

# SOS-242<sup>TM</sup>

## Deposition Control Software

IPN 074-551-P1A

 INFICON



O P E R A T I N G   M A N U A L

# SOS-242

## Deposition Control Software

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## Table Of Contents

<b>Trademarks</b>	
<b>Disclaimer</b>	
<b>Copyright</b>	
<b>Chapter 1</b>	
<b>Introduction</b>	
1.1    Introduction . . . . .	1-1
1.2    SQM-242 Deposition Control Card . . . . .	1-2
1.3    Digital I/O . . . . .	1-3
<b>Chapter 2</b>	
<b>Quick Start</b>	
2.1    Introduction . . . . .	2-1
2.2    Single-Layer Process Setup . . . . .	2-2
2.2.1    Create a New Process . . . . .	2-2
2.2.2    Edit Layer Parameters . . . . .	2-3
2.2.3    Edit Rate Ramps . . . . .	2-4
2.2.4    Edit Deposition . . . . .	2-5
2.2.5    Edit Pre/Post Conditioning . . . . .	2-5
2.2.6    Edit Source/Sensor . . . . .	2-6
2.2.7    Edit Errors . . . . .	2-6
2.2.8    Save Edits . . . . .	2-7
2.3    Single Layer Process Simulation . . . . .	2-7
2.3.1    Setup Displays . . . . .	2-8
2.3.2    Start Process . . . . .	2-8
2.3.3    Preconditioning Phases . . . . .	2-9
2.3.4    Deposition Phase with one Rate Ramp . . . . .	2-9
2.4    SoftKey Functions . . . . .	2-10
2.5    Multi-Layer CoDeposition Process . . . . .	2-11
2.6    Conclusion . . . . .	2-15
<b>Chapter 3</b>	
<b>SQS-242 Software</b>	
3.1    Introduction . . . . .	3-1
3.2    Installation and Registration . . . . .	3-3
3.3    Operation . . . . .	3-3

---

3.4	Menu .....	3-4
3.4.1	File: Process .....	3-4
3.4.2	File: Open and Save Database .....	3-5
3.4.3	File: Data Logging .....	3-5
3.4.4	File: Print .....	3-7
3.4.5	File: User Login .....	3-7
3.4.6	File: Exit .....	3-7
3.5	Edit Menu .....	3-8
3.5.1	Edit: Process .....	3-8
3.5.1.1	Layer Tab .....	3-10
3.5.1.2	Rate Ramps Tab .....	3-12
3.5.1.3	Deposit Tab .....	3-13
3.5.1.4	Condition Tab .....	3-14
3.5.1.5	Source/Sensor Tab .....	3-15
3.5.1.6	Errors Tab .....	3-16
3.5.1.7	Analog Inputs .....	3-17
3.5.2	Edit: Films .....	3-18
3.5.3	Edit: Materials .....	3-19
3.5.4	Edit: System .....	3-20
3.5.4.1	Outputs Tab .....	3-21
3.5.4.2	Sensors Tab .....	3-22
3.5.4.3	Analog Tab .....	3-23
3.5.4.4	Indexers Tab .....	3-24
3.5.4.5	I/O Tab .....	3-24
3.5.4.6	Card Tab .....	3-28
3.5.4.7	Comm Tab .....	3-29
3.5.5	Edit: Security .....	3-30
3.5.5.1	Users Tab .....	3-30
3.5.5.2	Access Tab .....	3-31
3.6	View Menu .....	3-32
3.7	Software Specifications .....	3-33
3.8	INI File Parameters .....	3-37

## Chapter 4

### Digital I/O

4.1	Introduction .....	4-1
4.2	PLC Installation .....	4-1
4.3	PLC Setup and Test .....	4-4
4.4	5.3 PLC Programming .....	4-4

## Chapter 5

### Communications

5.1	Introduction . . . . .	5-1
5.2	Serial Interface . . . . .	5-1
5.3	Ethernet Interface . . . . .	5-1
5.4	ActiveX (COM) Interface . . . . .	5-1
5.5	SQS-242 Comm Program . . . . .	5-2
5.5.1	Setup for RS-232 or Ethernet . . . . .	5-2
5.5.2	Setup for Active X Control . . . . .	5-2
5.5.3	Communicating with the SQS-242 Program . . . . .	5-2
5.6	Protocol . . . . .	5-2
5.6.1	Query Command Format . . . . .	5-3
5.6.1.1	Example: Software Version Query . . . . .	5-3
5.6.1.2	Example: Response to Software Version Query . . . . .	5-3
5.6.2	Update Command Format . . . . .	5-3
5.6.2.1	Example: Set Process Update . . . . .	5-3
5.6.2.2	Example Response: Set Process Update Succeeded . . . . .	5-3
5.6.2.3	Example Response: Set Process Update Failed . . . . .	5-4
5.7	Checksum Calculation . . . . .	5-4
5.8	Command Summary . . . . .	5-5
5.8.1	Query Process . . . . .	5-5
5.8.2	Update Process . . . . .	5-5
5.8.3	Query/Update Layer . . . . .	5-6
5.8.4	Query/Update Film . . . . .	5-7
5.8.5	Query Utility . . . . .	5-7
5.8.6	Update Utility . . . . .	5-8
5.8.7	Query Measurement . . . . .	5-8
5.8.8	Query Register . . . . .	5-8
5.8.9	Update Register . . . . .	5-8

## Chapter 6

### Loop Tuning

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# Chapter 1

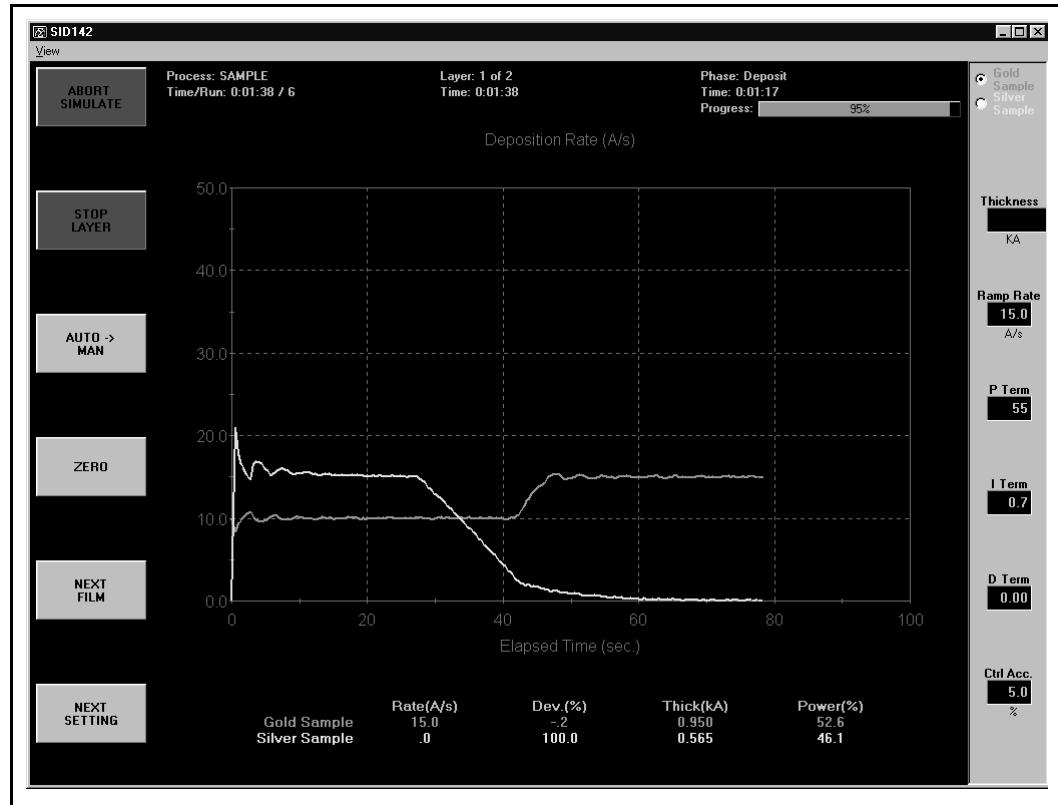
## Introduction

### 1.1 Introduction

The SQS-242 Deposition Control Software, see [Figure 1-1](#), works with the INFICON SQM-242 card to provide a powerful, PC based thin film deposition controller that can:

- Measure up to eight quartz crystal sensors simultaneously.
- Control up to six deposition source supplies simultaneously (CoDeposition).
- Provide 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
- Provide flexible and reliable digital I/O using an inexpensive PLC (PLC not provided by INFICON).

*Figure 1-1 SQS-242 Software*



The six Soft Keys provide easy access to the common operating functions. A single tabbed dialog box provides all of the settings required for a thin film process.

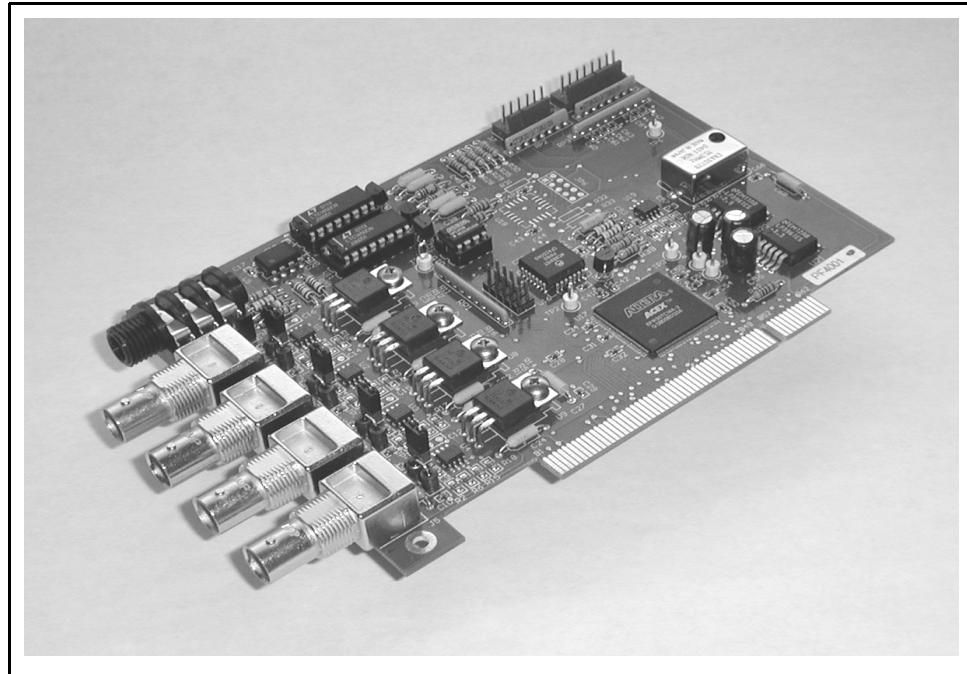
Material parameters, sensor/source setup, pre/post conditioning, and error conditions are all visible on a single dialog box. Process settings, numeric data, and graphical displays are displayed during all phases of deposition.

The SQS-242 software stores process parameters in a Microsoft Access compatible database. The SQS-242 software can be controlled from another computer using the RS-232 or Ethernet command protocol.

## 1.2 SQM-242 Deposition Control Card

The SQM-242 is a PCI expansion card for use in computers running the Microsoft® Windows® operating system. See [Figure 1-2](#). Each card measures up to four quartz sensors via BNC inputs, and supplies the control signal for two evaporation sources via a 1/4" stereo phone plug. Up to six SQM-242 cards can be installed in a computer. A single SAM-242 piggyback card with four analog inputs and two control outputs can also be installed.

*Figure 1-2 SQM-242 Card*



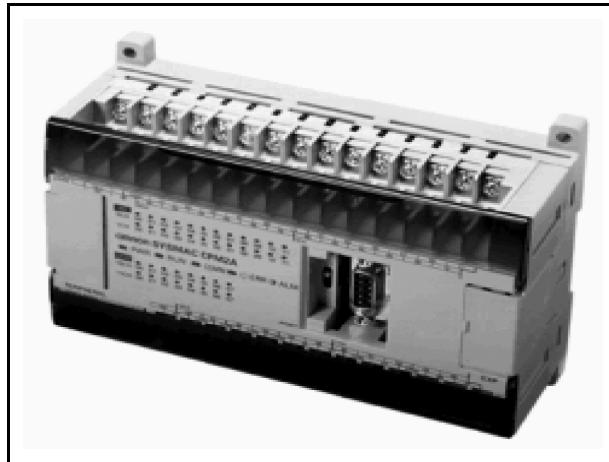
IPN 074-551-P1A

Consult the separate SQM-242 card Operating Manual for detailed information on installing and using the SQM-242 and the SAM-242 cards.

## 1.3 Digital I/O

Digital I/O for the SQS-242 software can be provided through an inexpensive, external, programmable logic controller (PLC), see [Figure 1-3](#). 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 computer. The PLC provides electrical isolation, fail-safe operation, and extensive I/O processing capabilities through its ladder logic programming.

*Figure 1-3 Programmable Logic Controller (PLC)*



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## Chapter 2

### Quick Start

#### 2.1 Introduction

This chapter will provide a general overview on how to setup the SQS-242 deposition control program.

**1** Power On the Computer.

**2** Start the SQS-242 software from: Start Menu >> Programs >> INFICON >> SQS-242 Codep.

**3** User Login Dialog Box

The SQS-242 displays a progress bar during program startup, then a User Login dialog box. Select a User Name from the drop down box, enter the Password, then click OK. See [section 3.5.5 on page 3-30](#) for more information on users, passwords, access levels, and registration.

**NOTE:** The SQS-242 software has one pre-assigned user by default. The user name is Super, with no Password.

**4** Process Database

The SQS-242 normally starts with the last active process displayed. If that process is not found, a Database Open dialog is displayed.

**5** Main Display

As you operate the SQS-242, the six SoftKey labels along the left of the dialog box 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 SQS-242 is stopped (i.e., not running a deposition process).

**6** Simulate Mode

Simulate mode allows you to familiarize yourself with SQS-242 operation and test process recipes. Simulate Mode will be used for the remainder of this chapter.

If the first SoftKey is labeled **START SIMULATE** then the Simulate mode is active. Otherwise, click the **Edit** menu selection along the top of the display, then click **System**. On the **Card** tab, click the **Simulate** button. Select the **Close** SoftKey to activate Simulate mode.

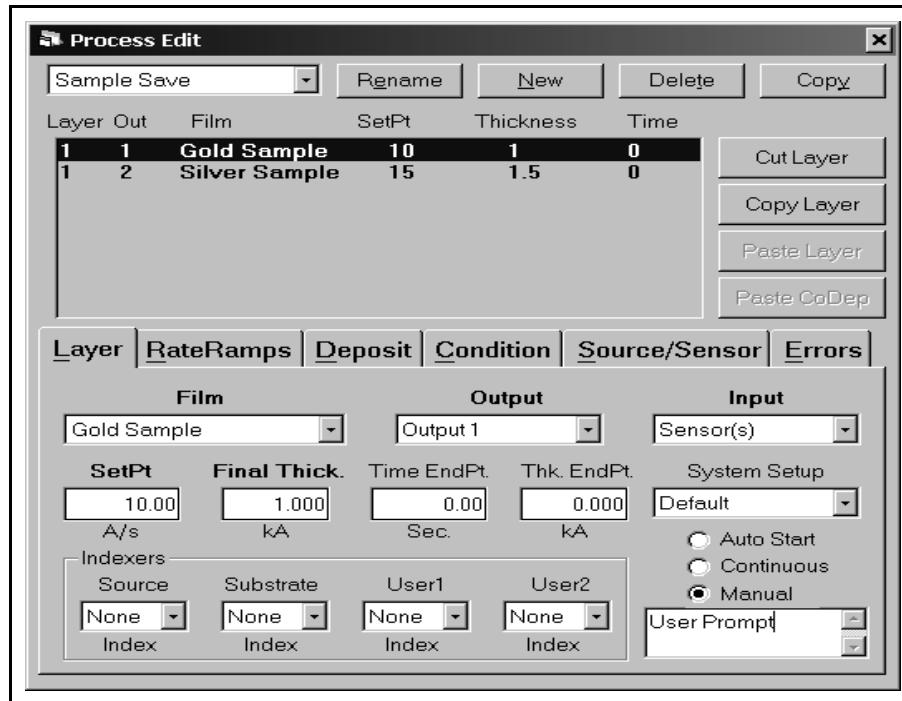
## 2.2 Single-Layer Process Setup

We will build a simple single-layer process as an introduction.

### 2.2.1 Create a New Process

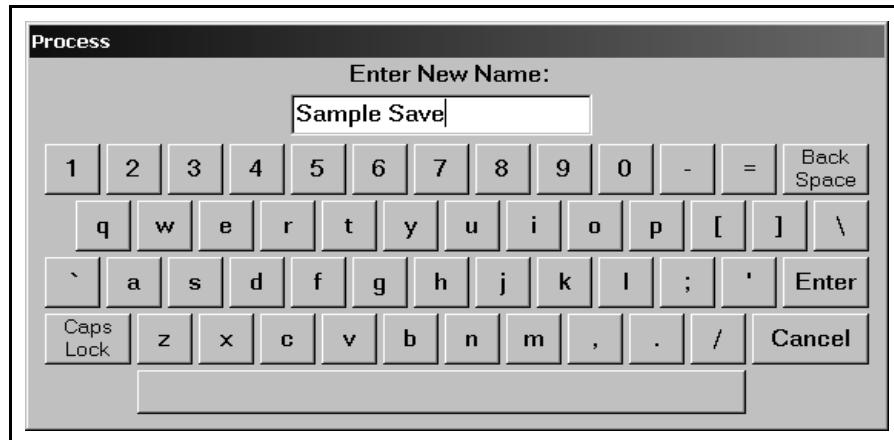
- 1 Click **Edit >> Process**.
- 2 The **Process Edit** dialog box will display the setup data for the active process. Click **New..** See [Figure 2-1](#).

*Figure 2-1 Process Edit dialog box*



- 3 Type a new process name using your keyboard, or the on-screen keyboard. Click **Enter** to save the new process name. See [Figure 2-2](#).

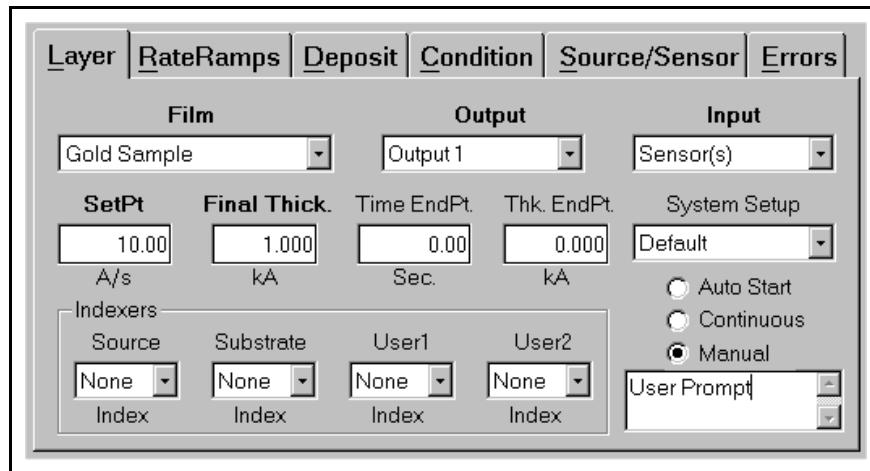
*Figure 2-2 Keyboard*



## 2.2.2 Edit Layer Parameters

4 Click **Layer** to display the layer parameters. See Figure 2-3.

Figure 2-3 Layer tab



5 A Film is basically a material, plus the settings that will control its deposition. Select **Film >> Gold Sample**.

6 We will be simulating a quartz sensor input that is controlling the deposition rate of Output 1. Select **Output >> Output 1**.

