SID-142
Thin Film Deposition Controller

SQM-142
Deposition Control Card

SQS-142
Deposition Control Software

Version 2.16

User's Guide

Sigma instruments

Safety Information

Read this manual before installing, operating, or servicing equipment. Do not install substitute parts, or perform any unauthorized modification of the product. Return the product to Sigma Instruments for service and repair to ensure that safety features are maintained.

Safety Symbols

WARNING: Calls attention to a procedure, practice, or condition that could possibly cause bodily injury or death.

CAUTION: Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.

Refer to all manual Warning or Caution information before using this product to avoid personal injury or equipment damage.

Hazardous voltages may be present.

Earth ground symbol.

Chassis ground symbol.

Equipotential ground symbol.

Warranty Information

This Sigma Instruments product is warranted against defects in material and workmanship for a period of 1 year from the date of shipment, when used in accordance with the instructions in this manual. During the warranty period, Sigma Instruments will, at its option, either repair or replace products that prove to be defective.

Limitation of Warranty

Defects from, or repairs necessitated by, misuse or alteration of the product, or any cause other than defective materials or workmanship are not covered by this warranty. NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. UNDER NO CIRCUMSTANCES SHALL SIGMA INSTRUMENTS BE LIABLE FOR CONSEQUENTIAL OR OTHER DAMAGES RESULTING FROM A BREACH OF THIS LIMITED WARRANTY, OR OTHERWISE.

Return Policy

The purchaser may return this product in new condition within 30 days after shipment for any reason. In case of return, purchaser is liable and responsible for all freight charges in both directions.

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1.0 Introduction

This manual covers both the hardware and software associated with the SID-142 Thin Film Deposition Controller. The SID-142 consists of four main elements, integrated into a complete deposition control system:

SRC Series Rack-mount Computer
SQM-142 PC Card(s)
SQS-142 Windows CoDeposition Software
PLC for Digital I/O (option)

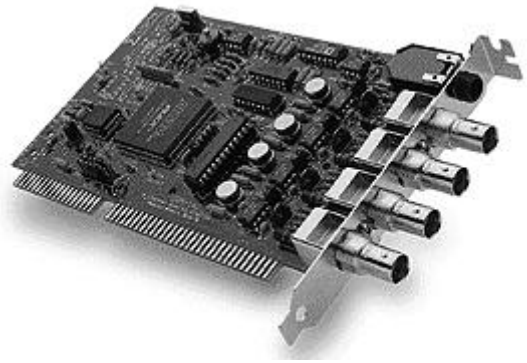
While the focus of this manual is on the SID-142 Controller package, it also covers each of these components separately. If you have purchased only the SQS-142 Software and/or the SQM-142 Card, we suggest that you also review Chapters 1 and 2 of this manual for important information.

1.1 SRC Series Computer

Sigma's SRC Series computers are Pentium class (or better) computers running the Windows 98 or NT operating system. The SRC computer series uses standard off-the-shelf components and Sigma's custom rack-mount chassis to provide a compact, low cost instrument.

Included in the 5.25" or 7" high rack-mount chassis are an LCD Display, a TouchPad pointing device, a setting Knob, and six SoftKeys. A keyboard is provided for initial setup, but is not necessary for normal operation of the SQS-142 deposition control software. An optional rack-mount keyboard is also available.

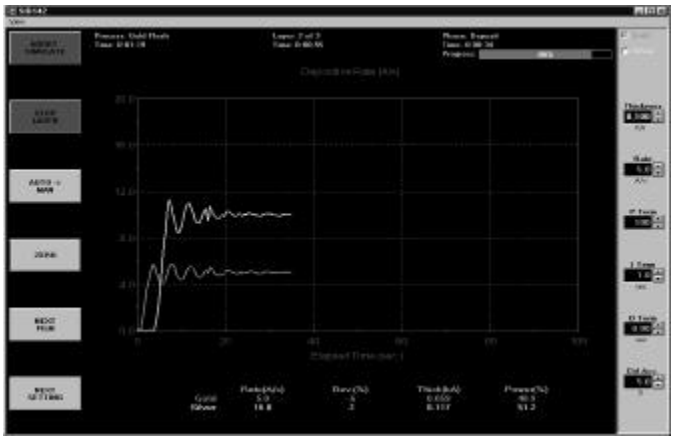
1.2 SQM-142 Deposition Control Card



Sigma's SQM-142 card installs in a computer ISA slot, and provides the interface to the vacuum deposition system. Each card measures up to four quartz sensors via BNC inputs, and supplies the control signal for two evaporation sources via a dual phone plug output. Up to two cards can be installed in a computer, creating an eight input, four output, codeposition controller.

The SQM-142 card is supplied with demonstration software written in Visual Basic and LabView, including complete source code. The SQM-142 card and a Pentium computer with Windows form a basic deposition control system (without digital I/O capabilities).

1.3 SQS-142 CoDeposition Control Software



Included with the SID-142 is Sigma's SQS-142 software, a Windows-based program that provides all of the functions required for an eight sensor, four output, codeposition process. It is optimized for use with the Setting Knob and six SoftKeys of our SID-142 controller. However, it will run on any Win9X system with our SQM-142 card installed.

The six SoftKeys provide easy access to the common operating functions. A single tabbed dialog box provides all of the settings required for a thin film process. Material parameters, sensor/source setup, pre/post conditioning, and error conditions are all visible on a single screen. Process settings, numeric data, and graphical displays are displayed during all phases of deposition.

The SQS-142 software stores process parameters in a Microsoft Access compatible database. This provides virtually unlimited access to desktop tools for building and analyzing thin film processes.

1.4 Digital I/O

Digital I/O for the SID-142 is provided through an inexpensive, external, programmable logic controller (PLC). This allows the PLC, and the associated I/O wiring, to be placed in a convenient location in a wiring cabinet. A single, serial communications cable runs to the SID-142 computer. The PLC provides electrical isolation, fail-safe operation, and extensive I/O processing capabilities through its ladder logic programming.

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2.0 Introduction

This section covers the minimum system connections and initial setup required to run the SID-142 Deposition Controller. Consult later chapters of this manual for more detailed setup and operational instructions.

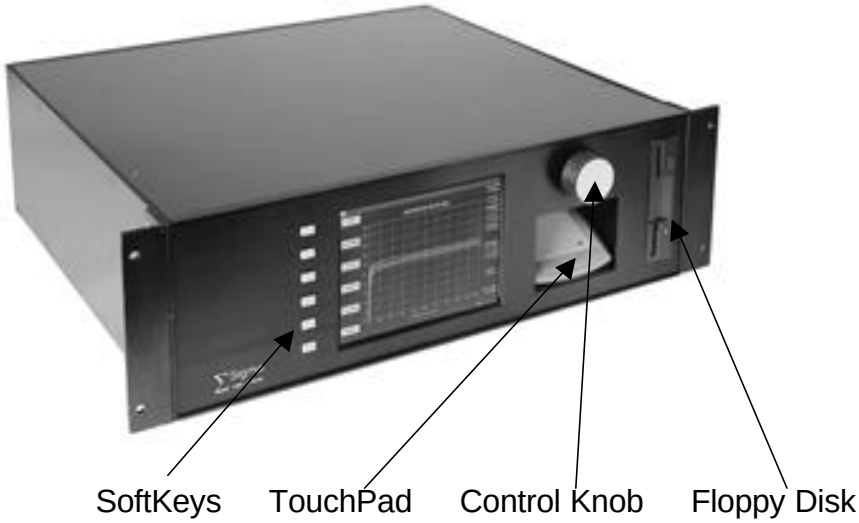
2.1 Installation

All electrical connections to the SID-142 are made at the back panel of the instrument.

WARNING: Care should be exercised to route SID-142 cables as far as practical from other cables that carry high voltages or generate noise. This includes other line voltage cables, wires to heaters that are SCR-controlled, and cables to source power supplies that may conduct high transient currents during arc down conditions.

Rack Installation	The SID-142 occupies a 5.25” high (4U) rack space. Install the unit in a 19” rack with the supplied hardware.
Power Connection	***WARNING***: Verify that the Voltage Selector Switch, located next to the power switch, matches your mains supply voltage. ***WARNING***: Verify that the power cable provided is connected to a properly grounded mains receptacle.
Sensor Input Connections	Connect the BNC cables and oscillators from your vacuum chamber feedthrough to the desired SQM-142 Card Input(s). Refer to Chapter 4 for detailed instructions on system hookup to the SQM-142 card(s).
Source Output Connections	Connect the dual phone plug from the SQM-142 output jack to your evaporation supply control input. Refer to Chapter 4 for detailed instructions on wiring the SQM-142 output phone plug.
Digital I/O Connections	Digital I/O is not required for initial operation of the SID-142. Perform initial setup and checkout of the SID-142 before connecting your digital I/O. Refer to Chapter 5 for detailed information on wiring the SID-142 for digital I/O.
Keyboard Connection	A keyboard is supplied for initial user setup of Windows. Attach the keyboard to the keyboard input jack on the rear of the SID-142. Once Windows is setup, use of the keyboard is optional.

2.2 Front Panel



Front Panel Controls

SoftKeys	Provide basic instrument operations within the SQS-142 deposition program. The SoftKeys are functional only in programs written specifically for the SRC computer.
TouchPad	Provides mouse functions in all Windows programs, including the SQS-142 software. Move your index finger along the touchpad surface to move the mouse. Press the left or right buttons below the touchpad surface to "click."
Control Knob	Used to adjust values within the SQS-142 software. Pushing the control knob stores the current setting, and moves to the next setting. Functional only in programs written specifically for the SRC computer.
Floppy Disk	1.44 MB floppy disk for upgrades, backup, and data storage/transfer.
Keyboard (not shown)	Required for Windows data entry, and useful during initial SID-142 setup. Not required for SQS-142 software operation. The F1 through F6 keys on the keyboard provide the same functions as the six SoftKeys on the front panel.

2.3 Program Startup

This section will start the SID-142 and run the SQS-142 deposition control program.

Power On the Computer

Move the rear panel power switch on the SID-142 to the On (|) position.

Start the Program

The SID-142 will boot Windows from the internal hard disk and start the SQS-142 deposition program. If the SQS-142 program does not start automatically, use the touchpad to double-click the desktop icon.

User Login Screen

The SID-142 displays a progress bar during program startup, then a User Login screen. Select a User Name from the drop down box, enter the Password, then click OK.

The SID-142 ships with one pre-assigned user. The user name is Super, with no Password. Depending on the access level of the selected user, a different set of program functions will be available. See Chapter 3 for more information on users, passwords, and access levels.

Process Database

The SID-142 normally starts with the last active process database. If that database is not found, a Database Open dialog will be displayed. Use the touchpad to navigate to the desired database.

Main Display

The main display shows a set of labels associated with the function of the six SoftKeys. As you operate the SID-142, these labels will change to display appropriate functions. Along the top of the display is a menu of less commonly used functions. This menu is available only when the SID-142 is stopped (i.e. not running a deposition process).

Simulate Mode

Simulate Mode allows you to familiarize yourself with SID-142 operation, and test process recipes. If the first SoftKey is labeled “Start Simulate” then the Simulate mode is active.

If the first SoftKey is labeled “Start” then normal mode is selected. Use the touchpad to select the Setup menu, then click System. Click the Simulate option button on the System tab. With the touchpad click the “Save” SoftKey label, or press the top SoftKey to activate simulate mode.

2.4 Single-Layer Process Setup

A thin film deposition process consists of one or more layers of material evaporated onto a substrate. Let's build a simple single-layer process.

Open Process Edit

Use the touchpad to click on the "Edit" menu selection along the top of the display, then click "Process." The Process Edit dialog will display the setup for the last process run.
To better understand process setup, see section 3.4.1.

Add A New Process

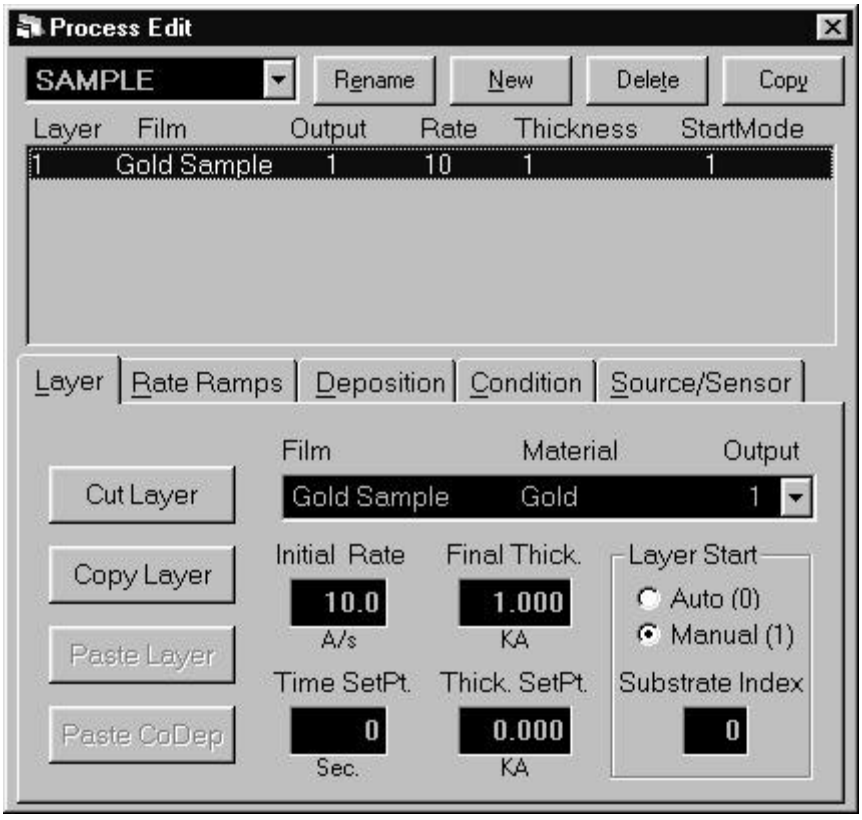
Click the "New" button in the dialog box. An on-screen keyboard appears, displaying the next numbered Process. Click "Backspace" several times to delete the name. Now "type" a new Process name using the touchpad and on-screen keyboard. Click "Enter" to save the new name.

Edit Film

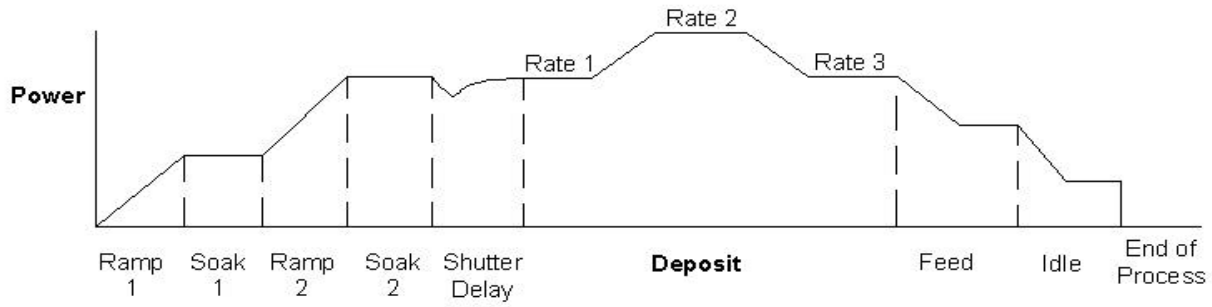
Click the "Layer" tab to assure the layer parameters are displayed. Select "Gold Sample" in the Film dropdown box.

Edit Rate and Thickness

Click the "Initial Rate" setting, and then use the Control Knob to adjust the Initial Rate to 10 A/s. Adjust the "Final Thickness" to 1.000 kA.



The diagram below illustrates a complete deposition cycle for a single layer. Refer to this diagram as we set the remaining process setup parameters.

