O P E R A T I N G M A N U A L

SQC-310™

Thin Film Deposition Controller

IPN 074-550-P1B

INFICON

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SQC-310™

Thin Film Deposition Controller

IPN 074-550-P1B

INFICON Instruments for Intelligent Control®

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CONFORMITY

This is to certify that this equipment, designed and manufactured by:

INFICON Inc.
Two Technology Place
East Syracuse, NY 13057
USA

meets the essential safety requirements of the European Union and is placed on the market accordingly. It has been constructed in accordance with good engineering practice in safety matters in force in the Community and does not endanger the safety of persons, domestic animals or property when properly installed and maintained and used in applications for which it was made.

Equipment Description: SQC-310 Rate / Thickness Controller (including all options).

Applicable Directives:
2006/95/EC (LVD)
2004/108/EC (General EMC)
2002/95/EC (RoHS)

Applicable Standards:

Safety:	EN 61010-1:2001
Emissions:	EN 61326-1:1997/A1: 1998/A2: 2001 (Radiated & Conducted Emissions) Class A: Emissions per Table 3 (EMC – Measurement, Control & Laboratory Equipment)
Immunity:	EN 61326-1:1997/A1: 1998/A2: 2001 (General EMC) Class A: Immunity per Table A1 (EMC – Measurement, Control & Laboratory Equipment)
RoHS:	Fully compliant

CE Implementation Date: May 2001 (Updated February, 2011)

Authorized Representative: Steve Schill

Thin Film Business Line Manager
INFICON Inc.

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NOTE: These instructions do not provide for every contingency that may arise in connection with the installation, operation or maintenance of this equipment. Should you require further assistance, please contact INFICON.

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Chapter 1
Quick Start

1.1 Introduction

INFICON SQC-310 series instruments are multi-channel QCM-based deposition controllers. They provide a unique combination of accuracy and powerful features in a compact, low cost instrument.

Figure 1-1 SQC-310C

The standard SQC-310 measures up to two quartz crystal sensors, and controls up to two evaporation sources. Eight process control relays and eight digital inputs are included to support a broad range of external devices. The number of sensors, outputs, and digital I/O can be doubled with an optional expansion card. The SQC-310C co-deposition instrument allows simultaneous deposition of up to four materials. RS-232 and USB communications are standard, with Ethernet optional.

NOTE: Both the SQC-310 and SQC-310C are referred to as the SQC-310 in this manual. If there is a reason to distinguish between the two models, the SQC-310 or SQC-310C model number will be called out.

This chapter will aid you in the initial setup and operation of your system. Please review the entire manual for detailed operational, programming, and safety information.

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1.2 Front Panel

Figure 1-2 Front Panel Controls

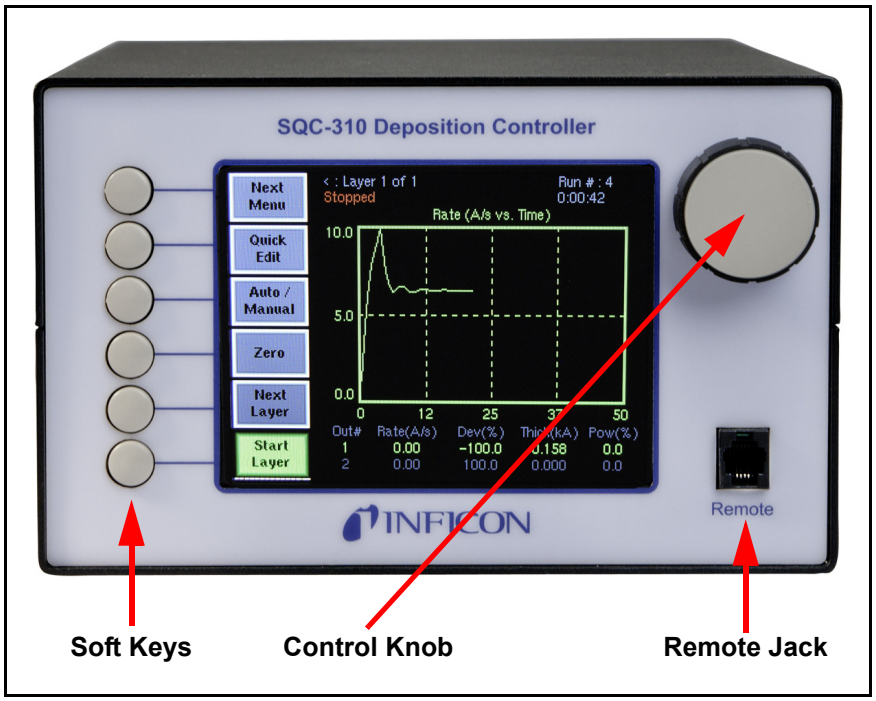

Table 1-1 Front Panel Controls

SoftKeys	Provide access to instrument operations and setup menus. The functions of the SoftKeys change to adapt to different operations and are displayed on the left of the screen.
Control Knob	Used to adjust values and select menu items. Pushing the control knob stores the current setting and moves to the next, similar to a keyboard's Enter key.
Remote Jack	Connection jack for the optional handheld remote controller.

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1.3 Rear Panel

Figure 1-3 Rear Panel

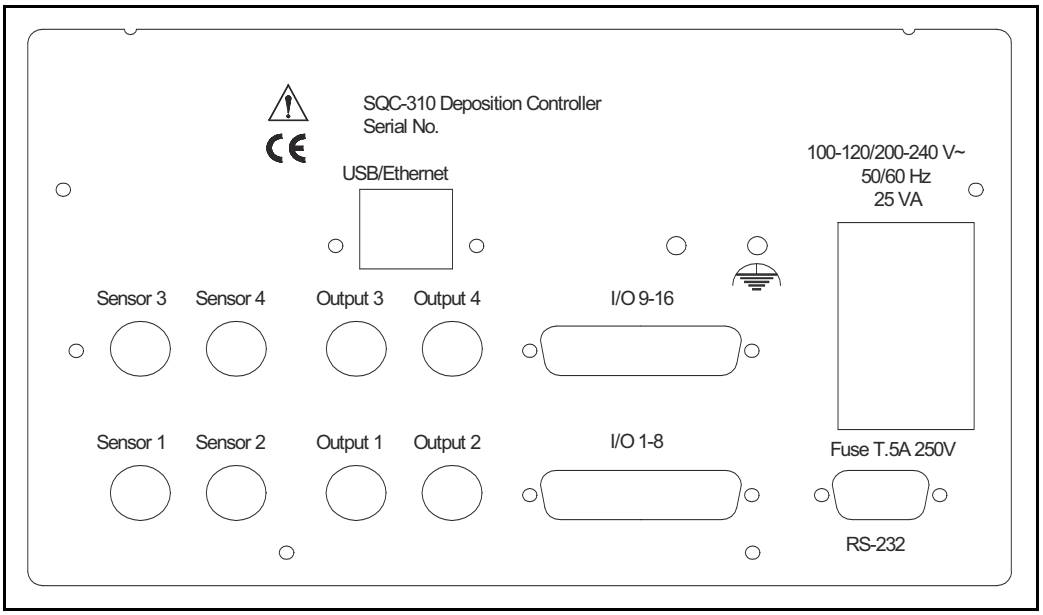

Table 1-2 Rear Panel Connections

Sensor 1 & 2	Connects to the oscillator. See section 1.4 on page 1-4.
Output 1 & 2	Connects the SQC-310 output to your evaporation supply control input (see next section).
I/O (1-8)	Connects 8 relays and 8 digital inputs to external equipment for process control. See Appendix C.
RS-232 **USB or Ethernet**	Connects to a computer for programming and data acquisition. RS-232 and USB are standard. Ethernet option replaces USB.
Sensor 3 & 4, **Output 3 & 4,** **I/O 9-16**	Increases the number of input, output, and digital I/O connections when the optional expansion card is installed.
	Measurement ground terminal useful for common system and cable grounding.
Power Input and Fuse	Connects to mains power. The SQC-310 automatically detects main voltages of 100-120 and 200-240 V (ac), 50/60 Hz  **WARNING - Risk Of Electric Shock** **For continued protection, replace fuses with the proper type and rating. Use power cords only of the specified type and rating, attached to a properly grounded receptacle.**

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1.4 System Connections

Figure 1-4 System Connections

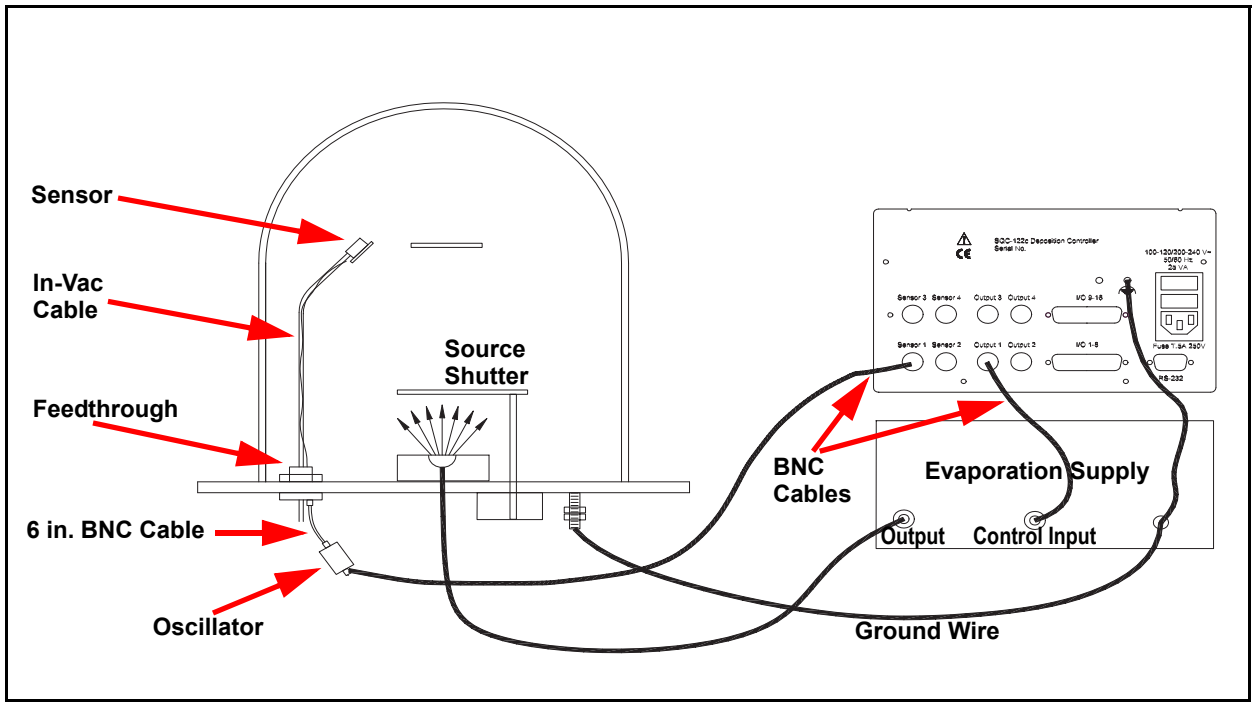

Table 1-3 System Components

Sensor	Holds the quartz crystal used to measure rate and thickness. Crystals must be replaced occasionally.
In-Vac Cable	A coaxial cable that connects the sensor to the feedthrough.
Feedthrough	Provides isolation between vacuum and atmosphere for electrical and cooling lines.
6” BNC Cable	Provides a flexible connection from the feedthrough to the oscillator. Keep this cable as short as possible.
Oscillator	Contains the electronics to operate the quartz crystal. Total cable length to the crystal should be under 40 in.
Sensor Input BNC Cable	Connects the oscillator to the SQC-310 sensor input. Lengths up to 100 ft. are acceptable.
Control Output BNC Cable	Connects the SQC-310 output to the evaporation source’s control voltage input. Keep the length under 10 ft..
Ground Wire	A wire, typically braided, that connects the vacuum system to the SQC-310 ground terminal. Important for noise rejection.

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1.5 Installation

CAUTION

Care should be exercised to route SQC-310 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.

Table 1-4 Installation

Rack Installation	The SQC-310 occupies a 5.25 in. high, half-rack space.. An optional installation kit (P/N 782-900-007) is available to adapt to a full rack (see section 4.6 on page 4-3).
Power Connection	The SQC-310 automatically detects main voltages of 100-120 and 200-240 V (ac), 50/60Hz. **WARNING - Risk Of Electric Shock** **Verify that the power cable provided is connected to a properly grounded mains receptacle.**
Sensor Input Connections	Connect the BNC cables and oscillators from your vacuum chamber feedthrough to the desired SQC-310 sensor inputs. See the previous section for cabling details.
Source Output Connections	Connect the BNC cables from the SQC-310 output connectors to your evaporation supply control input. Consult your Power Supply operator's manual for control input wiring instructions.
Digital I/O Connections	Refer to Appendix C for details on wiring digital I/O to the SQC-310 Relay I/O connectors.
Computer Connection	If you want to collect data or program the SQC-310, attach a straight-thru RS-232 cable from the RS-232 connector to your computer's serial port. You can also communicate via USB using a standard USB cable. If you ordered the Ethernet option, the USB connection is replaced with an RJ-45 Ethernet connector.

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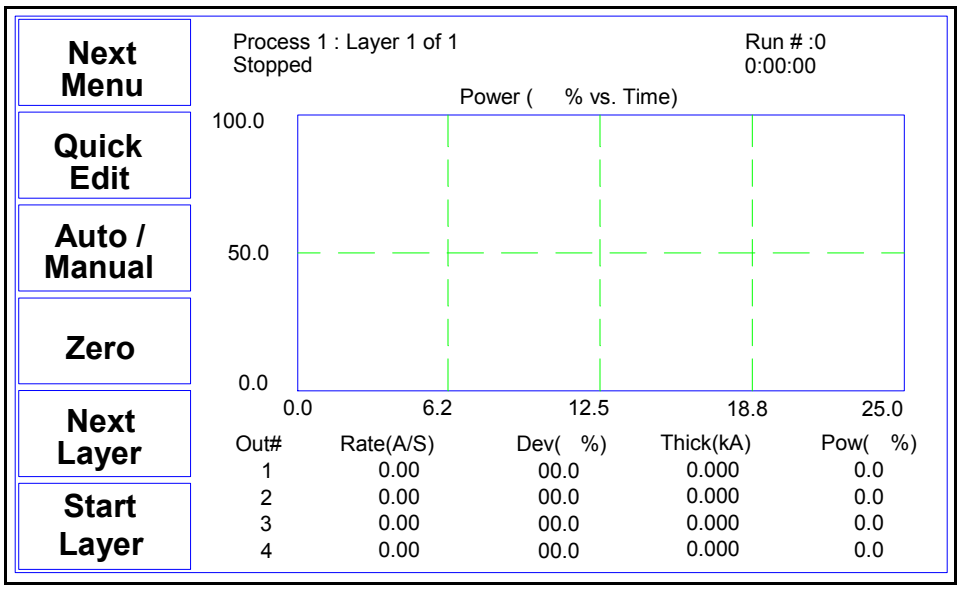
1.6 Menus

At power up the SQC-310 briefly displays the model number (SQC-310 or SQC-310C) and firmware version information, then the Main screen. See Figure 1-5.

NOTE: If you are prompted for a password, use the switches along the left of the screen to enter the password. The top switch is “1”, the bottom switch is “6.” The Control Knob switch is "7." See section 5.3.3, Get/Set System Parameters, on page 5-5 for password setup information.

Figure 1-5 Main Screen



The first line of the Main screen shows the name of the currently selected process. After the process name are the layer that will run when the Start SoftKey is pushed, and the total number of layers in the process. Further to the right is the number of times this process has been run.

The second line of the Main screen is a status line. It displays the current phase of the deposition cycle, and other status or error messages. When the process is running, the right side of this line shows the process elapsed time.

Three graphs are possible: rate, rate deviation, and output power. The graphs scale the vertical axis and scroll the horizontal axis based on the data displayed.

Below the graph are two lines that show deposition readings (four lines if the option card is installed). This section shows current rate, rate deviation, thickness, and output power as shown above. Alternatively it can show measured rate and thickness versus rate and thickness setpoints.

The six SoftKey legends along the left side of the screen will change, depending on the status of the process and the functions you select. Press Next Menu to display alternate main screen menus. See Figure 1-6.

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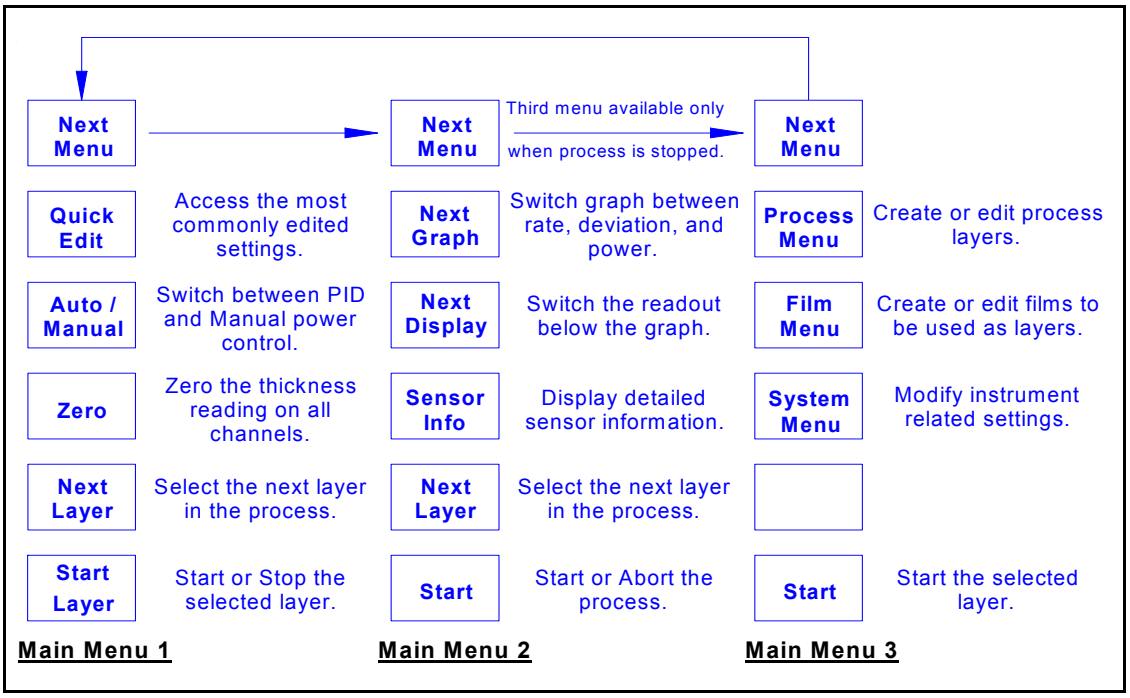
Figure 1-6 Alternate Main Screen Menus



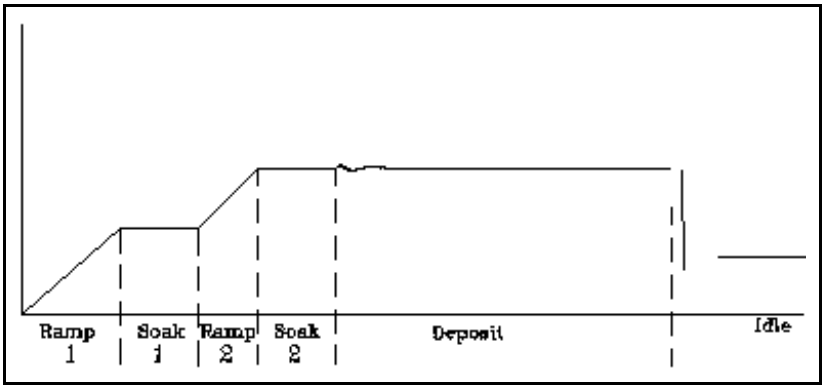
Because Main Menu 3 provides access to functions that can completely redefine a process, it is available only when the process is stopped.

Spend some time now moving between the three menus. Pay particular attention to the effects that the Main Menu 2 selections have on the display. We will cover the setup parameters of Main Menu 3 in the Building a Process section.

1.7 Thin Film Deposition Overview

The SQC-310 stores the recipes, and provides the operating functions, required to control thin film deposition processes. A typical thin film deposition cycle is shown in Figure 1-7.

Figure 1-7 Typical Thin Film Deposition Cycle



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The cycle can be broken into three distinct phases:

- Pre-conditioning (ramp/soak)
- Deposition
- Post-conditioning (feed/idle)

During pre-conditioning, power is supplied in steps to prepare the evaporation source for deposition. Once the material is near the desired deposition rate, material deposition begins.

During deposition, the PID loop adjusts the evaporation source power as required to maintain the desired rate. In Co-deposition, multiple films can be deposited simultaneously.

When the desired thickness is reached, the evaporation source is set to idle power. At this point the process may be complete, or deposition of another layer may begin.

1.8 Building a Process

This section presents a brief guide to building and running a simple one layer process. Chapter 2 covers instrument operation in much greater detail.

Table 1-5 Create a Film

Create a Film	A film is a material to be deposited, and its associated deposition settings. Initially the list of films may be empty. Press **Next Menu** until the Film Menu SoftKey is displayed. Press **Film Menu** to view a list of stored films. Turn the control knob to scroll to an entry in the list that is currently labeled <Empty>. Press the **Create** SoftKey to create a default film at that location. Note the film number that you just created. For now, accept the default film parameters. Press **Main Screen** to return to the main screen.

CAUTION

Be sure to exit to the Main Menu before powering the instrument down if you have made changes to settings. Your changes may not be saved otherwise.

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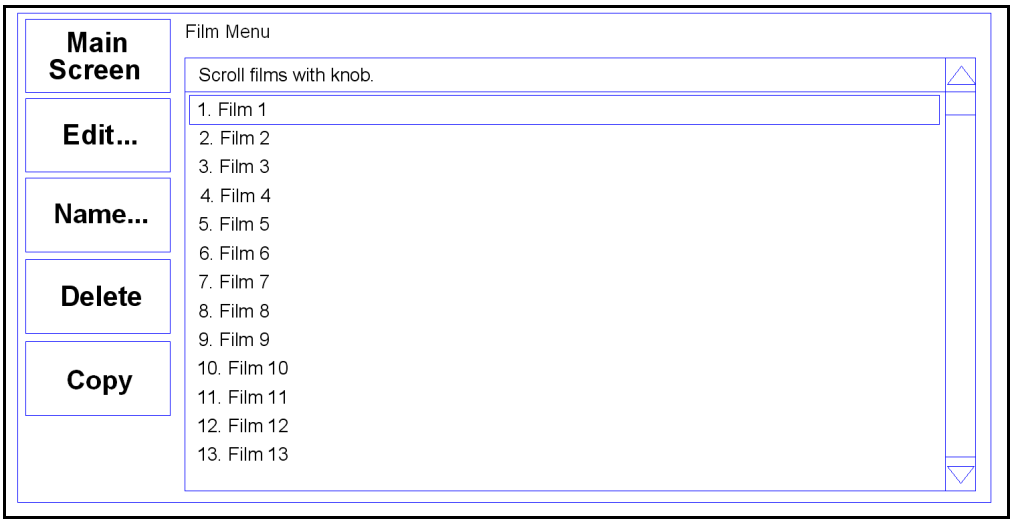
Figure 1-8 Film Select Menu



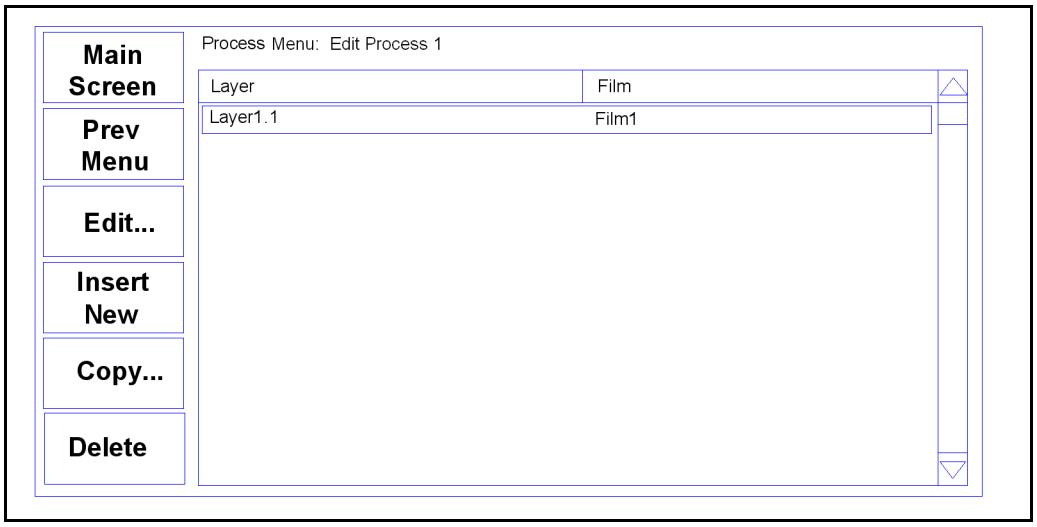
NOTE: Films are numbered from 1 to 50. Film names and process names can be changed by pressing the **Edit Name** SoftKey.

Now that we are sure that at least one film exists, we will build a simple single layer process using that film.

Table 1-6 Building a Layer

Select Process	Press the **Process Menu** SoftKey to view a list of processes. Turn the control knob to scroll to an entry in the list that is labeled <Empty>. Press the **Create** SoftKey to create a default process at that location. Press the **Select** SoftKey to make the selection the active process.
Edit	Press the **Edit** SoftKey to view a list of layers in the selected process. The layer list should be blank.
Edit Layer	Press **Insert New...**, then scroll down the list of films to the film you just created. Press **Insert Normal** to insert the selected film as Layer 1. The display returns to the Layer Select menu. **NOTE:** On SQC-310C, **Insert Codep** is also available to create Co-deposited layers.

Figure 1-9 Layer Select Menu



A process consists of one or more layers. Each layer can have a different film, or even multiple films (Co-deposition). For this example, we will stop with only a single layer. Layers are displayed as "Layer x.y", where x is the layer number and y is the source number assigned to the layer.

Table 1-7 Edit Layer

Edit Layer	With Layer 1.1 selected, press **Edit** to display the Layer Edit menu for Layer 1.1.