7 Select **Input >> Sensor(s)**.

8 Click **SetPt**, then adjust the rate setpoint to **10 Å/s**.

9 Adjust **Final Thickness** to **1.000 kÅ**.

**NOTE:** Time and Thickness Endpoints won't be used for this example.

10 **System Setup** determines the physical inputs and outputs that are used and displayed on the dialog box. For now use the **Default** system setup.

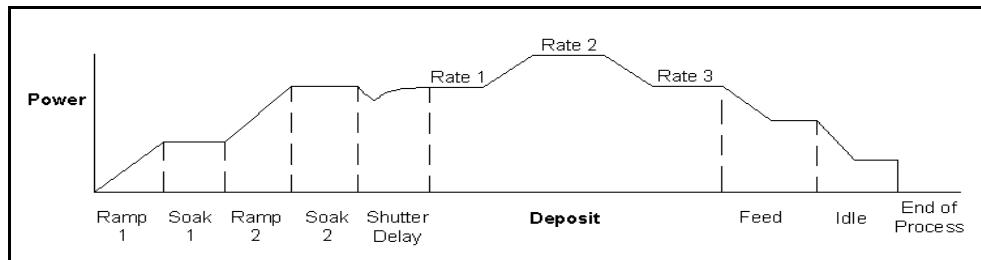
11 **Manual Start** causes this layer to wait for user input before beginning. An optional user prompt is possible.

12 We won't use any indexers for this example, so select **None**.

### 2.2.3 Edit Rate Ramps

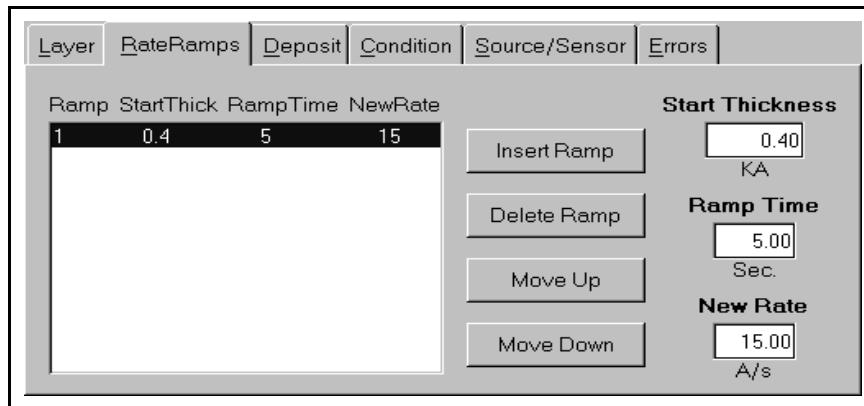
A thin-film deposition process consists of one or more layers of material evaporated onto a substrate. Figure 2-4 illustrates a complete deposition cycle for a single layer. Refer to this diagram as we set the remaining parameters. It may be desirable to vary the deposition rate during a layer. For example, to deposit slowly at first, then more quickly once the initial material is deposited.

Figure 2-4 Complete Deposition Cycle for a Single Layer



13 Click **Rate Ramps**. See Figure 2-5.

Figure 2-5 Rate Ramps tab



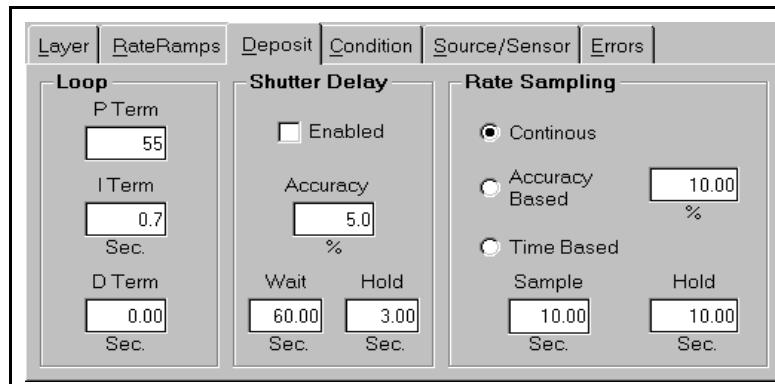
14 Click **Insert Ramp**.  
 15 Set **Start Thickness** to **0.400 kÅ**.  
 16 Set **Ramp Time** to **5** seconds.  
 17 Set **New Rate** to **15 Å/s**.

**NOTE:** Settings on the **Layer** and **Rate Ramp** tabs must be set for each layer in a process. Settings on the remaining four tabs (**Deposit**, **Condition**, **Source/Sensor**, and **Errors**) correspond to the Film that was selected on the **Layer** tab. This allows a Film's settings to be used in a number of layers, without the need to individually adjust each layer.

## 2.2.4 Edit Deposition

18 Select the **Deposit** tab. See Figure 2-6.

Figure 2-6 Deposit tab

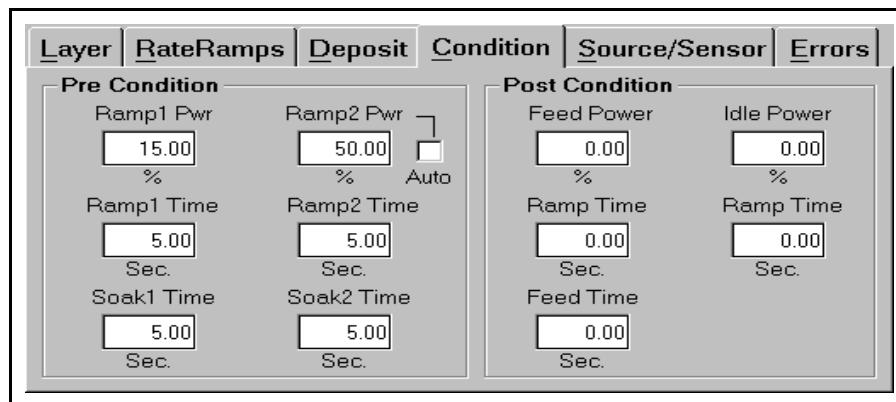


19 Set gain (**P Term**) to **55**.  
 20 Set time constant (**I Term**) to **0.7**.  
 21 Set dead time (**D Term**) to **0**.  
 22 Be sure **Shutter Delay Enabled** is not selected.  
 23 Set **Rate Sampling** to **Continuous**.

## 2.2.5 Edit Pre/Post Conditioning

24 Before deposition begins, the source material is often brought to a ready state by slowly raising the evaporation source power. Select the **Condition** tab and set each parameter to the values shown in Figure 2-7.

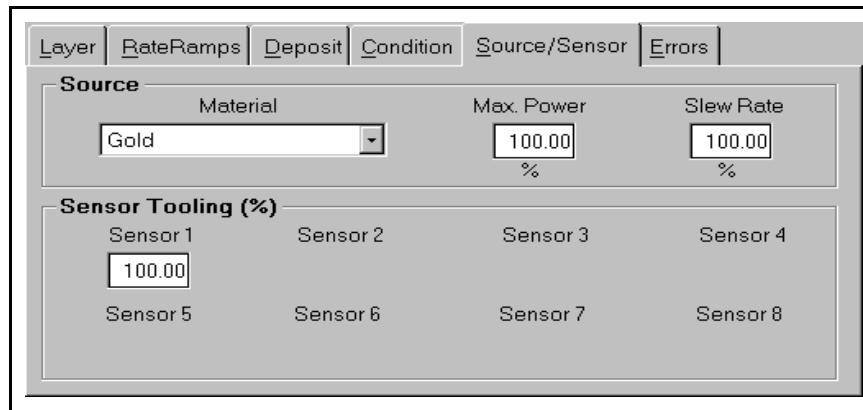
Figure 2-7 Condition tab



## 2.2.6 Edit Source/Sensor

25 Select the **Source/Sensor** tab. See [Figure 2-8](#)

*Figure 2-8 Source/Sensor tab*



26 Select the proper material for this film, **Gold**.

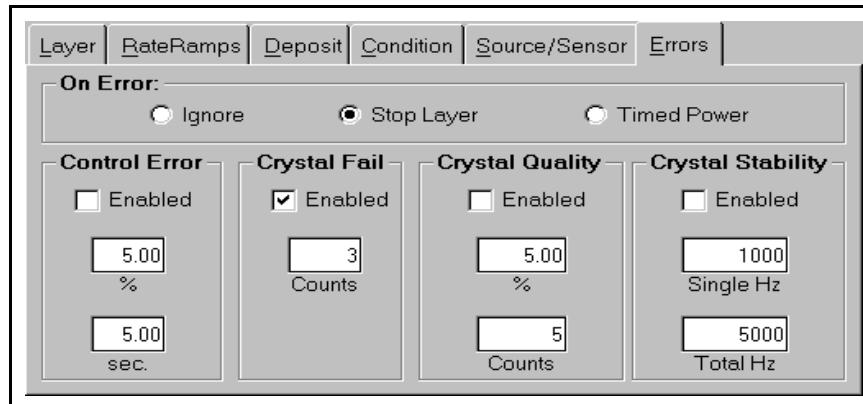
27 Set the maximum power and slew rate that should be used for the selected material.

28 **Sensor Tooling** adjusts for differences in the substrate deposition and that measured by each sensor. Select **100%** for now.

## 2.2.7 Edit Errors

29 Select the **Errors** tab, see [Figure 2-9](#), to control the actions taken when a sensor or deposition control error occurs. You can elect to ignore errors (unlikely), stop deposition for this layer, or continue deposition at a fixed power level. Select **Stop Layer** for this example.

*Figure 2-9 Errors tab*



30 Until a process is well established, it is best to enable only the **Crystal Fail** error checking. Uncheck the remaining error conditions.

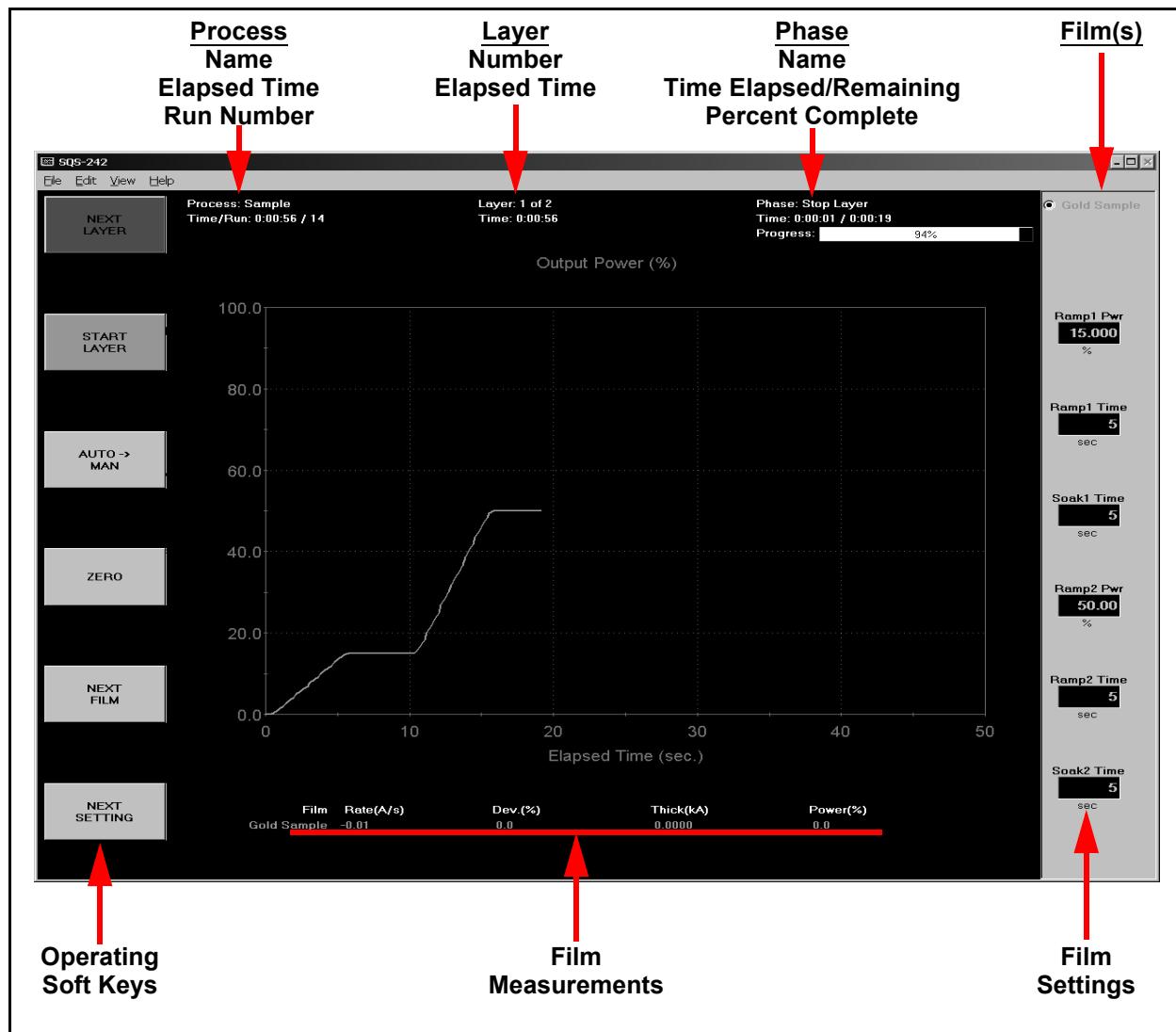
## 2.2.8 Save Edits

- 31 Select the **Close Form** SoftKey to save this one-layer process. If you are prompted **Do you want to change....** answer **Yes** to make this the current process.
- 32 Your new single-layer process is now the active process in the main window. Notice the process, layer, and time information above the graph.

## 2.3 Single Layer Process Simulation

If you have followed this chapter, you are ready to simulate a deposition process. First, take a look at the information provided on the main dialog box. See [Figure 2-10](#).

*Figure 2-10 Information on Main Dialog Box*



### 2.3.1 Setup Displays

Click the **View** menu and make sure that these options are selected:

- ◆ **Film Settings**
- ◆ **Film Readings**
- ◆ **Automatic**

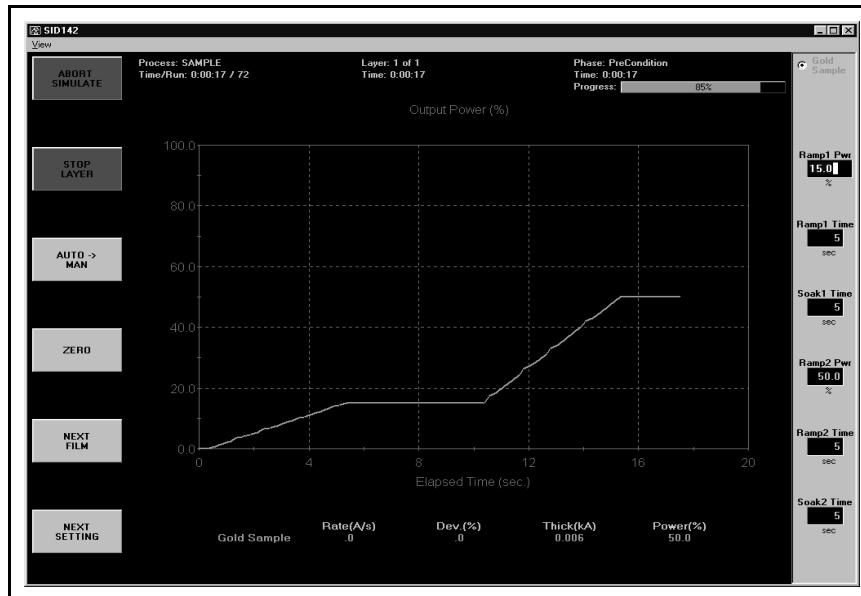
Note that the settings “ribbon” along the right side of the dialog box displays the pre-conditioning parameters you entered in the previous section.

### 2.3.2 Start Process

Verify that the top SoftKey label displays **START SIMULATE**. If **START PROCESS** is displayed, follow the instructions at the end of [section 2.1](#) to enable simulate mode. Press the **START SIMULATE** SoftKey to start the process.

The process will start with preconditioning (i.e., **Ramp1**, **Soak1**, **Ramp2**, **Soak2**) as shown in [Figure 2-11](#). Once preconditioning is complete, the process will enter the Deposit phase.

*Figure 2-11 Preconditioning*



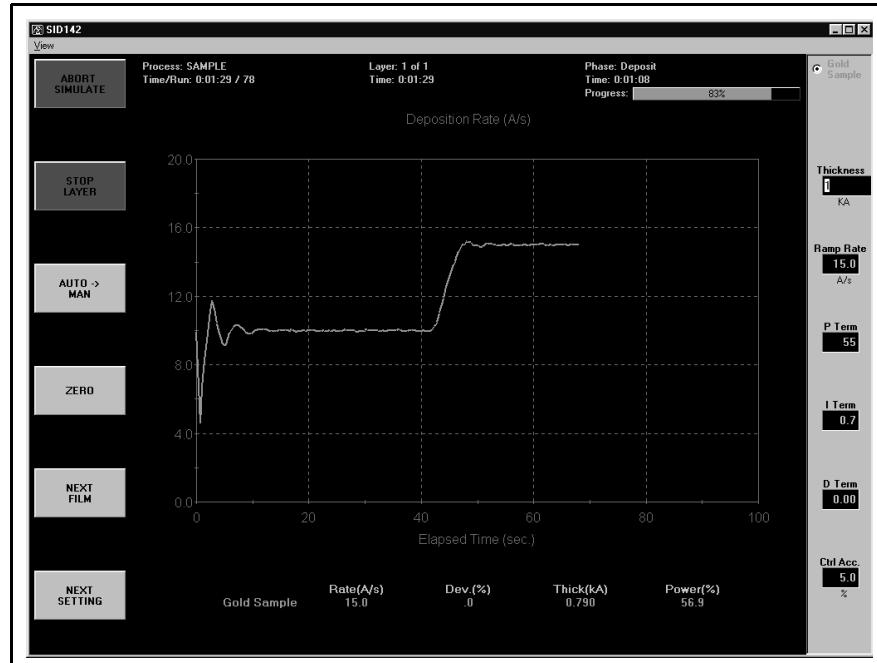
You may want to select **ABORT SIMULATE**, then **START SIMULATE** several times to familiarize yourself with the on-screen displays during preconditioning. You may also want to use the settings ribbon to adjust parameters while the process is running.

### 2.3.3 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 in [Figure 2-12](#), the initial deposition rate was 10 Å/s until a thickness of .400 kÅ. Then the deposition rate was ramped up to 15 Å/s, and held until the desired final thickness of 1.000 kÅ was achieved. At this point, this single-layer process is finished.

*Figure 2-12 Deposition Rate*



### 2.3.4 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.

**NOTE:** In Simulate Mode, a deposition rate is not “measured” until the output power exceeds 50%.

## 2.4 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.

### **START PROCESS**

Starts the first layer of a process when **START** is pushed. If **AUTO→MAN** is shown on the third SoftKey (AUTO mode) the process starts PreConditioning. If **MAN→AUTO** is shown on the third SoftKey (MANUAL mode) the process immediately starts in the Deposition phase.

### **ABORT PROCESS**

Aborts the process. The process can only restart at the first layer.

### **START LAYER**

Starts a stopped layer, or a layer that has been designated Manual Start in the process database. Starts the layer based on the state of the AUTO >> MAN SoftKey as described above.

### **STOP LAYER**

Stops the current layer. Also changes the function of the first SoftKey to **NEXT LAYER**.

