TELEMARK

MODEL 851 THICKNESS MONITOR

INSTRUCTION MANUAL

Manual Rev 1.0.1 August 2024

telemark.com

Current version of this manual can be found at
https://telemark.com/quartz-crystal-control/851-thickness-monitor/

SAFETY WARNING

HIGH (POTENTIALLY LETHAL) VOLTAGES ARE PRESENT WITHIN EVAPORATION SYSTEMS. GREAT CARE MUST BE EXERCISED WHEN PERFORMING MAINTENANCE. HUMAN CONTACT WITH THE VOLTAGES CAN BE FATAL.

WARRANTY

Telemark products are warranted to be free of defects in materials and/or workmanship for a period of 12 months after shipment from the Telemark factory. This warranty is valid only for normal use, where regular maintenance has been performed. This warranty shall not apply if the product has been repaired or alterations made by anyone other than authorized Telemark service representatives, or if a malfunction or damage occurs through abuse, misuse, negligence, shipping damage, or other accident. No charge will be made for repairs covered by this warranty at a Telemark service facility. Telemark reserves the right to determine if the malfunction was caused by defective materials or workmanship. The customer will be responsible for freight charges to Telemark's service facility.

USER RESPONSIBILITY

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

It is vitally important that the user properly install the equipment as described in Chapter 3 (Installation) of this manual, with particular attention to the correct grounding methods described.

The Warranty will be void if the equipment is improperly installed and/or not adequately grounded.

SOFTWARE

Parts of the 851 software are made with open source software.

Linux is licensed under GNU General Public License (GPL), version 2.

All Xenomai code running in kernel space is licensed under the terms of the Linux kernel license, GNU General Public License (GPL), version 2.

Xenomai libraries linked to application are licensed under the terms of the GNU Lesser General Public License (LGPL), version 2.1.

Qt is licensed under GNU Lesser General Public License (LGPL) version 2.1.

The original "open source" source code is available from Telemark for a nominal fee.

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SPECIFICATIONS

PURPOSE

The 851 thickness monitor allows improved manual control of the vacuum film deposition process by providing a direct display of film thickness and deposition rate during deposition.

Semiautomatic control of film thickness can be accomplished by utilization of the shutter control relay in the 851. The shutter control relay allows for direct operator control of the systems shutter and will also automatically close the shutter when the deposition thickness equals a preprogrammed value.

PACK LIST

STANDARD ITEMS

The standard items included with the 851 monitor are:

Part No.	Quantity	Description
122-0851-1	1	Cable, Shielded Twisted Pair, 25 FT.
124-0909-8	1	Connector Kit, 9 Pin, D-Sub Male
124-0925-8	1	Connector Kit, D-Sub, 25pin, Male
200-0002-1	1	Telemark Product Manuals USB Drive
376-9010-1	1	Power Cord
851-0004-1	2	Chassis Ear, 851
851-0005-1	2	Chassis Leg, 851
861-0502-1*	1	Adapter, BNC Male/Male
861-0500-1	1	Oscillator Assembly
851-0600-4	1	Assembly, Chassis 851

* A BNC male/male adaptor is supplied for installations that have a 6 inch female BNC cable coming from the vacuum system feedthrough.

ADDITIONAL ITEMS

Additional items that may be ordered and shipped with an 851.

1. Additional Oscillator and shielded RJ45 cable for sensor 2.

Part No.	Description
861-0505-1	Oscillator Kit

2. Each sensor needs a 6 inch coax cable to go between the oscillator and the feedthrough. The type needed depends on the feedthrough connection.

Part No.	Description
880-2420-8	Cable, 6" BNC Male/Microdot
880-2421-1	Cable, 6" BNC Male/Male

3. Each sensor needs a 30 inch coax in-vacuum cable to go between the feedthrough and the sensor inside the vacuum chamber.

Part No.	Description
880-2320-4	30 inch coax in-vacuum cable, Microdot

4. Telemark has a wide selection of O-Ring and CF flange feedthroughs available to pass the cooling water and coaxial signal in to the chamber.

5. Crystals

Part No.	Description
880-0201-3	6MHz gold coated sensing crystals (Disc of 10)
880-0202-3	6MHz aluminum alloy sensing crystals (Disc of 10)
880-0203-3	5MHz gold coated sensing crystals (Disc of 10)

Please refer to the Telemark Price List for feedthroughs, more accessories and other products.

SPECIFICATIONS

INPUT POWER

Input Power Requirements	90-264 VAC, 47-63 Hz

PHYSICAL

Operating Temperature Range	0 to 50°C
Physical Weight	4.3 LB
Physical Size	1/2 19" rackmount case 3 1/2" high x 8 1/2" deep

MEASUREMENT

Frequency Resolution	0.03 Hz @6.0 MHz
Mass Resolution	0.375 ng/cm^2
Thickness Accuracy	0.5% + 1 count
Measurement Update Rate	Dynamically adjusted, 0.5 to 10 Hz
Display Update Rate	1 Hz
Sensor Crystal Frequency	5 or 6 MHz

DISPLAY

Thickness Display	Autoranging: 0.000 to 999.9 KÅ
Rate Display	Autoranging: 0.0 to 999 Å/sec
Time To Go	0 to 9:59:59 H:MM:SS
Crystal Health %	0 to 99%
Graphics Display	480x800 Color LCD touch screen with backlighting

COMMUNICATION

	RS-232
	Ethernet (TCP/IP)

MATERIAL STORAGE CAPACITY

Material	99, user definable

MATERIAL PARAMETERS

Material Name	12 character string
Sensor #	1 or 2
Material Density	0.80 to 99.9 gm/cm3
Acoustic Impedance	0.50 to 59.9 gm/cm2 sec
Tooling Factor	10.0 to 499.9%
Target Thickness	0.000 to 999.9 KÅ
Crystal Marginal %	0 to 99%
Crystal Fail	Switch, Stop
Backup Sensor #	1 or 2
Backup Tooling Factor	0 to 499.9%

The 851 also has a built in material library that contains many common material names along with their density and acoustic impedance values.

INPUT/OUTPUT CAPABILITY

Discrete Input/Output	**4 pre-programmed inputs**
	Input 1 = Start/Zero
	Input 2 = Stop
	Input 3 = Source shutter
	Input 4 = Sensor shutter
	Passive/Active is software selectable:
	Passive TTL level inputs activated by a short across input pins.
	Active inputs activated by 12 to 24 volts DC across the input pins.
	4 pre-programmed outputs
	SPST relay, 50VDC max, 2A max.
	Output 1 = Target Thickness Reached
	Output 2 = Crystal Fail
	Output 3 = Source shutter
	Output 4 = Sensor shutter

SENSOR CAPABILITY

Sensor Inputs	RJ45 connector
	2 Standard

OSCILLATOR CAPABILITY

Oscillator Input	BNC, In a standard installation it is connected to a 6 inch coaxial cable, but the total cable length from crystal head to oscillator must be between 24 to 48 inches. Please contact the factory for options when the length is outside of this range.
Oscillator Output	RJ45 connector connects to the 851 via supplied 25 foot RJ45 shielded cable. Other lengths are available.

SHUTTER PARAMETERS

Source Shutter Relay Type	Normally open, normally closed, or none.
Sensor Shutter Relay Type	Dual or none.

UTILITY SETUP PARAMETERS

Crystal Frequency	5 or 6 MHz
Simulate Mode	On/Off
Interface Address	1 to 32
Attention Volume	0 to 10
Alert Volume	0 to 10
Alarm Volume	0 to 10
Touch Volume	0 to 10
Error Beep Volume	0 to 10
Data Points/Minute	30 to 600 PPM
Confirm Saves	Disable, Enable
Date	MM/DD/YY
Time	0 to 23:59

2

INSTALLATION

MOUNTING

The 851 is intended for rack mounting, but can be use on a tabletop. For maximum operating ease it should be mounted at approximately eye level. If the 851 is mounted in a rack containing other heat generating equipment, care should be taken that there is adequate ventilation to assure that the ambient temperature does not exceed the 851's ambient temperature rating.

PROPER GROUNDING

The 851 was designed for maximum noise immunity and in most cases will require no special grounding precautions. In the event that noise sensitivity is noted in unusually noisy environments, more attention to proper grounding may be required. It is important that the rack in which the 851 is mounted is tightly grounded to the vacuum station. This grounding is best accomplished by a multipoint mechanical connection through the structure itself or through grounding straps. Grounding straps should be as wide as practicable and can be solid or braid.

A small diameter copper conductor does not create an effective ground.

Although the D.C. resistance measured with such a connection may be low, the inductance can be high allowing rapidly changing currents to create large potential differences over the length of the ground wire. Multiple current paths significantly reduce the inductance, and since the inductance of a conductor is inversely proportional to its radius, wide straps will have the lowest inductance.

In particularly noisy environments it is desirable to ground the 851 to the rack frame, or other good ground, by means of a grounding strap connected to the grounding lug provided on the rear panel.

REAR PANEL CONNECTIONS

External connections are made through the rear panel (See figure 2-1).

Figure 2-1, 851 Rear Panel

POWER

The power receptacle is an internationally approved type. A fuse and RFI filter are part of the power receptacle assembly. The power plug must be removed to change the fuse.

USB

The USB port on the front panel is for connecting a USB drive to copy, backup and install; materials, system settings, data log and new system software.

GROUND LUG

In particularly noisy environments the 851 should be grounded to the instrument rack, or other good ground, by means of the grounding lug in the rear panel.

RS-232

The RS-232 connector is for connecting the 851 to a PLC or computer for remote operation and/or data collection, see chapter 8. CTS and RTS are optional.
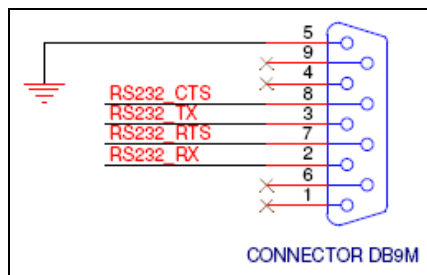
Figure 2-2, RS-232 Connection

ETHERNET

The Ethernet connector is for connecting the 851 to a computer to run the touch screen remotely using VNC, see chapter 4. **DO NOT PLUG THE CABLE FROM THE OSCILLATOR INTO THE ETHERNET CONNECTOR.**

SENSOR

The system interface with the sensor oscillator is a **Shielded** RJ45 cable that is supplied with the 851.

