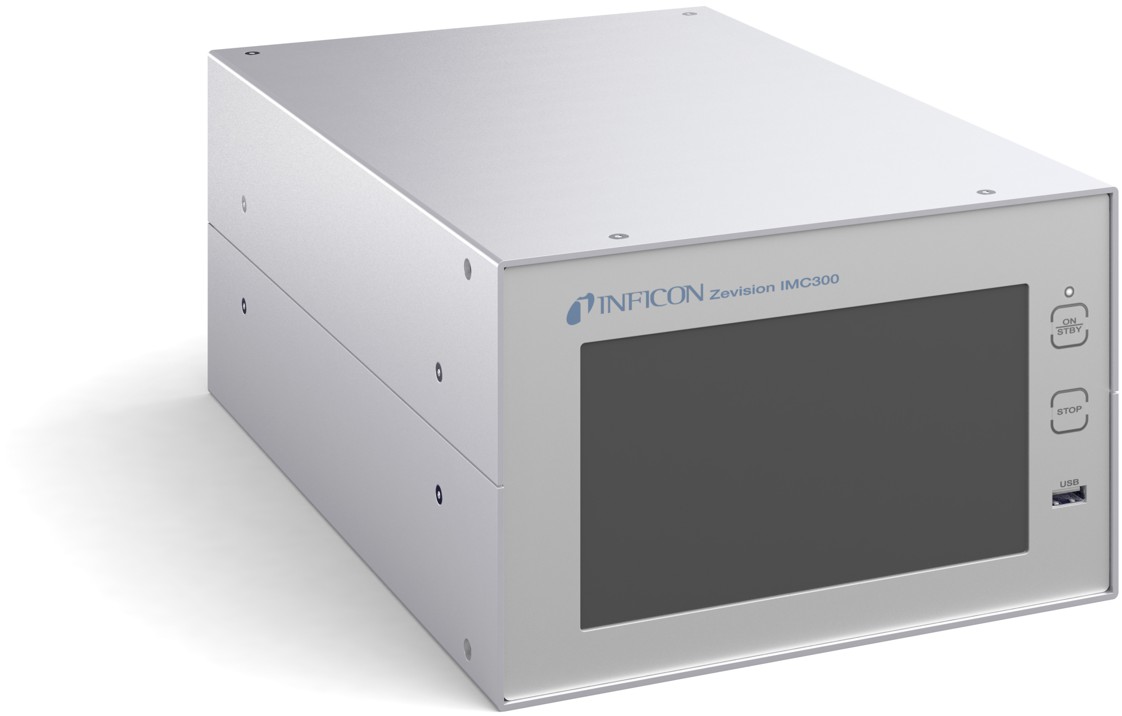

Operating Manual

Zevision® IMC300

Deposition Controller

INFICON

Two Technology Place

East Syracuse, NY 13057-9714

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WARRANTY AND LIABILITY - LIMITATION: Seller warrants the products manufactured by it, or by an affiliated company and sold by it, and described on the reverse hereof, to be, for the period of warranty coverage specified below, free from defects of materials or workmanship under normal proper use and service. The period of warranty coverage is specified for the respective products in the respective Seller instruction manuals for those products but shall not be less than two (2) years from the date of shipment thereof by Seller. Seller's liability under this warranty is limited to such of the above products or parts thereof as are returned, transportation prepaid, to Seller's plant, not later than thirty (30) days after the expiration of the period of warranty coverage in respect thereof and are found by Seller's examination to have failed to function properly because of defective workmanship or materials and not because of improper installation or misuse and is limited to, at Seller's election, either (a) repairing and returning the product or part thereof, or (b) furnishing a replacement product or part thereof, transportation prepaid by Seller in either case. In the event Buyer discovers or learns that a product does not conform to warranty, Buyer shall immediately notify Seller in writing of such non-conformity, specifying in reasonable detail the nature of such non-conformity. If Seller is not provided with such written notification, Seller shall not be liable for any further damages which could have been avoided if Seller had been provided with immediate written notification.

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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.

3 Declaration of Conformity

DECLARATION OF CONFORMITY

This declaration is issued under the sole responsibility of the manufacturer INFICON. The object of the declaration is to certify that this equipment, designed and manufactured by:

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

is in conformity with the relevant Community harmonization legislation. 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: IMC300, Thin Film Deposition Controller

Applicable Directives:

- 2014/35/EU (LVD) — Electrical Equipment (Safety) Regulations 2016 (UK)
- 2014/30/EU (EMC) — Electromagnetic Compatibility Regulations 2016 (UK)
- 2015/863/EU (RoHS) — Substances in Electrical and Electronic Equipment Regulations 2012 (AS AMENDED)

Applicable Standards:

Safety: IEC 61010-1:2010, IEC 61010-1:2010/AMD1:2016 3rd Edition

Emissions: EN 61326-1:2020 (Radiated & Conducted Emissions)
(EMC – Measurement, Control & Laboratory Equipment)