### **NEXT LAYER**

Abandons the current layer and moves to the next layer in the process. If it is the last layer of a process, the same as pushing **ABORT PROCESS**.

### **AUTO→MAN**

When **AUTO→MAN** is pushed, the source output is set to manual control. 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.

### **MAN→AUTO**

Returns the output to PID loop control. If the process is running (**ABORT PROCESS** and **STOP LAYER** shown on the first two SoftKeys) deposition continues. If the process is stopped, sets the output to zero and awaits a start command.

### **ZERO**

Resets the thickness reading to zero.

### **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.

## 2.5 Multi-Layer CoDeposition Process

Our final example builds on the previous sections. If you have modified the setup of your process, return to [section 2.2, Single-Layer Process Setup, on page 2-2](#) and adjust the process to those values. When your single-layer process matches [section 2.2](#), complete these steps:

### 1 Duplicate a Layer

Open the Edit Process dialog box. 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.

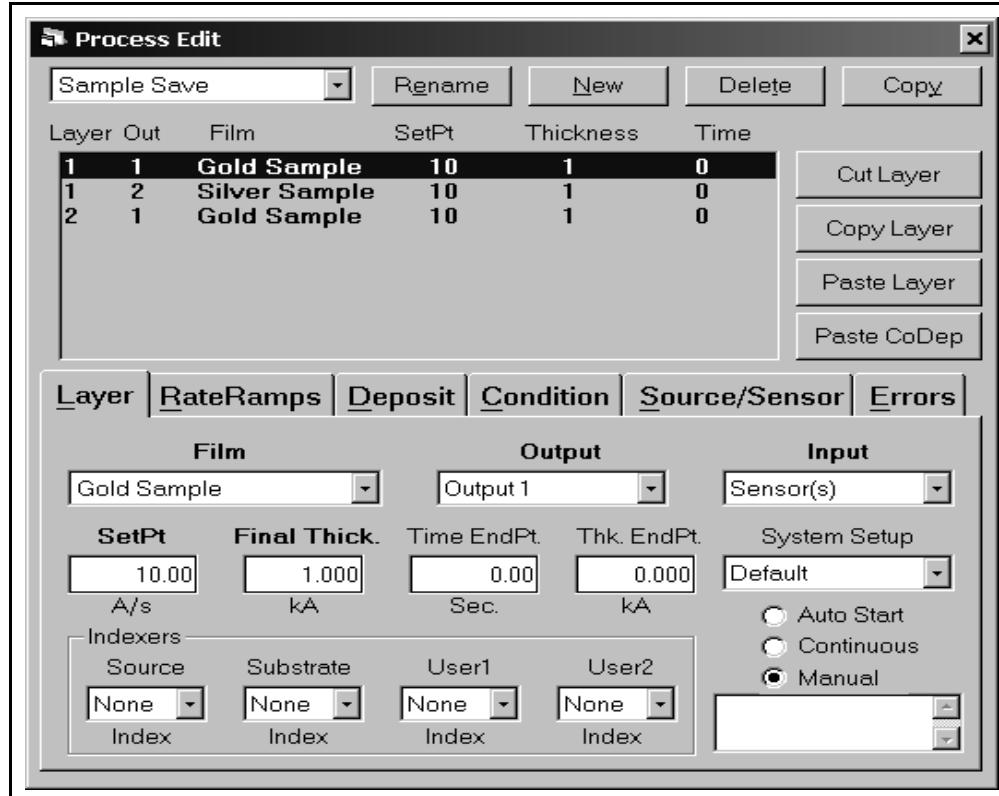
### 2 Select a CoDep Film

Select **Layer 3** in the layers list. Select **Films >> Silver Sample**. Select **Output >> Output 2**. The layers list will update to show the new Silver Sample film assigned to Layer 3.

### 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 [Figure 2-13](#).

Figure 2-13 Added CoDep Layer



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 easiest to copy a layer, then paste several temporary layers of that type as additional layers. Next, assign the films and outputs that you want to each of these additional layers. Now use **Cut Layer** on the temporary layers, and **Paste CoDep** to assign the film to the desired codeposition layers. Remember that each film in a codeposited layer must be assigned to a different source output! Review this example until you are comfortable with these concepts.

**4** Edit Layer 1 Rate & Thickness

Click **Silver Sample** in the list of layers. Set **Initial Rate** to **15 Å/s**, **Final Thickness** to **1.500 kÅ**. Click the **Rate Ramps** tab and set **Start Thickness** to **0.400 kÅ**, **Ramp Time** to **15** seconds, and **New Rate** to **0 Å/s**.

**5** Edit Layer 2 Rate & Thickness

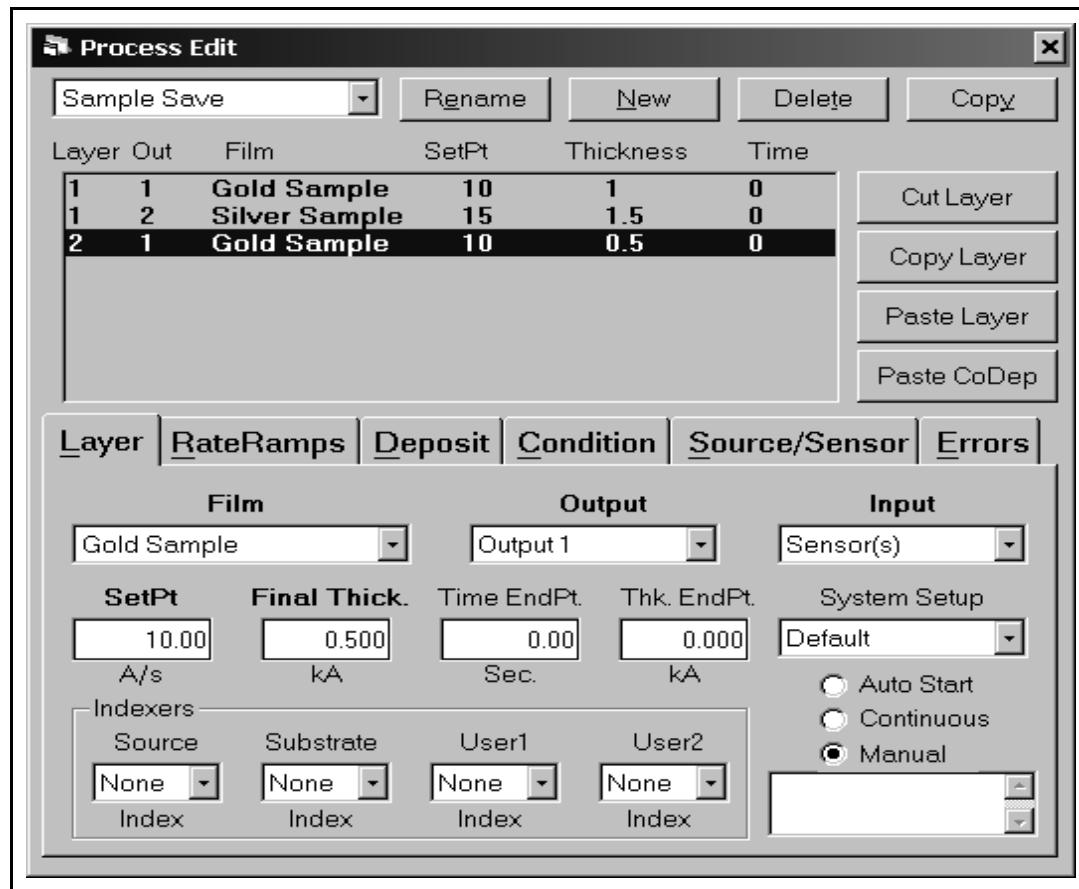
Click the **Layer** tab, then click **Layer 2 Gold Sample**. Set **Final Thickness** to **0.5000 kÅ**.

**6** 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 in [Figure 2-14](#).

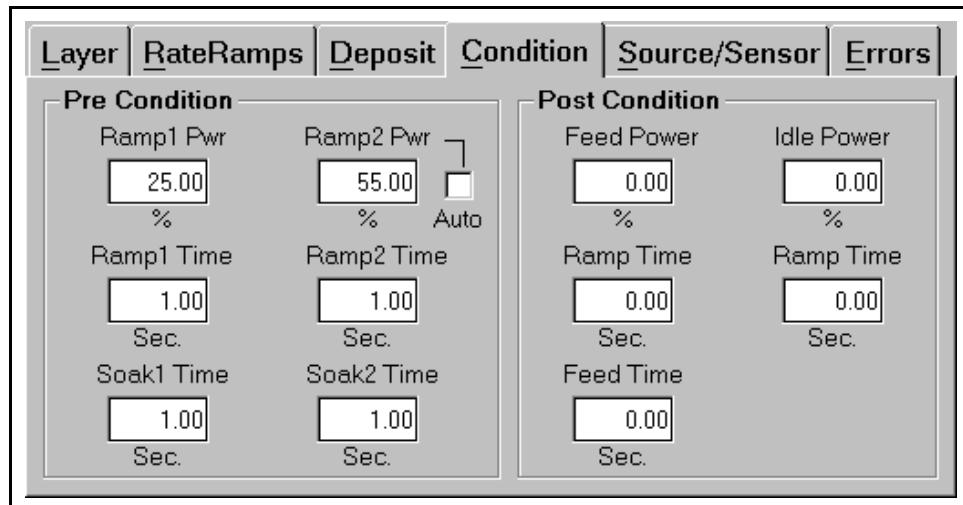
Figure 2-14 Process Edit Dialog Box



## 7 Edit Silver Conditioning

Select the **Condition** tab and the **Silver Sample** layer. Set each parameter to the values shown in Figure 2-15.

Figure 2-15 Condition Tab for Silver Sample Layer



## 8 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.

## 9 Start Process

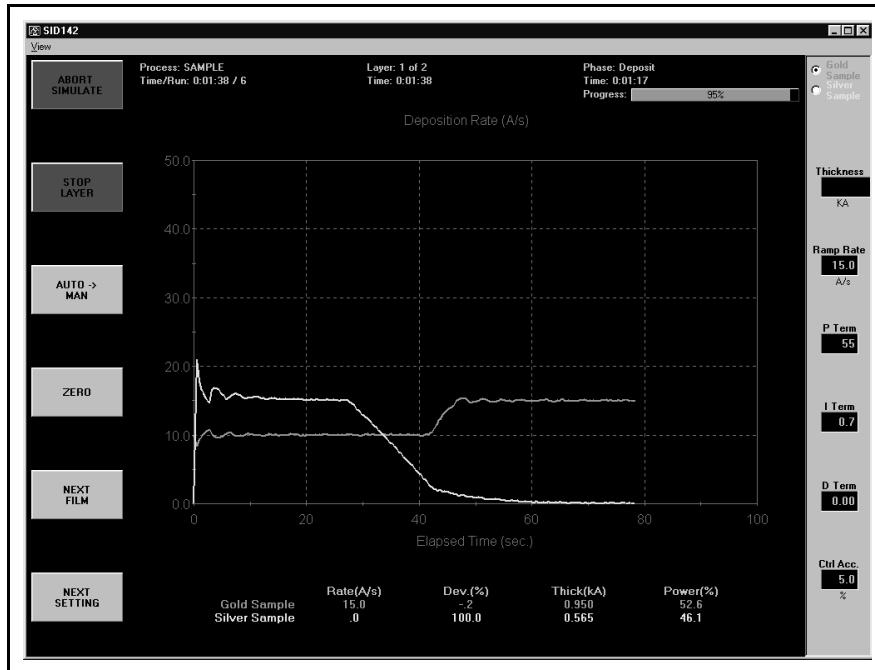
Press the **START SIMULATE** SoftKey to start the first layer preconditioning phases. Note that two outputs are displayed for this codeposition layer.

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 in [Figure 2-16](#) (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.

*Figure 2-16 Start Process Response*



At 0.400 kÅ thickness, the Silver Sample deposition rate ramps down from 15 Å/s to 0. Similarly, at 0.400 kÅ thickness the Gold Sample film ramps to a higher deposition rate of 15 Å/s. Because the initial rate for Gold was set lower than the initial rate for Silver, Gold reached its 0.400 kÅ 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.

## 2.6 Conclusion

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-242 card is “faking” an actual process. You can use the Simulate feature at any time to become familiar with SQS-242 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 **Edit** menu, then select **System** and set the **Mode** to **Normal** to begin running your real process with the SQS-242 software.

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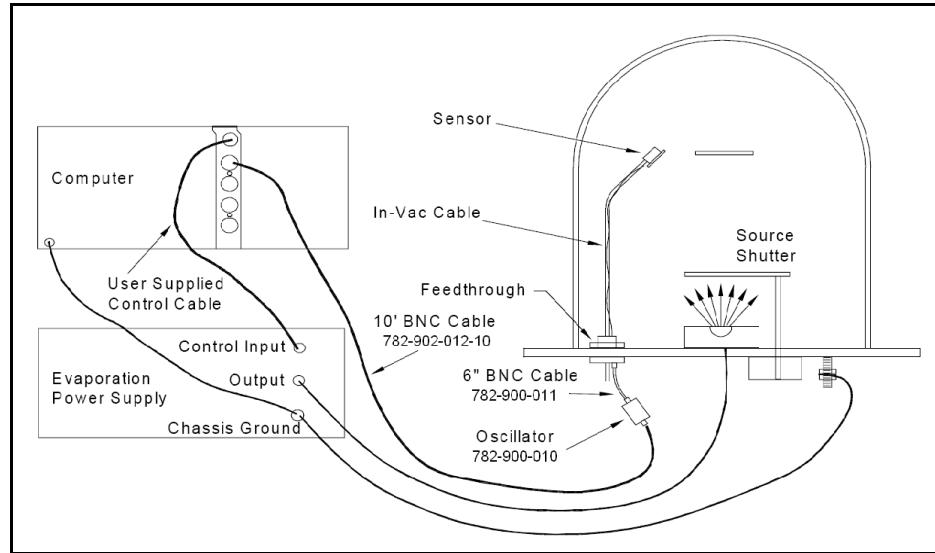
## Chapter 3

# SQS-242 Software

### 3.1 Introduction

This chapter covers the minimum system connections and initial setup required to run the SQS-242 software. Consult the SQM-242 operating manual for more detailed instructions. See [Figure 3-1](#).

*Figure 3-1 SQM-242 Setup*



#### 1 Sensor Input Connections

Connect the BNC cables and oscillators from your vacuum chamber feedthrough to the desired SQM-242 Card Input(s). Refer to Chapter 2 of the SQM-242 manual for detailed instructions on system hookup to the SQM-242 card(s).

#### 2 Source Output Connections

Connect the dual phone plug from the SQM-242 output jack to your evaporation supply control input. Refer to Chapter 2 in the SQM-242 manual for detailed instructions on wiring the SQM-242 output phone plug.

#### 3 Digital I/O Connections

Digital I/O is not required for initial operation of the SQS-242 software. Perform initial setup and checkout of the SQS-242 before connecting your digital I/O. See [Chapter 4](#) for detailed information on wiring the SQS-242 for digital I/O.

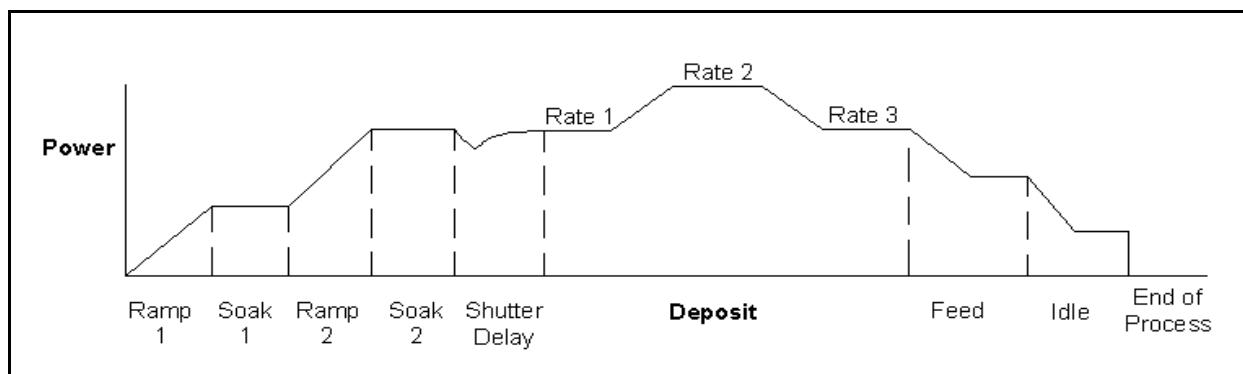


## WARNING

**Care should be exercised to route 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**

A typical deposition cycle for a thin film is shown in [Figure 3-2](#). The cycle can be broken into three distinct phases: pre-conditioning (ramp/soak), deposition, and post-conditioning (feed/idle)

*Figure 3-2 Typical Deposition Cycle*



During pre-conditioning, power is applied to prepare the source material for deposition. The first ramp/soak preconditioning phase is used to bring the material to a uniform molten state. The second ramp/soak phase is typically set to a power that is near the desired deposition rate.

When pre-conditioning ends, PID rate control of deposition begins. Initially, the substrate material may remain shuttered until the desired deposition rate is achieved (shutter delay). Once the control loop achieves the desired rate, the shutter opens and deposition begins. Multiple deposition rates (rate ramps) can be programmed.

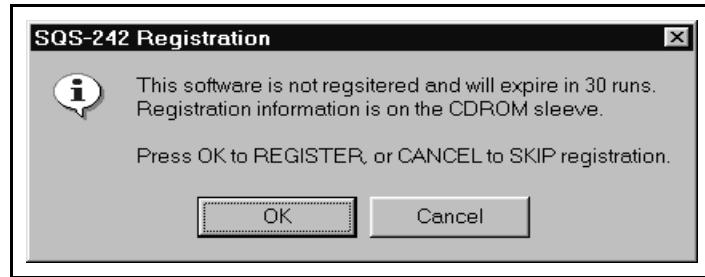
When the desired thickness is reached, the evaporation source is set to feed or idle power. At this point the process may be complete, or deposition of another film layer may begin. Up to six separate films can be codeposited within a single layer. There is no practical limit to the total number of processes, layers, or materials that can be stored in the process database.

### 3.2 Installation and Registration

The SQM-242 card can be installed before or after the SQS-242 software. Consult the separate SQM-242 card User's Guide for installation information. To install the program, insert the disk or CD-ROM. Click Start, then Run, then type <d>:Setup (where <d> is the drive you are using). Click OK to begin installation, and follow the on-screen prompts. When installation is complete, you may be prompted to restart the computer.

To start the SQS-242 program, click Start >> Programs >> INFICON >> SQS-242. If you see this Registration dialog box appear (see [Figure 3-3](#)), you have a older version of the SQS-242 software. contact INFICON for the latest version which removes this registration requirement.

*Figure 3-3 Registration Dialog Box*

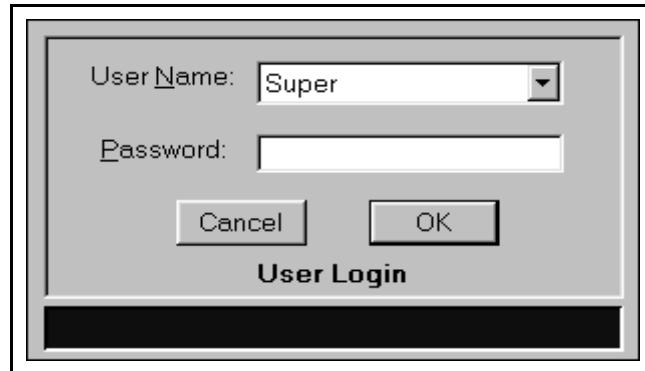


### 3.3 Operation

When the program is first started, it displays a progress bar during startup, then a User Login dialog box (see [Figure 3-4](#)).