ONLY PLUG THE CABLE FROM THE OSILLATIOR INTO RJ45 CONNECTOR ON THE SENSOR CARD.
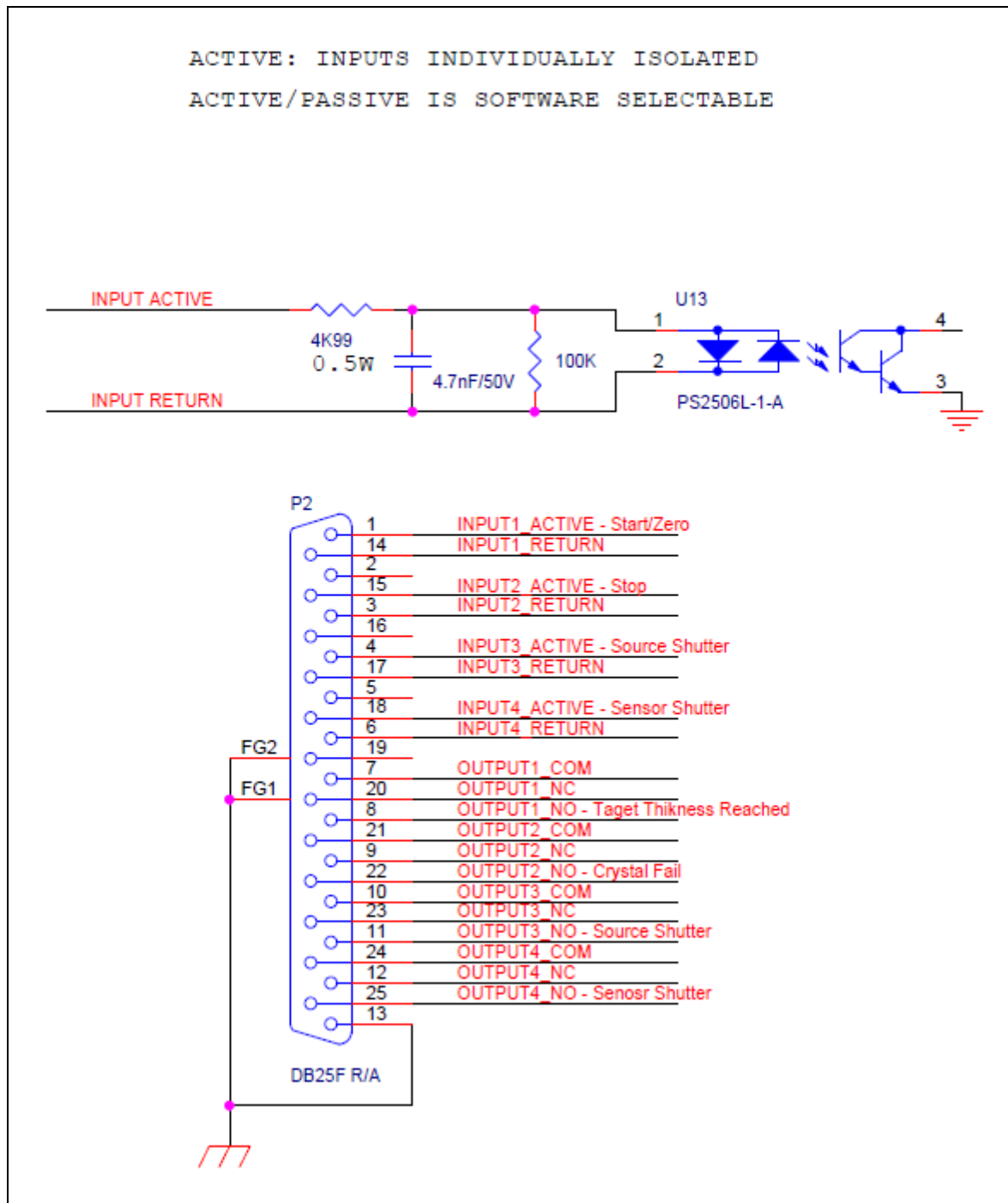
INPUT/OUTPUT

The input/output card is through a 25-pin female D connector has 4 preprogrammed inputs and 4 preprogrammed outputs.

The input type is **configured by software setting** one of two ways:

1. **Passive** TTL level inputs activated by a short across input pins.

2. **Active** inputs activated by 12 to 24 volts DC across the input pins.

The outputs are made through SPST relays that are 50VDC max and 2A max. Each output connection is made to the normally open (N.O.) and additionally for output 1 and 2 the normally closed (N.C.) may be used.

Figure 2-3, I/O Card Connections, Active Input

PASSIVE: NON-ISOLATED FROM GROUND

ACTIVE/PASSIVE IS SOFTWARE SELECTABLE

+24V

FDLL4148

10K
0.5W

U12

0.5W

4.7nF/50V

100K

INPUT PASSIVE

INPUT PASSIVE RETURN

PS2506L-1-A

100K

P1

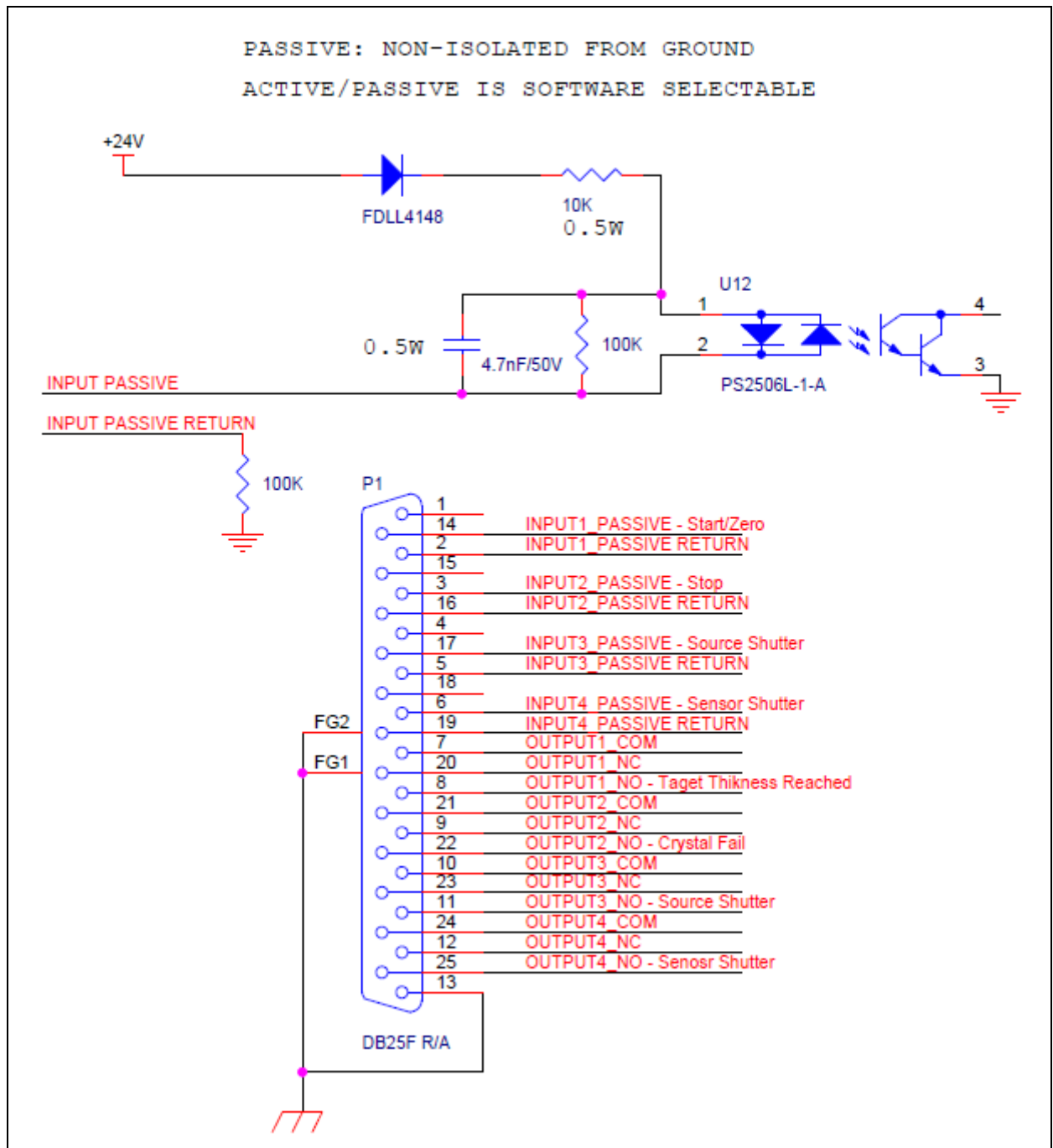| Pin	Signal
1	
14	INPUT1_PASSIVE - Start/Zero
2	INPUT1_PASSIVE RETURN
15	
3	INPUT2_PASSIVE - Stop
16	INPUT2_PASSIVE RETURN
4	
17	INPUT3_PASSIVE - Source Shutter
5	INPUT3_PASSIVE RETURN
18	
6	INPUT4_PASSIVE - Sensor Shutter
19	INPUT4_PASSIVE RETURN
7	OUTPUT1_COM
20	OUTPUT1_NC
8	OUTPUT1_NO - Taget Thikness Reached
21	OUTPUT2_COM
9	OUTPUT2_NC
22	OUTPUT2_NO - Crystal Fail
10	OUTPUT3_COM
23	OUTPUT3_NC
11	OUTPUT3_NO - Source Shutter
24	OUTPUT4_COM
12	OUTPUT4_NC
25	OUTPUT4_NO - Senosr Shutter
13	

FG2

FG1

DB25F R/A

Figure 2-4, I/O Card Connections, Passive Input

SENSOR HEAD INSTALLATION

The sensor head can be installed in any appropriate location in the vacuum chamber, preferably more than 10 inches from the evaporation source. The internal (vacuum) cable, supplied with a sensor kit, connects the sensor head to the electrical feedthrough, to which the oscillator is attached. The cable length from sensor

head to feedthrough connection should be 30 inches. Shield the sensor cable in the most expedient way possible to protect it from radiation heat released from the evaporation source or the substrate heater.