CISPR 11:2015/AMD2:2019
EN 55011:2016/A11:2020 Emission Standard for Industrial, Scientific and Medical (ISM) radio RF equipment
FCC Title 47 CFR Part 18 Class A emission requirements (USA)

Immunity: EN 61326:2020 (Industrial EMC Environments)
(EMC – Measurement, Control & Laboratory Equipment)
Immunity per Table 2

CE and UKCA Implementation Date: February 5, 2025

Authorized Representatives:

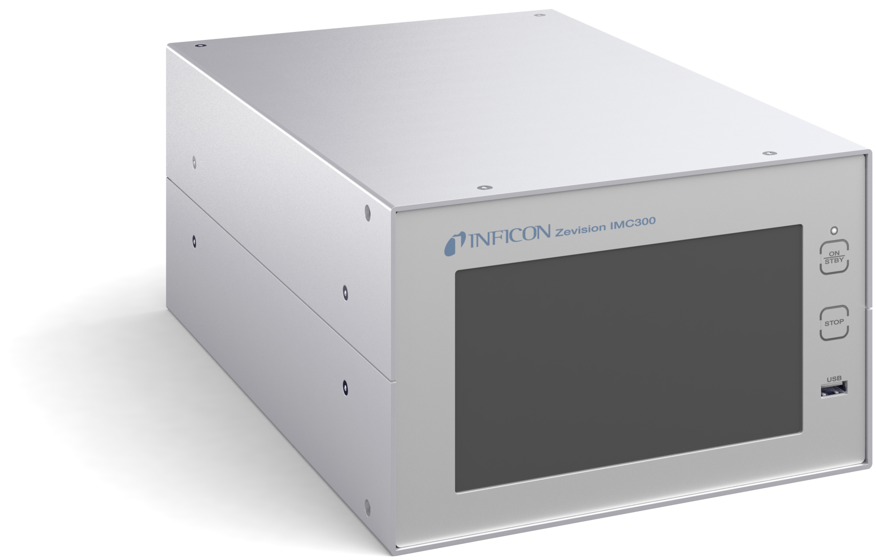
Andrew Klamm — Digitally signed by Andrew Klamm Date: 2025.02.10 10:09:20 -05'00'
Andrew Klamm
Quality Manager, ISS

Samuel Carroll — Digitally signed by Samuel Carroll Date: 2025.02.10 13:05:44 -05'00'
Samuel Carroll
Vice President of Engineering

ANY QUESTIONS RELATIVE TO THIS DECLARATION OR TO THE SAFETY OF INFICON'S PRODUCTS SHOULD BE DIRECTED, IN WRITING, TO THE AUTHORIZED REPRESENTATIVE AT THE ABOVE ADDRESS.

4 Introduction

INFICON Zevision IMC300 is a quartz crystal microbalance technology-based deposition controller, providing a unique combination of accuracy and powerful features in a compact, low-cost controller.



The standard Zevision IMC300 is a sequential layer thin film deposition controller that can monitor two quartz crystal sensors and control one of two evaporation sources at a time. Six process control relays and eight digital inputs are included to support a broad range of external devices. The number of sensors and source outputs can be doubled and the digital I/O increases the number of relays to 20 and inputs to nine with optional expansion cards. IMC300 comes standard with RS-232 and Ethernet communications.

Please review the entire manual for detailed operational, programming, and safety information.

4.1 Safety

4.1.1 Definition of Notes, Cautions, Warnings, and Dangers

When using this manual, please pay attention to the Notes, Cautions, Warnings, and Dangers found throughout. For the purposes of this manual they are defined as follows:

Pertinent information that is useful in achieving maximum efficiency of the instrument if followed.

⚠ CAUTION

Failure to heed these messages could result in damage to the instrument.

⚠ WARNING

This symbol alerts the user to the presence of important operating and maintenance (servicing) instructions.

⚠ DANGER

Immediate danger, death, or very severe injuries can occur.

⚠ DANGER

Risk of Electric Shock

Dangerous voltages are present which could result in personal injury.

4.1.2 General Safety Information

⚠ CAUTION

Do not use the product in a manner not specified by the manufacturer.

If used in a manner not specified by the manufacturer, protection provided by the equipment may be impaired.

⚠ CAUTION

The instrument contains delicate circuitry that is susceptible to transient power line voltages. Disconnect power whenever making any interface connections. Refer all maintenance to qualified personnel.

⚠ DANGER

Risk of Electric Shock

Do not open the instrument case. Potentially lethal voltages are present. Refer all maintenance to qualified personnel.

⚠ WARNING

Electrostatic Sensitive Device

Observe precautions for handling electrostatic sensitive devices.

⚠ CAUTION

Do not replace the power cord with an inadequately rated cord. The cord must be rated 10A or higher.