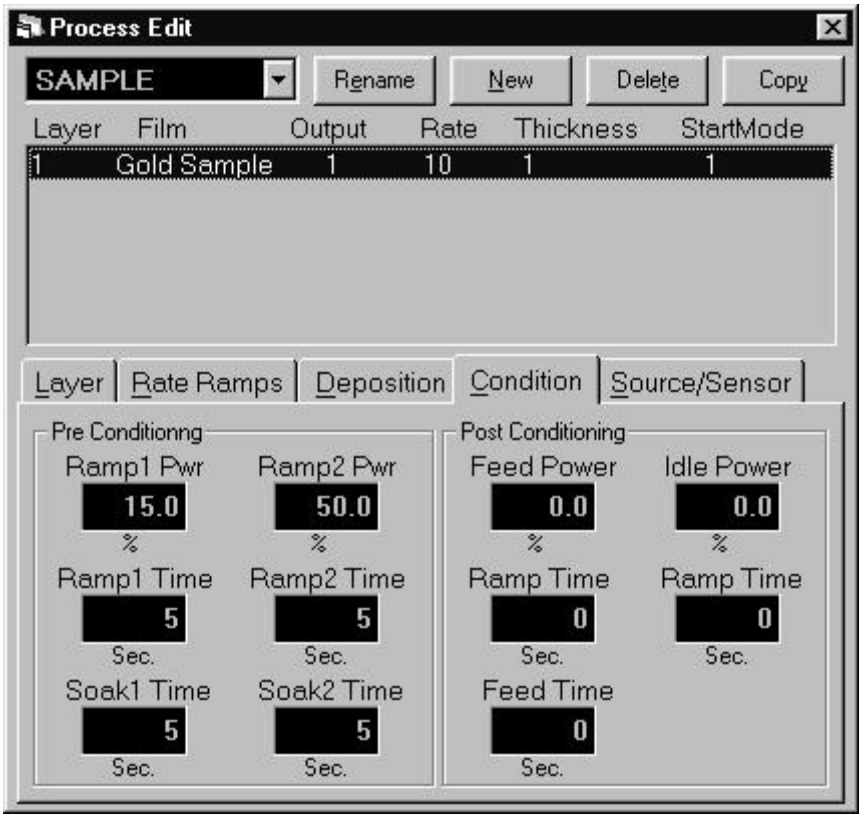


Edit Rate Ramps

It may be desirable to vary the deposition rate during a layer. For example, to deposit slowly at first, then more quickly once the initial material is deposited. Click the “Rate Ramps” tab, then click “Insert Ramp.” Adjust the “Start Thickness” to 0.400 kA, “Ramp Time” to 5 seconds, and “New Rate” to 15 A/s.

Edit Pre/Post Conditioning

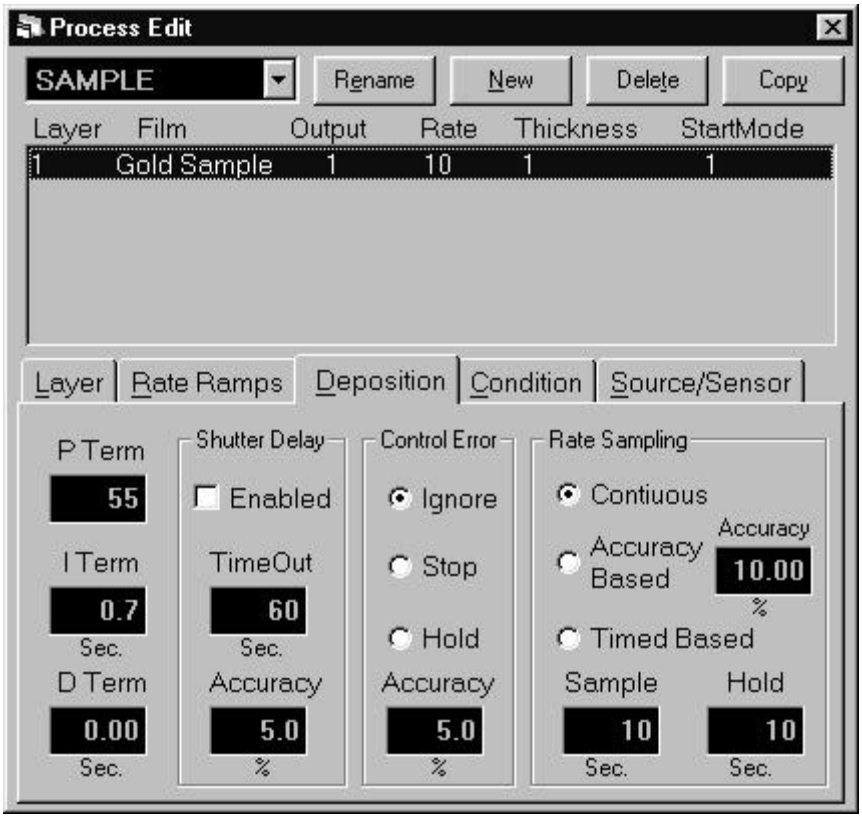
Before deposition begins, the source material is often brought to a ready state by raising the evaporation source power. Select the “Condition” tab and set each parameter to the values shown below.



Edit Deposition

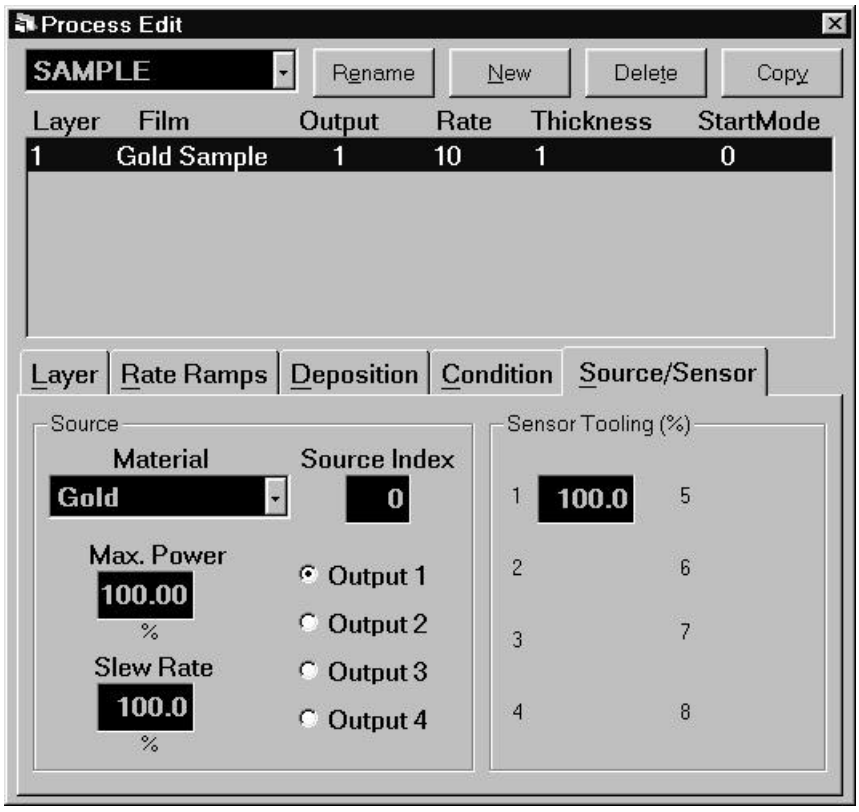
Select the “Deposition” tab. This tab establishes the gain (P Term), time constant (I Term), and dead time (D Term) for your process. Set these values to 55, .7, and 0 respectively.

Be sure Shutter Delay Enabled is not selected. Select Ignore for Control Error, and Continuous for Rate Sampling (see picture below).



Edit Source/Sensor

Select the “Source/Sensor” tab. This tab contains parameters associated with the physical layout of your evaporation system. For now, be sure that “Output 1” is selected and “Max Power” and “Slew Rate” are set to 100. Set the “Tooling” value to 100. Leave the Source Index as it is.



Save Edits

Click “Close Form” or press the first SoftKey to save this one-layer process. If you are prompted “Do you want to change….,” answer Yes to make this the current process.

Your new single-layer process is now the active process in the main window. Notice the process, layer, and time information above the graph.

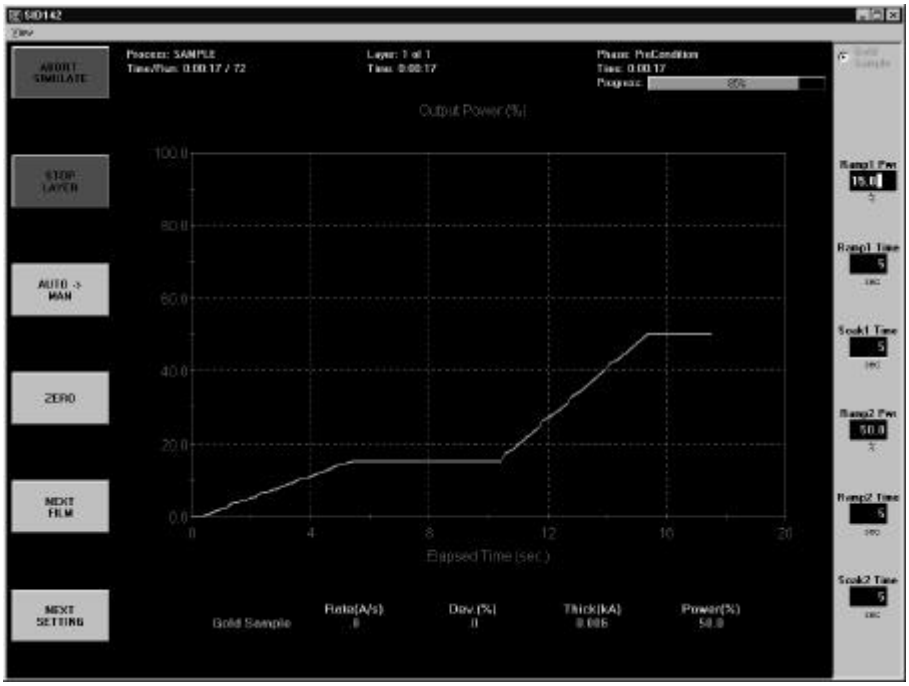
2.5 Single-Layer Process Simulation

If you have followed this chapter, you are ready to simulate a deposition process.

Setup Displays Click the "View" menu and assure that these options are selected: Film Settings, Film Readings, and Automatic. Note that the settings "ribbon" along the right displays the pre-conditioning parameters you entered in the previous section.

Start Process Verify that the top SoftKey label displays "START SIMULATE." If only "START" is displayed, follow the instructions at the end of Section 2.2 to enable simulate mode. Press the "START SIMULATE" SoftKey, or click the label with the touchpad, to start the process.

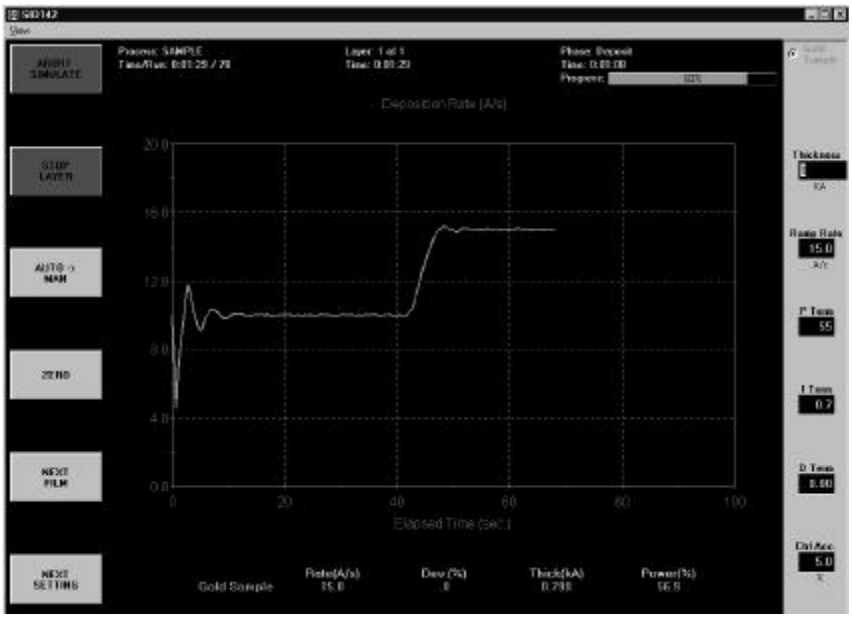
The process will start with preconditioning (i.e. Ramp1, Soak1, Ramp2, Soak2) as shown below. Once preconditioning is complete, the process will enter the Deposit phase. You may want to select "ABORT SIMULATE," then "START SUMULATE" several times to familiarize yourself with the on-screen displays during preconditioning. You may also want to use the settings ribbon to adjust parameters while the process is running.



Preconditioning Phases

Because we selected "Automatic," in the View menu, the graph displays Output Power during preconditioning, then switches to Rate during the deposition phase.

As shown below, the initial deposition rate was 10 A/s until a thickness of .400 kA. Then the deposition rate was ramped up to 15 A/s, and held until the desired final thickness of 1.000 kA is achieved. At this point, this single-layer process is finished.



Deposition Phase with one Rate Ramp

You should adjust the PID parameters on the setting ribbon, then Start/Stop the process several times to become familiar with their effect on control loop response.

2.6 SoftKey Functions

As you have seen, the SoftKey functions remain constant during deposition. Spend a few minutes to become familiar with each of these SoftKey functions.

STOP/ABORT	Starts the first layer of a process when START is displayed. Aborts the process when ABORT is shown. Once aborted, a process restarts at the pre-conditioning phase of the first layer.
START/STOP LAYER	Restarts a stopped layer, or starts a layer that has been designated “Manual Start” in the process database. During deposition, stops the current layer. Once a layer is stopped, pressing START LAYER restarts the current layer at the preconditioning phase.
AUTO-> MAN	Toggles the source output between PID and manual control. When AUTO->MAN is shown, pressing this switch causes the source output to hold at the current power. You may adjust the output using the settings ribbon. Because the PID loop is not running, you can manually set the output power to different levels and observe the associated deposition rate. When MAN->AUTO is shown, pressing the switch places the output under PID control as defined by the process database.
ZERO	Resets the thickness reading to zero. This is useful in Simulate Mode for preventing the deposition phase from ending because final thickness has been reached. As you change PID parameters, press “ZERO” from time to time to keep the process running.
NEXT FILM	Sequences the setting ribbon through each Film in a codeposition layer.
NEXT SETTING	When the settings ribbon is shown, sequences the setting knob action through each of the displayed parameters.

2.7 Multi-Layer CoDeposition Process

Our final example builds on the previous sections. If you have modified the setup of your process, return to Section 2.4 and adjust the process to those values. When your single-layer process matches Section 2.4, complete these steps:

Duplicate a Layer

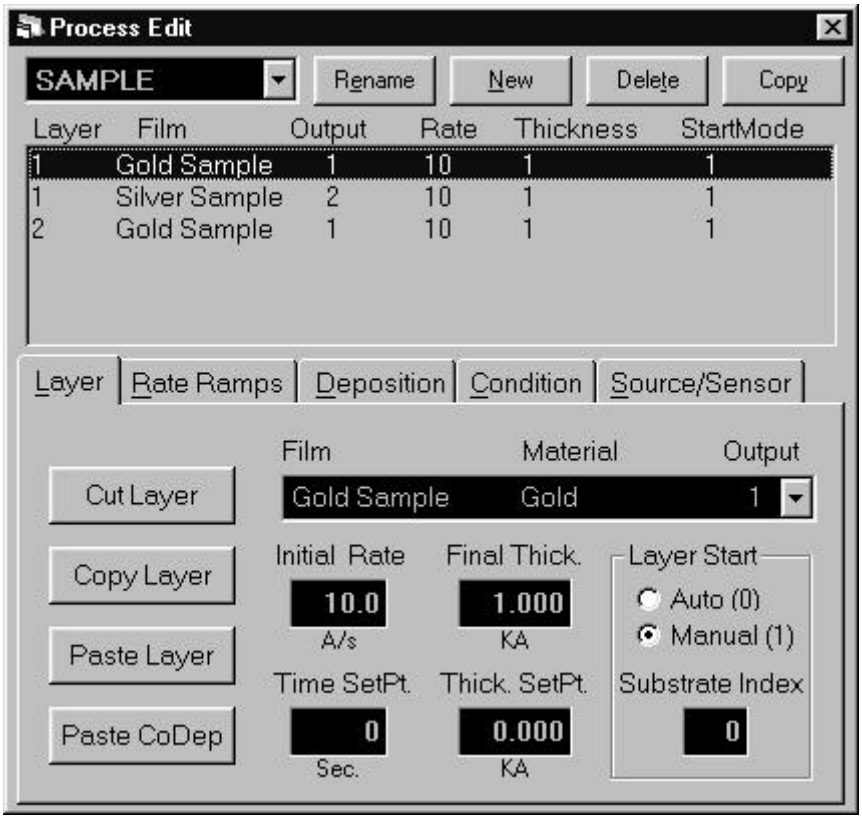
Open the Edit Process dialog. Click on Layer 1, click the "Layer" tab, then click "Copy Layer." Now click "Paste Layer." A duplicate Gold Sample film will be added as Layer 2. Click "Paste Layer" again to add a third Gold Sample layer.

Select a CoDep Film

Select Layer 3 in the layers list. Now select "Silver Sample" in the films dropdown. The layers list will update to show the new Silver Sample film assigned to Layer 3.

Add a CoDep Layer

Select Layer 3 in the layers list, then click "Cut Layer." Now select Layer 1. Click "Paste CoDep." The Silver Sample film will be added below Gold Sample as a codeposition layer. (Your setup should match the picture below.)