The water cooling tube connects to the feedthrough by brazing or vacuum couplings. If necessary, both cable and water lines may be wrapped in aluminum foil to extend their useful life. Water cooling of the sensor head should always be provided during depositions.

Use a shutter to shield the sensor during initial soak periods to protect the crystal from any sputtering that may occur. If a small droplet of molten material hits the crystal, the crystal may be damaged and oscillation may cease.

SENSOR OSCILLATOR

Figure 2-5, Oscillator and Cables

The sensor oscillator is designed to be used with industry standard 5 or 6 megahertz sensor crystals. The oscillator's characteristics enable it to obtain maximum life from the sensor crystal.

The oscillator is supplied with a 6-inch coaxial cable and a RJ45 shielded twisted pair 25-foot cable. The 6-inch cable interconnects the oscillator and the feedthrough. The 25-foot cable interconnects the oscillator and the 851. Cables of varying lengths are available upon request for replacing the 25-foot cable.

The standard 6-inch coaxial cable is fine for most installations, but the total cable length from crystal head to oscillator must be between 24 to 48 inches. Many UHV and multi crystal head installations will require a custom coaxial cable. Please contact the factory for custom cables. For installations where the crystal head to oscillator must be greater than 48 inches, the 851-0500-2 oscillator should be used.

CAUTION

Always use the cables supplied by Telemark to make the connections. Failure to make this connection correctly will create a mismatch in the impedance of the oscillator circuit.

INSTRUMENTATION FEEDTHROUGH

Telemark has a wide selection of O-Ring and CF flange feedthroughs available to pass the cooling water and coaxial signal in to the chamber.

SENSOR CRYSTAL REPLACEMENT

The Telemark Sensor Head is especially designed for easy sensor crystal replacement and reliable operation. Removal and replacement of sensor crystals should be performed in a clean environment. An

isolated clean work bench is recommended for crystal replacement. To prevent crystal contamination, use clean lab gloves or plastic tweezers when handling the crystal and keep the new crystals in a closed plastic case.

3

PROGRAMING CONTROLS

PROGRAM BUTTONS
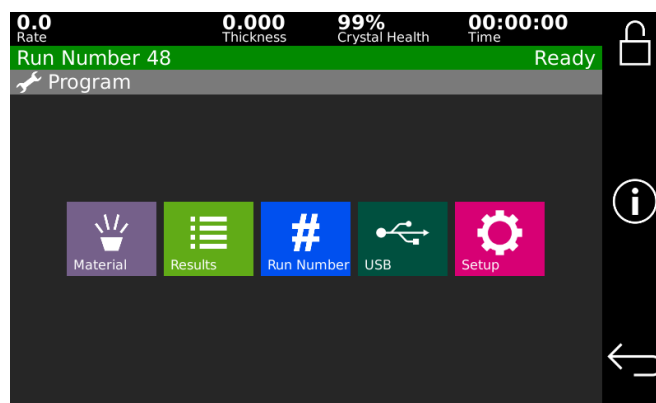
Figure 3-1, Program Menu

Press the Program button to enter the programming mode from the main screen. Pressing one of the five buttons will get you to the next level.

Material – Material setup (see chapter 4)

Results – Run history (see below)

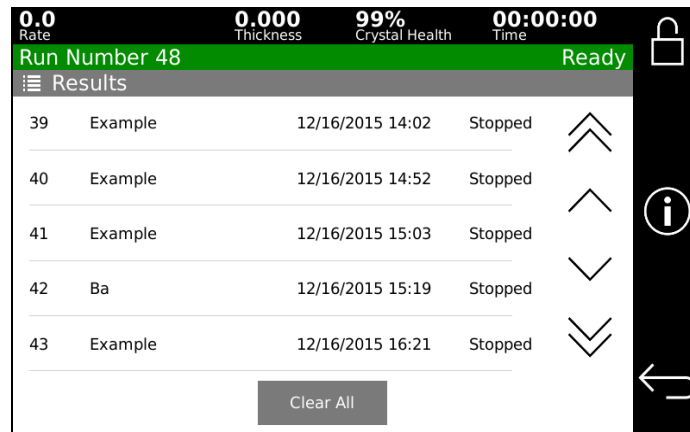**Run Number** – Set the next run number

USB – USB menu for transferring files, it is only active when an USB drive is inserted in the 851 (see below)

Setup – System configuration setup (see chapter 4)

RESULTS

Figure 3-2 shows the results screen. It can display the history of the last 16 runs. Items displayed are: Run number, Name, Date and time and Status (Normal or Aborted).


Figure 3-2, Results Screen

USB

A standard USB drive (some drives larger than 32GB may not work) may be inserted in the front panel to back up and restore settings and data from the 851.

The USB button on the Program menu is inactive and darken if no USB drive is inserted. Once a USB drive is inserted in to the front panel it will take several seconds before the USB drive is active. It will be active when the button is no longer darkened.

After selecting USB from the Program menu the USB menu is displayed.
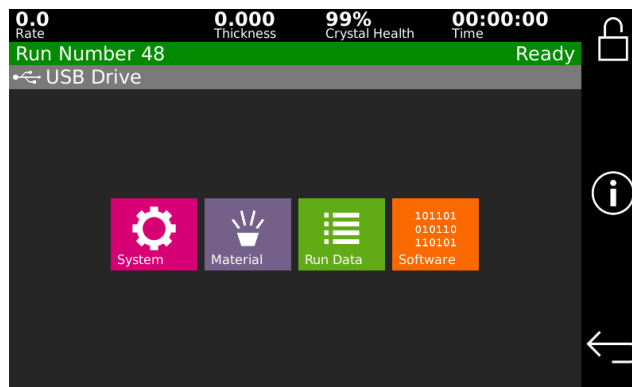
*Figure 3-3, USB Menu screen*

1. **System**

Backing up of the system settings is done by touching the gray "Save System Data" button. To restore all the system settings from the USB drive select one of the listed system data sets. **Note Restore will replace all the settings, materials on the current system with the values from the USB drive.**
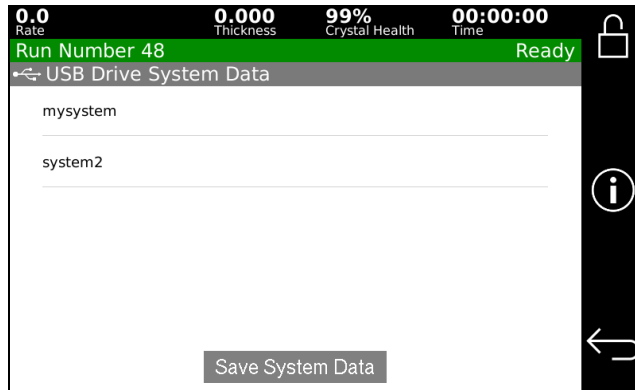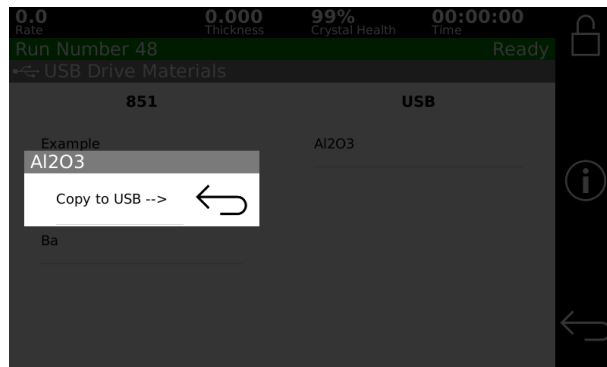
Figure 3-4, USB System Backup/Restore

2. Material

Material copying is for saving archives and to copy to other 851 systems. The left column shows what is stored on the 851. The right column shows what is stored on the USB drive.
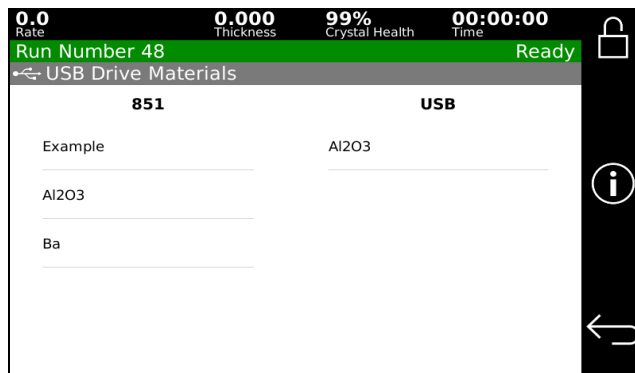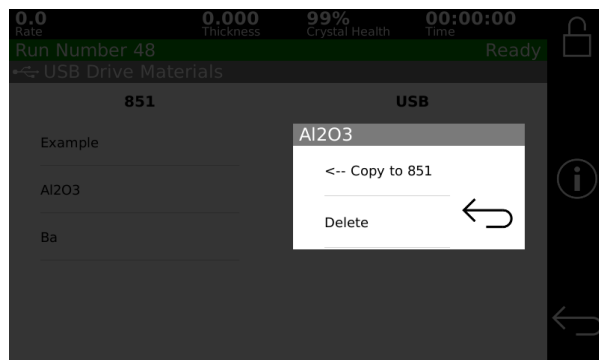

Figure 3-5, USB Material Backup/Restore

Touch item on the 851 column to copy it to the USB drive.

Figure 3-6, Copy 851 System Data to USB

Touch an item on the USB column to copy it to the 851 or delete it from the USB drive.

Figure 3-7, Copy System Data from USB to 851

3. Run Data

Pressing this button will save a text file with the last 16 runs to the USB drive. It will be saved with a file name with the current time and date in the folder \851\results\. The format is shown below, fields are separated by commas.