4.1.3 Earth Ground

When using the optional power supply, the instrument is connected to earth ground through a sealed three-core (three-conductor) power cable, which must be plugged into a socket outlet with a protective earth terminal. If an extension cable is used, it must always have three conductors, including a protective earth terminal. If a user-supplied power supply is used, the power supply connector must have a shield that is grounded to AC line ground.

⚠ DANGER

Warning of Electrical Shock

Never interrupt the protective earth circuit. Any interruption of the protective earth circuit inside or outside the instrument or disconnection of the protective earth terminal may cause dangerous voltages to be present on or inside the instrument.

This symbol indicates where the protective earth ground is connected inside the instrument. Never unscrew or loosen this connection.

4.2 How to Contact Us

Worldwide customer support information is available at www.inficon.com, where you can contact:

- a Product Engineer with questions regarding applications and programming INFICON equipment
- a Service Engineer with questions regarding troubleshooting, diagnosing or repairing INFICON equipment
- Sales and Customer Service, to find the INFICON Sales office nearest you
- Repair Service, to find the INFICON Service Center nearest you

If you are experiencing a problem with the instrument, please have the following information readily available:

- the serial number and software version numbers
- a description of the problem
- an explanation of any corrective action you may have already attempted
- the exact wording of any error messages you have received

4.2.1 Returning the Product

Do not return any component of the instrument to INFICON without first speaking with a Customer Support Representative to obtain a Return Material Authorization (RMA) number. If a package is sent to INFICON without an RMA number, the package will be held and the sender will be contacted. This will result in delays in servicing. Prior to being given an RMA number, a Declaration Of Contamination (DOC) form must be completed to document if the product has been exposed to process materials. DOC forms must be approved by INFICON before an RMA number is issued. INFICON may require the product be sent to a designated decontamination facility prior to being accepted by the factory.

4.3 IMC300 Aftercare Plan

INFICON is excited to introduce the new Zevision IMC300 Aftercare Plan, created to protect your investment. Two Aftercare Plan options are available and can be purchased up to one-year after the initial instrument purchase.

Details on these plans are found below. To purchase or to learn more, contact us at www.inficon.com.

Aftercare Plan 1

Value-Added Benefit	Benefit Description
Lifetime loaner instruments	If at any point your instrument requires service, a loaner instrument is provided
Free parts and labor for two years past the manufacturer's warranty	Four total years of free parts and labor when including the two-year manufacturer’s warranty (PN 786-080-P1 and PN 786-082-P1)

Aftercare Plan 2

Value-Added Benefit	Benefit Description
Lifetime loaner instruments	If at any point your instrument requires service, a loaner instrument is provided
Free parts and labor for four years past the manufacturer’s warranty	Six total years of free parts and labor when including the two-year manufacturer’s warranty (PN 786-081-P1 and PN 786-083-P1)

4.4 Unpacking and Inspection

✓ If the instrument has not been removed from its shipping container, do so now.

1. Carefully examine the instrument for damage that may have occurred during shipping. This is especially important if rough handling on the outside of the container is noticed. Immediately report any damage to the carrier and to INFICON.

   ⇨ Do not discard the packing materials until an inventory has been taken and the instrument has been successfully installed.

2. Take an inventory of the order by referring to the order invoice.
3. Install the instrument by following the installation instructions found in Installation [▸ 21].
4. For additional information or technical assistance, contact INFICON; refer to How to Contact Us [▸ 13].