**NOTE:** The SQS-242 software ships with one pre-assigned user. The user name is Super, with no Password.

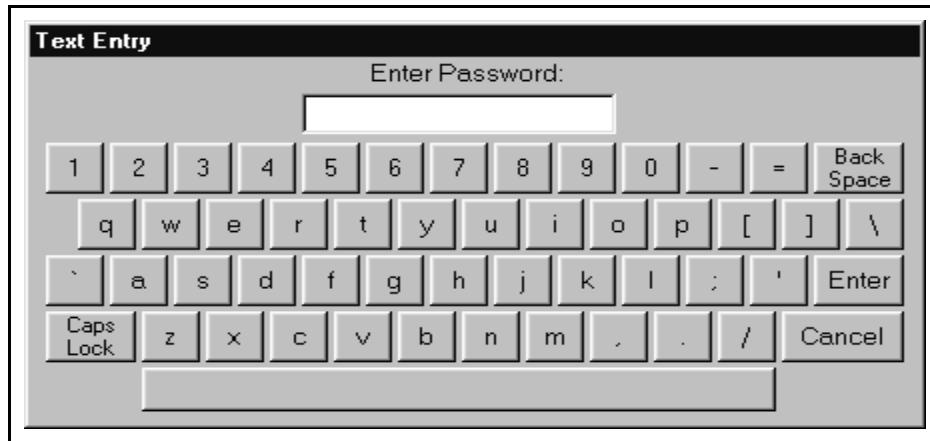
*Figure 3-4 User Name*



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

If your software is configured for keyboardless operation, an on-screen keyboard will appear as shown below. You can use your normal keyboard or mouse to “type” the password, then click Enter. See System Setup, SQM-242 Setup later in this chapter to enable or disable the on-screen keyboard (see [Figure 3-5](#)).

*Figure 3-5 On-screen Keyboard*



An Access Level is associated with each User Name. The Access Level controls which software functions are available to each user. For example, only users with an Access Level of Supervisor can add new 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 by menu selections. For a more “operational” approach, consult the previous Quick Start chapter.

**Menus:** The menus along the top of the main dialog box provide access to functions for building deposition processes, configuring the hardware for your vacuum system, and data display.

**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). Just move the cursor over the key label on dialog box 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.

## 3.4 Menu

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

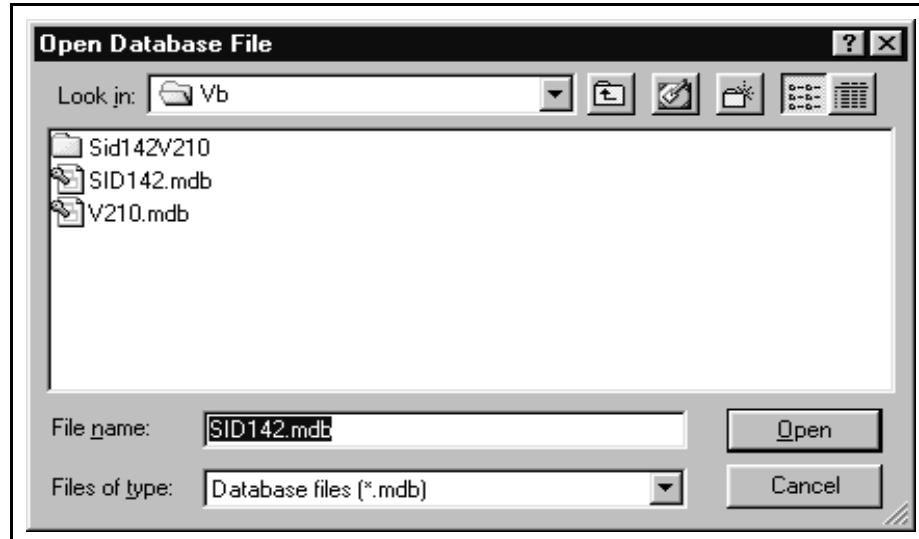
### 3.4.1 File: Process

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

### 3.4.2 File: Open and Save Database

**Open Database:** Selects a process database to be used for deposition. Remember, a single process database may contain an unlimited number of processes, films, and materials. See [Figure 3-6](#).

*Figure 3-6 Open Database File dialog*



**Save Database As:** Saves the current process database to disk under a different name. This is useful for saving the process database to floppy disk (for backup!), or for making trial changes without affecting your working database. Process databases are saved in Microsoft Access® format.

Once again, a pop-up keyboard may appear. If you want to browse, just select Cancel from the pop-up keyboard.

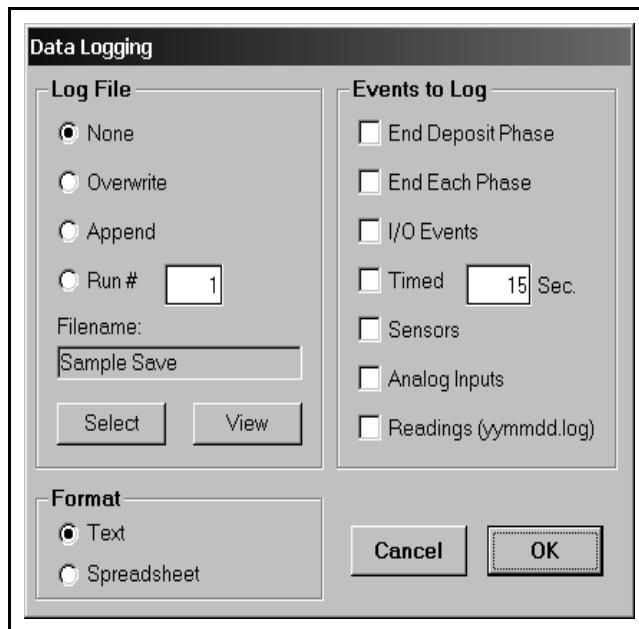
### 3.4.3 File: Data Logging

Logs data from a deposition process to a disk .LOG file. There are four options for file naming and logging. See [Figure 3-7](#).

**Log File:** Select None to disable data logging. If Overwrite is selected, the last run of the process is saved as FileName.LOG (where FileName is the name shown in the FileName text box). Subsequent runs overwrite the log file. If Append is selected, each run is appended to FileName.LOG. If Run# is selected, each run of the process is saved as a separate file under the format FileName\_Run#.LOG.

Changing Run# on this dialog box will also change the Run# displayed at the top of the main program dialog box.

Figure 3-7 Data Logging



Normally, the log file is saved to the folder where the program is installed. If desired, you can click Select and navigate to a different folder. Log files can be viewed in Notepad by clicking the View button.

**NOTE:** To avoid delays in data acquisition DO NOT log data to a floppy disk file. Instead, save to the hard disk, and transfer the files to a floppy disk later.

**Events to 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.

Timed logging records data at the selected time intervals throughout the process. Click the Sensors box to include individual sensor data in addition to the normal film based data. Click Analog Inputs to also log that data.

Finally, click Readings to log every reading from the SQM-242 card(s). The file will be saved in the application directory with a name in yymmdd.log format. That is, readings logged on January 15, 2011 will be saved as 110115.log.

**NOTE:** This file can grow quite large and cause Windows to slow significantly. Typically, the Timed option is a better choice unless you must record every reading. When Readings is selected, a reminder dialog box appears each time the SQS-242 program is started.

**Format:** 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 LOG file is a heading that illustrates the file format and content.

**NOTE:** To use a different delimiter than a comma, change the SQS242.INI file so that under the [DataLog] section, the LogDelimit= entry shows the character you want to use. To use a <TAB> character, type the word Tab. See [section 3.8 on page 3-37](#).

#### **3.4.4 File: Print**

**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.

#### **3.4.5 File: User Login**

Displays the User Login dialog box so that a different user may log in. The existing user is logged off automatically. The user Access Level changes immediately to that of the new user. See the Edit, Security section for more information on Users, Passwords, and Access levels.

#### **3.4.6 File: Exit**

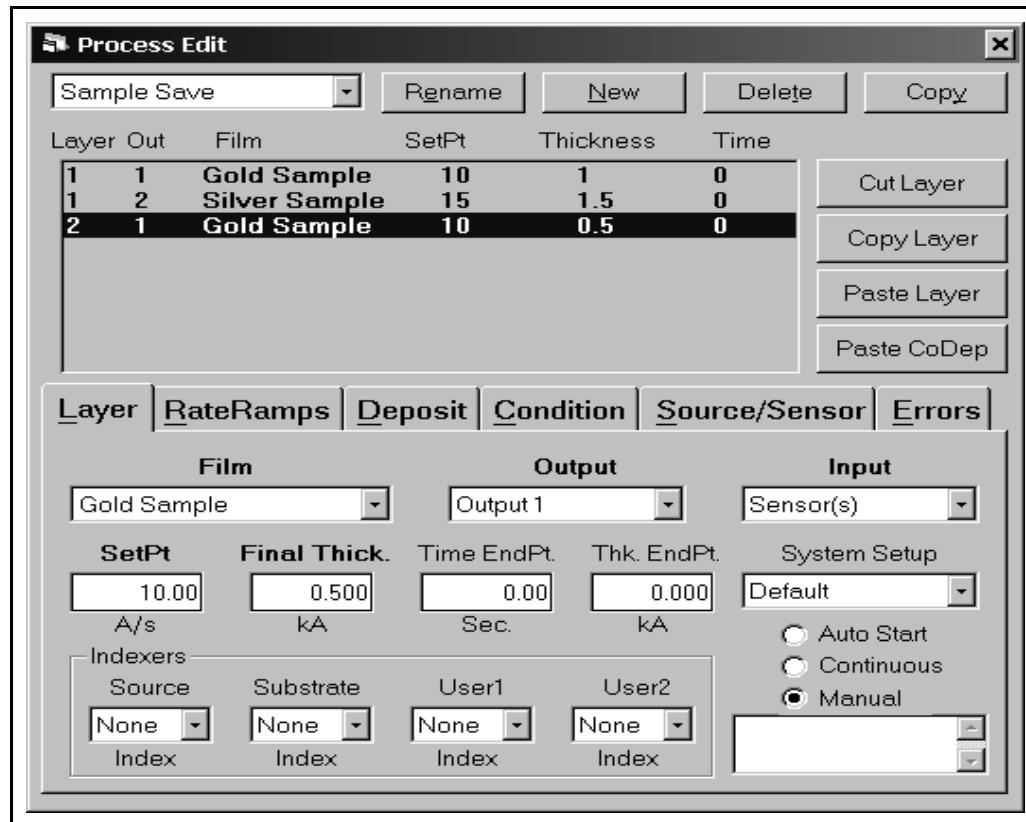
Exits the SQS-242 deposition control program and saves the current data.

## 3.5 Edit Menu

### 3.5.1 Edit: Process

A process is a sequence of thin film layers. Multiple films deposited in the same layer are known as CoDeposition. The Process Edit dialog box, see [Figure 3-8](#), provides the functions needed to develop a thin film deposition process from the database of existing films and materials.

*Figure 3-8 Process Edit dialog*



Controls along the top of the Process Edit dialog box apply to the entire process:

**Process:** A dropdown box that selects the process to be edited. Defaults to the current process. Below the process dropdown, a listing of each layer assigned to the Process. CoDeposition layers are listed with the same layer number, but a different output.

**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 selected process from the database. *There is no undelete!*

**Copy:** Creates a duplicate of the currently selected process.

**Layers List:** To select a process layer, click on it in the Layers list.

Cut/Copy/Paste the selected layer as described below:

**Cut Layer:** Removes the selected layer 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. Attempting to paste a layer that uses an output already assigned to the selected layer generates an error message.

**HINT:** To add layers to a process, it is easiest to select an existing layer in the layers list, then click Copy. Click Paste repeatedly to insert several temporary layers. Next, assign the proper film and layers parameters to each of these temporary layers.

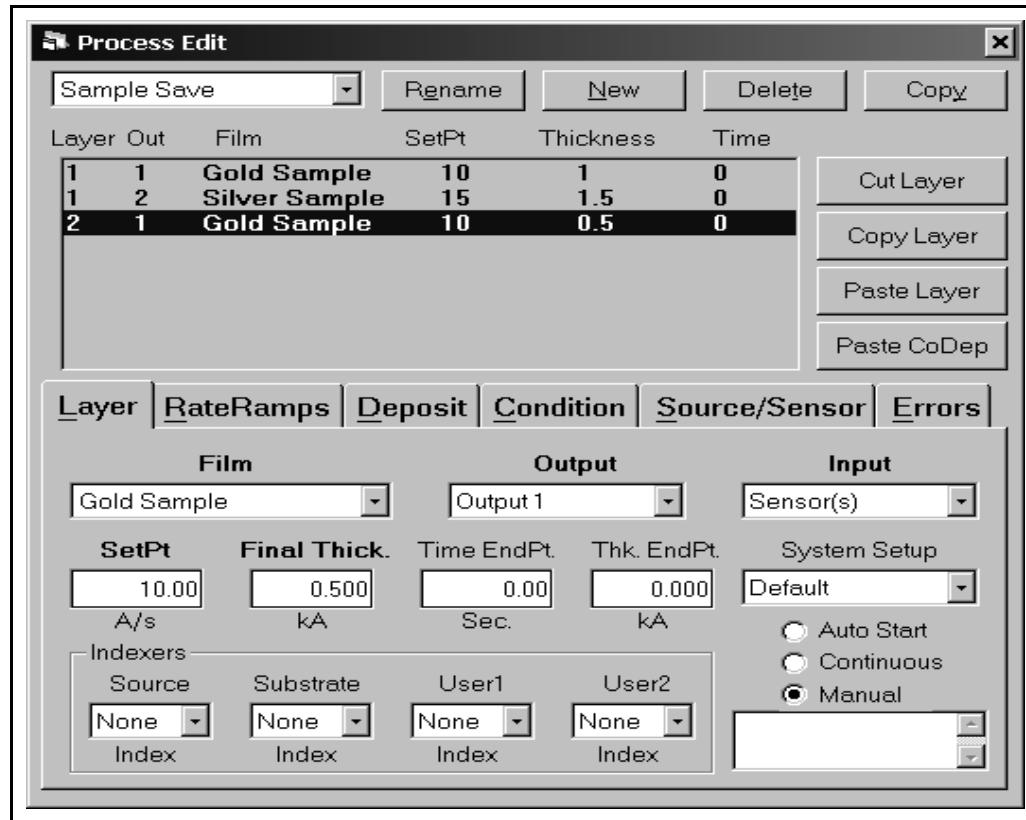
To change one of the temporary layers to a CoDep layer, highlight the temporary layer and click Cut Layer. Next click the layer desired for CoDep and click Paste CoDep to assign the selected layer.

Controls in the tabbed control apply to the layer selected above, in the Layers list. The Layer and Rate Ramp tabs assign layer-specific parameters to the selected layer. Note that captions on the Layer tab may change, depending on the input and output selections. The remaining tabs provide access to the film assigned to the selected layer.

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

### 3.5.1.1 Layer Tab

Figure 3-9 Layer Tab



**Film DropDown Box:** Assigns a film to the selected layer. A film is basically a Material, plus the other settings shown on the Deposit, Condition, Source/Sensor, and Error tabs.

**Output DropDown Box:** Selects the output that is used for deposition of the selected layer's film. A particular film often uses the same output (i.e., a thermal boat or E-Beam pocket).

**NOTE:** Due to the way outputs are stored in the process database, the physical output number (not its name) is listed in the layers listing. Outputs 1 and 2 refer to the first SQM-242 card outputs. Outputs 3 and 4 refer to the second SQM-242 card outputs (if installed). Outputs 13 and 14 are the SAM-242 card outputs (if installed).

**Input DropDown Box:** Selects the input used to measure and control deposition of the selected layer. The combination of an output and its input defines the deposition "control loop" for the selected layer. The Input selection can significantly alter operation of the deposition phase, as described in the following discussion on the SetPt parameter.

**SetPt:** The function of the setpoint parameter depends on the Input dropdown. If Sensor(s) are used as the input, the setpoint is Rate (in Å/s). This sets the initial Rate setpoint for the selected layer. Rate is controlled by the PID parameters for the film assigned to the layer. If no rate ramps are defined for the layer, this is the rate setpoint for the entire layer.

If the Input selected is Timed Power, the setpoint is shown as % Power. This sets a fixed % output Power during deposition. In Timed Power the Time Endpoint establishes the length of time for the deposition cycle. The layer will end when either the time endpoint is reached, or when the Final Thickness is reached, whichever occurs first.

If one of the SAM-242 analog inputs are selected, the setpoint is in volts (or the analog input's corresponding user-defined units). The layer will end when either Time Endpoint or Final Thickness is reached, whichever occurs first. See the Analog Inputs section later in this chapter for a discussion of programming for analog inputs.

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

**Time EndPoint:** Sets an arbitrary time, after deposition begins, when the time setpoint relay is activated. During % Power and Analog Input deposition, it also sets the length of the deposition cycle.

**Thickness EndPoint:** Sets an arbitrary thickness that activates the thickness limit relay.

**Auto/Manual/Continuous Start:** Auto Start begins the next layer automatically upon completion of the previous layer. Continuous ignores Conditioning phases and controls continuously at rate setpoint (see Analog Inputs). If Manual Start is selected, the previous layer ends at its idle power and waits for the user to push the Start Layer switch. An optional User prompt can be entered for Manual Start layers. (This feature can be disabled by editing ShowPrompts in the SQS242.INI file).

**NOTE:** The following parameters are common to all of the films in a layer. In the previous dialog box shot for this section, both layer 1.1 and 1.2 would share common values for the following parameters. Layer 2.1 could have different values.

**System Setup:** System setup assigns outputs to their controlling sensors (called sensor mapping). It also determines which physical sensor and output connections are displayed on the main dialog box. See [section 3.5.4 Edit: System](#) for detailed system setup information.

**Source Index:** Assigns each film to a specific source indexer pocket (one of 16 values). Each of the six possible outputs is associated with a unique source indexer. These values are sent to the digital I/O (PLC) at the beginning of each layer.

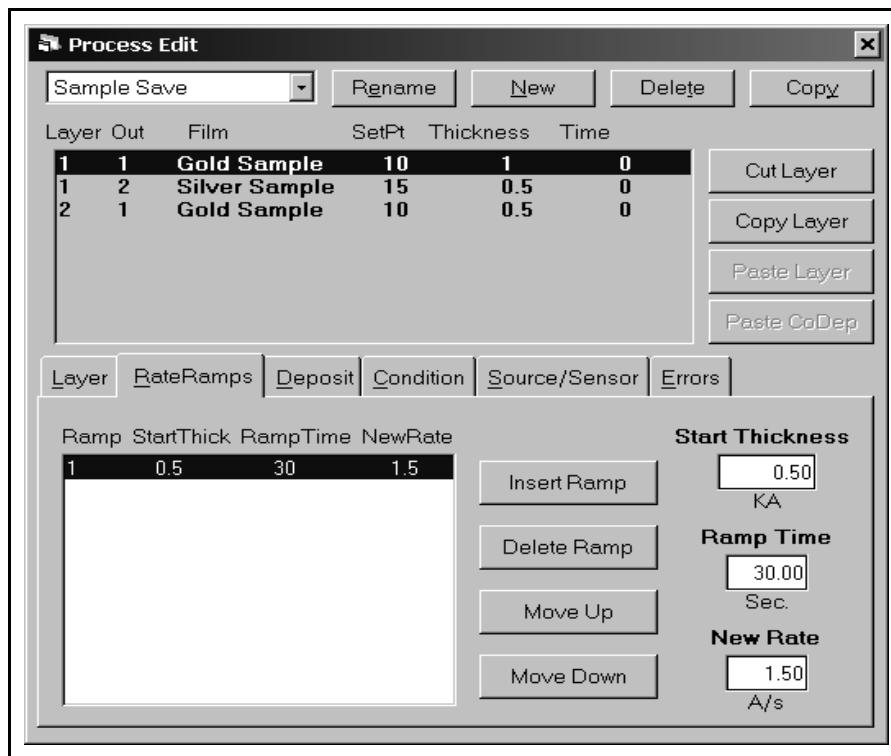
**Substrate Index:** If using a substrate indexer, assigns the substrate to one of 16 possible values. These values are set at the beginning of each layer.