Run Number	Status	Start Date Time	Stop Date Time	Data Points/Min	Material Number	Material Name

Example:

```
25,Stopped,12/15/2015 10:33:51,12/15/2015 10:34:09,600, 1, Al
26,Stopped,12/15/2015 11:06:16,12/15/2015 11:06:53,600, 3, Ba
```

4. Software

The 851 system software can be updated via USB drive with software provided by Telemark. Select software version from the displayed list of available on the USB drive. The update should not affect the system settings and materials, but a system back up should be done before the installation just in case. The 851 will ask for confirmation before installing the new software.

RIGHT SIDE BAR BUTTONS

LOCK/UNLOCK BUTTON

The lock/unlock button allows the material and system settings to be password protected with a single password.

The system can be either locked or unlock. In locked mode materials can be run and all settings can be viewed. In unlocked mode all settings can be changed. Pressing the lock icon brings up the Lock dialog window where the system can be locked/unlocked or the password can be changed. The default password is 0000.
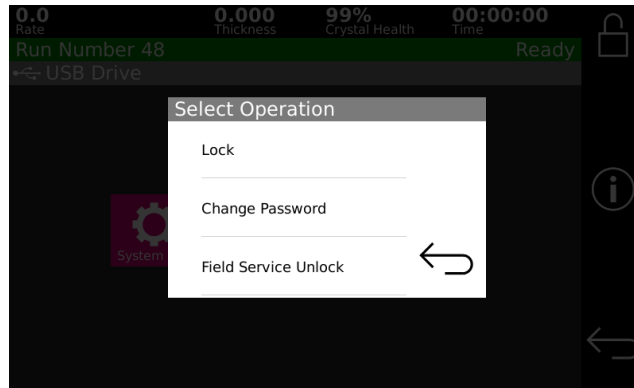
Figure 3-8, Password screen

SYSTEM INFORMATION BUTTON

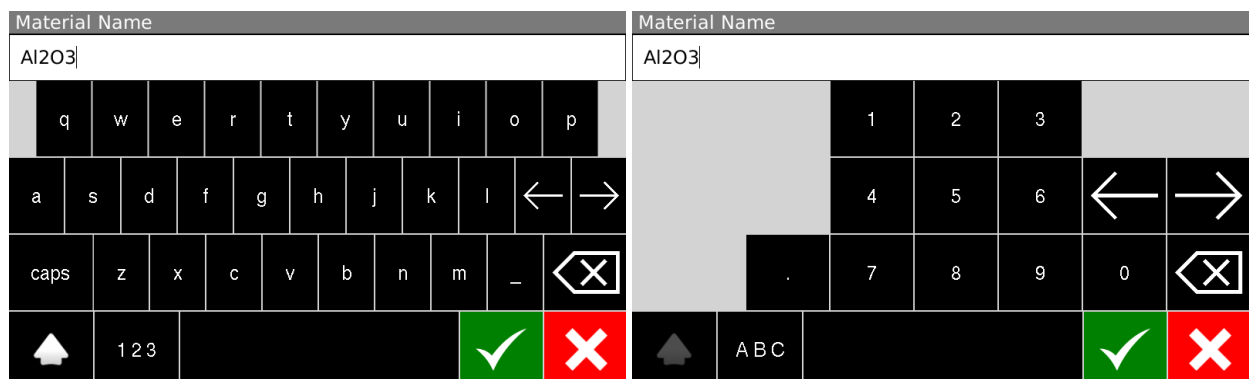Pressing the system information button will display the screen that shows what cards are installed in the 851 and the software version.

RETURN BUTTON

Pressing the return button will make the system go back to the previous screen.

ENTERING ALPHA CHARACTERS

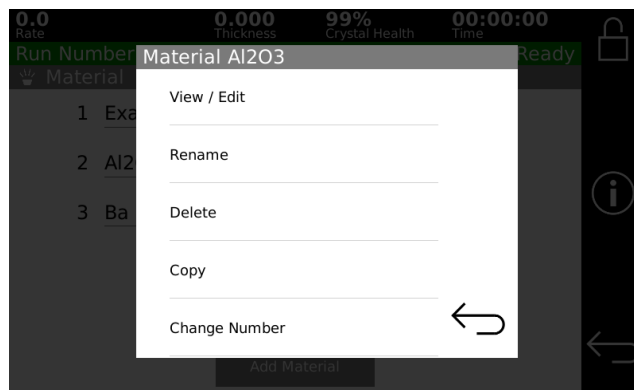**Figure 3-9, Keyboard**

The on-screen keyboard is provided to enter upper and lower case alpha characters and numbers.

COPYING, DELETING AND MOVING

Figure 3-10, Copying and Deleting

The 851 has the capability of copying and deleting materials. When copying, the new material is placed at the end of the list. Change Number menu button can be used to move a material to any empty number.

4

PROGRAMING

GETTING STARTED
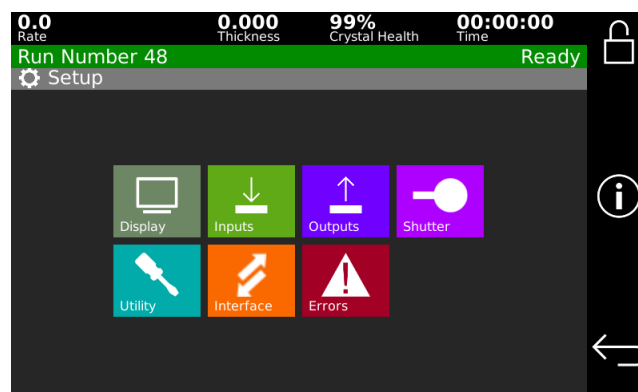
Figure 4-1, System Setup Menu screen

Once the 851 hardware is installed, the system needs to be programed for the desired material. The preferred order of programing is:

1. **Display**

2. **Utility**

3. **Shutter**

4. **Inputs**

5. **Materials**

Note: Inputs, Outputs and Shutter will be grayed out if no I/O card is installed.

SETUP

Choosing the Edit System Setup option from the Main Menu screen will present the System Setup Menu options as shown in figure 4-1. These options allow for setting up the monitor to interface with the vacuum

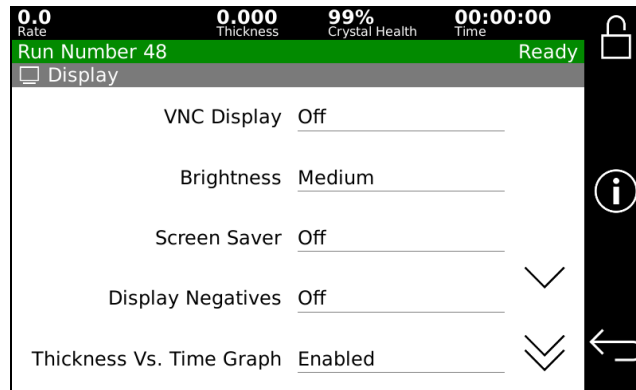system and are described below. See chapter one for a list of the possible parameters for each setting. All settings should be reviewed; of particular note is crystal frequency (5.0 or 6.0 MHz).

DISPLAY

Selecting Edit Display Setup will present the Display Setup screen.

Figure 4-2, Display Setup Screen

1. VNC Display (On/Off)

This parameter determines if the 851 screen is displayed remotely via VNC to a computer has a VNC viewer running. An Ethernet cable needs to be installed between the back of the 851 and network switch and a computer with VNC. The network needs to have a DHCP server to automatically supply the 851 with an IP address. VNC is a remote operation protocol. Telemark recommends TightVNC for Windows, but any VNC viewer on Windows, Apple, or Linux computer should work.
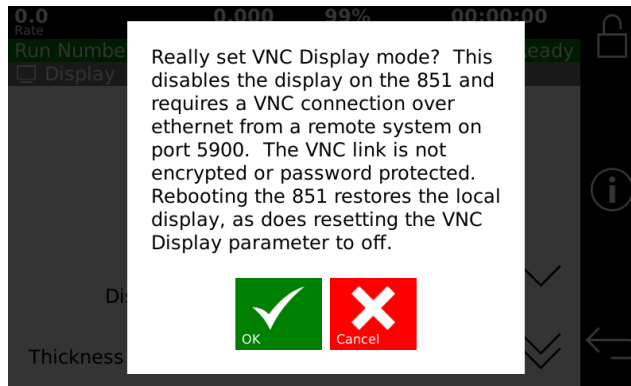
Figure 4-3, VNC Waning Screen

After saving Display Settings changes the 851 screen will turn green and be similar to screen shown below. A beep will sound after 20 seconds; this will indicate that the VNC is ready.

Figure 4-3, VNC Mode Screen

When the 851 is ready the VNC connection can be made. Mouse clicks can now control the 851.

Figure 4-4, TightVNC Connection in Windows

The 851 will automatically revert to normal display after a reboot.

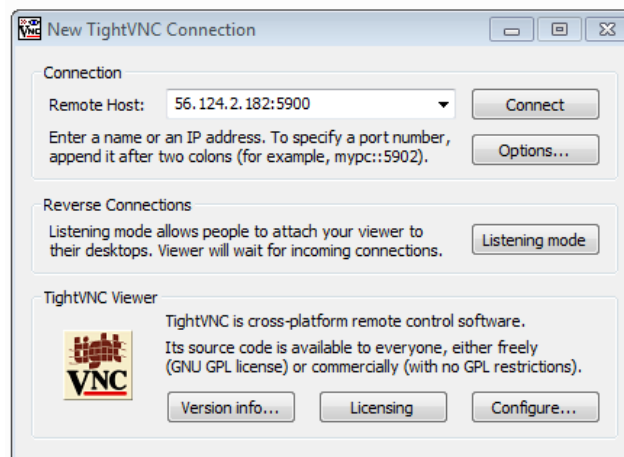### 2. Brightness (Low, Medium, High)

This parameter controls the brightness of the screen.

3. Screen Saver (Off, 5 min, 15min, 1hr, 4 hr)

This parameter defines the time from last touch of the screen till the screen will be turned off. The 851 is still active when the screen is off. Screen will be turned on if it is touched or there is external input. The screen will stay on when a material is running regardless of when the screen was last touched.