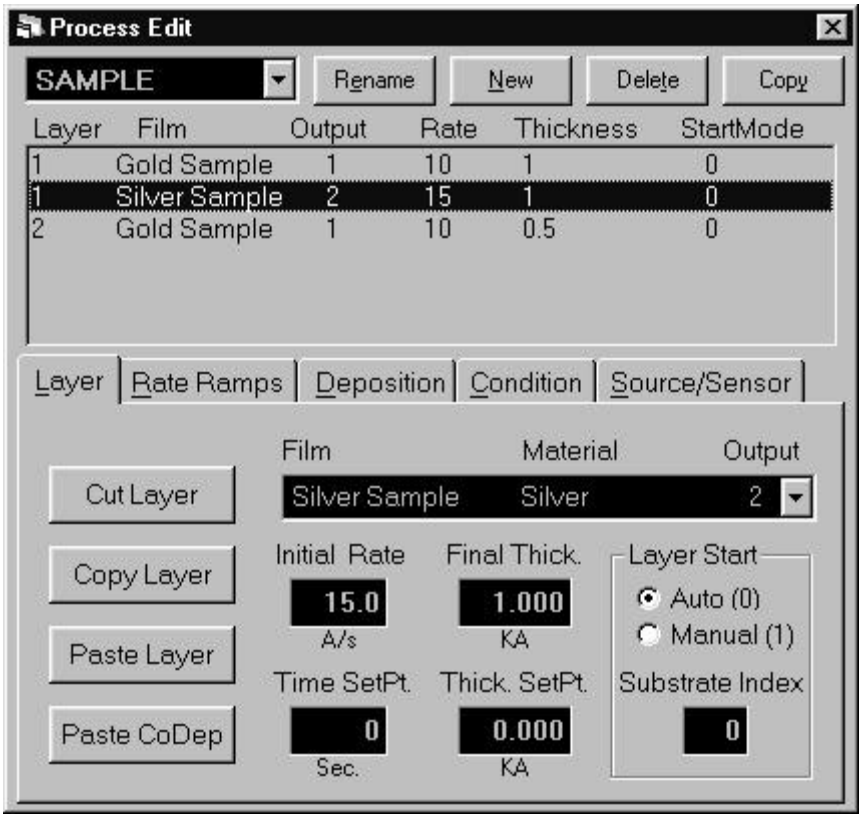
We now have two layers in our process. Layer 1 has Gold being deposited from source Output 1 and Silver is being codeposited on Output 2. Layer 2 is Gold alone.

Hint: It's usually best to copy a layer, then paste several temporary layers of that type. Next, assign the films that you want to each of the pasted layers. When selecting films for codeposition, remember that each film in a codeposited layer must be assigned to a different source output! Now use "Cut Layer" on the temporary layers, and "Paste CoDep" to assign the film to the desired codeposition layers. Review this example until you are comfortable with these concepts.

Edit Layer 1 Rate & Thickness Click Silver Sample in the list of layers. Set "Initial Rate" to 15 A/s, "Final Thickness" to 1.000 kA. Click the Rate Ramps tab and adjust "Start Thickness" to 0.400 kA, "Ramp Time" to 15 seconds, and "New Rate" to 0 A/s.

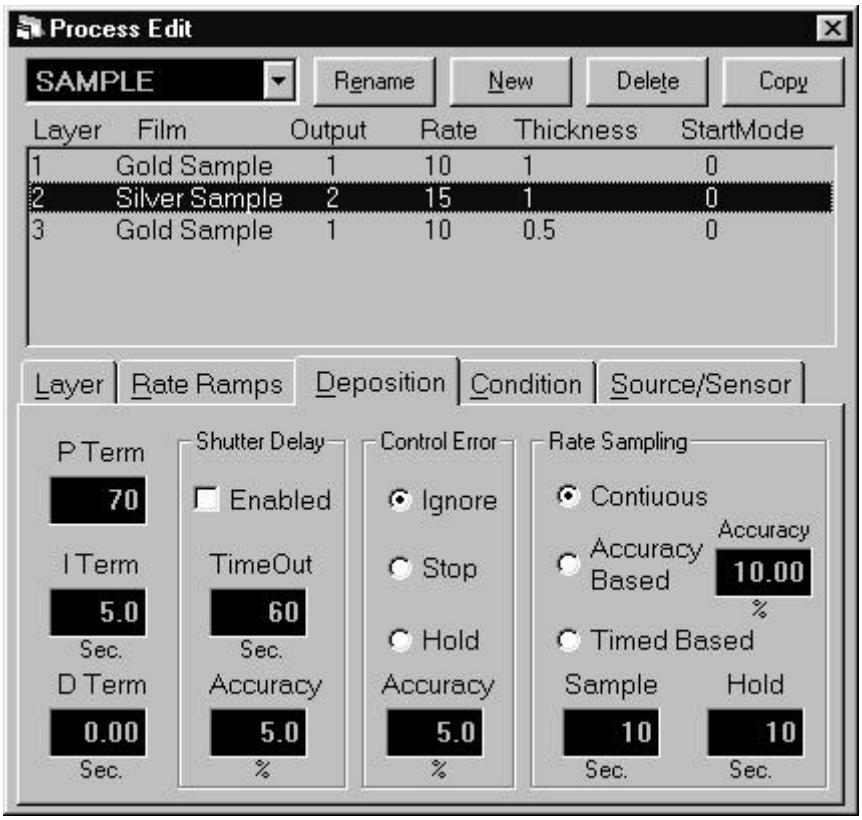
Edit Layer 2 Rate & Thickness Click the Layer Tab, then click Layer 2. Set Final Thickness to .5000 kA.

Set Layers to Auto Start At the end of deposition, you may choose to have the next layer wait for a Start Layer command, or to start automatically. Select each Layer in the layers list, then click Auto to set that layer to start automatically.



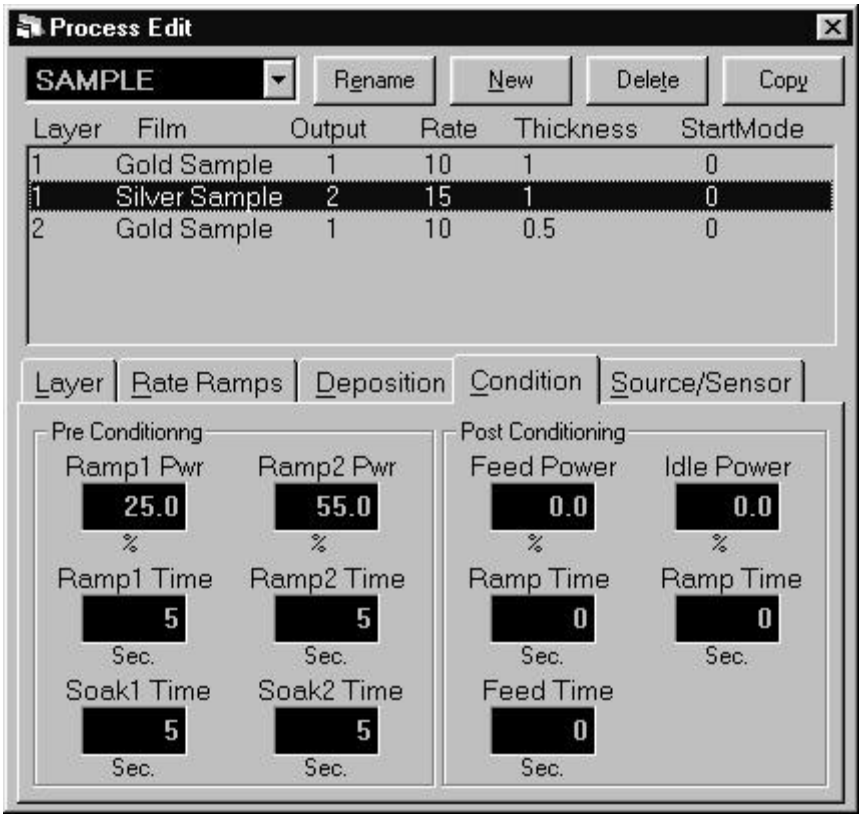
Verify that your process matches the one shown above.

Edit Silver Deposition Select the "Deposition" tab and the Silver Sample layer. Set each parameter to the values shown below.


Process Edit
SAMPLE
Rename
New
Delete
Copy
Layer Film Output Rate Thickness StartMode
1 Gold Sample 1 10 1 0
2 Silver Sample 2 15 1 0
3 Gold Sample 1 10 0.5 0
Layer
Rate Ramps
Deposition
Condition
Source/Sensor
P Term
70
I Term
5.0
Sec.
D Term
0.00
Sec.
Shutter Delay
Enabled
TimeOut
60
Sec.
Accuracy
5.0
%
Control Error
Ignore
Stop
Hold
Accuracy
5.0
%
Rate Sampling
Contiuous
Accuracy Based
Accuracy
10.00
%
Timed Based
Sample
10
Sec.
Hold
10
Sec.

Edit Silver Conditioning

Select the “Condition” tab and the Silver Sample layer. Set each parameter to the values shown below.



Save Edits

Click “Close Form” or press the first SoftKey to save this two-layer codeposition process. Answer Yes if it displays the “Do you want to change….” message box to make this the current process.

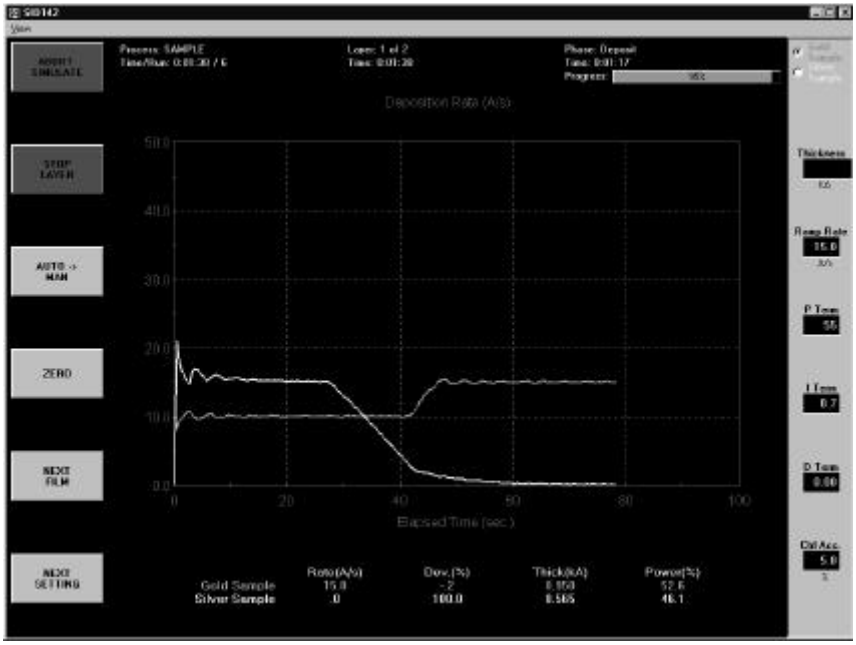
Start Process

Press the “START SIMULATE” SoftKey to start the first layer preconditioning phases. Note that two outputs are displayed for this codeposition layer.

Preconditioning of the two materials is entirely independent. If the preconditioning of one layer takes longer than the other, the start times are adjusted so that the end times coincide.

When preconditioning ends, codeposition of the two materials begins.

Your response should be similar to the graph shown below (your vertical scale may be slightly different). The slight ringing on the waveforms indicates some further tuning may be desired. However, this is an example of a reasonably well tuned loop.



At .400kA thickness, the Silver Sample deposition rate ramps down from 15A/s to 0. Similarly, at .400 kA thickness the Gold Sample film ramps to a higher deposition rate of 15A/s. Because the initial rate for Gold was set lower than the initial rate for Silver, Gold reached its .400 kA thickness rate ramp trigger later in the deposition cycle.

Try a P Term in the 25-30 range (less gain) for both Gold and Silver to decrease the loop susceptibility to noise. Increasing the I Term a little, say toward 1.0, will lessen overshoot during rate changes. The D term can be thought of as a “dead band” term. Most systems require little or no D term.

2.8 Conclusion

Once again, spend some time with this process to become familiar with its setup, and the effect of changes on deposition performance.

Because we selected Simulate Mode at the beginning of this Quick Start session, the SQM-142 card is “faking” an actual process. You can use the Simulate feature at any time to become familiar with SID-142 operation, and the effect of various settings on process performance. It is also a very useful feature for pre-testing your process setups. Return to the Setup menu, then select System and set the Mode to Normal to begin running your process with the SID-142 controller.

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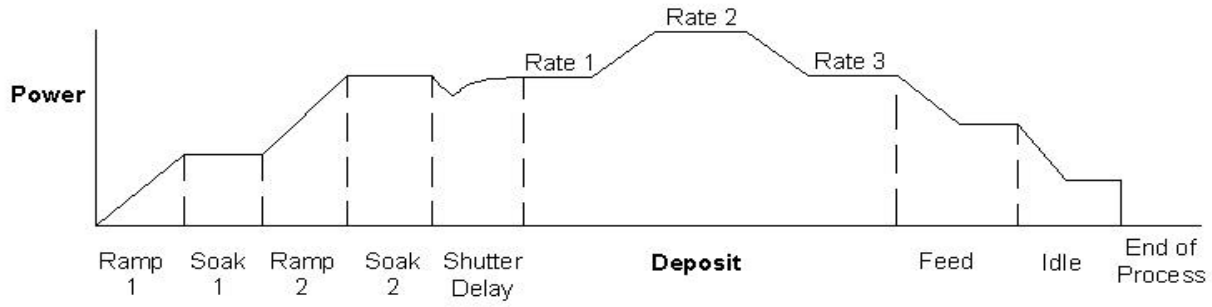
3.0 Introduction

The SQS-142 Deposition Control Software works with Sigma Instrument's SQM-142 QCM Card to provide an inexpensive, yet powerful, PC based Thin Film Deposition Controller that can:

- Measure up to eight quartz crystal sensors simultaneously
- Control up to four deposition source supplies simultaneously
- Codeposit up to four films with preconditioning, multiple rate ramps, and feed/idle phases
- Graph deposition rate, rate deviation, or power output
- Store process, film and material parameters in Microsoft Access database
- Use inexpensive PLCs for flexible and reliable external process controls

A typical deposition cycle for a thin film is shown below. The cycle can be broken into three distinct phases: pre-conditioning (ramp/soak), deposition, and post-conditioning (feed/idle). During pre-conditioning, power is supplied to prepare the evaporation source for deposition. Once the pre-conditioning period expires, material deposition begins. During deposition, the PID loop adjusts the evaporation source power as required to achieve the desired deposition rate. When the desired thickness is reached, the evaporation source is set to idle power. At this point the process may be complete, or deposition of another film layer may begin. If desired, up to four separate films can be codeposited within a single layer.



The SQS-142 software installs on any PC running Windows 95/98. An SQM-142 measurement card must also be installed in an ISA slot of the PC. The SQM-142 interfaces both to external quartz sensors and to an external evaporation power supply, in order to provide a complete deposition control system.

The SQS-142 software allows you to build the recipes and perform the operating functions required to control all aspects of multi-layer thin film deposition. Process recipes are stored in Microsoft Access format. There is no practical limit to the number of processes, films, or materials that can be stored in the database.

3.1 Installation

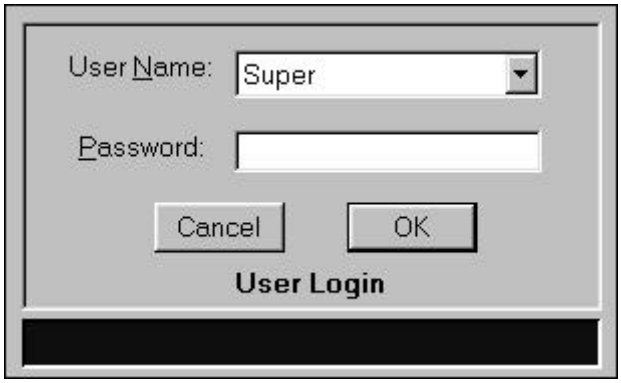
The SQS-142 install program is available on CD-ROM or 3 ½" diskettes. The 3 ½" diskette install is also available by copying the contents of each of the CD-ROM "Disk" subdirectories to blank 3 ½" diskettes.

To install the program, start Windows, then insert the disk or CDROM into your computer. Click Start, then Run, then type <d>:Setup (where <d> is the drive letter you are using). Click OK to begin installation, and follow the on-screen prompts. When installation is complete, you should restart your computer to load any new Windows DLL and OCX support files.

The SQS-142 software can simulate deposition for demonstration and tutorial purposes. However, an SQM-142 deposition controller card must be installed to actually read sensors and control a source supply. The SQM-142 card can be installed before or after the SQS-142 software. Consult Chapter 4 for SQM-142 card installation information.