**User1/User2 Index:** These additional values are output to the PLC for use as needed. Common applications are to select external equipment configurations. (The Index names, the range of values (0 to 15, or 1 to 16), and the first entry can be customized by editing entries in the SQS242.INI file - See section 3.8).

### 3.5.1.2 Rate Ramps Tab

Rate ramps cause changes to the deposition rate over time under PID control. Each rate ramp has a starting thickness, an elapsed time to ramp to the new rate, and a new rate setpoint. Each process layer can have an unlimited number of rate ramps. See [Figure 3-10](#).

*Figure 3-10 Rate Ramps tab*



**Insert Ramp:** Inserts a new rate ramp for the selected layer, at the selected position in the rate ramps list. 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 ignored.)

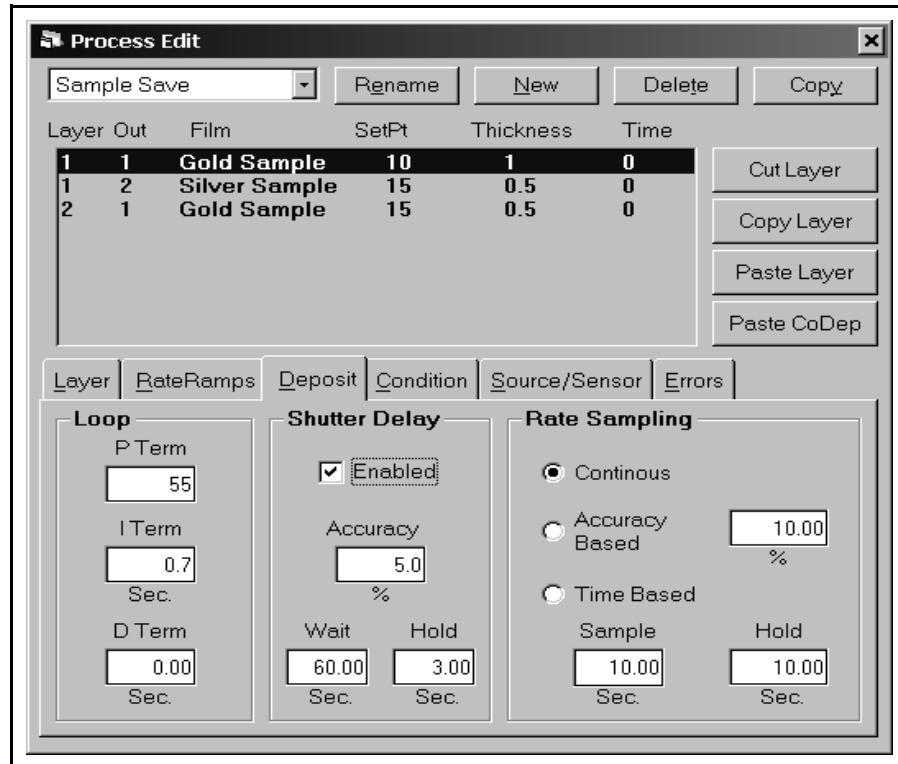
**Ramp Time:** The time (in seconds) to ramp to the new rate. If the rate ramp is too fast, a PID control error may be generated.

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

### 3.5.1.3 Deposit Tab

The **Deposit** tab contains parameters that directly affect the deposition phase of the process cycle. See [Figure 3-11](#).

*Figure 3-11 Deposit tab*



**P Term:** Sets the gain of the control loop. High gains yield more responsive, but potentially unstable loops. Try a value of 25, 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 1 to 3 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 (.1 x I Term) to avoid oscillations.

**Shutter Delay:** It is often desirable to assure stable process control before the substrate shutter opens. Enabling shutter delay requires that the system reach the programmed shutter delay Accuracy, and maintain that accuracy before deposition begins. If the accuracy is not reached within Wait seconds, the process halts. If

accuracy is achieved, and maintained for Hold seconds, then the substrate shutter opens and deposition begins. The Thickness reading is zeroed at the end of the shutter delay period.

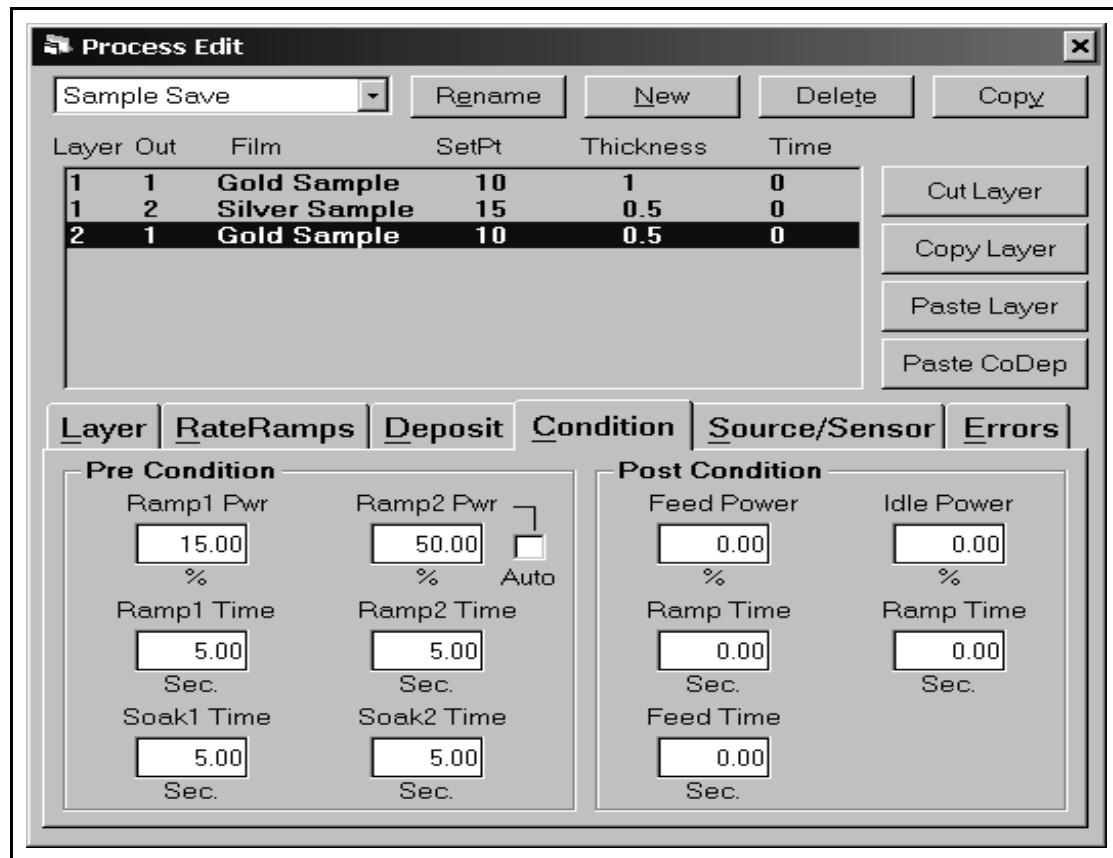
**Rate Sampling:** Rate sampling can extend the life of crystals. With rate sampling, the deposition rate is sampled for a period of time, then the sensor shutter is closed. Power is then held at the same level as the final power setting during the sample period.

Continuous selects no sampling; the sensor shutter remains open during deposition. Accuracy Based sampling opens the shutter until the desired accuracy is reached, leaves the shutter open for Sample time, then closes the shutter and holds power constant for Hold time. Time Based sampling opens the shutter for a fixed period of time then closes it for a fixed time.

#### 3.5.1.4 Condition Tab

Before the deposition begins, it is often necessary to PreCondition the source material. This places the system at the proper power level to achieve rapid PID control when deposition begins. See [Figure 3-12](#).

Figure 3-12 Condition tab



**Ramp 1:** Ramp power sets the power level that is 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 match the desired initial deposition rate. Selecting the Ramp2 Power Auto checkbox stores the power over the last few seconds of the deposit phase for this film. That value is used as the Ramp2 power for the next run of the selected film.

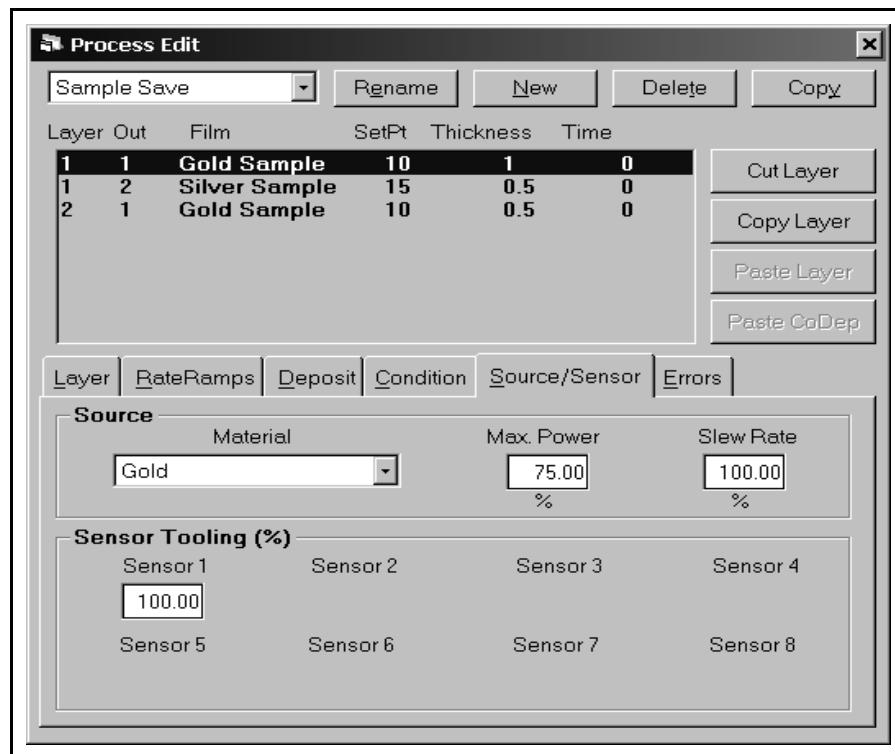
**Feed:** The feed phase begins immediately after deposition is complete. It holds output power at the level and time required to wire feed new material.

**Idle:** The Idle phase follows the Feed phase.

### 3.5.1.5 Source/Sensor Tab

The Source/Sensor tab controls the physical setup of the deposition system. See Figure 3-13.

Figure 3-13 Source/Sensor tab



**Material:** Selects the physical deposition material for the film selected on the Layers tab. Selecting a material sets the Density and Z Factor, as defined in the Edit Materials dialog box.

**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 Edit System menu, Outputs tab. Max Power controls the maximum % of the full scale power that can be used by this film in all phases (PreConditioning, Deposition, and Feed/Idle).

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

**Sensor Tooling:** Adjusts for sensor measured 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 200%. Setting Tooling to 0% causes a sensor to be ignored for this film.

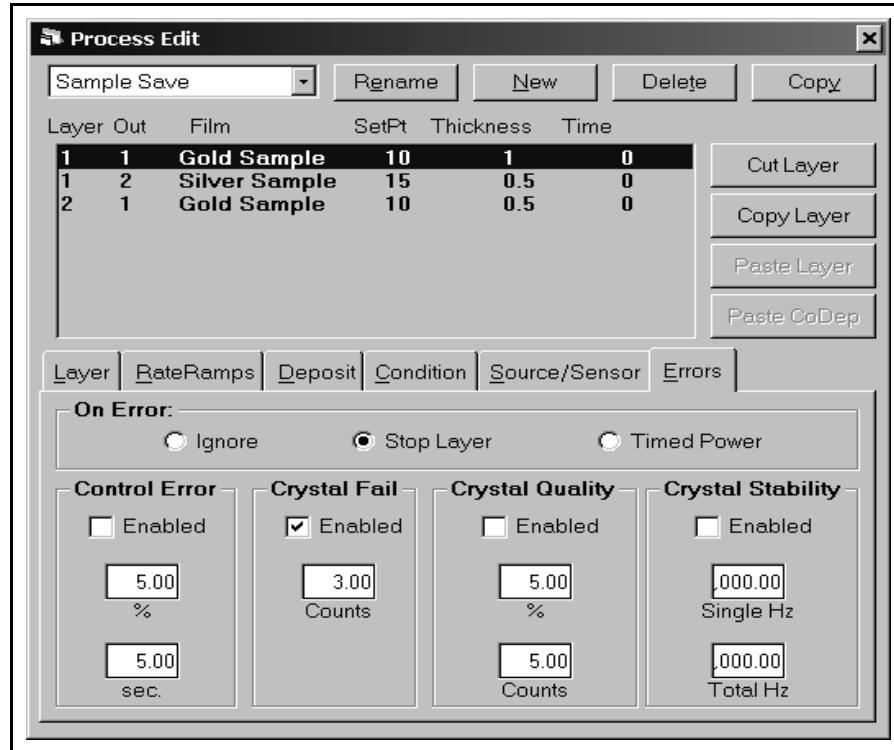
The System Setup selection on the Layer tab establishes which sensor(s) are visible. Only those sensors “mapped” to the layer’s output are visible.

### 3.5.1.6 Errors Tab

Several source or sensor error conditions are possible during deposition. This tab establishes the program’s response to errors. See [Figure 3-14](#).

**NOTE:** It is best to leave all error settings, except **Crystal Fail**, disabled until you are confident of the stability and repeatability of your process.

*Figure 3-14 Errors tab*



**Control Error:** If the control loop cannot maintain the desired deposition rate (due to loss of source material, excessively high rate ramps, or equipment malfunction) a control error occurs. Control error % is the accuracy that must be exceeded for the specified time (in seconds) to trigger a control error. Use shutter delay accuracy to assure adequate process control before entering the deposition phase.

**Crystal Fail:** Establishes the number of bad readings (i.e., 0 Hz) from a sensor that generates a Crystal Fail condition. If a crystal fails, the PID loop will send the source supply to max power. Therefore, it is unlikely you will ever want to disable this error.

**Crystal Quality:** Each time the rate deviation for this film exceeds the % value, a counter is incremented. Each time the rate deviation is within the % value, the counter is decremented (to zero minimum). If the counter exceeds the Counts value during the entire layer deposition, an error occurs.

**Crystal Stability:** When material is being deposited, a crystal's frequency normally drops. At the end of crystal life, sensor frequency may briefly "mode hop" to higher frequencies. Single Hz is the largest single positive frequency shift allowed. Total Hz is the sum of positive shifts allowed during a film's deposition.

**On Error:** When an error condition occurs, three actions are possible. Ignore the error and let the PID loop attempt to maintain rate control. Stop the layer and allow the user to fix or manually control deposition. The last choice, Timed Power, uses the last good Rate/Power settings to "estimate" rate and thickness.

In Timed Power, the output is set to the power level that last yielded a rate reading within the Control Error % deviation setting (10% deviation if Control Error is disabled). The program then calculates the estimated thickness based on that rate and the deposition elapsed time. When the calculated thickness reaches thickness setpoint, deposition stops.

### 3.5.1.7 Analog Inputs

Normally the SQS-242 software uses SQM-242 card quartz sensor inputs to measure or control rate and thickness. The SAM-242 Analog Input Card extends this capability to allow measurement and control on DC voltage-based process variables such as temperature transmitters, pressure/flow controllers.

Analog input based control is treated, for the most part, identically to quartz sensor based control. Considerations for using an analog input are discussed below.

**Layers Tab:** In the Inputs dropdown, select one of the Analog inputs. In the Outputs dropdown, select the output that is to be controlled. Enter the desired setpoint. Normally this setpoint is in Volts, but can be converted to other units (e.g., degrees or PSI) in the Edit, System, Analog dialog box.

Use Time Endpoint to stop the analog layer after a set time. Otherwise, a Sensor input, programmed as a Codep layer, can control the layer endpoint. Final Thickness and Thickness Endpoint settings have no effect for an analog input.

If Continuous Start is selected the analog input controls to its programmed Layer Setpoint through all of the Ramp/Soak/Feed phases. This allows temperature or pressure control (for example) to be maintained through all phases of the layer. If Stop Layer is selected, control is still maintained at setpoint. Pressing Abort Process will set the output to zero.

**Rate Ramps Tab:** Setpoint ramps can also be programmed for an analog signal.

**Deposition Tab:** The PID and Shutter Delay controls operate the same as a Sensor input. Rate sampling is not possible for analog inputs.

**Condition Tab:** Conditioning is identical to that of a Sensor input.

**Source/Sensor Tab:** Only Max Power and Slew Rate are functional.

**Errors:** Only Control Error applies.

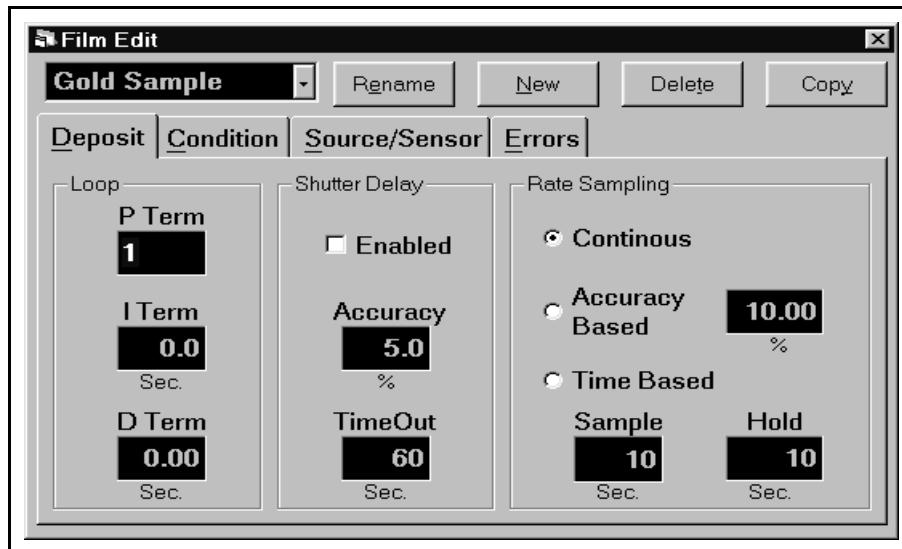
The Analog Input's measured value (converted to the defined units) and deviation from setpoint are shown below the graph. The analog input values are NOT shown on the normal Rate graph (the values could lead to poor rate resolution on the graph). Instead the analog input voltages are shown on the View, Analog graph. Volts are displayed on this graph, rather than the scaled units (again, to maintain adequate graph resolution).

### 3.5.2 Edit: Films

The Edit Films dialog, see [Figure 3-15](#), allows you to rename, delete, and copy films. The functions in the tabbed control are identical to those for this film on the Edit Processes dialog.

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

*Figure 3-15 Film Edit dialog*



**Film:** A dropdown box that selects the film parameters displayed in the edit film dialog box.

**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 process! To delete a film, you must first delete the film from each process where it is used.

