the default values which are entered at the factory. These will be present (upon initial power up, and future power ups) provided they are not replaced with new values during the program mode. The default values are as follows:

GAIN	10.	
APPROACH	00.	
DENSITY	1.000	gm/cc
Z-RATIO	1.000	
TOOLING FACTOR	100	%
MAXIMUM POWER	90	%

All other parameters are set to 0.

After the cursor reaches the bottom of a column, it will move to the top of the next column.

This completes the Initial Check Procedures. A more detailed checkout is provided in Section 2.

Section 2 of the XTC Manual contains a description of the functional characteristics of the front and back panels, programming guidelines, and operation instructions. The following topics are included:

FRONT PANEL DESCRIPTIONS:
- Keyboard Descriptions
- LCD Display Descriptions

REAR PANEL DESCRIPTIONS

OPERATING THE XTC AS A MONITOR

OPERATING THE XTC AS A CONTROLLER

USING AND CALIBRATING THE ANALOG OUTPUT

TYPICAL PERFORMANCE OF THE SPUTTERING SENSOR

XTC OPERATIONAL TEST

074-062S2/831101

Prior to installing and operating the XTC you should become familiar with the available indicators, switches, and connections that will be referenced throughout this section. Refer to Figure 2.1 for location of buttons, keys, and displays as well as a functional description of their use.

FRONT PANEL DESCRIPTIONS

The Front Panel Descriptions are divided into two main groups: the Keyboard Descriptions and the LCD Display Descriptions.

Keyboard Descriptions

The Keyboard Descriptions contain information on all front panel keys. Refer to Figure 2.1 for their location. There are (6) two function keys, and they are identified as such in the description.

•POWER

Applies power to the instrument upon activation, a green LED is used as the line power indicator.

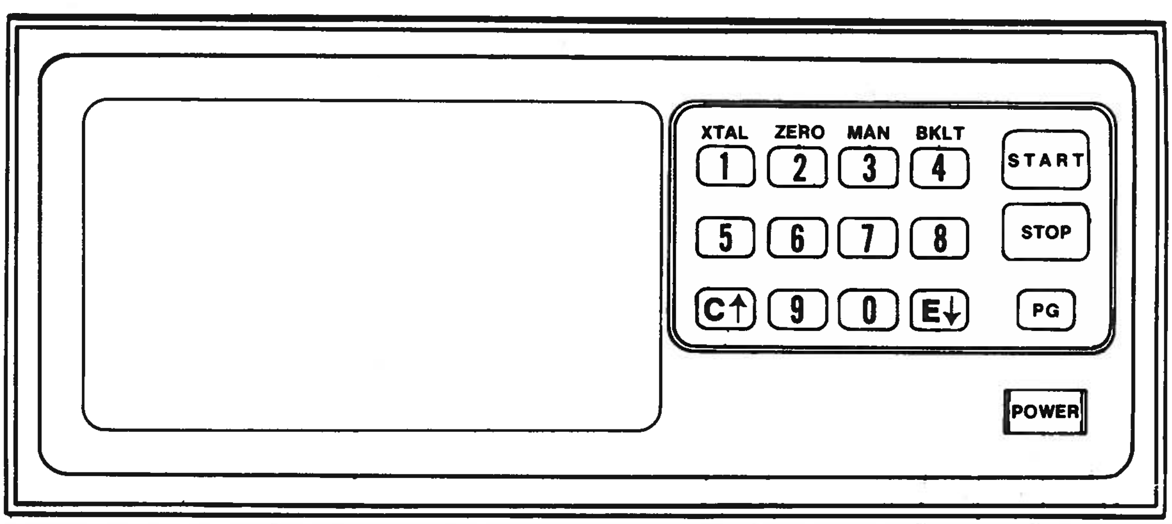

Figure 2.1 XTC Front Panel Description

- START

This button will initiate one of three functions depending upon the current state of the instrument. With the XTC in the READY state, this button is used to begin a programmed process. In the STOP state, pressing this button resets the unit to the READY state and frees the display. When the XTC is in the HOLD phase pressing start initiates a SAMPLE (used with RATEWATCHER only).

- STOP

This button is used to immediately place the system into the STOP mode. Source power is returned to zero and all display activity is frozen.

- PG

Depress this key to select the program mode; if in the program mode, depress this key to select the operational mode.

NOTE: The following four functions (second functions of the top row of numeric keys) are available only when the unit is in the operational mode - not in the program mode.

- XTAL [1] (Crystal Life)

This button, when pressed, provides a momentary display of the percent of crystal life used. The information will appear in the two digit power display location and indicates the relative amount of crystal usage with 99% indicating the maximum allowable usage. Percentage information will disappear 5 seconds after the button is released.

- ZERO [2]

This button zero's the thickness accumulation when pressed. It will zero thickness even during the deposit phase.

MAN [3] (Manual)

This button is used to place the unit into a manual power control mode. When activated, MANUAL is indicated on the LCD display and the source shutter is opened. The hand held MANUAL CONTROLLER is activated for remote control of the power. This function may be entered from any phase except STOP.

NOTE: The following keys function only when the unit is in the program mode.

● 0 thru 9

These keys are used for entry of numerical program data.

● C↑ (clear/cursor-up) (Two Function)

This button is used to clear data entry errors or, if held down, cursor will automatically scan up through all program parameters. When used to clear an illegal entry, cleared data is replaced with the last valid data in memory.

● E↓ (enter/cursor-down) (Two Function)

This button is used to enter displayed program data into memory or, if held down, will automatically scan cursor down through program parameters. If an illegal entry is attempted, error is indicated by the appearance of ERR in one of the numerical displays.

■ **LCD Display Descriptions**

The LCD display Descriptions are divided into five groups of related information. There are four groups of parameters which include Control Loop, Measurement, Predeposition, and Postdeposition Parameters. The final group contains Messages which may appear on the LCD. Refer to Figure 2.2 for location of each parameter or message below.

■ **Control Loop Parameters**

● GAIN (1-99)

A function which changes the source output voltage in proportion to the error between the actual rate and the rate set point. At the programmed setting of 10, the source voltage changes at the rate of approximately 1% per second for an error of 1Å per second.

• APPROACH (0-99)

Used to minimize overshoot during rate control acquisition, when the source requires a considerable length of time to reach the RATE set point. Without APPROACH action, the thermal inertia of the evaporation source may cause the rate to increase above the set point. The higher the setting, the more anticipation is added to the control system.

• RATE (0.0-999Å/s)

A programmable parameter which defines the desired rate of deposition. Actual rate is displayed at all times (except in the Program and Test mode) and may be positive or negative.

NOTE: **Compare with NEW RATE. The value of this parameter is called "Auto Control Rate" in the balance of the manual.**

• MAXIMUM POWER (0-99%)

A programmable set point which sets the maximum allowed relative power.

• RATEWATCHER (Time 0-99:99 min:sec/Accuracy 0-99%)

A programmable function that may be used with shuttered sensor heads to extend crystal life. This function has two parameters as follows:

- The display XX:XX min:sec is used to set the time period between samples (HOLD). Entry of 0 into this parameter deactivates the sample and hold control feature for use with the Standard Sensor Head.

- The display XX % is used to set the required accuracy of the sample (SAMPLE).

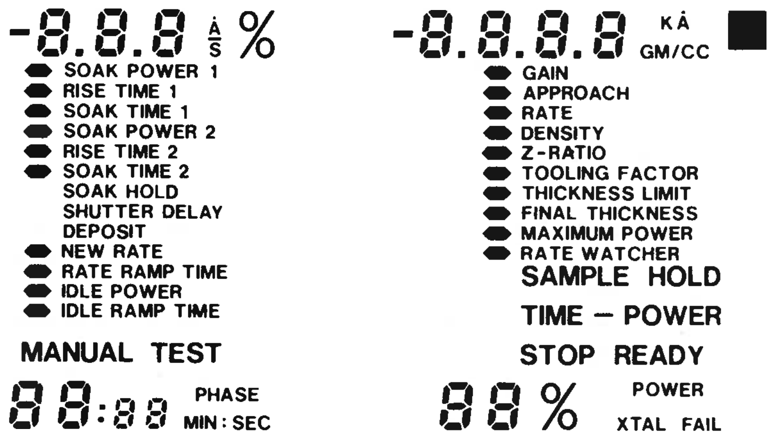

Figure 2.2 LCD Display

NOTE: **A guide on using RateWatcher begins on page 2-31.**

NEW RATE (0-999.9Å/s)

A programmable function which allows a linear controlled change in the Auto Control Rate during RATE RAMP TIME. The ramp to the NEW RATE is initiated at "THICKNESS LIMIT". If 0.0Å/sec. is programmed, the film terminates at the end of RATE RAMP TIME (end of deposition). Upon the completion of the RATE RAMP function the control rate is set via the NEW RATE value. New rate and rate ramp time to be used if a change in controlled rate is desired during the course of the deposition.

RATE RAMP TIME (0-99:99 min:sec)

A programmable parameter which controls the time used to linearly change the RATE set point to the NEW RATE set point. A programmed value of 00:00 disables the RATE RAMP function.

Measurement Parameters

- DENSITY (0.8-99.99 gm/cc)

This value refers to the density of the evaporated material and is used internally to convert the measured mass to a thickness value. See Section 4 and Table 4.1 for additional information.

- Z-RATIO (0.1-3.999)

A programmable reference value which is determined by the elastic properties of the material being evaporated. This value is used to match the acoustic properties of the film to quartz for extended accurate measured ranges. See Section 4 and Table 4.1 for additional information.

- TOOLING FACTOR (10-399%)

A programmable constant which corrects the thickness and rate for the geometric difference between the placement of crystal sensors and the substrate location. See Section 4 for more information.

- THICKNESS LIMIT (kÅ) (0-999.9kÅ)

A programmable set point that can be used to trigger events prior to FINAL THICKNESS. This parameter is also used to initiate NEW RATE.

- FINAL THICKNESS (kÅ) (0-999.9kÅ)

The accumulated thickness at which the deposit phase ends and source shutter closes. Total thickness is displayed at all times and is referenced from the last zero thickness command.

Pre-Deposition Parameters

- SOAK POWER 1 (0-99%)

A programmable power level generally used to precondition a new material melt.

- RISE TIME 1 (0-99:99 min:sec)

A programmable time interval which sets the duration of the SOURCE POWER increase from 0% to the achievement of SOAK POWER 1.

• SOAK TIME 1 (0-99:99 min:sec)

A programmable time interval which sets the time the SOURCE POWER remains at SOAK POWER 1

• SOAK POWER 2 (0-99%)

A programmable power level which is selected to produce a deposition rate close to Auto Control Rate.

• RISE TIME 2 (0-99:99 min:sec)

A programmable time interval from the end of SOAK TIME 1 to the SOAK POWER 2 level.

• SOAK TIME 2 (0-99:99 min:sec)

A programmable time interval which sets the time duration Source Power remains at Soak Power 2.

• SHUTTER DELAY (ON/OFF; OPTION SELECT Switch #6)

A selectable function which will establish rate control while holding the source shutter closed until the rate control error has been held to 5% of the set point or 1Å/s (whichever is greater) for a period of 5 seconds. Entry into this phase is automatic from SOAK 2 phase when OPTION SWITCH #6 is set to ON.

NOTE: Also see Shutter Delay page 2-15.

Post-Deposition Parameters

• IDLE POWER (0-99%)

A programmable parameter which maintains SOURCE POWER at the programmed level between depositions. If IDLE POWER is set to a non-zero value, the XTC will enter RISE TIME 2 phase when START is pressed, unless a STOP is encountered. If set to a value of zero, RISE TIME 1 phase will be entered on the next deposit start.

• IDLE RAMP TIME (0-99:99 min:sec)

A parameter which allows a controlled linear change in POWER from the deposition power level to the IDLE POWER level.

Messages

The XTC generates certain other non-programmable phase or condition messages to help the operator. For a list of other errors see page 5-16.

•SOAK HOLD (ON/OFF; Optional, requires I/O RELAY Module)

Indicates that the unit is being externally held from entering the Deposit phase. It is controlled by a remote input which holds the XTC in the SOAK 2 phase until the remote input becomes inactive. See Section 7.

•DEPOSIT

Indicates the XTC is in the process phase during which material from a source is deposited and the evaporation rate is automatically controlled. Entry into this phase is automatic following SOAK TIME 2, MANUAL POWER, SHUTTER DELAY, or RATE RAMP phases unless FINAL THICKNESS has been achieved or XTAL FAIL has occurred, in which case TIME- POWER phase may be entered.

•MANUAL (ON/OFF)

Indicates that the unit is in manual mode when displayed together with DEPOSIT. Source power may be increased or decreased by the remote power switch. MANUAL is entered via the front panel by pressing MAN, subsequent pressing of MAN returns unit to Deposit.

•TEST (ON/OFF)

Displayed when the OPTION SELECT switch #3 is in ON position. Provides an operational self test of the XTC. For a more detailed description refer to "Power Up And System Self Test" in this section.

•SAMPLE

Displayed with RATEWATCHER when the crystal sensor is being sampled (and shutter is open). SAMPLE will continue for at least (10) seconds. If the accuracy of the RATEWATCHER parameter is not met initially, SAMPLE will either continue until it is met, or, if the option switch #5 is ON, continue for (60) seconds and then go to the STOP mode. See Implementing RATEWATCHER, page 2-31.

•HOLD

Displayed with RATEWATCHER when the crystal shutter is closed. Source power remains constant and the thickness is accumulated at the Auto Control Rate (RATE).

- TIME-POWER

Indicates that the instrument has experienced a crystal failure and the process is continuing on in the TIME/POWER mode. Source power remains constant and thickness is accumulated at the Auto Control Rate. Deposition phase ends at Final Thickness, and the instrument goes to the STOP mode.

- STOP

Indicates the unit is in the STOP mode. This mode may be entered following any of the following occurrences: Pressing STOP button, an external input labeled STOP is activated, a condition such as crystal failure, an alarm has been experienced and option switches have been set to proceed to STOP, or STOP is initiated via the hand held MANUAL CONTROLLER.

- READY

Indicates that the instrument is ready to start programmed process control.

- POWER

Used to indicate that the "percentage" display reading is pertaining to source POWER.

- XTAL

This display appears with percentage display only when XTAL button is pressed. Indicates % of crystal life used (99% is equal to a 1MHz shift referenced from 6MHz). Crystal life will be displayed for 5 seconds before power information returns.

- FAIL

When displayed together with XTAL, this display indicates that the unit has experienced a crystal fail.

- ▮

Displayed when the instrument keyboard is locked out by a Host computer via IEEE-488 or RS-232 interface.

- Err [#]

Certain machine based Self Checks are done on power ups. Refer to Section 5 for a complete description.

REAR PANEL DESCRIPTIONS

The XTC Rear Panel provides interface connections for RS-232C communications (optional), IEEE-488 communications (optional), I/O Relay Module (optional), System Control connections (Analog Recorder, Source and Sensor Shutter Output etc.), Crystal Sensor input and Line Power input. Option selection is also provided on the rear panel. Refer to Figure 2.3 for location of all Rear Panel Components discussed under this heading.

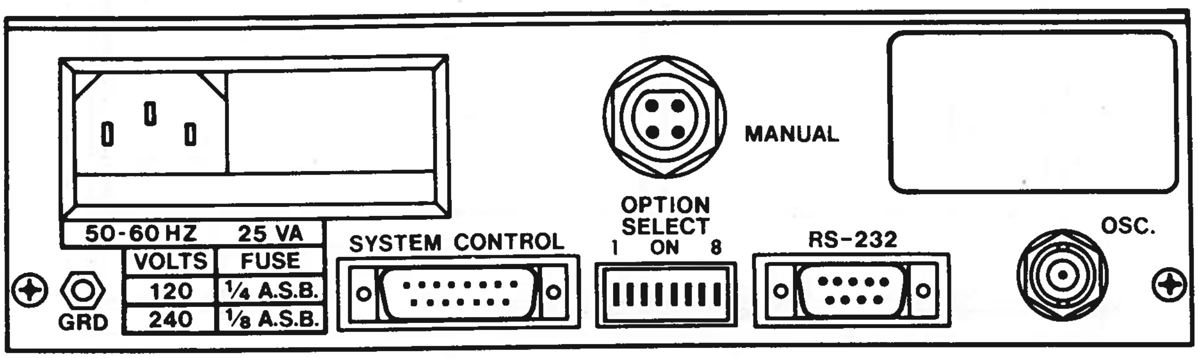

Figure 2.3 XTC Rear Panel Components

Rear Panel Connector Descriptions

•POWER MODULE

Allows selection of optional voltages along with system fuse holder and line cord connector. For directions on voltage selection and fuse replacement refer to Section 1 of this manual. See Figure 2.4 for voltage selector switch location.

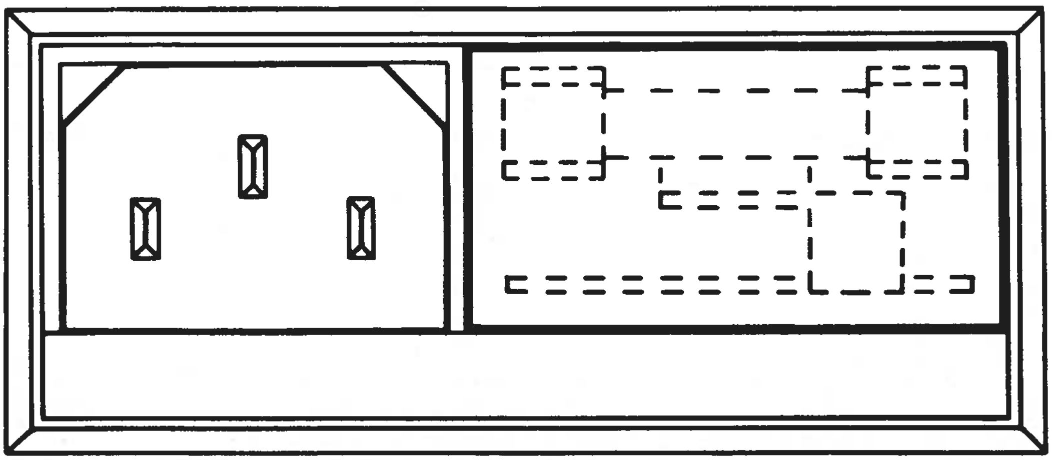

Figure 2.4 Power Module

•MANUAL POWER

Accepts the standard Inficon hand held source power controller. When connected, the controller provides remote control of source power provided the instrument is in MANUAL mode. The controller is a three selection switch. All positions are momentary and will return to rest when released. Pushing the SWITCH left or right causes the output control voltage to increase or decrease. Pressing the switch downward causes the XTC to STOP (same as pressing front panel STOP button). See Figure 2.5.

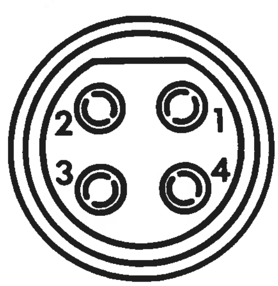

Figure 2.5 Manual Power Connector

• OSCILLATOR

Input connector (BNC) for Inficon oscillator IPN 013- 001. See Figure 2.6.

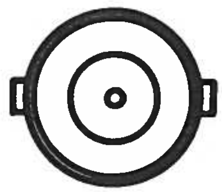

Figure 2.6 Oscillator (OSC) Connector

• RS-232C

A 9 pin "D" type connector which enables the XTC to be controlled by a Host computer (XTC must contain optional RS-232 software; however, all units have this connector). Units which contain the RS-232 option are designated on the serial number plate. See Figure 2.7 for connector pin designations.

Pin#	Definition
5	XTC Receiver
4	XTC Transmitter
1	Ground Shield
2	"
6	"

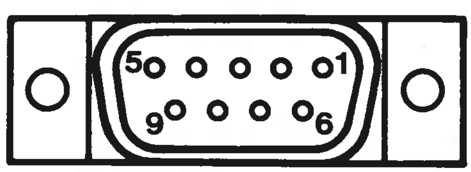

Figure 2.7 Connector Pin Diagram

- OPTION SELECT ON/OFF

An 8 position DIP switch used to select particular functions as follows: See Figure 2.8.

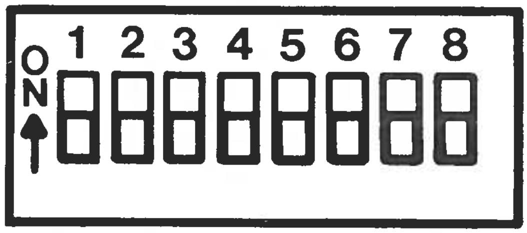

Figure 2.8 Option Select Switch

CAUTION: **The OPTION SELECT switch is read only on instrument power up. If an option is changed the instrument must be powered down and powered up again.**

---

0 = OFF, 1 = ON

Switch 1 Setting	0	1	0	1
Switch 2 Setting	0	0	1	1
Baud Rate	1200	2400	4800	9600

Switch	Definition
3 Test	(1) Activates Test mode providing simulated rate display (see POWER UP AND SYSTEM SELF TEST). Simulated Rate will be equal to 40Å/sec. when Density is set to 1gm/cm³ and tooling = 100%. For other settings the Rate display will read as follows:

$$\text{Display Rate (Å/sec)} = \frac{40\text{Å/sec} \times \text{Programmed Tooling \%}}{\text{Density} \times 100\%}$$

Switch		Definition
4	Rate/Thickness	OFF Selects RATE and ON Selects THICKNESS. Both provide an analog output of 0 to +10 volts. Rate output of +10 volts = 100Å/sec if desired Auto Control Rate is less than 100Å/sec., or 1000Å/sec. if desired Rate is greater than 100Å/sec. Thickness output of +10 volts = 1kÅ in accumulated thickness.
5	Stop on Alarm	ON places the unit in STOP if unit fails to meet Auto Control Rate criteria used in RATEWATCHER or Shutter Delay within 60 sec. OFF allows unlimited delays in obtaining the necessary control. The (optional) Alarm relay on I/O RELAY Module is active independent of this switch setting (See Section 7).
6	Shutter Delay	ON selects shutter delay option which starts Auto Control Rate before opening source shutter. The shutter will not open until rate control has been established to within +/-5% of the desired RATE. See Shutter Delay, page 2-8.
7	Xtal Fail	Selects either STOP (ON) or COMPLETE on Time-Power (OFF) if the XTC experiences crystal fail during a controlled Deposit phase.
8	MAX POWER	Selects either STOP (ON) or CONTINUE (OFF) if power is equal to programmed maximum power for a period of (5) continuous seconds.

System Control (Standard)

Every XTC has a SYSTEM CONTROL connector which enables the XTC to handle simple relay control of a deposition system. Standard functions controlled through this connector are source shutter and crystal sensor shutter operation as well as +/- Analog control voltages suitable for controlling most deposition sources. Analog voltages representing the Deposition rate or Accumulated Thickness are also available through this connector. See Figure 2.9 for pin out information. An optional I/O RELAY Module is available with the XTC which provides (8) inputs and (8) outputs. Refer to the options section of this manual for additional information.

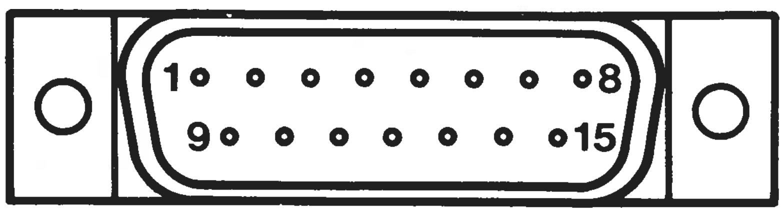

Figure 2.9 System Control Connector Pin Diagram

Pin #	Definition	Contact Ratings
1&2	Source Shutter	N.O. ISOL Contacts, 120V/100VA.
9&10	Sensor Shutter	N.O. ISOL Contacts, 120V/100VA. (100 OHM/0.01ufd/ARC SUP)
6	Source Control Positive*	0 TO +10 VOLTS F.S./3MA. DC
7	Source Control Negative*	0 TO -10 VOLTS F.S./5MA. DC
8	Rate/Thickness DAC	0 TO +10 VOLTS F.S./5MA. DC
4, 5&12	Analog Ground	0 VOLTS/100MA. MAX

3, 11, 13, 14, and 15 are unused.

* 0 TO +/- 5 VOLTS F.S. WITH JUMPER J 1/2 DAC on MEASUREMENT CONTROL Board removed. See Figure 6.2.

•GND (Ground)

Ground stud for interconnecting system ground strap. See Figure 2.11. Also see pg. 3-3 for suggested grounding.

Figure 2.11 Ground Stud

Warnings

Located on the XTC rear panel are two warning labels which warn of high voltage dangers within the instrument cabinet. With the cover plate removed from the unit, line voltage as well as various control voltages are present. Disconnect the power cord and other interface connectors to the system before attempting service to the instrument. XTC system power should be off when servicing any system related apparatus. See Figure 2.12.

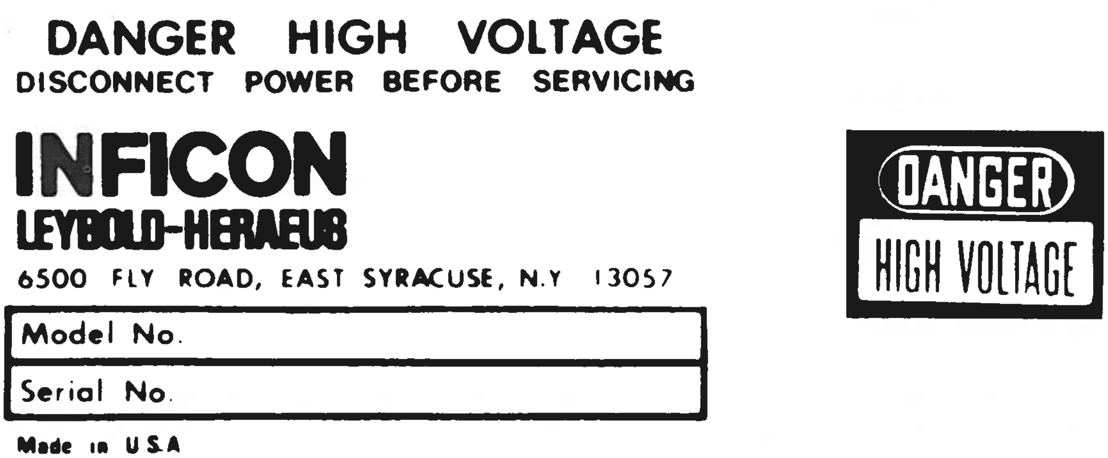

Figure 2.12 Warning Labels

OPERATING THE XTC AS A MONITOR

The XTC may be easily used as a rate and thickness monitor for experimental work involving evaporation or sputtering. The description will be divided into two parts. One covering systems that use source shutters and one covering systems which do not use source shutters. If your intent is to use automatic source power control proceed directly to Operation of the XTC as a Controller (page 2-21).