3.2 Operation

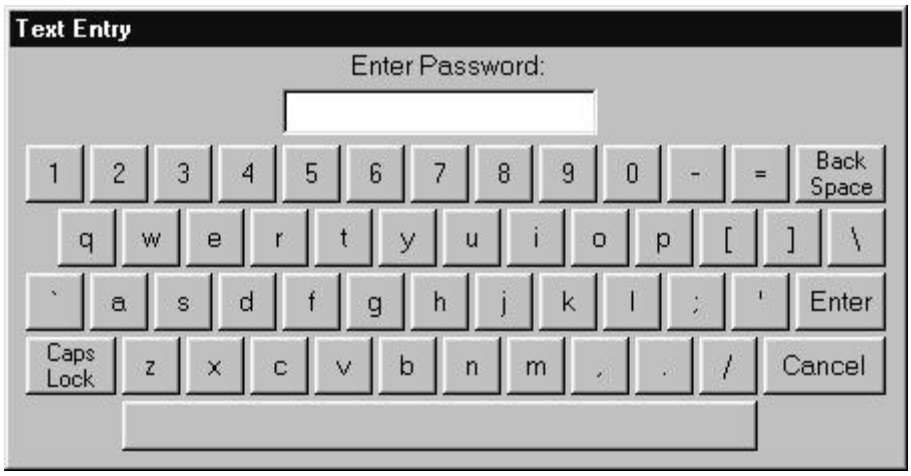
To start the SQS-142 program, click Start, Programs, Sigma Instruments, hen SQS-142. The SID-142 displays a progress bar during startup, then a User Login screen.



Note: The SQS-142 software ships with one pre-assigned user. The user name is Super, with no Password.

Select a User Name from the drop down box, type in the Password, and then click OK to start the program.

If your software is configured for keyboardless operation, an on-screen keyboard will appear as shown below. If the on-screen keyboard appears, use the mouse or touchpad to "type" the password, then click Enter. See the section System Setup, SQM-142 Setup later in this chapter to enable or disable the on-screen keyboard.



An Access Level is also associated with each User Name. The Access Level controls which software functions are available to a user. For example, only users with an Access Level of Supervisor can assign users. See the Security section of this chapter for information on setting up users.

The remainder of this chapter covers the purpose and operation of each software function, arranged my menu selections. For a more “operational” approach, consult the previous Quick Start chapter.

Menus: The menus along the top of the main screen provide access to functions for building deposition processes, configuring the hardware for your vacuum system, and other less commonly used functions.

SoftKeys: The six switches to the left of the display are used for the normal operation of the instrument, and to navigate the setup programs (see below for the individual switch functions). Normally, you press the button that is adjacent to the labels on the SID-142 screen, but you can also use the mouse. Just move the mouse over the key label on screen and single click the mouse. You can also use the keyboard F1 to F6 function keys to simulate the front panel function switches. The SoftKeys change during operation to address different user input requirements.

Setting Knob: The knob to the right of the display is used by the SID-142 to set numeric data. A keyboard can also be used.

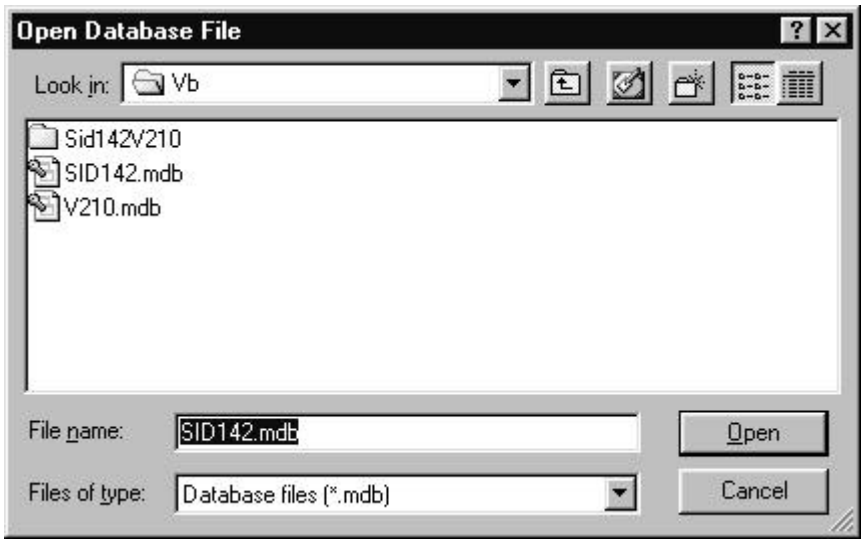
TouchPad: On the SID-142, a touchpad is located below the setting knob. The touchpad serves the same function as a normal mouse. Use your mouse to access the menus, and for functions not available from the six function keys.

3.3 File Menu

Note: The current process must be stopped for the File menu to be available.

Process: Used to select a process to be run from a list of processes in the database. If the process selected is different than the current process, you are prompted to confirm the change.

Open Database: Selects the process database to be used for thin film deposition. A single process database may contain an unlimited number of processes, films, and materials.

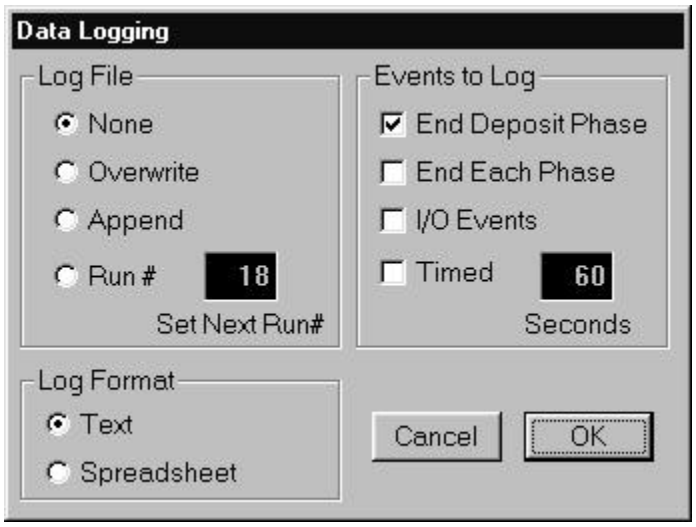


Save Database As: Saves the current process database to disk under a different name. This is useful for saving a process database to floppy disk, or for making trial changes without affecting a reference database. Once again, a pop-up keyboard may appear. If you want to browse or type in the database name, just select Cancel from the pop-up keyboard.

Process databases are saved in Microsoft Access format.

Data Logging: Saves deposition data to a .LOG text file. If an option other than “None” is selected in the Log File section, data logging is activated, and begins saving information in a .LOG file in the SQS-142 installation directory (typically: \Program Files\Sigma Instruments\SQS-142).

There are three options for file naming and logging. If “Overwrite” is selected, only last run of the process is saved, and it appears as ProcessName.LOG. Subsequent runs overwrite the log file. If “Append” is selected, each subsequent run will be appended to ProcessName.LOG. If “Run#” is selected, each run of the process is saved as a separate file under the format ProcessName_Run#.LOG.



A number of “events” can trigger a data entry in the log file. “End Deposit Phase” records process data (rate, thickness, time, etc.) at the end of each layer’s deposit phase. Similarly, “End Each Phase” logs data at the end of each phase (conditioning, depositing, etc.). “I/O Events” logs data each time an external digital input or output changes. Finally, “Timed Logging” records data at the selected time intervals throughout the process.

There are two formats for writing data. If “Spreadsheet” is selected, each entry is a comma-delimited line of data. If “Text” is selected, the data is formatted for easy reading. The first few lines of the file illustrate its format and content. Log files can be viewed using a word processing or spreadsheet program.

Print Process: Prints the parameters for the current process to the system printer. Select “Print to File” in the Printer Setup Menu to print the data to a file.

Print Setup: Selects and modifies the current system printer.

User Login: Displays the User Login screen so that a different user may login. The existing user is logged off automatically. The program access level changes immediately to that of the new user.

Exit: Exits the SQS-142 deposition control program.

3.4 Edit Menu

3.4.1 Edit: Process

A process is a sequence of film layers. Multiple films deposited in the same layer are known as codeposition. A listing of each film in the selected process appears in the layers list box. Films in codeposition layers are listed with the same layer number. Select a layer to edit its parameters in the tabbed dialog boxes.

The Edit Process dialog provides all the functions needed to develop a thin film deposition process from the database of existing films and materials. The Layer and Rate Ramp tabs specify the sequence of films to be deposited. The Deposition, Condition, and Source/Sensor tabs provide control over the individual films assigned to each layer.

Note: Edits to the Deposition, Condition, and Source/Sensor tabs will affect all processes and layers that use the selected film!

Process: A drop down box that selects the process to be edited. Defaults to the current process.

Rename: Edits the name of the selected process.

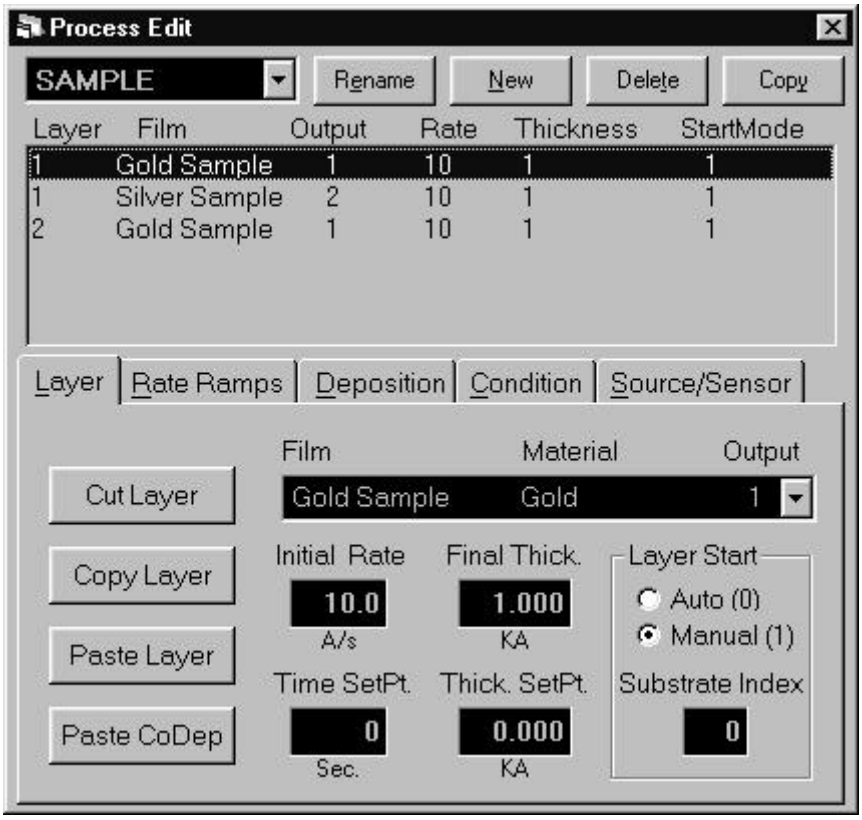
New: Creates a new process. Since every process must have at least one film, the first film of the currently selected process is used.

Delete: Deletes the currently selected process from the database. *There is no undelete!*

Copy: Creates a duplicate of the currently selected process.

Layer Tab

The layer tab provides the capabilities needed to add and delete process layers, as well as to edit the film, rate & thickness for each layer. Normally each film in a process is run sequentially, as layers. Codeposition represents different films that are deposited concurrently with other films, in the same layer.



Cut Layer: Removes the layer selected in the Layers list box from the process, and places the layer on the clipboard.

Copy Layer: Places the layer selected in the Layers list box on the clipboard, without removing it from the process.

Paste Layer: Inserts the clipboard layer above the currently selected layer in the Layers list box. Existing layers are shifted down.

Paste CoDep: Pastes the clipboard layer as a codeposition layer at the currently selected layer number. Films that use outputs already assigned to the selected layer are invalid.

Hint: It's usually best to copy an existing layer, then paste several temporary layers of that type. Next, assign the films that you want to each of the temporary layers. When selecting films for codeposition, remember that each film in a codeposited layer must be assigned to a different source output! Now use "Cut Layer" on the temporary layers, and "Paste CoDep" to assign each temporary layer to the desired codeposition layer. The Multi-Layer CoDeposition Process section of Chapter 2 illustrates this concept.

Film: Selects the film that is assigned to the selected layer. Changing a layer's film also changes the film related parameters for that layer (i.e. preconditioning, PID, material, etc.)

Initial Rate: Sets the initial rate setpoint for the selected layer. If no rate ramps are defined for the layer, this is the rate setpoint for the entire layer.

Final Thickness: Sets the endpoint thickness for the selected layer. When final thickness is reached, deposition is stopped for that layer and the feed/hold phase is entered.

Time Setpoint: Sets an arbitrary time, after deposition begins, when the time setpoint relay is activated.

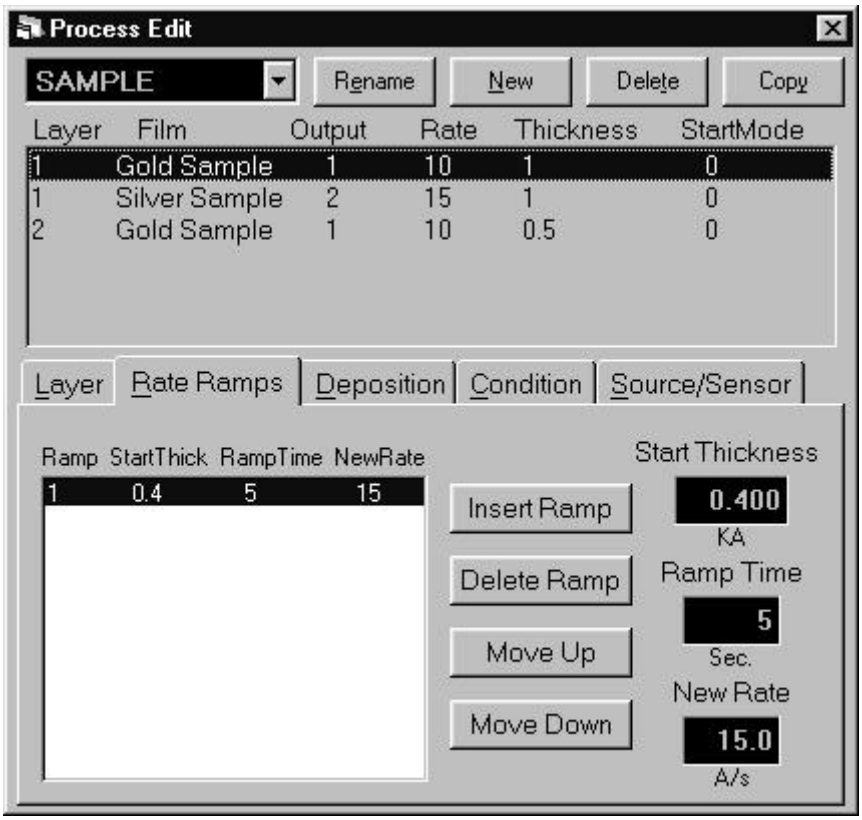
Thickness Limit: Sets an arbitrary thickness when the thickness limit relay is activated.

Auto/Manual Start: Determines whether a layer begins automatically upon completion of the previous layer. If Manual Start is selected, the previous layer ends at its idle power and waits for the user to push the Start Layer switch.

Substrate Index: If using a substrate indexer, assigns the substrate to a specific angle or placement value (0-15). These values are sent to the digital I/O PLC at the beginning of each layer for interfacing to a specific indexer. See System Setup and Digital I/O for other settings that pertain to the substrate index.

Rate Ramps Tab

Under PID control, rate ramps cause changes to the deposition rate over time. Each rate ramp has a starting thickness, an elapsed time to ramp to a new rate, and a new rate setpoint. Each process layer can have an unlimited number of rate ramps.



Insert Ramp: Inserts a new rate ramp for the selected layer, at the selected position. Existing rate ramps are shifted down.

Delete Ramp: Deletes the selected rate ramp.

Move Up: Shifts the selected rate ramp up one position.

Move Down: Shifts the selected rate ramp down one position.