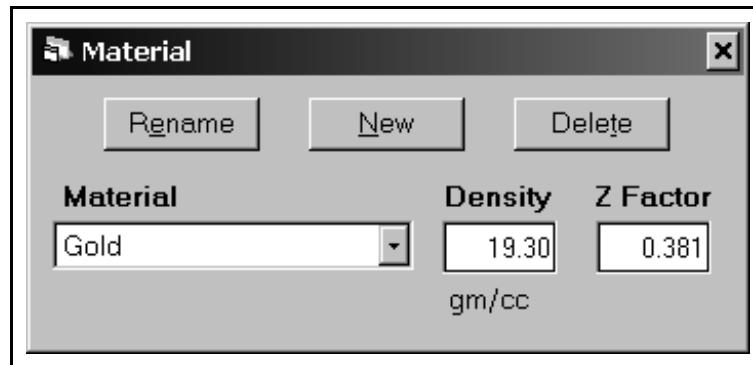
**Copy:** Creates a duplicate of the currently selected film.

The function of each Edit Films tab, and its associated controls, are identical to those detailed in the Edit Processes section. Please consult [section 3.5.1 on page 3-8](#) for that information.

### 3.5.3 Edit: Materials

The Edit Material dialog, see [Figure 3-16](#), provides the functions needed to build a materials database. In addition to the functions listed below, the main dialog box SoftKeys provide capabilities to add/edit/delete materials.

*Figure 3-16 Material dialog*



**Rename:** Edits the name of the selected material.

**New:** Creates a new material.

**Delete:** Deletes the currently selected material from the database. A material cannot be deleted if it is used in ANY process! To delete a material, you must first delete each film where it is used.

**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-Ratio, a measure of a material's effect on quartz crystal frequency change. Z-Ratio has no effect on measurements when using a new crystal. If the Z-Ratio for your material is not known, using crystals with >80% life will eliminate the effect of the Z-Ratio term.

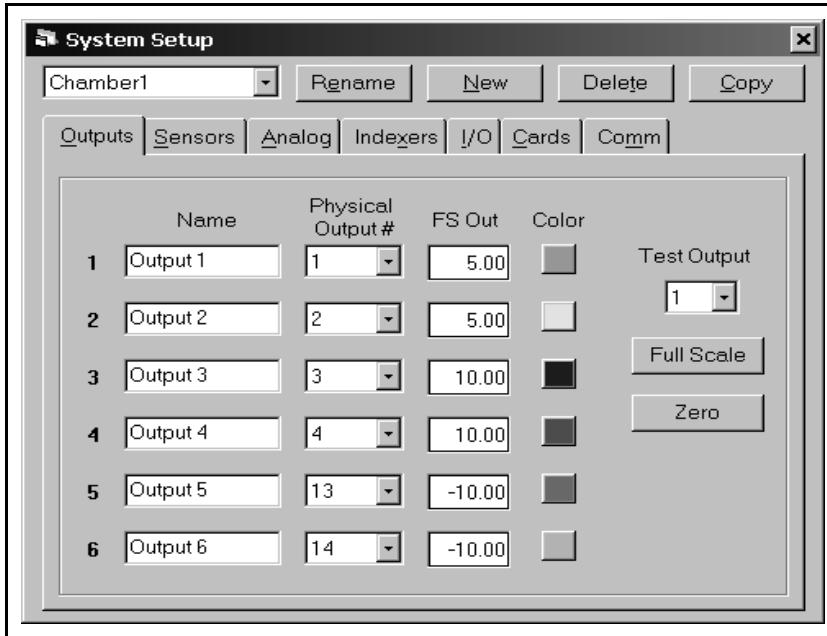
### 3.5.4 Edit: System

The System Setup dialog, Figure 3-17, configures the SQS-242 software to the physical setup of your deposition system. Several settings that control the overall operation of the program are also accessed in System Setup.

The combination of sensor input and control output assignments, known as a System Setup, are stored in the SQS-242 database. Most systems will have a single setup that applies to all processes. However, complex systems may use several different system setups within a single process.

**NOTE:** Settings on the Outputs, Sensors, Analog, and Cards tabs are unique for each System Setup. Settings on the Indexers, I/O, and Comm tabs apply to all System Setups. Output colors are also common to all setups.

Figure 3-17 System Setup dialog



Controls along the top of the System Setup dialog box apply to the selected system setup:

**System Setup:** A dropdown box that selects the setup to be edited. Defaults to the current setup.

**Rename:** Edits the name of the selected setup.

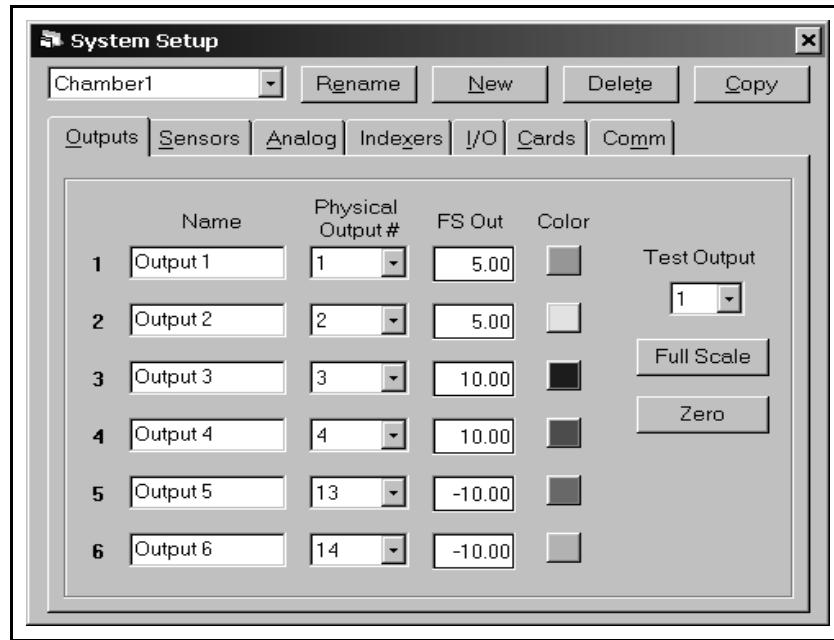
**New:** Creates a new system setup, based on the existing default setup.

**Delete:** Deletes the currently selected setup from the database. If the setup is used in a process, an error message is displayed.

**Copy:** Creates a duplicate of the currently selected system setup.

### 3.5.4.1 Outputs Tab

Figure 3-18 Outputs tab



**Name:** Assigns a name to each displayed output. For clear display, keep the name to less than 8 characters.

**Physical Output:** Up to six SQM-242 cards (physical outputs 1 to 12) and a single SAM-242 card (physical outputs 13 and 14) may be installed in a computer. However, the SQS-242 software can display and control a maximum of 6 outputs simultaneously. Use this dropdown to assign a “physical” output to a “display” output.

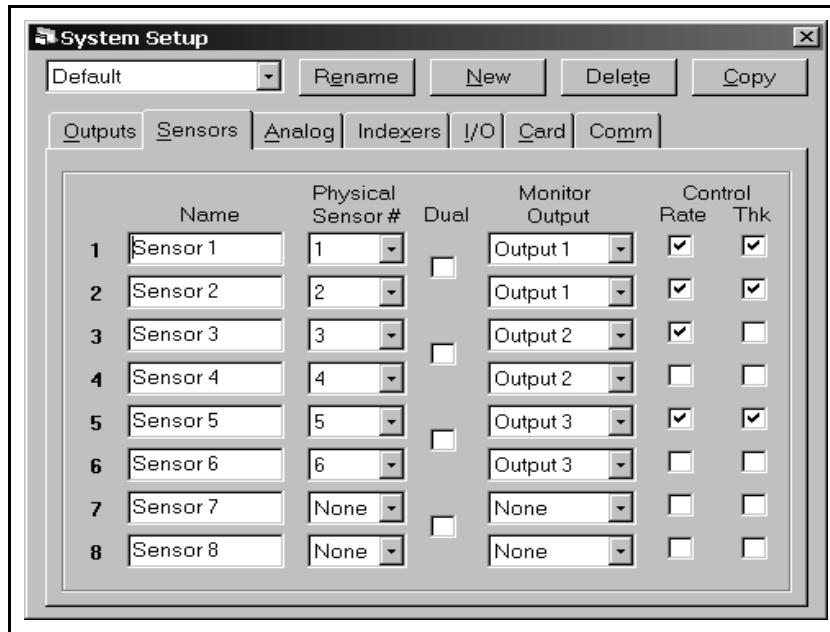
**FS Out:** The input voltage required by the deposition source power supply to produce 100% output power. Positive or negative full scale values are possible.

**Color:** Selects the color used to graph and display output data.

**Test Output:** Useful for testing output wiring and Full Scale voltage settings. Select an output, then click Full Scale to set the SQM-242 card output to its Full Scale voltage. Click Zero to return the selected output to 0 volts.

### 3.5.4.2 Sensors Tab

Figure 3-19 Sensors tab



**Name:** A meaningful name assigned to each sensor. For clear display, keep the name to less than 8 characters.

**Physical Sensor:** Up to six SQM-242 cards (physical sensors 1 to 24) may be installed in a computer. However, the SQS-242 software can display a maximum of 8 sensors simultaneously. Use this dropdown to assign a “physical” sensor to a “display” sensor.

**Dual:** Indicates that a pair of sensors is set up as primary/secondary duals. When a primary sensor fails, the SQS-242 switches to the secondary sensor.

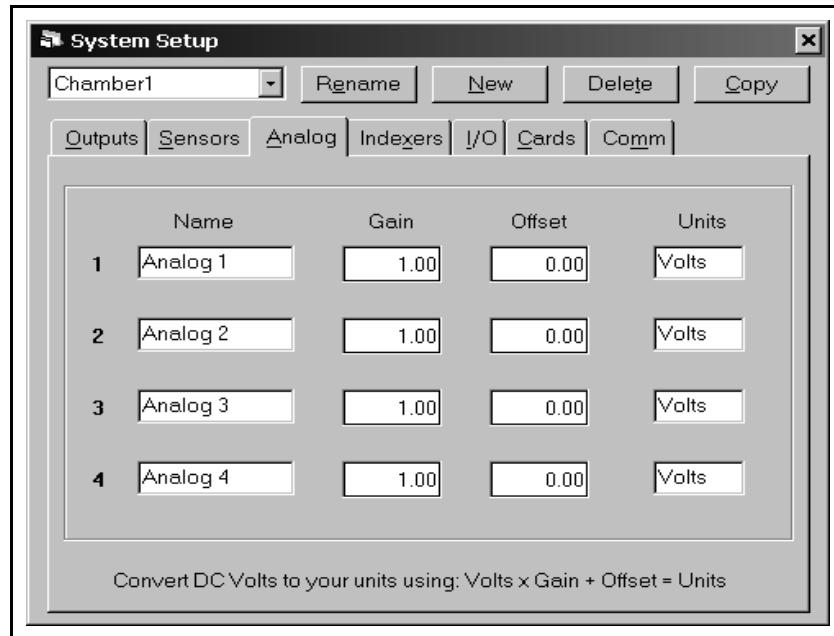
**Monitor Output:** Select the output that each sensor is positioned to measure. The rate and thickness displayed by the sensor will be calculated based on the material assigned to the selected output.

**Control Checkboxes:** Click Rate to assign the sensor to the PID rate control loop for the assigned output during deposition. Click Thk to use the sensor for Thickness endpoint detection. Typically you will check both boxes so that the sensor controls to rate setpoint and detects the thickness endpoint. If multiple sensors are assigned to control the same output, the sensor readings are averaged when calculating rate and thickness.

Uncheck both boxes to have a sensor monitor an output, without controlling deposition rate or stopping when final thickness is reached.

### 3.5.4.3 Analog Tab

Figure 3-20 Analog tab



The SAM-242 analog input card measures DC voltages in the +/-10 volt range. These voltages may represent temperature, flow, or any other process variable. The analog tab allows you to modify the display to show values in the desired units, using a linear ( $y = mx + b$ ) transformation.

For example, assume you have a temperature transmitter that sends 0V at 0°C and 1V at 100°C. To display temperature in °F, set the Gain to 180, Offset to 32, and Units to DegF. The SQM-242 will display setpoints and measurements associated with the analog input in degrees F.

To leave the analog input display in Volts, set Gain = 1 and Offset = 0.

**Name:** A meaningful name assigned to each analog input. For clear display, keep the name to less than 8 characters.

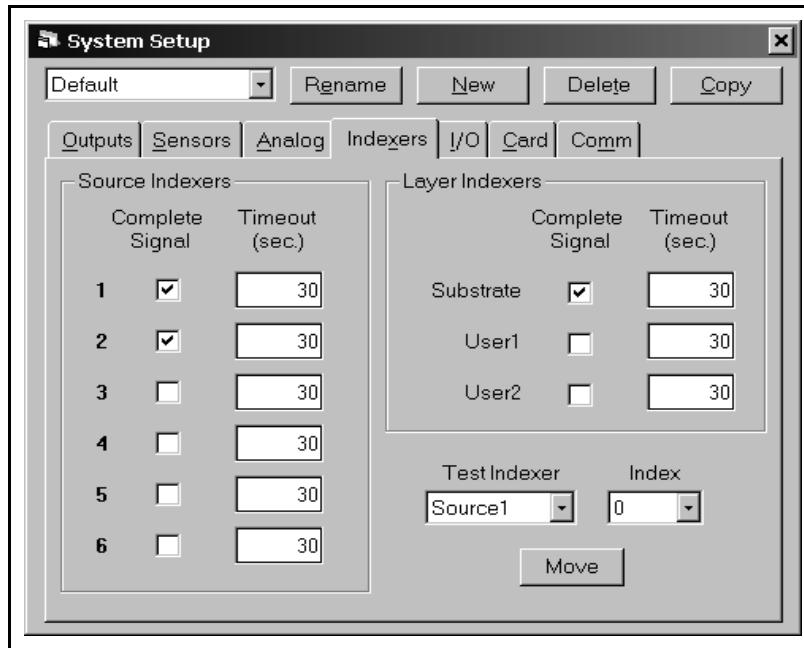
**Gain:** The gain term for transforming voltage to measured units. This is the m term in  $y = mx + b$ .

**Offset:** The offset term for transforming voltage to measured units. This is the b term in  $y = mx + b$ .

**Units:** The units that you wish to display for the analog input.

### 3.5.4.4 Indexers Tab

Figure 3-21 Indexers tab



**Source Indexers:** A unique source indexer (pocket rotator) is available for each output used. The source indexer moves at the beginning of each layer.

**Layer Indexers:** Three “layer indexers” are also available. Layer indexers also move at the beginning of each layer. Layer indexer values are useful for control of substrate indexers or other external process equipment.

**NOTE:** The Layer Indexer names, the range of values, and the first entry can be customized by editing entries in the SQS242.INI file (see [section 3.8](#)).

**Complete Signal:** Check this box if your indexer sends a signal indicating that the move is complete.

**Timeout:** 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.

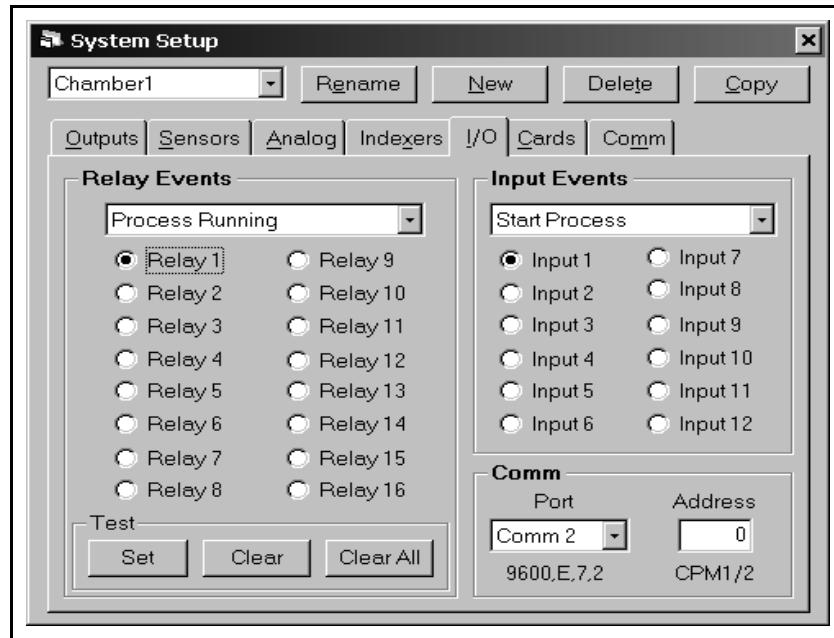
**Move:** Useful for testing indexer functions manually. Select an indexer, then an index (pocket). Click Move to move to the selected index. Layer indexers are typically named Substrate, User 1, and User 2. Layer indexer names can be edited in the SQS242.INI file (see [section 3.8](#)).

### 3.5.4.5 I/O Tab

A PLC must be used to provide digital I/O capabilities. The I/O tab assigns deposition events (i.e., open shutter, start deposit, final thickness, etc.) to the physical 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 I/O tab. Similarly, inputs 0.00 to 0.11 on the Omron PLC correspond to inputs 1 to 12 on this dialog box. See [Figure 3-22](#).

Figure 3-22 I/O tab



**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 to 6**

These relays control the Shutter that covers your deposition source. At the beginning of the deposit phase the relay will close its contacts. When the deposit phase finishes the shutter relay contacts open.

### **Sensor Relays 1 to 8**

These relays 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 close when Shutter Delay phase is entered on 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 Shutter Delay phase, 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 when Shutter Delay is entered.

If the software is configured for dual sensors, the relay operation is considerably different. Dual sensors use pairs of sensors (i.e., Sensor 1 and 2, or Sensor 3 and 4). With Sensors 1 or 3 selected, the associated relay contacts are open. If a Crystal Fail is detected, the relay contacts for the failed sensor will close to select the second sensor in the Dual Sensor assembly for the duration 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.

#### **Layer Stopped and Running Relays**

The Layer Running relay closes as soon as Start Layer is selected (by front panel or digital input), and opens when Stop Process is selected. The Layer Stopped relay contacts behave in the inverse manner.

#### **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.

#### **Process Active Relay**

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.

#### **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.

**Test:** The Test section provides a simple means of testing I/O wiring. To close a relay, select the desired relay button, then click Set. Click Clear to open the relay contacts.

**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 has the same effect as reaching Final Thickness setpoint.

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

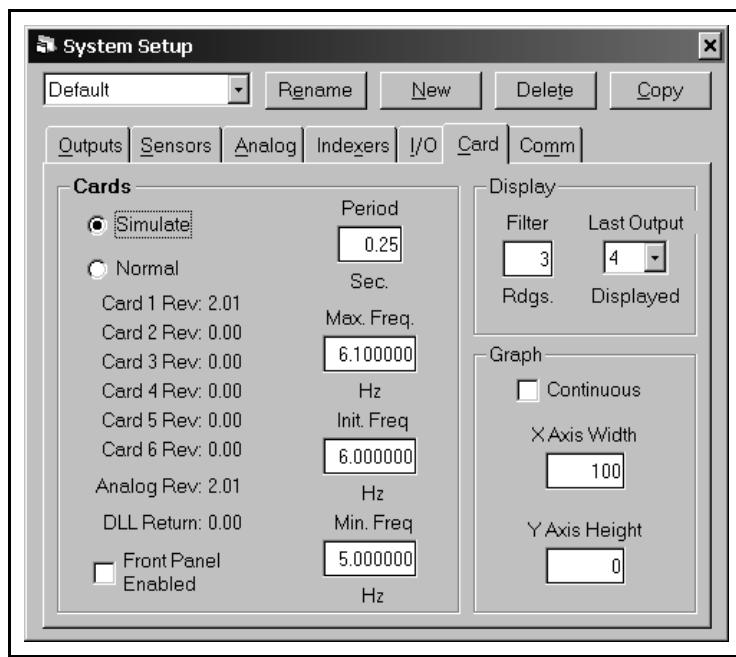
The communications parameters (baud, parity, bits, stop) are shown below the Comm Port dropdown. The baud rate can be changed in the SQS242.INI file (see [section 3.8](#)).