Figure 1-10 Edit Layer Menu

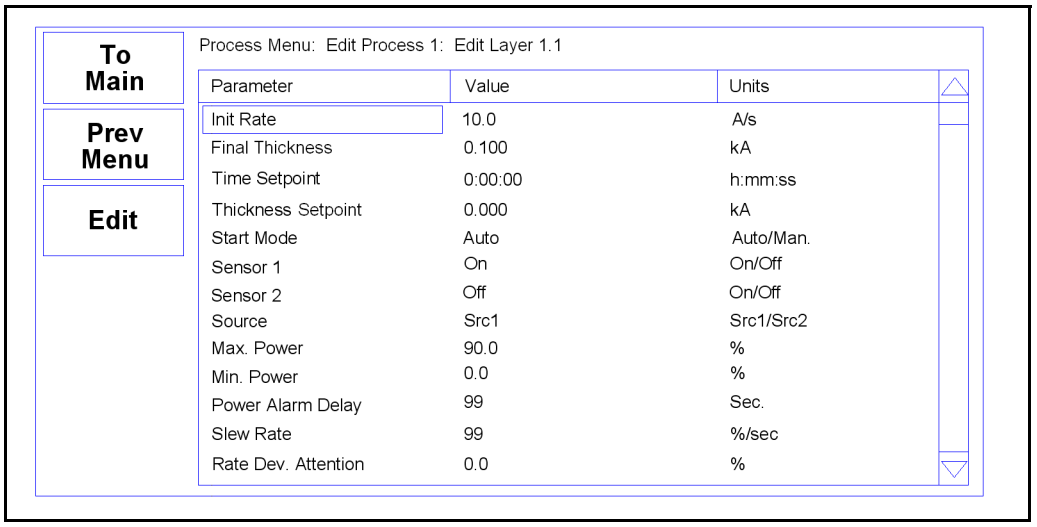


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Table 1-8 Editing a Setting

Edit Menu Operation	To edit a setting in any menu, turn the control knob to scroll to the desired setting, then press the **Edit** SoftKey. The cursor moves to the setting value, and the SoftKey functions change to show: **Next:** Store the parameter and move to next parameter for editing. **Cancel:** Stop editing and return the selected parameter to its previous value. **Enter:** Stop editing and save values for selected parameter. In Edit mode, adjust the control knob to set the desired parameter value.
Edit Layer 1	Spend some time navigating through the Layer 1 parameters and editing values. Be sure to enter an Initial Rate and Final Thickness, and select a Source and Sensor(s). Press **To Main** to return to the Main Screen.

We have completed the design of a single layer process.

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1.9 Depositing a Film

NOTE: You can simulate the steps below, without actually depositing a film, by going to the System Menu and selecting Simulate Mode ON. Simulate mode is useful for testing processes before applying power to the evaporation supply. See section 3.11 on page 3-19 for detailed System Menu information.

Table 1-9 Depositing a Film

Verify Sensor Operation	Press **Next Menu** until the Sensor Info option is shown. Press **Sensor Info** to display the quartz sensor readings. Sensor 1 should be ON and display a % life of over 50%. If not, check your sensor connections (see section 1.3 - section 1.5), and refer to Min/Max Frequency (System Menu, see section 3.11). Press **Exit** to return to the main screen.
Show Power Graph	Press the **Next Graph** SoftKey until the graph shows Power (% vs. Time).
Verify Output Operation	Press the **Next Menu** SoftKey until the Auto/Manual SoftKey is displayed. Now press **Auto/Manual** until Manual/Auto is displayed. Press **Start Layer** to begin deposition in manual mode. Slowly turn the control knob to increase the control voltage to your evaporation supply. Verify that the Power(%) reading for Output 1 (lower right, below graph) approximates the actual output of your evaporation supply. If not, check your hookup (see section 1.3 - section 1.5), and refer to Scale Voltage (section 3.11.3.2). **CAUTION** **Observe the output power versus your evaporation supply's actual output. If there is a problem, press the Stop SoftKey immediately.**
Enter Auto Mode	Press the **Next Menu** key until the Manual/Auto SoftKey is shown. Press **Manual/Auto** to change the SoftKey display to Auto/Manual. This places the output under PID deposition control. Press **Stop** at any time to halt deposition and set output power to zero.

Please take time to review the remainder of this manual for detailed operational, programming, and safety information.

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Chapter 2 Operation

2.1 Introduction

This chapter describes common tasks associated with operating the SQC-310. It assumes that you understand basic operation of the menus and parameter setup as described in Chapter 1, Quick Start. Detailed definitions of each parameter can be found under the appropriate menu description in Chapter 3, Menus.

2.2 Definitions

Several terms will be used repeatedly throughout this manual. It is important that you understand each of these terms.

Material: A physical material to be deposited. A database of 100 materials is stored in the SQC-310. Three parameters completely define a material: Name, Density, and Z-Ratio (also called Z-Factor). A table of common materials, their densities, and Z-Ratios is listed in Appendix A.

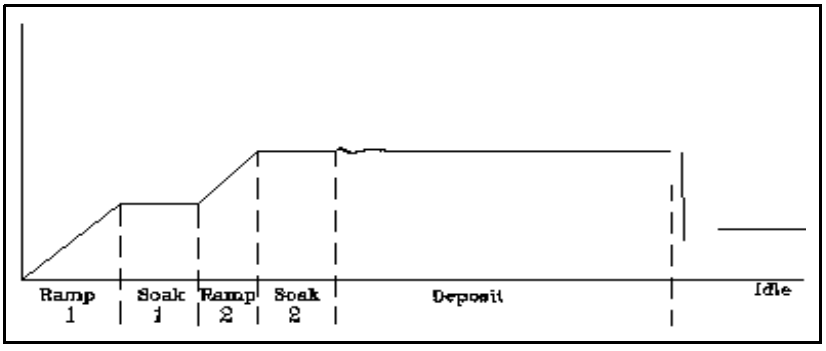
Film: A film describes in detail how a material will be deposited. It includes the material definition and all of the preconditioning, deposition, and post conditioning variables necessary to accurately deposit the material. Because the film definition does not include rate and thickness information, a single film can be used in several different layers and processes. The SQC-310 stores up to 50 films.

Layer: Layers are the basic building blocks of processes. A layer consists of a film and the thickness and rate setpoints for that stage of the process. Layers also define which outputs and sensors will be used at that point in the process. Co-deposition of multiple films occurs when more than one output is active during a layer.

Process: A process is a sequence of layers to be deposited. The SQC-310 can store up to 100 processes, consisting of a total of 1000 layers.

Phase: A step in the deposition cycle. Preconditioning phases include Ramp 1, Soak 1, Ramp 2, and Soak 2. Deposit phases include indexer rotate, shutter delay, deposition, and deposition rate ramps. Post-conditioning phases include Feed Ramp, Feed, and Idle Power.

Figure 2-1 Phase



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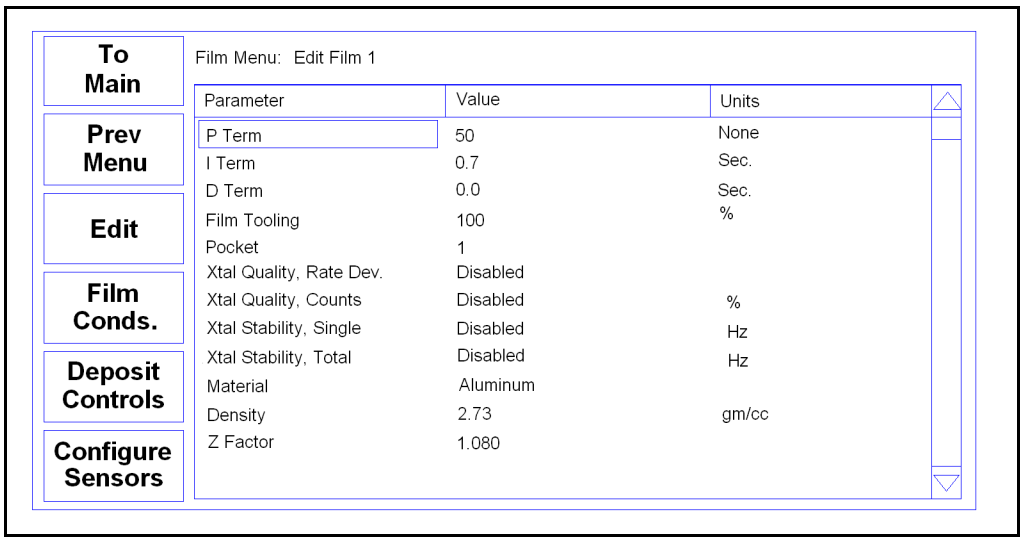
2.3 Defining a Film

A film is a material to be deposited, plus all of its associated setup parameters. Keep in mind that a film can be used in multiple layers, or even multiple processes. Editing a film's parameters will cause changes to every location where the film is used.

To define a film, press **Next Menu** until Film Menu is shown (Menu 3). Press **Film Menu**. A list of 50 films (or <Empty>) will be displayed. To define a new film, scroll to <Empty> and press **Create**. To change the name of a film, scroll to the film and press **Edit Name**. Scroll through the character set and **Insert** each character for the film name. Press **Save** to return to the Film Menu. Press **Edit** to display the parameters for this film.

Figure 2-2 Film Edit Menu



P Term is the proportional gain, which is the % process rate change divided by the % input power change. The I Term (integral) sums the rate deviations over time to more accurately achieve the rate setpoint. The D Term (derivative) speeds response to sudden changes in rate. Volumes have been written on determining the proper PID settings. See section 2.8 on Loop Tuning later in this chapter for a common PID loop tuning procedure. Start with P=25, I=.5, D=0.

Film Tooling adjusts for differences in actual versus measured thickness for this film (material). This parameter is seldom used, but can adjust for material specific dispersion patterns. See Xtal Tooling in the System menu for the more commonly used tooling correction.

Pocket selects the source pocket used for this film. This parameter requires that the System Menu, Source Setup be configured for an indexer (Sensors and Sources Menu, see section 3.11.3).

The next chapter will cover Crystal Quality and Stability. For initial operation leave Quality and Stability disabled.

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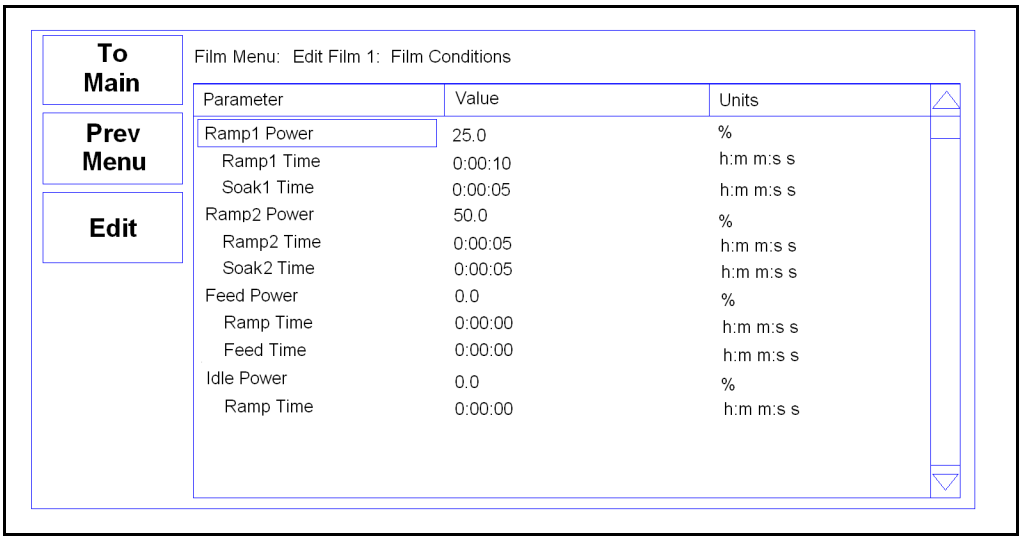
With Material highlighted, press **Edit** to scroll through the list of available materials. Select the desired material and press **Enter**. You could also change the Density and Z-Ratio for the selected material, but it is unlikely those values are wrong. You cannot add materials, but you can edit the Name, Density, and Z-Ratio of one of the 100 existing materials.

Film conditioning adjusts the output power level to achieve a desired material state before and after deposition. Press **Film Conds** to enter the film conditioning menu.

Figure 2-3 Film Conditioning Menu



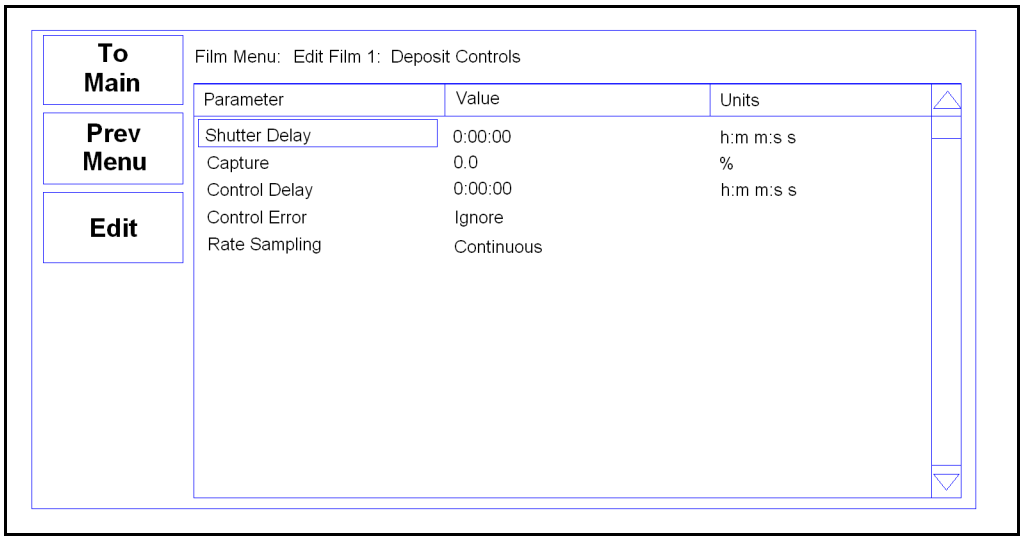
Ramp1 starts at 0% power and increases the power during Ramp1 Time to the Ramp 1 power level. Set the Ramp 1 Power and Time to gradually bring the material to a near molten state. Set the Soak 1 Time to a value that will allow the material to homogeneously achieve that state. Ramp 2 is used to slowly bring the material to a power level that nearly matches the desired deposition power. Use Soak 2 to hold the material at that level until deposition (i.e., rate control) begins.

If you use wire feed to replenish material after deposition, set the Feed Power and times as required. The idle conditioning phase typically ramps output power back toward zero at the end of a process.

From the Film Conds menu, press **Prev Menu** to return to the main Film Menu.

Now press **Deposit Controls**. The Deposit Controls menu contains parameters that modify operation during the deposition phase. See Figure 2-4.

Figure 2-4 Deposition Controls Menu



Shutter delay causes the SQC-310 to delay opening the shutter until the process has stabilized at the desired deposition rate. Capture is the % rate deviation that must be achieved to open the shutter and go to the Deposit phase. Shutter delay is the maximum amount of time to wait for capture to be achieved. Set Shutter Delay and Capture to zero to disable this feature.

NOTE: During co-deposition, the SQC-310 waits for all films to achieve capture before moving to the deposit phase. If any film fails to achieve rate capture within its programmed shutter delay time, an error occurs.

When the Control Delay function is used, the control loop will not react to the rate for a set amount of time at the beginning of the Deposit state. This helps to eliminate overcompensation by the control loop due to rate spikes when the sensor or source shutter opens. Control Delay is the amount of time the SQC-310 will wait before the control loop takes over.

Control Error is a setting that instructs the SQC-310 what to do if it is unable to maintain the desired deposition rate (for example, out of material or a bad sensor). One of three actions is possible: Keep trying (Ignore), set power to zero to halt deposition (Stop), or maintain constant power (Hold) and extrapolate thickness from the last good rate reading. Until your process is known and stable, it is best to leave the Control Error setting on Ignore.

Rate sampling can extend sensor life in high rate processes. Select Cont (continuous) to disable rate sampling. A Time selection closes the shutter for a fixed time, then opens the shutter for a fixed time to sample the rate. Acc Based (accuracy based) sampling closes the shutter for a fixed time, then opens the shutter until the desired rate is achieved. Rate Sampling assumes a very stable process!

Now, from the main Film Menu, press **Configure Sensors**. This menu defines operation of the film when a sensor fails. See Figure 2-5.

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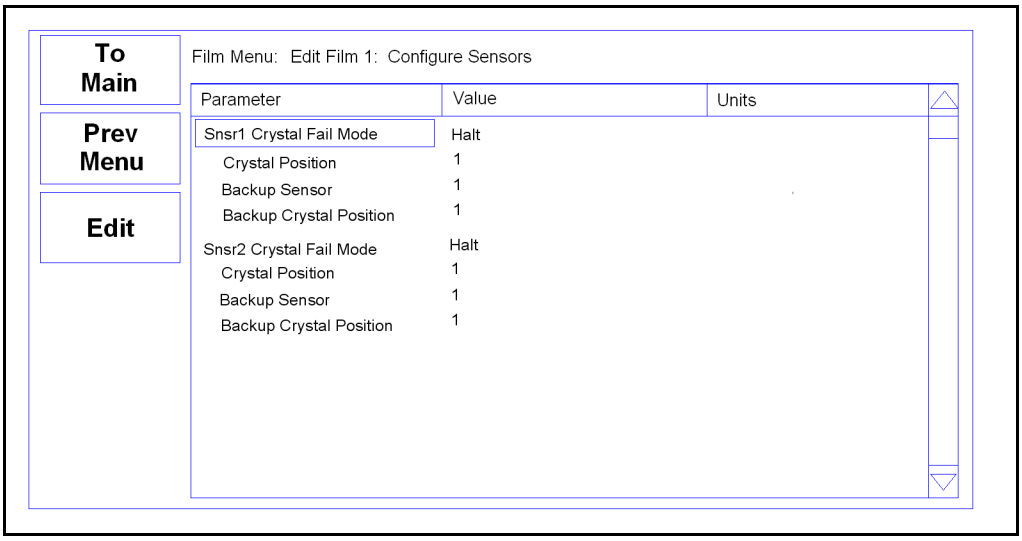
Figure 2-5 Configure Sensor Menu



Crystal Fail mode selects the action taken when a sensor crystal fails. Select Halt to halt the process on failure. Select Halt Last if multiple sensors are used for this film. Select Timed Power to enter Timed Power mode using the last good rate/power measurements. Select Switch to Backup to switch to a backup crystal.

The next three parameters define which position of a multi-crystal sensor is used as the primary, and which is the backup. The number of sensor positions displayed is determined by the sensor configuration on the Sensors & Sources screen of the System Menu.

2.4 Defining a Process

To define a process, press **Next Menu** until the Process Menu SoftKey is shown. Press **Process Menu**. A list of 100 processes (or <Empty>) will be displayed. To define a new process, scroll to <Empty> and press **Create**. A new Process# is added to the list of existing processes. Press Edit Name to change the process name.

Press **Select**, then **Edit** to display the sequence of layers and films that comprise the selected process. To add the first layer, press **Insert New**. Select a film from the films screen and press **Insert Normal.** To add more layers, scroll to below the last layer and press **Insert New**. Layers are always added above the selected layer.

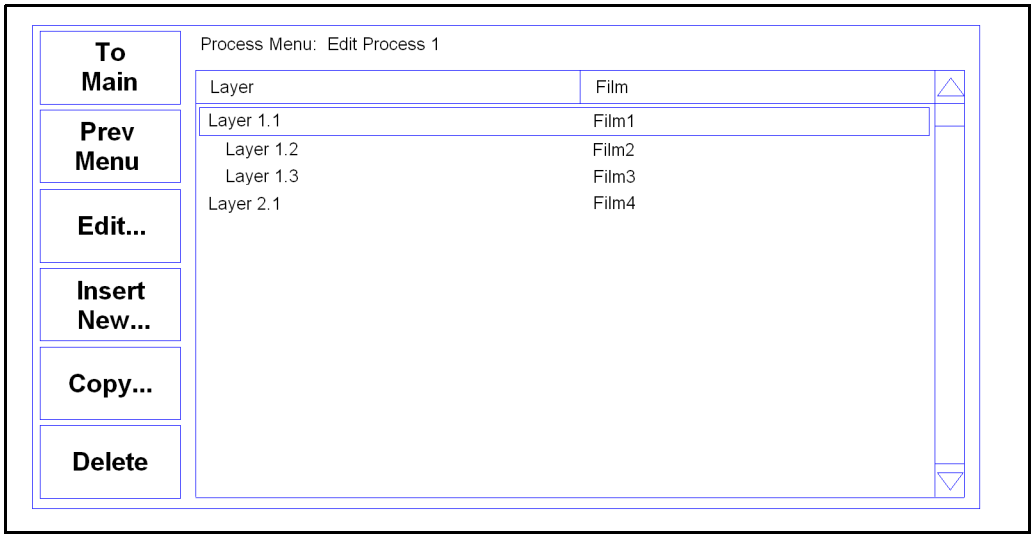
To insert a layer in a sequence of layers, scroll to below the desired location in the layer sequence, and press **Insert Normal**. Select a film from the list and press **Insert Normal** to insert the new layer above the selected layer. The selected layer and subsequent layers will be shifted down.

HINT: When building a process it may be easiest to add a “dummy” last layer and keep inserting above that layer. When the process is complete, delete the “dummy” layer.

To add a Codeposited film to an existing layer, scroll to below the desired Co-deposition layer. Press **Insert New**, select the desired film, then press **Insert CoDep**. The Codeposited film will be inserted in the layer above the selected layer, and indented to show that it is a Co-deposition film. CoDep is available only on the SQC-310C.

Figure 2-6 shows two films being Codeposited with Film1, then a fourth film being deposited as an additional layer. While layers are always numbered sequentially, the films are sequential only for this example. Any film can be used in any layer.

Figure 2-6 Edit Layer Menu



To delete a layer, highlight it in the Layer Select menu and press **Delete**.

To move or duplicate a layer, highlight it in the Layer Select menu and press **Copy**. On the Paste menu, press **Paste** to replace a layer. Press **Insert Normal** or **Insert CoDep** to insert it above the highlighted layer. A copy of the layer is saved to the cut/paste clipboard memory.

NOTE: Once a film is assigned to a process layer, you cannot change the film. Instead, cut the layer, then insert a new layer and select the desired film.

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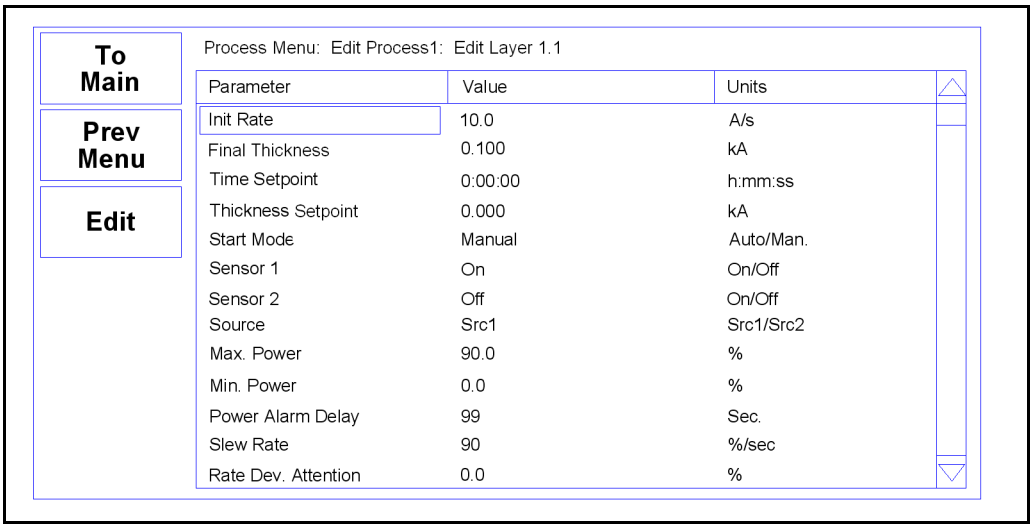
2.5 Defining a Layer

To edit a Process Layer, press **Process Menu**. Select the desired process, then press **Edit**. Finally, select the desired layer and press **Edit...**.

Figure 2-7



Initial Rate and Final Thickness are the main process setpoints for the film used in this layer. Time Setpoint and Thickness Limit are secondary values that can activate a relay when they are reached.

Start Mode controls operation in multi layer processes. In Auto Start the layer starts immediately on completion of the previous layer. Manual Start waits for a user signal via the front panel, digital input, or communications port to start the layer. Don't confuse this Manual Start mode with the Manual Power SoftKey function.

The SQC-310 can use multiple sensors to measure a film's deposition rate and thickness. If multiple sensors are selected, an average of the sensors is used. Set each sensor that will be used to measure this film to ON.

The Source entry assigns the layer to a specific SQC-310 rear panel source output. The layer (and associated film parameters) will be applied to the selected output. Assign the Max, Power, Min. Power, Power Alarm Delay and Slew Rate appropriate for the material and your power supply. For now, set Max Power & Slew rate to 100%. Set them to lower values if you find that small power changes cause excessively large changes in deposition rate. Leave Rate Deviation alarms at 0% for now.

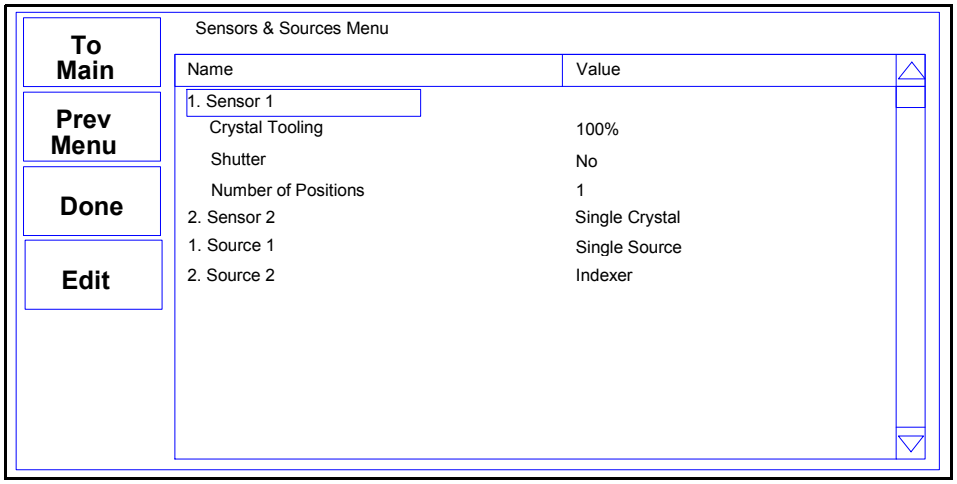
Rate Ramps allow the PID controlled deposition rate to change over time, under PID control. Each rate ramp has a starting thickness, an elapsed time to ramp to the new rate, and a new rate setpoint. Each process layer can have up to two rate ramps.