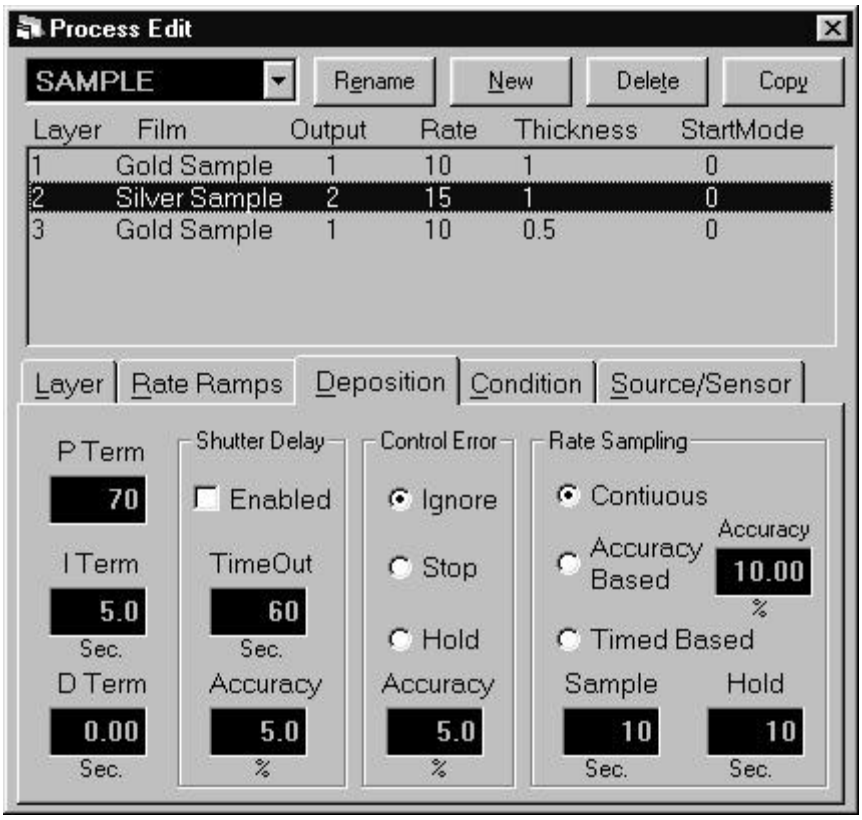
Start Thickness: The thickness that triggers a timed ramp to a new rate. (Start thickness should be greater for each subsequent ramp, and less than the final layer thickness, otherwise the rate ramp is skipped.)

Ramp Time: The time (in seconds) to ramp to the new rate. If the rate ramp is too fast, a PID control error may be generated.

New Rate: The new rate setpoint for the selected layer.

Deposition Tab

The deposition tab contains parameters that directly affect the deposition phase of the process cycle.



P Term: Sets the gain of the control loop. High gains yield more responsive (but potentially unstable) loops. Try a value of 50, then gradually increase/decrease the value to respond to step changes in rate setpoint.

I Term: The integral term controls the time constant of the loop response. A small I term, say .5 to 1 seconds, will smooth the response of most loops.

D Term: The differential term causes the loop to respond quickly to changes. Use 0 or a very small value to avoid oscillations.

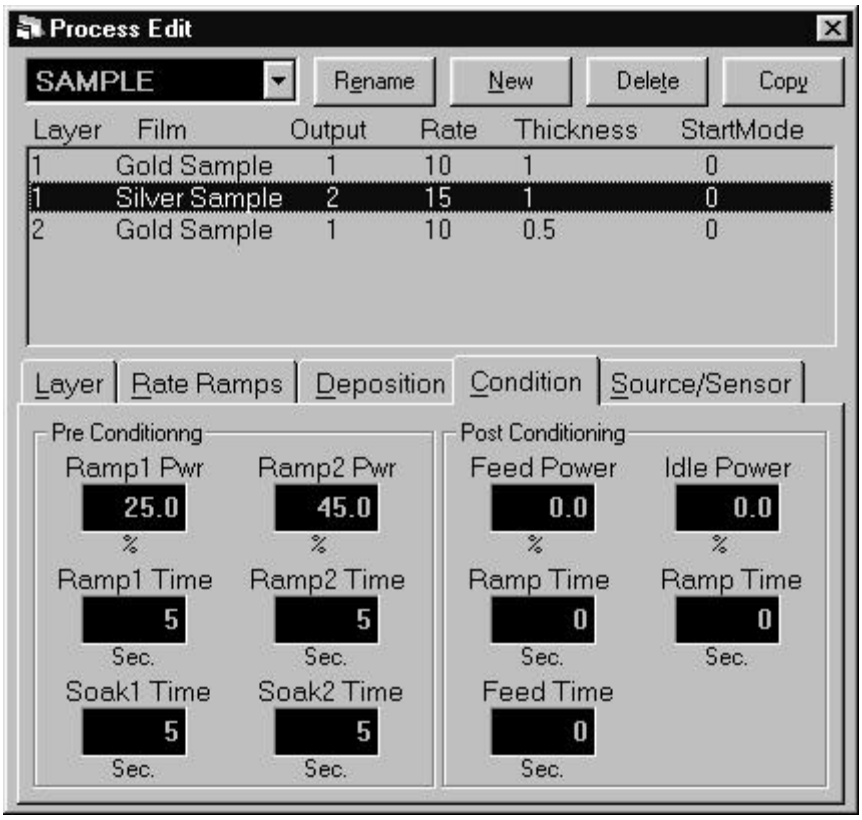
Shutter Delay: It is often desirable to obtain deposition control before the substrate shutter opens. Enabling shutter delay requires that the system reach a specific control accuracy before deposition begins. If the accuracy is not reached, the process halts. If accuracy is reached, the substrate shutter opens and deposition begins when control accuracy has been maintained for 5 seconds. The Thickness reading is zeroed at the end of the shutter delay period. If the system does not reach the control accuracy, the time out function determines the length of time before the process carries out the chosen action (halting, holding, etc.). Accuracy sets the accuracy that the process must reach before deposition begins.

Control Error: If the control loop cannot maintain the desired deposition rate, due to loss of source material, excess rate ramps, or equipment malfunction, a control error occurs. The error condition can be ignored, the process stopped (output power to 0%), or the output power held at the same level as when the error occurred. If hold is selected, PID control is abandoned, but the process will continue to be monitored for thickness setpoint. The control error accuracy is the value that must be exceeded for 5 seconds to trigger a control error. Use shutter delay accuracy, under the Conditioning tab, to assure adequate process control before entering the deposition phase.

Rate Sampling: Rate sampling can extend the life of crystals. With rate sampling, the deposition rate is sampled for a period of time, then the sensor shutter is closed. Power is then held at the same level as the final power setting during the sample period. Continuous selects no sampling; the sensor shutter remains open during deposition. Accuracy Based sampling opens and closes the shutter at the rate required to maintain the desired accuracy during the hold phase. Time Based sampling opens the shutter for a fixed period of time then closes it for a fixed time.

Condition Tab

Before deposition begins, it is often necessary to precondition the source material. This places the system in a state to achieve rapid PID control when deposition begins.



Ramp 1: Ramp power sets the power level desired at the end of the ramp phase, in % of full scale. Ramp time sets the time to ramp with a linear rate from the initial power to the Ramp power. Soak time sets the time the output remains at the ramp power level.

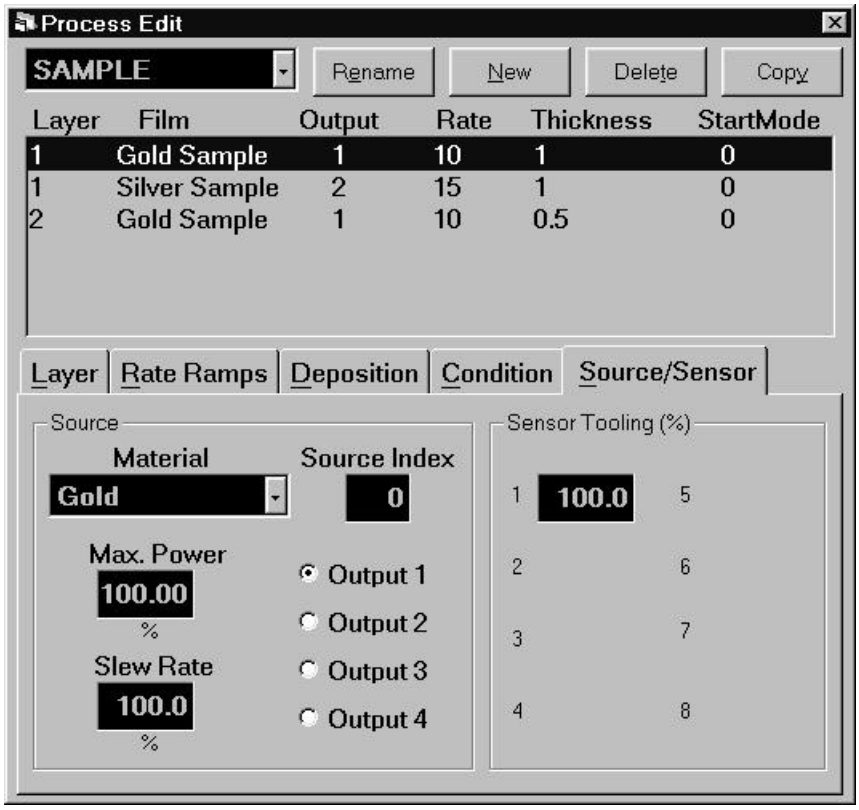
Ramp 2: Ramp 2 functions are the same as Ramp 1. Typically, Ramp 2 power is set near the power level required to achieve the desired initial deposition rate.

Feed: The feed phase holds output power at the level and time required to wire feed new material.

Idle: The Idle phase ramps the material to a state that is ready for deposition, typically the same as Ramp 2 power.

Source/Sensor Tab

The Source/Sensor tab controls the physical setup of the deposition system.



Material: Selects the physical deposition material

Max Power: The maximum output power allowed for the selected output. The full scale output voltage is a function of the deposition power supply input specifications, and is set in the SQM-142 setup. Max Power controls the maximum power that can be used by this process layer.

Slew Rate: The maximum power change allowed on an output, per second. If power or rate ramps exceed this value, an error will occur.

Source Index: If using a source index, assigns each film to a specific pocket (one of 16 values), in addition to an output. These values are sent to the PLC at the beginning of each layer. See the System Setup for other settings that pertain to the source index.

Output: Assigns the selected material to one of the source control outputs. When an output is selected, the Sensor Tooling panel changes to show only those sensors that are assigned to the output in the Edit, System dialog. The combination of a source output and its sensor inputs defines the deposition “control loop” for the selected material.

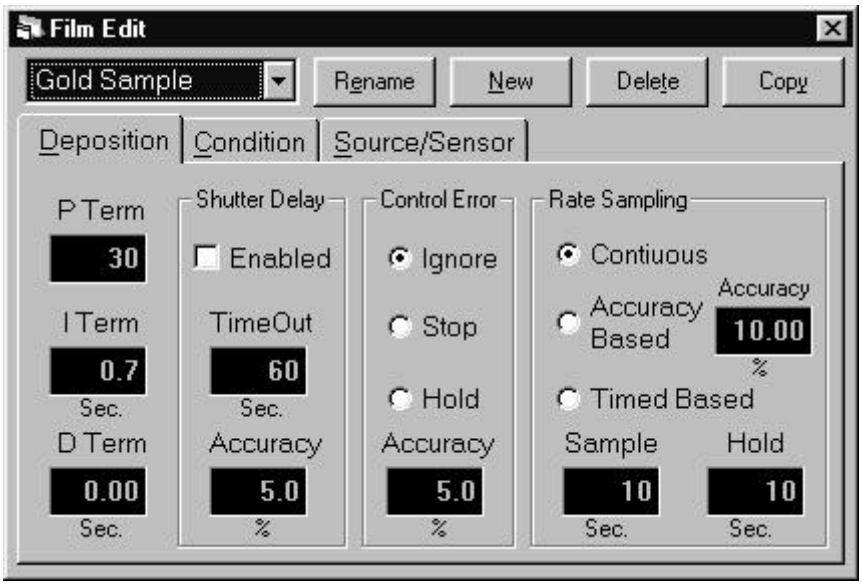
In codeposition, a layer may have multiple films, with each material using a different output and sensor selection for control. However, a layer cannot have the same output assigned to more than one film. If you try to assign the same output to multiple films in a layer, an error message will be displayed. Also, reassigning a film to a different output may impact other stored processes. If the change would create an output conflict in another process, an error message is displayed.

Sensor Tooling: Adjusts for sensor deposition rates that differ from the substrate deposition rate. For example, if the sensor sees only 50% of the substrate rate, set the value to 50%. Setting Tooling to 0% causes a sensor to be ignored for this film.

3.4.2 Edit: Films

The Edit Films dialog provides a subset of the functions of the Edit Processes dialog. The functions are those that pertain only to a specific film.

NOTE: Edits to a Film will affect all processes and layers that use that film!



Film: A drop down box that selects the film parameters displayed in the edit film dialog box. Defaults to the current process film.

Rename: Edits the name of the selected film.

New: Creates a new film.

Delete: Deletes the currently selected film from the database. A film cannot be deleted if it is used in ANY database process!

Copy: Creates a duplicate of the currently selected film.

The function of each Edit Films tab, and its associated controls, are detailed in the Edit Processes section. Please consult 3.4.1 for that information.

3.4.3 Edit: Materials

The Edit Material dialog provides the functions needed to build a materials database. In addition to the functions listed below, the main screen function keys provide capabilities to add/edit/delete materials.

Material: Selects a material to edit.

Density: Sets the density for this material. Material density has a significant impact on deposition calculations.

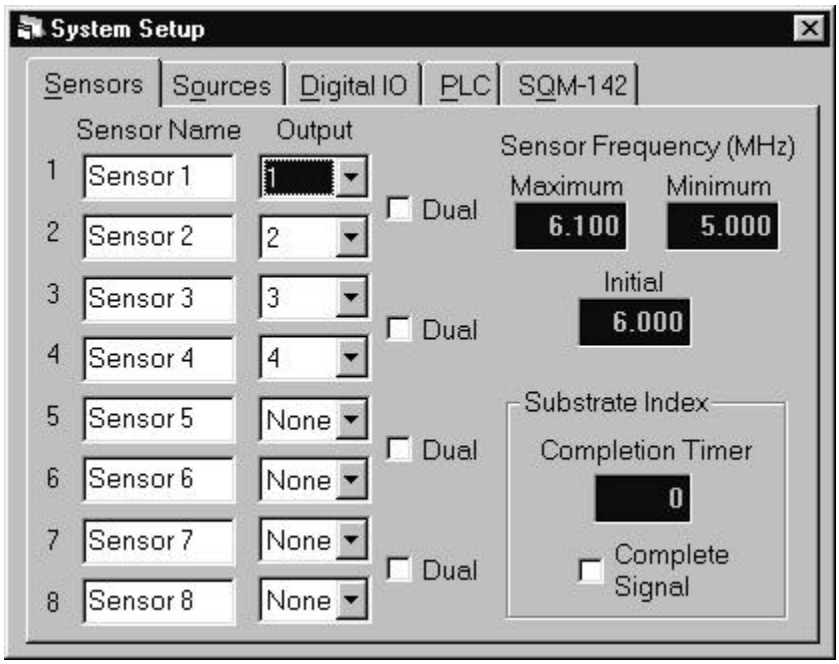
Z-Factor: Sets the Z-factor, an empirically determined measure of a material's effect on quartz crystal frequency change.

See the Appendix for a list of standard Material Parameters (Density and Z-Factor).

3.4.4 Edit: System

Sets the operation of system Sensors, Sources, Digital I/O, and SQM-142 measurement card(s).

Sensors Tab



Sensor Name: A meaningful name assigned to sensors 1 to 4 in single card systems; 1 to 8 in two card systems. For easy display, keep the name to less than 8 characters.

Sensor Output: The source output that a sensor is positioned to measure. Typically each sensor measures deposition from a particular source. If multiple sensors are assigned to a single output, the sensor readings are averaged when calculating rate and thickness. Setting a sensor's Tooling to 0% in Film setup can override this assignment - see the Sensor Tooling section.

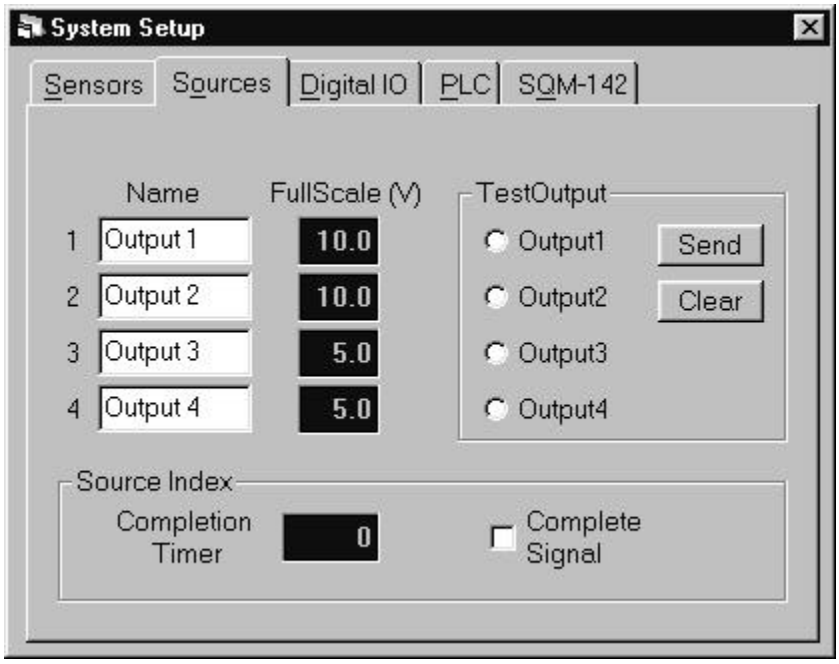
Sensor Dual: Indicates that a pair of sensors is setup as primary/secondary duals. When the primary sensor fails, the SQS-142 switches to the secondary sensor.