**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. Single PLC systems usually use Address 0. Consult your PLC User Manual.

If the PLC is found at the selected Comm Port and Address, the COMM LED on the PLC will flash continuously. The PLC model is displayed below the address.

### 3.5.4.6 Card Tab

Figure 3-23 Card tab



**Mode:** In Normal mode, the SQS-242 gets readings from the SQM-242 card(s). In Simulate mode, the SQS-242 generates simulated readings even if a card is not installed. This is useful for testing new processes and learning the software.

The firmware revisions of the installed SQM-242 cards are listed below the mode buttons. A value of 0 indicates the card is not installed. Analog Rev refers to the revision of an SAM-242 card if installed. DLL Return is the status of the SQM-242 card's Windows drivers. DLL return values of 9XX indicate a card installation error.

**Front Panel Enabled:** When used with the SRC series computer, enables/disables the SQS-242 software to read the SoftKeys.

**Period:** Sets the measurement period between 0.2 seconds (5 readings per second) and 2 seconds. A longer period gives higher reading accuracy, especially at low rates.

**Max/Init/Min Frequency:** The frequency values for the quartz crystal sensors used as inputs to the SQM-242. Typical values are Max=6.1, Init=6.0, Min=5.0. Sensor readings outside the min/max values cause a Sensor Fail error.

**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.

**Last Output:** Limits the maximum number of outputs shown on the main dialog box.

**Continuous:** Check this box to have the graph continuously display data for each phase of the deposition cycle. Uncheck this box to clear the graph at the end of the preconditioning, deposition, and post conditioning phases.

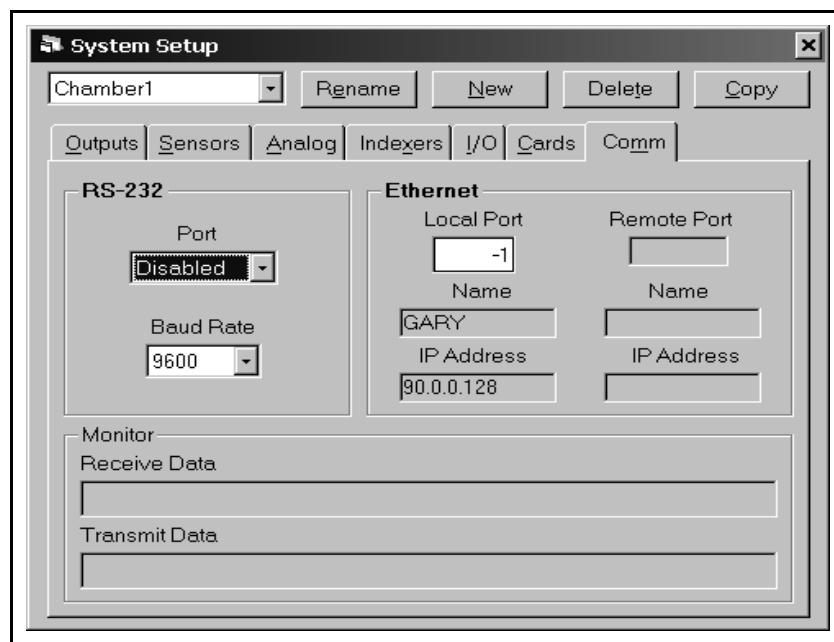
**Graph X Axis:** Sets the width of the X axis during deposition, normally 100 seconds. Whatever width is selected, the graph automatically scrolls the X axis as required. Due to screen resolution, setting a width of more than 10 minutes (600 seconds) may cause some data points to not be plotted.

**Graph Y Axis:** Sets the Y axis Rate graph maximum value during deposition. Setting the value to 0 causes the Y axis to automatically scale to the highest rate displayed.

### 3.5.4.7 Comm Tab

The SQS-242 software can be controlled by another computer through an RS-232 or Ethernet connection. See [section 5.2 on page 5-1](#) for more details.

Figure 3-24 Comm tab



**RS-232 Port:** Selects the comm port used for serial communications with another computer. The Comm Port dropdown box lists available ports.

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

**Ethernet Ports:** Local Port sets the TCP/IP port used by the SQS-242 software for Ethernet communications (1001 is a typical value, -1 for no Ethernet). When communications is established, Remote Port displays the TCP/IP port of the remote computer communicating with the SQS-242 software.

**Ethernet Name:** Displays the name of the local and remote computers, as set in their Windows, My Computer dialog box.

**Ethernet IP Address:** Displays the IP address (xxx.xxx.xxx.xxx) of the local and remote computers.

**Receive Data:** Displays the Query and Update requests received from the Comm and Ethernet port. See [section 5.6 on page 5-2](#) for a description of the serial communications protocol.

**Transmit Data:** Displays the response to Query and Update requests received from the Comm and Ethernet port.

**NOTE:** The Comm tab does not monitor communications with the PLC.

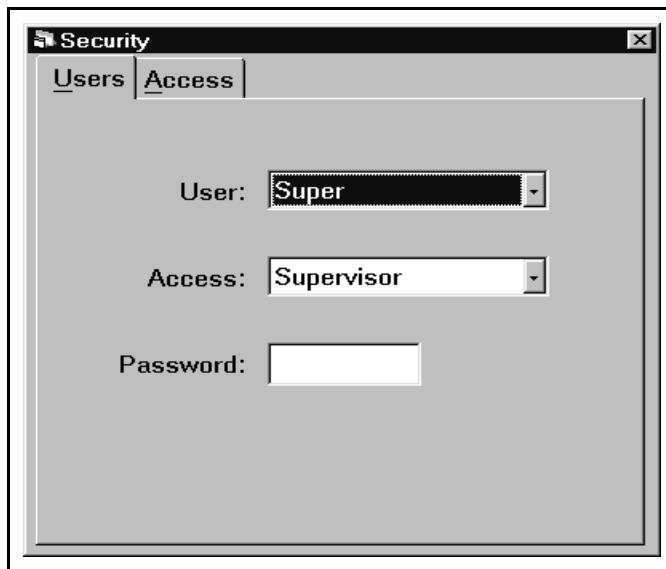
### 3.5.5 Edit: Security

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 box is available only to users with Supervisor Access.

#### 3.5.5.1 Users Tab

Figure 3-25 Users tab



**User:** Dropdown box used to select an existing user, to edit their Access or Password. It is not possible to edit or add a user name in the User dropdown. 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.

**NOTE:** User names and passwords are limited to A-Z, 0-9, \_, -, and space. Passwords are a maximum of 8 characters.

### 3.5.5.2 Access Tab

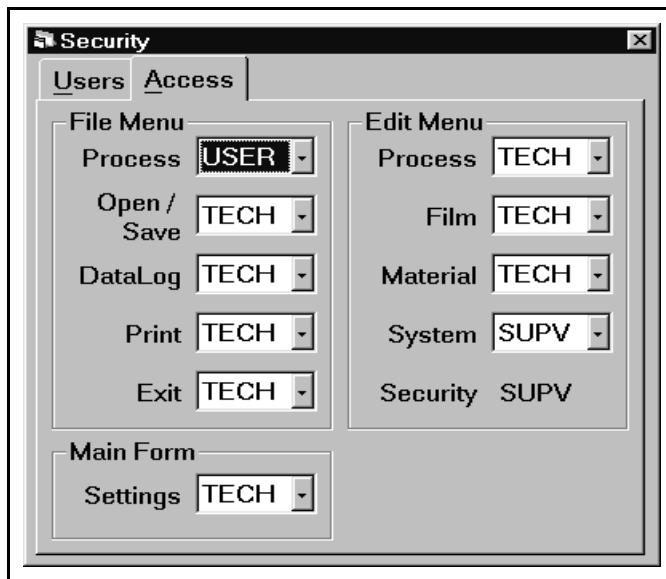
The Access tab allows Supervisors to assign which program functions are available to each of the three Access Levels. When a program function is assigned to a particular access level, it is automatically available to higher access levels.

In [Figure 3-26](#), 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.

The settings along the right side of the Main Form can be viewed by any user, but values can only be edited by TECH or higher access.

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

Figure 3-26 Access tab



## 3.6 View Menu

The View menu controls the appearance of the main display.

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

**Film Readings:** Displays/hides film deposition readings along the bottom of the dialog box. 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 dialog box'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 on the Sensor tab of System dialog box.

A (P) in the Control column indicates the sensor is the primary sensor of a dual sensor pair. (S) indicates a secondary sensor. An (R) in the Control column indicates that the sensor is being used only for rate control. A (T) indicates the sensor is used only for Final Thickness endpoint detection. An (M) indicates the sensor is being used to monitor, but not control, the output. These options are selected on the Sensor tab of System dialog box

**NOTE:** The Sensor Readings dialog box can be sized to also show SAM-242 card analog input readings and digital I/O information. The digital I/O information is useful for troubleshooting I/O problems during setup.

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

**Power Graph:** Fixes the main graph to output power. Output power is directly adjusted 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-242 Setup menu.

**Sensors Graph:** Normally the graph displays output, or film-based information. The Sensors Graph selection displays the rate readings from each individual sensor assigned to a system setup. It is a graphical display of the Rate column of the Sensor Readings dialog box.

**Analog Graph:** If an SAM-242 analog input card is installed, this graph shows the voltage readings from each analog input assigned to a system setup.

**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.

**NOTE:** To alter the appearance of a graph, right-click anywhere on the graph. Use the Graph Property Page dialog box to alter the graph to your preferences. To permanently save the changes, click the Control tab, the General tab, then the Save button. Save the graph setup to the appropriate .OC2 file for the graph you are modifying.

**High Resolution:** When this option is checked, rate is displayed to 0.01 Å/s, and thickness to 0.1kÅ. This can be useful for low rate applications, but annoying for moderate rates. The SQM-242 card resolution for PID control is unchanged.

## 3.7 Software Specifications

### Display

Graphs . . . . . Rate, Deviation, Power

Readouts . . . . . Rate, Dev, Thick, Power

### Process Parameters

Name . . . . . 12 characters

---

# Processes . . . . .	Unlimited
# Layers . . . . .	Unlimited
# Films . . . . .	Unlimited
# Rate Ramps . . . . .	Unlimited
# Sensors (Dual) . . . . .	1 to 8 (4 Dual)
# Sources . . . . .	1 to 6

**Layer Parameters**

Film . . . . .	Any defined
Output . . . . .	1 to 6
Input . . . . .	Sensor(s) Timed Power Analog Input
SetPoint . . . . .	0.00 to 999.99 Å/s 0.00 to 100.00% Power 0.00 to 10.00 V(dc)
Final Thickness . . . . .	0.0 to 999.9 kÅ
Time EndPoint . . . . .	0 to 30000 s
Thickness EndPoint . . . . .	0.0 to 999.9 kÅ
Start Mode . . . . .	Auto/Manual
Source Indexers . . . . .	6, Index 1-16
Layer Indexers . . . . .	3, Index 1-16
Rate Ramp Start . . . . .	0.0 to 999.9 kÅ
Rate Ramp Time . . . . .	0 to 1000 s
New Rate . . . . .	0.00 to 999.99 Å/s

**Film Parameters**

Name . . . . .	12 characters
Ramp Time (1,2) . . . . .	0 to 30000 s
Soak Power (1,2) . . . . .	0.0 to 100.0%
Soak Time (1,2) . . . . .	0 to 30000 s
Shutter Delay Time . . . . .	0 to 200 s
Shutter Delay Error . . . . .	0.0 to 30.0%
P Term . . . . .	1 to 9999

I Term ..... 0 to 999.9 s  
D Term ..... 0 to 99.9 s  
Control Error ..... Ignore/Stop/Hold  
Control Error Set ..... 0 to 30.0%  
Feed Ramp Time ..... 0 to 30000 s  
Feed Power ..... 0.0 to 100.0%  
Feed Time ..... 0 to 30000 s  
Idle Ramp Time ..... 0 to 30000 s  
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%/s  
Source Index (Pocket) ..... 0 to 15

#### **Material Parameters**

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

#### **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 6  
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

**Computer Interface**

Type ..... RS-232, Ethernet, ActiveX

### 3.8 INI File Parameters

Parameters that control operation of the SQS-242 program are stored in the SQS242.INI file. Most of these are easily altered within the program and updated automatically.

However, a few of the parameters cannot be changed within the program. Use a text editor to alter the parameters listed below.



#### CAUTION

**Always make a backup of the INI file before editing!**

**MDISize** = Left, Top, Width, Height (Screen size and location (in pixels))

**Debug** = True or False (Show SQM-242 card error messages)

**Show** = True or False (True loops continuously through a process)

**KillErrLog** = True or False (True clears error log each time application)

**NumberFormat** = 0 or 1 (0 uses Windows setting for number format)  
(1 uses the U.S. format (i.e., 1,000.00))

**BackColor** = Color (Default is BLACK)

**ForeColor** = Color (Default is LIGHTGRAY)

**HighLightColor** = Color (Default is WHITE)

The next four parameters control setup of the 4 indexer values where:

**Name** is the Indexer label on the Process form

**Start** is the first index number, typically 0 or 1

**End** is the last index number, typically 15 or 16

**First** is the text displayed for the Start index number

**SourceIndex** = Name, Start, End, First

**LayerIndex1** = Name, Start, End, First

**LayerIndex2** = Name, Start, End, First

**LayerIndex3** = Name, Start, End, First

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## Chapter 4

### Digital I/O

#### 4.1 Introduction

Digital I/O for the SQS-242 software can be handled by an inexpensive PLC. This section will cover interfacing a Omron CPM2 series PLC to the SQS-242 card and PC. It is not necessary, however, to use external I/O with the SQS-242 software.

There are several benefits to using an 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.

#### 4.2 PLC Installation



##### CAUTION

***The Omron PLC uses a special RS-232 cable as shown in Figure 4-1. Do not use a standard serial cable. Damage to the PC or the PLC could result.***

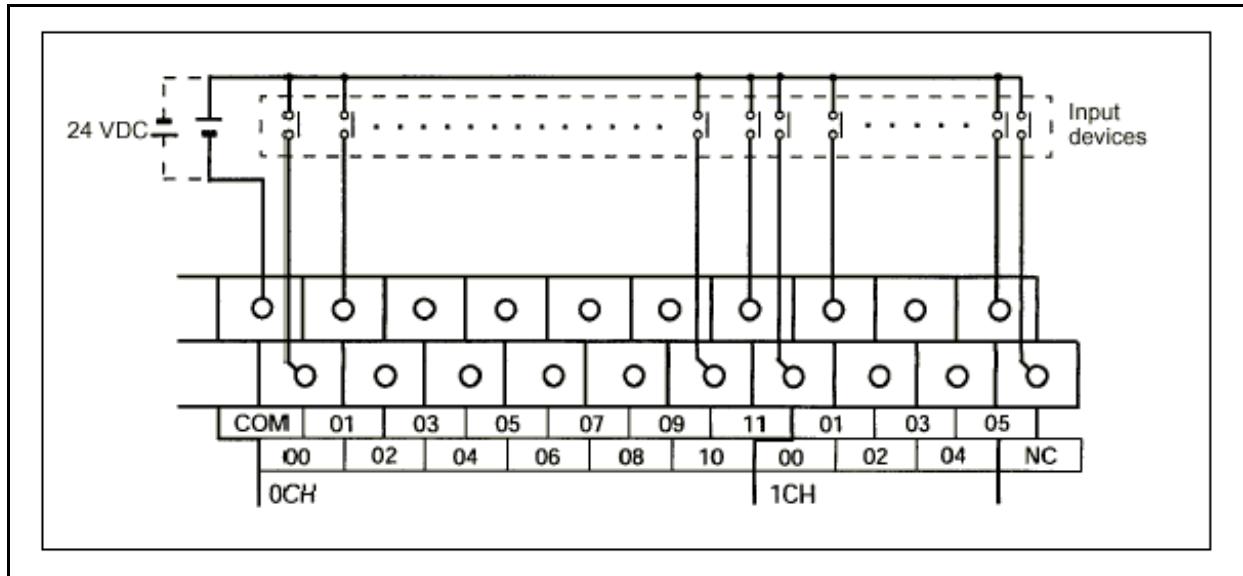
Figure 4-1 Omron PLC RS-232 Cable

SID-142 Serial Port		PLC Port	
Signal	Pin No.	Pin No.	Signal
CD	1	1/Cover	FG
RD	2	2	SD
SD	3	3	RD
ER	4	4	RS
SG	5	5	CS
DR	6	6	--
RS	7	7	--
CS	8	8	--
CI	9	9	SG

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

**Input Wiring:** The 0.0 to 0.11 inputs on Omron PLCs correspond to Inputs 1 to 12 in the SQS-242 software. Omron PLC input wiring is shown in [Figure 4-2](#).

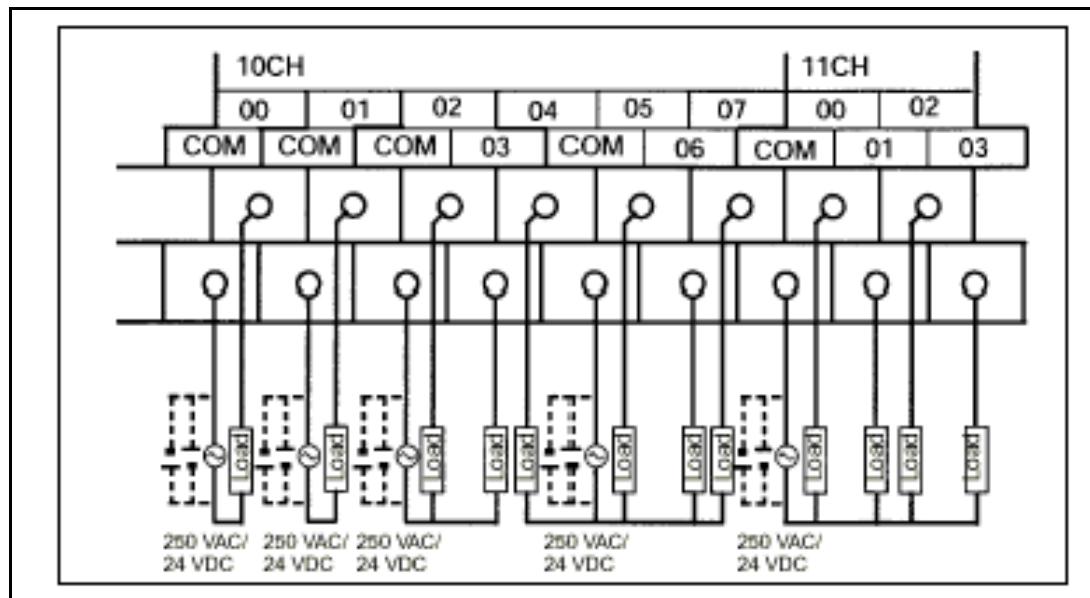
Figure 4-2 Omron PLC Input Wiring



**Output Wiring:** The PLC output relays are mapped to output events using the SQS-242 software's Edit, System dialog, I/O Events tab.

**NOTE:** Relays 1 to 8 in the SQS-242 software correspond to relays 10.00 to 10.07 on the PLC. Relays 9 to 12 correspond to Omron relays 11.00 to 11.03.