4.5 Specifications

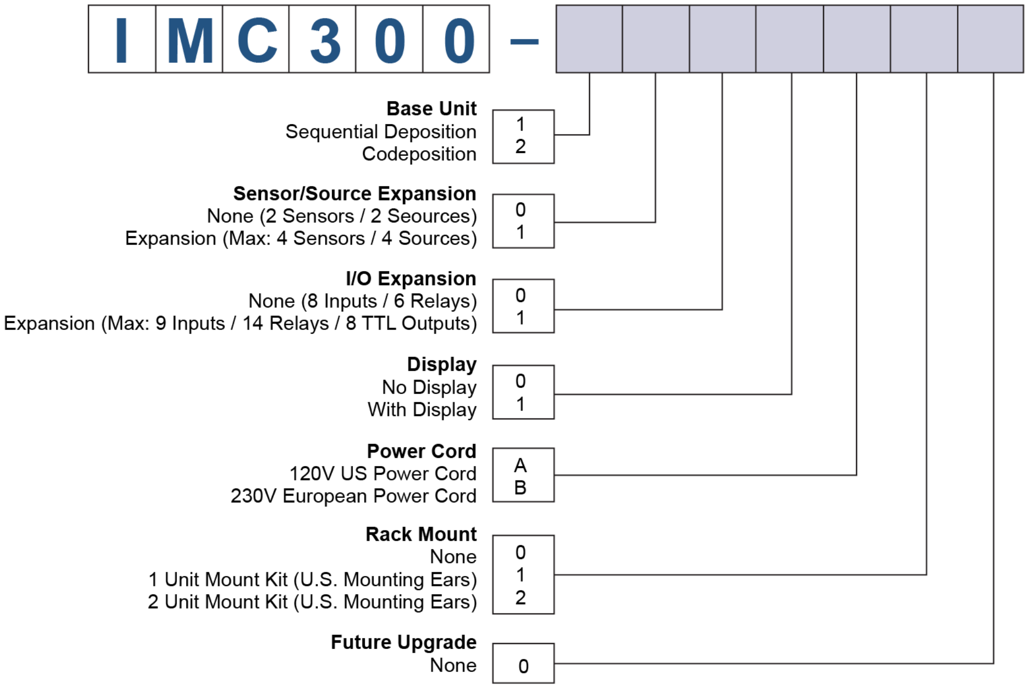
Crystal frequency range	6.0 to 4.5 MHz	
Frequency resolution	± 0.00656 Hz @ 6 MHz	
Frequency accuracy	± 2.5 ppm 0 to 50°C	
Measurement rate	10 Hz	
Thickness and rate resolution	±0.008 Å and ±0.08 Å/s	
Thickness accuracy	0.5% typical, (dependent on process conditions, especially sensor location, material stress, temperature, and density)	
Rate accuracy	Less than 1% jitter	
Sensor inputs	2 (+2 optional, 4)	
Measurement technique	ModeLock	
Sensor type	Single, Dual, CrystalTwo®, CrystalSix®, Crystal 12®, Generic	
Digital inputs	Functions	8, event configurable 1 additional input when I/O card is installed
	Input rating	24 V(dc) maximum 30 V(ac) maximum
Relay outputs	Functions	6, event configurable 6 relays and 8 TTL outputs additional when I/O card is installed
	Relay rating	30 V(dc) or 30 V(ac), RMS or 42 V peak at 2.5 A
Mains power supply	100-240 V(ac), 50/60 Hz	
Power consumption	30 W maximum, with all options installed	
Fuse (slow blow)	1.25 A, 250 V, 5 x 20 mm cartridge	
Installation (overvoltage)	Category III	
Temporary overvoltages	488 V(ac)	
Usage	Indoor only (IPXO)	
Operating temperatures	0 to 50°C (32 to 122°F)	
Humidity	Up to 80% RH at 31°C, non-condensing	
Altitude	Up to 2000 m	
Pollution degree	2	

Storage temperature	-10 to 70°C (14 to 158°F)
Warm up period	None required; for maximum stability, allow five minutes
Rack dimensions H x W x D	132.5 x 213.1 x 314.3 mm (5.2 x 8.4 x 12.4 in.)
Front clearance	Less than 26 mm (1.0 in.)
Rear clearance	Less than 102 mm (4.0 in.)
Weight	4.1 kg
Cleaning	Mild, nonabrasive cleaner or detergent. Prevent cleaner from entering IMC300 or contacting connectors.
Type	TFT LCD display with PCAP touchscreen
Format	WVGA
Resolution	800 x 480
Backlighting	LED
Thickness display resolution	1 Å for 0.000 to 9.999 kÅ, 10 Å for 10 to 99.99 kÅ, 100 Å for 100 to 999.9 kÅ, 1 kÅ for 1000 to 9999 kÅ
Rate display resolution	0.01 Å/s for 0.00 to 9.99 Å/s, 0.1 Å/s for 10.0 to 99.9 Å/s, 1 Å/s for 100 to 999 Å/s
Power display resolution	0.1%
Data display rate	1 Hz
Graphic display functions	Rate deviation 1, 2, 3, 4, 5, 10, or 15 Å/s or power at 0.0 to 100%
Recorder output functions	Rate, thickness, rate deviation, power and frequency
# Processes	250
# Films	The system supports a total of 250 Films, you can add only 1 film to a layer.
# Layers (total all processes)	250
Initial rate	0.0 to 999.9 Å/s
Final thickness	0.0 to 999.9 kÅ
Time setpoint	0:00:00 to 150:00:00 (hhh:mm:ss)
Thickness limit	0.0 to 1000.0 kÅ
Auto start next	Yes/No
Max power	100%
Min power	0%
Slew rate	0.0 to 999.9 Å/s
Rate dev. attention	0.0 to 999.9 Å/s
Rate dev. alert	0.0 to 999.9 Å/s