Systems Without A Source Shutter

To operate the XTC as a film thickness/rate monitor it is necessary to program only the following three parameters:

- Density (See Table 4-5) Depends on material to be deposited
- Z-Ratio (See Table 4-5) Depends on the material to be deposited
- Tooling (See Section 4.3) Corrects display for geometrical differences between sensor and substrate.

With the crystal head properly attached (see Section 3) and the XTC in the operational (not program) mode, the Rate display will show the evaporation rate and the Thickness display will increment accordingly. Ensure that the XTC is not in the STOP mode. When in the STOP mode all displays are frozen at the values when the STOP was encountered. The STOP mode is cleared by pressing the START button. Pertinent front panel controls work normally.

- XTAL - Pressing displays crystal life. (See Front Panel Description in this section.)
- ZERO - Zeros the thickness Display.
- START - Clears stops induced by crystal fail.
- PG - Controls entry and exit of the program mode.
- POWER - On/Off control for line power.

Systems With A Source Shutter

In addition to measuring rate and thickness, the XTC can be used to control process thickness. Implementation requires the deposition system have a source (or substrate) shutter capable of automatic operation. The source shutter control must be electrically connected to the source shutter pins of the SYSTEM CONTROL connector (See Figure 2.9).

Additionally, the following parameters must be programmed:

- Rate -- set to 0.0Å/sec
- Final Thickness -- set to desired thickness
- Set all pre and post deposition parameters to zero (see Section 2 XTC Phase Descriptions.

Once the operator brings the source power up to the nominal operating level he may start deposition by pressing the START button (in READY mode). This zeros the thickness and opens the shutter. The operator may adjust deposition power independently to achieve the desired rate. The shutter will close automatically when the final thickness set point is achieved.

Rate Sampling

In order to occasionally check Rate on a coating system, the XTC may be easily implemented as a manual sampling system by performing the following steps:

1. Choose and install a sensor head and associated shutter assembly.

   Standard Sensor
   Compact Sensor
   Sputtering Sensor
   Bakeable Sensor

   See Section 3 for installation of sensor heads.

2. Electrically connect the pneumatic shutter actuator control valve (IPN 007-199) to the source shutter pins of the System Interface connector. See Installing Pneumatic Shutter Actuator, Section 3.

CAUTION: **Verify proper connection, do not connect shutter actuator to sensor shutter pins.**

---

3. Set the Rate to 0.0 Å/sec (in the program mode).

4. Program Final Thickness to a value which allows several seconds (20 approx.) of accumulation on the sensor head. For example, if the nominal Rate is 20 Å/sec set the Final Thickness to 20 sec x 20Å/sec = 400Å.

A sample is initiated by pressing START (from READY mode). This zeros the thickness and opens the sensor shutter. The operator may view the deposition Rate display (allow it to stabilize) and compare it to the desired Rate. If a longer sample is needed to adjust the Rate the operator can press MAN. Once adjustments are completed, pressing MAN again closes the shutter.

OPERATING THE XTC AS A CONTROLLER

The XTC is designed to provide automatic rate control with thickness shutdown as well as pre and post deposition source conditioning. Fully automatic operation requires that the unit be interfaced with the evaporation source controller and automatic shutter via the SYSTEM CONTROL connector. The XTC can also be used to control or interface with other components of the system through the optional I/O RELAY Module connector.

XTC Phase Descriptions

To operate the XTC as a film thickness/rate controller it is necessary to program film sequence parameters. A film sequence begins with a START command and ends when the film in process reaches the idle phase. Any process control that occurs between these events is determined by the values programmed in the possible parameters. A film sequence consists of many possible phases, with a phase being defined as one process event. These phases are described below: See Figure 2.13.

	PHASE	CONDITION
	NOTE: 1 through 6 are Pre-Deposit Phases.	
1.	Ready	Source Shutter closed; will accept a START command.
2.	Rise Time 1	Source Shutter closed; source rising to Soak Power 1 level.
3.	Soak Time 1	Source Shutter closed; source maintained at Soak Power 1 level.
4.	Rise Time 2 (feed ramp)	Source Shutter closed; source rising to Soak Power 2 level.
5.	Soak Time 2 (feed soak)	Source Shutter closed; source maintained at Soak Power 2 level.
6.	Soak Hold	Source Shutter closed; Source maintained at Soak Power 2 level (Optional, requires I/O RELAY Module or RS-232).

NOTE: 7 through 12 are Deposit phases.

7.	Shutter Delay	Source Shutter closed; rate control.
8.	Deposit	Source Shutter open; rate control.
9.	Rate Ramp Time	Source Shutter open; rate control, desired rate changing.
10.	RateWatcher (SAMPLE)	Source Shutter open; rate control, crystal shutter (Sample) open.
11.	Ratewatcher (HOLD)	Source Shutter open; constant power, crystal shutter (Hold) closed.
12.	Manual	Source Shutter open; Crystal Shutter open source power controlled by hand held controller.
13.	Time-Power	Source Shutter open; crystal failed; source maintained at average control power prior to crystal failure.

NOTE: 14 through 15 are Post-Deposit phases.

14.	Idle Ramp Time	Shutter closed; source changing to Idle Power.
15a.	Idle Power (=0%)	Shutter closed; source maintained at zero power; will accept a START command
15b.	Idle Power (>0%)	Shutter closed; source resting at Idle Power; will accept a START command.

NOTE: The STOP phase - source shutter closed; sensor shutter closed; instrument will accept a START provided the Crystal Fail option is not selected and a Crystal Fail has not occurred.

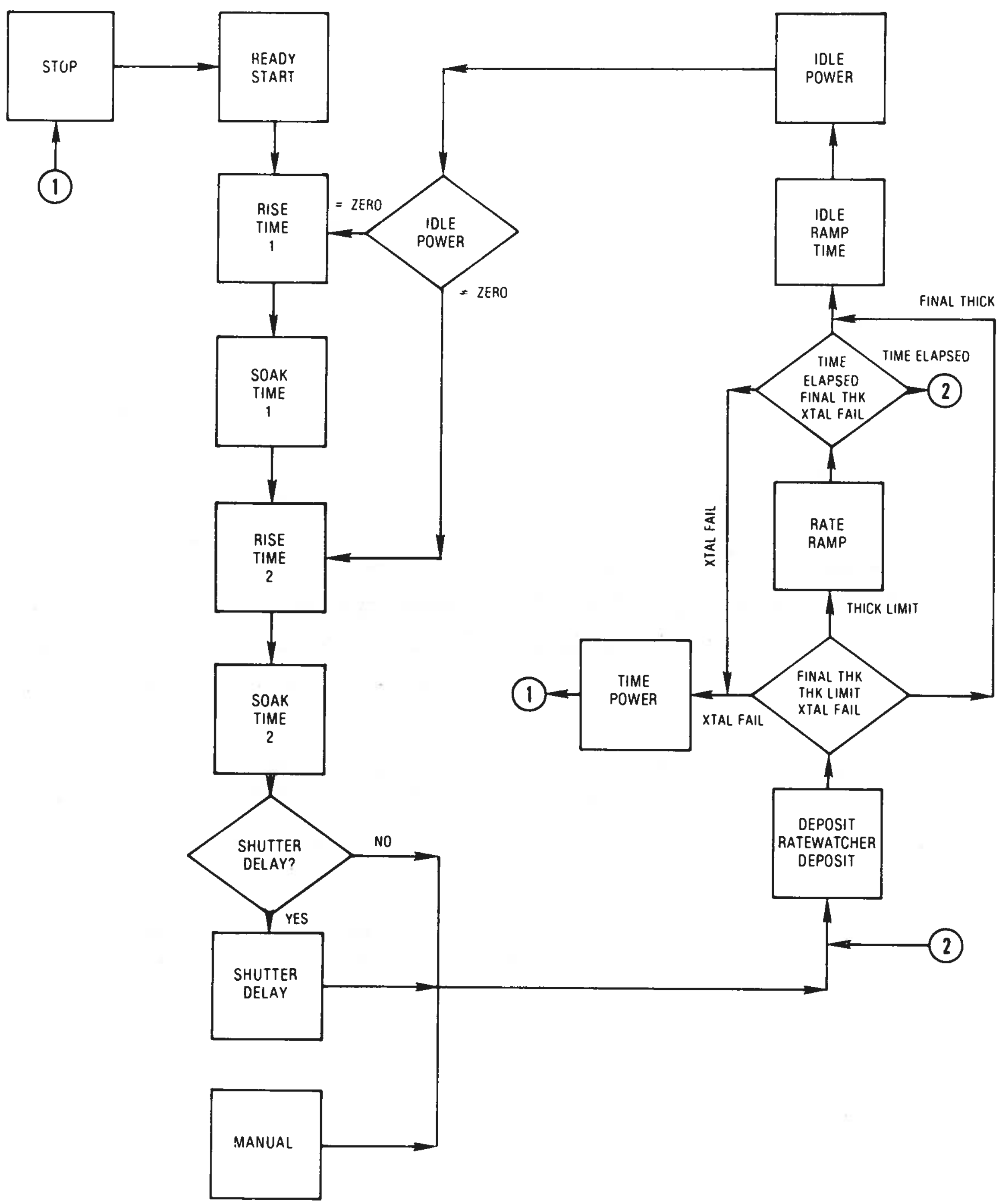

Figure 2.13 Phase Diagram

Programming The Parameters

Programming the XTC is easily accomplished once you have made the determination of whether to Monitor or Control the process, chose the type of material to evaporate along with the thickness required, and have become familiar with the instrument programming process.

You are not required to execute all XTC film phases when you generate a film. For example, phases will automatically be skipped if the film parameters are used to confirm which phases have been set to zero. The idle phase of a program, however, will always be executed. When the desired control rate is programmed to zero, the entire Deposit (including any Rate ramps) will be skipped. If no parameters have been programmed the film will sequence immediately to the Idle phase when a START command is executed.

When a film program finishes in an Idle phase at a power level other than zero, a subsequent START command will initiate the film program at the Rise Time 2 phase, skipping both Rise Time 1 and Soak Time 1 phases if they were programmed. If a Rise Time 2 phase is not present in the program, the unit will sequence to the next viable phase - Shutter Delay , Deposit, Idle Ramp Time or Idle (in that order).

You can enter the manual power phase whenever the XTC is not aborted or stopped. The shutter will always open and the Final Thickness event will be ignored. When the manual control phase is ended, the unit will sequence to the Deposit phase, provided the Final Thickness limit has not been exceeded. Any thickness accumulated while the unit was in Manual control will be retained when the manual phase is ended. The Time-Power control phase will only be entered while the XTC is in a Deposit or Rate Ramp phase and the film program has been set to complete on Time-Power in the event of crystal failure. The source power will remain at the average value set by the control loop prior to crystal failure and the Thickness will be accumulated at the Auto Control Rate set point value. The Time-Power phase will terminate when the Final Thickness limit is reached. Any post-deposit film activities will be executed exactly as if a normal deposition had occurred.

Setting Pre- and Post- Deposition Parameters

From the factory XTC provides a 0- +/- 10 volt source Power Control signal from pins 6(+), 7(-), and 4(GND) of the the SYSTEM CONTROL connector. This voltage is proportional to the percent of power display with 50% equalling 5 volts. Use pin 6 for supplies requiring positive control voltages and pin 7 for supplies requiring negative supply voltages. This may be changed to +/- 5 volts by removing jumper J1/2 DAC on the Measurement board (See Figure 6.2). The reduced voltage range is useful if the deposition power supply is normally running at a small fraction of its full power, or if the control voltage range is less than 10 volts. With the reduced voltage range, a Power setting of 60% gives an output of 3 volts. See Section 3, Connection And Setup Of Rear Panel Components for installation instructions.

Setting SOAK POWER 1 Parameters

Soak Power 1 is typically set at a level that produces a source temperature just below significant evaporation. This is easily translated into a power percentage (Soak Power 1) with the help of the hand held controller. Slowly bring the power level to the apparent desired deposition rate and then note the power percentage value on the LCD display. Use this value for the Soak Power 1 setting. This power level may also be used in fast coaters for a non-zero Idle Power. Set the associated Rise Time and Soak Time to insure that the melting does not cause violent turbulence but does not waste excessive time.

Setting SOAK POWER 2 Parameters

Soak Power 2 is typically set at a level that is just below the power that is used for maintaining the selected evaporation rate. This is determined by manually bringing the power level up to the desired rate and then entering automatic rate control. Allow the source to stabilize, then note the average power on the display. Use this value or one slightly lower for the Soak Power 2 value. Set the associated rise and soak time long enough to insure that the melting does not cause violent spattering, but short enough that expensive materials are not wasted.

Parameter Values On Power Up

On power up the XTC will retain the most recently entered values for the following parameters. However, with NEW (unprogrammed) instruments or in the event that the "Err 1" message appears the associated values for the parameters below will be in memory.

PARAMETER	DEFAULT VALUE
TOOLING	100.0%
DENSITY	1.000 gm/cc
Z RATIO	1.000
MAX POWER	90%
GAIN	10
APPROACH	0
RATEWATCHER	00:00 min:sec

Press start to escape from the Err state.

Adjusting Control Loop

The function of the control loop is to stabilize the evaporation rate at the Auto Control Rate. By selecting the most favorable gain and approach values, you can control sources with nearly any physical characteristics.

Even though theoretical methods exist for determining initial control settings, an experimental approach remains the most practical and least time-consuming for most installations. This approach requires recognition of basic symptoms of incorrect adjustment, from the shape of the analog rate output on a chart recorder. The most usual diagnostic technique is to observe both the negative and positive step changes in the Auto Control Rate. In some processes it may be necessary to comprise final adjustments for the sake of best overall control action. You should avoid setting the control loop to values of gain and approach where minor changes in process conditions can introduce cyclic system responses. Satisfactory control settings are those which produce acceptable results in overall rate control without sacrificing control stability. These settings will be arrived at experimentally as described below. Remember to allow conditions to stabilize between adjustments in order to properly assess the adjusted performance, especially in the case of slow sources. Once the best settings have been determined, they should be recorded to facilitate future resetting. Table 2.1 gives some starting values to be used when beginning to adjust the control loop.

TABLE 2.1 TYPICAL CONTROL LOOP PARAMETERS

SOURCE	GAIN	APPROACH
E Beam	60-99	0
Sputtering	60-99	0
Slow Resistance or Induction	5-10	40-80
E Beam w/Crucible	20-40	5-30

Setting Gain

As you initially adjust the gain, you should keep the approach parameter at the preprogrammed value of 0. As the gain is increased, the control voltage rate of change increases for a given error. To find the initial gain setting, the gain setting on the XTC must be progressively increased. Observe the effect of gain change on a chart recorder. Use the same rate change for both rate increases and decreases. Allow sufficient time after each adjustment for the system to stabilize. When the system is cycling (oscillating) steadily, note the frequency and magnitude of the cycle and decrease the gain until the cycling stops or is minimized. If extremely low values of gain (less than 10) are necessary to achieve this, increase the approach by units of five and repeat the above procedure until cycling is eliminated.

Setting Approach

Approach should be increased when the rate control displays overshoot (or undershoot) of the Auto Control Rate or if the rate controls oscillate when an incremental change of rate is made. Experiment to achieve the correct approach setting, in conjunction with the gain setting. Use the minimum value of approach that eliminates (or nearly eliminates) overshoot, since large values tend to increase control loop noise. Figure 2.14 shows the effects of the approach setting adjustment on the control loop.

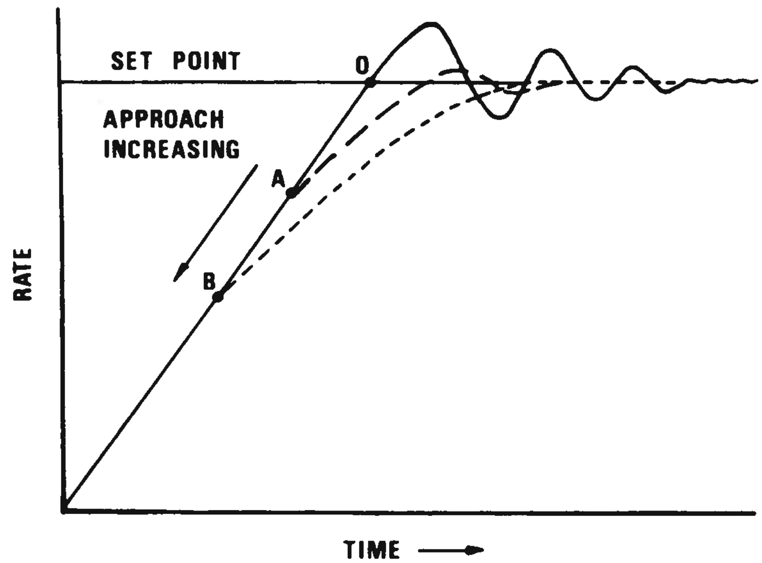

Figure 2.14 Effect of Approach Setting on Control Loop

Summary of Control Loop Adjustments

NOTE: Allow sufficient time after each adjustment for the system to stabilize. Use a chart recorder and the Analog Rate output.

1. Adjust gain to the maximum stable setting for acceptable rate deviation.

2. If cycling or overshoot with step change of rate occurs, increase the approach setting. As gain and approach controls interact, steps 1 and 2 should be repeated to determine the best values.

3. Reverse any adjustments that deteriorate control performance. If cycling cannot be totally eliminated, adjust approach and gain for best overall control action.

Figure 2.15 shows the analog display response to both positive and negative rate steps.

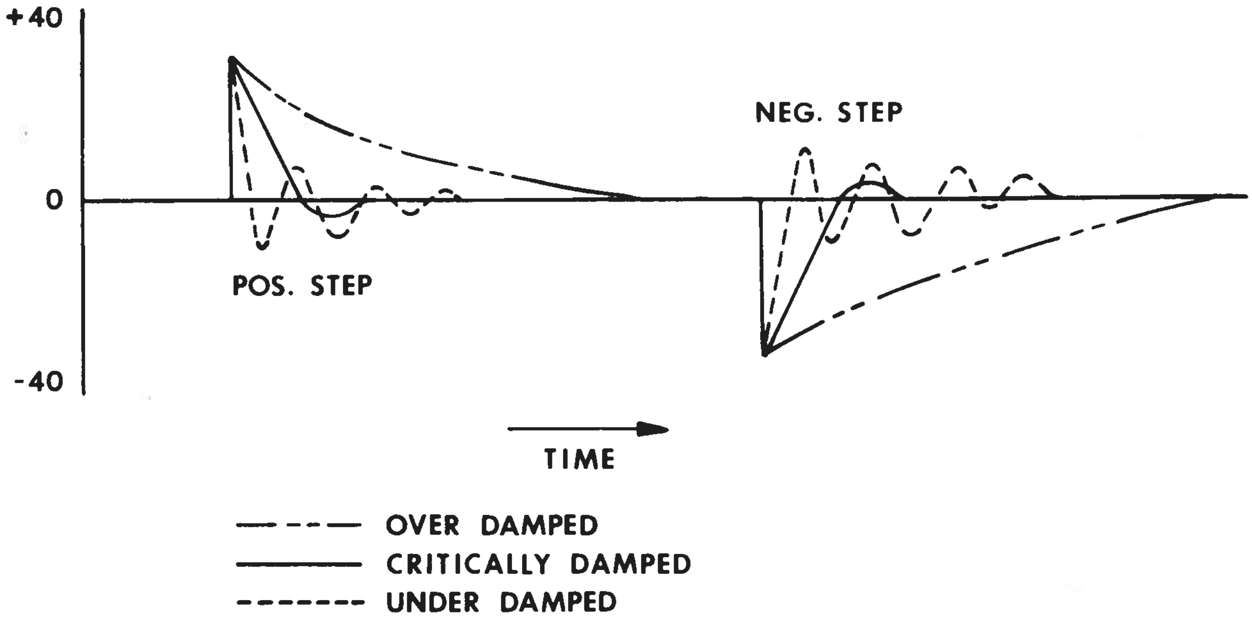

Figure 2.15 Analog Display Response to Rate Steps

Starts From IDLE Phase

When a film program terminates at a non-zero Idle Power, a subsequent start of the same film program will initiate the film sequence at the Rise Time 2 phase. The Rise Time 1 and Soak Time 1 phases will be ignored. The cycle time between layers is decreased, since the source has been maintained at some interim power level and does not require the long preconditioning time provided by the Rise Time 1/Soak Time 1 phases. The Rise Time 2 phase will begin at the Idle Power level at the the time of the START command, and will ramp to the programmed Soak Power 2 level. A film program that is started from either the READY mode or the Idle Power (0) phase will always execute the Rise Time 1 phase if programmed in the film sequence.

Programming Rate Ramp

The XTC film program includes a means to change the rate during the deposition phase. It may be used to generate a precise linear variation in the evaporation rate. These rate ramp programs operate during the deposit phase of the film sequence, and are initiated when the programmed THICKNESS LIMIT is reached. The rate ramp phase will continue for the programmed duration of the ramp, or until the Final Thickness set point of the film program is reached. If the rate ramp phase terminates before reaching Final Thickness, the XTC will return to the Deposit phase. The slope of a rate ramp is determined by the following equation: change in rate per second = |new rate - desired rate| divided by ramp time. If a ramp parameter is changed during a ramp, the new slope will be calculated, taking into consideration the time the ramp has already been in process. Rate ramps are disabled by setting RATE RAMP TIME to 00:00.

Rate Ramp To Zero Rate

It is sometimes desirable to ramp to zero rate for phasing purposes, and also to complete the film processing as if the Final Thickness had been achieved. Therefore, when a New Rate value of 00.0 is achieved, the film program will proceed as if the Final Thickness limit had been reached.

Shutter Delay

Shutter Delay is used to establish rate control before exposing the substrates to the evaporant. The sensing crystal must be exposed to the source during the Shutter Delay phase for this to be accomplished. Shutter delay is accessed by placing the OPTION SELECT Switch #6 to ON. The control loop attempts to establish rate control at the end of the pre-deposition film phases. However, the source shutter opening is delayed for a period of time to insure stable rate control. When rate control has been established, the shutter opens, the accumulated thickness is zeroed, and the substrates are immediately exposed to an evaporant that is under tight rate control. With proper adjustment of the control loop parameters, the delay time can be kept to a minimum. If the XTC is unable to establish rate control in 60 seconds the alarm relay on the option I/O RELAY Module will close. Also the XTC may be setup to automatically STOP on this alarm condition if OPTION SELECT Switch #5 is turned ON.

Implementing RATEWATCHER

The XTC may be easily set up to automatically sample the deposition rate periodically and then maintain the proper source power level necessary to keep the Auto Control Rate at the set point for extended periods of time. With inherently stable deposition sources; such as the planar magnetron, an occasional check of the rate (with the associated automatic recomputation of the necessary power level) is all that is needed.

This sample and hold type of control can supercede the fully active type of rate control that normally limits the utility of the crystal monitor for inline or load locked systems.

The RATEWATCHER feature requires a dual parameter entry. First the HOLD time must be programmed. This is the length of time between the completion of the last sample period (or the achievement of rate control) and the initiation of the next sample period. The process engineer may set the interval up to a maximum of 99:99 for automatic operation by the XTC itself or if longer intervals or periodic samples are needed, SAMPLE initiate and SAMPLE inhibit inputs are available on the I/O RELAY Module During these HOLD periods, thickness is accumulated at the Auto Control Rate.

Next, the Process Engineer must decide on the sample accuracy. This parameter sets the maximum acceptable deviation allowable in the rate control during the interval when the average power needed to maintain proper rate is being computed.

Accuracies of 0 to 99% are allowed, but the unit automatically insures that the minimum error acceptable is 1Å/sec. Otherwise accuracies greater than the precision of the rate measurement could be requested but never obtained.

When operating in the SAMPLE mode the crystal shutter is open for a minimum period of 10 seconds. When a SAMPLE is initiated, the crystal shutter immediately opens but the crystal readings are still ignored for the first five seconds because of thermal considerations. During the next 5 seconds the XTC is in true rate control. At the end of the 5 seconds the average deviation between the actual 250ms rate readings and and the rate set point are compared and the difference averaged. If the difference satisfies the accuracy setting (or 1Å/sec) the crystal shutter closes and a new HOLD cycle begins. If sufficient accuracy was not obtained the unit stays in rate control and a new readings taken until the accuracy is achieved (SAMPLE). If the necessary accuracy cannot be achieved in 60 sec. the optional alarm relay closes. If the Stop On Alarm function is enabled the XTC will stop at this time. Tooling calibration of the unit is performed in the normal manner but recalibration should be performed if the Ratewatcher parameters are changed. (See Section 4).

Completing On TIME-POWER

When used as a controller the XTC has the ability to complete a deposition normally if a crystal fails during the deposit phase. Depending on the setting of the OPTION SELECT switch #7, the XTC will either complete on TIME-POWER (0), OR STOP (1) on crystal fail. When the XTC is set up to complete on TIME-POWER and a crystal fail is encountered the deposition will establish an average power. This average power is used to accumulate thickness at the Auto Control Rate. The deposition will terminate normally. The thickness accuracy will depend on the duration of the TIME- POWER phase. A shorter duration will increase the Final Thickness accuracy;longer durations will decrease accuracy. This feature has no utility when used in a monitor only situation.

Crystal Fail Inhibit (Option; Requires I/O Relay Module, RS-232C, or IEEE-488)

In many coating plants the crystal fail output is given major importance and causes the entire system to shut down. This can cause problems when the crystal is changed as part of the normal reloading procedure. This potential conflict is resolved by utilizing the crystal fail inhibit input. When this input is activated the crystal fail relay will not close on crystal fail; neither will the instrument go to STOP (assuming it is in a non-depositing phase). The front panel messages still work normally. The operator may now change the crystal and verify that it is operating without inducing a major process interruption. This input may be switched manually or automatically using the END OF PROCESS relay (optional).

USING AND CALIBRATING THE ANALOG OUTPUT

Both rate and thickness analog output may be calibrated prior to actual deposition by using the internal TEST mode which provides adequate simulation to fine adjust the recorder for zero and span. The analog output signal is available at the SYSTEM CONTROL connector using Pin 8 for the signal and Pins 4, 5, or 12 for analog ground. The available output voltage range at this pin is 0 volts to 10 volts. For proper operation the chart recorder must be configured to accept a 0-10 volt signal for a full deflection sweep and the recorder inputs must be connected to the pins noted above. Refer to Back Panel Descriptions for additional information on the contact ratings for this output.