2.6 Sensor and Source Setup

The SQC-310 must be configured to match the type of sensor installed in your system. We will set up a single sensor without a shutter. Chapter 3 discusses the other Sensor configuration options.

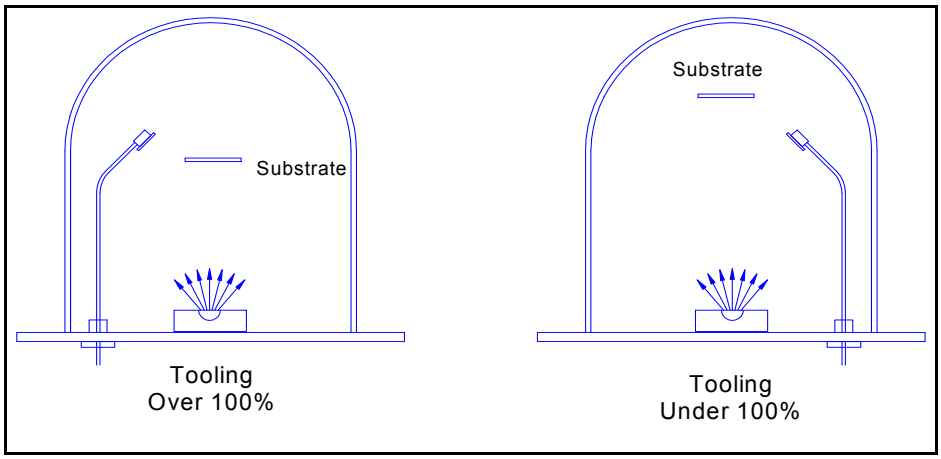
Select **System Menu**, **Sensors & Sources**, scroll to Sensor 1 and press Select to Display the Sensor 1 menu. See Figure 2-8.

Figure 2-8 Sensor 1 Edit



Crystal Tooling adjusts for the difference in measured deposition rate between the sensor and the substrate being coated.

Figure 2-9 Tooling Over/Under



In the left illustration in Figure 2-9, the sensor will measure less rate or thickness than is actually deposited on the substrate because of its positioning. In the right illustration, the sensor will measure high. Tooling is the ratio of the actual substrate deposition rate or thickness, to that measured by the sensor.

A simple rule to remember is: If the rate/thickness reading is low, then increase the tooling value. If the rate/thickness reading is high, then lower the tooling value.

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If your sensor has a shutter, select Dual or Yes. Dual sets the sensor inputs for a dual sensor (one that uses two sensor inputs). Yes is used for either a shuttered single or multi-crystal sensor. Either Dual or Yes will automatically assign the first available relay as the shutter relay. The relay opens immediately when a layer enters the Deposit, Shutter Delay, or Control Delay states.

For multi-crystal sensors set Number of Positions to the number of crystals. Several other parameters are required for multi-crystal heads. Set the Control type and Feedback for the type of Digital I/O used by your sensor. The SQC-310 will automatically create relays and inputs to control the sensor. Detailed explanations of multi-crystal setup can be found in section 3.11.3.1, Sensor Setup, on page 3-31.

Source setup is nearly identical to the Sensor Setup described above.

Set the Voltage Scale to the control voltage that corresponds to 100% output on your source supply. The SQC-310 uses 0 volts as 0% output, and the programmed value as 100% output. Scale values from –10 volts to 10 volts are possible.

Source shutters will open after pre-conditioning, when deposition begins. In your system, this may actually be the substrate shutter.

For a multi-position source, select the number of positions. Control and feedback settings similar to those used for multi-position sensors become available. See section 3.11.3, Sensors and Sources Menu, on page 3-31 for detailed information on these settings.

2.7 Running a Process

Once a Process is defined with the desired Layers, and the sensors and source supply are properly connected, the deposition process is ready to run. This section describes the steps to select, start, and stop a process.

NOTE: Depending on the Main Menu screen displayed, the last key will be shown as either Start or Start Layer. For simplicity, this section will use Start to refer to either.

There are three Main Menu screens while the process is stopped (two when it is running). Pressing the Next Menu SoftKey accesses the three screens. Next Menu is the first SoftKey in each of the three menus. Likewise, Start/Stop is the last SoftKey on each Main Menu. Main Menu 1 displays the SoftKeys used to control the process.

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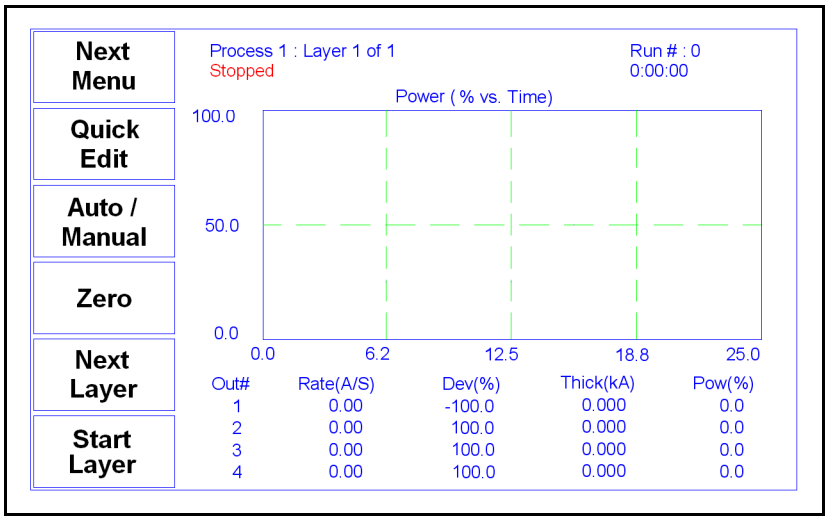
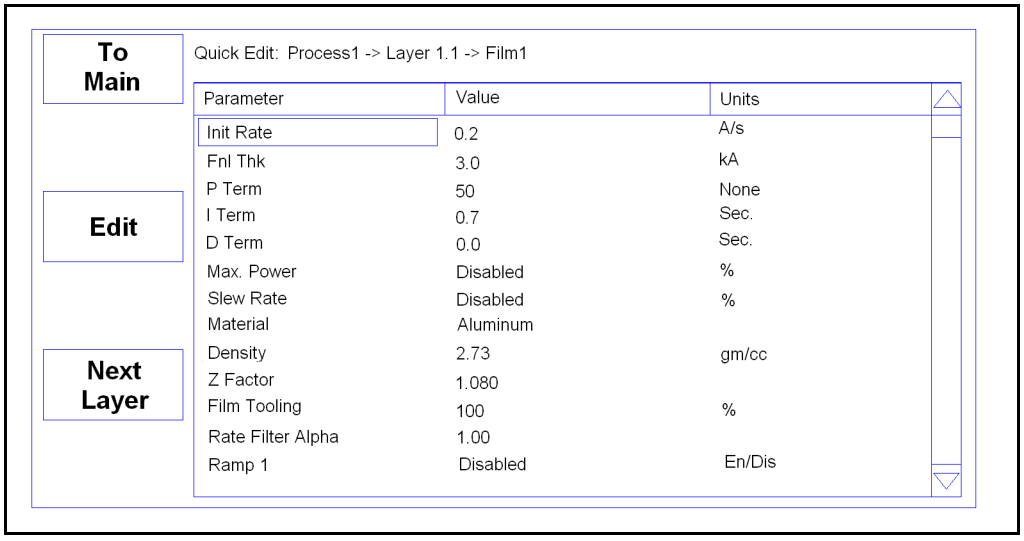
Figure 2-10 Main Screen



The **Quick Edit** SoftKey (available while the process is running) provides easy access to the most commonly set process parameters.

Figure 2-11 Quick Edit Menu



Press **Next Layer** and **Prev Layer** on the Quick Edit screen to review each layer.

Press **To Main** to return to the Main screen.

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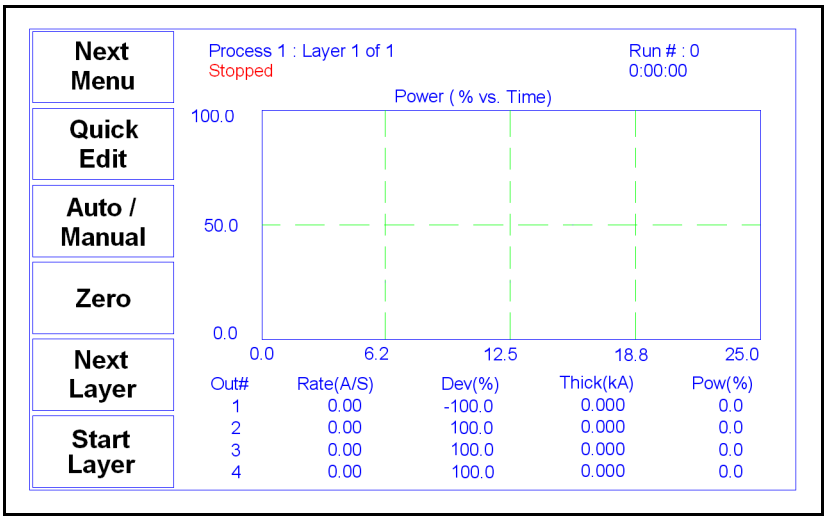
Figure 2-12 Main Screen



The **Auto/Manual** key alternates between Automatic (PID) output control and Manual (user) output control. In Manual mode, the SQC-310 immediately starts the deposition phase for the current layer, whether the process was stopped or running. However, the PID loop is disabled and the front panel control knob controls output power.

In Manual Mode, you will usually display the Rate Graph, and manually adjust the output power to achieve the desired deposition rate. It is easy to exceed a layer's Final Thickness in Manual mode, so watch the Thickness reading carefully. Manual mode is particularly useful for determining preconditioning power levels, and loop tuning.

Moving from Manual mode to Auto mode places the SQC-310 into automatic (PID) control. The PID control loop will try to achieve rate setpoint, so there may be a rapid change in output power.

NOTE: Don't confuse the Auto/Manual SoftKey with a layer's Manual/Auto Start parameter. Manual/Auto Start is an Edit Layer parameter that tells the SQC-310 to wait for operator intervention before starting a Layer.

The **Zero** SoftKey can be used to zero the thickness reading at any time. It is not normally needed, since the SQC-310 automatically zeroes the thickness at the beginning of each layer. However, it is useful when simulating a process, and when operating in Manual mode.

Next Layer moves the starting point for the **Start** SoftKey to the next layer, wrapping back layer 1 at the end of the process.

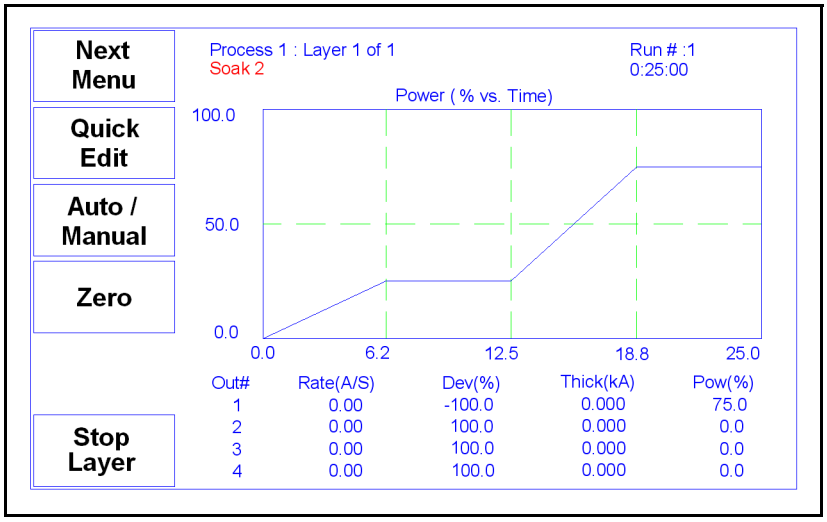
The last SoftKey on this menu is used to Start and Stop the deposition cycle. Press **Start** to start the layer shown on the first line of the screen at the preconditioning phase. Press **Stop Layer** to halt the current layer. You can restart the current layer by pressing **Start**. Press **Next Layer**, then **Start**, to start any other process layer.

NOTE: It is best (and safest!) to place the SQC-310 in Simulate mode when a process is first run. If the bottom SoftKey does not show Start Simulate, press **System Menu** and turn Simulate Mode ON.

Enough preliminaries, let's start the process!

Press **Start** to start deposition. If the first layer Start mode was programmed as Manual, you will need to press the **Start Layer** SoftKey now to start the layer.

Figure 2-13 Preconditioning



The process starts with the first layer preconditioning phase. When preconditioning is complete, the deposition phase begins. The deposition phase ends when Final Thickness is reached for the layer, then Feed and Idle phases run (if programmed).

If the second layer is Auto Start, its cycle begins immediately when the first layer is complete. If the second Layer is Manual Start, or it's the last layer in the process, the process halts and waits for operator intervention.

While the process is running, a Stop Layer SoftKey is shown. Pressing **Stop Layer** temporarily halts the current Layer.

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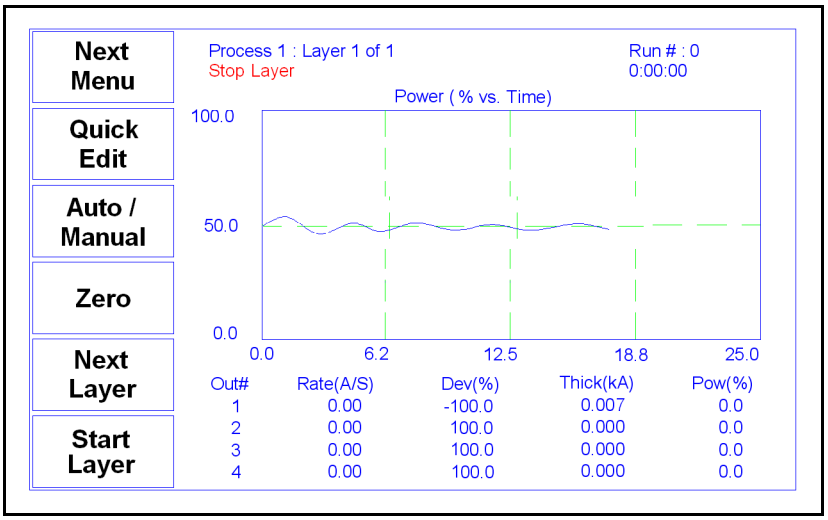
Figure 2-14 Layer Stopped



Start repeats the stopped layer, beginning with preconditioning. **Next Layer** allows you to select another layer to start.

NOTE: Pressing the Reset SoftKey on Main Menu 2 at any time completely aborts the process.

Spend some time in Simulate mode verifying that the process sequences through each phase of each layer as expected. If not, use the Quick Edit, Process, and Film menus to make corrections.

Because the process is being “simulated,” some parameters will not be correct for your process (particularly PID). However, you can become familiar with the effect of each parameter in this simulated process. Also practice using the Next Menu options, especially Auto/Manual modes.

Once you have verified the process in Simulate Mode, you may return to the System menu and turn Simulate OFF to start testing your process. Use the next section to finalize the loop PID settings.

2.8 Loop Tuning

This section will help you adjust your SQC-310 to achieve a stable deposition process. Keep in mind that there is no “best” way to determine tuning parameters, and no one set of settings that are best.

The first factor to consider is the type of deposition source. Thermal sources are slow responding and typically free of noise transients. To avoid overshooting and constantly seeking setpoint, they require PID parameters that anticipate their long dead time and slow response to changes. Ebeam sources, on the other hand, are fast responding and often noisy. They are also subject to arcing, which can create large electrical noise spikes.

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NOTE: Control loop tuning is a trial and error process and there is no "best" procedure to accomplish this task. The procedure described here works best for fast sources.

Set System Parameters: A Period of 0.25 seconds is a good starting point. Set Tooling parameters to 100% for now. Initially set the Rate Filter to 1.00 (no filter) to see the noise of the system. Simulate should be OFF. Keep in mind that Simulate mode is a tool for testing process layers. It is not likely to match the control response of your vacuum system.

Create a One-Layer Test Process: Create a new film with all default values and select the material you will be depositing. Create a process that has the new film as its only layer, and edit that layer. Set Init Rate to your desired rate and Final Thickness to a large value to avoid the layer stopping during the tests. Select the proper Sensor(s) and Source. Leave the other layer and film parameters at their default values.

Test the Setup: Press Next Menu until the Sensor Info button is displayed, and press Sensor Info. Verify that the Sensor Status is ON and a stable frequency is displayed. Exit to the main screen and press Next Menu until the Auto/Manual button is displayed. Press Auto/Manual to enter Manual mode, then press Start Layer.

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 near your desired setpoint is achieved. Again, verify that the power supply output agrees with the SQC-310 Power (%) reading. If the readings don't agree, check your wiring and verify that the System Menu, Source setup Voltage Scale agrees with your power supply's input specifications.

With the power set to your desired rate (Init Rate in the Quick Edit menu), push Next Menu then Next Graph until the Rate Deviation graph is displayed, and observe the noise. If the system has significant short term noise at fixed power (maybe >10%), the control loop will be very difficult to adjust, especially at low rates. It is better to eliminate the source of the noise before attempting to set the PID values.

Select a Filter Alpha: On the Quick Edit menu, slowly decrease the filter Alpha from 1 to a lower value until the rate display noise is minimized. If you set Alpha too low, the display will lag the true system response and may hide significant problems. A value of 0.5 equally weights the current reading and the previous filtered readings.

Determine Open Loop Gain: Record the Power reading at the desired rate as PWR_{DR}. Slowly lower the power until the Rate (Å/s) reading is just at (or near) zero. Record the zero rate Power reading as PWR_{0R}.

Determine Open Loop Response Time: Calculate 1/3 of your desired rate ($RATE_{1/3}$), and 2/3 of the desired rate ($RATE_{2/3}$) for this layer. Slowly increase the power until Rate (Å/s) matches $RATE_{1/3}$. Get ready to record the loop's response

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to an input change. Quickly adjust Power (%) to PWR_{DR}. Measure the time for the Rate (Å/s) reading to reach $RATE_{2/3}$. You may want to do this several times to get an average response time. Displaying the Rate graph will also help. Twice the measured time is the step response time, $TIME_{SR}$. $TIME_{SR}$ is typically 0.2 to 1 seconds for E-Beam evaporation, 5 to 20 seconds for thermal evaporation.

Set PID Values: Set the power to zero. In the Quick Edit menu set P=25, I= $TIME_{SR}$, D=0. Set Max. Pwr to ~20% higher than PWR_{DR}. Exit the Quick Edit menu and press Manual/Auto to move to Auto (PID control) mode and observe the Power graph. The power should rise from 0%, and stabilize near PWR_{DR} with little ringing or overshoot. If there is more than about 10% overshoot, lower the P Term. If the time to reach PWR_{DR} 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 adjust P & I values, alternating between Manual Power 0% and Auto mode 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. Typical I values for thermal systems are 4 to 10; Ebeam I values are 0.5 to 2. It's impossible to predict P values, but it is best to select the lowest value that provides adequate rate control.

Ebeam systems may require additional steps to limit the control loop's response during arcing. First, be sure Max. & Min. power are set to limit the output to reasonable values for this material and rate. Slew Rate can further limit too-aggressive power changes. Remember that slew rate is % of full scale per second. At rates below 10 Å/s, a slew rate of 1-2% per second is common. Finally, decreasing the filter Alpha will limit the PID response to occasional large noise spikes, such as from arcing.

Set Preconditioning: The power level you recorded as PWR_{0R} is the power where deposition just begins. That's a good value for Ramp 1 power in the Film Conds menu. PWR_{DR}, or slightly less, is a good value for Ramp 2 Power. This will prevent 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.

2.9 Troubleshooting

Most SQC-310 problems are caused by defective crystals or improper film setup, particularly incorrect PID settings for the control loop. Follow the procedures below to identify and correct common problems.

No Readings, or Erratic Readings from Sensors

Disconnect the deposition source power supply. This eliminates the possibility that a noisy source, or poor loop tuning, are causing an unstable PID loop.

Verify that the sensors, oscillator and cabling are connected as shown in section 1.3 - section 1.5. Assure that a good ground connection has been made to the SQC-310 chassis.

Replace the quartz crystal. Crystals sometimes fail unexpectedly, or exhibit erratic frequency shifts before total failure. Depending on the material being deposited, crystals may fail well before the typical 5 MHz value. If you find that crystals consistently fail early, you may want to set Min Frequency in the System Menu to a value higher than 5 MHz.

In the System Menu, assure that Simulate Mode is OFF, and Frequency Min/Max are set properly for your crystals (typically Freq Min=5.0 MHz, Freq Max=6.0 MHz). Some manufacturer's crystals exceed 6 MHz when new. Setting Frequency Max to 6.1 MHz will correct that problem, with no bearing on instrument accuracy.

Press Sensor Info and assure that the proper sensors are enabled. While not depositing, observe the % Life display for each active sensor. The value should be stable, between 20% and 100%.

If the % Life reading is zero or unstable: Recheck the wiring from the sensor to the SQC-310, and verify that the SQC-310 is properly grounded. Also check that the crystal is seated properly in the sensor head. You can swap the sensor to the other SQC-310 input. If both SQC-310 inputs show zero or unstable readings, the problem is almost certainly a wiring or sensor problem.

If the % Life is less than 50%: Replace the crystal and assure that % Life is near 100%, very stable. If % Life is not near 100%, check the Frequency Min/Max limits.

If the problem is not corrected: Referring to section 1.4, disconnect the 6” M/F BNC cable from the external oscillator module. A 5.5 MHz test crystal and BNC barrel adapter is supplied with each oscillator kit. Attach the test crystal to the oscillator Sensor connector. The display should read about 5.5 MHz, very stable. If not, contact INFICON technical support.

When the frequency reading is stable, reconnect the source supply and sensor. Start the deposition process in Manual mode with 0% power. The % Life readings should remain stable.

Slowly raise the % Power until a rate reading is displayed above the graph. As material is deposited on the crystal, the % Life reading should remain stable, or drop slowly and consistently. If not, check your source supply for erratic output. Also assure that the sensor is not too close to the source (particularly in sputtering).

Incorrect Rate or Thickness Measurement

First, complete the procedures in the beginning of section 2.9 to assure reliable sensor operation.

Set the Xtal Tooling as described in section 3.11, System Menu, on page 3-19. Incorrect Xtal Tooling values will cause consistently low or high rate/thickness values for every material.

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Once the Xtal Tooling is set, set Film Tooling in the Film Menu to 100% unless you are certain that another value is needed for a specific film.

Verify that the Density and Z-Factor values match those in the Materials Parameters Appendix. If the material is not listed, check a materials handbook. Density has a significant effect on rate/thickness calculations.

Z-Factor corrects for stresses as a crystal is coated. If readings are initially accurate, but deteriorate as crystal life drops below 60-70%, you need to adjust the Z-Factor or replace crystals more frequently. The relationship between Z-Factor and Acoustic Impedance is discussed in Appendix A, Material Table.

Poor Rate Stability

First, be sure that a stable rate can be achieved in Manual mode, as explained in section 2.8. Once a stable rate is achieved in Manual mode, follow the Loop Tuning procedures.

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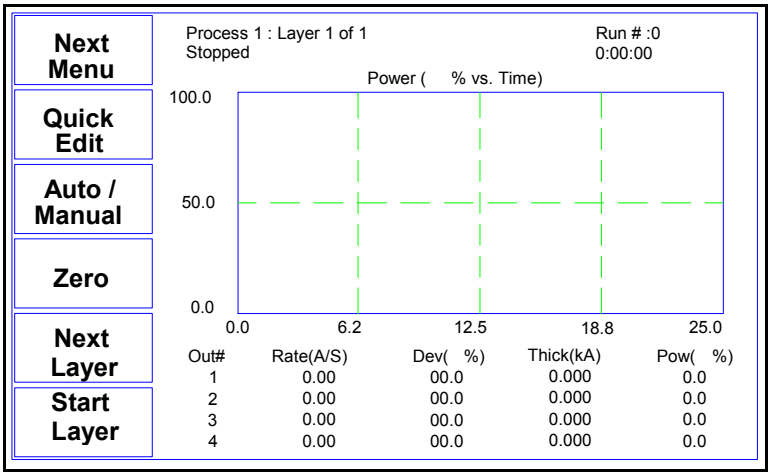
Chapter 3
Menus

3.1 Introduction

Three menus on the Main Screen control SQC-310 operation. The SoftKeys associated with each of these menus leads to sub menus. This chapter describes the function of each setting in each menu. It is arranged by Main Screen menus, then by major sub menus.

The Main Screen for the SQC-310 is shown in Figure 3-1.

Figure 3-1 Main Screen



At the top of the screen you will find information about the current process, layer, and run status. Immediately below is the current deposition phase and error conditions.

The central graph displays Rate, Rate Deviation, or Output Power. If multiple materials are being deposited, the graph shows each material in a different color.

Below the graph is a display of deposition readings. This display always shows the current rate and thickness readings. The remaining columns can be set to display either Power and Deviation readings or Rate and Thickness setpoints. For a standard SQC-310 there will be two lines, corresponding to the two control outputs. With an expansion card installed there will be four lines, as shown.

The Main Screen SoftKey legends will change based on the Menu selection and the current process status. The three different menus for the main screen are accessed by pressing the Next Menu SoftKey.

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3.2 Main Screen, Menu 1

Table 3-1 describes the function of each SoftKey on Main Screen, Menu 1.

Table 3-1 Main Screen SoftKeys

Next Menu	Sequences through each of the three Main Screen menus.
Quick Edit	Displays the Quick Edit Menu of commonly changed process values. If this key is not visible, the active process has no layers defined.
Auto / Manual	Toggles between Auto and Manual power control. When Auto/Manual is shown, output power is set by the SQC-310 to achieve the programmed deposition rate. When Manual/Auto is shown, the control knob sets the output power.
Zero	Zeros the thickness reading. Useful for resetting or extending the current deposition layer.
Next Layer	Sequences through each process layer. Use this key to start or restart the process at any layer. Only visible when the process is stopped.
Start Layer	Each layer in a process can be defined as Auto Start or Manual Start. Auto Start layers begin immediately on completion of the previous layer. Manual start layers wait for the operator to press Start Layer. Only visible when waiting to start a Manual Start layer.
Start/Reset	Starts or halts the current process. Sets all outputs to zero.