4. Display Negatives (On, Off)

This parameter defines whether the Rate displays negative numbers. Negative numbers are displayed in Red. When off the smallest number displayed is 0.0.

5. Thickness Vs. Time Graph (Enabled, Disabled)

This parameter defines whether the thickness verses time graph is enabled as one of the status screens.

6. Rate Vs. Time Graph (Enabled, Disabled)

This parameter defines whether the rate verses time graph is enabled as one of the status screens.

7. Sensor Status (Enabled, Disabled)

This parameter defines whether the sensor status screen is enabled as one of the status screens.

8. I/O Status (Enabled, Disabled)

This parameter defines whether the I/O status screen is enabled as one of the status screens.

Note, if all six status screens are disabled, the Rate Vs. Time Graph will be displayed when the Status button is pressed.

9. Show Clock Errors (Enabled, Disabled)

This parameter controls the display of clock "low battery" warning.

INPUTS

Figure 4-5 Program Inputs

The monitor has four inputs that are pre-defined, pin numbers can be seen in figure 4-5. They are each momentary inputs for Start/Zero, Stop, Source Shutter, Dual Sensor Shutter.

The only user changeable input setting is to set True to either High or Low. An input defined as High true will be true when the input's voltage is at or above the high level.
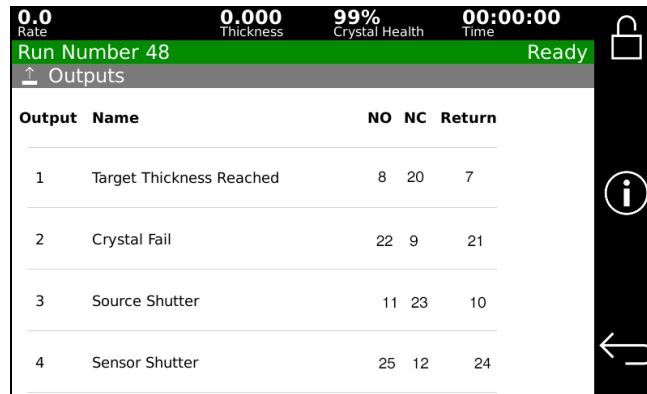
1. PASSIVE/ACTIVE

The Input can be set to use Passive or Active. Press the "Configure" button to change

Passive inputs have TTL level (0 to 5 volt DC) inputs. The Passive inputs are pulled up to 5 volts internally through a resistor and are set true, assuming the input's True level is set to Low, by shorting the input pins together.

Active inputs have 12 to 24 volt DC inputs. The Active inputs are set true, assuming the input's true level is set to High, by supplying 12 to 24 volt AC or DC across the input pins.

OUTPUTS
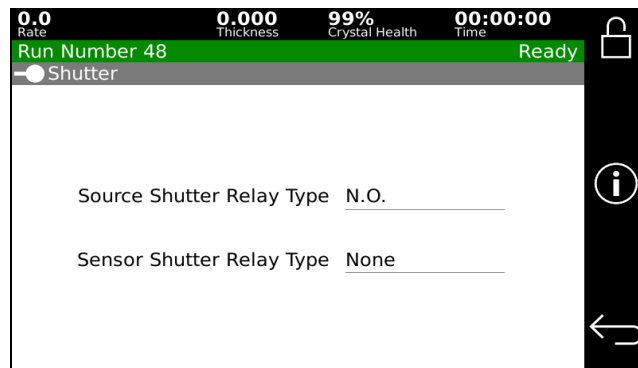
Figure 4-6, Output screen

The monitor has four outputs that are pre-defined, pin numbers can be seen in figure 4-6. They are each relay closures for Target Thickness Reached, Crystal Fail, Source Shutter, Dual Sensor Shutter.

There are no user changeable output settings.

SHUTTER

Selecting Edit Shutter Setup will present the Shutter Setup screen shown in figure 4-7. In this screen you define the shutters.

Figure 4-7, Shutter Setup Screen

1. Source Shutter Relay Type (N.O., N.C., None)

This parameter defines the shutter relay type used to control the source shutter. The following three relay types are available:

N.O. - Relay is normally open and closes to close shutter.

N.C. - Relay is normally closed and opens to close shutter.

None - No sensor shutter output is created.

2. Sensor Shutter Relay Type (None, Dual)

This parameter defines the shutter relay type used to control the sensor shutter. The following two relay types are available:

None - No sensor shutter.

Dual - Select this type for a dual sensor head.

UTILITY

Selecting the Edit Utility Setup from the Edit System Setup menu will present the Utility Setup screen. Figure 4-13 shows the first page of this screen. All parameters are described below.

Figure 4-9, Utility Setup screen

1. Crystal Frequency (5.0 or 6.0 MHz)

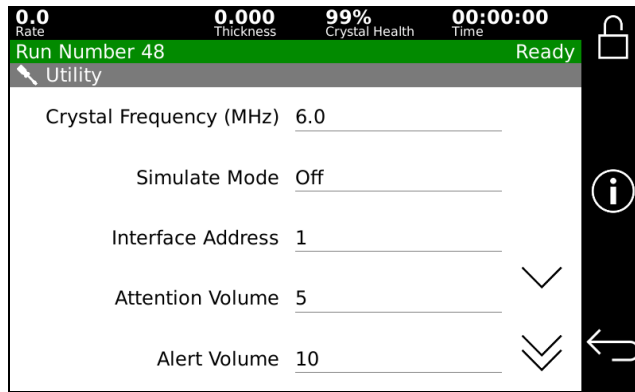This parameter determines the uncoated crystal frequency type for all sensor inputs. The default setting is 6.0 MHz.

2. Simulate Mode (On, Off)

This parameter enables or disables the Simulate mode of the monitor. The Simulate mode is used for testing and differs from the Normal mode only to the extent that the Thickness and Rate displays are derived from a simulated sensor input rather than the actual sensor. While in this mode, the simulated thickness build- up is independent of actual thickness on the sensor. It also allows the tooling factor, density and acoustic impedance calculations to be conveniently checked and altered at the end of the run, if necessary.

3. Interface Address (1-32)

This parameter sets the monitor's computer interface address for the RS-232 interface.

4. Attention Volume (0-10)

This parameter sets the volume of audio attention sound. Attention sounds indicate that the monitor is waiting for an operator response or action before continuing. A setting of zero disables audio attention sound.

5. Alert Volume (0-10)

This parameter sets the volume of audio alert sound. Alert sounds indicate that a material alert level has been exceeded. A setting of zero disables audio alert sounds.

6. Alarm Volume (0-10)

This parameter sets the volume of audio alarm sound. Alarm sounds indicate that a material alarm level has been exceeded. A setting of zero disables audio alarm sounds.

7. Touch Volume (0-10)

This parameter sets the volume of audio when the touch screen is pressed.

8. Error Beep Volume (0-10)

This parameter sets the volume of audio error beeps.

9. Data Points/Min (30 to 600 PPM)

This parameter sets the number of run-time data point sets per minute that will be written to the log. The default is 600 data points/minute. During a run, data is logged automatically up to 10 data point sets per minute. This parameter is only visible when the data logging option is installed.

10. Confirm Saves (Enabled, Disabled)

This parameter sets whether or not changes to system settings are confirmed before saving.

11. Date (01/01/00-12/31/99)

This parameter sets the system date in month/day/year format.

12. Time (00:00-23:59)

This parameter sets the system time. Time is entered in 24-hour format.

MATERIAL

From the Main Menu, selecting View/Edit Material will present the Select Material screen shown below.
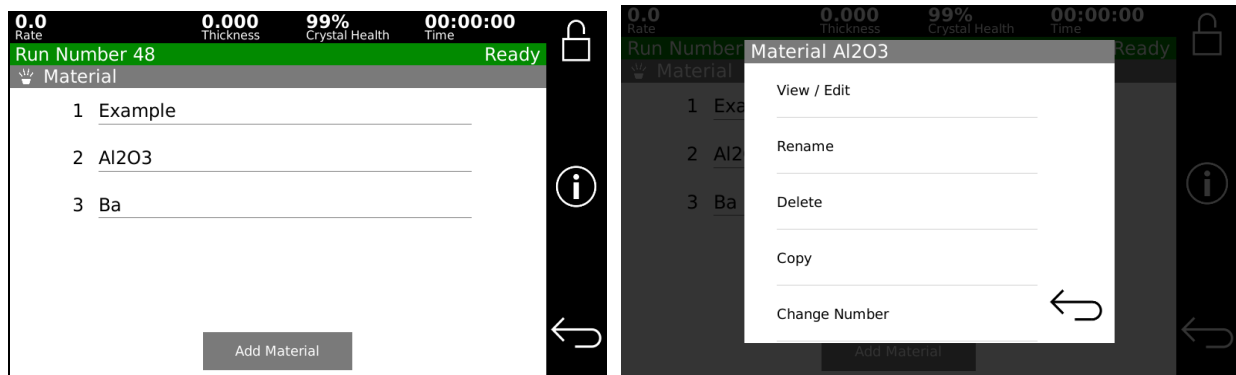
Figure 4-10, Select Material screen

Selecting a material for viewing and/or editing will present the screen, which permits the material to be defined. In this screen, you define all of the material parameters for the selected material. The material parameters are described in detail below.

1. Material Name (A 12 character material name)

An existing material can be renamed from the menu choice "Rename" that is displayed when the material is selected.

Select "Add Material" button to add a new material. This will display a complete list of materials that are stored in the 851. The first item "New Material" will wait for a name to be input.

If a predefined material is chosen, the stored values for the density and acoustic impedance for that material are automatically entered into their respective parameters.

Figure 4-11, Define Material screen

2. Sensor# (1 or 2)

This parameter defines the sensor input number that will be used for this material, and cannot be greater than the number of sensor inputs fitted to the monitor. The default setting is 1.

3. Density (0.80 to 99.99 gm/cm³)

This parameter provides the material density so that the monitor can calculate and display the physical film thickness. If the film density is known, it should be used. A list of the more commonly used film densities is available in pdf form on the supplied USB. As a first approximation, bulk material density can be used in programming. Empirical calibration of this parameter is described in chapter 6.