Calibrating Analog Rate

To adjust the analog output for Auto Control Rate, set the TEST switch (Option Select Switch 3) to ON and the OPTION SELECT switch (4) for RATE. This provides an analog output of 0 to +10 volts. A Rate output of +10 volts = 100Å/sec. if desired Rate is less than 100Å/sec., or 1000Å/sec. if desired Rate is greater than 100Å/sec. Momentarily power down the XTC then power up (option switches are only read on system power up). Select the program mode and enter 25Å/sec for Auto Control Rate, 0.8 gm/cc for DENSITY, and 198% for TOOLING. Adjust the chart recorder for zero. Press start and observe the analog output at the recorder. The signal should climb to the 10 volt level and stabilize. Fine adjust the chart recorder span to accurately position the 10 volt level. (n x 10 x voltage level = rate Å/sec).

Calibrating Analog Thickness

To adjust the analog output for thickness, leave XTC in TEST mode and set the OPTION SELECT switch (4) for THICKNESS. This provides an analog output of 0 to +10 volts. A Thickness output of +10 volts = 1kÅ in accumulated thickness. Momentarily power down the XTC then power up. Select the program mode and enter 10.000kÅ or more (to provide adequate time in the DEPOSIT phase). Zero the thickness and adjust the chart recorder for zero. Press start and observe the recorder trace. A series of triangular ramps will be produced each representing a 1000Å (1kÅ) thickness. Fine adjust the chart recorder to position the pulses such that the full sweep extends from the bottom of the graph to the top of the graph (number of ramps x 1kÅ = thickness).

■TYPICAL SPUTTERING SENSOR PERFORMANCE CURVE

An actual performance curve of the Inficon Sputtering Thickness Sensor is shown in Figure 2.16. The curves within the circles show the details of the performance curve at the beginning and end of the deposition. The numbers within the circles indicate scale factors for time and thickness and particular points in the deposition cycle. Note that the thickness shift due to thermal stress is very small and is established within 30 seconds after the start of termination of the glow discharge. The thickness shift at the termination of the glow discharge is about the same, but in the opposite direction, (as compared to that at the start of the glow discharge), even after one hour of sputtering. The actual thickness being deposited on the crystal, with density setting at 4.00 gm/cc, is indicated by the Reading 4 (6.034kÅ), because the thickness reading was zeroed before the deposition (Reading 1= 0.000kÅ). If you zero the thickness indication at Reading 2 (actual reading: 5.982kÅ or -0.027kÅ), Reading 3 (actual reading: 5.982kÅ) will become 6.009kÅ, only 0.4% less than Reading 4. The stability of the thickness reading after the termination of the glow discharge also indicates the lack of any accumulative heating effect on the sensing crystal during sputtering. This demonstrates the excellent stability and accuracy of the Inficon Sputtering Thickness Sensor when used in the sputtering environment.

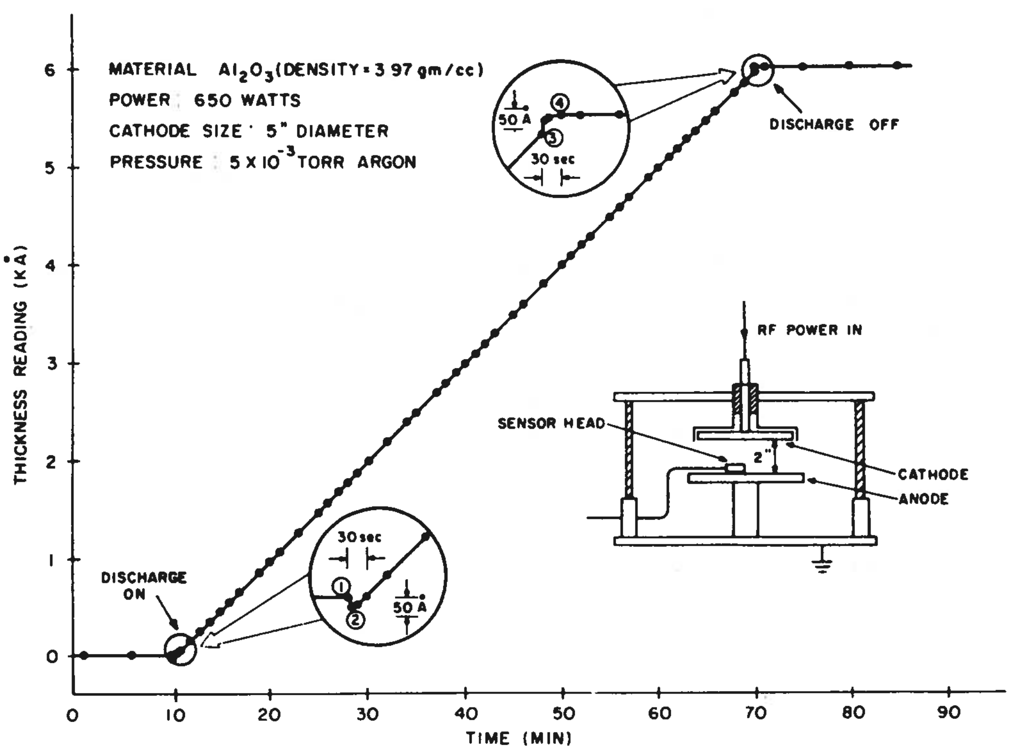

Figure 2.16 Typical Performance Curve of the Inficon Sputtering Sensor

During Sputtering Sensor Operation, at the start and the termination of the glow discharge, it is normal to observe a sudden but small shift of the thickness display on the XTC. The shift is negative at the start and positive at the termination of the glow discharge. This is due to the thermal stress generated in the crystal when the surface is exposed to the glow discharge. The magnitude of this thickness shift depends on the sputtering power and other parameters. The shift at the termination of the glow discharge is about the same magnitude as the shift at the start of the glow discharge, but in the opposite direction. It is independent of the total deposition time, and thus it is completely predictable. If you want to stop the deposition by using the Final Thickness Relay on the control unit to turn off the power or to close a shutter you should zero the thickness reading after the establishment of the glow discharge. This will eliminate the effect of the initial thickness shift due to thermal stress. The thermal drifts encountered will be symmetrical and will therefore not effect repeatable thickness control.

■XTC OPERATIONAL TEST

The XTC contains a software controlled test mode which simulates actual operation. The purpose of the test is to verify basic operation while demonstrating typical operation to the technician.

The POWER button should be in the OFF position before the instrument is connected to line power. The button locks in when in the ON position and unlocks in the OFF position.

Perform the XTC self test as follows:

1. Verify that no cables other than the power cord are connected to the unit.

2. Locate the OPTION SELECT ON/OFF switch (rear panel) and set switch (3) to ON. All other switches should be in the OFF position.

3. Press the POWER button, the power LED should light. If Err is displayed on the LCD refer to "XTC Error Messages, page 5-14."

4. The following LCD displays will appear:

   TEST
   READY
   XX:XX PHASE MIN:SEC
   XX% POWER XTAL FAIL

5. Press the PG button. The program display will appear and the cursor will be located beside GAIN.

6. Refer to the list of parameters in Table 2.2 below and enter the data as they are given.

TABLE 2.2 OPERATIONAL TEST PARAMETERS

GAIN	10.	
APPROACH	00.	
RATE	16.2	Å/s
DENSITY	02.73	gm/cc
Z-RATIO	1.000	
TOOLING FACTOR	110	%
THICKNESS LIMIT	0.000	kÅ
FINAL THICKNESS	2.000	kÅ
MAXIMUM POWER	50	%
RATEWATCHER	00.00	min:sec
RATEWATCHER	00	%
SOAK POWER 1	20	%
RISE TIME 1	00:20	min:sec
SOAK TIME 1	00:10	min:sec
SOAK POWER 2	35	%
RISE TIME 2	00:15	min:sec
SOAK TIME 2	00:10	min:sec
NEW RATE	00.0	Å/s
RATE RAMP TIME	00:00	min:sec
IDLE POWER	02	%
IDLE RAMP TIME	00:00	min:sec

NOTE: Steps 7 and 8 are intended for new or infrequent users of the XTC. If you are familiar with data entry on the XTC go to Step 9.

7. To enter the new parameter data, press the numerical keys entering the numerals as read. To enter 1000, press "1", "0", "0", and "0". Pressing the first numerical key will cause the associated display to flash. The numerical displays shift decimal points as required to display the most significant digits. Entries which are incorrect or "illegal" (not within function parameter limits) can be deleted by pressing either the correct sequence of numerals or the C↑ key, which replaces cleared data with data in memory. Illegal entries are signified by a flashing Err in the rate display. The entry must be corrected.

8. When the correct sequence of numerals appear in the flashing display, press the E↓ key to enter and store the data.

9. Press the PG button to exit the program display.

10. Press START to begin the programmed sequence.

11. RISE TIME 1 will be displayed, the min:sec counter begins to decrement from 00:20, and POWER increases to 20%. At time 00:00 the phase message changes to SOAK TIME 1 and the counter begins to decrement from 00:10. Upon reaching time 00:00, the phase message again changes to RISE TIME 2.

12. RISE TIME 2 begins to decrement from time 00:15 and POWER increases to 35%. Upon reaching time 00:00, the phase message changes to SOAK TIME 2 and the time again begins to decrement from time 00:10. At time 00:00 the phase message changes to DEPOSIT.

13. Once in DEPOSIT, the time begins to increment and the deposition rate will increase to 16.1Å/s. The THICKNESS LIMIT function is displayed and power is at 36%. Upon reaching the FINAL THICKNESS parameter of 2.000kÅ, deposition stops with an elapsed time of 02:03. The clock immediately begins counting up from 00:00.

14. The XTC is now in IDLE POWER and will remain in this mode until START is pressed.

15. When START is pressed, the process will repeat steps 12 through 14.

NOTE: **If IDLE POWER is reprogrammed to 0, the process will begin at RISE TIME 1.**

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16. After successful completion of the above steps, power down the XTC and reset switch 3 (set in step 2) to OFF.

Section 3 of the XTC Manual covers installation procedures and instructions for Sensors, Electrical connections, and overall system interface with the coating system. The following topics are covered:

- INSTRUMENT INSTALLATION
  - Connecting Rear Panel Components
  - Installing I/O RELAY Module or IEEE-488 Module Options
- SENSOR INSTALLATION
  - General Guidelines for Sensor Installation
  - Pre-Installation Sensor Checkout
  - Installing Compact* and Standard* Sensors (* w/o Shutter)
  - Installing the Bakeable Sensor
  - Installing the Sputtering Sensor
  - Installing Sensor Shutters on Existing Equipment

After you have become familiar with the controls, displays, and connectors on the XTC you may proceed with the installation.

INSTRUMENT INSTALLATION

Should your installation require that the XTC be rack mounted do so at this time using the optional Inficon rack adaptor kit IPN #751-028-G1. This kit mounts either a single unit or two XTC's side by side. Instructions on assembly and installation of the adapter are included in the kit (also see Section 7 Options). When installing the XTC in an electronics rack make certain of adequate ventilation around the instrument. At this time connect only the power cable to the instrument. Other cable connections will be discussed following installation of the sensor(s).

NOTE: **The XTC can be ordered with various types of sensors depending upon the application intended.**

After reading the sections on Pre-Installation Checkout and General Guidelines, go to the installation instructions below for the type(s) of sensor(s) shipped with your instrument.

Connecting Rear Panel Components

The XTC Rear Panel provides all possible interconnection for the instrument. Figure 2.3 shows locations of all rear panel components.

•CONNECTING THE MANUAL POWER CABLE

The Manual Power cable has a keyed connector to prevent improper connection. To connect this cable, simply align the connector body with the rear panel connector, press inward and tighten the (threaded) retainer ring.

•CONNECTING THE OSCILLATOR CABLE

The Oscillator cable has a standard BNC coaxial cable connector. To connect this cable carefully press the connector onto the jack and twist the connector barrel until it locks. See Figure 3.2 for a pictorial of the oscillator properly installed between the XTC and feedthrough.
Maximum length between oscillator and XTC is 30 ft. RGS8/4 50 Ω coax cable.

•CONNECTING THE RS-232 CABLE (Optional)

The RS-232 cable uses a 9 pin keyed connector to prevent improper connection. Spring clips retain the cable connector to the receptacle. To connect the cable, align the connector and press inward until the spring clips engage. To disconnect, squeeze the spring clips and pull outward on the connector. Figure 2.7 lists pin out information .

NOTE: **Units equipped with RS-232 software are so identified by a marking on the instrument serial number plate.**

• CONNECTING THE GROUNDING STRAP

The Ground connection is a threaded stud with a hex nut. One suggestion is to connect a ring terminal to the ground strap, thus allowing a good connection, and easy removal and installation. See Figure 3.1 for the suggested method of grounding. When used with RF powered sputtering systems the grounding method may have to be modified to the specific situation.*

CAUTION: The proper operation of the XTC, as well as the safety of your operators and service people, depends on a low impedence earth ground. If you have not already done so, verify the quality of your system ground with your plant engineering department.

NOTE: If a ground must be established, several major power supply manufacturers recommend the following procedure:

Where soil conditions allow, drive two ten foot copper clad steel rods into the ground six feet apart. Pour a copper sulfate or salt solution around them to improve the ground's conduction. Measure resistance between these rods. A near zero resistance measurement indicates earth ground is achieved.

Keep connections to this grounding network as short as possible.

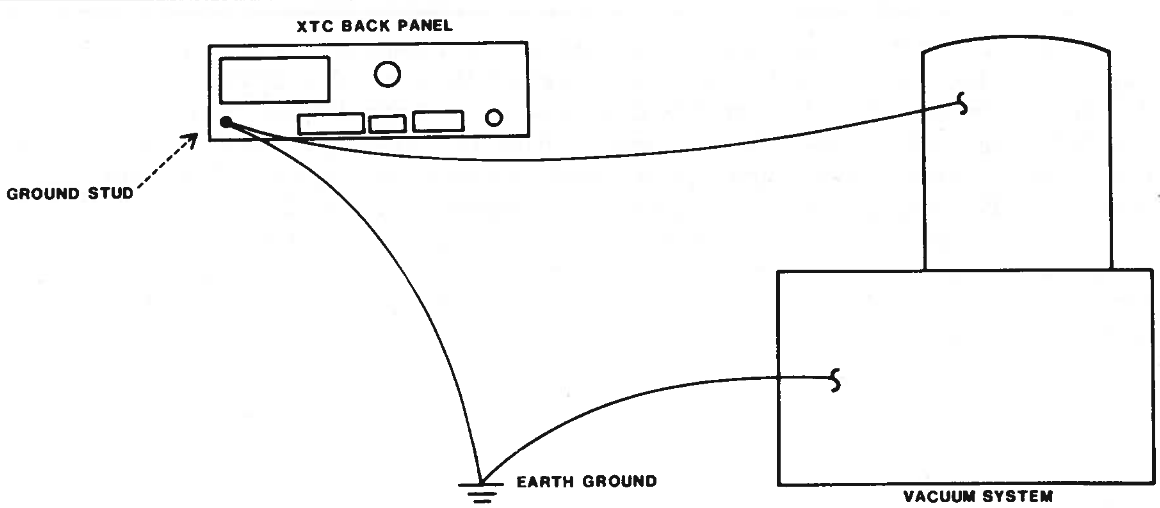

Figure 3.1 System Grounding Diagram

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*An informative article on the subject of Grounding and RFI Prevention was recently published by H.D. Alcaide, in "Solid State Technology" P.117, April 1982.

•CONNECTING THE SYSTEM CONTROL CABLE

The SYSTEM CONTROL cable uses a 15 pin keyed connector which connects exactly like the RS-232 cable connector. Figure 2.9 lists pin out information and contact ratings.

•CONNECTING THE I/O RELAY CONNECTOR (Optional)

The I/O RELAY connector is held secure by a latch block connector. To connect, align the connector to the receptacle and press inward until the connector snaps locking the assembly together.

•CONNECTING THE IEEE-488 CONNECTOR (Optional)

The IEEE-488 connector is held secure by two retaining screws mounted on the connector. To connect, align the connector to the receptacle and press inward until seated. Tighten the screws to assure proper connection.

▮ Installing I/O RELAY Module or IEEE-488 Module Options

NOTE: **The I/O RELAY Module and the IEEE-488 Modules are designed to occupy the same position in the XTC cabinet and installation is the same for either board. Therefore only one of these options may be used at any given time.**

CAUTION: **Before attempting installation of these modules, disconnect the line cord and all XTC Rear Panel interface connectors.**

The XTC cabinet lower rear panel must be removed (see Figure 2.10, page 2-17 for location) to facilitate installation of the option board. To do this, remove the phillips head screw from both lower rear corners on the XTC cabinet sides. Next, remove the two phillips head screws from the face of the lower back panel and remove the panel. Position the option PCB component side down and insert it into the cabinet. Use caution to avoid bending any component leads. Once the option PCB is fully seated into its internal connector you may reinstall the (4) screws which held the blank panel in place. Refer to Section 7 for additional information on both option modules.

■ SENSOR INSTALLATION

A choice of sensor type must be determined by the type of process to be performed, the type of material to be evaporated and the physical characteristics of the process chamber.

■General Guidelines

Figure 3.2 shows a typical installation of an Inficon water-cooled crystal sensor in the vacuum process chamber. Use the illustration and the following guidelines to install your sensors for optimum performance and convenience.

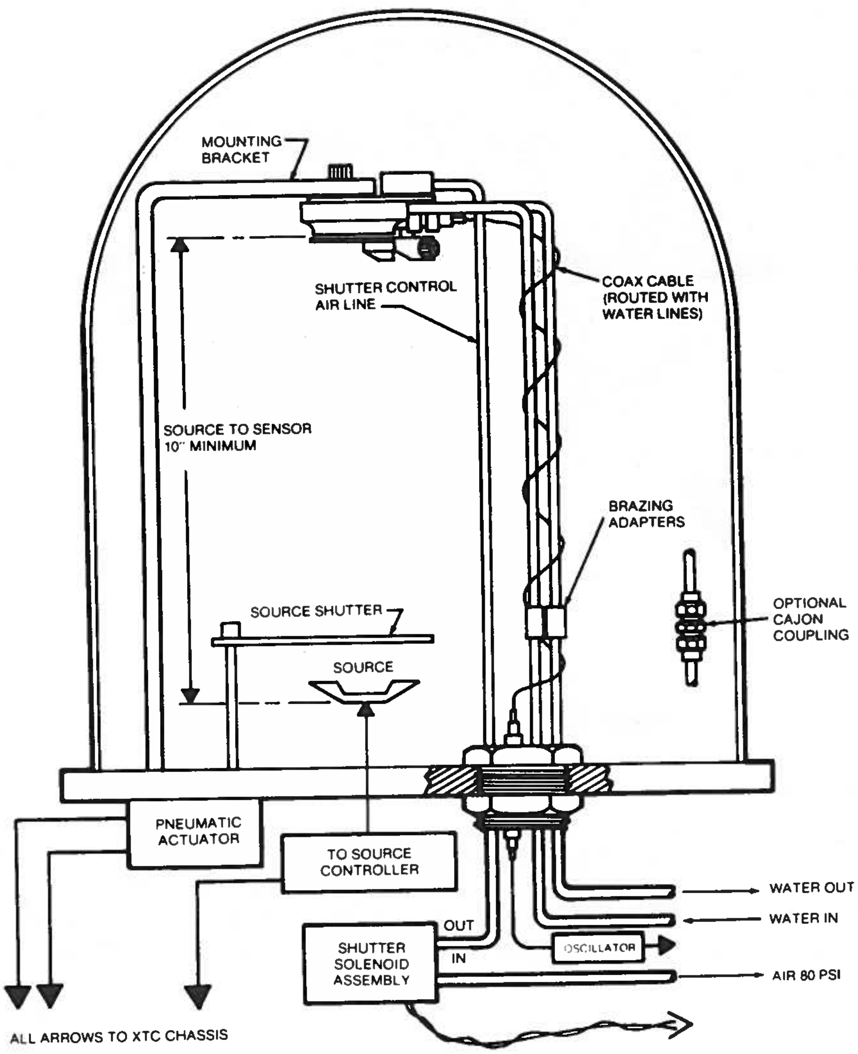


Figure 3.2 Typical Installation

Generally, install the sensor as far as possible from the evaporation source (a minimum of 10" or 25.4cm) while still being in a position to accumulate thickness at a rate proportional to accumulation on the substrate. Figure 3.3 shows proper and improper methods of installing sensors.

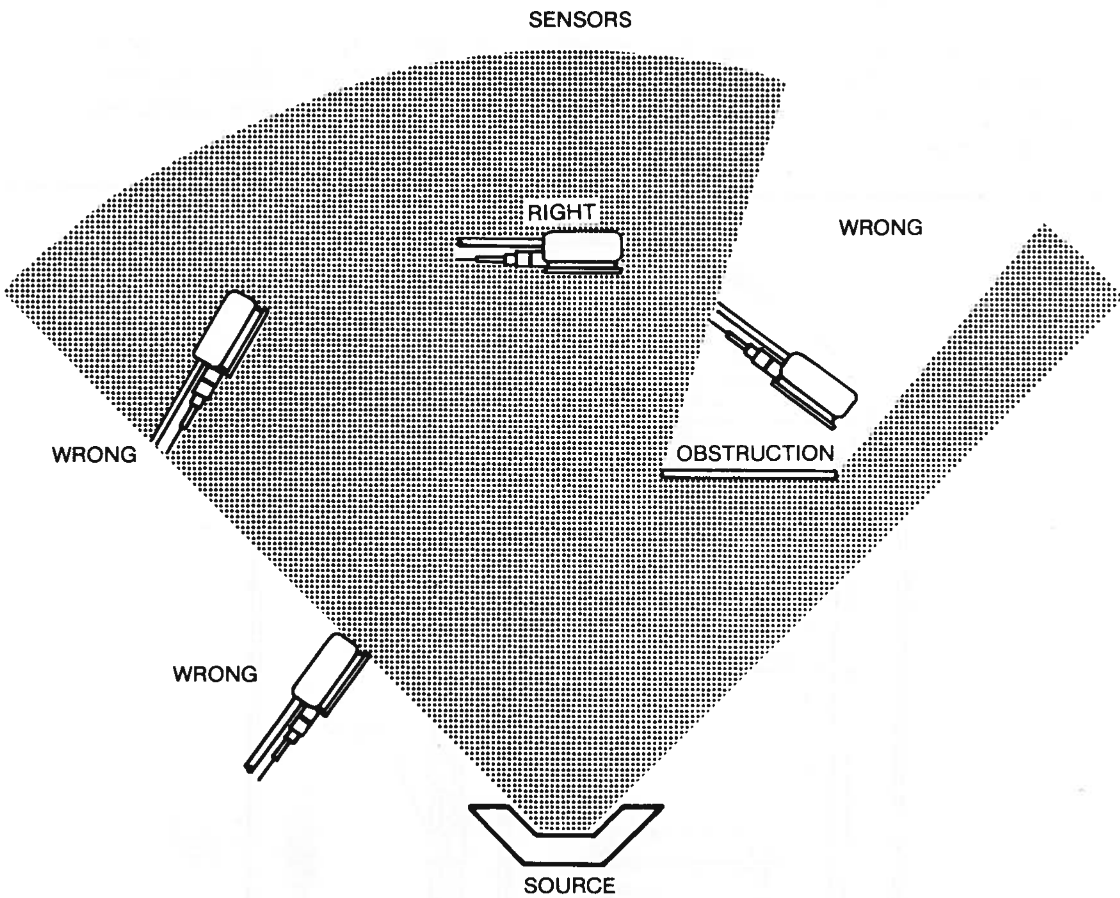


Figure 3.3 Sensor Installation Guidelines

To guard against spattering, use a source shutter to shield the sensor during the initial soak periods. If the crystal is hit with even a minute particle of molten material, it may be damaged and stop oscillating. Even in cases when it does not completely stop oscillating, it may become unstable.

Plan the installation to insure that there are no obstructions blocking a direct path between the sensor and the source.

Install sensors in such a manner that the center axis is aimed directly at the source to be monitored. Verify that the angle of the sensor location (with reference to the source) is well within the evaporant stream.

Assemble the sensor mounting bracket on the process system. With the bracket in place, temporarily position and attach the sensor head as outlined in the general guidelines above. Next, temporarily install the feedthrough. You may now form, measure, and mark the sensor lines (use a bending tool to form tubes in the system).

Build the Sensor/Feedthrough Assembly. Remove the sensor and the feedthrough, cut the water cooling tubes and air lines to the proper length and connect them directly to the feedthrough or use vacuum rated couplings. Allow an adequate length of water line from the feedthrough and sensor to prevent damage to the feedthrough or sensor during brazing (approximately 1 inch).

After cutting water and air lines, verify that they are cleared of metal particles by forcing compressed air through the tubing. Heliarc welding is recommended (torch brazing may also be acceptable) for connecting the sensor to the feedthrough water line.

Vacuum rated connectors such as Cajon are recommended for use between the sensor and the feedthrough to aid in maintenance. If brazing adapters are to be used, attach them to the sensor water-cooling lines prior to connection to the feedthrough. Make connections as follows:

1. Clean the water line and adapter surfaces with solvent if necessary.
2. Apply silver brazing flux to surfaces being joined.
3. Braze the connections using a flame temperature appropriate for the brazing material being used. Excessive heat or brazing material may result in blockage of the water line.
4. Verify that each joint is not blocked before installing the sensor and feedthrough into the process chamber.
5. Thoroughly clean the braze joint prior to installation.

NOTE: The sensor head, water line, cable, etc. should be clean and grease free when installed in the vacuum chamber. These parts should be handled while wearing clean nylon gloves. If parts do become contaminated, clean them thoroughly using a suitable solvent to avoid outgassing.

Pre-Installation Sensor Checkout

Before you install the sensor in the vacuum system, you should make sure it is in proper working condition by following the procedure outlined below:

1. Connect the sensor end of the oscillator cable to the sensor using either the feedthrough ordered or a coax adapter (Microdot™ BNC).

2. Plug the coaxial connector end of the oscillator cable to the receptacle marked OSC on the XTC rear panel.

3. Connect power to the XTC and set power switch to ON. Set density at 01.00gm/cc, and zero the thickness. The display should indicate 0 or +/- 0.001. Crystal life should read from 0 to 3%.

4. Breathe on the crystal and observe whether a thickness indication of 1.000 to 2.000kÅ appears on the display. When the moisture evaporates, the thickness indication should return to approximately zero.

If the above conditions are observed, you can assume the sensor is in proper working order and may be installed.

Installing the Compact* and Standard* Sensors

The Compact and Standard sensors may be installed in any appropriate location within the vacuum system. Two tapped holes are provided on the back of the sensor body for attaching to the system. The cable length from the sensor to the feedthrough is 30 inches (76.2cm). It is not recommended that this distance exceed 40 inches (101.6cm).