3.3 Main Screen, Menu 2

Table 3-2 describes the function of each SoftKey on Main Screen, Menu 2.

Table 3-2 Main Screen, Menu 2 Softkeys

Next Menu	Sequences through each of the three Main Screen menus.
Next Graph	Sequences through the graph options for the Main Screen. Choose between Rate, Rate Deviation, and Power graphs. The Y-axis of the Rate Deviation graph can be scaled in the System Parameters menu. A fourth “graph” screen displays rate, thickness, and power in large text format for easy viewing.
Next Display	Toggles between data display options at the bottom of the Main Screen. The first display option shows Rate, Rate Deviation, Thickness, and Power readings. The second option shows Rate measurements in the first column and Rate setpoints in the second column. Thickness measurements are shown in the third column, then Thickness setpoints in the fourth.

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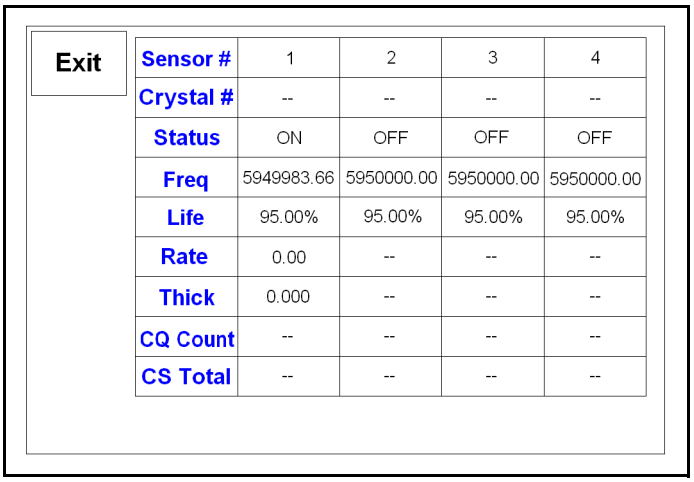
Table 3-2 Main Screen, Menu 2 Softkeys (continued)

Sensor Info	Replaces the Main Screen with the Sensor screen. 
Next Layer	Sequences through each process layer. Use this key to start or restart the process at any layer.
Start Layer	Each layer in a process can be defined as Auto Start or Manual Start. Auto Start layers begin immediately on completion of the previous layer. Manual start layers wait for the operator to press Start Layer. Only visible when waiting to Manual Start.
Start/Reset	Starts or halts the current process. Sets all outputs to zero.

3.4 Main Screen, Menu 3

Menu 3 can be accessed only while the process is stopped. This menu gives access to process, film, and system setup parameters that cannot be altered while a process is running.

To change these parameters when a process is running: Stop the process; modify the parameters; then restart the process at the desired layer.

Table 3-3 describes the function of each SoftKey on Main Screen Menu 3.

Table 3-3 Main Screen Menu 3 Softkeys

Next Menu	Sequences through each of the three Main Screen menus.
Process Menu	A process is a sequence of layers of deposited film(s). The Process Menu selection allows you to build and edit the sequence of process layers.
Film Menu	A film is basically a material plus the setup information necessary to deposit that material. Settings on the Film Menu include pre/post conditioning, deposition error controls, and the physical chamber setup for that material.

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Table 3-3 Main Screen Menu 3 Softkeys (continued)

System Menu	System parameters control the overall operation of the SQC-310. Tooling, crystal frequency, and operating modes are examples of settings found on the System Parameters Menu.
Start/Reset	Starts or halts the current process. Sets all outputs to zero.
View Logic	View Logic is a read-only screen available while a process is running. This allows you to view whether logic statements are true or false at any point in the process.

The remainder of this chapter provides a detailed explanation of each sub menu and its settings.

3.5 Quick Edit Menu

The Quick Edit Menu provides access to the most commonly adjusted parameters for the current process and layer. See Figure 3-2.

Figure 3-2 Quick Edit Menu

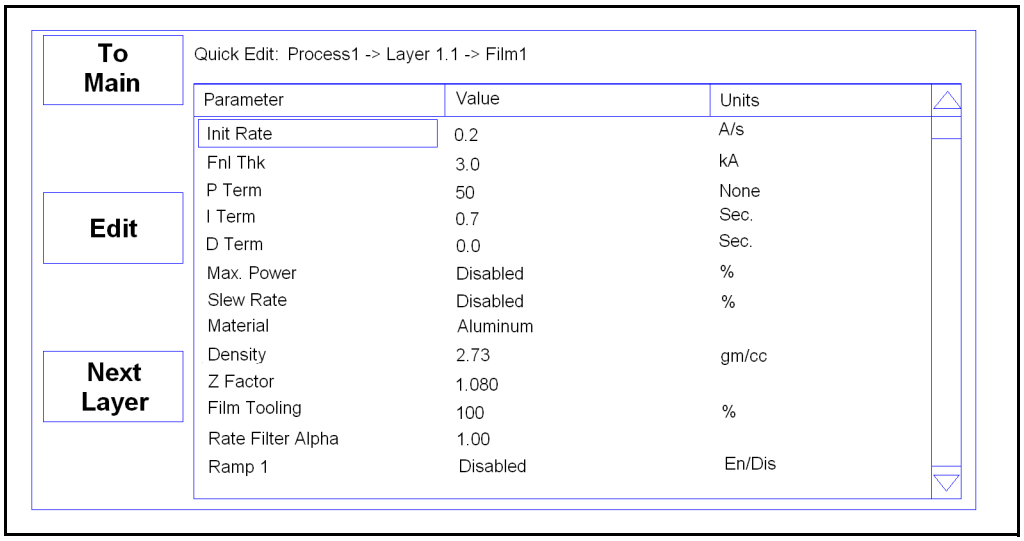

Table 3-4 Quick Edit Menu SoftKeys

To Main	Returns to the Main Screen Menu 1.

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Table 3-4 Quick Edit Menu SoftKeys (continued)

Edit	Selects the highlighted parameter for edit. SoftKey functions change to: **Next:** Store parameter and move to next for editing. **Cancel:** Stop editing and undo changes to selected parameter. **Enter:** Stop editing and save values for selected parameter. **Control Knob:** Turn to adjust value. Push to store value and move to next parameter.
Prev Layer	Displays the parameters for the previous layer in the process.
Next Layer	Displays the parameters for the next layer in the process.

Quick Edit parameters are described below:

Initial Rate: The beginning rate of deposition for this layer. This is the target rate that the control loop tries to maintain througough the deposit (assuming no rate ramps are used).

Final Thickness: The desired final thickness of this layer. The deposition phase of this layer will end when this thickness is reached.

P Term: The proportional 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 0.5 to 1 seconds, will smooth the response of most loops.

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

Max Power: The maximum output power allowed for the selected source. Power is limited to this value and a power alarm occurs if the power remains at the maximum for "Power Alarm Delay" seconds.

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

Material: Selects a material assigned to this film. As materials change, their density and Z-Factor are updated.

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

Z-Factor: Sets the Z-factor, an empirically determined measure of a material's effect on quartz crystal frequency change. Z-Factor is the ratio of the acoustic impedance of the sensor to that of the deposited material. It is used to match the acoustic (oscillation) properties of the material to the quartz sensor. If you know the "acoustic impedance" of your material, divide it by 8.83 (the acoustic impedance of SiO_2) to obtain the material's Z-Factor.

Film Tooling: Compensates for sensor sensitivity to the selected material. Use Xtal Tooling in the System Parameters menu to compensate for each sensor individually.

Rate Filter Alpha: Selects the amount of filtering used to display rate data. An Alpha of 1 is no filtering; Alpha of .1 is heavy filtering.

Ramp 1: During the deposition of a layer, it may be desirable to change the deposition rate. For example, you may want to deposit slowly at first, then increase the rate once an initial thickness is reached. Enabling rate ramps provides that capability. Once enabled, these parameters are added to the list.

Start Thickness: The deposited thickness at which the new rate will begin.

Ramp Time: Time allowed for the rate to change from initial rate to new rate.

New Rate: The rate of deposition, which is reached at the end of Ramp 1.

Ramp 2 / Ramp3: Three rate ramps are available for each layer. Ramps 2 and 3 both have Start Thickness, Ramp Time, and New Rate parameters similar to those described above for Ramp 1. The start thickness for Ramp 2 should be greater than the start thickness for Ramp 1. Likewise, the start thickness for Ramp 3 should be greater than the start thickness for Ramp 2.

3.6 Process Menus

There are several tiers of Process Menus. The first menu (shown in Figure 3-3) selects the current process. The current process is the process that is ready to run, and also the process that is selected for editing.

Figure 3-3 Process Select Menu

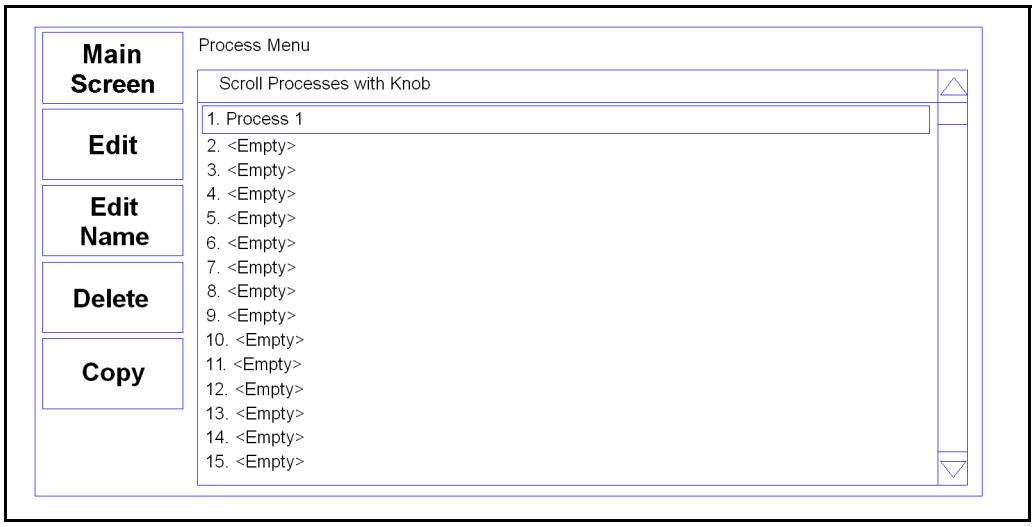

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Table 3-5 Process Select Menu SoftKeys

To Main	Returns to the Main Screen, Menu 3.
Edit...	Edit displays the Layer Select Menu for the current process.
Edit Name...	Displays the character entry screen to edit the selected process name.
Delete	Deletes the highlighted process and all of its layers. A prompt will follow if delete is selected to safeguard against accidental process deletion.
Copy/Paste	Copies the highlighted process and all of its layers. Scroll to an Empty process and press Paste to paste the copied process.

Selecting Edit on the Process Select Menu shows the sequence of layers that will be deposited in the selected process.

Figure 3-4 Layer Select Menu

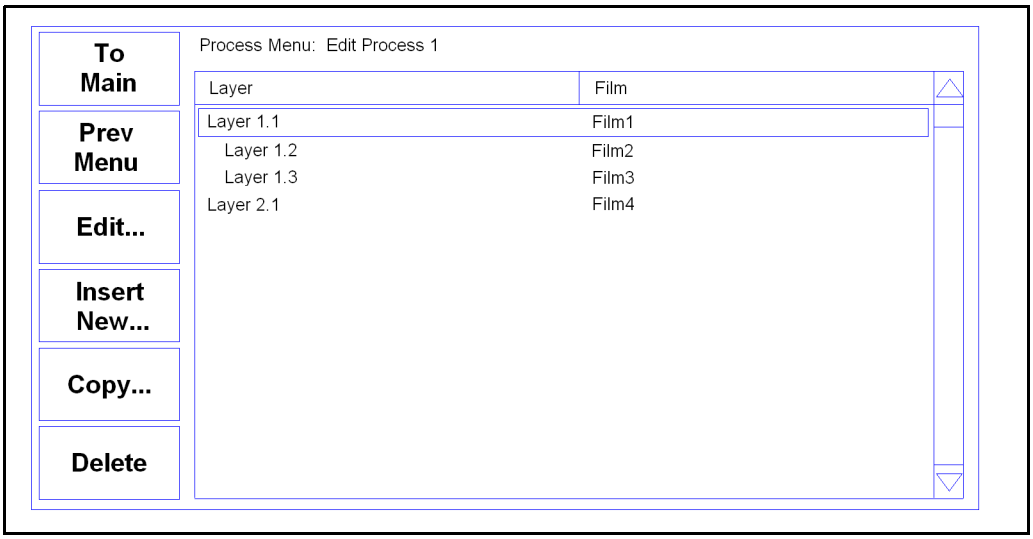

Table 3-6 Layer Select Menu SoftKeys

Main Screen	Returns to the Main Screen Menu 3.
Prev Menu	Returns to the Process Select Menu.

Table 3-6 Layer Select Menu SoftKeys (continued)

Edit	Displays the Layer Edit Menu for the highlighted layer (see the next section).
Insert New . . .	Shows the list of 50 films. Select a film, then press Insert Normal or Insert CoDep to insert the film as a new layer.
Copy/Paste	Used to develop the sequence of layers in a process. Copies the highlighted layer, which can then by pasted or inserted. Pasting overwrites the highlighted layer. After copying, Insert also becomes available. Insert pastes the layer in front of the highlighted layer, see section 3.8, Layer Copy, Insert and Delete Menus, on page 3-10.

3.7 Layer Edit Menu

Each layer consists of a film, plus the rate, thickness, and a few other parameters needed for the layer. The Layer Edit Menu provides access to these layer parameters. See Figure 3-5.

Figure 3-5 Layer Edit Menu

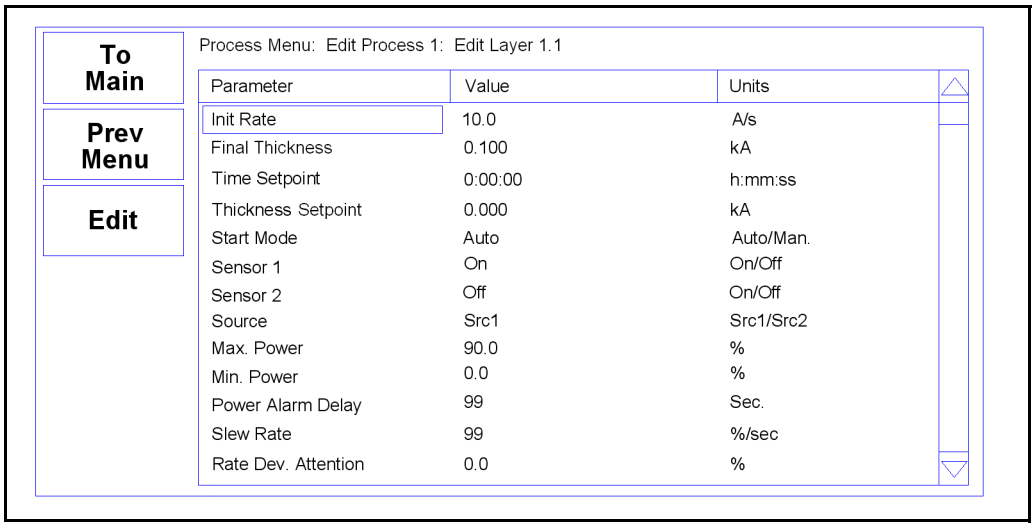

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Table 3-7 Layer Edit Menu SoftKeys

To Main	Returns to the Main Menu.
Prev Menu	Returns to the Layer Select Menu.
Edit	Selects the highlighted parameter for edit. SoftKey functions change to: **Next:** Store parameter and move to next for editing. **Cancel:** Stop editing and undo changes to selected parameter. **Enter:** Stop editing and save values for selected parameter. **Control Knob:** Turn to adjust value. Push to store value and move to next parameter.
Control Knob	Scrolls through the list of layer parameters.

A description of each parameter on the Layer Edit Menu follows:

Initial Rate: The beginning rate of deposition for this layer.This is the target rate that the control loop tries to maintain througough the deposit (assuming no rate ramps are used).

Final Thickness: The desired final thickness of this layer. The deposition phase of this layer will end when this thickness is reached.

Time Setpoint: Sets an arbitrary time, after deposition begins, when the time setpoint logic event becomes true.

Thickness Setpoint: Sets an arbitrary thickness when the thickness Setpoint logic event becomes true.

Start Mode: Determines whether a layer begins automatically upon completion of the previous layer. If Manual start is selected, the previous layer ends at its idle power and waits for the user to press the Start button.

Sensor 1-4: Allows each quartz crystal Sensor to be selected for the selected film. If multiple sensors are assigned to a film, their readings are averaged. If multiple sensors are assigned to a film, and one fails, it is excluded from measurements.

Source: Selects the source output that is active for the selected layer.

Max. Power: The maximum output power allowed for the selected source. Power is limited to this value and a power alarm occurs if the power remains at the maximum for “Power Alarm Delay” seconds.

Min. Power: The minimum output power desired for the selected output. An alarm occurs if power remains below this value for “Power Alarm Delay” seconds.

Power Alarm Delay: The time that source power must remain outside the Min/Max Power settings to trigger an alarm.

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

Rate Dev. Attention: The % rate deviation that triggers an attention alarm. The default value of 0% disables this function.

Rate Dev. Alert: The % rate deviation that triggers an alert alarm. The default value of 0% disables this function.

Rate Dev. Alarm: The % rate deviation that triggers an alarm. The default value of 0% disables this function.

Ramp 1: During the deposition of a layer, it may be desirable to change the deposition rate. For example, you may want to deposit slowly at first, then increase the rate once an initial thickness is reached. Enabling rate ramps provides that capability. Once enabled, these parameters are added to the list.

Start Thickness: The deposited thickness at which the new rate will begin.

Ramp Time: Time allowed for the rate to change from initial rate to new rate.

New Rate: The rate of deposition, which is reached at the end of Ramp 1.

Ramp 2 / Ramp3: Three rate ramps are available for each layer. Ramps 2 and 3 both have Start Thickness, Ramp Time, and New Rate parameters similar to those described above for Ramp 1. The start thickness for Ramp 2 should be greater than the start thickness for Ramp 1. Likewise, the start thickness for Ramp 3 should be greater than the start thickness for Ramp 2.

3.8 Layer Copy, Insert and Delete Menus

Copy, Delete and Insert are used to build and edit a sequence of process layers.

The Layer Select Menu, see Figure 3-6, shows a process consisting of four layers. The first three layers will be co-deposited with Layer 1 (note the indentation of layers 2 and 3). The fourth layer will be deposited after layers 1-3 are codeposited.

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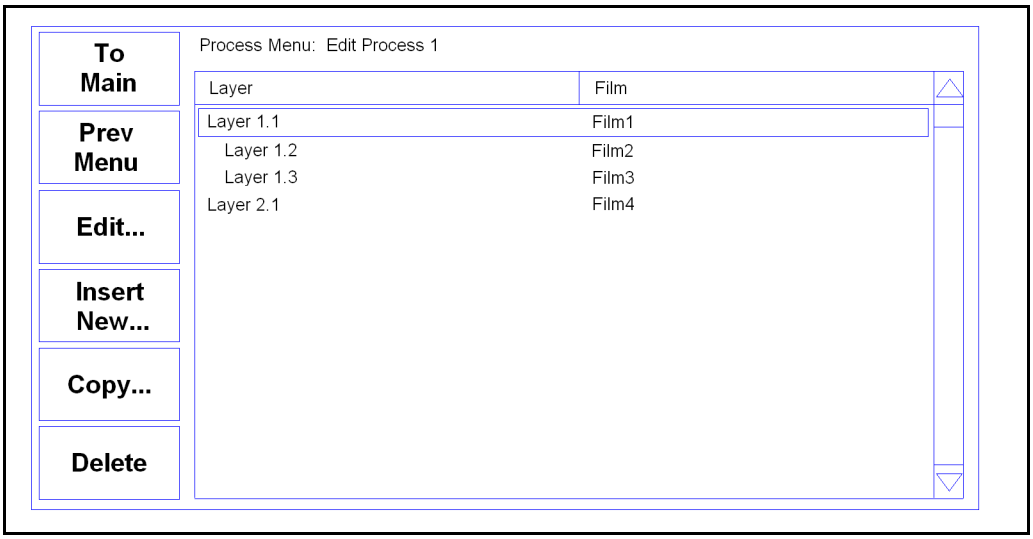
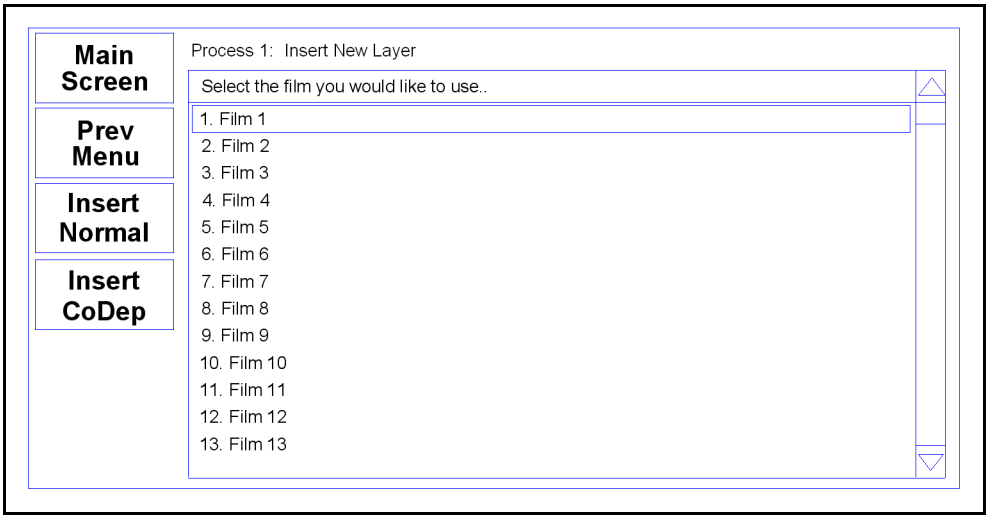
Figure 3-6 Layer Select Menu



To insert a new layer, scroll to the layer you want the new layer inserted above and press Insert New. The Film Select menu allows you to select a film to be used for this layer.

Figure 3-7 Film Select Menu



Once a film is selected, press Paste Normal or Paste CoDep. The Paste CoDep option only appears when a valid layer has been selected for inserting. After the paste, you are returned to the Layer Select menu.

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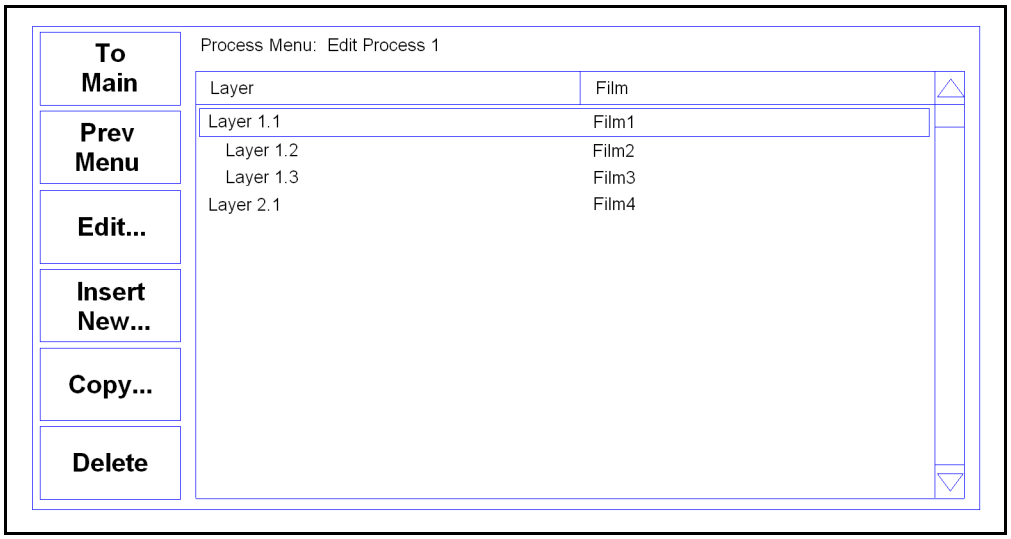
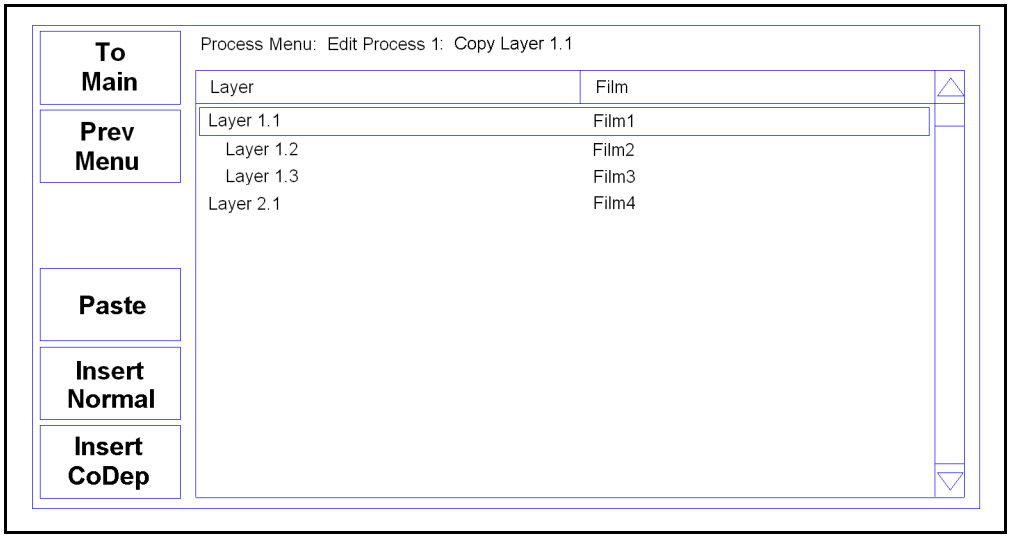
Figure 3-8 Layer Select Menu



Highlight a layer and press Copy to store a copy of the layer in memory.

Figure 3-9 Copy Layer Menu



The display changes to the CopyLayer Menu. The Paste, Insert Normal, or Insert CoDep SoftKeys may not be visible if the operation is not legal for the selected layer.

Paste replaces the selected layer with the one stored in memory.

Remember that when Insert Normal or Insert Codep is used, layers are always inserted above the highlighted layer. That is, the inserted layer will have the same number as the highlighted layer, and the highlighted layer will move down one layer.

HINT: When building a process it is easiest to add a “dummy” last layer and keep inserting above that layer. When the process is complete, delete the “dummy” layer.