Rate dev. alarm	0.0 to 999.9 Å/s	
Rate ramp	Starting thickness	0.000 to 1000 kÅ
	Ramp time	0 to 5999s or 0:00:00 to 150:00:00 (hhh:mm:ss)
	New rate	0.0 to 999.9 Å/s
Material	250	
Density	0.1 to 100 g/cm^3	
Z-Factor	0.1 to 15.0	
P term	0.01 to 1000	
I term	0.0 s to 10000.0 s	
D term	0.0 s to 10000.0 s	
Tooling	1.0 to 9999.9%	
Crucible	Up to 32	
XTAL quality, rate dev	0 to 99%	
XTAL quality, counts	0 to 99	
XTAL stability, single	0 to 9999 Hz	
XTAL stability, total	0 to 9999 Hz	
Failure action	Unused, post deposition, stop, suspend, time power	
Rise time/soak time/ramp time/hold time	0:00:00 to 150:00:00 (hhh:mm:ss)	
Soak power/power	0.0% to 100%	
Shutter delay time	0:00:00 to 150:00:00 (hhh:mm:ss)	
Capture	0.0 to 100%	
Rate watcher	Yes/No	
	Time limit	0:00:00 to 150:00:00 (hhh:mm:ss)
	Accuracy	100%

4.6 Configurations and Accessories

4.6.1 IMC300 Configuration



IMC300 configuration includes:

- 25-pin female high-density solder cup D-sub connector (PN 051-1846) and connector housing (PN 051-1794). One of each included for a two-channel standard configuration. Two of each included when I/O Expansion Board option is selected.
- Power Cord - Based on origin of order (universal power supply)
  - Power Cord North American (PN 068-0433)
  - Power Cord European (PN 068-0434)
  - Power Cord China (PN 068-0805)
- RS-232 Cable (PN 068-0464)
- Ethernet Cable (PN 068-0478)

4.6.2 Accessories

Cables and Oscillator Kit

XIU PKG with 4.6 m (15 ft.) cable, 6 in. BNC	780-611-G15
XIU PKG with 9.1 m (30 ft.) cable, 6 in. BNC	780-611-G30
XIU PKG with 15.2 m (50 ft.) cable, 6 in. BNC	780-611-G50
XIU PKG with 30.5 m (100 ft.) cable, 6 in. BNC	780-611-G100
4m XIU PKG with 4.6 m (15 ft.) cable, 6 in. BNC	780-612-G15
4m XIU PKG with 9.1 m (30 ft.) cable, 6 in. BNC	780-612-G30
4m XIU PKG with 15.2 m (50 ft.) cable, 6 in. BNC	780-612-G50
4m XIU PKG with 30.5 m (100 ft.) cable, 6 in. BNC	780-612-G100
4m XIU PKG with 4.6 m (15 ft.) cable, 20 in. BNC and 3.5 m in-vacuum cable	780-613-G15
4m XIU PKG with 9.1 m (30 ft.) cable, 20 in. BNC and 3.5 m in-vacuum cable	780-613-G30
4m XIU PKG with 15.2 m (50 ft.) cable, 20 in. BNC and 3.5 m in-vacuum cable	780-613-G50
4m XIU PKG with 30.5 m (100 ft.) cable, 20 in. BNC and 3.5 m in-vacuum cable	780-613-G100

One XIU PKG is required for each crystal sensor that will be connected to IMC300.

Rack Mount Kits

3U rack extender - mounts one IMC300 controller in a 48.3 cm (19 in.) rack	786-023-G1
3U rack adapter - mounts two IMC300 controllers in a 48.3 cm (19 in.) rack	786-023-G2

Crystal Sensors

Front load single sensor	PN SL-XXXXX
Front load dual sensor	PN DL-AXXX
UHV bakeable sensor	PN BK-AXF
Cool drawer single sensor	PN CDS-XXFXX
Cool drawer dual sensor	PN CDD-XFXX
ALD sensor	PN 750-71X-GX
CrystalSix	PN 750-446-G1
RSH-600	PN 15320X-XX
Crystal 12	PN XL12-1XXXXX

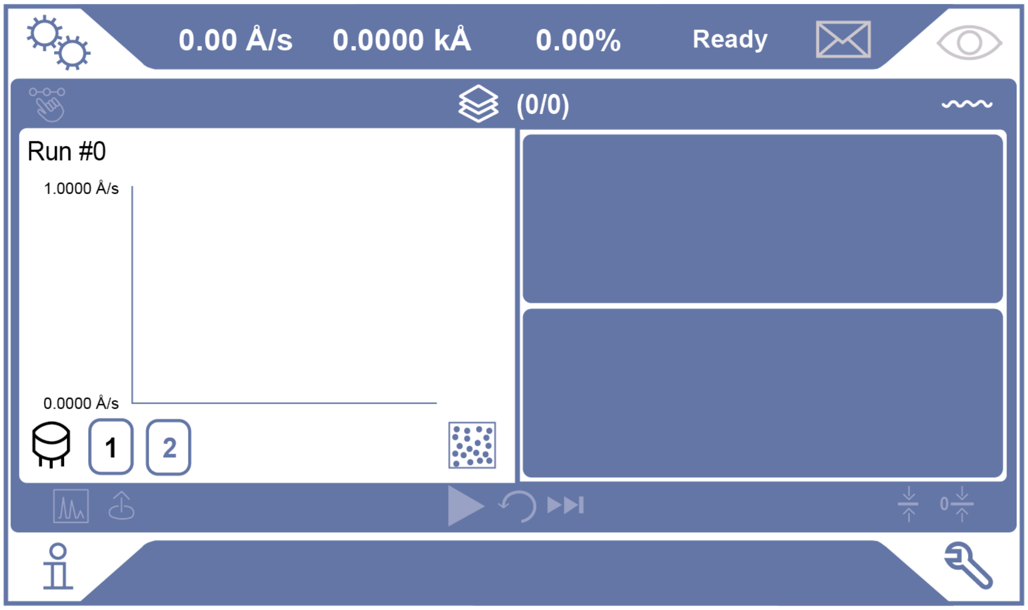
X represents feature selections particular to that sensor. For help identifying a sensor, contact INFICON. (Refer to How to Contact Us [▶ 13])