With all line connections installed, install the sensor and feedthrough assembly into the process system and secure all retaining hardware. Shield the coax cable from heat radiating from the evaporant source or the substrate heater. You can do this very simply, if your process allows, by wrapping aluminum foil around the cable and water lines. Connect the external water lines from the feedthrough to your water

* W/O shutter

supply system and flow controller. We recommend using a detachable coupler (Swagelok® or equivalent) for external water line connections. Apply water pressure and verify the water connections. For information on installing shutters refer to "Standard Shutter Installation, page 3-12.

Installing the Bakeable Sensor

The Bakeable sensor may be installed as described above, or with clamps on the lines running to the sensor. The cable length and air lines are not adjustable, and it is not necessary to shield the cables. However, we do suggest that you install a shield to prevent accumulation of material on the cam mechanism. If the water and coax lines require bending, maintain a minimum bending radius of 1/2" (1.3cm). Always use a bending tool or form to avoid kinking. Refer to Section 1 for other installation requirements, including maximum operating temperatures.

Installing the Sputtering Sensor

The Sputtering sensor can be installed in any position. It should be supported by more than the water-cooled tubes. Plan the installation and build the sensor/feedthrough assembly as described above. Avoid exposing the sensor cable to the glow discharge by wrapping the cable around the water-cooling tube and covering it with aluminum foil. Figures 3.4 and 3.5 show possible locations for the sensor in various sputtering systems.

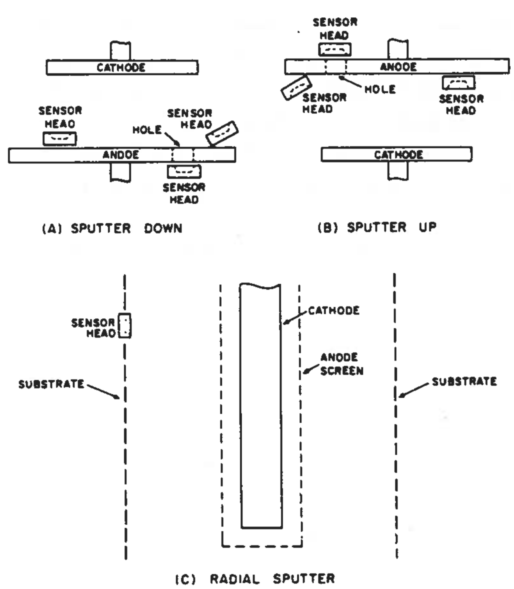


Figure 3.4 Suggested Sputtering Sensor Locations

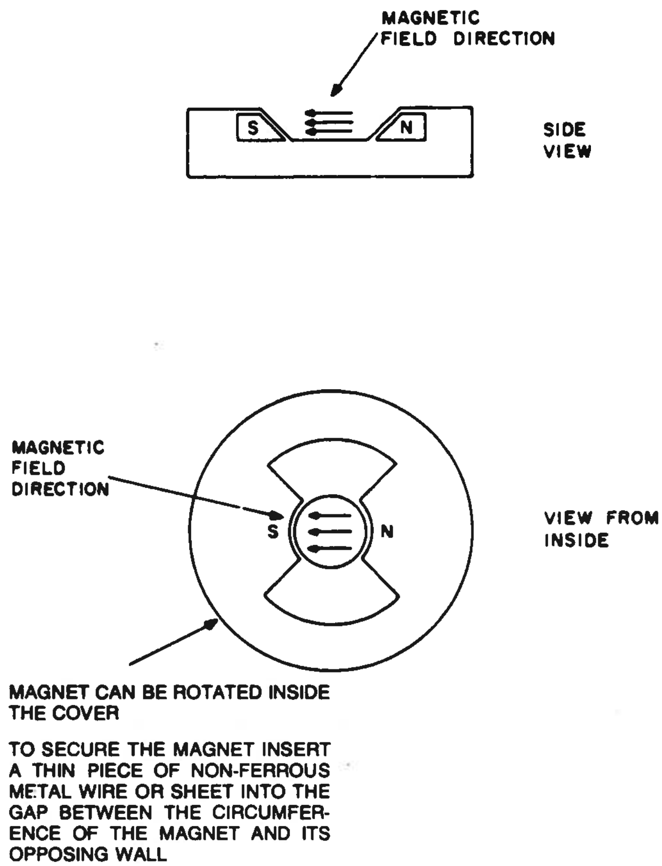


Figure 3.5 Sputtering Sensor Magnet Field Configuration

Because of geometric factors, variations in surface temperature, and differences in electrical potential, the crystal and substrates often do not receive the same amount of material. If you want the thickness indication on the unit to represent the thickness on the substrates, extra care in calibration is required to determine the tooling factor.

The following precautions must be observed when installing the Sputtering sensor:

- Use water-cooling during the sputtering process. Approximately 0.2 (750cc/min) gpm water flow should be sufficient for most applications. Always check the water flow before starting the glow discharge.

- In sputtering systems which use a substrate shutter, the sensor should be mounted in a location where it is always exposed to the glow discharge. If it is not, and the shutter is covering the sensor, there will be a small thickness jump when the shutter is opened, caused by thermal stress in the crystal.

• The sensor contains a permanent magnet. If the sensor is to be installed in a sputtering system which employs external magnetic fields, make sure the magnetic field direction of the sensor magnet is not opposing the external magnetic field. See Figure 3.5. The cancellation of the magnetic fields near the sensing crystal may cause undesirable heating of the crystal. Use a small magnet to determine the field direction and rotate the magnet in the sensor to a desirable position. The sensor magnet can be held in place by inserting a small piece of thin non-ferromagnetic wire or sheet into the gap between the circumference of the magnet and the opposing wall. The sensor's magnetic field is localized, and will not affect the external magnetic field to any extent.

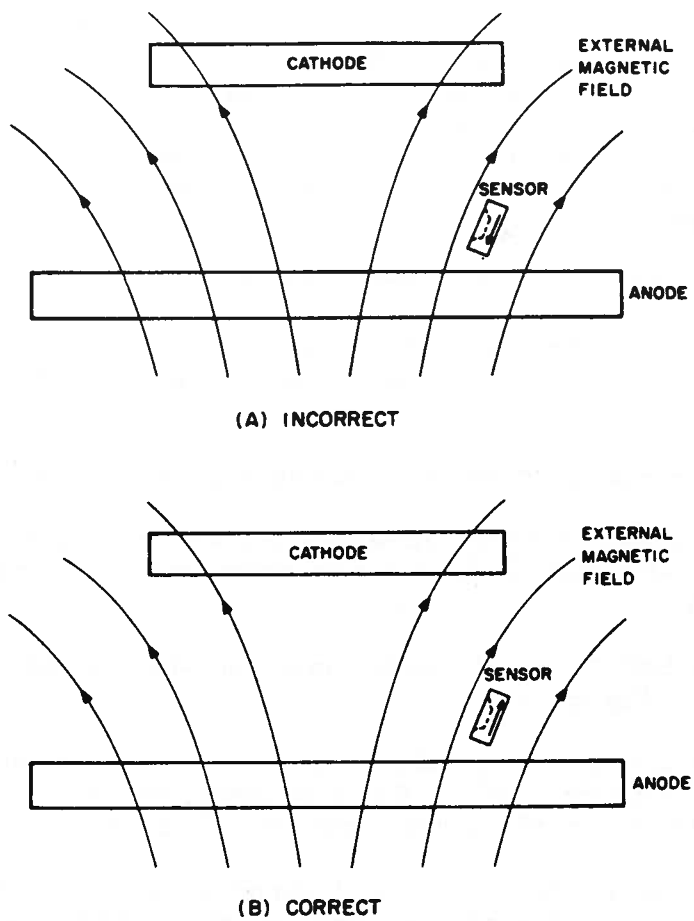


Figure 3.6 Sensor Magnetic Field Orientation

- The sensor is always at ground potential and cannot be made a floating ground. In sputtering systems where the substrate holder (anode) is biased, the sensor should be located where it is electrically isolated from the substrate holder and where it does not affect the electric field near the substrates.

- Be sure both the sensor and vacuum system are adequately grounded. See "Connecting the Grounding Strap", page 3-3.

Installing Sensor Shutters on Existing Equipment

Installation of Sensor shutters on existing equipment requires an optional Sensor Shutter Module installation kit. The kit includes necessary hardware, adapters, etc. to install the Sensor Shutter Module on either the Standard Crystal Sensor, the Compact Crystal Sensor, or the Sputtering Crystal Sensor assemblies. For testing purposes the Actuator Assembly is mounted to the Shutter Module Assembly at the factory. If the Shutter Module is to be mounted on a Standard Sensor, the Shutter Adapter Assembly must be detached from the Actuator Assembly (Figure 5.7b); installation onto a Compact Sensor does not require disassembly of the Shutter Module. Refer to Figure 3.7 for installation diagrams.

STANDARD SENSOR SHUTTER INSTALLATION

1. Disassemble the Shutter Module Assembly by removing the (2) screws attaching the Actuator Assembly to the Shutter Adapter Assembly.

2. Position the Standard Sensor Assembly as shown in Figure 3.7.

3. Place the Sensor Adapter Assembly on the back side of the sensor as shown, and install the (2) flat head screws as noted. Tighten the screws.

4. Insert the Bell Crank Assembly into the shutter Adapter Assembly as shown in Figure 3.7.

5. With the actuator in the relaxed position (zero pressure), align the assemblies allowing (.010"/.040") between the cam pin and the left edge of the slot in the piston coupling. Tighten the assembly.

6. Hold the sensor with the crystal opening facing upward and mount the Shutter Assembly on the Bell Crank Assembly shaft. Do not tighten the shutter assembly.

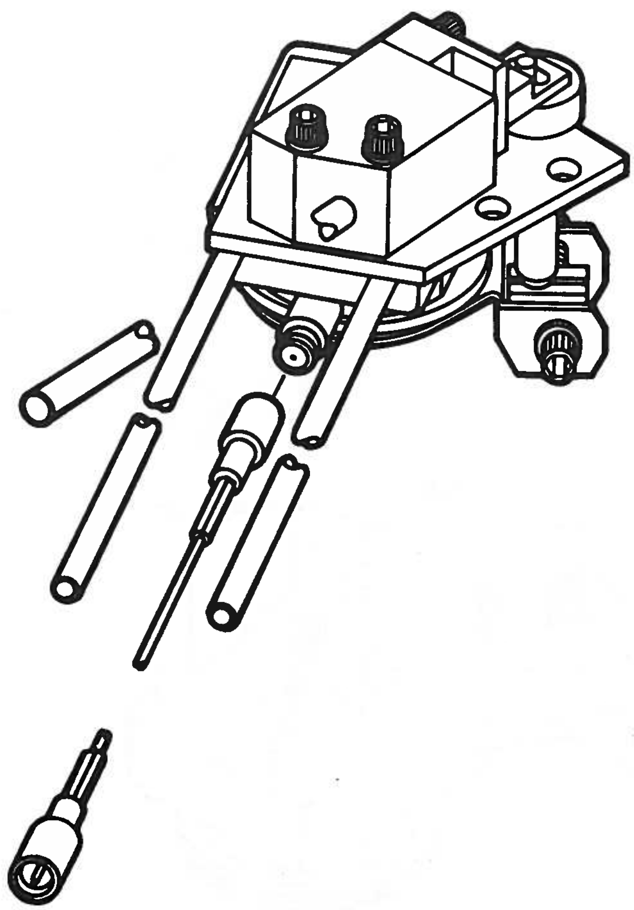


Figure 3.7 Standard Crystal Sensor with Shutter Assembly

Position the Shutter Assembly so that activation will rotate the shutter directly over the center of the crystal opening. Tighten the Shutter Assembly cap screw.

COMPACT SENSOR SHUTTER INSTALLATION

1. Position the Compact Crystal Sensor Assembly as shown in Figure 3.8.

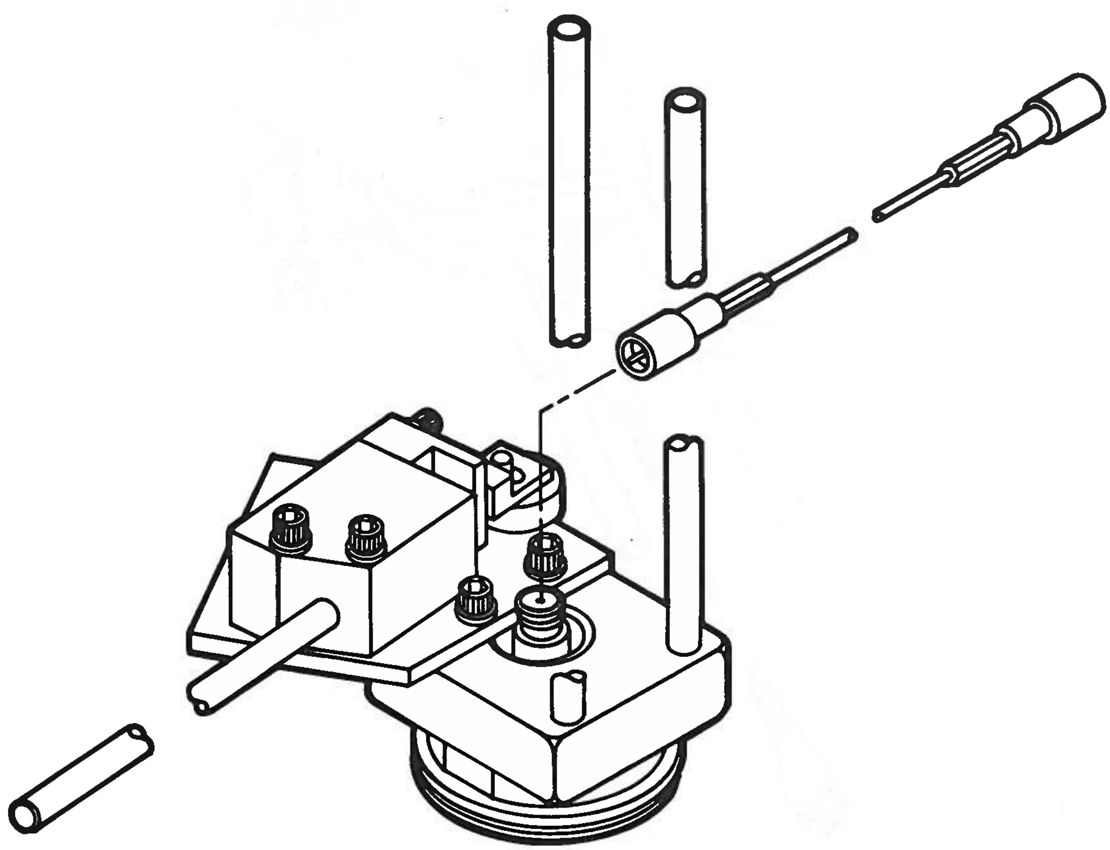


Figure 3.8 Compact Crystal Sensor with Shutter Assembly

2. Place the assembled Shutter Module Assembly on the back side of the sensor, and install the screws as noted in Figure 3.8. Tighten the screws.

3. Hold the sensor with the crystal opening facing upward and mount the Shutter Assembly on the Bell Crank Assembly shaft. Do not tighten the Shutter Assembly.

4. Position the Shutter Assembly so that activation will rotate the shutter directly over the center of the crystal opening. Tighten the Shutter Assembly cap screw.

SPUTTERIING SENSOR SHUTTER INSTALLATION

Detailed instructions for installing a Sensor Shutter Module on a Sputtering Sensor are included in the installation kit (IPN 750-005-G1)

SENSOR SHUTTER FUNCTION CHECK

Testing Procedures are similar for both applications. Temporarily connect an air supply (100 psi max.) to the actuator air line and test operation (10-25 cycles). Shutter movement should be smooth, rapid, and complete. When deactivated, the shutter should completely cover the crystal opening; when activated, the shutter should retract completely from the crystal opening. You may have to reposition the Shutter Assembly to achieve optimum on/off positioning. If operation is impaired, lubricate the moving parts with molybdenum disulfide or graphite. Should operation continue to be impaired, perform the Sensor Shutter Adjustment. Refer to "Sensor Shutter Actuator Alignment," Section 5. If the functional check was successful, make appropriate air line, water line, and coax cable connection using a suitable feedthrough assembly.

Installing the Pneumatic Shutter Actuator Control Valve (007-199)

Read and follow the guidelines for the specific sensor type you have. Additionally the Shutter Control Valve Assembly must be installed as described below. The shutter control valve assembly and the feed-through assembly should be installed at the same time. The same valve assembly is used for the 1" and the (recommended) 2 3/4" feed-throughs. However, if the assembly is to be used with the 2 3/4" feedthrough, you will need to modify the valve bracket as follows:

1. Align the slot in the valve assembly over the edge of a table or other square edge.

2. Using pliers, grasp the part of the bracket extending over the edge and push down. The assembly will break along the slot. Use a file to smooth any rough edges which may be formed along the break.

INSTALLATION WITH 1" BOLT

To install a Standard, Compact or Sputtering Sensor you may use the 1" Bolt feedthrough (IPN 750-030-G1). To use this feed through you must solder an adapter (IPN 007-133) to one of the tubes.

WARNING: **Do not exceed the maximum pressure rating of 100 psi. Connection to excessive pressure may result in personal injury and/or damage to the equipment.**

Now follow the steps below:

1. Insert 1" bolt
2. Add bracket
3. Add washer
4. Add nut
5. Tighten
6. Add the air fitting to the 3/16"tube which has the fitting adapter installed
7. Connect 1/8" teflon air line
8. Install air line to 80 psi source (MAX 100 psi)

INSTALLATION WITH 2 3/4" FEEDTHROUGH (IPN 002-080)

1. Install feedthrough
2. Add Valve bracket (modified) to desired location
3. Tighten feedthrough bolts
4. Install air fitting to air adapter
5. Connect 1/8" teflon air line
6. Install air line to 80 psi air source (MAX 100 psi)

NOTE: Maximum assembly temperature is 105°C for bakeout and operation.

PIN CONNECTIONS

To complete installation of the actuator assembly, make connections for 25 volts (AC or DC) using the diagram in Figure 3.9 below.

NOTE: Use pins D and B for DC; use pins A and C for AC.

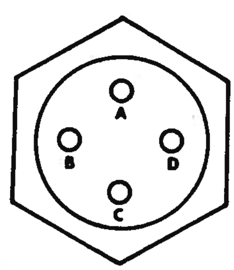


Figure 3.9 Shutter Actuator Connections

Section 4 of the XTC Manual provides instructions for determining several of the XTC program values, as well as for calibrating the analog output. It also contains a section on measurement theory for those interested in the evolution of quartz crystal monitors. The following topics are covered:

DETERMINING DENSITY

DETERMINING Z-RATIO

DETERMINING TOOLING

MEASUREMENT THEORY

Table of Bulk Densities and Z Values for Common Materials (Table 4-1)

Please refer to Section 5 for troubleshooting procedures.

DETERMINING DENSITY

NOTE: Bulk density values are sufficiently accurate for most applications (see Table 4.1).

Follow the steps below to determine density value:

1. Place a substrate (with proper masking for film thickness measurement) adjacent to the sensor, so that the same thickness will be accumulated on the crystal and this substrate.

2. Set density to the bulk value of the film material or to an approximate value.

3. Set Z-ratio to 1.000 and tooling to 100%.

4. Place a new crystal in the sensor and make a short deposition (1000-5000 Å), using the manual control.

5. After deposition, remove the test substrate and measure the film thickness with either a multiple beam interferometer or a stylus-type profilometer.

6. Determine new density value with the following equation:

$$\text{Density (g/cm}^3\text{)} = D_1 \frac{T_x}{T_M}$$

where D_1 = Initial density setting

T_x = Thickness reading on XTC

T_M = Measured thickness

7. A quick check of the calculated density may be made by programming the instrument with the new density value and observing that the displayed thickness is equal to the measured thickness, provided that the instrument has not been zeroed between the test deposition and the entering of calculated density.

NOTE: Slight adjustment of density may be necessary in order to achieve $T_x = T_M$.

DETERMINING Z-RATIO

A list of Z-values for materials commonly used is given in Table 4.1. For other materials, Z can be calculated from the following formula:

$$Z = (d_q \mu_q / d_f \mu_f)^{1/2}$$

$$= 8.84 \times 10^5 \, (d_f \mu_f)^{-1/2}$$

where

d_f = density (g/cm^3) of deposited film

μ_f = shear modulus ($dynes/cm^2$) of deposited film

d_q = density of quartz (crystalline) ($2.648 g/cm^3$)

μ_q = shear modulus of quartz (crystalline) (2.95×10^{11} $dynes/cm^2$)

(The densities and shear moduli of many materials can be found in a number of handbooks.) If the shear modulus of the film is not know, the shear wave velocity (V_f) can be substituted, since:

$$\mu_f = V_f^2 d_f$$

Laboratory results indicated that the Z-values of materials in thin-film form are very close to the bulk values. However, for high stress-producing materials, z-values of thin films are slightly smaller than those of the bulk materials. For applications that require more precise calibration, the following direct method is suggested:

1. Using the calibrated density and 100% tooling, make a deposition such that the percent crystal life display will read approximately 50%, or near the end of crystal life for the particular materials, whichever is smaller.

2. Place a new substrate next to the sensor and make a second, short deposition (1000-5000Å).

3. Determine the actual thickness on the substrate (as suggested in density calibration).

4. Adjust Z-ratio value in the XTC to bring thickness reading in agreement with actual thickness.

For multiple layer deposition (for example, two layers), the Z-value used for second layer is determined by the relative thickness of the two layers. For most applications the following three rules will provide reasonable accuracies:

If the thickness of layer 1 is large compared to layer 2, use material 1 Z-value for both layers.

If the thickness of layer 1 is thin compared to layer 2, use material 2 Z-value for both layers.

If the thickness of both layers is similar, use a value for Z-ratio which is the weighted average of the two Z values for deposition of layer 2 and subsequent layers.

DETERMINING TOOLING

1. Place a test substrate in the system's substrate holder.
2. Make a short deposition and determine actual thickness.
3. Calculate tooling from the relationship:

$$\text{Tooling } (\%) = TF_I \times \frac{T_M}{T_x}$$

where T_M = Actual thickness at substrate holder

T_x = Thickness reading in the XTC

TF_I = Initial tooling factor

4. Round off percent tooling to the nearest %.
5. When entering this new value for tooling into the program, T_M will equal T_x if calculations are done properly.

NOTE: When calibrating tooling, we recommend that you make a minimum of three separate runs. Variations in source distribution and other system factors will contribute to slight thickness variations from run to run. An average value tooling factor should be used for final calibrations.

MEASUREMENT THEORY

Commercial quartz-crystal film thickness monitors have evolved in three distinct stages: (1) frequency measurement technique, (2) period measurement technique, and (3) z-match technique.

Sauerbrey[1] used the quartz-crystal resonator to measure deposited film thickness which was later developed into a commercial unit. The thickness frequency used is given by:

$$T_f = (N_q d_q / d_f f_q^2)\ (f_q - f_c) \qquad (1)$$

where

T_f = film thickness (cm)

d_q = density of quartz ($2.60 g/cm^3$)

d_f = density of film (g/cm^3)

$N_q = f_q l_q$ = frequency constant for AT-cut quartz crystal ($1664 x 10^4 Hz/cm$)

l_q = thickness of quartz crystal (cm)

f_q = resonant frequency of unplated crystal ($6.050 x 10^6 Hz$)

f_c = resonant frequency of loaded crystal (Hz)

Experiments have shown that in order to keep the thickness measurement reasonably accurate, the maximum frequency shift allowable is limited to about 2% of f_q.

The period measurement technique was used by the second generation quartz-crystal thickness monitors, with the following equation used for thickness computation:

$$T_f = (N_q d_q / d_f)\ (t_c - t_q) \qquad (2)$$

In this equation, $t_c - 1/f_c$ and $t_q = 1/f_q$ are the periods of oscillation for the loaded and original crystals, respectively. For a small frequency shift, Eq (1) becomes a good approximation of Eq (2).

Although experiments demonstrated that Eq (2) is reasonably accurate for selected materials with frequency shifts of up to 10% of f_q, the theoretical justification of using Eq (2) for thickness computation has been lacking. Tests on the validity of Eq (2) indicate that significant errors begin to appear for a majority of materials with crystal frequency shift as small as 5% of f_q. When the quartz crystal monitor is used to measure the rate of deposition, the errors in indicated time become even more serious, because the thickness error is a time-varying function, and rate is the derivative of thickness with respect to time.

Advances in crystal design and improved driving circuitry allow the quartz crystal to keep oscillating even with very large amounts of deposited material on it. In many cases it is possible to achieve frequency shifts of more than 20% of f_q. Also, complex and precise mathematical calculations can be easily performed with modern microcomputers.

Miller and Bolef[2] were the first to treat the quartz-film composite as a one-dimensional compound acoustical resonator. Their results indicated that the elastic properties of the deposited film should be related to the frequency shift. A further study on their original solution resulted in a simpler thickness frequency equation in the form of

$$T_f = (N_q d_q / \pi d_f f_c Z) \tan^{-1}(Z \tan[\pi(f_q - f_c)/f_q]) \qquad (3)$$

where

$$Z = (d_q \mu_q / d_f \mu_f)^{\frac{1}{2}}$$

is the acoustic impedance ratio with μ_f and μ_q the shear moduli of deposited film and quartz crystal, respectively. Eq (3) shows that materials with different elastic properties will obey different thickness frequency relations. This phenomenon has been verified experimentally in our laboratory for a number of materials.[3] The experimental results demonstrated that if the density and Z-value of the deposited material are known, Eq (3) is remarkably accurate in determining film thickness.

Another significance of Eq (3) is that for the first time the validity of "period measurement" technique, or Eq (2), can be explained from a theoretical point of view. Through a simple algebraic exercise, one can easily show that Eq (2) is a special case of Eq (3) with Z = 1, or quartz-on-quartz.

The XTC incorporates an approximated form of Eq (3) for thickness computation. The acoustic impedance ratio Z can be entered into the instrument as a separate material constant. A reproducibility of better than 2% for both thickness and rate can thus be achieved over a full 1 MHz shift in crystal frequency and Z ratios up to 1.99.

[1]Sauerbrey, G.Z., Physik 155, 206 (1959).
[2]Miller, J.G. and Bolef, D.I., J applied Phys 39, 4589 and 5815 (1968).
[3]Lu, Chih-Shun, J. Vac. Sci. Technology 12, (1975).