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NOTE: Each CoDep layer must be assigned to a different output and sensor. A warning message is displayed if there is a conflict. Highlight each CoDep layer, press Edit, and assign unique sensors and outputs.

3.9 Film Menus

Each film has certain characteristics that determine how it should be deposited. The Film Menus allow you to set parameters that regulate the deposition of each film. These parameters apply any time this film is used (in any process).

Figure 3-10 Film Select Menu

Table 3-8 Film Select Menu SoftKeys

Main Screen	Returns to the Main Menu.
Edit	Displays the Film Edit Menu for the highlighted film.
Edit Name	Displays the character entry screen to edit the selected film name.
Delete	Deletes the highlighted film. (Note: Films cannot be deleted if they are used in any process.)
Copy/Paste	Copies the highlighted film. Scroll to a film labeled as "<Empty>" and use Paste to paste the copied film.
Create	Available only when an undefined film (labeled as "<Empty>") is highlighted. This button defines the empty slot as a film and assigns it a film number, allowing it to be used in a process.

Press Edit to view the setup parameters for the selected film.

3.10 Film Edit Menu

Figure 3-11 Film Edit Menu

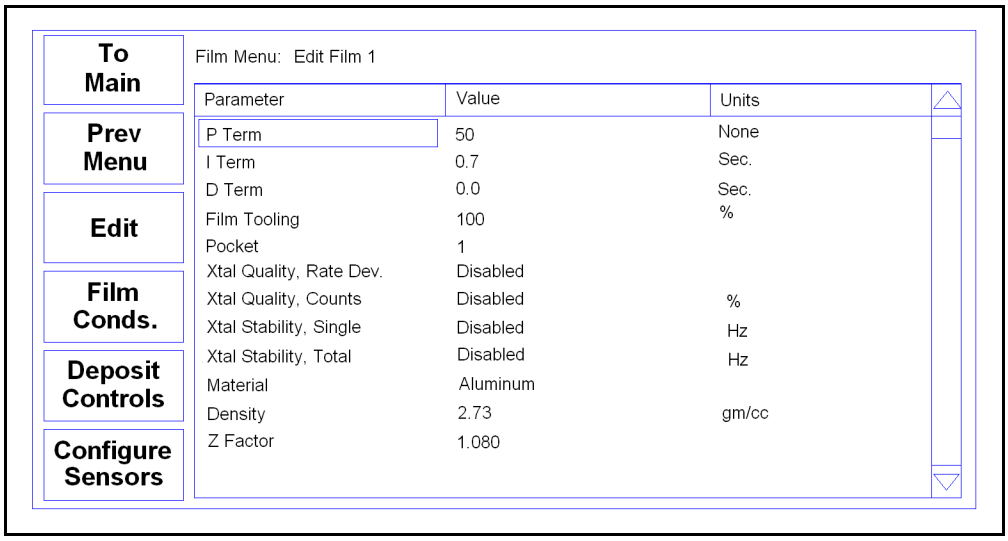

Table 3-9 Film Edit Menu SoftKeys

Exit to Main	Returns to the Main Menu.
Prev Menu	Returns to the Film Select Menu.
Edit	Selects the highlighted parameter for edit. SoftKey functions change to: **Next:** Store parameter and move to next for editing. **Cancel:** Stop editing and undo changes to selected parameter. **Enter:** Stop editing and save values for selected parameter. **Control Knob:** Turn to adjust value. Push to store value and move to next parameter.
Film Conds.	Displays pre/post conditioning settings (See section 3.10.1).
Deposit Controls	Displays deposition control settings (See section 3.10.2).
Configure Sensors	Displays crystal fail mode control settings (See section 3.10.3).

A description of each film parameter follows:

P Term: The proportional 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. Try 0.5 to 1 seconds for Ebeam systems, 5 to 10 for thermal systems.

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

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Film Tooling: Compensates for sensor sensitivity to the selected material. Use Xtal Tooling in the System Parameters menu to compensate for each sensor individually.

Pocket: Indicates which pocket of a multi-material indexer should be used. You must first configure the Source in the Sources and Sensors screen of the System Menu.

Crystal Quality, Rate Deviation: The maximum allowed rate deviation, from the rolling average of the previous 16 rate readings. Each time the rate deviation exceeds the selected percent value, a counter is incremented. Each time the deviation is within the selected value, the counter decrements (to 0 minimum). If the counter reaches Crystal Quality, Counts (see below) during a layer, the process is aborted. Setting this value to zero disables the Crystal Quality alarm.

Crystal Quality, Counts: A counter is incremented each time Crystal Quality, Rate Deviation is exceeded, then decremented each time a reading is within the rate deviation. If the counter reaches Crystal Quality, Counts during a layer, the process is aborted. Setting this value to zero also disables the Crystal Quality alarm.

NOTE: The Crystal Quality settings are very sensitive to PID loop tuning. It is best to leave Crystal Quality disabled until you are confident of your process and PID settings.

Crystal Stability, Single: As material is deposited on the crystal, the frequency normally decreases. However arcing, mode hopping, or external stresses may cause the crystal frequency to increase. If a single large positive shift exceeds this value (in Hz) during a process, a crystal fail condition is indicated.

Crystal Stability, Total: As material is deposited on the crystal, the frequency normally decreases. However arcing, mode hopping, or external stresses may cause the crystal frequency to increase. If the accumulated value of these positive frequency shifts exceeds this value (in Hz) during a process, a crystal fail condition is indicated.

Material: Selects a material assigned to this film. As materials change, their density and Z-Ratio are updated.

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

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

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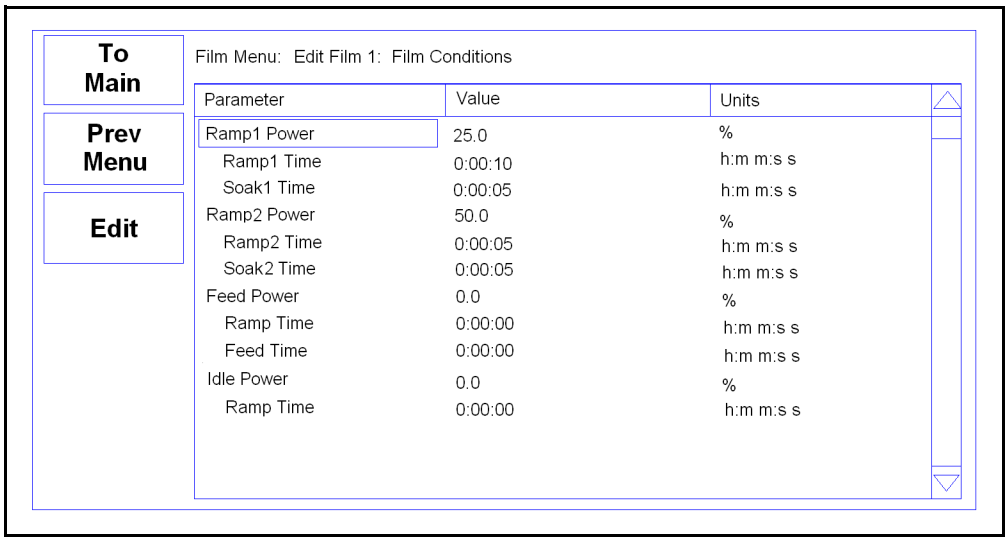
3.10.1 Film Conditioning Menu

The Film Conditioning Menu contains the power settings used before and after deposition. Definitions of each parameter appears later in this section.

Figure 3-12 Film Conditioning Menu



Ramp 1: Ramp power sets the power level (% of full scale) desired at the end of the ramp phase. Ramp time sets the time to ramp linearly from the initial power to the Ramp power. Soak time sets the time the output remains at the ramp power level.

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

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

Idle: Idle power ramps output power back to zero, or holds the material at a state that is ready for deposition (usually the same as Ramp 2 power).

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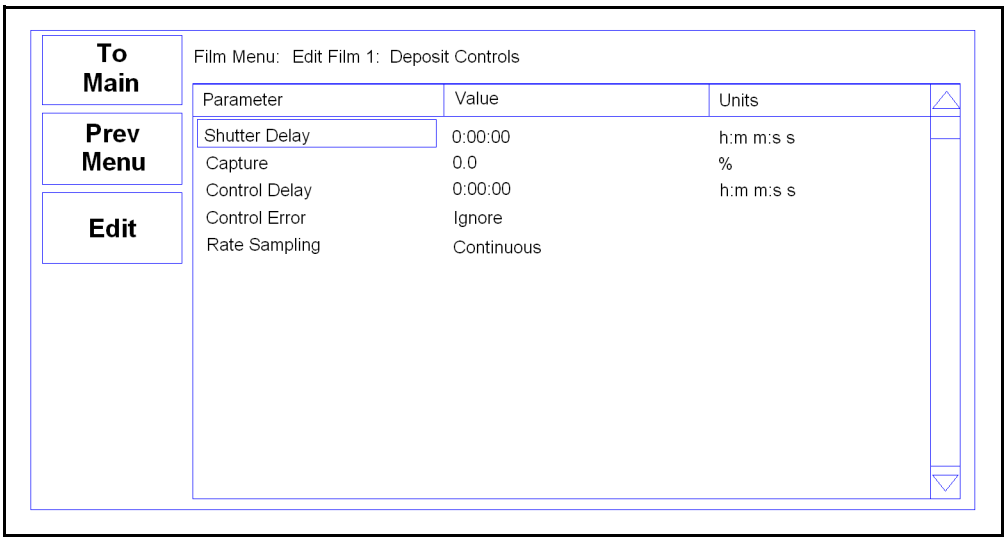
3.10.2 Film Deposit Controls Menu

The Deposit Controls Menu, see Figure 3-13, contains the settings used to control shutters and instrument response during error conditions.

Figure 3-13 Deposition Controls Menu



Shutter Delay: It is often desirable to obtain deposition control before the substrate shutter opens. Enabling shutter delay requires that the system reach a specific capture accuracy before the shutter opens. If the capture accuracy is not reached within the shutter delay time, the process halts. Otherwise, the substrate shutter opens and deposition begins when control accuracy has been maintained for 5 seconds. The thickness reading is zeroed at the end of the shutter delay period.

Capture: The control accuracy (%) that must be reached to end the shutter delay.

Control Delay: It is common to see a negative rate spike at the beginning of the Deposit state when using a source or sensor with a shutter. This is due to the sudden change in temperature that the crystal is exposed to when the shutter opens. When the Control Delay function is used, the control loop will ignore the rate for a set amount of time at the beginning of the Deposit state. This helps to eliminate overcompensation by the control loop due to rate spikes when the sensor or source shutter opens. The Control Delay setting is the amount of time the SQC-310 will wait before the control loop takes over.

Control Error: If the control loop cannot maintain the desired deposition rate, due to loss of source material, excess rate ramps, or equipment malfunction, a control error occurs. The error condition can be ignored, the process stopped (output power to 0%), or the output power held at the same level as when the error occurred. If hold is selected, PID control is abandoned, but the process will continue to be monitored for thickness setpoint.

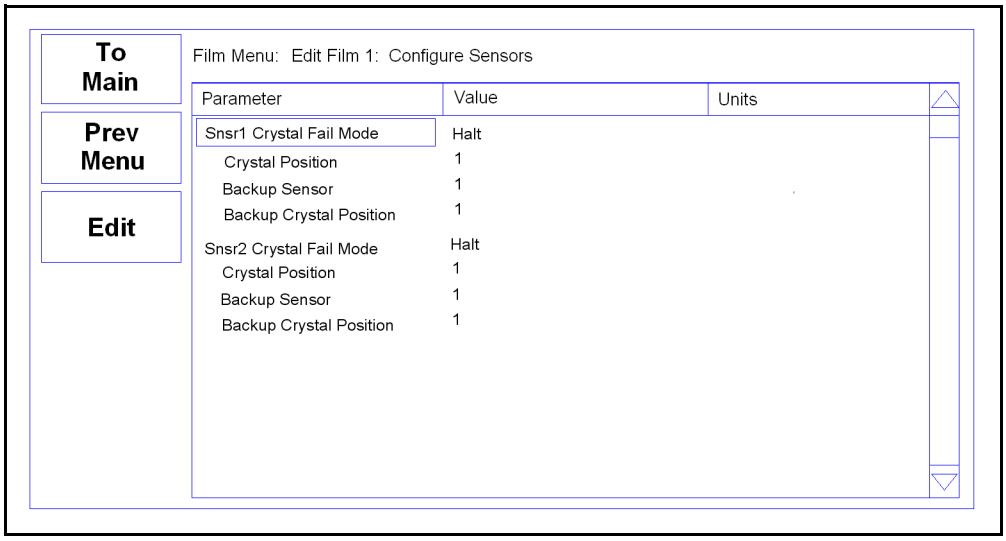
Rate Sampling: Rate sampling can extend the life of crystals. With rate sampling, the deposition rate is sampled for a period of time, then the sensor shutter is closed. Power is then held at the same level as the final power setting during the sample period.

- Continuous selects no sampling; the sensor shutter remains open during deposition.
- Time based sampling opens the shutter for a fixed period of time, then closes it for a fixed time.
- Accuracy based sampling opens and closes the shutter at the rate required to maintain the desired accuracy during the hold phase.

3.10.3 Film Configure Sensor Menu

The Configure Sensors Menu, see Figure 3-14, contains the settings used to control crystal fail modes during error conditions.

Figure 3-14 Configure Sensors Menu



Crystal Fail Mode: The action that is executed if the sensor crystal fails.

Halt: The process will be halted in the event of a sensor failure.

Halt Last: The process will be halted if the last sensor of multiple assigned sensors fails.

Timed Power: The current layer is completed based on the last power and rate readings.

Switch to Backup: The sensor is switched to the backup sensor (see below) in the event of a sensor failure.

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Backup: This sensor is selected solely for use as a backup sensor. It may not be used or selected as a sensor for a film but may be used in the event of a sensor failure. Timed Power mode will be enabled if this is the last sensor to fail.

Crystal Position: The desired crystal position in a multi-crystal sensor head.

Backup Sensor: The designated sensor is to be used as a backup in the event of the main sensor failing. For example, if this setting is set to "2" under Sensor 1, Sensor 2 will be used as a backup when Sensor 1 fails. This will automatically set Snsr 2 Crystal Fail Mode to "Backup".

Backup Crystal Position: The position on the backup the sensor where the backup crystal is located.

3.11 System Menu

The System Menu contains settings that affect the basic operation of the SQC-310. System parameters generally pertain to the physical setup of your vacuum system equipment.

Figure 3-15 System Parameter Menu

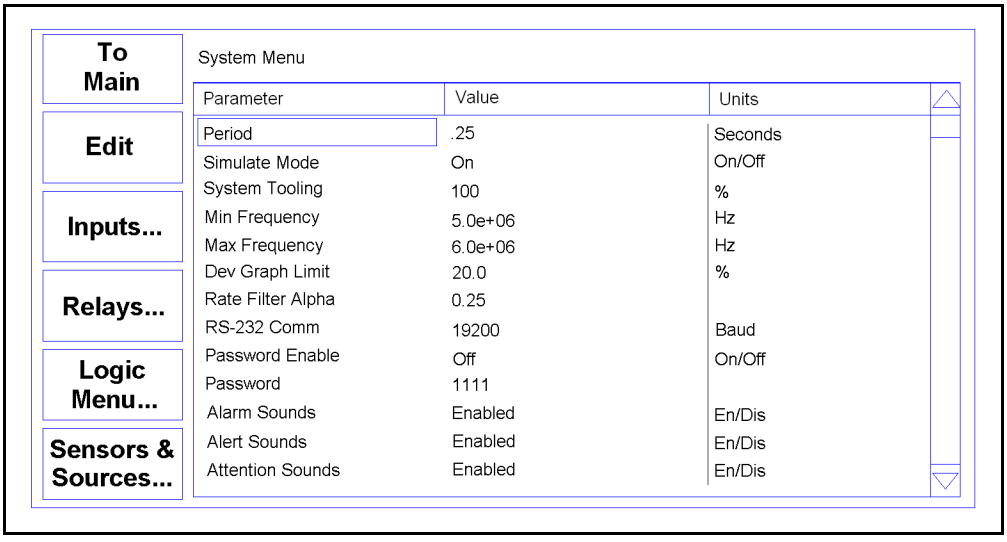

Table 3-10 System Menu SoftKeys

To Main	Returns to the Main Menu.
Edit	Selects the highlighted parameter for edit. SoftKey functions change to: **Next:** Store parameter and move to next for editing. **Cancel:** Stop editing and undo changes to selected parameter. **Enter:** Stop editing and save values for selected parameter. **Control Knob:** Turn to adjust value. Push to store value and move to next parameter.
Input & Relays	Displays menu for assigning inputs and relays.
Logic Menu	Displays menu for building logic statements.
Sensors & Sources	Displays menu for identifying sensor and source types.

Descriptions of each System Parameter follows:

Period: Sets the measurement period between 0.1 second (10 readings per second) and 1 second. A longer period gives higher reading accuracy, especially in low rate and low density applications.

Period (seconds)	Frequency Resolution (Hz)
.10	.03
.25	.01
.50	.005
.75	.004
1.00	.003

Simulate Mode: Normal mode uses the quartz crystals as inputs to the SQC-310 for PID calculations and source output control. Simulate mode simulates the quartz crystals based on the crystal frequency min/max. Simulate mode is useful for debugging process recipes but does not accurately mimic actual process control performance.

System Tooling: Adjusts for overall sensor deposition rates that differ from the measured substrate deposition rate.

Min/Max Frequency: The frequency values for the quartz crystal sensors used as inputs to the SQC-310. The maximum frequency should be set to the frequency of a new crystal, typically 6 MHz. Sensor readings outside the min/max values cause an error.

Dev Graph Limit: Sets the upper limit for the Rate Deviation graph Y-axis.

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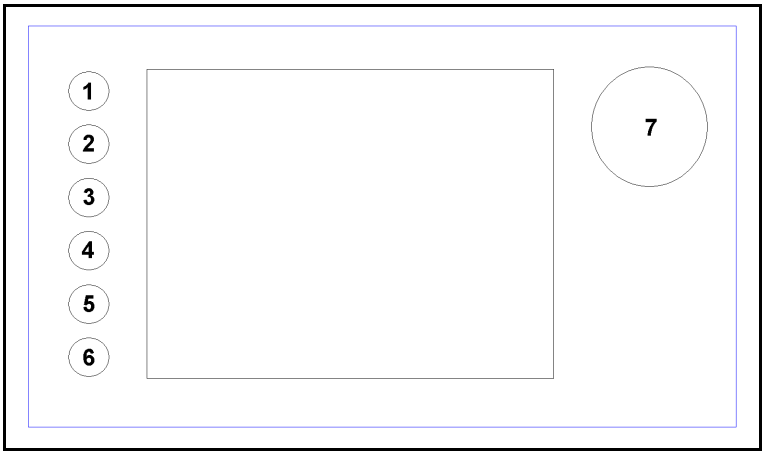
Rate Filter Alpha: Establishes the amount of filtering done for rate display. Alpha of 1 is no filtering. Alpha of 0.1 means that each new reading only represents 1/10 of the value displayed. The previous filtered value represents 9/10 of the displayed value. Low alpha values give a very stable display, but will lag actual rate readings and can hide noise problems.

RS-232 Comm: Baud rate used for RS-232 communications.

Password Enable: If Password is enabled, the Quick Start, Film and System Menus require a password. The Process Menu can be used to select a process, but a password is required to make any changes on the Process Menu.

Password: If password is enabled, this parameter sets the sequence of SoftKeys to press to enter menus. Press the desired sequence to set the password. Refer to figure Figure 3-16 on page 3-21 for an illustration of the password number designations.

Figure 3-16 Password Number Designations



NOTE: Holding down SoftKeys 1 and 6 while powering up the SQC-310 sets the password to 1111.

CAUTION

While holding down SoftKeys 1 and 6 during bootup will reset the password, holding down 1, 6, and 7 (control knob) will default memory for the entire system to the factory settings. There is no way to reverse this, so be sure you are holding down the correct buttons.

Alarm Sounds: Enabled/disables the audio alarm associated with alarm conditions (most severe).

Alert Sounds: Enabled/disables the audio alarm associated with alert conditions (less severe).

Attention Sounds: Enabled/disables the audio alarm associated with attention conditions (least severe).

3.11.1 Input and Relay Menus

The Input and Relay Menus of the System Parameters Menu allow you to view and customize relays and inputs.

Inputs and relays already assigned are indicated in the Use column by Snsr (Sensor), Src (Source), or LS (Logic Statement).

This menu also displays the current state of each input or relay. Items in green are currently active. Those is red are inactive.

The Relay selections have an additional SoftKey (Turn On Relay) that allows each relay to be toggled manually for testing purposes, see Figure 3-17. Relays are returned to their proper defined state on exit from this screen.

Figure 3-17 Relay Menu

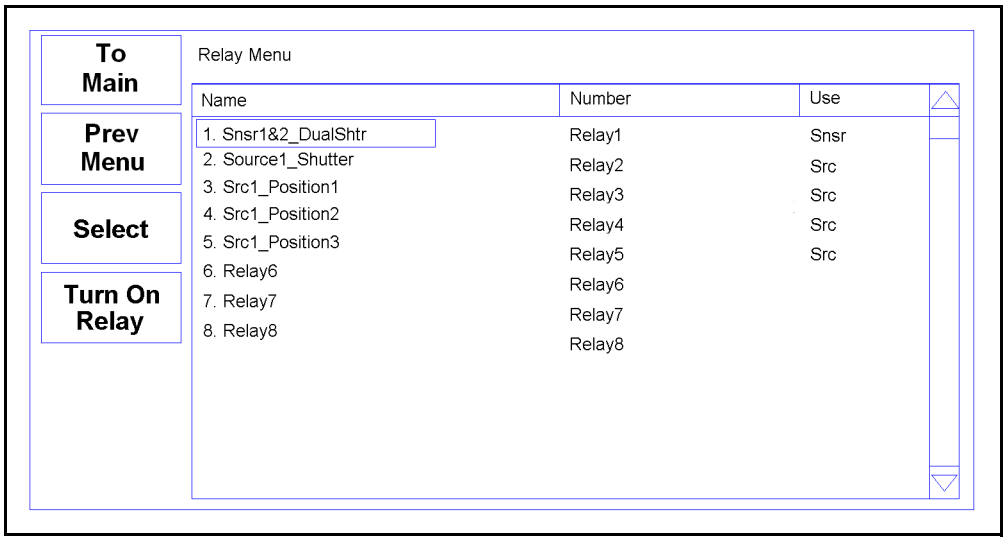


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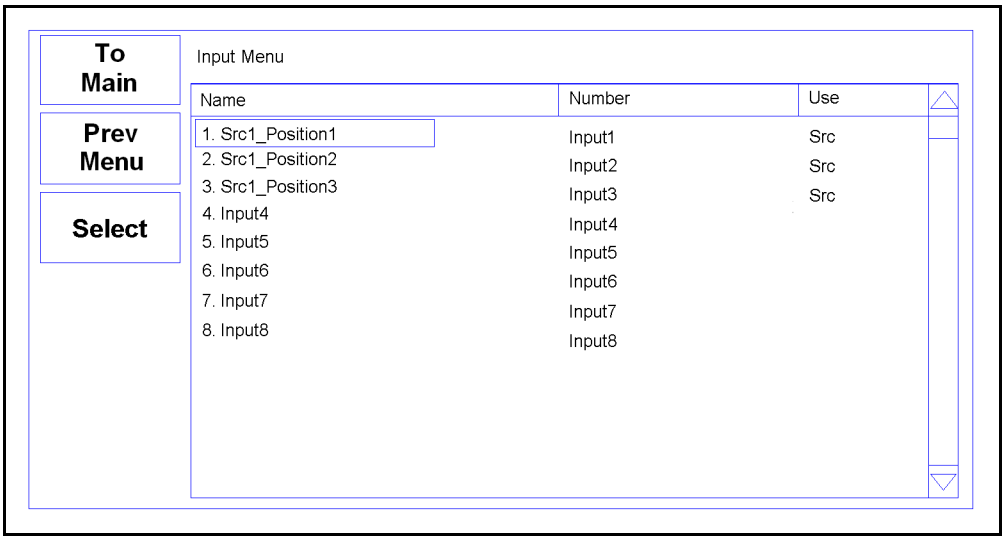
Figure 3-18 Input Menu



To edit an Input or Relay, highlight it and press Select.

Editable Input parameters are:

Name: A logical name for this input. You can return to the input's system-defined default name by pressing the Set to Default SoftKey.

Active Level: The level, high (5 V) or low (0 V) that triggers the input.

Input Number: The physical input assigned to this logical input function. Alows for re-assignment of inputs without physically re-wiring any inputs or connectors.

Editable Relay parameters are:

Name: A logical name for this relay. You can return to the relay's system-defined default name by pressing the Set to Default SoftKey.

Type: Normally Open (NO) contacts or Normally Closed (NC) contacts. The SQC-310 uses software to implement the NO/NC function. All relays are actually normally open and will open when the SQC-310 is not powered.

Pulses: Selecting None causes the relay to activate when the logical relay function is true, and deactivate when it is not. Some multi-crystal sensors require one or two pulses for activation.

Pulse Width: The time (in seconds) that the relay activates if One or Two Pulses are selected.

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Relay Number: The physical output assigned to this logical relay function. This allows for re-assignment of relays without physically re-wiring any relays or connectors. Connector pins for these assignments are shown in Table 3-11.

Table 3-11 Relay & Input Connector Pin Assignments

Relay Number	Connector Pins		Input Number	Connector Pin
Relay 1	14,15		Input 1	16
Relay 2	1,2		Input 2	17
Relay 3	3,4		Input 3	18
Relay 4	5,6		Input 4	19
Relay 5	7,8		Input 5	20
Relay 6	9,10		Input 6	21
Relay 7	11,12		Input 7	22
Relay 8	13,25		Input 8	23
			Ground	24

CAUTION

If changes are made in the Input or Relay Menu, be sure to exit to the System Menu or Main Screen before powering down. Your changes will not be saved otherwise.

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3.11.2 Logic Menu

Logic statements allow you to program the SQC-310 to respond to inputs, and activate relays, based on a variety of process conditions.

To create logic statements select **System Menu**, then **Logic Menu**. The logic menu also displays the current state of each logic statement. Statements in green are currently true. Those is red are false.

From the list of 32 logic statement names, scroll to a statement and select **Edit** to view the Edit Logic screen. See Figure 3-19.