4. Acoustic Impedance (5.00 to 59.99 gm/cm²/sec)

This parameter is the acoustic impedance of the material. The acoustic impedance of the deposited film is required by the 851 in order to accurately establish the sensor scale factor when the sensor crystal is heavily loaded. If the acoustic impedance of the film material is known, it can be entered directly in units of 105 gm/cm² sec. In most cases the acoustic impedance of the bulk material can be used and can be obtained from The Handbook of Physics or other source of acoustic data. The shear wave impedance should be used. The shear wave acoustic impedance can be calculated from the shear modulus or the shear wave velocity and the density by using the following equation:

$$AI = \rho \cdot C = \sqrt{\rho \cdot G}$$

Where:

AI= Acoustic Impedance

ρ = Density (gm/cm³)

C= Transverse (shear) wave velocity (cm/sec)

G= Shear Modulus (dynes/cm²).

A list of the acoustic impedance and density of the more commonly deposited materials is is available in pdf form on the supplied CD and a technique for empirically determining this parameter is presented in chapter 6.

In many cases and particularly if the sensor crystal is not heavily loaded, sufficient accuracy can be achieved by using the acoustic impedance of quartz which is 8.83 X 10^5 gm/cm² sec.

5. Tooling Factor (10.0 to 499.9%)

This parameter is the tooling factor for the primary sensor. The Tooling Factor parameter is used to compensate for geometric factors in the deposition system which result in a difference between the deposition rate on the substrates and the rate on the sensing crystal. This parameter is entered in percent

units and 100% corresponds to equal rates at the substrate and at the sensing crystal. To a first approximation the tooling factor can be calculated using the following equation:

$$Tooling\% = \left(\frac{dc}{ds}\right)^2 \cdot 100$$

where:

dc= Distance from source to crystal.

ds= Distance from source to substrate.

Empirical calibration of the tooling factor is described in Section 0.

6. Target Thickness (0 to 999.9 KÅ)

This parameter defines the target thickness to stop the monitoring and close the "Target Thickness Reached" output relay. If Target Thickness is 0 then the monitor will continue indefinitely.

7. Crystal Marginal % (0-99)

This parameter defines percent that causes the Crystal Marginal event. Default is 82%.

8. Crystal Fail (Stop, Switch)

This parameter defines the monitor's action in the event of a crystal failure. The options are to stop or switch to a backup crystal.

9. Backup Sensor (1 or 2)

This parameter defines the backup sensor input for the backup crystal.

10. Backup Tooling Factor % (10.0 to 499.9%)

This parameter defines the tooling factor for the backup sensor head

INTERFACE

Interface displays the sent and received data on the RS-232 port for debugging purposes (see chapter 8)

5

OPERATION DISPLAYS AND CONTROLS

Figure 5-1, Splash Screen
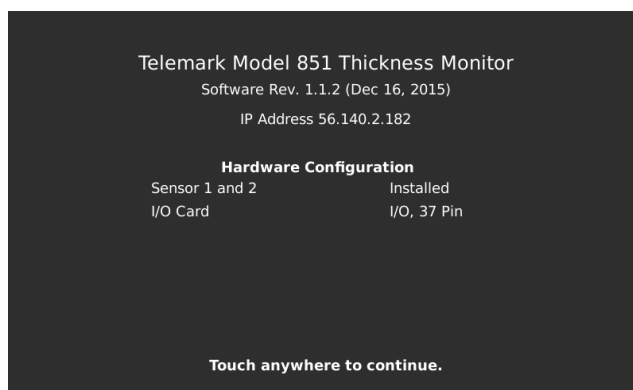
Figure 5-2, 851 Configuration Screen

INITIAL POWER UP

Upon initial power up the unit will screen will be white for 10 seconds, then black for 20 seconds, then display a splash screen for approximately 45 seconds. The display will then show the monitor configuration information. The unit will stay in this state until anywhere on the touch screen is pressed then the unit will go to the main screen.

DISPLAYS

All of the operating displays are updated several times per second.
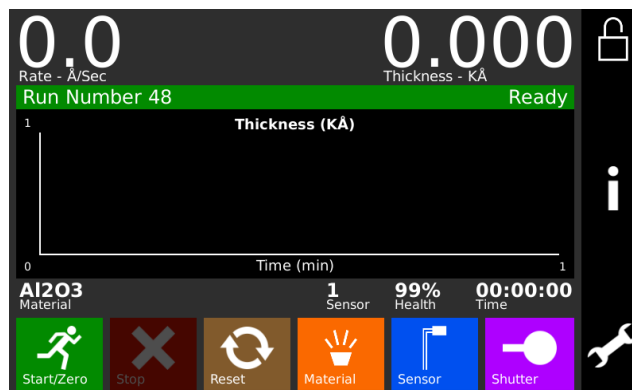
Figure 5-3, Operating Display

RATE

A two to three digit display with a floating decimal point is used to display deposition rate in angstroms per second at a resolution of 0.1 Å/sec from 0 to 99.9 Å/sec, and a resolution of 1.0 Å/sec for rates from 100 to 999 Å/sec.

THICKNESS

Four digits with an auto-ranging decimal point display measured thickness in KÅ with a resolution of 1 Å from 0 to 9.999 KÅ, a resolution of 10 Å from 10.00 KÅ to 99.99 KÅ and a resolution of 100 Å from 100.0 KÅ to 999.9 KÅ. Green numbers indicating the target thickness for a material are displayed during a run. If the target is 0, then no number is displayed.

RUN NUMBER

The current or last run number is displayed on the left of the status bar. Note the status bar will be purple in simulate mode.

SYSTEM STATUS

The current 851 system status is displayed on the right of the status bar.

MATERIAL NAME

The current material is displayed.

SENSOR NUMBER

The current censor number is displayed.

CRYSTAL HEALTH %
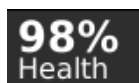
A two digit display is used to show the health percentage of the sensor crystal in use. A fresh crystal starts out with a health of 99%. If no crystal is attached, this will show "--".

TIME TO GO

Time To Go is displayed in hours, minutes and seconds. This display shows the elapsed time since the start.

OPERATING CONTROLS

Normal operation of the 851 is controlled by six operating buttons, Start/Zero, Stop, Reset, Material, Sensor, and Shutter.

START/ZERO BUTTON
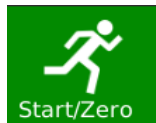
The Start button zeros the thickness, starts a material and starts the timer. **When the button is surrounded by a white box it indicates the monitor is running.**

STOP BUTTON

The Stop button puts the 851 in Run Complete mode.

RESET BUTTON
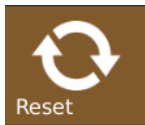
The Reset button is used to clear the monitor from "crystal fail" mode and put it into the Ready mode.

MATERIAL BUTTON

The Material button brings up the material selection list.

SENSOR BUTTON

This button switches the sensor input between 1 and 2. It also switches the sensor output relay if a dual sensor is configured.

SHUTTER BUTTON
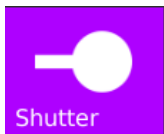
This button is used to manually open and close the source shutter. **A white outline around this button indicates that the active source shutter relay is closed** (If any shutter is configured). When the monitor is in the Ready mode, this button may be selected to open or close the shutter.

SIDE BAR CONTROLS

STATUS BUTTON

This button is used to cycle through the different status screens. The display settings allow the four different status screens to be active or not. Refer to chapter 6 for a detailed description of these status screens.

PROGRAM BUTTON

Pressing the programming button will bring up the main programming screen.

6

OPERATION

SIMULATE OPERATION

Testing the 851 is best accomplished by checking its operation in the Simulate mode. This mode can be selected by using the programming Main Menu, Edit System Setup, Edit Utility Setup, to select Simulate mode ON, then use Start to run a material in Simulate mode.

The Simulate mode is identical to the Normal mode except that the sensor input is simulated.

SELECTING A MATERIAL

The Material button brings up the material selection list.
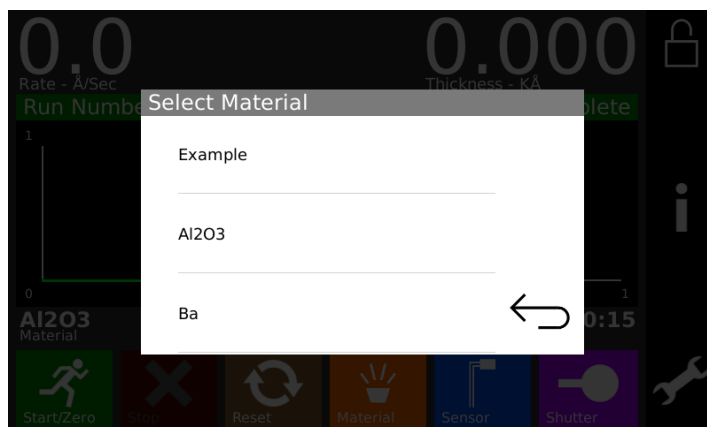
Figure 6-1, Material Selection Screen

STARTING A MATERIAL
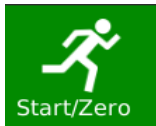
Pressing the Start button while the monitor is in the "Ready" or "Run Complete" state will reset the Thickness measurement to zero, reset the graphs and start the timer.