TABLE 4.1 BULK DENSITIES AND Z-VALUES FOR COMMON MATERIALS

MATERIAL	SYMBOL	BULK DENSITY (g/cm^3)	Z-RATIO
ALUMINUM	Al	2.70	1.08
ALUMINUM OXIDE	Al_2O_3	3.97	0.336
ANTIMONY	Sb	6.62	0.768
ARSENIC	As	5.73	0.966
BARIUM	Ba	3.5	2.1
BERYLLIUM	Be	1.85	0.543
BISMUTH	Bi	9.8	0.79
BISMUTH OXIDE	Bi_2O_3	8.9	---
BORON	B	2.54	0.389
CADMIUM	Cd	8.64	0.682
CADMIUM SELENIDE	CdSe	5.81	---
CADMIUM SULFIDE	CdS	4.83	1.02
CADMIUM TELLURIDE	CdTe	5.85	0.98
CALCIUM	Ca	1.55	2.62
CALCIUM FLUORIDE	CaF_2	3.18	0.775
CARBON (DIAMOND)	C	3.52	0.22
CARBON (GRAPHITE)	C	2.25	3.26
CERIUM (III) FLUORIDE	CeF_3	6.16	---
CERIUM (IV) OXIDE	CeO_2	7.13	---
CHROMIUM	Cr	7.20	0.305
CHROMIUM (III) OXIDE	Cr_2O_3	5.21	---
COBALT	Co	8.71	0.343
COPPER	Cu	8.93	0.437
COPPER (I) SULFIDE (Alpha)	Cu_2S(Alpha)	5.6	0.69
COPPER (I) SULFIDE (Beta)	Cu_2S(Beta)	5.8	0.67
COPPER (II) SULFIDE	CuS	4.6	0.82
CRYOLITE	Na_3AlF_6	---	---
DYSPROSIUM	Dy	8.54	0.6
ERBIUM	Er	9.05	0.74
GADOLINIUM	Gd	7.89	0.67
GALLIUM	Ga	5.93	0.593
GALLIUM ARSENIDE	GaAs	5.31	1.59
GERMANIUM	Ge	5.35	0.516
GOLD	Au	19.3	0.381
HAFNIUM	Hf	13.09	0.36
HAFNIUM OXIDE	HfO_2	9.63	---
HOLNIUM	Ho	8.8	0.58
INDIUM	In	7.3	0.841
INDIUM ANTIMONIDE	InSb	5.76	0.769
INDIUM OXIDE	In_2O_3	7.18	---
IRIDIUM	Ir	22.4	0.129
IRON	Fe	7.86	0.349

MATERIAL	SYMBOL	BULK DENSITY (g/cm^3)	Z-RATIO
LANTHANUM	La	6.17	0.92
LANTHANUM FLUORIDE	LaF_3	5.94	---
LANTHANUM OXIDE	LaO_3	6.51	---
LEAD	Pb	11.3	1.13
LEAD SULFIDE	PbS	7.50	0.566
LITHIUM	Li	0.53	5.9
LITHIUM FLUORIDE	LiF	2.64	0.774
MAGNESIUM	Mg	1.74	1.61
MAGNESIUM FLUORIDE	MgF_2	3.18	0.637
MAGNESIUM OXIDE	MgO	3.58	0.411
MANGANESE	Mn	7.20	0.377
MANGANESE (II) SULFIDE	MnS	3.99	0.94
MERCURY	Hg	13.46	0.74
MOLYBDENUM	Mo	10.2	0.257
NEODYNIUM FLUORIDE	NdF_3	6.506	---
NEODYNIUM OXIDE	Nd_2O_3	7.24	---
NICKEL	Ni	8.91	0.331
NIOBIUM	Nb	8.57	0.493
NIOBIUM (V) OXIDE	Nb_2O_5	4.47	---
PALLADIUM	Pd	12.0	0.357
PLATINUM	Pt	21.4	0.245
POTASIUM CHLORIDE	KC_1	1.98	2.05
RHENIUM	Re	21.04	0.15
RHODIUM	Rh	12.41	0.21
RUBIDIUM	Rb	1.53	2.54
SAMARIUM	Sm	7.54	0.89
SCANDIUM	Sc	3.0	0.91
SELENIUM	Se	4.82	0.864
SILICON	Si	2.32	0.712
SILICON (II) OXIDE	SiO	2.13	0.87
SILICON DIOXIDE (Fused Quartz)	SiO_2	2.20	1.07
SILVER	Ag	10.5	0.529
SILVER BROMIDE	AgBr	6.47	1.18
SILVER CHLORIDE	AgCl	5.56	1.32
SODIUM	Na	0.97	4.8
SODIUM CHLORIDE	NaCl	2.17	1.57
SULFUR	S	2.07	2.29
TANTALUM	Ta	16.6	0.262
TANTALUM (IV) OXIDE	Ta_2O_5	8.2	0.30
TELLURIUM	Te	6.25	0.9
TERBIUM	Tb	8.27	0.66
THALLIUM	Tl	11.85	1.55
THORIUM (IV) FLUORIDE	ThF_4	6.32	---
TIN	Sn	7.30	0.724

MATERIAL	SYMBOL	BULK DENSITY (g/cm^3)	Z-RATIO
TITANIUM	Ti	4.50	0.628
TITANIUM (IV) OXIDE	TiO_2	4.26	0.40
TITANIUM OXIDE	TiO	4.9	N/A
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	1.13
YTTRIUM	Y	4.34	0.835
YTTRIUM OXIDE	Y_2O_3	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	0.60
ZIRCONIUM OXIDE	ZrO_2	5.6	---

Section 5 of the XTC Manual provides maintenance procedures for the Sensors, Shutter Actuators, and the XTC Instrument. The following topics are included:

- SENSORS
  - Troubleshooting Sensors
    - Standard, Compact, and Bakeable Sensor
    - Sputtering Sensor
  - Replacing the Crystal
    - Standard and Compact Sensors
    - Shuttered Sensors
    - Bakeable Sensor
    - Sputtering Sensor
  - Sensor Shutter Actuator Alignment
  - Improving Cooling for the Bakeable Sensor
- INSTRUMENT
  - XTC Error Conditions
  - LCD Display Contrast Adjustment
- PLUG-IN OPTIONS

WARNING: Potentially lethal voltages are present within the XTC when the line cord is connected. Certain control voltages may also be present at the I/O Relay Module connector. Disconnect the line cord when removing, installing, or servicing any component of the XTC instrument. Refer all maintenance to qualified personnel.

CAUTION: The XTC contains delicate circuitry which is susceptible to shock caused by electrical shorting. Disconnect the line cord when making any interface connections or performing any internal service on the XTC. Refer all maintenance to qualified personnel.

SENSORS

Sensors which may be used with the XTC include:

Standard (w/wo Shutter)
Compact (w/wo Shutter)
Bakeable
Sputtering

Troubleshooting Sensors

Troubleshooting Sensors is divided as shown above since different styles of sensors may experience different malfunctions.

STANDARD, COMPACT, AND BAKEABLE SENSORS

	SYMPTOM		CAUSE		REMEDY
1.	large jumps of thickness reading during deposition	a.	mode hopping due due to defective crystal	a.	replace crystal
		b.	crystal near the end of its life	b.	replace crystal
		c.	scratches or foreign parti-cles on the crystal holder seating surface	c.	clean or polish the crystal seating surface on the crystal holder
2.	crystal ceases to to oscillate during deposi-tion before it reaches its "normal" life	a.	crystal is being hit by small droplets of molten material from the evaporation source	a.	use a shutter to shield the sensor during initial period of evaporation; move the sensor further away

NOTE: **Crystal life is highly dependent on process conditions of rate, power radiated from source, location, material, and residual gas composition.**

	SYMPTOM		CAUSE		REMEDY
2.	(cont'd)	b.	defective crystal	b.	change crystal
		c.	built-up material on edge of crystal holder touching crystal	c.	clean the crystal holder
		d.	material on crystal holder partially masking full crystal area	d.	clean crystal holder
3.	crystal does not oscillate or oscillates intermittently (both in vacuum and in air)	a.	defective or damaged crystal	a.	replace crystal
		b.	existence of electrical short or poor electrical contacts	b.	check for electrical continuity and short in sensor cable, connector, contact springs, and the connecting wire inside the sensor; check for electrical continuity in feed-throughs
4.	crystal oscillates in vacuum but stops oscillation after open to air	a.	crystal was near the end of its life; opening to air causes film oxidation, which increases film stress	a.	replace crystal
		b.	excessive moisture accumulation on the crystal	b.	turn off cooling water to sensor before opening it to air

	SYMPTOM		CAUSE		REMEDY
5.	thermal instability: large changes in thickness reading during source warm-up (usually causes thickness reading to decrease) and after the termination of deposition (usually causes thickness reading to increase)	a.	crystal is not properly seated	a.	check and clean crystal seating surface of the crystal holder
		b.	excessive heat input to the crystal	b.	if heat is due to radiation from the evaporation source, move sensor further away from source and use sputtering crystals for better thermal stability; if the crystal heating is due to secondary electron beam source, change regular sensor to a sputtering sensor.
		c.	no cooling water	c.	check cooling water flow rate (Refer to specications Section 1, for the type of sensor used.)

	SYMPTOM		CAUSE		REMEDY
6.	poor thickness reproducibility	a.	erratic source emission characteristics	a.	move sensor to a different location; check the evaporation source for proper operating conditions; insure relatively constant pool height and avoid tunneling into the melt
		b.	material does not adhere to the crystal	b.	check the cleanliness of the crystal surface; evaporate a layer of proper material on the crystal to improve adhesion

SPUTTERING SENSOR ONLY

See preceding pages for other sensors.

	SYMPTOM		CAUSE		REMEDY
1.	large jumps of thickness readings during sputtering	a.	improper crystal seating	a.	check and clean the crystal seating surface
		b.	small pieces of material fell on the crystal (for crystal facing-up situation)	b.	check the crystal surface and blow it off with clean air

	SYMPTOM		CAUSE		REMEDY
1.	(cont'd)	c.	small pieces of magnetic material being attracted by the sensor magnet and contacting the crystal	c.	check the sensor opening hole and remove any foreign material
		d.	other	d.	see symptom(s) of standard sensor
2.	thickness reading jumps back and forth	a.	RF interference from the sputtering power supply	a.	check groundings; change location of instrument and oscillator; connect instrument to different power line
3.	large drift of thickness reading (greater than 200 Å for density reading = 5.00 gm/cc) after termination of sputtering	a.	crystal heating due to poor thermal contact	a.	check and clean the crystal seating surface
		b.	external magnetic field interferes with the sensor magnetic field	b.	rotate the sensor magnet to a proper orientation with respect to the external magnetic field
		c.	sensor magnet defective	c.	check sensor magnet field strength; if a gaussmeter is available, the maximum field at the center of the opening hole should give a reading of 700 gauss or greater

Replacing the Crystal

STANDARD AND COMPACT SENSORS

The procedure for replacing the crystal is basically the same with either the standard, compact, or bakeable sensor. (Refer to page 5-12 for replacement of sputtering sensor.) Before you begin, please observe the following precautions:

CAUTIONS: **Always use clean nylon lab gloves and plastic tweezers for handling the crystal (to avoid contamination which may lead to poor adhesion of the film to the electrode).**

Do not rotate the ceramic retainer assembly after it is seated (as this will scratch the crystal electrode and cause poor contact).

Do not use excessive force when handling the ceramic retainer assembly since breakage may occur.

NOTES: **Certain materials, especially dielectrics, may not adhere strongly to the crystal surface and may cause erratic readings.**

Thick deposits of some materials, such as SiO, Si, and Ni will normally peel off the crystal when it is exposed to air, as a result of changes in film stress caused by gas absorption. When you observe peeling, change the crystals.

Follow the procedure below to replace the crystal in the Standard and Compact sensor:

1. Gripping the crystal holder with your fingers, pull it straight out of the sensor body.

2. Gently pry the crystal retainer from the holder (or use crystal snatcher; see Figure 5.4).

3. Turn the retainer over and the crystal will drop out.

4. Install a new crystal, with the patterned electrode face up.

5. Push the retainer back into the holder and replace the holder in the sensor body.

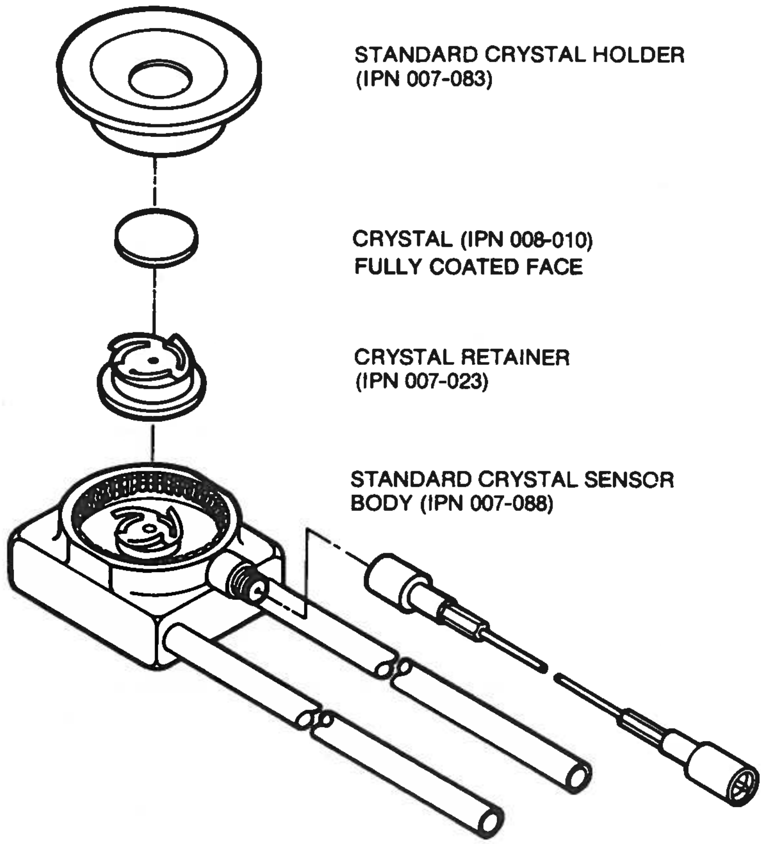


Figure 5.1 Standard Crystal Sensor (Exploded)

SHUTTERED SENSORS

There is no difference in the crystal changing procedure between shuttered and non-shuttered Standard and Compact sensors, since the shutter pivots away from the crystal opening in the relaxed state.

BAKEABLE SENSOR

For the Bakeable sensor, the procedure is the same as the regular crystal except that you must first unlock the cam assembly by flipping it up. Once the crystal has been replaced, place a flat edge of the holder flush with the cam mechanism and lock it in place with the cam (Figure 5.2).

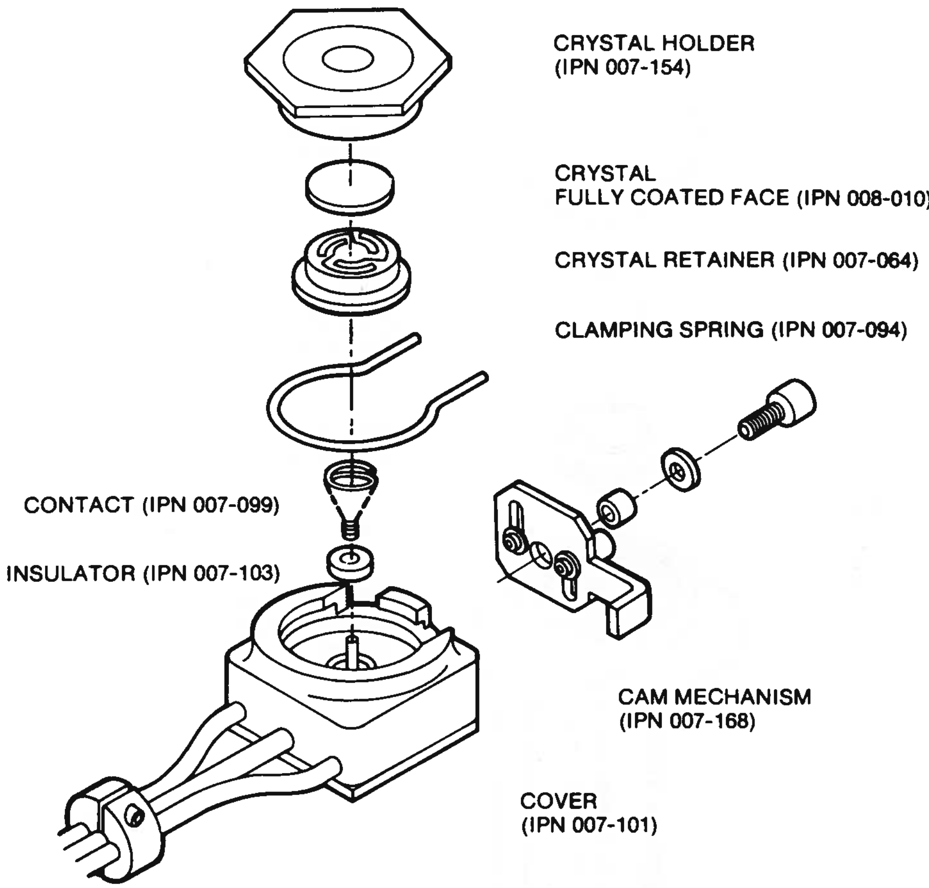


Figure 5.2 Bakeable Crystal Sensor (Exploded)

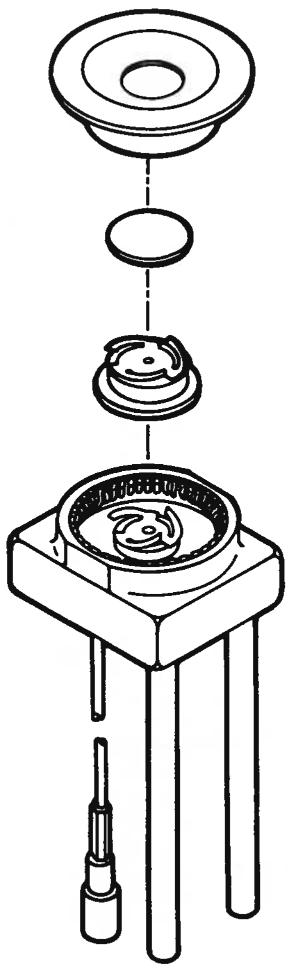


Figure 5.3 Compact Crystal Sensor (Exploded)

To use the crystal snatcher supplied with the sensor follow the instructions below:

1. Insert crystal snatcher into ceramic retainer (1) and apply a small amount of pressure. This locks the retainer to the snatcher and allows the retainer to be pulled straight out (2).

2. Re-insert the retainer into the holder after the crystal has been changed.

3. Release the crystal snatcher with a slight side-to-side motion.

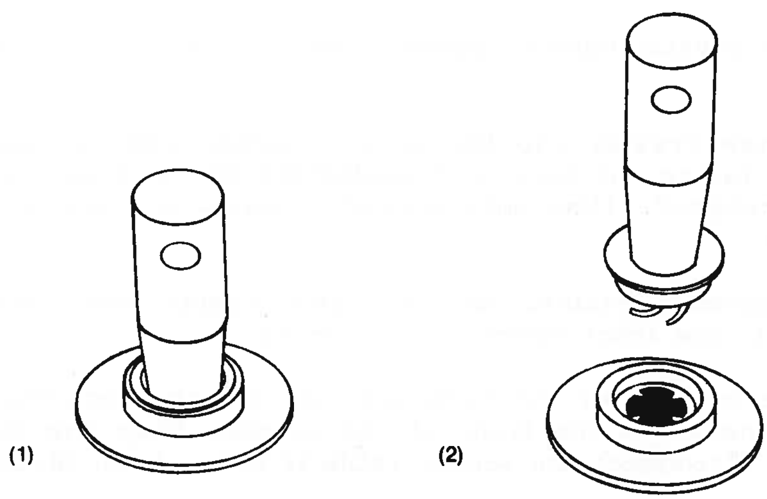


Figure 5.4 Replacing the Sputtering Crystal

SPUTTERING SENSOR

Observe the general precautions (p. 5-7) for replacing crystals and follow the instructions below to replace the crystal in a sputtering sensor.

1. Grip the back part of the sensor with your fingers and pull it straight out to separate it from the water-cooled front part. (You may have to disconnect the sensor cable in order to separate the parts.)

2. Pull the crystal holder straight out from the back of the sensor.

3. Remove the ceramic retainer from the crystal holder by pulling it straight out with the crystal snatcher (see Figure 5.4.).

4. Turn the crystal holder upside down so that the crystal drops out.

5. Drop a new crystal into the crystal holder with the patterned electrode facing the back and contacting the leaf springs on the ceramic retainer. (Use only special crystals for sputtering, IPN 008-009.)

6. Put the ceramic retainer back into the crystal holder and put the holder into the front cover of the sensor.

7. Align the position of the back part so that the connector matches with the notch on the front of the sensor. Snap the two parts together. Reconnect the sensor cable if it has been disconnected.

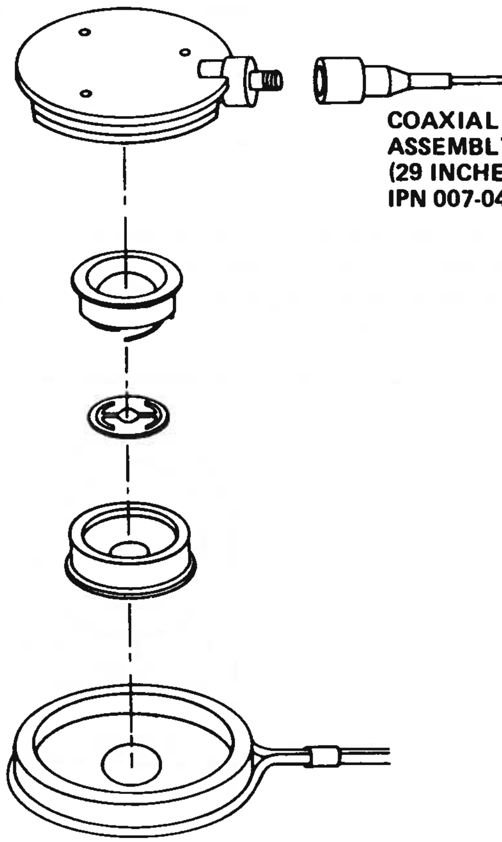


Figure 5.6 Sputtering Crystal Sensor (Exploded View)

Improving Cooling for the Bakeable Sensor

Because of temperature requirements, the bakeable sensor is made entirely of stainless steel. This fact poses a difficult problem from the design standpoint of thermal transfer. After trying several concepts, our laboratory found that the clamping action of the spring and cam mechanism provided better transfer of heat then other methods, because it allows continuous contact pressure throughout the temperature cycles encountered. However, for some applications where the materials are evaporated at high rate and/or high temperatures, thermal transfer may still be insufficient for ideal operation of the quartz crystal.

To improve the thermal transfer between the crystal holder and the watercooled body of the bakeable sensor, you can fabricate a thin washer of easily deformable metal to insert between the holder and the body. Once fabricated, this washer will last indefinitely, and can provide a 50% improvement in thermal transfer between the two parts, by increasing the surface contact over the non-deformable stainless steel.

Both gold and aluminum have been used successfully in this way, but since aluminum foil is nearly perfect in thickness, it should be the first choice. (Gold works only slightly better.) The illustration is a guide to the fabrication of the washer.

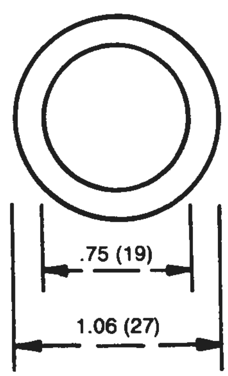


Figure 5.7 Washer Fabrication Guide

INSTRUMENT

This section describes Instrument Error Messages, Test Point Waveforms, LCD Contrast Adjustment, and Plug-in Options.

XTC Error Messages

- MESSAGE (ERR) appears in the top left display along with a possible number in the top right hand display area for the following conditions:

- Err (Illegal entry data)

ENTRY ERROR - You have attempted to enter parameter data that is illegal. The illegal data will be displayed and must be cleared via the clear key to continue any operations.

- Err (1)

  PROGRAM LOSS - The stored program parameters have not been retained during the power off time and have been reprogrammed to a default set of values. A battery failure may also cause this condition. The unit will be in the stop phase if this condition occurs and pressing the start key will clear the ERROR 1 message and allow operations to continue.

- Err (2)*

  ROM FAILURE - The instrument self check system has detected an operating system ROM failure. The instrument will be in stop phase and the instrument must be turned off to clear the error condition.

- Err (3)*

  RAM FAILURE - The instrument self check system has detected an operating system RAM failure. The instrument will be in stop phase and must be turned off to clear the error condition.

- Err (4)*

  STACK GUARD - The instrument self check system has detected an operation system execution error. The instrument will be in stop phase and power must be turned off to clear the error condition.

  *If these problems happen more than once, there has been a hardware failure that must be corrected.

LCD Display Contrast Adjustment

The XTC LCD may be adjusted by the user for differing viewing angles. An LCD may appear to contain the correct display from a front center vantage point but, when viewed from an angle (left, right, top or bottom) segments may appear or disappear indiscriminately.

To correct the LCD for the best possible contrast, position the instrument as it is to be used and observe the display. Locate the front panel Contrast adjustment (see Figure 2.1). Using a small common screwdriver, turn the pot clockwise or counterclockwise as required to obtain the best possible display contrast.

■ PLUG-IN OPTIONS

There are two plug-in option modules available for the XTC. These options are the IEEE-488 Computer Interface and the I/O Relay Module. Either module may occupy the lower portion of the XTC. The IEEE-488 Computer Interface enables external computer control of the XTC instrument; the I/O Relay Module provides (8) input and (8) lines for system control capability.

Installation of either module requires removing the instrument lower rear panel, inserting the module, and fastening (2) retaining screws. Prior to installing an option module please read "Replacement/Warnings and Cautions" below. For additional information on the option modules refer to Section 7, Options.

WARNING:	**Potentially lethal voltages are present within the XTC when the line cord is connected. Certain control voltages may also be present at the I/O Relay Module connector. Disconnect the line cord when removing, installing, or servicing any component of the XTC instrument.**
CAUTION:	**The XTC contains delicate circuitry which is susceptible to shock caused by electrical shorting. Disconnect the line cord when making any interface connections or performing any internal service on the XTC.**

Sensor Shutter Module Installation Instructions

(Reference DWG 750-001 Xtal Sensor to Shutter Module pg. 5-21)

The Sensor Shutter Module Installation kit was designed for mounting the sensor shutter on either the Standard Crystal Sensor Assembly or the Compact Crystal Sensor Assembly, and includes the following parts:

Item #	Qty.	Description	IPN
1	(1)	Actuator Assembly	007-174
2	(1)	Shutter Assembly	007-084
3	(2)	PH Flat HD SS Screw (#4-40 x .25 Lg)	084-048
4	(2)	Soc Hd Cap Screw SS (#4-40 x .62 Lg)	007-228
5	(2)	Soc Hd Cap Screw SS (#4-40 x .25 Lg)	007-128
6	(6)	Split SS Lockwasher	070-201
7	(1)	Shutter Adapter Assembly	750-002-G1
8	(1)	Piston Support Assembly	750-121-G2
9	(1)	Shaft Assembly	750-120-G1
10	(2)	Soc Hd Cap Screw SS (#4-40 x .38 Lg)	084-032
11	(2)	Spacer, Stn Stl B4-4	070-441

074-061/071387

NOTE: The following parts are listed as suggested equipment and may be ordered separately.