Figure 3-19 Edit Logic Screen

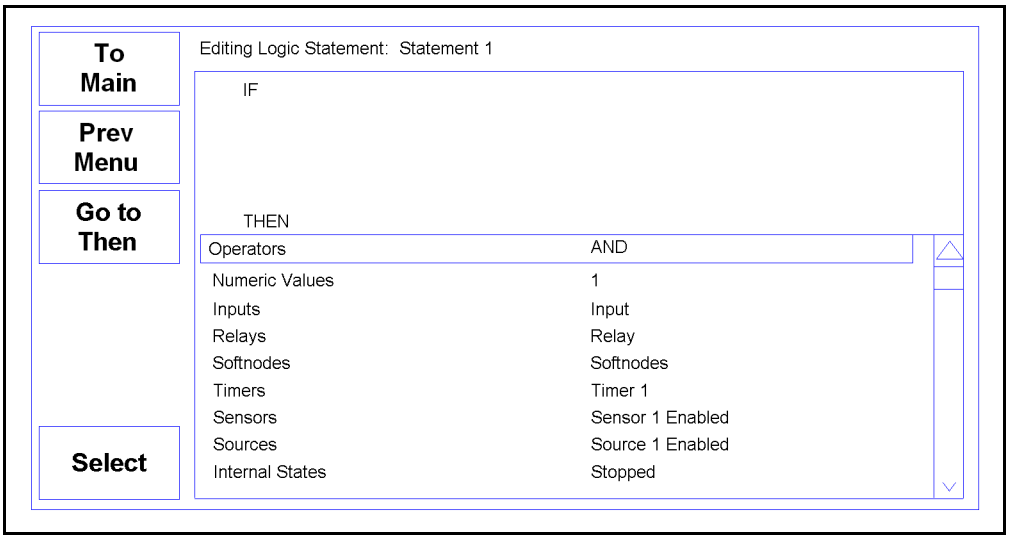

Table 3-12 Edit Logic Screen SoftKeys

Go to Name	Moves cursor to the name field. Press Edit Name to display the character input screen.
Go to Then	Moves the cursor to the THEN (action) part of the logic string. See section 3.11.2.1 for a details on creating a logic statement.
Go to If	Moves the cursor to the IF (condition) part of the logic string. See section 3.11.2.1 for a details on creating a logic statement.
Delete	Removes last condition in the logic statement.
Select	Selects the highlighted condition for edit. SoftKey functions change to: **Done:** Returns to regular logic menu selections. **Delete:** Removes last condition in selected logic statement. **Insert:** Add the highlighted condition for current logic statement. **Control Knob:** Turn to adjust value. Push to store value and move to next parameter.

3.11.2.1 Entering a Logic Statement

A logic statement consists of two parts. The first part of the string (IF) indicates the condition that must be satisfied. The second part (THEN) indicates the action that takes place once the IF part has been satisfied.

To create a logic statement string you must follow three simple rules. For the IF portion of the statement:

- There must be an equal number of closed and open parentheses.
- All conditions must be separated by an AND, OR, or NOT operator.
- Condition strings cannot end in an operator.

Enter Logic Condition: To enter a logic condition, press **Go to IF**. Scroll down the condition categories, and press **Select** to view the specific conditions for that category. Scroll through the list of conditions and press **Insert** to add the condition to the IF portion of the logic statement. Press **Done** to continue building the logic statement.

To add another condition, you will need a logic operator such as AND, OR, NOT, or a parenthesis. Scroll to the top of the condition categories, highlight Operators and press select. Scroll to the desired operator and press Done. Enter another logic condition as described above. Continue these operations until the desired IF condition is built.

If you make a mistake, press Delete to delete the last entry in the IF statement.

Enter Logic Action: To enter a logic action, press **Go to Then**. Scroll down the action categories, and press **Select** to view the specific actions for that category. Scroll through the list of actions and press **Insert** to add the action to the THEN portion of the logic statement. Press **Done** to complete the action portion of the logic statement. Only one action is possible per logic statement.

When you exit the Edit Logic Statement screen, the statement is tested for proper syntax. If there is an error, you are given the choice of correcting the statement. If you chose to not correct errors, the logic statement will always evaluate as false.

Besides listing the names of the 32 logic statements, the Logic Menu shows the current state of each statement. Statements that currently evaluate as true are shown in green. Statements that evaluate as false are shown in red. This can be a handy aid for troubleshooting logic statement and digital I/O problems.

3.11.2.2 Logic Statement Conditions ("IF")

Operators: For more complex logic statements logical operators such as AND, OR, NOT, parentheses ( ), greater than >, and less than < can be added. Parenthesis are used to group logic conditions, such as “IF (Input1 AND Input2) OR Input3”. Every open parenthesis “(“ must have a matching closed parenthesis “)”. The less than “<” and “>” than operators are used only with Timer conditions.

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Numeric Values: Any integer between 1 and 64133. Numeric values are used with timer conditions, such as IF Timer1 < 100 THEN Relay1.

Inputs: Choose the logic state (active state) of one the SQC-310 digital inputs as a condition. If the specified input becomes active, the logic statement will become true (choose input 1 - 16*)

Relays: Choose the logic state (active state) of one the SQC-310 relays as a condition. If the specified relay becomes active, the the logic statement will become true (choose relay 1 - 16*).

SoftNodes: SoftNodes allow you to build logic statements that are based on other logic statements. There are 8 softnodes available for use.

For example, you might create a logic statement:

IF (Input1 AND Input2) OR Input3 THEN SoftNode1

You can now use that logic statement in another logic statement such as

If (SoftNode1 AND CrystalFail) THEN Stop Layer

Timers: The timer condition is evaluated true whenever the timer's value is greater than the value entered in the timer condition. There are 8 timers available for use.

Sensors: Allows you to choose between various sensor conditions. Available sensor conditions include:

Sensor Enabled (choose sensor 1 - 4*)

Sensor Shutter (choose sensor 1 - 4*)

Sensor Fail (choose sensor 1 - 4*)

All Crystals Fail

All Crystals Good

Dual Crystal Shutter (choose dual sensor 1 or 2*)

Sensor Timeout (choose sensor 1 - 4*)

Sources: Allows you to choose between various source conditions. Available source conditions include:

Source Enabled (choose source 1-4*)

Source Shutter (choose source 1-4*)

Source Timeout (choose source 1-4*)

Internal States: Allows you to choose an internal state as a condition. Available states include:

Stopped

Crystal Verify

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Initialized Layer

Manual Start Layer

Rotate Crystal

Rotate Pocket

Preconditioning

Soak Hold

Shutter Delay

Deposit

Timed Power Recovery

Crystal Switch

Next Crystal

Feed Ramp

Idle Ramp

Start Next Layer

Crystal Fail

Stop Layer

Snsor Feedback Timeout

Sorce Feedback Timeout

Sensor Feedback Error

Source Feedback Error

Invalid Crystal Position

Invalid Pocket Position

Internal Events: Allows the user to select an internal event as a condition. Available events include:

Simulate

Manual Mode

Interlock

Last Layer

Process Hold

Process Active

Process Stopped

Shutter Delay Error

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Thickness Setpoint

Final Thickness

Time Setpoint

Soak Hold

Rate Dev Alarm

Max Power Alert

Min Power Alert

Crystal Index: Allows you to select a specific crystal on a multi-crystal sensor as a condition. Choose sensor 1 - 4* and crystal 1 - 16.

Pocket Index: Allows you to select a specific pocket on a multi-pocket source as a condition. Choose source 1 - 4* and pocket 1 - 16.

Processes: The process condition is evaluated true whenever the selected process is the current process. Choose process 1 - 100.

Layers: The layer condition is evaluated true whenever the current layer number equals the specified layer number. Choose layer 1 - 100.

Films: The film condition is evaluated true whenever the current film number equals the specified film number. Choose film 1 - 50.

NOTE: References to sensor 1 - 4, source 1 - 4, relay 1 - 16, or input 1 - 16 assume the SQC-310 is equipped with the 4-channel option card. Units not equipped with the option card will have sensor 1 - 2, source 1 - 2, relay 1 - 8, and input 1 - 8.

3.11.2.3 Logic Statement Actions ("THEN")

General Actions: A selection of actions that do not fit into another category. Available actions include:

No Action

Manual

Hold in State

Step From State

Interlock

Sensor & Sources: Actions related to moving multi-crystal sensors and multi-pocket sources. Available actions include:

Switch Crystal (choose sensor 1 - 4*)

Move Snsr to Next Position (choose sensor 1 - 4*)

Move Src to Next Pocket (choose source 1 - 4*)

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Relays: Activate one of the SQC-310 relays (choose relay 1 - 16*).

SoftNodes: Sets a Softened to true (choose softnote 1 - 8).

Timers: Start a timer (choose timer 1 - 8).

Alarms: Activate one of the SQC-310 alarms. Alarm options include:

Attention (least severe)

Alert (more severe)

Alarm (most severe)

Process Actions: Start or Reset current process, or select process 1 - 100.

Layer Actions: Perform an action on the current layer. Available actions include:

Start Layer

Start Next Layer

Stop Layer

Force Final Thickness

Zero Thickness

Zero Time

Soak Hold

CAUTION

If changes are made in the Logic Menu, be sure to exit to the System Menu or Main Screen before powering down. Your changes will not be saved otherwise.

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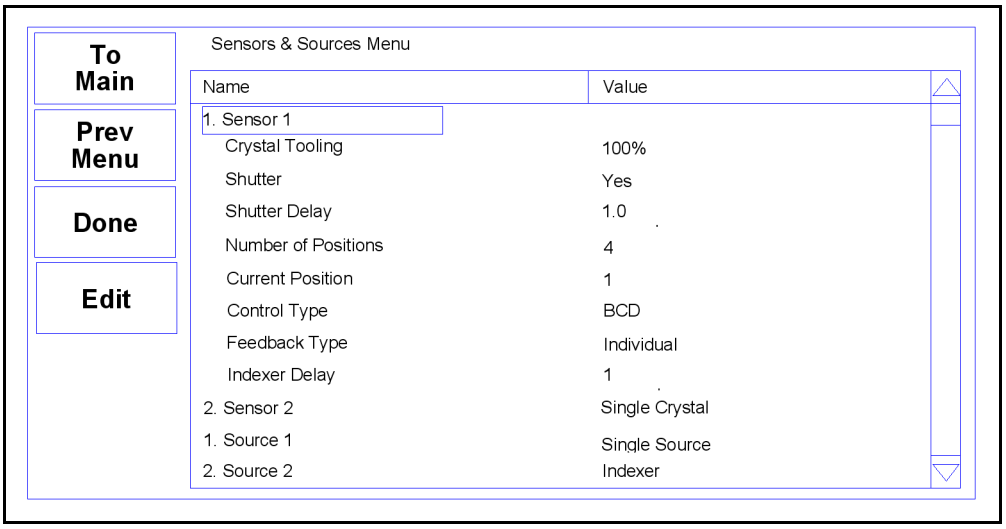
3.11.3 Sensors and Sources Menu

The Sensors and Sources Menu allows you to configure the SQC-310 to the types of sensors and sources in your system, particularly multi-crystal sensors and multi-pocket sources.

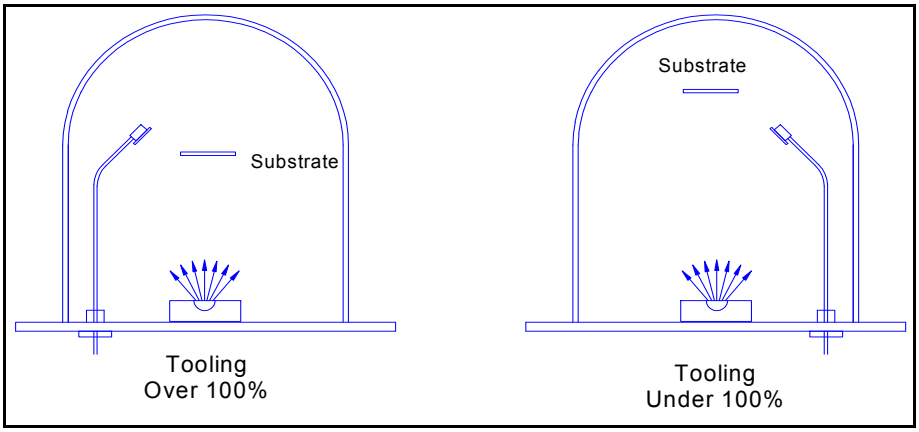
Figure 3-20 Sensor 1 Edit



3.11.3.1 Sensor Setup

Crystal Tooling: Adjusts for the difference in measured deposition rate between the sensor and the substrate being coated.

Figure 3-21 Tooling



In the left illustration, the sensor will measure less rate or thickness than is actually deposited on the substrate because of its positioning. In the right illustration, the sensor will measure more. Tooling is the ratio of the actual substrate deposition rate or thickness, to that measured by the sensor. If the rate/thickness reading is low, then increase the tooling value. If the rate/thickness reading is high, then lower the tooling value.

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Shutter: If the sensor has no shutter, select none to disable sensor shutter features. If the sensor is a typical dual sensor, with a shutter that is only activated when the primary sensor fails, select Dual. For other sensor shutters that activate when the sensor is used, select Yes.

Shutter Delay: If the Yes option is selected for shutter, enter the time required for the shutter to open and stabilize.

Number of Positions: This parameter defines the number of crystals available for that sensor input. For single head sensors set to one. For a typical dual sensor head with separate oscillators and sensor connections, this is also set to one because there is only one crystal for each sensor input. For a rotary type multi-crystal head set to the number of crystals available.

Current Position: If a multi-crystal sensor has position feedback, this parameter is not needed. For sensors with only In Position or no position feedback, enter the current crystal position.

Control Type: Defines the type of crystal or pocket position control utilized for a multi-crystal sensor.

Manual: Not under control of the SQC-310. With manual control, the SQC-310 will stop the process upon the completion of the current layer. If the next layer requires a different crystal position. a message is displayed prompting the operator for the number of the crystal required. Once the position has been changed the operator presses the Continue SoftKey.

Direct: Used when the actuating device is driven directly. In this case the controller creates one or two outputs, one for each available direction, to drive a motor or solenoid.

Drive Type: Defines the drive method or direction for Direct control

Up, Down, Fast, and Inline: Select Up to create a single relay output which the SQC-310 activates to increment the sensor to the next crystal position. Down works identically, except the relay output is labeled “Sensor Drive Down”. Select Fast to create both an up and down outputs. The controller will then determine the fastest direction to the target crystal position by activating the appropriate output. The Inline drive type informs the controller that continuous travel in one direction is not possible. Therefore to get from position 6 to 1, the direction must be down through 5,4 etc. until 1 is reached.

Single Step and Double Step: Used when multi-crystal sensor heads are actuated by pulsing a pneumatic value. INFICON CrystalSix uses Double Step. INFICON Crystal12 and RSH-600 use Single Step.

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BCD: Select when position control is through an external rotation controller which accepts Binary Coded Decimal inputs for position selection. BCD inputs are common because they require only a few signal lines to select several positions. The SQC-310 automatically creates the number of relay outputs required to interface with the external controller.

Individual: Select when position control requires a unique signal line for each position. The SQC-310 automatically creates the number of relay outputs required to interface with the external controller.

Feedback Type: Defines the type of feedback for a multi-crystal sensor head. This is how the SQC-310 identifies the current crystal position.

None: No crystal feedback is provided. The SQC-310 tracks crystal position from the current position setting (above). This setting is used for the INFICON CrystalSix and Crystal12.

Individual: Uses one input for each pocket position in the source. All inputs are normally false (open circuit) unless the respective pocket is in position when that input is true (closed to ground). This setting is used for the INFICON RSH-600.

BCD: Uses binary coding to indicate the pocket position. For example, an eight-pocket source would use three inputs. With pocket one in position, all inputs would be false. With pocket four in position, inputs one and two would be true and input three would be false.

Single Home: This feedback indicates there is a single feedback signal that indicates when pocket one is in position.

In Position: The input is normally false (open circuit) and goes true (closed to ground) when any pocket is in position.

Indexer Delay: This parameter has two different functions. If the Feedback Type is “None” the controller waits the designated time on the assumption that the pocket will get into position by the end of the delay. If there is position feedback, the controller will wait this time for the pocket to reach its target position. If it does not receive the feedback signal, a Pocket Wait Timeout error is issued.

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3.11.3.2 Source Setup

Source setup parameters are identical to the sensor setup parameters, with one exception.

Voltage Scale: Sets the maximum output voltage for the source power supply input. Voltages from –10 V to +10 V are possible. Your power supply manual will state the required input voltage, typically 10 V, 5 V, -10 V, or –5 V.

CAUTION

If changes are made in the Logic Menu, be sure to exit to the System Menu or Main Screen before powering down. Your changes will not be saved otherwise.

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Chapter 4
Maintenance & Accessories

4.1 Introduction

This section covers maintenance, cleaning, software upgrades, and the installation of optional accessories.

WARNING

There are no adjustments or user-serviceable parts inside the SQC-310 Series controllers. For maintenance, contact INFICON.

4.2 Cleaning

Use a damp cloth, wetted with water or a mild detergent, to clean the outer surfaces.

4.3 Software Upgrades

The SQC-310 firmware can be upgraded through its RS-232 port. Some restrictions apply. Contact INFICON for instructions and availability of firmware updates. Please record and have your firmware version and hardware version (displayed at system startup) available when contacting INFICON for updates.

4.4 Clearing the Memory

The SQC-310 has two ways to clear system memory. Both involve pressing and holding a combination of SoftKeys and the Control Knob. Figure 4-1 shows the number designations given to each SoftKey and the Control Knob. These are the same number designations used for entering system passwords. See section 3.11 for more information on passwords.

CAUTION

Memory clearing procedures cannot be reversed. Be sure to back up your configuration file using SQC-310 Comm software if possible before attempting to clear system memory.

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Figure 4-1 SoftKey Number Designations

To clear all memory except or the material index, press and hold the #1 and #6 SoftKeys along with the Control Knob (#7) during startup. On the bootup screen the following should be displayed:

Loading Materials . . . . . Failed!

Loading Films . . . . . Failed!

Loading System . . . . . Failed!

Loading Processes . . . . . Failed!

Once the SQC-310 boots up, turn the power off and back on again. Now the SQC-310 should load normally and should display:

Loading Materials . . . . . Done

Loading Films . . . . . Done

Loading System . . . . . Done

Loading Processes . . . . . Done

If any "Failed!" messages still appear during loading, turn the power off and back on again. Only "Done" messages should appear after memory clearing is complete.

To clear all memory except the material index and set the SQC-310 back to factory default, press and hold the #2 and #5 buttons along with the Control Knob (#7) during startup. All loading messages will now display "Failed!", except Materials. Repeat the rebooting procedure described above until all loading messages display "Done".

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4.5 Half Rack Adapter Installation

The optional Half Rack Adapter kit (PN 782-900-016) mounts two SQC-310 instruments side by side in a standard 19 in. rack.

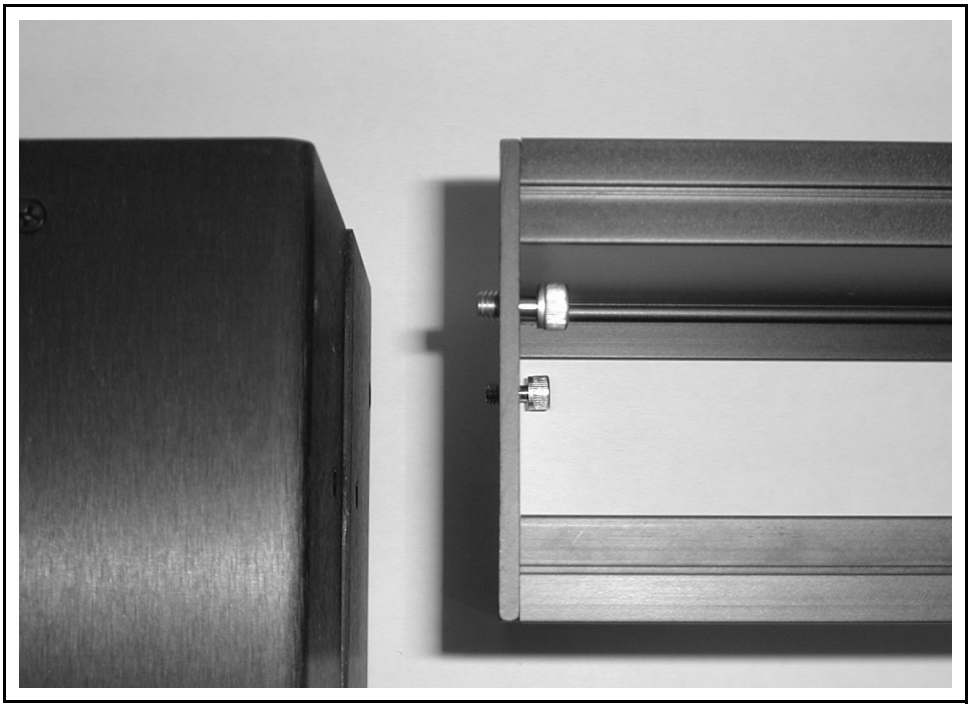
The Half Rack Adapter kit consists of two standard rack mount ears and an adapter bracket. Attach one of the standard rack mount ears to each SQC-310 with the 10-32 flat head screws supplied. Connect the two SQC-310 instruments together by place them side by side and installing the adapter bracket to their back panels using the existing screw holes. You will need to remove one screw from each back panel to make these holes available. Attach the assembly to the 19 in. rack using two screws on each side (not included).

4.6 Full Rack Extender Installation

The Full Rack Extender option (PN 782-900-007) mounts an SQC-310 into a full width 19 in. rack space.

Assemble the two 3 in. x 5 in. Extender Kit side panels and the larger front and rear panels into a box configuration using the eight 6-32 flat-head screws.

Figure 4-2 Attaching the Extender



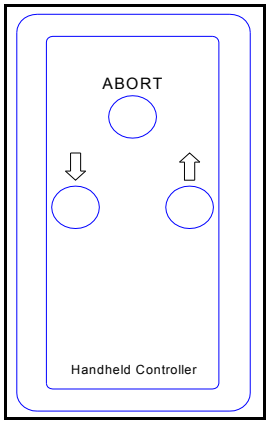
Thread two 10-32 shoulder screws from the inside of one of the box sides until the threads extend fully to the outside. Now attach the Extender Kit to the SQC-310 by threading the shoulder screws into the matching holes in the SQC-310 covers.

Attach the rack mounting ears with the 10-32 flat-head screws provided. Carefully lift the assembly into a full width, 5¼ in. high rack space. Attach the assembly to the rack with 10-32 screws (not provided).

4.7 Handheld Remote Controller

The Handheld Controller (PN 782-900-017) provides the capability of adjusting output power remotely when the SQC-310 is in Manual Mode.

Figure 4-3 Handheld Remote Controller



To use the handheld controller, attach the cable from the handheld controller to the Remote jack on the SQC-310 front panel. Select a Process using the SQC-310 front panel SoftKeys. Press Next Menu until the Auto/Manual SoftKey is displayed. Press Auto/Manual to change to Manual power mode (SoftKey shows Manual/Auto). Press Start to begin the film deposition.

You can now use either the front panel Control Knob or the Handheld Controller to adjust output power. Pressing Abort on the handheld controller stops the layer and returns output power to 0%.

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Chapter 5
Communications

5.1 Introduction

The SQC-310 communicates with a host computer through three possible protocols:

- RS-232: 19200 to 115200 baud, 8 data bits, and no parity
- USB: PID 8292
- Ethernet (option): Port 2101, Address 192.168.1.200.

5.2 SQC-310 Comm.exe

SQC-310 Comm.exe is found on the 074-5000-G1 Thin Film Instrument and Sensor Manuals CD supplied with your SQC-310.

The program provides real-time instrument control and process data logging. It also allows you to set process, layer, film, and material parameters, download them to the SQC-310 and save them to disk.

NOTE: SQC-310's with firmware Version 5.01 and earlier are not compatible with SQC-310 Comm. For these older units, please use SQC-300 Comm (Version 4.xx). Contact INFICON for more information.

5.2.1 Communications Protocol

The SQC-310 only responds to commands received. It never initiates communications.

The command protocol sent to the instrument is:

sync character> <length character> <1 to n data characters> <CRC1><CRC2>

The sync character is always an exclamation point '!'. Following the sync character is the length character. This is the number of characters in the packet (not counting the sync, length, and CRC characters). The length character has a decimal 34 added to it so there cannot accidentally be a sync character (!) embedded in the packet.

Following the length character are the command and data characters as detailed later in this section. After the data come two CRC characters.

NOTE: If you do not want to use CRC checking in your application, send two Null characters (CHR$0) for the CRC. The SQC-310 will ignore the CRC. The SQC-310 will still return a CRC in its response, but you can ignore it.

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The CRC is computed using the following algorithm:

1 The CRC is initialized to 3FFF hex.

2 Each character in the message is examined, bit by bit, and added to the CRC in the following manner:

2a The character is exclusive OR'd with the CRC.

2b The CRC is shifted right one bit position.

2c If bit position 0 has a value of 1 before each shift, the CRC is exclusive OR'd with 2001 hex. This is done a total of 8 times per message character.

3 Step 2 is repeated for each character in the message (excluding the sync and length characters).

4 Mask the contents of the CRC by logical AND with 3FFF hex.

5 The CRC contains 14 significant bits. This is split into two pieces of 7 bits each. A decimal 34 (22 hex) is added to each CRC in order to avoid there being an embedded sync character.

5a Extract bits 0 - 6 of the CRC and add a decimal 34 (22 hex). This is CRC1.

5b Extract bits 7 - 13 of the CRC and add a decimal 34 (22 hex). This is CRC2.

NOTE: Sync characters are not included in the CRC calculation.

Code examples for calculating the CRC can be found in section 5.4, CRC Examples, on page 5-18.

Once a command is received by the SQC-310, it responds with a Response Status character as shown in Table 5-1.

Table 5-1 Response Status Characters

Response Status	Meaning
A	Command understood, normal response
B	Command understood, but instrument reset
C	Invalid command
D	Problem with data in command
E	Instrument in wrong mode for this command

If the response status is "A", the requested data follows the status character.

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5.3 SQC-310 Commands

5.3.1 Get Model

Command: . . . . . @

Description: . . . . Returns the model number and software version number.

Parameters: . . . . None

Example: . . . . . The @ command returns “SQC-310 Ver 6.01”

5.3.2 Get/Set Film Parameters

Command: . . . . . A

Description: There are four film commands. A1 sets/gets the film name. A2 sets/gets the main film edit screen parameters. A3 sets/gets the film conditioning parameters. A4 sets/gets the deposit controls parameters.
To Get Film Parameters send the command (i.e., A1), a space, the film number, a question mark, then a series of spaces and parameter numbers. You may include as many parameters as you want, in whatever order you want. The format of the return string is a series of parameter numbers, a comma, and its value, separated by spaces.