Shuttered sensors, CrystalSix, and Crystal 12 require a solenoid valve (PN 750-420-G1).

4.7 Initial Power-On Verification

A preliminary functional check of IMC300 can be made before formal installation. It is not necessary to have sensors, source controls, inputs, or relays connected to do this. For more complete installation information, see Installation [▶ 21].

1. Confirm that the proper AC line mains voltage is supplied to IMC300.
2. Confirm that the rear panel (main) AC switch is in the ON Position.
3. After the initial boot-up screen, IMC300 displays the operate screen. This screen will be similar to the screen displayed in the figure below.



5 Installation

5.1 Introduction

This chapter provides information for the necessary connections and user interfaces for IMC300.

⚠ CAUTION

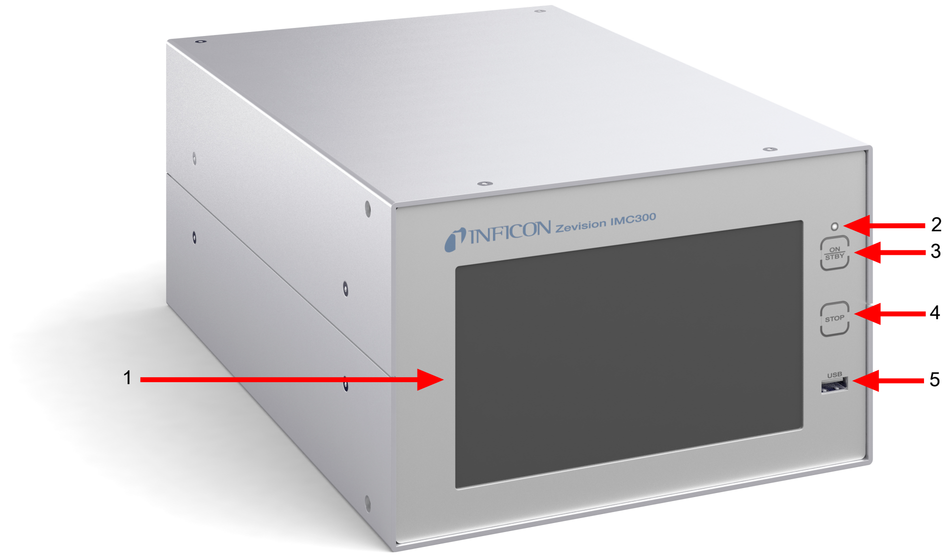
Care should be exercised to route IMC300 cables as far as is practical from other cables that carry high voltages or generate noise. This includes other line voltage cables, wires to heaters that are SCR-controlled, and cables to source power supplies that may conduct high transient currents during arc down conditions.

⚠ CAUTION

To maintain proper IMC300 performance, use only the BNC cable, included in the XIU PKG, to connect the oscillator to the crystal sensor.

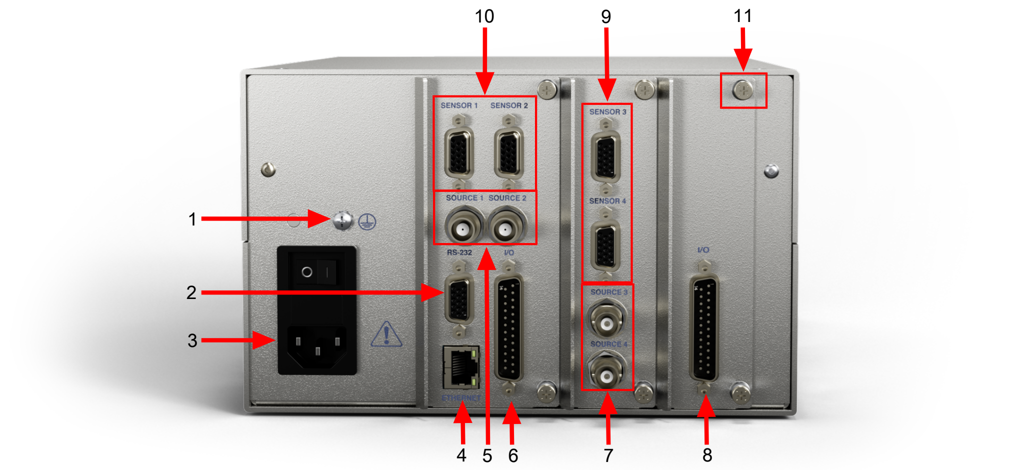
Ensure there is enough room to disconnect the power when needed.