STATUS DISPLAYS

There are four different run time status screens that can be displayed at any time by pressing the Status button (providing they have each been enabled using Edit Display Setup). Repeatedly pressing the Status button will cycle through the four status screens, shown below.
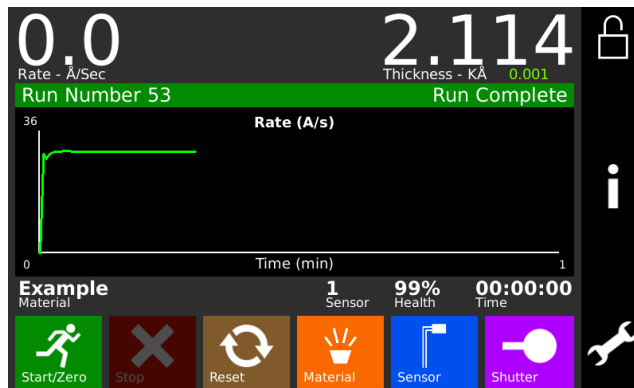
Figure 6-2, Rate vs. Time Graph
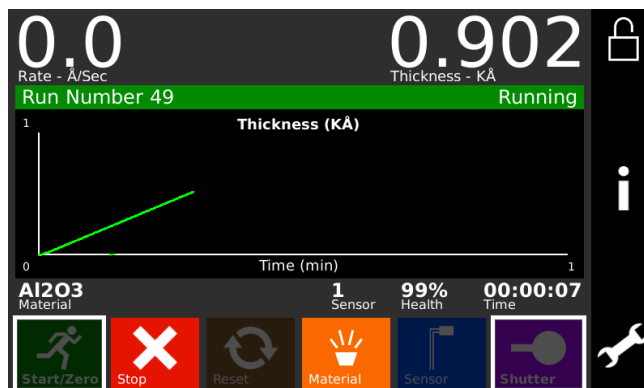
Figure 6-3, Thickness vs. Time Graph
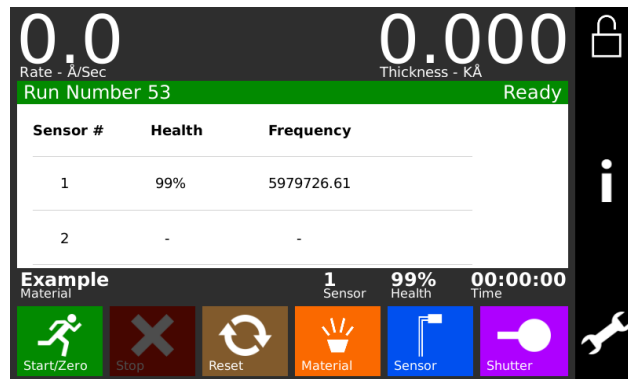
Figure 6-4, Sensor Status screen
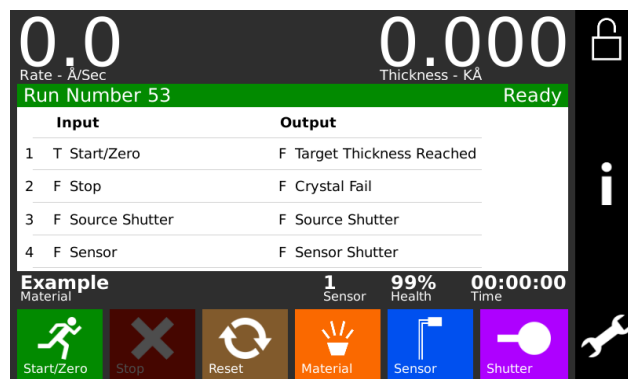
Figure 6-5, I/O Status Screen

MODES

Modes are conditions which the monitor can occupy. Some modes are indicated by white boxes around the operating buttons. Other modes are displayed in the top right hand corner of the status display. These monitor modes are described below.

READY

The Ready Mode indicates the 851 has been reset and is awaiting a Start button press.

RUNNING

A white box around the Start button is displayed when the monitor is in the Running Mode.

RUN COMPLETE

This mode indicates that the selected material has run to completion. A Run Complete message is displayed in the top right hand corner of the status display. In addition, an attention warning will sound. The monitor remains in this mode until a reset signal puts it into the Ready mode.

SIMULATE

The 851 can be put in to simulate mode simulates rate and thickness build-up by simulating the sensor input rather than the actual sensor.

ERROR, WARNING, AND INFORMATION MESSAGES

These messages are displayed on the status screen.

In addition, there are three levels of audible warnings associated with the trouble conditions, Attention, Alert and Alarm. An asterisk in the Clear column indicates the warning sound will clear when the condition clears. Touching the screen will also clear the sound.

The list below is arranged in descending order of priority. In the event that more than one warning level is triggered, the higher level has priority. The action column indicates what if any action is taken as a result of the trouble.

Messages	Type	Clear	Action
Crystal Failure	Alarm/Attn	NO/*	Halt
Crystal Marginal	Alert/Attn	NO/*	
Xtal Fail Switch	Attention		Crystal Switch
Xtal Mrgn Switch	Attention		Crystal Switch

An asterisk in the Clear column indicates the warning sound will clear when the condition clears. Touching the screen will also clear the sound.

Table 6-1, Error, Warning, and Information Messages

Each of the messages is described below.

CRYSTAL FAILURE

This condition indicates lack of a valid signal from the sensor, and generally results from a failed crystal but may also indicate problems in the crystal mounting or the interconnection between the sensor and the monitor. If the primary crystal fails when no material is running, the Attention warning will sound. If the backup crystal fails and the material is not running, the alarm will sound and the run will be stopped.

CRYSTAL MARGINAL

The sensor crystal in use has exceeded the allowable crystal marginal setting. If the crystal is the backup one, the Alert warning will sound when the material is running. If the primary crystal is in poor quality, then the Attention will sound. The percent that causes a crystal to be marginal in set in the material settings, default is 82%.

XTAL FAIL SWITCH

This message indicates the primary crystal has failed and the sensor input has been switched to the backup crystal. In addition, the Attention warning sounds. Press any button to clear the sound.

XTAL MRGN SWITCH

This message indicates the primary crystal is marginal and the sensor input has been switched to the backup crystal. In addition, the Attention warning sounds. Press any button to clear the sound.

7

TUNING

EMPIRICAL CALIBRATION

For many film materials, the film density and acoustic impedance is known to sufficient accuracy that the values can be used directly, and empirical calibration of these parameters is not necessary. A library of material names, density and acoustic impedance of the more commonly deposited materials is stored in the 851 memory. These materials are also listed in supplied pdf.

If the values of the density and acoustic impedance are not known they can be calibrated empirically as described below.

Calibration requires the establishment of the film density, the tooling factor and the acoustic impedance in this order. If the approximate value of the parameters is known they should be used initially. If the acoustic impedance is not known use the value 8.83, the value for quartz.

FILM DENSITY

Establishing the film density can be accomplished by depositing a trial film on several test substrates placed around and as close as possible to the sensor crystal and in the same plane. The trial deposition should be thick enough to allow an independent measurement of the film on the test substrates to be made with adequate precision using an optical interferometer or surface measuring device.

When making the trial deposition, use a fresh crystal and remember to write down the final thickness reading displayed by the 851, as this will be needed in the calculation. If the acoustic impedance parameter has been accurately established previously, a fresh crystal is not required.

Determine the average film thickness on the test substrates and use the following equation to calculate the material's density:

Density = (Displayed Thickness/Average Measured Thickness) * Density(test)

Where Density(test) is the density parameter setting used during the calibration run.

Once the calibration procedure is complete, the programmed film density is correct for this particular film.

TOOLING FACTOR

Having established the film density the tooling factor should be established. Place several test substrates at representative locations in the deposition fixture. Again deposit a trial film as above using the known film

density, and a fresh crystal unless the programmed acoustic impedance is known to be correct. Remember to write down the final thickness reading displayed by the 851, as this will be needed in the calculation. Determine the average film thickness on the test substrates. If the average measured thickness differs from the displayed thickness, use the following equation to calculate the correct tooling factor.

Tooling = (Average Measured Thickness/Displayed Thickness) * Tooling(test)

Where Tooling(test) is the tooling parameter setting used during the calibration run.

ACOUSTIC IMPEDANCE

Establishment of the acoustic impedance requires that the crystal be heavily loaded. Continue to deposit on the sensor crystal until the crystal health approaches 50% or until the crystal is approaching the end of its useful life.

The 851 is now fully calibrated for the film in question and should produce consistent and accurate films.

8

COMPUTER INTERFACE

GENERAL

The 851 Thickness Monitor comes standard with an RS-232 serial interface that permits remote control and data collection from a personal computer.

RS-232 SERIAL INTERFACE

The standard RS-232 serial interface of the 851 allows one 851 to be connected to any other device with a RS-232 serial interface. A D9P connector is provided on the rear panel for permanent connection to the host computer. See figure 2-2.

The 851 acts as DTE, and accordingly, the 9-pin connector has 'plug' pins.   It can be used with a DCE or a DTE host cable connection providing the sense of the RxD/TxD data lines and the control lines is observed. Pin 2 'TxD' transmits data from the 851 to the host; pin 3 'RxD' receives data from the host. Pin 7 'CTS' is a control output signal from the 851, and pin 8 'RTS' is a control input signal.

In this implementation, pin 7 'CTS' means what is says, namely, this is an output control line, and when the 851 asserts this control line 'true' the host can transmit to the 851. On the other hand, pin 8 'RTS' is not quite what it may seem because this is a signal input to the 851, and it is intended that the host should assert this line 'true' only when the 851 is allowed to transmit data to the host. The 851 does not generate an RTS 'request-to-send' as such for the host PC, so the host should assert pin 8 true whenever the 851 is allowed to transmit to the host, without being asked to do so.

The 851's RS-232 port is automatically set up to operate with the following specifications:

9600 Baud, 8 Bit data, No Parity, 1 Stop bit

The 851 will process a maximum of 20 RS-232 input messages a second.

PROTOCOL

All communications between the computer and the 851 are in bytes.

Example: To initiate a zero thickness instruction the computer would send the following bytes shown below. Different formats are shown that are used in different programming environments.

	Header	Interface Address	Instruction	Length	Message	Checksum
Decimal Bytes	255 254	001	000	001	064	190
Character String	Chr$(255) Chr$(254)	Chr$(1)	Chr$(0)	Chr$(1)	Chr$(64)	Chr$(190)
Hex	FF FE	01	00	01	40	BE

Header - Two byte header – FF FE i.e. decimal bytes 255 254

Interface Address - One byte controller address - The controller address byte defines the controller that should receive the message, or should respond to the message by transmitting data. The controller address will range from 0 to 32 (set via Edit System Setup, Edit Utility Setup, Interface Address).

Instruction - One byte instruction code.

Length - One byte message length.

Message - 0-249 byte message.