(1)	1" Crystal Feedthrough with airline (or equivalent) (see Figure 8-16)	750-030-G1
(1)	2-3/4" Dual Coaxial Instrumentation Feedthrough	002-080-**

**(Copper Gasket - G1, Viton Gasket - G2)

INSTALLATION

Prior to installation familiarize yourself with DWG 750-001, pg. 5-21; and DWG 750-020, pg. 6-20, to obtain an idea of how the parts are assembled. For testing purposes, both the Piston Support Assembly and the Shutter Adapter Assembly are mounted to the Actuator Assembly at the factory. If the Shutter Module is to be mounted on a Standard Sensor, detach the Shutter Adapter Assembly from the Actuator Assembly. Installation onto a Compact Sensor does not require disassembly of the Shutter Module.

Compact Sensor Installation:

1. Position the Compact Crystal Sensor Assembly as shown in DWG 750-001.

2. Place the Shutter Module Assembly on the back side of the sensor, and fasten the screws as noted in DWG 750-001.

3. Position the sensor with the crystal opening facing upward and mount the Shutter Assembly on the end of Shaft Assembly. Do not tighten the Shutter Assembly.

4. Since the shaft rotation is counterclockwise when activated, position the Shutter Assembly so that activation will rotate the shutter directly over the center of the crystal opening. Tighten the Shutter Assembly set screw.

Standard Sensor Installation:

1. Disassemble the Shutter Module Assembly by removing the (2) screws attaching the Actuator Assembly to the Shutter Adapter Assembly.

2. Position the Standard Sensor Assembly as shown in DWG 750-001.

3. Place the Sensor Adapter Assembly on the back side of the sensor as shown, and install the (2) flat head screws as noted. Tighten the screws.

4. Apply lubrication to shaft hole in Shutter Adapter Assembly as indicated on DWG 750-001. .

5. Insert the Shaft Assembly into the Shutter Adapter Assembly as show in DWG 750-001.

6. Position roll pin that protrudes from Piston Support Assembly, into .086 diameter hole on Shutter Adapter Assembly.

7. Rotate Actuator Assembly until the long side of the .062 diameter pin of Shaft Assembly engages the noncountersunk side of hole in Piston Support assembly. Secure Actuator Assembly to Shutter Adapter Assembly utilizing (2) #4-40 x .62 long screws.

8. Position the sensor with the crystal opening facing upward and mount the Shutter Assembly on the end of the Shaft Assembly. Do not tighten the Shutter Assembly.

9. Since the shaft rotation is counterclockwise when activated, position the Shutter Assembly so that activation will rotate the shutter directly over the center of the crystal opening. Tighten the Shutter Assembly cap screw.

TESTING PROCEDURE

Testing procedures are similar for both applications:

Temporarily connect an air supply (80 psi. max.) to the actuator air line and test operation (10-25 cycles). Shutter movement should be smooth, rapid and complete. When activated, the shutter should retract completely from the crystal opening; when deactivated, the shutter should retract completely over the crystal opening. You may have to reposition the shutter assembly to achieve optimum on/off positioning. If operation is impaired, verify that molybednum disulfide or graphite has been applied to the specified locations. If verification was successful, make appropriate air line, water line, and coax cable connection using one of the suggested Feedthrough Assemblies mentioned previously.

MAINTENANCE

Sensor assembly should be dismantled and lubricated approximately every 2000 strokes at areas indicated by a ▲. Failure to lubricate may significantly reduce life of operation or cause assembly to become totally inoperative.

Sputtering Sensor Shutter Module Installation Instructions

(Reference DWG 750-005, pg. 5-26)

INTRODUCTION

The Sputtering Sensor Shutter Module installation kit was designed to facilitate the mounting of a pneumatic shutter module onto a sputtering sensor. The pneumatic shutter module is assembled and tested prior to shipment.

To install the pneumatic shutter module, you must have the following parts:

Qty.	Description	IPN
(1)	Pneumatic Shutter Assy.	750-005-G1
(1)	Sputtering Sensor Assy.	007-031

NOTE: **The following parts are listed as suggested equipment and may be ordered separately.**

---

(1)	1" Crystal Feedthrough With Airline (or equivalent)	750-030-G1
	(OR)	
(1)	2-3/4" Dual Coaxial Instrumentation Feedthrough Copper Gasket	002-080-G1
(1)	Shutter Control Valve Assy.	007-199

INSTALLATION

Before you being the installation, refer to the illustrations to get an idea of how the parts are assembled. The shutter assembly may be installed onto a new Sputtering sensor or a used sensor in good condition.

1. Remove the actuator cover screw (4-40 x 3/16) on the shutter assembly and remove the actuator cover. (Reference Figure 1.)

2. Remove two water line clamp screws (4-40 x 1/4) (not shown) and remove the clamp. (Reference Figure 1.)

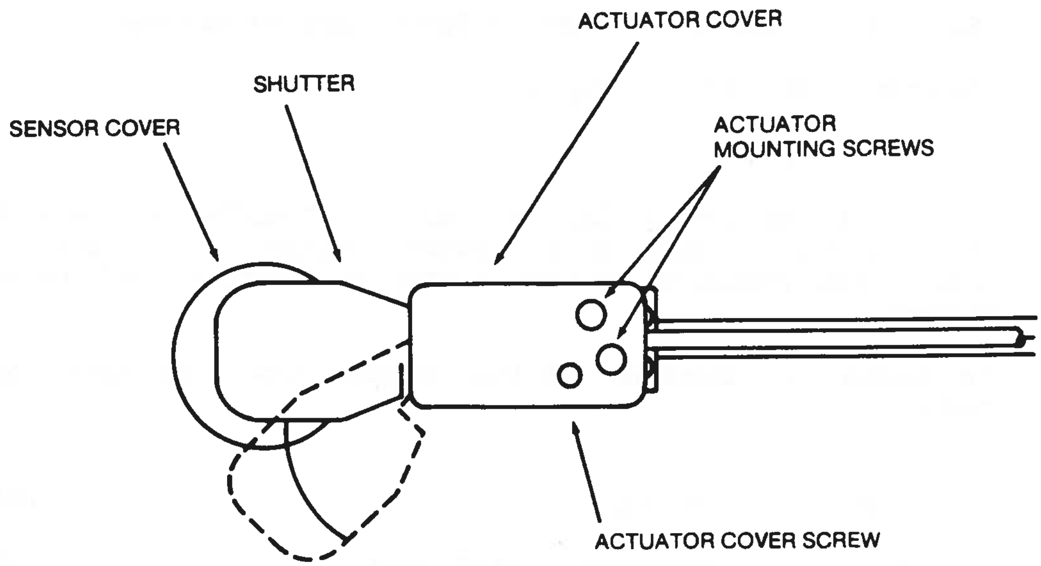


Figure 1 - Top View

3. **Remove the sensor body assembly from the sensor cover and set it in a clean safe place. This is to protect the head during the installation. (Reference Figure 2.)**

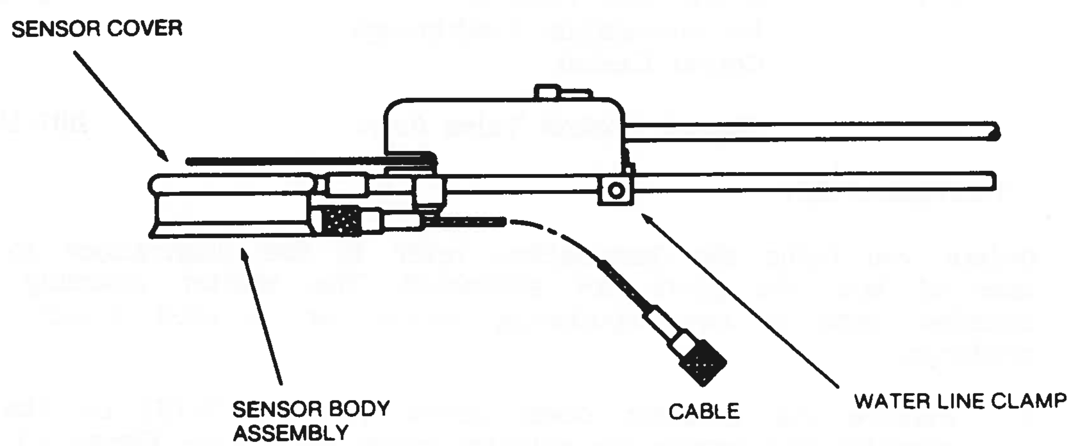


Figure 2 - Side View

4. Place the sensor cover on the shutter module assembly as shown in Figure 3. The sensor water lines will fit between the shutter pivot and stop screw. Carefully bend the water lines as shown.

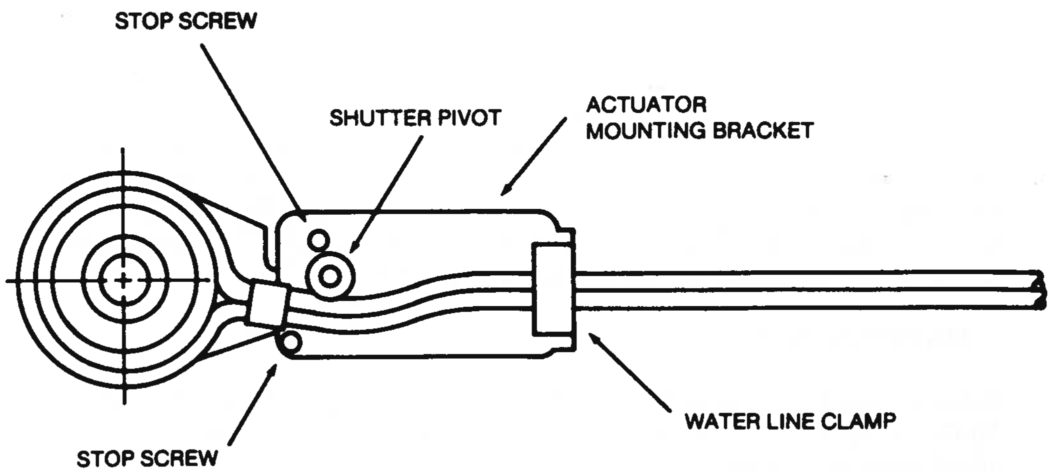


Figure 3 - Bottom View

5. Position the water line clamp on the shutter assembly and install the two mounting screws. Tighten the screws finger tight.

6. Position the assembly as shown in Figure 1. The shutter should cover the sensor cover as shown in Figure 1. It may be necessary to align the sensor slightly to achieve correct positioning.

7. The plane of the shutter and sensor cover should be parallel as shown in Figure 2. Again, it may be necessary too align the sensor slightly to achieve correct positioning.

8. Tighten the two water line clamp screws.

9. Manually rotate the shutter away from the sensor cover as shown in Figure 1; operation should be smooth and unobstructed.

10. Install the actuator cover on the shutter actuator assembly and install the actuator cover screw (4-40 x 3/16). (Reference Figure 1.)

11. Install the sensor body assembly into the sensor cover. The assembly will now appear as Figure 2.

TEST

NOTE: Test procedures apply to shutter operation only.

To perform the test, connect a temporary air supply (100 psi max.) to the actuator air line and test operation (10-25 cycles). Shutter movement should be smooth, rapid, and complete when operated at 60-80 psi. When activated, the shutter should rotate away from the crystal opening. When deactivated, the shutter should retract completely over the crystal opening. If operation is impaired, lubricate the moving parts with molybdenum disulfide or graphite.

MAINTENANCE

Sensor module should be dismantled and lubricated approximately every 2000 strokes at area indicated by a ▲ . Failure to lubricate may significantly reduce life of operation or cause assembly to become totally inoperative.

Shuttered Bakeable Sensor Instructions

The Shuttered Bakeable Sensor Assembly installation kit was designed to facilitate simple installation of the sensor into your system. the pneumatic shutter module is assembled and tested prior to shipment.

To install the Shuttered Bakeable Sensor you must have the following parts:

Qty.	Description	IPN
(1)	Shuttered Bakeable Sensor With Feedthrough ** G1 12", G2 20", G3 30", & G4 Special Length	750-029-**

NOTE: **The following parts are listed as suggested equipment and may be ordered separately.**

Qty.	Description	IPN
(1)	Pneumatic Shutter Actuator Control Valve	007-199

TEST

This test covers shutter operation only and should be performed prior to installation of the Shuttered Bakeable Sensor.

WARNING: **Do not exceed the maximum pressure rating of 100 psi. Connection to excessive pressure may result in personal injury and/or damage to the equipment.**

CAUTION: **If the water or coax lines require bending, we suggest a minimum bending radius of ½". Always use a bending tool or form to avoid kinking.**

To perform the test, connect a temporary air supply (100 psi max.) to the actuator air line and test operation (10-25 cycles). Shutter movement should be smooth, rapid, and complete when operated at 60-80 psi. When activated, the shutter should rotate away from the crystal opening. When deactivated, the shutter should retract completely over the crystal opening. if operation is impaired, lubricate the moving parts with molybdenum disulfide or graphite.

INSTRUCTIONS

1. Mount piston support assembly in bore of actuator weld assembly utilizing two (2) #4-40 x .38 long screws.

2. Place the Actuator Support on the back side of the sensor as shown, and install the (4) flat head screws and tighten.

3. Apply lubrication (graphite or molybdenum disulfide) to shaft 'hole in actuator support as indicated on DWG 750-029.

4. Insert the shaft assembly into the actuator support as shown in DWG 750-029.

5. Position roll pin that protrudes from piston support assembly into .086 diameter hole on actuator support as shown on DWG 750-029.

6. Rotate actuator weld assembly until the long side of the .062 diameter pin of Shaft assembly engages the noncountersunk side of hole in piston support assembly. Secure actuator weld assembly to actuator support utilizing (2) #4-40 x .62 long screws.

7. Position the sensor with the crystal opening facing upward and mount the shutter assembly on the end of the shaft assembly. Do not tighten the shutter assembly.

8. Since the shaft rotation is counterclockwise when activated, position the shutter assembly so that activation will rotate the shutter directly over the center of the crystal opening. Tighten the shutter assembly cap screws.

MAINTENANCE

Sensor assembly should be dismantled and lubricated approximately every 2000 strokes at areas indicated by an ▲ . Failure to lubricate may significantly reduce operation or cause assembly to be inoperative.

INSTALLATION

The assembly is shipped fully assembled and is installed in the same manner as a ConFlat Flange. Use standard installation procedures for installing the flange (always use a new gasket when making connections).

Water and electrical connections are performed outside of the system after sensor installation.

The recommended pneumatic connection requires the installation of the Pneumatic Shutter Actuator Control Valve IPN 007-199. To install the valve on the Shuttered Bakeable Sensor you must modify the valve bracket as follows:

WARNING: Do not exceed the maximum pressure rating of 100 psi. Connection to excessive pressure may result in personal injury and/or damage to the equipment.

1. Align the slot in the valve assembly bracket over the edge of a table or other square edge. (Reference DWG 750-029)

2. Using pliers, grasp the part of the bracket extending over the edge and push down. The assembly will break along the slot. use a file to smooth any rough edges which may be formed along the break.

3. Install the feedthrough.

4. Install the modified valve bracket on the feedthrough flange at the desired position.

5. Tighten the feedthrough bolts.

6. Install air fitting to air adapter.

7. Connect 1/8" Teflon air line.

8. Install air line to air source.

NOTE: **Maximum operation temperature is 105°C, maximum bakeout temperature is 400°C.**

9. Pin connections must be made for the actuator. Operating voltage is 25 volts (AC or DC). Use pins D and B for DC; use pins A and C for AC.

10. Make appropriate water line connections and sensor cable connection.

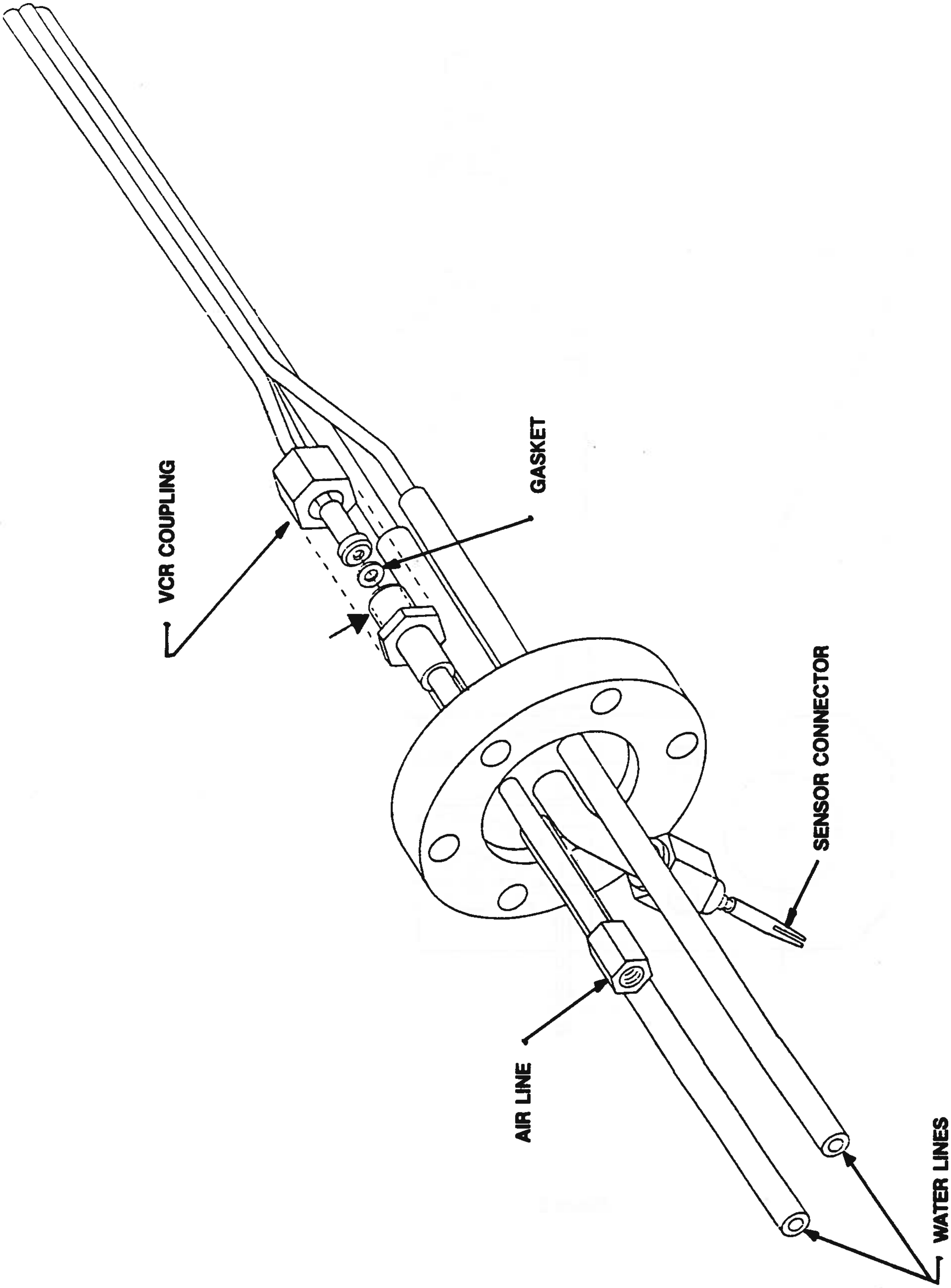


Figure 1

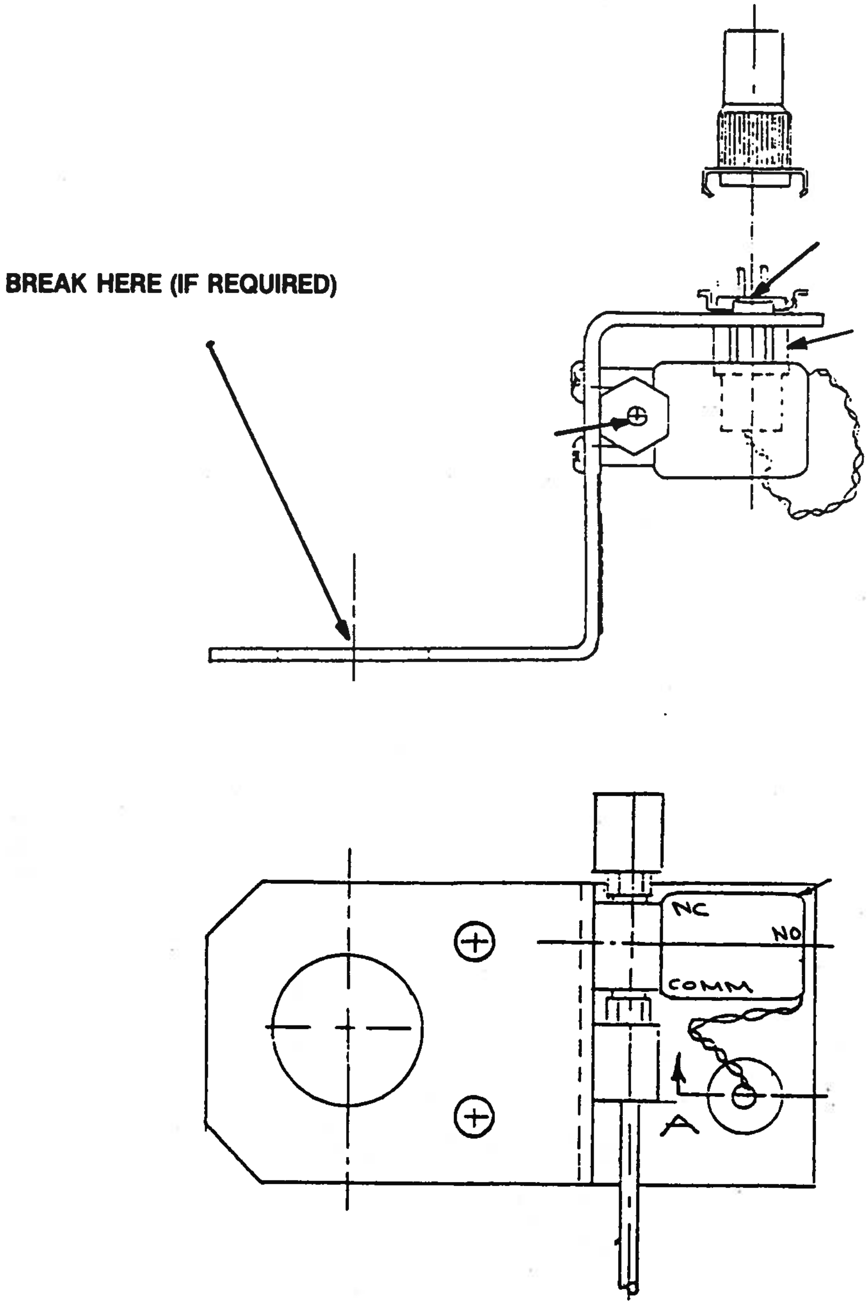


Figure 2

Section 6 of the XTC manual includes schematic drawings for all Printed Circuit Boards (PCB) with a supporting theory description. Pictoral representations of the various styles of sensors and feedthrough assemblies available are also included in this section. Refer to the listing below for the location of information within this section:

FRONT PANEL PCB DESCRIPTION

XTC MEASUREMENT CONTROL PCB DESCRIPTION (w/wo RS-232C)

IEEE-488 OPTION MODULE DESCRIPTION

I/O RELAY OPTION MODULE DESCRIPTION

SENSOR OUTLINE DRAWINGS

FEEDTHROUGH OUTLINE DRAWINGS

FEEDTHROUGH DIMENSIONAL DRAWINGS

FRONT PANEL PCB DESCRIPTION

The front panel PC board contains the LCD display and the display driver chips Z1 and Z2. These parts provide the multiplexed segment and backplane scanning information to the LCD. The chips communicate with the main PC board through interface connector P3/J3. R7 determines the operating clock frequency of approximately 100 Khz. Both parts are initialized on a power turn-on condition by the DSPRST line. LED CR1 indicates when XTC power is turned on and is driven by the 5 volt vcc supply. Display contrast control is provided thru contrast adjustment R2. Temperature stabalization for the LCD contrast Via R3. An electroluminessant panel is also provided to backlight the LCD under low ambient light conditions. The panel power is powered by PS-1 and is enabled via the keyboard. The keyboard is arranged in a 3 by 5 matrix and is scanned and debounced by a controller on the main PC board.

■ XTC MEASUREMENT CONTROL PCB (w/wo RS-232 Capability)

■ Power Supply

The Power Supply used in the XTC utilizes a pulse width modulated switching regulator to generate the +5 volt logic supply. Plus and minus 12 volts is also generated for the analog circuitry. A regulated 20 volts DC is provided by line transformer T1, bridge rectifier CR4, and filter capacitor C24. This DC voltage is regulated to +5 volts by PWM Z20, switching transistor Q1, and switching transformer T2. The PWM operates at approximately 50 KHz. Short circuit protection is provided by sensing the current within safe limits. Two secondary windings on the switching transformer operate in a flyback mode to provide a regulated plus and minus 16 volts to linear 12 volt regulators VR1 and VR2. Overvoltage protection is provided by clamp diode CR6. Low line conditions are detected by monitoring the unregulated +20 volt DC bus and generating a system interrupt (via OP amp B2) when the 20 volt bus drops to approximately 15 volts. The supply also provides an accurate 5 volt reference line that is used in the low line detection circuitry as well as the power on reset circuitry. Dual rectifier CR12, capacitors C49 and C50 provide an unregulated 10V DC source for the fluorescent lamp backlight. All power can be removed from the main electronics by removing the shorting jumpers on P1.

■ Micro Computer

The Micro Computer system used in the XTC consists of a Z-80 CPU (Z24), a ROM (Z21), a RAM (Z22), and a Timer / Interrupt Controller (Z16). The CPU executes the operating system program contained in the ROM. The CMOS RAM is used for data storage and variable computations. Power for the RAM is provided by battery (BT1) when the XTC is turned off thus preserving any stored data. The battery is charged via R18 and is decoupled from the main VCC supply by diode CR7. Accidental RAM access conditions are prevented by "AND" gate (Z23). During power fail or reset times the RAM cannot be accessed. The serial timer controller (STI) chip handles all system interrupt and time interval functions. This part also handles the serial RS232 communications when the option software is present. The serial Baud clock is also generated by this part. All memory mapped address decoding is provided by Z14 and all I/O address decoding is provided by Z13.