Max/Min/Initial Frequency: The frequency values for the quartz crystal sensors used as inputs to the SQM-142. Sensor readings outside the min/max values cause an error.

Completion Timer: If Complete Signal is checked, the process will halt if a move complete signal is not received within this timeout period. If Complete Signal is not checked, the process waits for this fixed time period before starting a layer.

Complete Signal: Check this box if your substrate index sends a signal designating that the move is complete and preconditioning can begin.

Sources Tab



Output Name: A meaningful name assigned to SQM-142 outputs 1 and 2 in single card systems; 1 to 4 in two card systems. For easy display, keep the name to less than 8 characters.

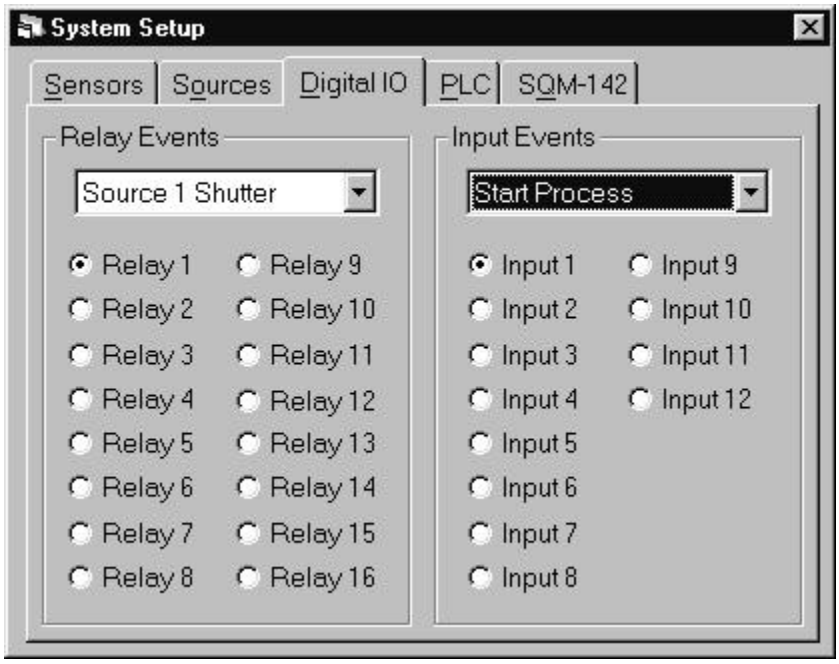
Full Scale: The input voltage required by the deposition source power supply to produce 100% output power. Positive or negative full scale values are possible.

Completion Timer: If Complete Signal is checked, the process will halt if a move complete signal is not received within this timeout period. If Complete Signal is not checked, the process waits for this fixed time period before starting a layer.

Complete Signal: Check this box if your source index sends a signal designating that the move is complete and preconditioning can begin.

Test Output: Select an output, then click Send to set the SQM-142 card output to its Full Scale voltage. Click Clear to return the selected output to 0 volts.

Digital IO Tab



The SID-142 uses an inexpensive PLC to provide digital I/O capabilities. The Digital I/O tab assigns deposition events (i.e. open shutter, start deposit, final thickness, etc.) to the available relays and inputs on the PLC.

Note: *Omron CPM series PLCs number relays from 10.00 to 10.07, then 11.00 to 11.07. These correspond to Relays 1 to 16 on the Digital I/O tab. Similarly, inputs 0.00 to 0.11 on the Omron PLC correspond to inputs 1 to 12 on this screen.*

Relay Events: The relay events dropdown box lists the deposition events that can cause a relay output to be activated. To assign a deposition event to a relay, click the Relay #, then select the desired event from the dropdown box. As you click each Relay#, the dropdown will change to show its currently assigned event. A description of each relay (output) event follows:

Source Shutter 1 and 2 (and 3-4 for a Dual Card System)

These 2 relays are used to control the Shutter that covers your deposition source. When you enter the deposit phase, the appropriate relay will close its contacts, which causes the shutter to swing out of the way. When the deposit phase finishes the shutter relay contacts open.

Sensor Relays 1 through 4 (and 5-8 for a Dual Card System)

These 4 relays are used to control sensor shutters. Their function depends on whether you have single or dual sensors.

If Dual Sensor is not selected (i.e. a single sensor), the relay contacts are closed when you are in a layer with the sensor enabled. As an example, let's say you have sensors 1 and 3 enabled for Film 1 and sensors 2 and 4 enabled for Film 2. When you start Film 1, the contacts for Sensor Relays 1 and 3 will close. When you start Film 2, these contacts open and the contacts for Sensor Relays 2 and 4 will close.

If you have the SQS-142 software configured for dual sensors, the operation of these relays is considerably different. Dual sensors use either Sensor Inputs 1 and 2, or Inputs 3 and 4. In this case, only Sensor Shutter Relays 1 and 3 have meaning, Relays 2 and 4 are always open. With the relay contacts open, Sensors 1 and 3 are selected. If a Crystal Fail is detected during the running of a film, the Sensor Shutter Relay's contacts will close for the duration of that film. This selects the second sensor in the Dual Sensor assembly for the remainder of the film.

Xtal All Good and Xtal All Fail Relays

These two relays provide an indication of the general health of your sensors. If the Xtal All Good Relay is closed, then all enabled sensors are returning a valid reading. If the Xtal All Fail Relay is closed, none of the enabled sensors are returning a valid reading.

Process Stopped and Running Relays

These relays indicate the overall status of the process. The Process Running relay closes as soon as Start Process is selected (by front panel or digital input), and opens when Abort Process is selected. Even if a layer is stopped within a process, the Process Running relay remains closed until the last film of a process has finished. The Process Stopped relay contacts behave in the inverse manner.

Process Active

This relay action is similar to the Process Running relay, except it will open if the process is temporarily halted for any reason, e.g. a Manual Start layer.

Deposit Phase Relay

This relay indicates that you are in the deposit phase of a film. It is like having the two Source Shutter Relays connected in parallel. If you have shutter delay enabled, this relay will wait until the end of the shutter delay before going active.

Pre-Cond Phase Relay

This relay closes for the preconditioning phases (Ramp1, Soak1, Ramp2, Soak2) of a film.

Soak Hold Phase Relay

This relay closes for the Soak and Hold phases after deposition.

Manual Mode Relay

Closes when the program is placed in Manual mode.

Max Power Relay
Closes when any control voltage output is at the programmed maximum power level.

Thickness Setpoint Relay
This relay will become active when the Thickness Setpoint is reached. This is a programmable process parameter.

Time Setpoint Relay
This relay will become active when the Time Setpoint has been reached. This is measured from the beginning of the deposit phase, and is a programmable parameter.

Input Events: The input events dropdown box lists the deposition events that can be caused by an external digital input. To assign a deposition event to an input, click the Input #, then select the desired event from the dropdown box. As you click each Input#, the dropdown will change to show its currently assigned event. A brief description of each input event follows:

Start Process Input
Triggering this input is the same as pushing the Start Process button.

Abort Process Input
Triggering this input will abort the process.

Start Layer Input
Triggering this input will start or restart the current layer.

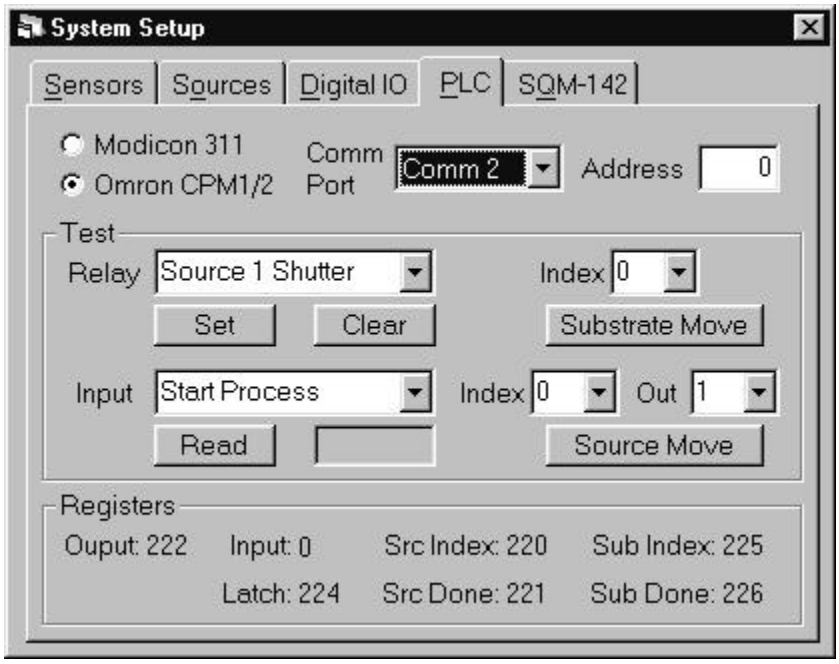
Stop Layer Input
Triggering this input will stop the current layer.

Start Next Layer Input
Triggering this input will skip the current layer and start the next layer.

Zero Thickness Input
This will zero the thickness. It is identical to pressing the Zero Button.

Force Final Thickness Input
Triggering this input will cause the current film to act as if the Final Thickness has been reached.

PLC Tab



Model: Two models of PLC are supported. Select the model you are using.

Comm Port: Selects the serial port used to communicate with the PLC. The Comm Port drop down lists available ports. However, some of the ports may be used by other devices (modem, mouse, etc.). Select Disabled to prevent I/O from using the PLC.

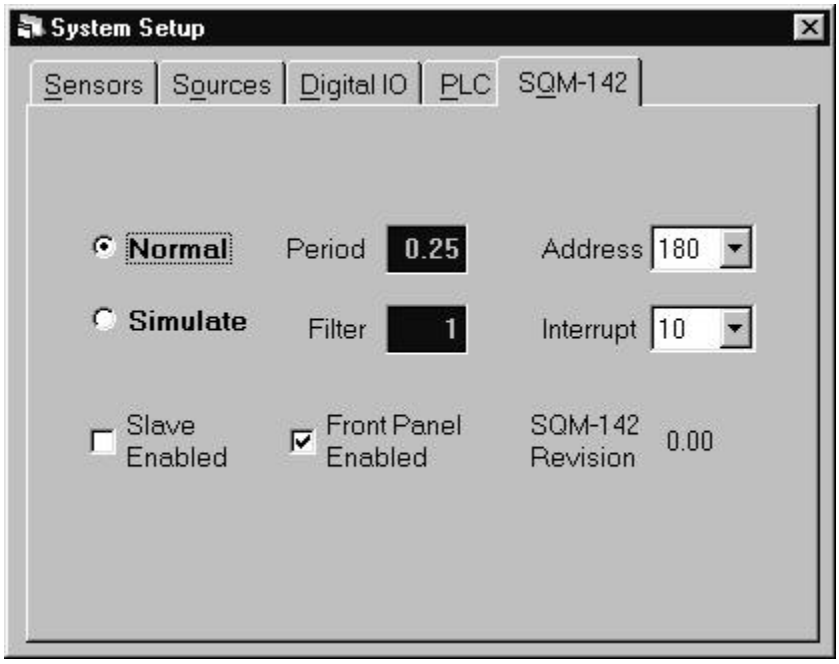
Address: Several PLCs can be controlled from a single computer Comm Port by connecting their expansion ports. The slave address of each such PLC is usually set by a rotary or dip switch, and must be unique. Consult your PLC User Manual.

Test: The Test section provides a simple means of testing your PLC communications and digital I/O wiring. To set a relay on the PLC, go to the Digital I/O tab and find which I/O event is assigned to that relay. On the PLC tab, select the same event in the test dropdown, then click Set Relay. The assigned Relay# should close. Click Clear Relay to open the relay. Use the Source and Substrate Move sections to test indexers.

To test a digital input, find the Input# that is assigned to an event on the PLC tab. Select the input event in the dropdown, then click Read Input to verify the state of the PLC input.

Registers: The PLC used for I/O runs a small monitor program that transfers relay and input states from the PLC I/O connecting block to internal registers. The SQS-142 software reads/writes to those registers though the PLC's Comm port. The registers shown are those that have been programmed for your PLC. Because their redefinition is not a trivial task, these values cannot be changed in the SQS-142 program. Contact Sigma Instruments if you need to change the internal PLC register definitions.

SQM-142 Tab



Comm Port: Selects the serial port used to communicate with the PLC. The Comm Port drop down lists available ports. However, some of the ports may be used by other devices (modem, mouse, etc.). Select Disabled to prevent I/O from using the PLC.

Period: Sets the measurement period between .2 seconds (5 readings per second) and 2 seconds. A longer period gives higher reading accuracy, especially at low rates.

Filter: Sets the number of readings used in the reading filter. A low setting gives rapid response to process changes, high settings give smoother graphs.

Address: Sets the address of the SQM-142 card in the computer's address space. See the SQM-142 Chapter of this manual for detailed setup instructions.

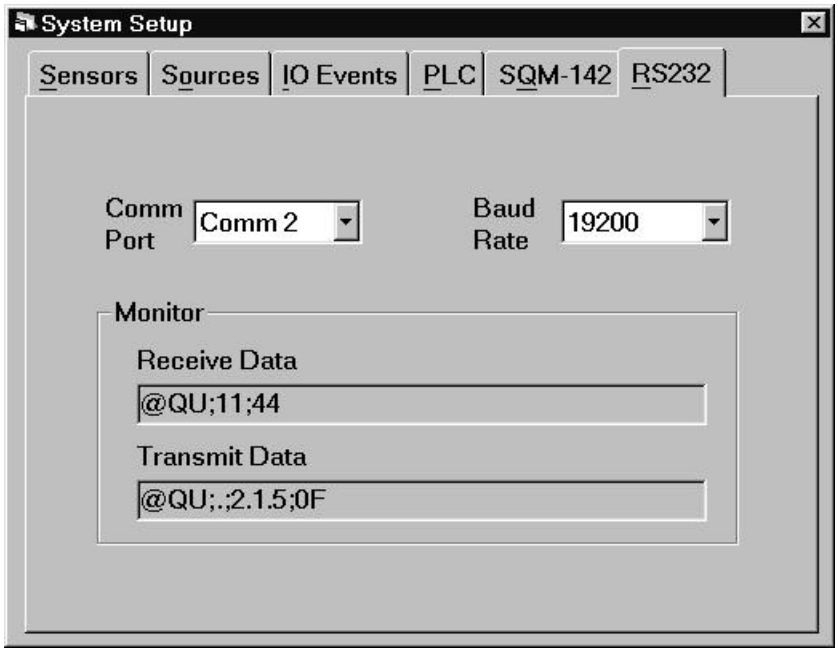
Interrupt: Sets the interrupt used by the card. See the SQM-142 Chapter of this manual for detailed setup instructions.

Slave Enabled: When a second SQM-142 card is present, it enables/disables sensors 5-8 and outputs 3 and 4.

Front Panel Enabled: When used with the SRC series computer, enables/disables the SQS-142 software to read the SoftKeys and setting knob.

SQM-142 Revision: Firmware revision of the SQM-142 card.

RS232 Tab



Comm Port: Selects the comm port used for serial communications. The Comm Port drop down lists available ports. However, some of the ports may be used by other devices (PLC, modem, mouse, etc.).

Baud Rate: Sets the comm port baud rate used for serial communications.

Receive Data: Displays the Query and Update requests received from the serial port. See Appendix B for a description of the serial communications protocol. In the screen capture above, the SQS-142 has received a QU (Query Utility), Parameter 11 (Software Version) request.

Transmit Data: Displays the response to Query and Update requests received from the serial port. In the screen capture above, the response to the query is software version 2.1.5.

3.4.5 Edit: Security

The Security menu assigns Users, their Password, and their Access Level. It also provides a flexible way to assign program functions to different Access Levels.

Note: The Security dialog is available only to users with Supervisor Access.

Users Tab

User: Drop down used to select an existing user for editing their Access or Password. It is not possible to edit or add a user name in the User drop down. Use the New SoftKey to create a new User. Use the Delete SoftKey to delete the selected user.

Access: Assigns a program access level to the selected user. Generally speaking, Supervisor (SUPV) provides access to all program functions. Technicians (TECH) have access to a subset of functions. While User level access (USER) has access to only those functions needed to run deposition processes. See the Access Tab section to assign SUPV, TECH, and USER program capabilities.

Password: Each user will typically have their own password. When a password is entered, a second box will appear for password confirmation. If the Password box is left blank, no Password is needed for that user to login.

Access Tab

The Access tab allows Supervisors to assign which main menu selections are available to each of the three Access Levels. When a program function is assigned to a particular access level, it is automatically available to higher access levels.

In the example below, every user has access to the File Process menu and the File Exit menu. Only Supervisors have access to the Edit System and Edit Security menus. The remaining menus are assigned TECH access. They will be available to TECH and SUPV users, but not to USER access users.