To Set Film Parameters send the command, a space, the film number, then a series of parameter numbers, a comma, and the parameter value.

Parameters: . . . . A1: FilmName

A2:	1	P Term	7	Crystal Quality, Rate Dev %
	2	I Term	8	Crystal Stability, Single Freq Shift
	3	D Term	9	Xtal Fail Mode (obsolete)
	4	Material #	10	Crystal Quality, Max Count
	5	Pocket*	11	Crystal Stability, Total +Freq Shift
	6	Tooling		

A3:	1	Ramp1 Power	7	Idle Power
	2	Ramp1 Time	8	Idle Ramp
	3	Soak1 Time	9	Feed Power
	4	Ramp2 Power	10	Feed Ramp
	5	Ramp2 Time	11	Feed Time
	6	Soak2 Time		

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A4:	1	Shutter Delay	5	Rate Sampling (0,1,2)
	2	Capture	6	Sample Accuracy
	3	Control Error (0,1,2)	7	Sample Hold
	4	Control Percent	8	Sample Time

A5:	1	Snsr 1 Crystal Fail Mode	9	Snsr 3 Crystal Fail Mode
	2	Snsr 1 Crystal Position	10	Snsr 3 Crystal Position
	3	Snsr 1 Backup Sensor	11	Snsr 3 Backup Sensor
	4	Snsr 1 BackupXtalPosition	12	Snsr 3 BackupXtalPosition
	5	Snsr 2 Crystal Fail Mode	13	Snsr 4 Crystal Fail Mode
	6	Snsr 2 Crystal Position	14	Snsr 4 Crystal Position
	7	Snsr 2 Backup Sensor	15	Snsr 4 Backup Sensor
	8	Snsr 2 BackupXtalPosition	16	Snsr 4 BackupXtalPosition

Example: . . . . . To Get the PID parameters of Film 1, send: A2 1? 1 2 3
The return string would be of the form: 1,50 2,5 3,0

To Set the PID parameters of Film 1, send: A2 1 1,50 2,5 3,0

NOTE: Numeric film parameter values sent and received by the SQC-310 are integers. To convert between the integer value and the parameter's actual value, you must multiply or divide by the number of decimal digits in the displayed parameter.

In the examples above, the P term is displayed as an integer value, so no conversion is required. However, the I Term is displayed with one decimal digit (i.e., 0.5). A Get response of 5 actually represents a parameter value of .5. Similarly, a Set value of 5 for the I Term sets its value in the SQC-310 to .5.

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5.3.3 Get/Set System Parameters

Command: . . . . . B

Description: . . . . Gets/Sets the system parameters screen values. The format is similar to Get/Set Film Parameters. See the examples below.

Parameters:				
	1	Period	11	Scale 4 (obsolete)
	2	System Tooling	12	Xtal Tool 3 (obsolete)
	3	Xtal Tool 1 (obsolete)	13	Xtal Tool 4 (obsolete)
	4	Xtal Tool 2 (obsolete)	14	Alarm Sounds
	5	Simulate Mode	15	Alert Sounds
	6	Min. Frequency	16	Attention Sounds
	7	Max. Frequency	17	Rate Dev Graph Limit
	8	Scale 1 (obsolete)	18	Password Enabled
	9	Scale 2 (obsolete)	19	Password
	10	Scale 3 (obsolete)	20	RateFilterAlphaValue

Example: . . . . . To Get the Xtal Tool 1 and Xtal Tool 2, send: B? 3 4
The return string would be of the form: 3,100 4,100

To Set the parameters you would send: B 3,100 4,100

Command: . . . . . BA

Description: . . . . Switch the graphs/displays on the main screen.

Parameters:		
	1	Display Rate vs. Time Graph
	2	Display Rate Deviation vs. Time Graph
	3	Display Power vs. Time Graph
	4	Display Large Format Screen

Format: . . . . . BA [Parameter]

Example: . . . . . BA 1
Returns: A

Command: . . . . . BB

Description: . . . . Turns the remote mode on or off. Remote mode ignores all local user input such as button presses.

Parameters:		
	1	Turn Remote Mode: Off
	2	Turn Remote Mode: On

Format: . . . . . BB [Parameter]

Example: . . . . . BB 1
Returns: A

5.3.4 Get/Set Process Parameters

Command: C

Description: . . . . Gets/sets the four process parameters. In the parameter list below, Number Layers is the number of layers in a process, counting CoDep layers as 1 layer. Actual Layers is the total number of layers. For example, a process with one CoDep layer (using two films) would have Number Layers=1 and Actual Layers=2.

The First Layer is the layer number of the first layer in the process. Subsequent layers are found by reading the Next Layer parameter (see the D command, Layer Parameters).

Parameters:				
	1	Process Name	3	First Layer
	2	Number Layers	4	Actual Layers

Example: . . . . . To Get Process 1 name, send: C1? 1

The return string would be of the form: AnyName

To Set the parameter, send: C1 1,AnyName

NOTE: Unlike Get/Set Film Parameters, you can only get/set one process parameter at a time.

Command: . . . . . CA

Description: . . . . Performs a process specific command.

Parameters:		
	1	Create A New Process
	2	Delete A Process
	3	Delete All Layers In This Process
	4	Check This Process (1 is 'process is OK')

Format:. . . . . CA[Process#]? [Parameter]

Example: . . . . . CA1? 1
Returns: A1,1

Command: . . . . . CB

Description: . . . . Performs a process & layer location specific command.

Parameters:		
	1	Cut this Layer from this Process

Format:. . . . . CB[Process#] [LayerPosition#]? [Parameter]

Example: . . . . . CB1 2? 1
Returns: A1,1

Command: CC

Description: . . . . Performs a process, layer location & film specific command.

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Parameters: Insert a NonCoDep Layer in this Process

Insert a CoDep Layer in this Process.

Format: . . . . . CC[Process#] [LayerPosition#] [Film#]? [Parameter]

Example: . . . . . CC1 2 9? 1
Returns: A1,1

5.3.5 Get/Set Layer Parameters

Command: . . . . . D

Description: . . . . Most layer parameters are directly related to a setting on the layer edit screen. You can get/set multiple layer parameters as explained in Film Parameters.

Parameters:			
	1	Init Rate	16. Ramp1 Time
	2	Final Thickness	17. Ramp2 Enable
	3	Time SetPoint	18. Ramp2 Start
	4	Thickness Limit	19. Ramp2 Rate
	5	Start Mode	20. Ramp2 Time
	6	Output	21. Film Number
	7	Max. Power	24. Layer Available
	8	Slew rate	25. Min. Power
	9	Sensor 1	26. Power Alarm Dev (sec.)
	10	Sensor 2	27. Rate Dev. Attention
	11	Sensor 3	28. Rate Dev. Alert
	12	Sensor 4	29. Rate Dev. Alarm
	13.	Ramp1 Enable	
	14.	Ramp1 Start	
	15.	Ramp1 Rate	

Command: . . . . . DA

Description: . . . . Gets/Sets the parameters for the given layer as specified by the given process number, layer number in the process, and the assigned source number.

Parameters: (same as above)

1	Init Rate	16. Ramp1 Time
2	Final Thickness	17. Ramp2 Enable
3	Time SetPoint	18. Ramp2 Start
4	Thickness Limit	19. Ramp2 Rate
5	Start Mode	20. Ramp2 Time

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6	Output	21. Film Number
7	Max. Power	24. Layer Available
8	Slew rate	25. Min. Power
9	Sensor 1	26. Power Alarm Dev (sec.)
10	Sensor 2	27. Rate Dev. Attention
11	Sensor 3	28. Rate Dev. Alert
12	Sensor 4	29. Rate Dev. Alarm
13.	Ramp1 Enable	
14.	Ramp1 Start	
15.	Ramp1 Rate	

Format:. . . . . DA[Process#] [LayerInProcess#] [Source#]? [Parameter1] [Parameter2] …

Example: . . . . . DA1 1 1? 1 2
Returns: A1,50 2,501

Command: . . . . . DB

Description: . . . . Gets the layer that is currently running or set to run next if not currently running a layer.

Parameters: 1 Current Layer's Layer Numbers

2 Current Layer's NonCoDep Position In Process

3 Current Layer's NonCoDep Position(s) In Process With Source Num

4 Current Layer's CoDep Positions In Process

Format:. . . . . DB? [Parameter1] [Parameter2] …

Example: . . . . . DB? 1 2 3 4
Returns: A1,20:21:22:19 2,2 3,2.1:2.2:2.3:2.4 4,5:6:7:8

5.3.6 Delete All Layers

Command: . . . . . E

Description: . . . . Deletes all 1000 layers! Most often used to clear the entire instrument in preparation for downloading a new list.

Parameters: . . . . None

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5.3.7 Get/Set Material Parameters

Command: . . . . . F

Description: . . . . Gets/Sets the parameters of the 100 stored materials.

Parameters:				
	1.	Material Name	3.	Zfactor
	2.	Density		

Example: . . . . . To Get Material 1 name, send: F1? 1
The return string would be of the form: Aluminum
To Set the parameter you would send: F1 1,AnyName

NOTE: You can only get/set one material parameter at a time.

5.3.8 Get/Set Input & Relay Parameters

Command: . . . . . G

Description: . . . . Gets/Sets the logical function of each of the 16 digital inputs.

Parameters:				
	1	Start Process	32	Soak Hold
	2	Abort Process	33	Zero Thickness
	3	Start Layer	34	Zero Time
	4	Stop Layer	35	Out1 Pocket Ready
	5	Start Next Layer	36	Out2 Pocket Ready
	6	Force Final Thick	37	Out3 Pocket Ready
	7-31	Start Process 1-25	38	Out4 Pocket Ready
			39	Not Used

Example: . . . . . To Get Input 1 and Input 2 functions, send: G? 1 2
The return string for Start Layer and Stop Layer would be: 1,3 2,4

To Set the same parameters you would send: G1 1,3 2,4

Command: . . . . . GA

Description: . . . . Gets/Sets the parameters of each of the 8 or 16 digital inputs.

Parameters:				
	1	Name	3	Pin Number
	2	Active Level	4	Input In Use *
			5	NameMode

Format: . . . . . GA[Input#]? [Parameter1] [Parameter2] …

Example: . . . . . GA1? 2 3
Returns: !A2,0 3,1

NOTE: When changing the name (GA1), you MUST also send the Name Mode command (GA5) as the next parameter.

Command: . . . . . GB

Description: . . . . Gets/Sets the parameters of each of the 8 or 16 digital relays.

Parameters:				
	1	Name	4	Pulse Width (milliseconds)
	2	Type (N.O. or N. C.)	5	Pin Number
	3	Pulses	6	Relay In Use *
			7	NameMode

Format:. . . . . GB[Relay#]? [Parameter1] [Parameter2] …

Example: . . . . . GB1? 2 5
Returns: !A2,0 5,1

NOTE: When changing the name (GB1), you MUST also send the Name Mode command (GB7) as the next parameter.

Command: . . . . . GC

Description: . . . . Gets the current state of each of the 8 or 16 digital relays and inputs.

Parameters:		
	1	Current Relay State (off=0, on=1)
	2	Current Input State (off=0, on=1)

Format:. . . . . GC[RelayOrInput#][?] [Parameter1] [Parameter2] …

Example: . . . . . GC1? 1 2
Returns: A1,0 2,1

Command: . . . . . GD

Description: . . . . Override the current relay state for one of the 8 or 16 digital relays. Overriding the relay is only available while the instrument is stopped. If a relay is accidentally left on, the relay is turned off at the start of a new process.

Parameters:		
	1	Override Relay: Turn On
	2	Override Relay: Turn Off

Format:. . . . . GD[Relay#] [Parameter1]

Example: GD1 1
Returns: A

Command: . . . . . GE

Description: . . . . Allows any relay that is not controlled by a Logic Statement, Sensor or Source, to be set remotely. Once a relay's state has been set remotely, that relay is locked and the instrument will not allow it to be controlled via a Logic Statement Action, Sensor or Source. Be sure to unlock the relay after it is no longer needed; doing so will also turn the relay off.

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Parameters:	1	Turn Relay: On (locks relay for remote use only)
	2	Turn Relay: Off (locks relay for remote use only)
	3	Unlock Relay (Releases the Relay back to the Instrument)

Format: . . . . . GE[Relay#] [Parameter1]

Example: GE1 1
Returns: A

5.3.9 Get/Set Sensor, Source, Relay Parameters

Command: . . . . . H (obsolete)

Description: . . . . Gets/Sets the logical function of each of the 16 relays.

Parameters:	1	Source 1 Shutter	21	Max. Power
	2	Source 2 Shutter	22	Stopped
	3	Source 3 Shutter	23	Time Setpoint
	4	Source 4 Shutter	24	Thick Limit
	5-8	Sensor 1-4 Shutter	25	Final Thickness
	9-12	Sensor 1-4 Fail	26	Dual Xtal 1/2 Shutter
	13	All Crystals Good	27	Dual Xtal 3/4 Shutter
	14	All Crystals Bad	28-35	Out1 Pocket 1-8
	15	Process Hold	36-43	Out1 Pocket 1-8
	16	Deposit Phase	44-51	Out1 Pocket 1-8
	17	PreCond Phase	52-59	Out1 Pocket 1-8
	18	SoakHold Phase		
	19	Process Active		
	20	Manual Mode		

Example: . . . . . To Get Relay 1 and Relay 2 functions, send: H? 1 2

The return for Source 1 Shutter and Sensor 1 Shutter would be: 1,1 2,5
To Set the same parameters you would send: H1 1,1 2,5

Command: . . . . . HA

Description: . . . . Gets/Sets the parameters of each of the 2 or 4 sensors.

Parameters:	1	Crystal Tooling	6	Drive Type
	2	Number of Positions	7	Feedback Type
	3	Shutter	8	Indexer Delay (sec.)
	4	Shutter Delay (ms)	9	Current Crystal Position
	5	Control Type		

Format:. . . . . HA[Sensor#]? [Parameter1] [Parameter2] …

Example: . . . . . HA1? 2 5 9
Returns: !A2,4 5,3 9,1

Command: . . . . . HB

Description: . . . . Gets/Sets the parameters of each of the 2 or 4 sources.

Parameters:				
	1	Voltage Scale	6	Drive Type
	2	Number of Positions	7	Feedback Type
	3	Shutter	8	Indexer Delay (sec.)
	4	Shutter Delay (ms)	9	Current Pocket Position
	5	Control Type		

Format:. . . . . HB[Source#]? [Parameter1] [Parameter2] …

Example: . . . . . HB1? 2 5 9
Returns: !A2,4 5,3 9,1

Command: . . . . . HC

Description: . . . . Gets the status flags for each of the 2 or 4 sensors.

Parameters:		
	1 Dual Crystal has Switched	6 Sensor is currently in use
	2 Backup Crystal Switch has begun	7 Next Crystal Move Complete
	3 Backup Crystal Switch is done	8 Sensor Initiated Time Power
	4 Sensor is Disabled	9 Sensor Initiated Halt
	5 Original Crystal has failed	

Format:. . . . . HC[Sensor#]? [Parameter1] [Parameter2] …

Example: . . . . . HC1? 5 6
Returns: A5,1 6,0

Command: . . . . . HD

Description: . . . . Gets the status flags for each of the 2 or 4 sources.

Parameters: 1 Source is currently in use

Format:. . . . . HD[Source#]? [Parameter1]

Example: . . . . . HD1? 1
Returns: A1,1

Command: . . . . . HE*

Description: . . . . Gets/Sets the IO mappings of each of the 2 or 4 sensors.

Parameters:				
	1	Input Map*	2	Relay Map*

Format:. . . . . HE[Sensor#]? [Parameter1] [Parameter2] …

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Example: . . . . . HE1? 1 2
Returns: !A1,0:0:0:0:0:0:0:0:0:0:0:0:0:0:0:0
2,0:0:0:0:0:0:0:0:0:0:0:0:0:0:0:0

Command: . . . . . HF*

Description: . . . . Gets/Sets the IO mappings of each of the 2 or 4 sources.

Parameters: 1 Input Map* 2 Relay Map*

Format: . . . . . HF[Source#]? [Parameter1] [Parameter2] …

Example: . . . . . HF1? 1 2
Returns: !A1,0:0:0:0:0:0:0:0:0:0:0:0:0:0:0:0
2,0:0:0:0:0:0:0:0:0:0:0:0:0:0:0:0

5.3.10 Get/Set Logic Statement Parameters

Command: I

Description: . . . . Gets/Sets the parameters of each of the 32 logic statements.

Parameters:
1 Name (16 chars)*
2 If Condition(max 16) *
3 Then Action *
4 If Condition Syntax Valid (get only)
5 IfCondition CurrentState (get only)
6 LS Defined

Format: . . . . . I[LogicStatement#]? [Parameter1] [Parameter2] …

Example1: . . . . . I1? 1 2 3
Returns: A1,Statement 1 2,201:3:202 3,301

Example2: I1 1,LS 1 2,202:3:201 3,302
Returns: A

Command: . . . . . IA

Description: . . . . Copy and Pastes a Logic Statement from one index to another.

Parameters: . . . . None

Format: . . . . . IA[LogicStatement#ToCopyFrom] [LogicStatement#ToCopyTo]

Example: IA1 5
Returns: A

Command: . . . . . IB

Description: . . . . Deletes a Logic Statement.

Parameters: . . . . None

Format: . . . . . IB[LogicStatement#]

Example: IB1
Returns: A

5.3.11 Get Num Channels

Command: . . . . . J

Description: . . . . Returns the number sensor/output channels installed.

Parameters: . . . . None

Example: . . . . . The J command returns either 2 or 4.

5.3.12 Get Readings

Command: . . . . . K

Description: . . . . Returns the phase time and sensor or output readings for all installed channels.

Parameters: . . . . 1 = Output Readings2 = Sensor Readings

Example: . . . . . To Get Output readings, send: K1

The return string is of the form:

Time Rate1 Dev1 Thick1 Power1 Rate2 Dev2 Thick 2 etc.

To Get Sensor readings, send: K2

The return string is of the form:

Time Rate1 Thick1 Frequency1 Rate2 Thick 2 etc.

Command: K3

Same as K but will respond with an error if there are not new sensor readings since the last time the command was sent. Used primarily for the testing the instrument.

5.3.13 Get Sensor Rate

Command: L

Description: . . . . Returns the sensor rate for the requested sensor.

Parameters: . . . . Sensor Number

Example: . . . . . To Get Sensor 1 rate, send: L1

The return string is of the form: 1.00

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5.3.14 Get Output Rate

Command: . . . . . M

Description: . . . . Returns the average rate of all sensors assigned to the requested output.

Parameters: . . . . Output Number

Example: . . . . . To Get Output 1 rate, send: M1

The return string is of the form: 1.00

5.3.15 Get Sensor Thickness

Command: . . . . . N

Description: . . . . Returns the thickness reading for the requested sensor.

Parameters: . . . . Sensor Number

Example: . . . . . To Get Sensor 1 thickness, send: N1

The return string is of the form: 1.000

5.3.16 Get Output Thickness

Command: . . . . . O

Description: . . . . Returns the average thickness of all sensors assigned to the requested output.

Parameters: . . . . Output Number

Example: . . . . . To Get Output 1 thickness send: O1

The return string is of the form: 1.000

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5.3.17 Get Sensor Frequency/Crystal Life

Command: . . . . . P

Description: . . . . Returns the frequency of the requested sensor.

Parameters: . . . . Sensor Number

Example: . . . . . To Get Sensor 1 frequency, send: P1

The return string is of the form: 5543210.00

Command: . . . . . PA

Description: . . . . Returns the status, frequency, and crystal life of the requested sensor.

Parameters: . . . . Sensor Number

Example: . . . . . To Get Sensor 1 info, send: PA1

The return string is of the form:

status frequency life

where status 0=inactive,1=active

For example: 1 5950000.00 95.00

5.3.18 Get Output Deviation

Command: . . . . . Q

Description: . . . . Returns the % deviation of the requested output.

Parameters: . . . . Output Number

Example: . . . . . To Get Output 1 deviation, send: Q1

The return string is of the form: 1.00

5.3.19 Get/Set Output Power

Command: . . . . . S

Description: . . . . Returns output power. Sets outputs to PID loop mode or manual mode. In manual mode, also sets the output power. Power is sent as an integer value.

Parameters: . . . . Output Number, Power

Example: . . . . . To Get Output 2 power send: S? 2

To Set Output 2 to 50.0% of full scale send: S2 500

NOTE: This places other outputs in Manual mode at their current power.

To set all outputs to PID loop control send: S0

5.3.20 Set Active Process

Command: . . . . . T

Description: . . . . Sets the currently selected process. If a process is running, it is not changed and an E response status is returned.

Parameters: . . . . Process Number

Example: . . . . . To set the process to Process 1 send: T1

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5.3.21 Set Run State

Command: . . . . . U

Description: . . . . Sets the instruments operating state.

Parameters:

0 = Start Process	32 = Zero Thickness
1 = Stop Process	33 = Zero Time
2 = Start Layer	38 = SoakHold Enable
3 = Stop Layer	39 = SoakHold Disable
4 = Next Layer	
5 = Force Final Thickness	

Example: . . . . . To start the active process, send: U0

5.3.22 Get Run State

Command: V

Description: . . . . Returns the Phase #, Process Elapsed Time (as shown on display), Process #, and Active Layer of the active process.

Parameters:

0 = Stopped	13 = Deposit	26 = Manual Power
1 = Crystal Verify	14 = Rate Ramp	27 = Snsr Feedback Timeout
2 = Initialize Layer	15 = Rate Ramp Deposit	28 = Src Feedback Timeout
3 = Manual Start Layer	16 = Timed Power	29 = Invalid Crystal Position
4 = Crystal Rotate	17 = Rate Sample Hold	30 = Invalid Pocket Position
5 = Pocket Rotate	18 = Rate Sample	31 = Sample Hold
6 = PreCond (CoDep only)	19 = Crystal Switch	32 = Sampel Continuous
7 = Ramp1	20 = Feed Ramp	33 = Crystal Fail, Halted
8 = Soak 1	21 = Feed Soak	34 = Next Crystal
9 = Ramp 2	22 = Idle Ramp	
10 = Soak 2	23 = Start Next layer	
11 = Soak Hold	24 = Crystal Fail	
12 = Shutter Delay	25 = Stop Layer	

Example: . . . . . To read the run state, send: V

The return string for the Deposit Phase, Elapsed Time =15 seconds, Active Process #1, Layer #2 is: 13 15 1 2

Command: . . . . . VA

Description: . . . . Gets the on/off status of each possible alarm.

Parameters:

1 Alarm: MinRate&MaxPower	15 Alert: Min Power
2 Alarm: MaxRate&MinPower	16 Alert: Logic Statement Action
3 Alarm: ShutterDelayError	17 Attention: Crystal Failure
4 Alarm: Crystal Failure	18 Attention: Xtal Failed & Xtal Switched
5 Alarm: Source Timeout	19 Attention: Rate Deviation
6 Alarm: Sensor Timeout	20 Attention: Max Power
7 Alarm: No Sensors Enabled	21 Attention: Min Power
8 Alarm: In Time Power	22 Attention: Manually Move Source
9 Alarm: Rate Deviation	23 Attention: Manually Move Sensor
10 Alarm: Invalid Pocket	24 Attention: Interlock
11 Alarm: Invalid Crystal	25 Attention: Logic Statement Action
12 Alarm: Logic Sttmnt Action	
13 Alert: Rate Deviation	
14 Alert: Max Power	

Format:. . . . . VA? [Parameter1] [Parameter2] …

Example: . . . . . VA? 1 2 3

Returns: A1,0 2,0 3,1

5.3.23 Start Download/Upload Session

Command: . . . . . XSTART

Description: . . . . Starts a upload/download session & places in the instrument in remote mode. The instrument must be Stopped in order to start an upload/download session.

Parameters:

5.3.24 Stop Download/Upload Session

Command: . . . . . XSTOP

Description: . . . . Stops an upload/download session & kicks the instrument out of remote mode.

Parameters:

5.4 CRC Examples

In this section you will find examples of code for calculating the CRC in Visual Basic, Java, and C++. Instructions for calculating the CRC are located in section 5.2.