5.2 Front Panel



1	Touch screen	Main user interface that allows the user to run IMC300.
2	LED indicator	The green LED indicates that the system is ON/active. The amber LED indicates that the system is in Standby mode. The red LED indicates that the system is stopped.
3	ON/STBY button	Enters and exits Standby mode.
4	STOP button	Stops a process.
5	USB port	Allows a USB drive or hand controller to be connected to IMC300.

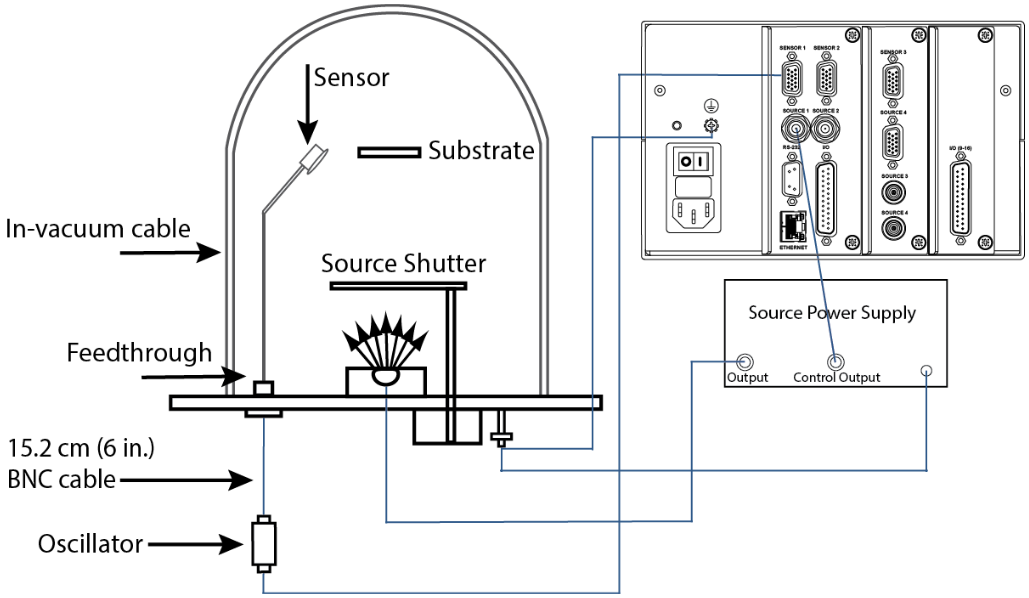
5.3 Rear Panel



1	Ground terminal	Ground terminal for common system and cable grounding.
2	RS-232	Connection to a computer for programming and data acquisition. This comes standard with IMC300.
3	AC power inlet and fuse	Connects to mains power. IMC300 automatically detects mains voltages of 100 to 120 and 200 to 240 V(ac), 50/60 Hz. Only use a power cable and slow blow fuse with a current rating of 1.25 amps. Verify that the power cable provided is connected to a properly grounded mains receptacle.
4	Ethernet	Connection to a computer for programming and data acquisition. This comes standard with IMC300.
5	Source 1 and 2	BNC connection for either source power supply control voltage input or for use as a recorder output.
6	I/O	25 pin D-sub connection for 6 relays (outputs) and 8 digital inputs. For use with external equipment.
7*	Source 3 and 4	These source, sensors, and I/O ports are optional with IMC300. NOTE: The I/O option card has 8TTL outputs, 6 relays and 1 input
8*	I/O option card	
9*	Sensor 3 and 4	
10	Sensor 1 and 2	Interconnect cable connections to the crystal interface unit (XIU) for sensors 1 and 2.
11	Thumb screws	There are six thumb screws on the back panel, two on each sub-panel.

Rack installation	Rack mounting hardware is not included with all configurations ordered. Optional 3U rack adapter and 3U rack extender kits are available to mount either one or two IMC300 controllers in a standard 48.3 cm (19 in.) rack (see section Rack Mount).
Sensor input connections	Connect the XIU interconnect cables, BNC cables and oscillators from the vacuum chamber feedthrough to the desired IMC300 sensor inputs (see section System Connections [25]).
Source output connections	Connect user-supplied BNC cables from the IMC300 output connectors to either the source power supply control input or to the external device using the recorder output. Refer to the source power supply operating manual for control input wiring instructions.
Digital I/O connections	See section I/O Connections [31] for details on wiring digital I/O to the IMC300 I/O connectors.
Computer connection	To collect data or program IMC300 remotely, attach a straight-through RS-232 cable from the RS-232 connector to a computer serial port. IMC300 can also communicate via Ethernet using a Cat 5 Ethernet cable or better via the RJ-45 Ethernet connector.
Ground connection	Connect a grounded wire or strap to the ground terminal on the IMC300 rear panel (see Rear Panel [23] and Ground Requirements [26]).