Those who login with USER access can select and run processes, but they cannot edit process parameters. TECH's can also select and run processes (because they are assigned to lower level USER access). However, TECH's can also edit process parameters. Only Supervisors can change System Setup or Security assignments.

3.5 View Menu

The view menu controls the appearance of the main display.

Film Settings: Displays/hides a ribbon of process settings along the right of the screen. In codeposition, click on the desired film to display its parameters. When displayed, the settings ribbon allows the user to easily modify common process settings during deposition without leaving the main screen. Changes are made to the current process operation and the process database immediately. Additional process parameters are available in the Edit menu.

Film Readings: Displays/hides film deposition readings along the bottom of the screen. Readouts of Film, Rate, Deviation, Thickness, and Power are displayed simultaneously for each of the active outputs. The rate, deviation, and thickness readings displayed represent an average of the quartz sensors assigned to each film.

Sensor Readings: Displays/hides a pop up window of sensor rate, thickness, remaining life, and frequency readings. Unlike the main screen's Film Readings, this display is the raw data coming from each sensor. In addition, the output (i.e. PID control loop) that each sensor is assigned to is displayed. Sensor assignments are established in the SQM-142 Setup menu.

Rate Graph: Fixes the main graph as deposition rate. Deposition rate is useful during the shutter delay, rate ramp, and deposition phases. During other phases, the power output graph is usually more useful.

Deviation Graph: Fixes the main graph as the percent deviation from the rate setpoint. Rate deviation is useful for fine tuning the PID control loop.

Power Graph: Fixes the main graph at output power. Output power is controlled (rather than PID control of rate) during the preconditioning, feed, and hold phases. Output power is also useful during the deposition phases to detect error conditions, which cause oscillations. Be sure the Full Scale voltage is set properly in the SQM-142 Setup menu.

Automatic: Changes the main graph to display the most pertinent information for each deposition phase. During preconditioning, output power is displayed. During shutter delay, rate ramps, and deposition, the main graph displays deposition rate. During feed and hold phases, the graph reverts to output power.

3.6 Software Specifications

Display

Graphs	Rate, Deviation, Power
Readouts	Rate,Dev,Thick,Power

Process Parameters

Name	12 characters
# Processes	Unlimited
# Layers	Unlimited
# Sensors (Dual)	1 to 8 (4 Dual)
# Sources	1 to 4

Layer Parameters

Start Mode	Auto/Manual
Rate	0.0 to 999.9 Å/sec.
Thickness	0.0 to 999.9 Å
Thickness Limit	0.0 to 999.9 Å
Time Setpoint	0 to 30000 sec.
# Rate Ramps	Unlimited
Rate Ramp Start	0.0 to 999.9 Å
Rate Ramp Time	0 to 1000 sec.
New Rate	0.0 to 999.9 Å/sec.
Substrate Index	0 to 15

Film Parameters

Name	12 characters
Ramp Time (1,2)	0 to 30000 sec.
Soak Power (1,2)	0.0 to 100.0 %
Soak Time (1,2)	0 to 30000 sec.
Shutter Delay Time	0 to 200 sec.
Shutter Delay Error	0.0 to 30.0 %
P Term	1 to 9999
I Term	0 to 99.9 sec.
D Term	0 to 99.9 sec.
Control Error	Ignore/Stop/Hold
Control Error Set	0 to 30.0 %
Feed Ramp Time	0 to 30000 sec.
Feed Power	0.0 to 100.0 %
Feed Time	0 to 30000 sec.
Idle Ramp Time	0 to 30000 sec.
Idle Power	0.0 to 100.0 %
Tooling (Sensor 1 to 8)	10.0 to 999.0
Max Power	0.0 to 100.0 %
Slew Rate	0.0 to 100.0 %/sec.
Source Index (Pocket)	0 to 15

Material Parameters

Name ..... 12 characters
Density ..... 0.40 to 99.99 gm/cm^3
Z-Factor ..... 0.100 to 9.900

Computer Interface

Type RS-232
Protocol ..... Text string with checksum

Digital Inputs *(available only with PLC option)*

Start Process .....
Stop Process .....
Start Layer .....
Stop Layer .....
Start Next Layer .....
Zero Thickness .....
Force Final Thickness .....
Substrate Index Complete
Source Index Complete

Relay Outputs *(available only with PLC option)*

Source Shutter ..... 1 to 4
Sensor Shutter ..... 1 to 8
All Crystal Fail .....
All Crystal Good .....
Process Running .....
Process Stopped .....
Process Active .....
Deposit Phase .....
Pre-Cond Phase .....
Feed/Idle Phase .....
Manual Mode .....
Max Power .....
Thickness Setpoint .....
Time Setpoint .....
Final Thickness .....
Substrate Index Select ..... 0 to 15
Source Index (Pocket) Select ..... 0 to 15

Security

User Name ..... 16 characters
Password ..... 8 characters
Access ..... 3 levels

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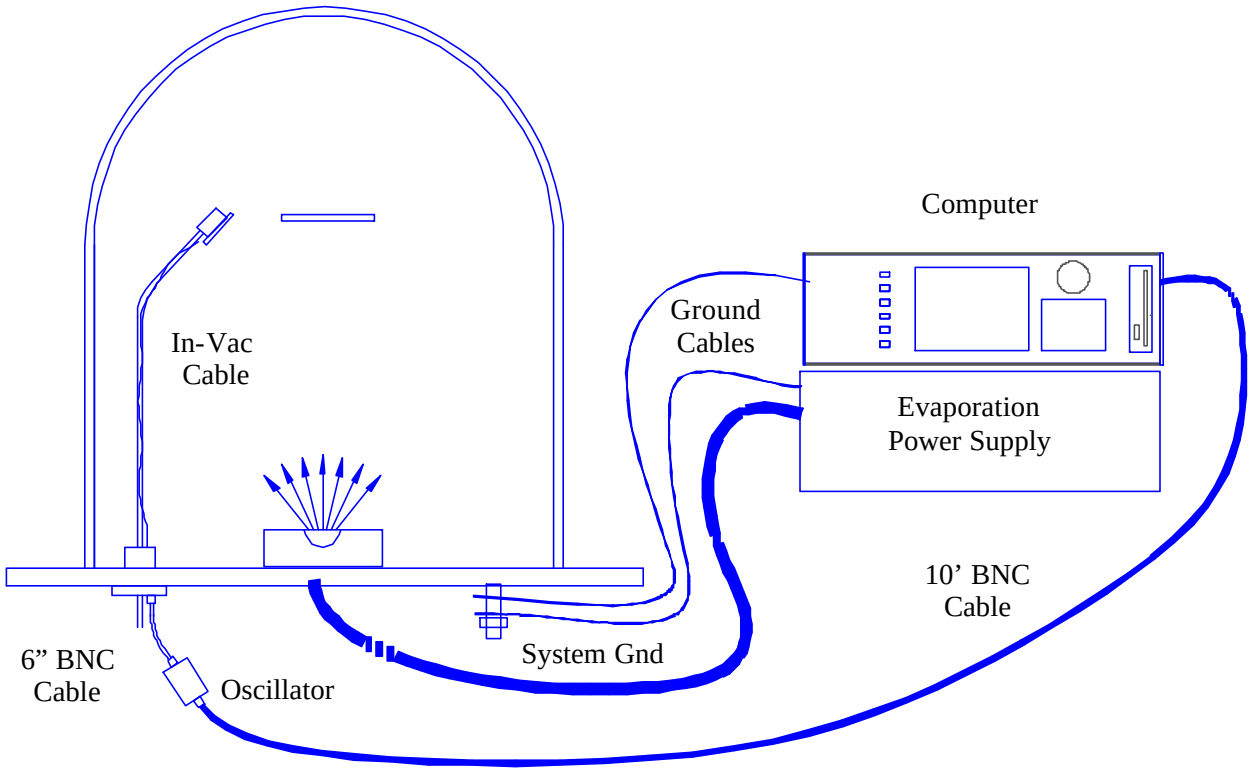
4.0 Introduction

This section covers installation, operation, and programming of the SQM-142 card.

The SQM-142 is a deposition controller on a PC card. Each SQM-142 card has four 1-10MHz quartz sensor inputs, and two 0-10V control outputs. Up to two cards can be installed in a computer.

The diagram below shows a typical single-sensor deposition system. The SQM-142 receives sensor inputs via a BNC cable from each sensor oscillator. It supplies a control voltage to the evaporation power supply (this connection is not shown in this diagram). The SQM-142's internal circuitry measures the sensor inputs, calculates the measured deposition rate against the desired rate, and updates the output voltage based on its PID control loop calculations. The evaporation supply adjusts power to the evaporation source based on the control voltage input.

Visual Basic and LabView demonstration programs allow easy setup and operation. A Windows DLL also provides user-written programs access to SQM-142 setup and readings.



4.1 Installation

The deposition control software uses a hardware interrupt (IRQ) to communicate with the SQM-142 card. Before installation, your computer BIOS and Windows operating system must be configured to accept the SQM-142 card,

Identify an Unused Interrupt

WIN 9X/ME: Open Control Panel, System, Device Manager, Properties.

WIN NT: Open Administrative Tools, NT Diagnostics , Resources

WIN 2000: Open Accessories, System Tools , System Info, Hdwe Resources

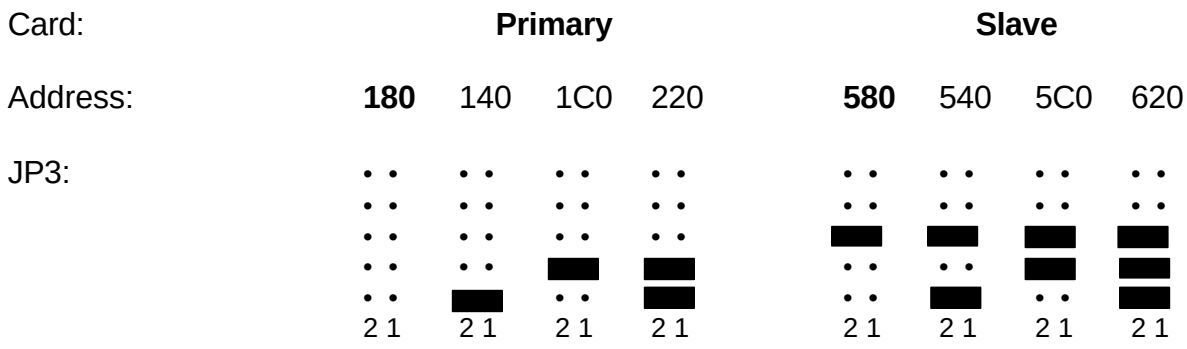
Find an unused IRQ. The default SQM-142 setting is IRQ 10.

Set SQM-142 Jumpers

Set JP2 to an available IRQ.

JP3 sets the I/O address. The default address (180) will work on most systems.

***Note**: A slave card requires no IRQ jumper, and an address 400 above the primary card address. See address settings below:*



Reserve IRQ in the BIOS

The computer BIOS is usually accessed by pressing a key during startup - consult your computer manual. In the BIOS, reserve the IRQ selected on JP2 of the SQM-142 for an ISA card. Be sure to save changes on exit.

Reserve IRQ in Windows

WIN 9X/ME: Open Control Panel, System, Device Manager, Properties. Select Reserve Resources and reserve the IRQ selected on JP2 of the SQM-142.

WIN NT/2000: An NT Patch program is included on CD-ROM with the SQM-142 card. Follow these three steps for NT/2000 systems:

1. Run the SETUPNT.EXE program.

2 If IRQ 10 is NOT the selected interrupt, edit the \windows\sqm32swnt.inf file (a standard text file) to the proper interrupt.

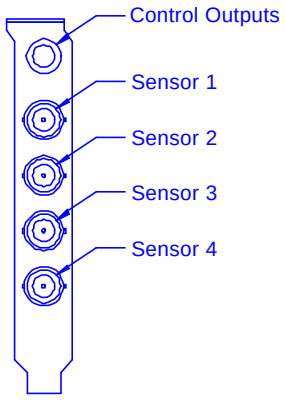
3. Execute the \windows\sqm32swnt.reg file to setup the registry keys.

Install Card

Power down the PC and remove the cover. Insert the card into any available 16 bit (long) ISA slot.

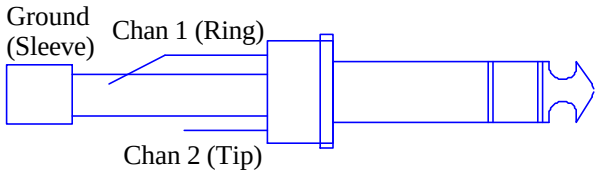
4.2 Sensor Connection

Once the SQM-142 is installed in the PC, connect the cable from the sensor oscillator to the BNC jack on the SQM-142 card. Avoid running the sensor wires near high voltage or noisy lines.



4.3 Power Supply Connection

The connection to your evaporation power supply is done through a 1/4" Stereo Phone Jack on the SQM-142 card. There are 2 control voltages on this connector, as shown in the figure below. The ground is common to both channels. Power supply input connectors vary. Consult your power supply manual.



4.4 Demo Programs

The CD-ROM supplied with each SQM-142 contains three demonstration programs:

SQS-142 Demo is a demonstration version of the SQS-142 software described earlier in this manual. It is fully functional with two exceptions: 1) it operates only in Simulate mode, it will not actually take readings from an SQM-142 card; 2) it will not communicate with a PLC for digital I/O.

SQM-142 VB (SQM32.EXE) is a basic deposition control program, complete with Visual Basic source code. Operation of SQM32.EXE is explained in the on-screen tool tips and help file.

SQM-142 LV is a LabView program that demonstrates techniques for communicating with the SQM-142 card using LabView.

4.5 SQM32C.DLL

SQM32C.DLL and VSQM32D.VXD are Windows programs that provide access to all SQM-142 card functions. Both files should be copied to your \WINDOWS\SYSTEM directory.

SQM32C.DLL can be used by C/C++, Visual Basic, and LabView. The CD-ROM that accompanies the SQM-142 contains a text file that gives the syntax for function calls to SQM32C.DLL

4.6 SQM-142 Specifications

Sensor Inputs .....4 (BNC)
Input Frequency.....1 to 10 MHz
Input Type.....Active Oscillator
Sample Period.....1 to 2 sec.
Thickness Resolution*.....2Å @ .25sec.
.025Å @ 2sec.
Thickness Accuracy*.....5% + 1 count

Control Outputs.....2 (dual phone jack)
Output Voltage.....0 to ±10VDC
Output Resolution.....15 bits
Output Impedance .....1 Kohm

Computer Interface
Interface Type .....16 bit ISA
IRQ Select.....5, 10, 11, 12, 14, 15
Address Select 140, 180, 1C0, 220

- Density=1, Z-Factor=1, Sensor Freq.=6MHz

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5.0 Introduction

Digital I/O for the SQS-142 software is handled by an inexpensive Omron CPM1/CPM2 PLC. It is not necessary, however, to use external I/O with the SQS-142 software.

There are several benefits to using an inexpensive external PLC for I/O. First, noisy high voltage wiring can be placed near the control sources, rather than routed into the controller's equipment rack. Only a single serial cable runs from the PLC to the controller. The PLC also provides electrical isolation for the process controller. And finally, the PLC's ladder logic programming provides fail-safe process protection and allows I/O to be easily tailored to each end user's installation.

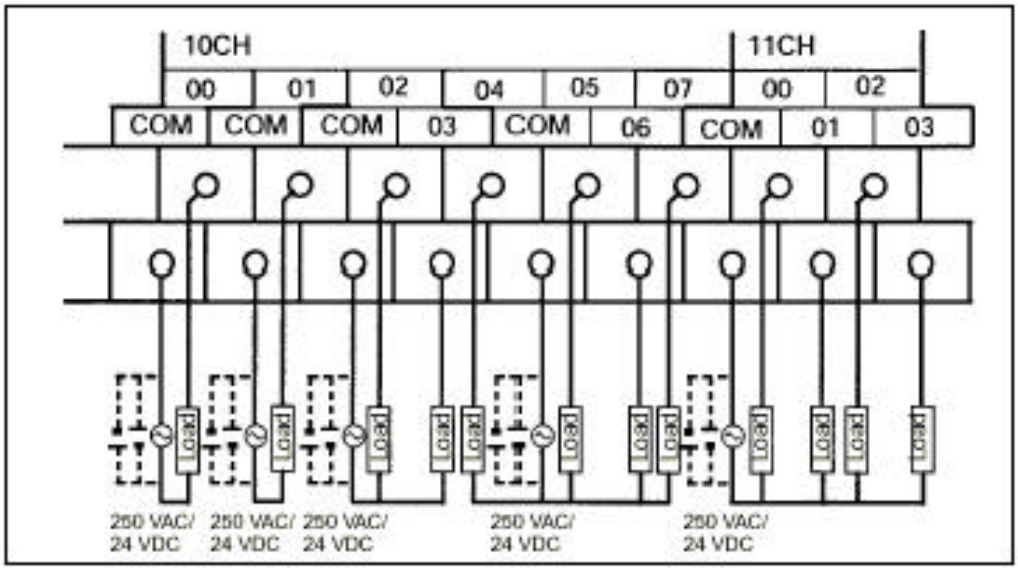
The PLC runs a small ladder logic program that communicates with the SQS-142 software. The ladder logic program transfers relay and input states from the PLC I/O connecting block to internal registers. The SQS-142 software reads/writes to those registers though the PLC's Comm port. If you need to perform logic functions on an I/O event, such as AND, OR, or INVERT, it can be easily accommodated by the PLC's ladder logic program.