Checksum - One byte checksum, for the instruction code byte, message length byte and the 0-249 byte message.

The checksum is the two's complement of the one byte sum of all bytes from, and including, the instruction code to the end of the message. If the one byte sum of all these bytes is added to the checksum, the result should equal 255.

A single byte checksum can be generated using the calculation:

`checksum= !(sum of all but the header bytes % 256) + 1,`

i.e. the checksum is the bit inversion of the remainder byte which results from dividing the sum of all bytes by 256.

In Excel the check some can be calculated by:

`=(255-MOD(SUM(all but the header bytes),256))+1`

DATA TYPES

There are three data types sent over RS-232: one byte, two byte, and three byte parameters. All data types are sent as integers in binary format with the most significant byte first. The one byte data types are either ASCII characters, numeric values (0-255), or 8 bit registers. Some of the multiple byte data types are decimal values stored as integers. To convert these values to their decimal equivalent, use the following equation:

$\text{Decimal Value} = (\text{Integer Value})/(10^{DP})$

where DP is the value's decimal point position. The decimal point positions for all the parameters are constant and are given in tables along with the parameters' range.

MESSAGE RECEIVED STATUS

Following the receipt of each message, the monitor will send a one-byte 'received status' message, indicating how the message was received, with the following format:

Header

Address

Instruction Code = 253

Length = 2

Instruction Code of the received message

Receive code, see table below

Checksum

A value of 253 for the instruction byte indicates that this is a received status message. The Instruction Code byte indicates the instruction code of the message that was received. The following table shows a list of possible receive codes:

Receive Code	Description
0	Message received O.K.
1	Invalid checksum.
2	Invalid instruction code.
3	Invalid message length.
4	Parameter(s) out of range.
5	Invalid message.
8	Can't send log data while running.

DEBUG COMPUTER INTERFACE

From the Program menu select the Interface button to get to a screen that will show all the sent and received RS-232 data. This may be helpful debugging any problems interfacing the 851 to a computer or PLC. This display is meant for low frequency messaging debugging. Depending on the messages the debug computer interface display will not display all the messages under the maximum of 20 RS232 input messages a second.
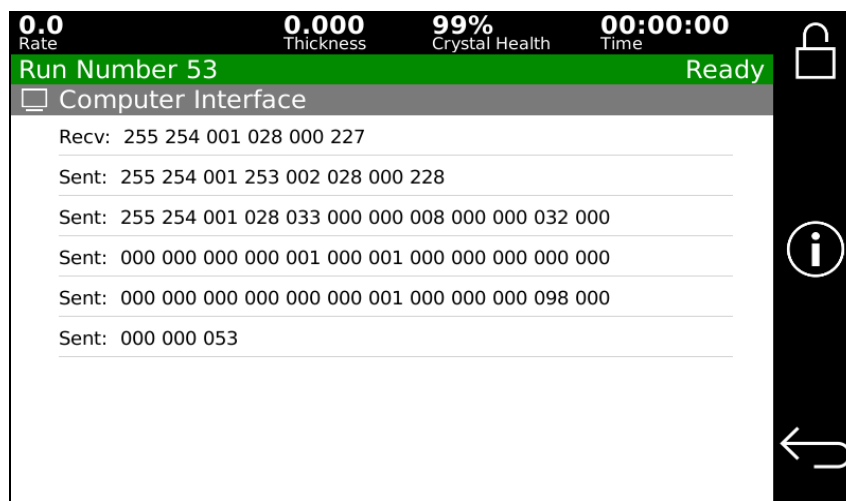
Figure 8-1, RS-232 Debug Computer Interface Screen

INSTRUCTION SUMMARY

The following table is a list of valid instruction codes.

Instruction Code	Description
0	Remote activation of monitor
28	Send monitor status
29	Start material
30	Send run-time values
31	Initiate automatic data logging
36	Send Material Log Directory

INSTRUCTION DESCRIPTIONS

The following is a description of all the valid instructions along with an example of how they are used. All the examples assume the monitor address is 1.

Remote activation of monitor (Code #0)

This instruction initiates a button press of the 851. The valid button codes are shown in the following table:

Remote Activation Code	Description
2	Sensor button
4	Shutter button
32	Stop button
64	Start/Zero button

Format: Header, Instruction=1, Length=1, Button Code, Checksum

Example: To initiate a Start/Zero instruction the computer would send:

`Chr$(255)+Chr$(254)+Chr$(1)+Chr$(0)+Chr$(1)+Chr$(64)+Chr$(190)`

Example: To initiate instructions the computer would send bytes:

	Header	Address	Instruction	Length	Remote Activation Code	Checksum
Sensor	255 254	001	000	001	002	252
Shutter	255 254	001	000	001	004	250
Stop	255 254	001	000	001	032	222
Start/Zero	255 254	001	000	001	064	190

Send monitor status (Code #28)

Instructs the monitor to send the monitor status data list. A description of the monitor status data list is as follows:

Parameter Name	Length (bytes)	Range
Monitor state	1	0 = Ready 1 = Running 2 = Thickness Reached/Run finished 26 =Initializing
Alarm Errors	1	bit 3 = Crystal Fail
Alert Errors	1	bit 7 = Crystal Marginal
Attention Errors	1	bit 4 = Crystal Marginal&! Running bit 5 = Crystal Fail&! Running bit 6 = Crystal Marginal& Running, Switch bit 7 = Crystal Fail& Running, Switch
Discrete Input Register	1	bit 0 = Input #1 to 4. (0=False, 1=True)
Discrete Output Register	1	bit 0 = Output #1 to 4. (0=False, 1=True)
Monitor Status	1	bit 0 = Ready Mode bit 7 = Running
Sensor #1 Crystal Health	1	(0-99)%
Sensor #2 Crystal Health	1	(0-99)%
	Total 10 bytes	

Format: Header, Address, Instruction=28, Length=0, Checksum

Example: To instruct the monitor to send the monitor status the computer would send:

```
Chr$(255)+Chr$(254)+Chr$(1)+Chr$(28)+Chr$(0)+Chr$(227)
```

Start Material (Code #29)

Instructs the monitor to start material # n.

Format: Header, Address, Instruction=29, Length=3, Material #(0-98) 1byte, Checksum.

Example: To instruct the monitor to start material # 5 the computer would send:

```
Chr$(255)+Chr$(254)+Chr$(1)+Chr$(29)+Chr$(1)+Chr$(4)+Chr$(221)
```

Send run-time values (Code #30)

Instructs the monitor to send the run-time value list one time. A description of the run-time value list is as follows:

Value Name	Length (bytes)	Format	Units
Thickness	5	String	KÅ
Deposition rate	4	String	Å/sec
Time to go	7	String	Seconds
Crystal health	2	String	%
Active material number	1	(0-98)	
Active sensor number	1	(1-4)	
	Total 20 bytes		

The string values are in ASCII format including decimal points or colons.

Example: To instruct the monitor to send the run-time value list the computer would send:

```
Chr$(255)+Chr$(254)+Chr$(1)+Chr$(30)+Chr$(0)+Chr$(225)
```

Initiate Automatic Data Logging (Code #31)

This operation allows the computer to setup the 851 to automatically output selected values to the RS232 port at the rate that is set in Setup – Utility - Data Points/Minute. A "stop" command must be sent to stop the 851 from sending data.

The values sent are determined by the bit value of the message byte in the data logging instruction message.

Byte #	Bit #	Description	Length(bytes)	Format	Units
	0	Unused			
1	1	Thickness	5	String	KÅ
	2	Deposition rate	4	String	Å/sec
	3	Time	7	String	Seconds
	4	Crystal health	2	String	%
	5	Material number	3	String	None

All values are in ASCII format including decimal points or colons.

For example, to instruct the 851 to output thickness and rate the computer would send the following message:

Chr$(255)+Chr$(254)+Chr$(1)+Chr$(31)+Chr$(1)+Chr$(6)+Chr$(218)

Data logging is stopped by sending the following message:

Chr$(255)+Chr$(254)+Chr$(1)+Chr$(31)+Chr$(1)+Chr$(0)+Chr$(223)

Send Log Directory (Code #36)

Instructs the monitor to send the log directory to the host computer. The log directory consists of 16 individual run logs. The data format of a run log is listed in the following table:

Parameter Name	Length (bytes)	Allowable Range
Log Name	12	All ASCII Characters
Run Number	2	(1-9999)
Starting Time	3	(00:00:00-23:59:59) HH:MM:SS
Starting Date	3	(01/01/00-12/31/99) MM:DD:YY
Completion Time	3	(00:00:00-23:59:59) HH:MM:SS
Completion Status	1	(0=Normal, 1=Stoped)
Data Points/Minute	1	(38=30ppm, 39=60ppm, 40=120ppm, 41=300ppm, 42=600ppm, 255=other)
Material Number	2	(0-999)
Total 27 bytes		

Each byte in the time and date data is an integer value representing hour, minute, second, month, day, or year. The run number is a 2-byte integer.

If the first byte of the name of any log is equal to 255 then that log is considered blank.

Since the 851's message length is limited to 249 bytes, the monitor will send the log directory data in two separate 232 byte messages. The first message will contain the first eight logs and the second message will contain the last eight logs.

Example: To instruct the monitor to send the log directory the computer would send:

Chr$(255)+Chr$(254)+Chr$(1)+Chr$(36)+Chr$(0)+Chr$(219)

9

TROUBLE SHOOTING

Symptom	Possible Cause
Unit blows line fuse.	a) Incorrect fuse size.
	b) Shorted transformer or filter capacitor.
Front Panel display never illuminates.	a) Blown fuse.
"Crystal Failure" message flashes with selected sensor properly connected.	a) Defective cable or cables.
	b) Defective or overloaded sensor crystal.
	c) Bad Oscillator unit.
Unit does not retain programmed data in memory.	a) Bad Main Processor board.
The unit fails to activate externally controlled devices (Shutters)	a) Faulty Relay (Discrete I/O board)
	b) Bad Discrete I/O board.
Unable to remotely control the unit via Discrete I/O inputs.	a) Improperly wired cable/connector.
	b) Inputs not properly grounded.
	c) Bad Discrete I/O board.