Sensor Period Measurement

Circuitry to accurately determine the oscillation period of the crystal sensor is also resident on the measurement board. The remote sensor oscillator is interfaced to the XTC via the BNC connector on the rear panel. DC power is provided to the oscillator thru this connector as well as allowing the the high frequency information from the oscillator to be coupled back to the XTC electronics. RFC1 provides the DC path while presenting a high impedence to the RF signal. The RF is amplified by one section of the CMOS gate (Z11) biased in the linear region via R5 and is then sent to the measurement electronics by another buffer section of Z11. One half of a "D" type flip flop (Z12) syncronizes the 250 ms start measurement strobe with the sensor. The second half of Z12 generates the actual measurement gate. A high frequency reference clock (39.3 Mhz) provided by oscillator Y1 is accumulated for the duration of the measurement gate. The reference clock is accumulated by prescaler (Z18) and two sections of a programmable timer chip (Z17). Accumulated data is read into the CPU via input port Z10 and the timer chip Z17. The measurement gate time is set by the sensor operating frequency, prescaler Z15, and the third section of the timer chip Z17. The 2.45 Mhz. CPU clock is also derived from the high frequency reference by the divide by 16 IC (Z19). The XTC makes 4 measurements per second of the sensor oscillation period.

D/A Converters

The XTC contains 2 Digital to Analog converters. One converter generates the analog control signal that is fed back to a deposition power supply to achieve a rate controlled deposition. The second converter provides a analog signal representing either RATE or THICKNESS as selected by the user via the rear panel option switch. Both converters operate in the following maner. A pulse width modulated signal is generated by timer chip Z7 in which the off time to on time ratio represents the digital value. The PWM signal is filtered by RC networks and operational amplifier Z1 to provide a DC voltage proportional to the digital value. Both converters are 10 volts full scale and the output signals appear at the system interface connector on the rear panel. Both plus and minus voltages are provided for the rate control feedback signal. The rate feedback signals may be reduced to 5 volts fullscale by removing shorting strap J 1/2 DAC. RC networks Z2 and Z4 along with zener diodes CR1 thru CR3 provide transient voltage protection for the electronics.

RS-232C Interface (Optional)

The RS-232C Interface is provided by RS-232C tranceivers Z8 and Z9. These parts generate RS-232C voltage levels from logic levels provided by the STI chip (Z16) and also translate RS-232C levels from a external source to logic levels for the STI chip. Baud rate selection is provided on the rear panel option select switch. The interface connector is a standard 9 pin "D" type. The RS-232C communications system is a factory installed system and is not operational in the standard unit.

Front Panel PCB Interface

The XTC utilizes a multi-backplane LCD display for the visual operator interface. This display is driven by two intelligent display controller chips on the front panel PC board. The measurement board communicates with the display control chips in a byte serial fashion. All data and select functions are handled by output port Z25 and buffer IC Z28. Data is transmitted serially and clock, chip select, and control mode information is also present. A communications handshake is provided by the busy line. The display generated scanning clock (100 Khz) is present at TP DSP CLK. The XTC keyboard is arranged in a 4 by 4 matrix and is scanned and debounced by keyboard encoder Z27. A key valid line from the encoder is sent to the STI (Z16) to generate a keyboard interrupt and also to provide key down data for continuous cursor scanning.

Miscellaneous

USER OPTIONS SELECTION - The rear panel system option switches (S1) are read by input port Z6 on power turn on only.

SYSTEM RELAYS - Two control relay outputs are provided at the system interface connector. K1 is defined as the deposition source shutter relay and K2 is defined as the sensor shutter relay. Relay driver Z29 and output port Z25 control relay operation. A set of normally open contacts is provided for each relay capable of handling 120 VAC AT 100 VA. Arc supression is provided by a RC network across each set of relay contacts.

POWER FAIL DETECTION AND RESET CIRCUITRY - Power fail detection is provided by monitoring the unregulated DC provided by the line transformer and rectifier. When this voltage (normally 20 volts) drops to 15 volts comparator amp Z30 generates a non maskable interrupt signal for the CPU. The CPU then shuts down in an orderly manner and protects the CMOS memory by generating a HALT signal. A system reset ocurrs approximatly 10 Ms after a HALT to insure proper system recovery if line power returns. Comparator amp Z3 also insures that the

Vcc supply is at the proper level before allowing the CPU to begin operating. The power source for the comparator amplifiers is supplied by the 5 volt reference potential present on the power supply PWM chip Z20.

The Measurement Control board consists of the following functional sections: Power Supply, Micro Computer, Sensor Period Measurement, D to A Converters and Buffers, RS 232 Interface, Front Panel Interface, Miscellaneous, (each discussed independently).

IEEE-488 MODULE DESCRIPTION (Optional)

This option card contains the electronics necessary to interface an XTC to the IEEE 488 bus as a TALKER / LISTENER device. The XTC may reside at any device address from 0 thru 31, and is settable via the rear panel dip switch bits 1 thru 5. The electronics consists of 488 bus buffers Z1 and Z2, Talker / Listener IC Z3, and address decoder Z5. Z4 acts as an input port to read the device address selection switches S1. Diode CR1 acts as a board installed identifier to the main operating system. The XTC to IEEE 488 interface cable is the industry standard 24 pin connection.

I/O RELAY MODULE DESCRIPTION (Optional)

The output interface electronics consists of 8 relays (K1 thru K8), relay driver Z6, and output port Z7. Contact arc supression is provided by a 0.01 UFD capacitor and a 100 ohm resistor in series across each set of relay contacts. The input interface electronics consists of filter network Z1,Z2,and Z3. Inverting buffer Z5 ,pullup network Z4, and input port Z8. Z9 provides address decoding and diode CR2 provides an indication of the module installation to the main operating system.

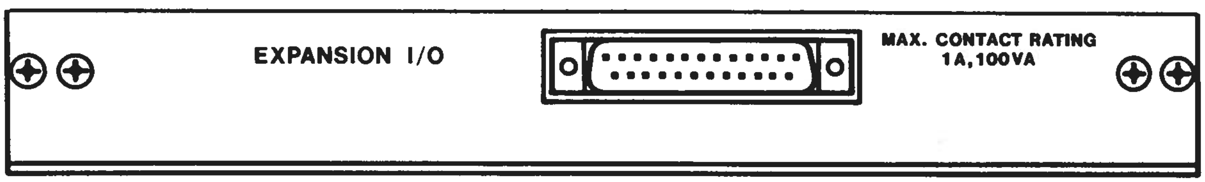


Figure 6.4 I/O Relay Module (751-112-61)

SENSOR OUTLINE DRAWINGS

The following Sensor Outline Drawings provide dimensions and other pertinant data necessary for planning equipment configurations.

FEEDTHROUGH OUTLINE DRAWINGS

The following Feedthrough Outline Drawings provide dimensions and other pertinant data necessary for planning equipment configurations.

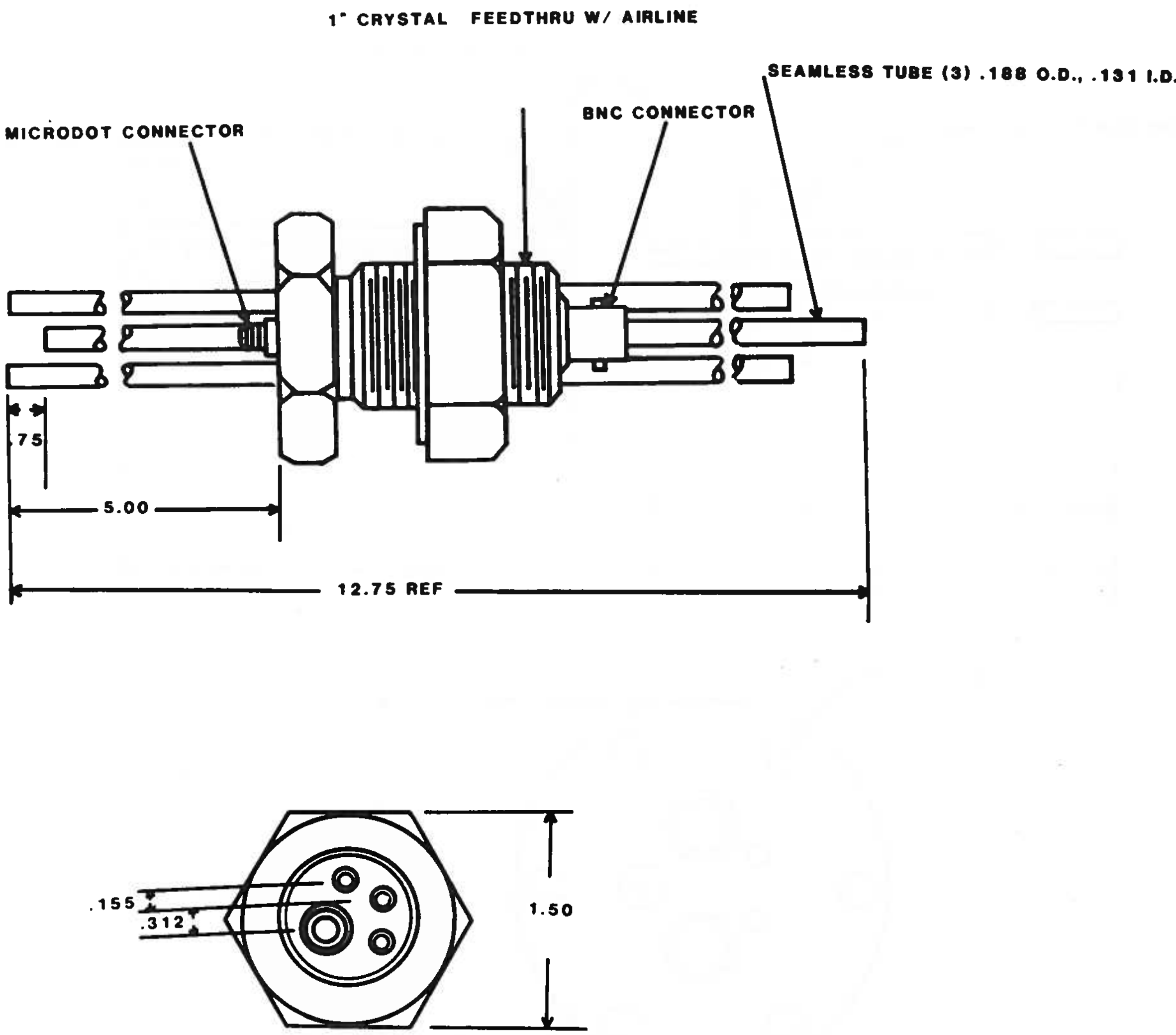


Figure 6.14 1″ Crystal Feedthrough with Airline (750-030-G1)

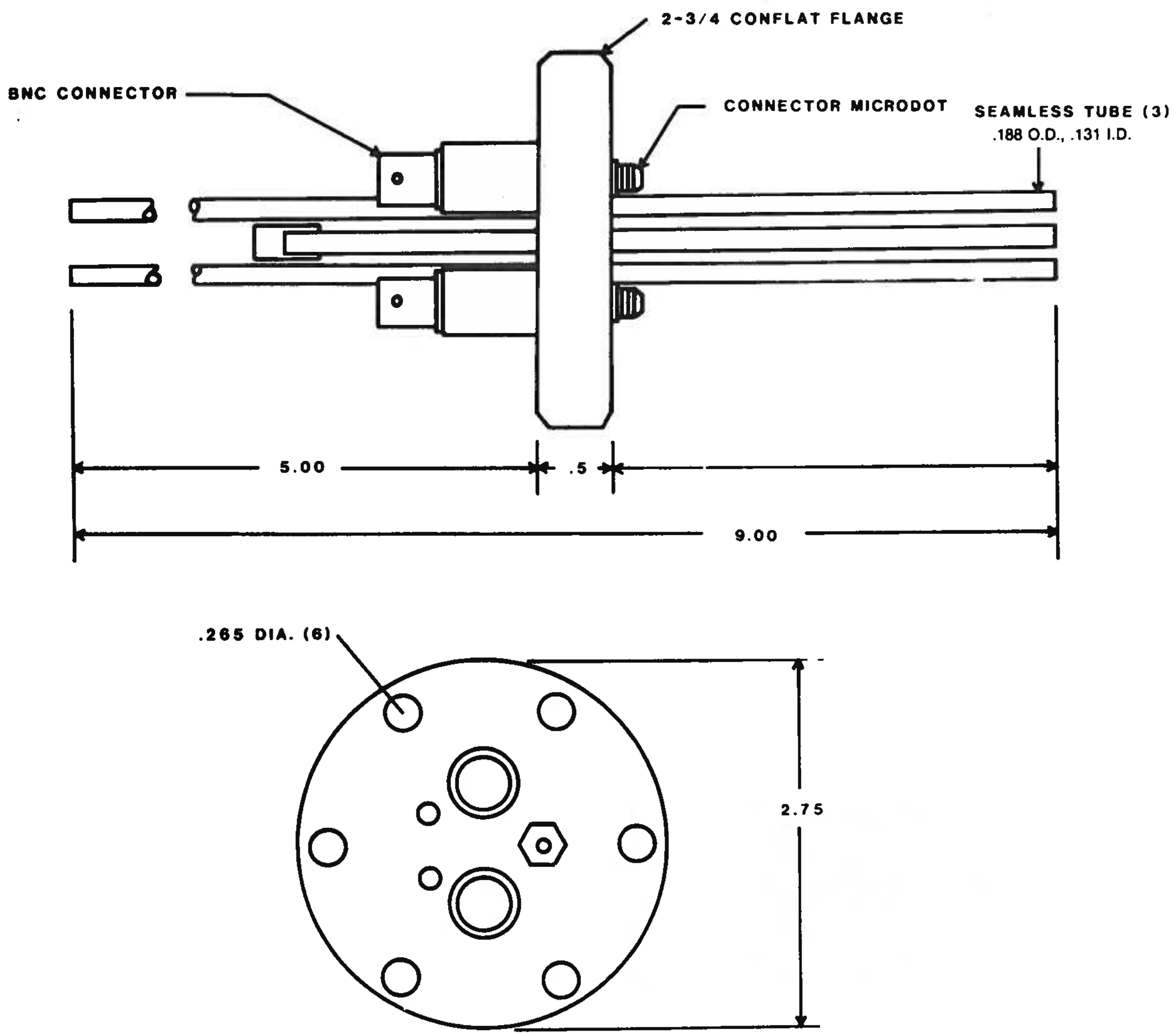


Figure 6.15 2¾" Dual Coax Feedthrough with Airline (002-080)

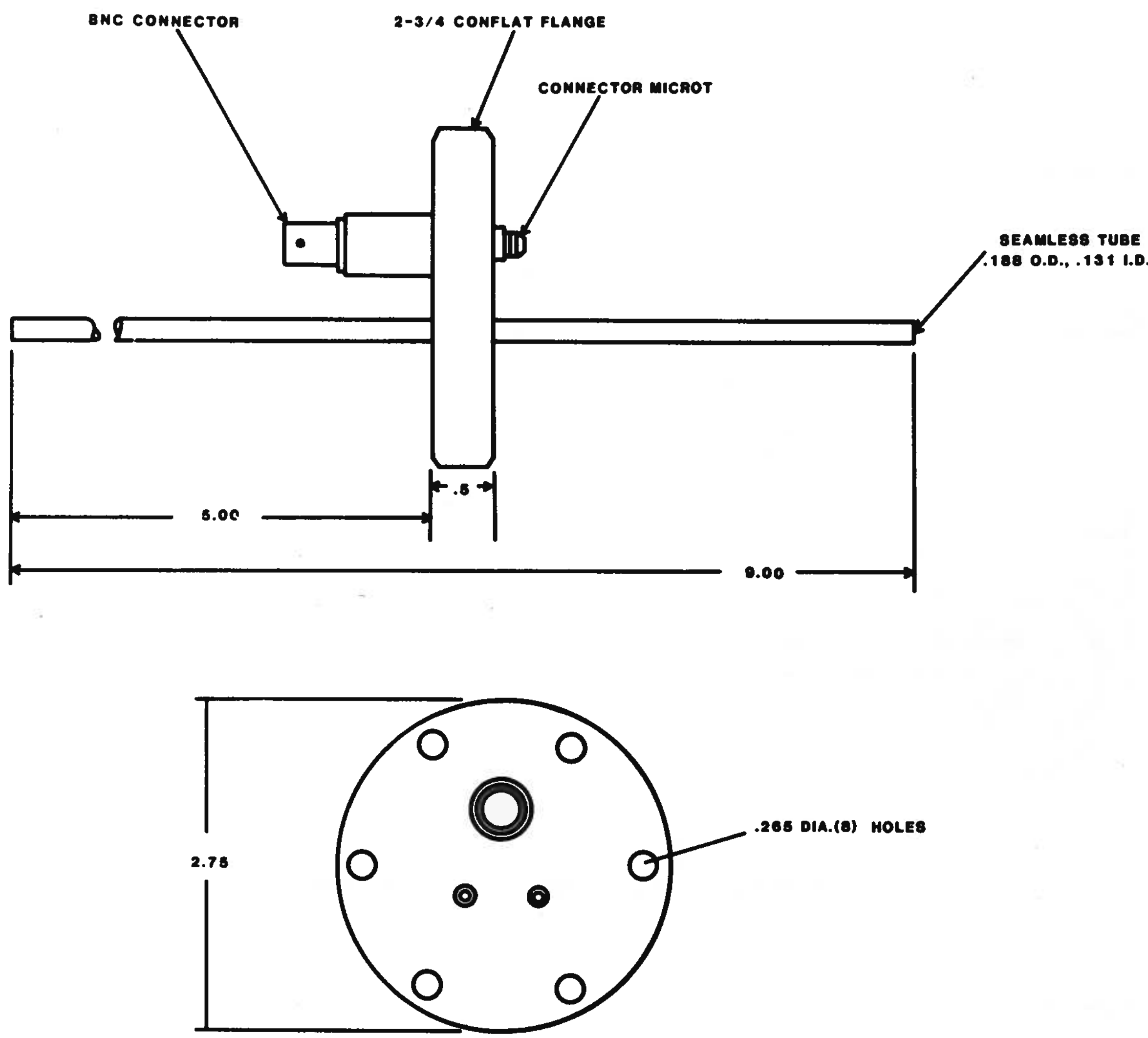


Figure 6.66 2¾" Single Coax Feedthrough (002-043)

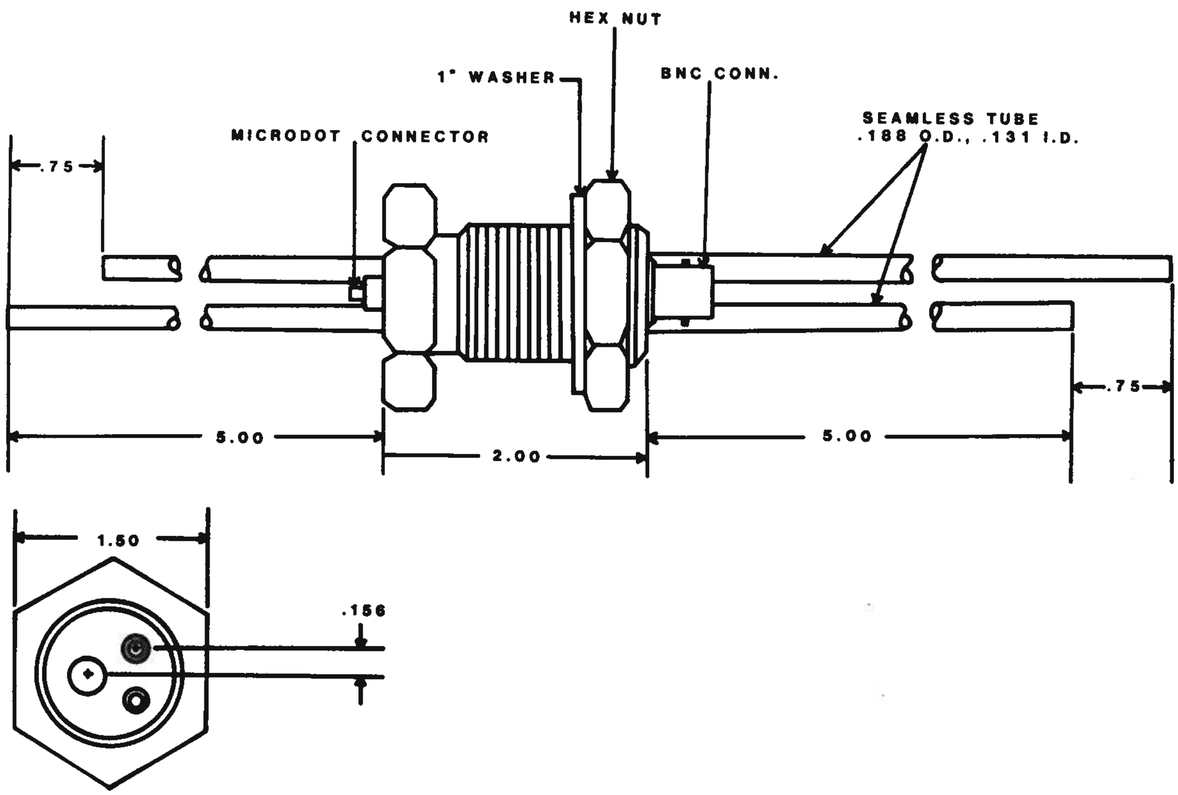


Figure 6.17 1″ Crystal Feedthrough (002-042)

Section 7 of the XTC Manual contains a functional description and instructions on various XTC options. This information can be found as follows:

COMPUTER INTERFACE

The Computer Interface provides a means of electronic communication with the XTC. Using suitable equipment, the XTC can be operated from a remote location, can be operated without operator intervention and can be integrated into computer controlled instrumentation systems. Data from the XTC can also be acquired, manipulated and stored by computer equipment.

The XTC has the capability of interfacing to a computer via RS-232, a printer via RS-232, or a computer via IEEE-488 and a printer at the same time via RS-232 communications.

Commands

Available commands and their formats.

Command Quick Reference List

Command	Function
A	Autolog Enable/Disable
D	Display Values
F	Fetch Parameters
L	Lock/Unlock Keyboard
P	Print Datalog
Q	Query Remote Inputs
R	Remote Input Enable
S	Status Fetch
U	Update Parameter

Command Complete Reference List

Command	Description	Format
A	Autolog Disable	(A) (1 or 0) (ACK) 1 = Yes 0 = No

Example: A1 (ACK)
Meaning: Autolog Disable
Response = (ACK)

NOTE: With RS-232 communications Autolog is enabled on power up and data is sent to a printer (optional) every time a Final Thickness is achieved. If a

---

computer is attached to the RS-232 port instead of the printer, the Data Log information will still be transmitted out the RS-232 port when Final Thickness is achieved. There is no guarantee that the computer will receive the Data Log information, since it is dependent on the type of computer in use. It is recommended that Autologging be disabled in this configuration. In this configuration the computer must send a "P" command to receive the Datalog information. In IEEE-488 communications Autolog is enabled on power up. Operation of this function differs depending on the system configuration. If the XTC is connected to a computer through the 488 interface and to a printer through the RS-232 interface the Autolog will automatically be sent to the printer upon achievement of Final Thickness. The computer will receive no service request and must send a "P" command to retrieve Datalog information. If the XTC is connected to a computer through the IEEE-488 connector and no printer is connected to the RS-232 interface, it is recommended that Autologging be disabled. This causes a service request to be sent to the computer when Final Thickness is reached (Datalog has data) and the computer can then send a "P" to retrieve the data.

Command	Description	Format
D	Display values	(D)(ACK)

Example: D(ACK)
Meaning: Display values for RATE, THICKNESS, TIME, POWER, and LIFE
Response =

```
nnnn(SP)nnnnnnn(SP)nnnn(SP)nn(SP)nn(ACK)
    RATE    THICK     TIME   PWR    LIFE
```

NOTE: Display data will always be returned with the greatest precision possible and with no decimal point or colon information.

Command	Description	Format
F	Fetch parameter	(F)(PAR#)(ACK)

Example: F17(ACK)
Meaning: Fetch parameter 17 (FINAL THK) value
Response = (DATA)(ACK)

NOTE: **Parameter data will always be returned with the greatest precision possible and with no decimal point or colon information.**

Command	Description	Format
L	Lock/Unlock keyboard	(L)(1 or 0)(ACK) 1 = Lock 0 = Unlock

Example: L1(ACK)
Meaning: Lock keyboard
Response = (ACK) + front panel indicator off

NOTE: **Only the numeric keys used in the program mode for parameter updating are locked out. No other keys are affected.**

Command	Description	Format
P	Print Datalog	(P)(ACK)

Example: P(ACK)
Meaning: Print Datalog table
Response = printout + (ACK)
Sample Printout:

```
RATE = nnn.n A/S
THK = nnnnnnn ANG
DEP TIME = nn:nn
DEP PWR = nn %
XTL LIFE = nn %
NRM or T/P
(ACK)
```

NOTE: **The Datalog command is generated automatically upon achievement of Final Thickness or may be requested.**

Command	Description	Format
Q	Query remote inputs	(Q)(ACK)

Example: Q(ACK)
Meaning: Query status of the remote input ports
Response = (Data string)(ACK)

NOTE: The I/O relay module must be installed to use the Q command.

Data string = 8 digits (n0n1n2n3n4n5n6n7) 1 = On
0 = Off

n =
0 for START
1 for STOP
2 for END DEPOSIT
3 for ZERO THK
4 for SOAK HOLD
5 for XTAL FAIL INHIBIT
6 for SAMPLE INITIATE
7 for SAMPLE INHIBIT

Command	Description	Format
R	Remote input command	(R)(n)(SP)(1 or 0)(ACK) 1 = On 0 = Off

Example: R1 1(ACK)
Meaning: Remote input command to set STOP to On

NOTE: The "R" command is used to initiate any of the XTC functions described below. The I/O relay module is not needed to use this command. In the example above, a STOP would be initiated and would be acknowledged to the host computer.

---

n =
0 for START
1 for STOP
2 for END DEPOSIT
3 for ZERO THK
4 for SOAK HOLD
5 for XTAL FAIL INHIBIT
6 for SAMPLE INITIATE
7 for SAMPLE INHIBIT

Response = (ACK) + requested action

Command	Description	Format
S	Status fetch	(S)(ACK)

Example: S(ACK)
Meaning: Fetch the status (On/Off) of the data listed below.
Response = (Data string)(ACK)

NOTE: Only the On/Off status data will be in the Data string, the number of the particular data (1 - 15) is understood.