5.4.1 Visual Basic® 5/6

```
Public Sub CalcChkSumByte(ByRef ByData() As Byte, ByRef byCRC() As
Byte)

    Dim CRC As Integer
    Dim TmpCRC As Integer
    Dim LastIndex As Long
    Dim i As Integer
    Dim j As Integer

    LastIndex = UBound(ByData())

    ' Avoid on length messages
    If ByData(1) > 0 Then
        ' Set 14 bit CRC to all ones
        CRC = &H3FFF
        For j = 1 To LastIndex - 2
            ' XOR current character with CRC
            CRC = CRC Xor ByData(j)
            ' Go thru lower 8 bits of CRC
            For i = 1 To 8
                ' Save CRC before shift
                TmpCRC = CRC
                ' Shift right one bit
                CRC = Shri(CRC, 1)
                If (TmpCRC And 1) = 1 Then
                    ' If LSB is 0 (before shift), XOR with hex 2001
                    CRC = CRC Xor &H2001
                End If
            Next i
        Next j
        ' Be sure we still have 14 bits
        CRC = CRC And &H3FFF
        byCRC(0) = (LoByte(CRC) And &H7F) + 34
        byCRC(1) = (LoByte(Shri(CRC, 7)) And &H7F) + 34
    Else
        ' Empty message
        byCRC(0) = 0
        byCRC(1) = 0
    End If

End Sub

Public Function LoByte(ByVal intNumber As Integer) As Byte
    ' Comments  : Returns the low byte of the passed integer
    ' Parameters: intNumber - integer value for which to return the low
byte
    ' Returns   : byte
```

```
    ' Source    : Total VB SourceBook 6
    '
    On Error GoTo PROC_ERR

    LoByte = intNumber And &HFF&

PROC_EXIT:
    Exit Function

PROC_ERR:
    MsgBox "Error: " & Err.Number & ". " & Err.Description, , _
        "LoByte"
    Resume PROC_EXIT

End Function

Public Function Shri( _
    ByVal lngValue As Long, _
    ByVal bytPlaces As Byte) _
    As Integer
    ' Comments  : Shifts a long Value right the selected number of places
    ' Parameters: lngValue - integer Value to shift
    '             bytPlaces - number of places to shift
    ' Returns   : Shifted value
    ' Source    : Total VB SourceBook 6
    '
    Dim lngDivisor As Long

    On Error GoTo PROC_ERR

    ' if we are shifting 16 or more bits, then the result is always
zero
    If bytPlaces >= 16 Then
        Shri = 0
    Else
        lngDivisor = 2 ^ bytPlaces
        Shri = Int(IntToLong(lngValue) / lngDivisor)
    End If

PROC_EXIT:
    Exit Function

PROC_ERR:
    MsgBox "Error: " & Err.Number & ". " & Err.Description, , _
        "Shri"
    Resume PROC_EXIT

End Function
```

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5.4.2 Java®

```
private short calcCRC(byte[] str) {
      short crc = 0;
      short tmpCRC;
      int length = 1 + str[1] - 34;
      if (length > 0) {

         crc = (short) 0x3fff;
         for (int jx = 1; jx <= length; jx++) {
            crc = (short) (crc ^ (short) str[jx]);

            for (int ix = 0; ix < 8; ix++) {
               tmpCRC = crc;
               crc = (short) (crc >> 1);
               if ((tmpCRC & 0x1) == 1) {
                  crc = (short) (crc ^ 0x2001);
               }
            }
            crc = (short) (crc & 0x3fff);
         }
      }
      return crc;
   }

   private byte crcHigh(short crc) {
      byte val = (byte) (((crc >> 7) & 0x7f) + 34);
      return val;
   }

   private byte crcLow(short crc) {
      byte val = (byte) ((crc & 0x7f) + 34);
      return val;
   }
```

5.4.3 C++

```
class CRC14
{
public:
      CRC14(void) { crc = 0x0;};

public:
      short crc;

public:
      short calcCRC( unsigned char * str)
      {
      int length = (str != NULL) ? 1 + str[1] - 34 : 0;
```

```
            if (length > 0) {

         crc = (short) 0x3fff;
         for (int jx = 1; jx <= length; jx++) {
            crc = (short) (crc ^ (short) str[jx]);

            for (int ix = 0; ix < 8; ix++) {
               short tmpCRC = crc;
               crc = (short) (crc >> 1);
               if ((tmpCRC & 0x1) == 1) {
                  crc = (short) (crc ^ 0x2001);
               }
            }
            crc = (short) (crc & 0x3fff);
         }
      }
      return crc;
   }
      unsigned char crc2() {
      unsigned char val = (unsigned char) (((crc >> 7) & 0x7f) +
34);
      return val;
   }
      unsigned char crc1() {
      unsigned char val = (unsigned char) ((crc & 0x7f) + 34);
      return val;
   }
};
```

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Appendix A
Material Table

A.1 Introduction

The following Table A-1 represents the density and Z-Ratio for various materials. The list is alphabetical by chemical formula.

CAUTION

Some of these materials are toxic. Please consult the material safety data sheet and safety instructions before use.

An * is used to indicate that a Z-Ratio has not been established for a certain material. A value of 1.000 is defaulted in these situations.

Table A-1 Material Table

Formula	Density	Z-Ratio	Material Name
Ag	10.500	0.529	Silver
AgBr	6.470	1.180	Silver Bromide
AgCl	5.560	1.320	Silver Chloride
Al	2.700	1.080	Aluminum
Al_2O_3	3.970	0.336	Aluminum Oxide
Al_4C_3	2.360	*1.000	Aluminum Carbide
AlF_3	3.070	*1.000	Aluminum Fluoride
AlN	3.260	*1.000	Aluminum Nitride
AlSb	4.360	0.743	Aluminum Antimonide
As	5.730	0.966	Arsenic
As_2Se_3	4.750	*1.000	Arsenic Selenide
Au	19.300	0.381	Gold
B	2.370	0.389	Boron
B_20_3	1.820	*1.000	Boron Oxide
B_4C	2.370	*1.000	Boron Carbide
BN	1.860	*1.000	Boron Nitride
Ba	3.500	2.100	Barium
BaF_2	4.886	0.793	Barium Fluoride

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Table A-1 Material Table (continued)

Formula	Density	Z-Ratio	Material Name
BaN_2O_6	3.244	1.261	Barium Nitrate
BaO	5.720	*1.000	Barium Oxide
$BaTiO_3$	5.999	0.464	Barium Titanate (Tetr)
$BaTiO_3$	6.035	0.412	Barium Titanate (Cubic)
Be	1.850	0.543	Beryllium
BeF_2	1.990	*1.000	Beryllium Fluoride
BeO	3.010	*1.000	Beryllium Oxide
Bi	9.800	0.790	Bismuth
Bi_2O_3	8.900	*1.000	Bismuth Oxide
Bi_2S_3	7.390	*1.000	Bismuth Trisulphide
Bi_2Se_3	6.820	*1.000	Bismuth Selenide
Bi_2Te_3	7.700	*1.000	Bismuth Telluride
BiF_3	5.320	*1.000	Bismuth Fluoride
C	2.250	3.260	Carbon (Graphite)
C	3.520	0.220	Carbon (Diamond)
C_8H_8	1.100	*1.000	Parlyene (Union Carbide)
Ca	1.550	2.620	Calcium
CaF_2	3.180	0.775	Calcium Fluoride
CaO	3.350	*1.000	Calcium Oxide
$CaO\text{-}SiO_2$	2.900	*1.000	Calcium Silicate (3)
$CaSO_4$	2.962	0.955	Calcium Sulfate
$CaTiO_3$	4.100	*1.000	Calcium Titanate
$CaWO_4$	6.060	*1.000	Calcium Tungstate
Cd	8.640	0.682	Cadmium
CdF_2	6.640	*1.000	Cadmium Fluoride
CdO	8.150	*1.000	Cadmium Oxide
CdS	4.830	1.020	Cadmium Sulfide
CdSe	5.810	*1.000	Cadmium Selenide,
CdTe	6.200	0.980	Cadmium Telluride
Ce	6.780	*1.000	Cerium
CeF_3	6.160	*1.000	Cerium (III) Fluoride
CeO_2	7.130	*1.000	Cerium (IV) Dioxide
Co	8.900	0.343	Cobalt

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Table A-1 Material Table (continued)

Formula	Density	Z-Ratio	Material Name
CoO	6.440	0.412	Cobalt Oxide
Cr	7.200	0.305	Chromium
Cr_2O_3	5.210	*1.000	Chromium (III) Oxide
Cr_3C_2	6.680	*1.000	Chromium Carbide
CrB	6.170	*1.000	Chromium Boride
Cs	1.870	*1.000	Cesium
Cs_2SO_4	4.243	1.212	Cesium Sulfate
CsBr	4.456	1.410	Cesium Bromide
CsCl	3.988	1.399	Cesium Chloride
CsI	4.516	1.542	Cesium Iodide
Cu	8.930	0.437	Copper
Cu_2O	6.000	*1.000	Copper Oxide
Cu_2S	5.600	0.690	Copper (I) Sulfide (Alpha)
Cu_2S	5.800	0.670	Copper (I) Sulfide (Beta)
CuS	4.600	0.820	Copper (II) Sulfide
Dy	8.550	0.600	Dysprosium
DY_2O_3	7.810	*1.000	Dysprosium Oxide
Er	9.050	0.740	Erbium
Er_2O_3	8.640	*1.000	Erbium Oxide
Eu	5.260	*1.000	Europium
EuF_2	6.500	*1.000	Europium Fluoride
Fe	7.860	0.349	Iron
Fe_2O_3	5.240	*1.000	Iron Oxide
FeO	5.700	*1.000	Iron Oxide
FeS	4.840	*1.000	Iron Sulphide
Ga	5.930	0.593	Gallium
Ga_2O_3	5.880	*1.000	Gallium Oxide (B)
GaAs	5.310	1.590	Gallium Arsenide
GaN	6.100	*1.000	Gallium Nitride
GaP	4.100	*1.000	Gallium Phosphide
GaSb	5.600	*1.000	Gallium Antimonide
Gd	7.890	0.670	Gadolinium
Gd_2O_3	7.410	*1.000	Gadolinium Oxide

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Table A-1 Material Table (continued)

Formula	Density	Z-Ratio	Material Name
Ge	5.350	0.516	Germanium
Ge_3N_2	5.200	*1.000	Germanium Nitride
GeO_2	6.240	*1.000	Germanium Oxide
GeTe	6.200	*1.000	Germanium Telluride
Hf	13.090	0.360	Hafnium
HfB_2	10.500	*1.000	Hafnium Boride,
HfC	12.200	*1.000	Hafnium Carbide
HfN	13.800	*1.000	Hafnium Nitride
HfO_2	9.680	*1.000	Hafnium Oxide
$HfSi_2$	7.200	*1.000	Hafnium Silicide
Hg	13.460	0.740	Mercury
Ho	8.800	0.580	Holminum
Ho_2O_3	8.410	*1.000	Holminum Oxide
In	7.300	0.841	Indium
In_2O_3	7.180	*1.000	Indiurn Sesquioxide,
In_2Se_3	5.700	*1.000	Indium Selenide
In_2Te_3	5.800	*1.000	Indium Telluride
InAs	5.700	*1.000	Indium Arsenide
InP	4.800	*1.000	Indium Phosphide
InSb	5.760	0.769	Indium Antimonide
Ir	22.400	0.129	Iridium
K	0.860	10.189	Potassium
KBr	2.750	1.893	Potassium Bromide
KCl	1.980	2.050	Potassium Chloride
KF	2.480	*1.000	Potassium Fluoride
KI	3.128	2.077	Potassium Iodide
La	6.170	0.920	Lanthanum
La_2O_3	6.510	*1.000	Lanthanum Oxide
LaB_6	2.610	*1.000	Lanthanurn Boride
LaF_3	5.940	*1.000	Lanthanum Fluoride
Li	0.530	5.900	Lithium
LiBr	3.470	1.230	Lithium Bromide
LiF	2.638	0.778	Lithium Fluoride

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Table A-1 Material Table (continued)

Formula	Density	Z-Ratio	Material Name
$LiNbO_3$	4.700	0.463	Lithium Niobate
Lu	9.840	*1.000	Lutetium
Mg	1.740	1.610	Magnesium
$MgAl_2O_4$	3.600	*1.000	Magnesium Aluminate
$MgAl_2O_6$	8.000	*1.000	Spinel
MgF_2	3.180	0.637	Magnesium Fluoride
MgO	3.580	0.411	Magnesium Oxide
Mn	7.200	0.377	Manganese
MnO	5.390	0.467	Manganese Oxide
MnS	3.990	0.940	Manganese (II) Sulfide
Mo	10.200	0.257	Molybdenum
Mo_2C	9.180	*1.000	Molybdenum Carbide
MoB_2	7.120	*1.000	Molybdenum Boride
MoO_3	4.700	*1.000	Molybdenum Trioxdide
MoS_2	4.800	*1.000	Molybdenum Disulfide
Na	0.970	4.800	Sodium
Na_3AlF_6	2.900	*1.000	Cryolite
$Na_5Al_3F_{14}$	2.900	*1.000	Chiolite
NaBr	3.200	*1.000	Sodium Bromide
NaCl	2.170	1.570	Sodium Chloride
$NaClO_3$	2.164	1.565	Sodium Chlorate
NaF	2.558	1.645	Sodium Fluoride
$NaNO_3$	2.270	1.194	Sodium Nitrate
Nb	8.578	0.492	Niobium (Columbium)
Nb_2O_3	7.500	*1.000	Niobium Trioxide
Nb_2O_5	4.470	*1.000	Niobium (V) Oxide
NbB_2	6.970	*1.000	Niobium Boride
NbC	7.820	*1.000	Niobium Carbide
NbN	8.400	*1.000	Niobium Nitride
Nd	7.000	*1.000	Neodynium
Nd_2O_3	7.240	*1.000	Neodynium Oxide
NdF_3	6.506	*1.000	Neodynium Fluoride
Ni	8.910	0.331	Nickel

Table A-1 Material Table (continued)

Formula	Density	Z-Ratio	Material Name
NiCr	8.500	*1.000	Nichrome
NiCrFe	8.500	*1.000	Inconel
NiFe	8.700	*1.000	Permalloy
NiFeMo	8.900	*1.000	Supermalloy
NiO	7.450	*1.000	Nickel Oxide
P_3N_5	2.510	*1.000	Phosphorus Nitride
Pb	11.300	1.130	Lead
$PbCl_2$	5.850	*1.000	Lead Chloride
PbF_2	8.240	0.661	Lead Fluoride
PbO	9.530	*1.000	Lead Oxide
PbS	7.500	0.566	Lead Sulfide
PbSe	8.100	*1.000	Lead Selenide
$PbSnO_3$	8.100	*1.000	Lead Stannate
PbTe	8.160	0.651	Lead Telluride
Pd	12.038	0.357	Palladium
PdO	8.310	*1.000	Palladium Oxide
Po	9.400	*1.000	Polonium
Pr	6.780	*1.000	Praseodymium
Pr_2O_3	6.880	*1.000	Praseodymium Oxide
Pt	21.400	0.245	Platinum
PtO_2	10.200	*1.000	Platinum Oxide
Ra	5.000	*1.000	Radium
Rb	1.530	2.540	Rubidium
RbI	3.550	*1.000	Rubidiurn Iodide
Re	21.040	0.150	Rhenium
Rh	12.410	0.210	Rhodium
Ru	12.362	0.182	Ruthenium
S_8	2.070	2.290	Sulphur
Sb	6.620	0.768	Antimony
Sb_2O_3	5.200	*1.000	Antimony Trioxide
Sb_2S_3	4.640	*1.000	Antimony Trisulfide
Sc	3.000	0.910	Scandium
Sc_2O_3	3.860	*1.000	Scandium Oxide

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Table A-1 Material Table (continued)

Formula	Density	Z-Ratio	Material Name
Se	4.810	0.864	Selenium
Si	2.320	0.712	Silicon
Si_3N_4	3.440	*1.000	Silicon Nitride
SiC	3.220	*1.000	Silicon Carbide
SiO	2.130	0.870	Silicon (II) Oxide
SiO_2	2.648	1.000	Silicon Dioxide
Sm	7.540	0.890	Samarium
Sm_2O_3	7.430	*1.000	Samarium Oxide
Sn	7.300	0.724	Tin
SnO_2	6.950	*1.000	Tin Oxide
SnS	5.080	*1.000	Tin Sulfide
SnSe	6.180	*1.000	Tin Selenide
SnTe	6.440	*1.000	Tin Telluride
Sr	2.600	*1.000	Strontium
SrF_2	4.277	0.727	Strontium Fluroide
SrO	4.990	0.517	Strontium Oxide
Ta	16.600	0.262	Tantalum
Ta_2O_5	8.200	0.300	Tantalum (V) Oxide
TaB_2	11.150	*1.000	Tantalum Boride
TaC	13.900	*1.000	Tantalum Carbide
TaN	16.300	*1.000	Tantalum Nitride
Tb	8.270	0.660	Terbium
Tc	11.500	*1.000	Technetium
Te	6.250	0.900	Tellurium
TeO_2	5.990	0.862	Tellurium Oxide
Th	11.694	0.484	Thorium
ThF_4	6.320	*1.000	Thorium.(IV) Fluoride
ThO_2	9.860	0.284	Thorium Dioxide
$ThOF_2$	9.100	*1.000	Thorium Oxyfluoride
Ti	4.500	0.628	Titanium
Ti_20_3	4.600	*1.000	Titanium Sesquioxide
TiB_2	4.500	*1.000	Titanium Boride
TiC	4.930	*1.000	Titanium Carbide

Table A-1 Material Table (continued)

Formula	Density	Z-Ratio	Material Name
TiN	5.430	*1.000	Titanium Nitride
TiO	4.900	*1.000	Titanium Oxide
TiO_2	4.260	0.400	Titanium (IV) Oxide
Tl	11.850	1.550	Thallium
TlBr	7.560	*1.000	Thallium Bromide
TlCl	7.000	*1.000	Thallium Chloride
TlI	7.090	*1.000	Thalliurn Iodide (B)
U	19.050	0.238	Uranium
U_3O_8	8.300	*1.000	Tri Uranium Octoxide
U_4O_9	10.969	0.348	Uranium Oxide
UO_2	10.970	0.286	Uranium Dioxide
V	5.960	0.530	Vanadium
V_2O_5	3.360	*1.000	Vanadium Pentoxide
VB_2	5.100	*1.000	Vanadium Boride
VC	5.770	*1.000	Vanadium Carbide
VN	6.130	*1.000	Vanadium Nitride
VO_2	4.340	*1.000	Vanadium Dioxide
W	19.300	0.163	Tungsten
WB_2	10.770	*1.000	Tungsten Boride
WC	15.600	0.151	Tungsten Carbide
WO_3	7.160	*1.000	Tungsten Trioxide
WS_2	7.500	*1.000	Tungsten Disulphide
WSi_2	9.400	*1.000	Tungsten Silicide
Y	4.340	0.835	Yttrium
Y_20_3	5.010	*1.000	Yttrium Oxide
Yb	6.980	1.130	Ytterbium
Yb_2O_3	9.170	*1.000	Ytterbium Oxide
Zn	7.040	0.514	Zinc
Zn_3Sb_2	6.300	*1.000	Zinc Antimonide
ZnF_2	4.950	*1.000	Zinc Fluoride
ZnO	5.610	0.556	Zinc Oxide
ZnS	4.090	0.775	Zinc Sulfide
ZnSe	5.260	0.722	Zinc Selenide

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Table A-1 Material Table (continued)

Formula	Density	Z-Ratio	Material Name
ZnTe	6.340	0.770	Zinc Telluride
Zr	6.490	0.600	Zirconium
ZrB_2	6.080	*1.000	Zirconium Boride
ZrC	6.730	0.264	Zirconium Carbide
ZrN	7.090	*1.000	Zirconium Nitride
ZrO_2	5.600	*1.000	Zirconium Oxide

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Appendix B
Specifications

B.1 Measurement

Number of Sensors . . . . . 2 (+2 optional)
Frequency Range . . . . . 4.0 MHz to 6.0 MHz
Frequency Accuracy 001%
Frequency Resolution . . . . . .03 Hz @ 10 readings/s
Rate Accuracy . . . . . .5% typical
Rate Display Resolution . . . . . .01 or .1 Å/s
Thickness Accuracy . . . . . .5% typical
Thickness Resolution . . . . . .001 kÅ
Measurement Period . . . . . .1 to 1 s

B.2 Source

Number of Sources . . . . . 2 (+2 optional)
Control Voltage . . . . . 0 to ±10 V into 2 kΩ load
Resolution . . . . . 15 bits

B.3 Digital I/O

Digital Inputs . . . . . 8 (+8 optional)
- Functions . . . . . User Selected (See Chapter 3)
- Input Rating . . . . . 5 V (dc), non-isolated

Relay Outputs . . . . . .8 (+8 optional)
- Functions . . . . . User Selected (See Chapter 3)
- Relay Rating . . . . . $30V_{rms}$ or 30 V (dc), 2 A maximum

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B.4 General Specifications

Mains Power Supply	100-120/200-240~, ±10% nominal 50/60 Hz, auto detect
Power Consumption	25 W
Operating & Transportation	0°C to 50°C
Environment	0 to 80% RH non-condensing
	0 to 2,000 meters
	Indoor Use Only
	Class 1 Equipment (Grounded Type)
	Suitable for Continuous Operation
	Ordinary Protection (not protected ?against harmful ingress of moisture)
	Pollution Degree II
	Installation (Overvoltage) Category II for transient overvoltages
Storage Environment	-40°C to 70°C
Rack Dimensions (HxWxD)	5.23 in x 8.4 in x 10.0 in 132.8 mm x 213.4 mm x 254.0 mm
Weight	4 lbs. (1.8 kg)

B.5 Display

Graphs	Rate, Deviation, Power
Readouts	Thickness, Rate, Power

B.6 Process Parameters

NOTE: A Process is a sequence of layers.

# Processes	100
# Films	50
# Layers (total all processes)	1000

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B.7 Layer Parameters

NOTE: Layer is a Film, plus these values.

Initial Rate . . . . . 0.0 to 99.9 Å/s

Final Thickness . . . . . 0.0 to 99.999 kÅ

Time Setpoint . . . . . 0 to 30000 s

Thickness Limit. . . . . 0.0 to 99.999 kÅ

Start Mode . . . . . Auto/Manual

Output Select 1, 2, 3, 4

Max Power . . . . . 0.0 to 100.0 %

Slew Rate . . . . . 0.0 to 100.0 %/s

Sensor Select (1 to 4). . . . . On/Off

Rate Ramps. 2

Rate Ramp Start. . . . . 0.0 to 99.999 kÅ

Rate Ramp Time . . . . . 0 to 1000 s

New Rate . . . . . 0.0 to 99.9 Å/s

B.8 Film Parameters

NOTE: Film is a Material, plus these values.

Material. . . . . 100 stored

Density . . . . . 0.40 to 99.99 gm/cm^3

Z-Factor . . . . . 0.100 to 9.900

P Term . . . . . 1 to 9999

I Term . . . . . 0 to 99.9 s

D Term . . . . . 0 to 99.9 s

Tooling . . . . . 10 to 400

Pocket . . . . . 1 to 8

Crystal Quality . . . . . Disabled to 30 %

Crystal Stability. . . . . Disabled to 5000 Hz

Crystal Fail Mode . . . . . Halt or Timed Power

Ramp1, Ramp2, Feed Ramp,
Feed, Idle Ramp Time . . . . . 0 to 30000 s

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Soak1, Soak2, Feed, Idle Power . . . 0.0 to 100.0 %

Shutter Delay Time. . . . . 0 to 200 s

Shutter Delay Error . . . . . 0.0 to 30.0 %

Control Error. . . . . Ignore/Stop/Hold

Control Error Setting. . . . . 0 to 30.0 %

Rate Sampling . . . . . Continuous/Time/Accuracy

Sample Time . . . . . 10.0 to 999.0 s

Hold Time . . . . . 10.0 to 999.0 s

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Appendix C
I/O Connections

C.1 Introduction

A 25 pin D-sub connector, located on the rear of the SQC-310, provides Input/Output connections.

Inputs can be activated either by connecting to a switch and shorting to Ground, or they can be driven by a TTL compatible signal.

CAUTION

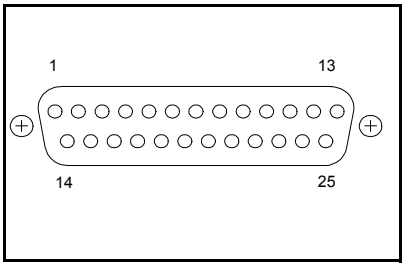
These are not isolated inputs! The voltage level applied must be limited to between 0 and +5 volts with respect to Ground.

WARNING

Output relays are rated for 30 V_{rms} or 30 V (dc), at 2 A maximum. Proper fusing, and adequate wiring insulation and separation, should be provided to assure these limits are not exceeded.

The pin assignments for the rear panel mounted I/O connector are shown in Figure C-1 and Table C-1

Figure C-1 Rear Panel I/O Pin Assignments



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I/O Connector Wiring

Table C-1 I/O Connector Wiring

Relay	Pins		Input	Pins
Relay 1	14,15		Input 1	16
Relay 2	1,2		Input 2	17
Relay 3	3,4		Input 3	18
Relay 4	5,6		Input 4	19
Relay 5	7,8		Input 5	20
Relay 6	9,10		Input 6	21
Relay 7	11,12		Input 7	22
Relay 8	13,25		Input 8	23
			Ground	24

C.2 Interfacing to a INFICON CI-100 Indexer

C.2.1 BCD I/O

BCD wiring is suggested over Binary I/O wiring because it uses fewer relays. The wiring below interfaces the SQC-310 I/O connector to the CI-100 BCD I/O connector for controlling an 8 pocket source.

SQC-310	CI-100 BCD I/O	
Pin 14---------->	Pin 1	OutX Pocket Bit1
Pin 1 ---------->	Pin 2	OutX Pocket Bit2
Pin 3 ---------->	Pin 7	OutX Pocket Bit3
Pin 16 ----------<	Pin 5	OutX Pocket Ready
Pin 15,2,4----------	Pin 6	Common
	Short Pin 3 to Pin 9	Interlock
	Short Pin 4 to Pin 8	Pocket Ready A

On the CI-100 rear panel: set Select On/Off Switch #5 UP and #7 DOWN.

On the SQC-310 System Menu, Sensors & Sources set up the source with:

- Number of Positions: 8
- Control Type: BCD
- Feedback Type: In Position
- Indexer Delay: 5 seconds

MDC 991270 and Sycon SRT-400 Indexer compatibility: The CI-100 pins 1, 2, 3, and 7 are identical to the MDC and Sycon indexers. For a compatible pocket ready signal (pin 5), jumper pin 4 to pin 6. Set Select Switch #7 UP.

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C.2.2 Binary I/O

To use binary wiring between the CI-100 and SQC 310 for a four pocket crucible:

SQC-310	CI-100 Binary I/O	
Pin 1,3,5,14,24	---------- Pin 1, 2	Common
Pin 16	----------<---------- Pin 3	OutX Pocket Ready
Pin 15	----------><---------- Pin 4	OutX Pocket 1
Pin 2	----------><---------- Pin 6	OutX Pocket 2
Pin 4	----------><---------- Pin 8	OutX Pocket 3
Pin 6	----------><---------- Pin 10	OutX Pocket 4

On the CI-100 rear panel, set Select Switch #5 Down.

On the SQC-310 System Menu, Sensors & Sources set up the source with:

- Number of Positions: 4
- Control Type: Individual
- Feedback Type: In Position
- Indexer Delay: 5 seconds

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C.3 Interfacing to a MDC E-Beam Sweep Controller

C.3.1 BCD I/O

Wiring between the SQC-310 and an MDC E-Beam Sweep Controller to Select Pattern 1 to 8

SQC-310		Sweeper	
Pin 14	---------->	Pin 8	OutX Pocket Bit1
Pin 1	---------->	Pin 7	OutX Pocket Bit2
Pin 3	---------->	Pin 6	OutX Pocket Bit3
Pin 5	<----------	Pin 12	Process Stopped
Pin 7	<----------	Pin 13	SourceX Enable
Pin 15,2,4,6,8	----------	Pin 16	Common

On the SQC-310 System Menu, Sensors & Sources set up the source with:

- Number of Positions: 8
- Control Type: BCD
- Feedback Type: None
- Indexer Delay: 1 seconds
- Logic Statement: IF SourceX Enable AND NOT Crystal Verify AND NOT Preconditioning AND NOT SoakHold THEN Relay 4
- Logic Statement: IF NOT Stopped AND NOT Stop Layer AND NOT Manual Start Layer THEN Relay 5

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