Contact Sigma Instruments for more information on programming your PLC.

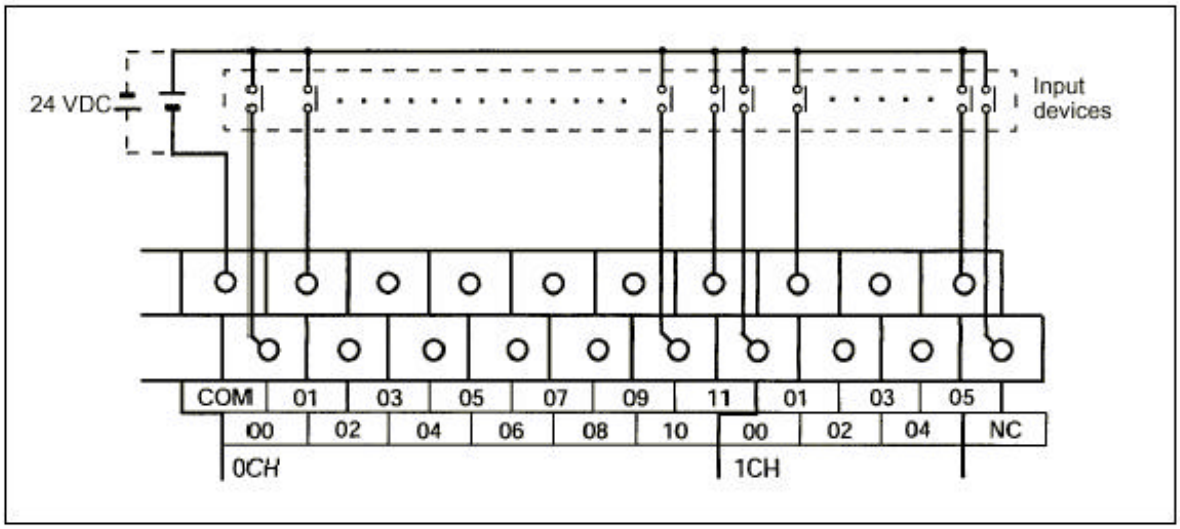
5.1 PLC Installation

Mount the PLC controller near the devices it is controlling and sensing. Connect the PLC to a properly grounded power source. Connect a serial cable from the PLC serial port to a computer serial port. See the PLC User Manual for detailed mounting and connection information.

Output Wiring: The 10CH relays on Omron PLCs correspond to Relay# 1 to 8 in the SQS-142 software. These physical relays are mapped to relay events in the SQS-142 System Setup dialog. Omron PLC output wiring is illustrated below.



Input Wiring: The 0CH inputs on Omron PLCs correspond to Input# 1 to 12 in the SQS-142 software. These physical inputs are mapped to input events in the SQS-142 System Setup dialog. Omron PLC input wiring is illustrated below.



Indexer Wiring: The SQS-142 software supports up to four source indexers (of up to 15 pockets) and a 15 position substrate indexer. However, each indexer is unique. Contact Sigma Instruments for information on the PLC program and I/O wiring required for your indexer.

5.2 PLC Setup and Test

In the SQS-142 software select Edit, Setup, then the PLC tab. Set the Address to match the PLC Address. Set the Comm Port to the serial port you are using.

The registers shown are those that have been programmed for your PLC. Because their redefinition is not a trivial task, these values cannot be changed in the SQS-142 program. Contact Sigma Instruments if you need to change the internal PLC register definitions.

The Test section provides a simple means of testing your PLC communications and digital I/O wiring. To set a relay on the PLC, go back to the Digital I/O tab and find which I/O event is assigned to that relay. On the PLC tab, select the same event in the test dropdown, then click Set Relay. The assigned Relay# should close. Click Clear Relay to open the relay.

To test a digital input, find the Input# that is assigned to an event on the PLC tab. Select the input event in the dropdown, then click Read Input to verify the state of the PLC input.

To move a source or substrate indexer, select the index (i.e. pocket) to activate, then click the appropriate move button. For source indexers, each indexer will move.

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6.0 Introduction

The computer interface capabilities of the SQS-142 program allow operation from an external computer via RS-232 serial communications. The active process can be selected, process parameters read or changed, operation controlled, and data collected.

Parameters may be read (Query commands) while the process is running, but can only be changed (Update commands) while the process is stopped. Changes to the "structure" of a process (e.g. add or delete layers) are not allowed from the computer interface.

6.1 Serial Interface

Connect a serial cable from the SID-142 serial port to a computer serial port. The cable required is a DB9 female to female with pins 2 and 3 crossed, commonly referred to as a null modem cable.

In the SQS-142 program select the Edit, System menu, then the RS-232 tab. Set the Comm Port to match the serial port the cable is connected to on the SID-142. Set the baud rate to match the baud rate of the host computer that will be connected to the SID-142. Communications format is No Parity, 8 bits, 1 stop bit.

6.2 SerialComm Program

SerialComm, found on the SQS-142 CDROM, is a simple Windows program to demonstrate SQS-142 computer interfacing concepts. With SerialComm you can easily send commands to, and read the responses returned by, the SQS-142 program. SerialComm is written in Visual Basic, and the source code is included as an example of programming concepts for computer interfacing.

Connect a cable from the host computer to the SID-142. Start the SQS-142 program on the SID-142 controller, then select Edit, System, RS-232. Be sure the Comm Port and Baud rate are set properly. Leave the Edit, System,RS-232 dialog box displayed.

Run the Setup program for SerialComm to install it on the host computer. Start SerialComm then select the Utility tab. Set the Comm Port and Baud Rate for the host computer. Click the Version button under the SID-142 Controller heading. Click Send to send the query to the SQS-142 program.

The query string should show in the SQS-142 Monitor Receive Data, and the response in Transmit Data. The response should also show on the SerialComm Response display. The next section describes the Query/Update and Response strings in detail

6.3 Protocol

The SQS-142 program never initiates communications. It only responds to commands from the host computer.

SQS-142 computer Interface commands fall into two general categories. Query commands request data from the SQS-142 program. Update commands instruct the SQS-142 program to take an action. The SQS-142 responds to both Query and Update commands with a response that indicates the results of the command request.

Query Command:

@<command>;<param1>;…;<paramn>;<Chksum><CR>

Query Example: Software Version Query

@QU;11;44<CR>

Description:

@	Message start character
;	Separator
QU	Query Utility command
;	Separator
11	Parameter 11 (SID142 Software Version)
;	Separator
44	Checksum (see section that follows on checksums)
<CR>	Carriage Return (ASCII 13)

Response Example: Software Version Query

@QU;<ACQ>;2.1.6;??<CR> (Response to Software Version query)

Description:

@;QU;<ACQ>;	Query Acknowledged (ASCII 06)
2.1.6	Message (Software Version)
;	Separator
0C	Checksum (actual checksum varies with different versions)
<CR>	Carriage Return (ASCII 13)

Update Command:

@<command>;<param1>;...;<paramn>;<data>;<Chksum><CR>

Update Example: Set Process

@UP;11;MyProcess;44<CR>

Description:

@;UP;	Update Process command
;	Separator
01	Parameter 01 (Set Process)
;	Separator
MyProcess	Data
;	Separator
??	Checksum
<CR>	Carriage Return (ASCII 13)

Response Example: Set Process Completed

@UP;<ACQ>;??<CR>

Response Example: Set Process Failed

@UP;<NAK>;<ERR>;??<CR> (Response to Update Process)

ERR:	01	Illegal Command
	02	Illegal Parameter
	03	Illegal Format
	04	Checksum Error
	05	Request Denied
	06	Unknown Error

Checksum Calculation

The sample code below calculates the FCS checksum of a string of characters. In the code, Message is a string that has been stripped of terminator and checksum characters before being passed to this routine

```
' XOR ASCII codes
For i = 1 To Len(Message)
    FCS = Asc(Mid$(Message, i, 1)) Xor FCS
Next i

' Convert FCS to two character hex string
If Len(Hex$(FCS)) = 1 Then
    CalcChkSum = "0" & Hex$(FCS)
Else
    CalcChkSum = Hex$(FCS)
```

6.3 Command Summary

Note: Update Queries (except UP02-UP10) are only valid in Stop Mode

Query Process: **@QP;<param1>** **(Query)**
@QP;O6;Response **(ACK Response)**
@QP;21;ErrNum **(NAK Response)**

<param1>

01 Process Name
@QP;01 (Query Process)
@QP;06;MyProc (Process is MyProc)

02 Process Time
@QP;02 (Query Process Time)
@QP;06;32:45 (Time is 32 min., 45 sec.)

03 Layer
@QP;03 (Query Process Layer)
@QP;06;1 (Layer is Layer 1)

04 Layer Time

05 Phase (Phase numbers are shown below)

00	Application Startup	9	ShutterDelay Phase
01	Program Initializing	0	Deposit Phase
02	Not Used	1	Layer Stopped
03	Not Used	2	Layer Starting
04	Process Stopped	3	
05	Ramp1 Phase	4	Feed Ramp Phase
06	Soak1 Phase	5	Feed Hold Phase
07	Ramp2 Phase	6	Idle Ramp Phase
08	Soak2 Phase	7	Idle Phase

06 Phase Time

07 Run #

08 All Process Names (returns comma delimited list)

1n Source Shutter, n=1 to 4 (0=Open, 1 =Close)
@QP;12 (Query Source Shutter 2)
@QP;06;0 (Source Shutter 2 is Open)

2n Sensor Shutter, n=1 to 8 (0=Open, 1 =Close)

30 All Crystal Good (0=False, 1=True)

3n Crystal n Good, n=1 to 8 (0=False, 1 =True)

39 All Crystal Fail (0=False, 1=True)

Update Process: **@UP;<param1>;<data>** **(Update)**
@UP;O6;Response **(ACK Response)**
@UP;21;ErrNum **(NAK Response)**

<param1>

01 Set Process
@UP;01;MyProc (Select MyProc)

@UP;06;

02 Start Process
@UP;02
@UP;06

03 Stop Process
04 Start Layer
05 Stop Layer
06 Start Next layer
07 Auto Mode
08 Manual Mode
09 Zero Thickness
10 Force Final Thickness
2n Output n Power (Manual Mode Only)
@UP;21;50 (Set Output 1 to 50%)

Query/Update Layer: **@QL;<param1>;<layer>;<output>**
@UL<param1>;<layer>;<output>;<value>

<param1>

01 Film Name (Example: Set Layer 1, Output 1 film to My Film)
@UL;01;1;1;MyFilm
02 Material
03 Start Rate (A/s)
04 Start Thickness (kA)
05 Time SP (mm:ss)
06 Thickness SP (kA)
07 Start Mode (0/1)
08 Substrate Index (0 to 15)
1n Ramp n Start Thickness (n=1 to 9)
2n Ramp n Ramp Time (n=1 to 9)
3n Ramp n New Rate (n=1 to 9)

Query/Update Film: **@QF;<param1>;<layer>;<output>**
@UF;<param1>;<layer>;<output>;<value>

<param1>

01 P Term
02 I Term
03 D Term
04 Shutter Delay Status (0/1)
05 Shutter Timeout
06 Shutter Accuracy
07 Control Error Status (0/1/2)
08 Control Error Accuracy
09 Rate Sampling Status (0/1/2)
10 Sample Accuracy

11 Sample Time
12 Sample Hold
13 Ramp 1 Power
14 Ramp 1 Time
15 Soak 1 Time
16 Ramp 2 Power
17 Ramp 2 Time
18 Soak 2 Time
19 Feed Power
20 Feed Ramp Time
21 Feed Time
22 Idle Power
23 Idle Ramp Time
24 Output (1-4)
25 Source Index
26 Max Power
27 Slew Rate
28 Material
3n Tooling n (n=1 to 8)

Query Measurement: @QM;<param1>

1n Output n Power (n=1 to 4)
2n Output n Rate
3n Output n Thickness
4n Output n Deviation
5n Sensor n Rate (n=1 to 8)
6n Sensor n Thickness
7n Sensor n Frequency
8n Sensor n % Life

Query Utility: @QU;<param1>

01 SQM142 Version
02 SQM142 Mode (0/1)
03 SQM142 Period
04 SQM142 Filter
05 SQM142 Slave Enabled (0/1)
06 Front Panel Enabled (0/1)
11 SID142 Software Version
12 SID142 Operating System
13 SID-142 Computer Name

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A. Material Parameters

Material	Density	ZFactor
Aluminum	2.73	1.08
Aluminum Oxide	3.97	1
Antimony	6.62	0.768
Arsenic	5.73	0.966
Barium	3.5	2.1
Beryllium	1.85	0.543
Bismuth	9.8	0.79
Bismuth Oxide	8.9	1
Boron	2.54	0.389
Cadmium	8.64	0.682
Cadmium Selenium	5.81	1
Cadmium Sulfide	4.83	1.02
Cadmium Teluridium	5.85	0.98
Calcium	1.55	2.62
Calcium Fluoride	3.18	0.775
Carbon Diamond	3.52	0.22
Carbon Graphite	2.25	3.26
Cerium Fluoride	6.16	1
Cerium Oxide	7.13	1
Chromium	7.2	0.305
Chromium Oxide	5.21	1
Cobalt	8.71	0.343
Copper	8.93	0.437
Copper Sulfide	4.6	0.82
Copper Sulfide B	5.8	0.67
Copper Sulfide A	5.6	0.69
Dysprosium	8.54	0.6
Erbium	9.05	0.74
Gadolinium	7.89	0.67
Gallium	5.93	0.593
Gallium Arsenide	5.31	1.59
Germanium	5.35	0.516
Gold	19.3	.381
Hafnium	13.1	0.36
Hafnium Oxide	9.63	1
Holnium	8.8	0.58
Indium	7.3	0.841
Indium Intimnide	5.76	0.769
Indium Oxide	7.18	1
Iridium	22.4	0.129
Iron	7.86	0.349
Lanthanum	6.17	0.92
Lanthanum Fluoride	5.94	1
Lanthanum Oxide	6.51	1
Lead	11.3	1.13
Lead Sulfide	7.5	0.566
Lithium	0.53	5.9
Lithium Fluoride	2.64	0.774
Magnesium	1.74	1.61

Material	Density	ZFactor
Magnesium Fluoride	3	1
Manganese	7.2	0.377
Manganese Sulfide	3.99	0.94
Mercury	13.46	0.74
Molybdenum	10.2	0.257
Neodymium Fluoride	6.506	1
Neodymium Oxide	7.24	1
Nickel	8.91	0.331
Niobium	8.57	0.493
Niobium Oxide	4.47	1
Palladium	12	0.357
Platinum	21.4	0.245
Potassium Chloride	1.98	2.05
Rhenium	21.04	0.15
Rhodium	12.41	0.21
Samarium	7.54	0.89
Scandium	3	0.91
Selenium	4.82	0.864
Silicon	2.32	0.712
Silicon Dioxide	2.2	1.07
Silicon Oxide	2.13	0.87
Silver	10.5	0.529
Silver Bromide	6.47	1.18
Silver Chloride	5.56	1.32
Sodium	0.97	4.8
Sodium Chloride	2.17	1.57
Sulfur	2.07	2.29
Tantalum	16.6	0.262
Tantalum Oxide	8.2	0.3
Tellurium	6.25	0.9
Terbium	8.27	0.66
Thallium	11.85	1.55
Thorium Fluoride	6.32	1
Tin	7.3	0.724
Titanium	4.5	0.628
Titanium Oxide	4.9	1
Titanium Oxide IV	4.26	0.4
Tungsten	19.3	0.163
Tungsten Carbide	15.6	0.151
Uranium	18.7	0.238
Vanadium	5.96	0.53
Ytterbium	6.98	1.13
Yttrium	4.34	0.835
Yttrium Oxide	5.01	1
Zinc	7.04	0.514
Zinc Oxide	5.61	0.556
Zinc Selenide	5.26	0.722
Zinc Sulfide	4.09	0.775
Zirconium Oxide	5.6	1.001

Z-Factor is used to match the acoustic properties of the material being deposited to the acoustic properties of the base quartz material of the sensor crystal. Z-Factor is the ratio of the acoustic impedance of the sensor to that of the deposited material.

If you know the acoustic impedance of your material, it is easy to calculate the Z-Factor. The sensor is basically silicon dioxide, and has an acoustic impedance of 8.83. For example, Gold has an acoustic impedance of 23.18, so:

Gold ZFactor = 8.83/23.18 = .381