Data string = 15 digits (n1n2n3n4n5---n15)

n = 1 phase (see Table 7.1)
2 phase (see Table 7.1)
3 space

} Indicates the Phase Status of the instrument as defined in Table 7.1.

n = 4 for Manual Phase
5 for Sample Phase
6 for Hold Phase
7 for Time Power Phase
8 for Stop
9 for Ready
10 for Xtal life dspl
11 for Xtal fail
12 for Thick limit
13 for Final thickness
14 for Max Power
15 for Soak Hold

Command	Description	Format
U	Update parameter	(U)(PARAMETER #)(SPACE)(VALUE)(ACK)

Example: U17(SP)2500000(ACK)
Meaning: Update parameter 17 (FINAL THK) TO 2500000 ANG.
Response = (ACK)

Error Codes

The error codes listed below will result in the following XTC response:

Response = (Data)(NACK)

Data:
A, 65D, 41H = Command Error
B, 66D, 42H = Illegal Parameter Value
C, 67D, 43H - Illegal Parameter Number

TABLE 7.1 PHASE

N1/N2	Phase
00	STOP
01	READY
02	RISE 1
03	SOAK 1
04	RISE 2
05	SOAK 2
06	SHUTTER DELAY
07	DEPOSIT
08	RATIO DEPOSIT
09	RATE RAMP
10	TIME POWER
11	FALL
12	IDLE
13	MANUAL

Parameter number assignments and format descriptions:

PARAMETER	NAME	LIMITS	NOTES	UNITS
0	SOAK POWER 1	0 TO 99		%
1	RISE TIME 1	0 TO 99:99	1	MIN/SEC
2	SOAK TIME 1	0 TO 99:99	1	MIN/SEC
3	SOAK POWER 2	0 TO 99		%
4	RISE TIME 2	0 TO 99:99	1	MIN/SEC
5	SOAK TIME 2	0 TO 99:99	1	MIN/SEC
6	NEW RATE	0 TO 999.9	2&5	ANG/SEC
7	RATE RAMP TIME	0 TO 99:99	1&3	MIN/SEC
8	IDLE POWER	0 TO 99	1	%
9	IDLE RAMP TIME	0 TO 99:99	1	MIN/SEC
10	GAIN	0 TO 99		%
11	APPROACH	0 TO 99		%
12	RATE	0 to 999.9	2&5	ANG/SEC
13	DENSITY	0.8 TO 99.99	2	GM/CC
14	Z-RATIO	0.1 TO 3.999	2	
15	TOOLING	0 TO 399		%
16	THICKNESS LIMIT	0 TO 9999999	4	ANG
17	FINAL THICKNESS	0 TO 9999999	4	ANG
18	MAXIMUM POWER	0 TO 99		%
19	SAMPLE TIME	0 TO 99:99		MIN/SEC
20	SAMPLE ACCURACY	0 TO 99		%

NOTES:

1. The colon character is an implied colon and is not part of the data structure.
2. The decimal point is an implied decimal point and is not part of the data structure.
3. A rate ramp time of zero disables the RATE RAMP function.

4. **The thickness display will autorange all data to the 4 most significant digits in units of KA, however the internal data structure is accurate to units of angstroms.**

5. **The rate display will autorange data to the three most significant digits, however the tenths digit accuracy is preserved internally.**

RS-232C Communications Discussion

The RS-232C Interface provides a means of electronic communication with the XTC. Using suitable equipment, the XTC can be operated from a remote location, operated without operator intervention and integrated into computer controlled instrumentation systems. Data from the XTC can also be acquired, manipulated and stored by computer equipment.

When communicating with an external device through the RS-232 Interface, the external device is required to assume the role of the "host" and the XTC acts as the "peripheral" device. The host issues commands to the XTC to change mode or to respond with data to be read by the host. The host device will normally be a computer which has been programmed to issue suitable commands to the XTC. In RS-232 Communications the host computer can control one device per link, as compared to the IEEE-488 controller which can control and interface to a number of devices.

The XTC uses a software handshake to control the flow of information between the XTC and the host computer. When operating the RS-232 communications observe the following: No Parity; 1 Stop Bit; 1 Start Bit; 8 Data Bits.

Every command sent from the host to the XTC must be terminated with an ASCII (ACK). This is an indication to the XTC that this is the end of the present command and to begin interpreting that command. ACK is the control F(^F) character and is usually supressed from the display.

Upon successful completion of the current command the XTC will return any data, if the current command includes a request for data, plus an ASCII (ACK). The (ACK) is an indication to the host computer that the command it just transmitted to the XTC was completed successfully and the data preceding it, if any, is the data the host computer requested.

NACK is the control U (^U) character and is usually supressed from the display. If an ASCII (NACK) is received this is an indication to the host computer that the command it just transmitted is somehow in error. The ASCII character preceding the (NACK) is the error code indicating the type of error that occurred (see the Error code listing above).

From the time the (ACK) is received by the XTC until the (ACK/NACK) is received by the host computer, any data that the XTC receives will be read but will not be stored or acted upon in any way. No indication or response is sent to the host computer that this has occurred.

Below is a typical communications sequence:

1 - XTC is running - There are no messages being handled.

2 - Host originates a command message - The host sends a character by character message followed by an ACKnowledge (^F) to the XTC.

3 - The command is then processed and the resultant data (if any) is sent to the host one character at a time. The command is then terminated by an ACKnowledge (^F).

4 - If the command message is invalid the XTC sends an NACK (^U not acknowledge) to the host.

Baud Rate is selectable via the OPTION SELECT ON/OFF switches at the XTC Back Panel. Refer to Figure 2.8 for switch location. Baud rate selection requires the proper setting of switches 1 & 2 as follows:

Switch 1	OFF	ON	OFF	ON
Switch 2	OFF	OFF	ON	ON
Baud Rate	1200	2400	4800	9600

DATALOG

Datalog provides a means of automatically generating the values for RATE, THICKNESS, DEPOSITION TIME, DEPOSIT POWER, XTAL LIFE, AND, whether deposition was completed and normal conditions or TIME-POWER. This data is automatically sent to the RS-232 port following the achievement of FINAL THICKNESS unless it is disabled by the "C" command (Autolog Enable/Disable). Datalog may be requested at any time by entering the P command (Print Datalog).

With RS-232 communications Autolog is enabled on power up and data is sent to a printer (optional) every time a Final Thickness is achieved. If a computer is attached to the RS-232 port instead of the printer, the Datalog information will still be transmitted out the RS-232 port when Final Thickness is achieved. There is no guarantee that the computer will receive the Datalog information, since it is dependent on the type of computer in use. It is recommended that Autologging be disabled in this configuration. With Autologging disabled the computer must send a "P" command to receive the Datalog information.

ERROR CODES

All errors transmitted by the XTC is an error code followed by a (NACK). The list of error codes are as follows.

"A", 65D, 41H = Command Error

"B", 66D, 42H = Illegal Parameter Value

"C", 67D, 43H = Illegal Parameter Number

"K", 75D, 4BH = Receive Buffer Overflow

The following sample program, written for the Digital Equipment Corporation, MINC-11 Laboratory Computer, enables the computer to operate the XTC in a monitor mode:

```
1Ø REM \ THIS IS A PROGRAM TO IMPLEMENT THE RS-232 INTERFACE BETWEEN THE
11 REM \ INFICON MODEL XTC QUARTZ CRYSTAL DEPOSITION CONTROLLER/MONITOR
3Ø REM \ AND THE DIGITAL EQUIPMENT CORP. MINC-11 LABORATORY COMPUTER
4Ø REM \ 1200 BAUD MINC CHANNEL #1 (SLU1)
5Ø PRINT \ PRINT "INPUT COMMAND STRING" \A$="" \D%=Ø
6Ø INPUT #Ø,A$
7Ø A$=A$+CHR$(6)
8Ø REM\ CONTROL F IS CONCANTENATED TO THE INPUT STRING (A$) INSTATEMENT7Ø
9Ø COUT(,A$,LEN(A$),1)
1ØØ CIN(,B$,1ØØ,1,1)
11Ø REM\ STATEMENT 9Ø SENDS A$ ON PORT 1
12Ø REM \ STATEMENT 1ØØ RECEIVES B$ ON PORT 1
13Ø PRINT "SENT A$"
14Ø PRINT B$
15Ø C$=SEG$(B$,LEN(B$),LEN(B$)) \IF C$=CHR$(6) THEN PRINT "ACK" \GO TO 5Ø
16Ø IF C$=CHR$(21) THEN PRINT CHR$(7) \PRINT "NACK" \D%-ASC(SEG$(B$,1,1))\
    GO TO 19Ø
17Ø REM\ STATEMENT 15Ø CHECKS FOR THE ACK AT THE END OF B$
18Ø REM\ STATEMENT 16Ø CHECKS FOR NACK AT THE END OF B$
19Ø IF D%-65 THEN PRINT "ILLEGAL COMMAND OR MODULE" \ GO TO 5Ø
2ØØ IF D%=66 THEN PRINT "UPDATE OF PARAMETER OUT OF BOUNDS" \ GO TO 5Ø
21Ø IF D%=67 THEN PRINT "ILLEGAL PARAMETER NUMBER USED" \ GO TO 5Ø
22Ø IF D%=75 THEN PRINT "XTC(LISTENER) BUFFER OVERFLOW" \ GO TO 5Ø
23Ø PRINT "UNKNOWN ERROR CODE" \PRINT
24Ø GO TO 5Ø
25Ø END
```

■IEEE-488 Communications Discussion

The IEEE-488 Interface provides the capability for a variety of devices to communicate with each other and to share the resources of a single bus. This means that the entire system can share one printer or one computer instead of each instrument having a computer and printer dedicated specifically for its use alone.

In the IEEE-488 Communications discussion the "Computer" will be referred to as the Controller since all communications in IEEE-488 systems are handled by one main Controller (computer).

Every command sent from the Controller to the XTC must be terminated with an ASCII (ACK). This is an indication to the XTC that this is the end of the present command and to begin interpreting that command. The controller has the option of asserting the EOI line on transmission of the (ACK), since the XTC checks each received character for the (ACK). ACK is often the control F (^F) character and is usually supressed from the display.

Upon successful completion of the current command the XTC will return any data, if the current command includes a request for data, plus an ASCII (ACK). The (ACK) is an indication to the Controller computer that the command it just transmitted to the XTC was completed successfully and the data preceding it, if any, is the data the Controller computer requested.

If an ASCII (NACK) is received this is an indication to the Controller computer that the command it just transmitted is in error. The ASCII character preceding the (NACK) is the error code indicating the type of error that occurred. NACK is often the control U (^U) character and is usually supressed from the display.

Upon transmission of either the (ACK) or (NACK), the XTC also asserts the EOI line.

From the time the (ACK) is received by the XTC until the (ACK/NACK) is received by the Controller computer, any data that the XTC receives will be read but will not be stored or acted upon in any way. No indication or response is sent to the Controller computer that this has occurred.

ADDRESS SWITCH

An eight segment switch is located on the IEEE-488 Module rear panel. This switch sets the XTC bus address. Switches 1 through 5 are used to select an address of 0 through 30. Switches 6, 7, and 8 are unused.

Address selection is as follows: 1 = Switch Off
0 = Switch On

Address	Switch numbers #54321	Address	Switch numbers #54321
0	00000	16	10000
1	00001	17	10001
2	00010	18	10010
3	00011	19	10011
4	00100	20	10100
5	00101	21	10101
6	00110	22	10110
7	00111	23	10111
8	01000	24	11000
9	01001	25	11001
10	01010	26	11010
11	01011	27	11011
12	01100	28	11100
13	01101	29	11101
14	01110	30	11110
15	01111		

The IEEE-488 Module connector is shown below along with associated pin information.

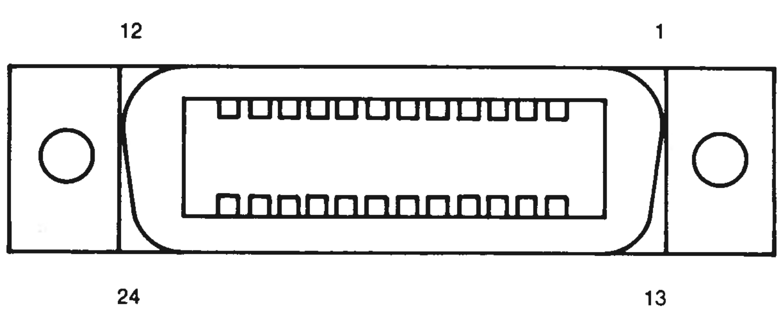


Figure 7.1 XTC IEEE-488 Connector

CONTACT	SIGNAL LINE	CONTACT	SIGNAL LINE
1	DIO 1	13	DIO 5
2	DIO 2	14	DIO 6
3	DIO 3	15	DIO 7
4	DIO 4	16	DIO 8
5	EOI	17	REN
6	DAV	18	GND
7	NRFD	19	GND
8	NDAC	20	GND
9	IFC	21	GND
10	SRQ	22	GND
11	ATN	23	GND
12	SHIELD	24	GND, LOGIC

Below is a typical communications sequence:

1 - XTC is running - There are no messages being handled.

2 - Controller originates a command message (or receives a request for XTC data from another peripheral device) - the controller sends a character by character message followed by an ACKnowledge (^F) to the XTC.

3 - The command is the processed and the resultant data (if any) is sent to the controller one character at at time followed by an (ACK) (^F) to the XTC.

4 - If the command message is not properly received, the XTC sends a NACK (^U) to the controller.

DEVICE CLEAR

Device clear may be initiated by the Controller and sent to the XTC. When the signal is received by the XTC the receive and transmit buffers will be cleared.

ERROR CODES

All errors transmitted by the XTC is an error code followed by a (NACK). The list of error codes are as follows.

"A", 65D, 41H = Command Error

"B", 66D, 42H = Illegal Parameter Value

"C", 67D, 43H = Illegal Parameter Number

"K", 75D, 4BH = Receive Buffer Overflow

"L", 76D, 4CH = XTC Addressed to Listen with Data still in XTC Transmit Buffer (Data Still Intact)

SERVICE REQUESTS

Service Requests are automatically generated by the XTC for particular events. XTC Service Requests are listed below:

"U", 85D, 55H = FINAL THICKNESS REACH for DATALOG purposes when not disabled.

"V", 86D, 56H = STOP condition is invoke.

"W", 87D, 57H = End of deposit.

"X", 88D, 58H = Power Up.

DATALOG

Datalog provides a means of automatically generating the values for RATE, THICKNESS, DEPOSITION TIME, DEPOSIT POWER, XTAL LIFE, and, whether deposition was completed under normal conditions or TIME-POWER. This data is automatically sent to the RS-232 port following the achievement of FINAL THICKNESS unless it is disabled by the A command (Autolog Enable/Disable). Datalog may be requested at any time by entering the P command (Print Datalog).

In IEEE-488 communications Autolog is enabled on power up. Operation of this function differs depending on the system configuration. If the XTC is connected to a computer through the 488 interface and to a printer through the RS-232 interface the Autolog will automatically be sent to the printer upon achievement of Final Thickness. The computer will receive no service request and must send a "P" command to retrieve Datalog information. If the XTC is connected to a computer through the IEEE-488 connector and no printer is connected to the RS-232 interface, it is recommended that Autologging be disabled. This causes a service request to be sent to the computer when Final Thickness is reached (Datalog has data) and the computer can then send a "P" to retrieve the data.

The following sample program, written for the Digital Equipment Corp. MINC-11 Laboratory computer, enables the computer to operate the XTC in a monitor mode:

```
10 REM\ THIS IS A PROGRAM TO IMPLEMENT THE IEEE-488 INTERFACE BETWEEN THE
20 REM\ INFICON MODEL XTC QUARTZ CRYSTAL DEPOSITION CONTROLLER/MONITOR
30 REM \ AND THE DIGITAL EQUIPMENT CORP. MINC-11 LABORATORY COMPUTER
40 SET_TERMINATORS
50 PRINT \ PRINT "INPUT COMMAND STRING"
60 A$=""
70 TEST_SRQ(S)  /REM\CHECKS FOR SERVICE REQUESTS ON BUS
80 IF S=-1 THEN GO TO 250
90 GET_CHAR(C$)
100 IF LEN(C$)=0 THEN GO TO 70
110 IF C$=CHR$(13) THEN GO TO 140  /REM\CHECKS FOR CARRIAGE RETURN
120 A$=A$+C$
130 GO TO 70
140 GET_CHAR(C$)
150 A$=A$+CHR$(6)
160 REM \ CONTROL F IS CONCANTENATED TO THE INPUT STRING (A$)
        INSTATEMENT150
170 SEND(A$,3)  /REM\SENDS A$ TO DEVICE #3 OVER IEEE-488 BUS
180 RECEIVE(B$,90,3)   REM RECEIVES B$ FROM XTC (DEVICE#3), MAXIMUM90
        CHARACTERS
190 PRINT "SENT A$"
200 PRINT B$
210 C$=SEG$(B$,LEN(B$),LEN(B$))   IF C$=CHR$(6) THEN PRINT "ACK"
220 IF C$=CHR$(21) THEN PRINT CHR$(7)   PRINT "NACK"   D%=ASC(SEG$B$1,1))
        GO TO 290
230 GO TO 50
250 PRINT "SERIAL POLL"
260 SERIAL_POLL(D%,,3)
270 PRINT D%
280 IF D%=88 THEN PRINT "XTC REINITIALIZED   POWERED UP"   GO TO 50
290 IF D%=86 THEN PRINT "FINAL THICKNESS REACHED"   A$="P"   GO TO 150
300 IF D%=85 THEN PRINT "STOP"   A$="D"   GO TO 150
310 IF D%=87 THEN PRINT "END OF PROCESS"   A$="D"   GO TO 150
320 IF D%=65 THEN PRINT "ILLEGAL COMMAND OR MODULE"   GO TO 50
330 IF D%=66 THEN PRINT "UPDATE OF PARAMETER OUT OF BOUNDS"   GO TO 50
340 IF D%=67 THEN PRINT "ILLEGAL PARAMETER NUMBER USED"   GO TO 50
350 IF D%=75 THEN PRINT "XTC(LISTENER) BUFFER OVERFLOW"   GO TO 50
360 IF D%=76 THEN PRINT "DATA LEFT IN XTC(TALKER) BUFFER"   GO TO 50
370 PRINT "UNKNOWN POLL"
380 END
```

I/O RELAY MODULE

This option card contains the electronics necessary to interface an XTC to a user hardware system. The option provides 8 sets of normally open relay contacts with the following functions:

Relay Outputs (Contacts close when:)

1.	FINAL THICKNESS	The programmed final thickness value has been reached. Contacts re-open at the start of the next deposit cycle or a Zero Thickness event.
2.	THICKNESS LIMIT	The programmed thickness limit value has been reached. Contacts re-open at the start of the next deposition cycle or a Zero Thickness event.
3.	IN PROCESS	The programmed process sequence has been started and has not reached IDLE phase.
4.	STOP	The XTC has been placed in the STOP phase.
5.	END OF PROCESS	The XTC has completed a programmed process and has reached the IDLE phase.
6.	FEED TIME	TIME 2 the XTC is in the Soak 2 or Soak (Soak Time 2) Hold phase.
7.	ALARMS	The deposition rate has failed to meet the accuracy criteria to properly exit either the SHUTTER DELAY phase or the SAMPLE phase. The ALARM condition begins after 60 seconds of failure and continues until the proper exit conditions are met (see "Stop on Alarm" option switch Section 2, Back Panel Descriptions.
8.	XTAL FAIL	The sensor crystal has failed to operate in the proper frequency range. This signal may be inhibited via the remote inhibit line (See XTAL FAIL and TIME-POWER option switch Section 2, Back Panel Descriptions.)

The option card also provides 8 ground referenced input lines with the following functions:

Remote Inputs

1.	START	Provide the same functions as the front panel START key.
2.	STOP	Provide the same functions as the front panel STOP key.
3.	END DEPOSITION	Force a premature FINAL THICKNESS event.
4.	ZERO THICKNESS	Zero the accumulated thickness display.
5.	SOAK HOLD	Prevent the process sequence from completing the SOAK 2 phase until released.
6.	XTAL FAIL INHIBIT	Allow sensor crystals to be changed without causing a system STOP, thus preserving any IDLE power that may be present on a deposition source.
7.	SAMPLE INITIATE (RateWatcher)	Force a sensor SAMPLE cycle to begin. (Used during sample and hold depositions)
8.	SAMPLE INHIBIT (RateWatcher)	Prevent the XTC from executing a SAMPLE cycle. A SAMPLE cycle will begin immediately after the inhibit line is released (Used during sample and hold depositions.)

The REMOTE inputs require an active low (ground) signal to operate. the signal source may be a set of relay contacts or can be a voltage level in the range of 0 to 30 volts DC+. The sensing thresholds are the same as TTL logic for a 1 and 0 condition. The signal source must be capable of sinking 2 TTL equivalent loads.

The interface connector is a 25 pin male "D" type with the following pin assignments:

OUTPUT FUNCTIONS		INPUT FUNCTIONS	
NAME	PINS	NAME	PINS
FINAL THICKNESS	22, 24	START	14
THICKNESS LIMIT	12, 23	STOP	16
IN PROCESS	3, 8	END DEPOSIT	18
STOP	5, 10	ZERO THICKNESS	20
END OF PROCESS	4, 9	SOAK HOLD	19
FEED TIME	6, 7	XTAL FAIL INHIBIT	17
ALARMS	11, 13	SAMPLE INITIATE	15
XTAL FAIL	21, 25	SAMPLE INHIBIT	1
		GROUND	2

Relay contact ratings are 120 volt 100VA maximum.

Additional information on the circuitry is located in Section 6.

■RACK ADAPTER

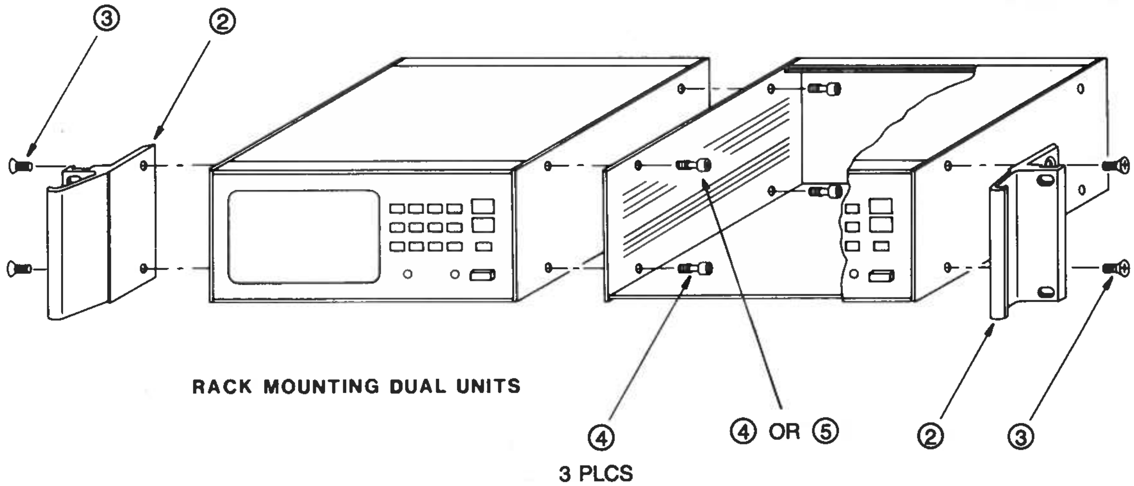
The Rack Adapter Kit IPN 751-028-G1 is required to rack mount one or two XTC instruments. Refer to Figure 7.2 for an illustration of component configuration.

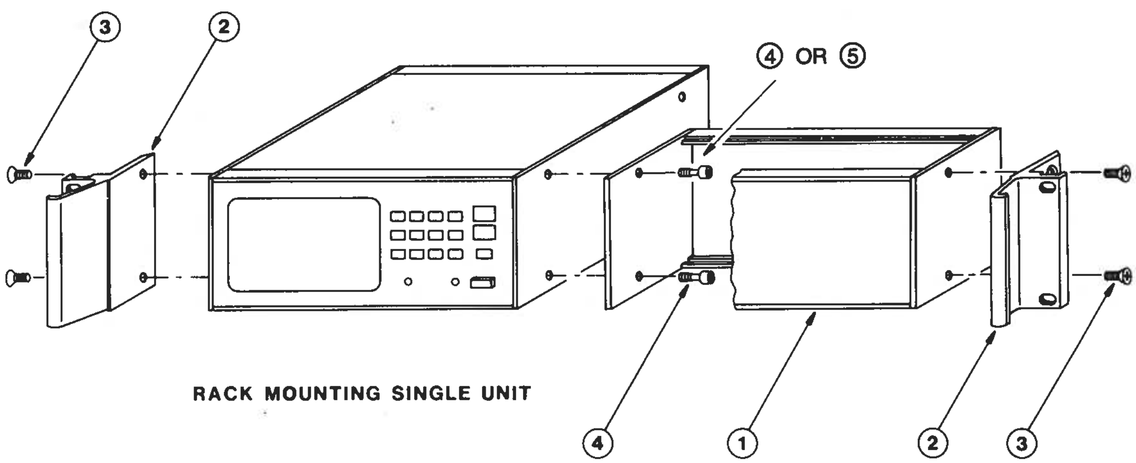
Assembly procedures are similar for mounting one instrument and the Rack Adapter Assembly (Item 1) or two instruments. The top and bottom case covers must be removed from the instrument (or Rack Adapter Assembly) which is to be mounted on the right as you face the mounting rack.

CAUTION: **Do not attempt to install the assembly screws (Item 4) from the left to the right when two instruments are being installed, as this may cause physical damage to the instrument circuitry.**

Install the four screws (Item 4) to connect the two instruments (or one instrument and the adapter case) and reinstall the case covers. Next, install the Mounting Handles (Item 2) on the assembled cases. Install the assembled unit into your electronics rack using the appropriate hardware (not included). Make sure that the rack location will not cause strain on the cables, excessive heat, or obstructed view.

XTC RACK ADAPTER OPTION (751-028-G1)





① **RACK ADAPTER ASSEMBLY**
751-041-G1

② **MOUNTING HANDLE**
751-018-P1 (QTY. 2)

③ **NO. 10-32 x .25 LG. PHIL. FLAT HD. SCREW**
090-024 (QTY. 4)

④ **NO. 10-32 x .38 LG. HEX SOC. HD. SCREW w/ UNDERCUT**
751-504 (QTY. 4)

⑤ 5/32 x 7/16 DOWEL PIN
070-773 (QTY 1)

Figure 7.2 Rack Adapter (Exploded View)

When mounting XTCs equipped with fluorescent backlights (20 series and up), first insert the item 5 dowel pin from the outside at the front top corner and then secure the units together using two item 4 screws at the back.

To install an XTC with fluorescent backlights next to an older XTC with an electroluminescent backlight, place the fluorescent backlight XTC (20 series and up) on the left and use the four item 4 screws.