Figure 4-3 Omron PLC Output Wiring



Omron PLC output wiring is illustrated in Figure 4-3. Notice that some relays (i.e., 02/03 and 04/05/06/07) share a common terminal.

**NOTE:** The internal 24 V (dc), .3 A supply of the Omron PLC is NOT adequate to serve as the supply shown in the diagram above.

**Indexer I/O:** Indexers from different manufacturers use a variety of pocket decoding schemes. The PLC monitor program adapts information from the SQS-242 program to a specific indexer. The two most common indexer decoding schemes are illustrated below.

**Binary Pocket Select:** Each pocket requires a dedicated relay. That is 8 pockets require 8 relays. The CPM2A-Basic PLC monitor program assigns relays 11.00 to 11.03 to operate a 4 pocket indexer of this type.

**Binary Coded Pocket Select:** Pockets are selected by a value that is the binary representation of the pocket. That way fewer relays are required. For example, 16 pockets can be selected with only four relays. The CPM2A-BCD monitor program assigns relays 11.00 to 11.03 to this function.

Please contact INFICON for information on your indexer.

**Other Digital I/O:** Depending on the PLC model used, additional relay and input pins are available for other functions (i.e., source indexer operation). Please contact INFICON.

## 4.3 PLC Setup and Test

In the SQS-242 software select Edit, System, then the I/O tab. Set the Address to match the PLC Address (usually 0). Set the Comm Port to the serial port you are using. The COMM LED on the PLC should flash several times a second when the Address and Comm Port are set properly.

The Test section of the I/O tab provides a 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. The assigned Relay# should close. Click Clear to open the relay.

The Indexers tab of the Edit System dialog box allows you to move a source or substrate indexer. Select the index (i.e., pocket) to activate, then click the appropriate move button.

## 4.4 5.3 PLC Programming

The PLC runs a small ladder logic program that communicates with the SQS-242 software. This program transfers external relay and input states from the PLC connecting block to internal PLC registers. The SQS-242 software reads/writes to those registers.

The preset functions of the SQS-242 software will be adequate for most applications. If you need to perform additional logic functions, they can be programmed using Omron's CX-Programmer software. Contact INFICON for more information on programming your PLC.

The functions of the internal PLC registers used by the standard SQS-242 program are shown below.

<u>PLC Register</u>	<u>SQS-242 Function</u>																																								
200	<p>Layer/Phase Register</p> <p>Bits 0-9 are BCD layer number running            Bits 10-15 are BCD Phase# as shown below</p> <table> <tbody> <tr><td>00</td><td>Application Startup</td><td>09</td><td>ShutterDelay Phase</td></tr> <tr><td>01</td><td>Program Initializing</td><td>10</td><td>Deposit Phase</td></tr> <tr><td>02</td><td>Not Used</td><td>11</td><td>Layer Stopped</td></tr> <tr><td>03</td><td>Not Used</td><td>12</td><td>Layer Starting</td></tr> <tr><td>04</td><td>Process Stopped</td><td>13</td><td>Not Used</td></tr> <tr><td>05</td><td>Ramp1 Phase</td><td>14</td><td>Feed Ramp Phase</td></tr> <tr><td>06</td><td>Soak1 Phase</td><td>15</td><td>Feed Hold Phase</td></tr> <tr><td>07</td><td>Ramp2 Phase</td><td>16</td><td>Idle Ramp Phase</td></tr> <tr><td>08</td><td>Soak2 Phase</td><td>17</td><td>Idle Phase</td></tr> <tr><td></td><td></td><td>18</td><td>Continuous Phase</td></tr> </tbody> </table>	00	Application Startup	09	ShutterDelay Phase	01	Program Initializing	10	Deposit Phase	02	Not Used	11	Layer Stopped	03	Not Used	12	Layer Starting	04	Process Stopped	13	Not Used	05	Ramp1 Phase	14	Feed Ramp Phase	06	Soak1 Phase	15	Feed Hold Phase	07	Ramp2 Phase	16	Idle Ramp Phase	08	Soak2 Phase	17	Idle Phase			18	Continuous Phase
00	Application Startup	09	ShutterDelay Phase																																						
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05	Ramp1 Phase	14	Feed Ramp Phase																																						
06	Soak1 Phase	15	Feed Hold Phase																																						
07	Ramp2 Phase	16	Idle Ramp Phase																																						
08	Soak2 Phase	17	Idle Phase																																						
		18	Continuous Phase																																						
201	<p>Sensors/Outputs 1-4 Register (updated each layer)</p> <p>Bits 0-7 are sensors used (1=used, 0=unused)</p> <p>Bits 12-15 are outputs used, 12 is Out1, 13 is Out2, etc.</p>																																								

202	Analog/Outputs 5-6 Register (updated each layer) Bits 0-3 are analog inputs used (1=used, 0=unused) Bits 4-5 outputs used, 4 is Out5, 5 is Out6 Bits 8-11 are BCD of Output source index Bits 12-15 are BCD of Output 6 source index
220	Source Index Register (updated each layer) Bits 0-3 are BCD of Output 1 source index Bits 4-7 are BCD of Output 2 source index Bits 8-11 are BCD of Output 3 source index Bits 12-15 are BCD of Output 4 source index
221	Source Indexer Done Flag Bit 0 is Source Indexer 1 (1= Indexer Done, 0=Not Done) Bit 1 is Source Indexer 2 Bit 2 is Source Indexer 3 Bit 3 is Source Indexer 4 Bit 4 is Source Indexer 5 Bit 6 is Source Indexer 6
222	Relays 1-16 Bit 0 is Relay 1, etc.
224	Inputs 1-12 Bit 0 is Input 1, etc.
225	Layer Index Register Bits 0-3 are BCD of Layer Indexer 1 Bits 4-7 are BCD of Layer Indexer 2 Bits 8-15 are BCD of Layer Indexer 3
226	Layer Indexer Done Flag Bit 0 is Layer Indexer 1 (1= Indexer Done, 0=Not Done) Bit 1 is Layer Indexer 2 Bit 2 is Layer Indexer 3

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## Chapter 5

# Communications

### 5.1 Introduction

The computer interface capabilities of the SQS-242 program allow operation from an external computer via Ethernet or RS-232 serial communications and a simple ASCII command set. Programs running on the same computer, can also control the SQS-242 program using ActiveX® and the same ASCII command set.

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.

### 5.2 Serial Interface

Connect a serial cable from the serial port of the computer the SQM card is installed on to another computer’s 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-242 program select the Edit, System menu, then the Comm tab. Set the Comm Port to match the serial port the cable is connected to on the other computer. Set the baud rate to match between the host computer and the remote computer. Communications format is No Parity, 8 bits, 1 stop bit.

### 5.3 Ethernet Interface

Connect a cable from the Ethernet card to your Ethernet network. In the SQS-242 program select the Edit, System menu, then the Comm tab. Set the Ethernet Port to 1001, and the Ethernet name to the Network name, or IP Address of the computer you wish to communicate with. Enter a –1 for the Ethernet Port to disable the Ethernet functions.

### 5.4 ActiveX (COM) Interface

Any program that supports Microsoft’s COM (ActiveX) interface (i.e., LabVIEW®, etc.) can communicate with the SQS-242 program. A small ActiveX interface program, SQS242X.EXE, provides receive data and transmit data entry points to the global cComm242 class. Contact INFICON for examples in other languages, and detailed technical information.

## 5.5 SQS-242 Comm Program

SQS-242 Comm, found on the SQS-242 CD-ROM, is a simple Windows program to demonstrate SQS-242 communications concepts. With SQS-242 Comm you can easily send commands to, and read the responses returned by the SQS-242 program.

### 5.5.1 Setup for RS-232 or Ethernet

In the SQS-242 program, select Edit, System and set the RS-232 or Ethernet settings as detailed in the previous sections.

Load the Comm program on a computer (the host), and connect an Ethernet or RS-232 cable between the host and the computer running the SQS-242 program. Start the Comm program on the host computer, then select the Utility tab. Set the Comm Port and Baud Rate for the host computer, or select Ethernet and set the Ethernet Port (typically 1001).

### 5.5.2 Setup for Active X Control

Load the Comm program on the same computer that is running the SQS-242 program. Start the Comm program, then select Active X on the Utility tab. Start the SQS-242 program but minimize it, or bring the Comm program to the foreground.

### 5.5.3 Communicating with the SQS-242 Program

In the Comm program, Utility tab, click the Version button under the SID-242 Controller heading. Click Send to send the query to the computer running the SQS-242 program.

The response from the SQS-242 program should show in the Comm program Response window. A typical response is @QU;ACK;3.2.9;32, which indicates software version 3.29. The next section describes the Query/Update and Response strings in detail.

The transmissions to and from the Comm program will also show in the SQS-242 Edit, System, Comm, Receive Data and Transmit Data windows.

## 5.6 Protocol

SQS-242 commands fall into two categories:

- **Query** commands request data from the SQS-242 program.
- **Update** commands update a setting or instruct the program to take an action.

The SQS-242 responds to both Query and Update commands with a response that indicates the results of the command request. The SQS-242 program never initiates communications. It only responds to commands from the host.

## 5.6.1 Query Command Format

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

### 5.6.1.1 Example: Software Version Query

@QU;11;44<CR>  
where:  
@ Message start character  
; Separator  
QU Query Utility command  
; Separator  
11 Parameter 11 (SQS-242 Software Version)  
; Separator  
44 Checksum (see section that follows on checksums)  
<CR> Carriage Return (ASCII 13)

### 5.6.1.2 Example: Response to Software Version Query

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

## 5.6.2 Update Command Format

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

### 5.6.2.1 Example: Set Process Update

@UP;11;MyProcess;44<CR>  
where:  
@;UP; Update Process command  
; Separator  
01 Parameter 01 (Set Process)  
; Separator  
MyProcess Data  
; Separator  
?? Checksum  
<CR> Carriage Return (ASCII 13)

### 5.6.2.2 Example Response: Set Process Update Succeeded

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

### 5.6.2.3 Example Response: Set Process Update Failed

@UP;<NAK>;<ERR>;??<CR>

Where:

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

## 5.7 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)
```

**NOTE:** While checksums “may” be useful for RS-232 communications, they are not needed for Ethernet or ActiveX. If you don’t want to use a checksum, replace the checksum in each command with “00” (two ASCII zero (Hex 30) characters). The program response will contain two checksum characters, which you can just ignore.

## 5.8 Command Summary

**NOTE:** *Update commands (except UP02-UP10) are only valid in Stop Mode.*

### 5.8.1 Query Process

```
@QP;<param1>
where <param1> is:
01 Process Name
    Example Query: @QP;01
    Example Response: @QP;06;MyProc(Process is MyProc)
02 Process Time          (mm:ss)
03 Active Layer #
04 Layer Time           (mm:ss)
05 Phase # (where phase numbers returned are)
    00 Application Startup 09 ShutterDelay Phase
    01 Program Initialize 10 Deposit Phase
    02 Not Used           11 Layer Stopped
    03 Not Used           12 Layer Starting
    04 Process Stopped    13 Not Used
    05 Ramp1 Phase        14 Feed Ramp Phase
    06 Soak1 Phase         15 Feed Hold Phase
    07 Ramp2 Phase        16 Idle Ramp Phase
    08 Soak2 Phase         17 Idle Phase
06 Phase Time (mm:ss)
07 Run #
08 All Process Names    (comma delimited list)
1n Source Shutter Status, n=1 to 6 (0=Open, 1=Close)
2n Sensor Shutter Status, n=1 to 8 (0=Open, 1=Close)
30 All Crystal Good Status (0=False, 1=True)
3n Crystal n Good, n=1 to 8 (0=False, 1=True)
39 All Crystal Fail (0=False, 1=True)
4n Sensor to Output Map, n=1 to 8
50 DataLog Filename
51 DataLog Type (0=None, 1=Overwrite, 2=Append, 3=Run#)
52 DataLog Interval in seconds
```

### 5.8.2 Update Process

```
@UP;<param1>;<data>
where <param1> is:
01 Set Process
    Example Update @UP;01;MyProc(Select MyProc)
    Example Response: @UP;06;
02 Start Process
03 Stop Process
04 Start Layer
05 Stop Layer
06 Start Next Layer
07 Auto Mode (all films in layer)
08 Manual Mode (all films in layer)
09 Zero Thickness (all films in layer)
10 Set Run #
```

```

11  Set Active Layer #
2n  Output n (1 to 6) Power (Manual Mode Only)
4n  Map Sensor n to Output #
50  Set DataLog filename without extension (Stop mode only)
51  DataLog type (0=None, 1=Overwrite, 2=Append, 3=Run#)
52  DataLog Interval in seconds (set Bit 3 in Command 53 below)
53  DataLog Events (bit weighted integer)
     Bit 0 End Deposit Phase
     Bit 1 End Each Phase
     Bit 2 I/O Event
     Bit 3 Timed
     Bit 8 Every Reading
     Bit 9 Sensor Readings
     Bit 10 Analog Readings

```

### 5.8.3 Query/Update Layer

```

@QL;<param1>;<layer>;<output>
@UL<param1>;<layer>;<output>

```

**NOTE:** A <layer> value of zero sets/returns data on the current layer.

where <param1> is:

01	Film Name	
	Example: @UL;01;1MyFilm,New Film	(set Layer 1, MyFilm to NewFilm)
02	Setpoint	Å/s, V, or % Power
03	Start Thickness	kÅ
04	Time SP	mm:ss
05	Thickness SP	kÅ
06	Start Mode	0/1
07	Substrate Index (obsolete)	0 to 15
08	# Layers in Process (query)	
09	Start Prompt	250 characters or less
10	Phase of the requested output (query)	
1n	Ramp n Start Thickness, n=1 to 9	kÅ
2n	Ramp n Ramp Time, n=1 to 9	mm:ss
3n	Ramp n New Rate, n=1 to 9	Å/s
41	Layer Indexer 1 Index	0 to 15
42	Layer Indexer 2 Index	0 to 15
43	Layer Indexer 3 Index	0 to 15
44	Source Indexer Index	0 to 15
45	Input Type (Sensors=0, TimedPower=1, Analog1-4 = 2-5)	
46	System Configuration	
47	Source Indexer Done	0/1
48	Layer Indexer 1 Done	0/1
49	Layer Indexer 2 Done	0/1
50	Layer Indexer 3 Done	0/1

### 5.8.4 Query/Update Film

```
@QF;<param1>;<layer>;<output>
@UF;<param1>;<layer>;<output>;<value>
Note: <layer>=0 is active layer
where <param1> is:
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 (1-6)
25    Source Index (obsolete)
26    Max Power
27    Slew Rate
28    Material
3n    Tooling n (n=1 to 8)
40    AutoSoak2 (0/1)
```

### 5.8.5 Query Utility

```
@QU;<param1>
01    SQM242 DLL Version
02    SQM242 Mode (0/1)
03    SQM242 Period
04    SQM242 Filter
05    SQM242 Number of Cards Installed
06    Front Panel Enabled (0/1)
07    Application Visible (0/1)
11    SQS-242 Software Version
12    SQS-242 Operating System
13    SQS-242 Computer Name
```

### 5.8.6 Update Utility

```
@QU;<param1>;<Index>
02    SQM242 Mode (0/1)
03    SQM242 Period
04    SQM242 Filter
06    Front Panel Enabled (0/1)
07    Application Visible (0/1)
08    Full Scale Output (Index=1 to 6)
14    Application On Top(0/1)
```

### 5.8.7 Query Measurement

```
@QM;<param1>
1n    Output n Power (n=1 to 6)
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
9n    Analog Input n Voltage
```

### 5.8.8 Query Register

```
@QR;<param1> (returns register value in HEX)
0    Layer/Phase Register
1    Sensor/Output Register
2    Analog/Output Register
20   Source Index Register
21   Source Index Done Register
22   Relay Register
24   Input Register
25   Layer Index Register
26   Layer Index Done Register
```

### 5.8.9 Update Register

```
@UR;<param1>;<value> (value in HEX)
0    Layer/Phase Register
1    Sensor/Output Register
2    Analog/Output Register
20   Source Index Register
21   Source Index Done Register
22   Relay Register
24   Input Register
25   Layer Index Register
26   Layer Index Done Register
XXX  Any Register
```

## Chapter 6

# Loop Tuning

This section will help you adjust your control loop PID parameters to achieve a stable deposition process. Keep in mind that there is no "best" way to determine PID parameters, and no one set of settings that are "best."

- 1 Setup System Parameters:** Be sure that the output Full Scale voltage and crystal Min/Max Frequency parameters are accurate for your system. All Tooling parameters are best set to 100% for now. A Period of .25 seconds is also a good starting point. Simulate should be OFF.
- 2 Create a One-Layer Test Process:** Create a new process that has a single film as its only layer, and select it as the current process. Set the film's Initial Rate to your desired rate and Final Thickness to a large value, say 10X your desired Final Thickness. Select the proper Sensor(s), Output, and Material. Set Max Power to 100% and Slew rate to 100%. Disable all errors except Crystal Fail. Set On Error to Stop Layer.
- 3 Test the Setup:** Press Auto/Manual to start the layer in Manual mode. Slowly turn the control knob to a power of 10%, and verify that your power supply output is about 10% of full scale. Continue to turn the control knob until a Rate(Å/s) above 0 is shown. Again, verify that the power supply output agrees with the SQS-242 Power(%) reading. If the readings don't agree, check your wiring and process setup. In particular, verify that the System, Outputs, Full Scale voltage agrees with your power supply input specifications.
- 4 Determine Open Loop Gain:** Slowly adjust the control knob until the Rate(Å/s) reading approximately matches your Initial Rate setting. Record the Power(%) reading as PWRDR (power @ desired rate). Slowly lower the power until the Rate(Å/s) reading is just at (or near) zero. Record the zero rate Power(%) reading as PWR0R.
- 5 Determine Open Loop Response Time:** Calculate 1/3 of your desired rate (RATE1/3), and 2/3 of the desired rate (RATE2/3) for this layer. Slowly increase the power until Rate(Å/s) matches RATE1/3. Get ready to record the loop's response to an input change. Quickly adjust Power(%) to PWRDR. Measure the time for the Rate (Å/s) reading to reach RATE2/3. You may want to do this several times to get an average response time reading. Displaying the Rate graph will also help. Twice the measured time is the step response time, TIMESR. TIMESR is typically 0.7 to 1.5 seconds for E-Beam evaporation, 5 to 20 seconds for thermal evaporation.

Press Abort Process, then Manual/Auto to return to Auto mode. Follow these steps to set the loop PID parameters:

**6 Set PID Values:** In the Edit Process, Deposition tab set P=25, I= TIMESR, D=0. Assure that all Conditioning values are set to zero. Save the values and close the Edit Process dialog. Press Start Process and observe the Power graph. The power should rise from 0%, and stabilize near PWRDR with little ringing or overshoot. If there is more than about 10% overshoot, lower the P Term. If the time to reach PWRDR is very slow, increase the P Term. A lower I Term will increase response time, a higher value will eliminate ringing and setpoint deviations. It is unlikely you will need any D Term.

Continue to Start the process and adjust PID until steady-state response is smooth and the step response is reasonably controlled. You don't need to totally eliminate ringing during the step if the steady-state response is smooth. Preconditioning will minimize step changes.

**7 Set Preconditioning:** The power level you recorded as PWR0R is the power where deposition just begins. That's a good value for Ramp 1 power. PWRDR, or slightly less, is a good value for Ramp 2 Power. This will eliminate a large step change when entering the deposition phase.

Once PID terms are established for a material, they will typically be similar for other materials. Only the P Term and preconditioning power levels may need adjustment.