5.4 System Connections



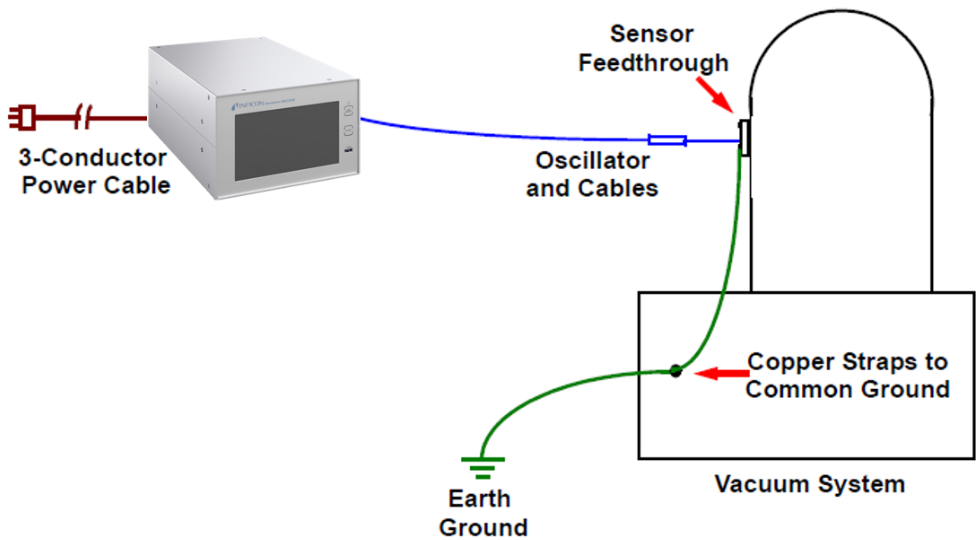
Sensor	Holds the quartz crystal used to measure rate and thickness. Crystals must be replaced regularly.
In-vacuum cable	A coaxial cable that connects the sensor to the feedthrough.
Feedthrough	Provides isolation between vacuum and atmosphere for electrical connections, water, air, and/or purge gas tubes.
15.2 cm (6 in.) BNC cable	Provides a flexible connection from the feedthrough to the oscillator.
Oscillator	Contains the electronics to oscillate the quartz crystal. Total cable length to the crystal should be under 200 cm (78.7 in.).
Sensor input cable	Connects the oscillator to the IMC300 sensor input. Lengths up to 30.5 m (100 ft.) are acceptable.
Control output BNC cable	Connects the IMC300 output to the source power supply control voltage input.
Ground wire/strap	A wire or strap that connects the vacuum system to the IMC300 ground terminal. The wire or strap is important for noise rejection (see section Ground Requirements [▸ 26]).

5.5 Ground Requirements

Low impedance wires or straps must be used to connect the chassis of all control components to a common ground point connected to earth ground (see Establishing Earth Ground [▹ 27] for the earth ground requirement).

Solid copper straps at least 12.7 mm (0.5 in.) wide and approximately 0.56 mm (0.022 in.) thick (as short as possible) are recommended where RF is present. This is particularly important in high-noise e-beam systems.

The oscillator is grounded through the interconnect cables, and the crystal sensor is typically grounded to the wall of the vacuum system. If the sensor feedthrough is not properly grounded to the vacuum system, connect a copper strap between the sensor feedthrough and the common ground point for the system components.



5.5.1 Connections to Earth Ground

There are two required earth ground connections:

- The earth ground connection on IMC300 is a threaded stud with a hex nut. Connect a ring terminal to the ground strap, thus allowing a good connection and easy removal and installation. This connection must be made at installation. For best protection against high frequency noise, the length-to-width ratio of the earth conductor should not exceed 5:1.
- This IMC300 is also connected to earth ground via a sealed three-core power cable, which must be plugged into a socket outlet with a protective earth ground terminal. Extension cables must always have three conductors including a protective earth ground conductor.

5.5.2 Establishing Earth Ground

⚠ WARNING

Follow local electrical regulations and codes.

1. Install two 3 m (10 ft.) long copper-clad steel ground rods into the soil, spaced at least 1.9 m (6.2 ft.) apart. The ideal distance between the rods is twice the rod length.
2. Pour a solution of magnesium sulfate or copper sulfate around each rod to reduce resistance to earth ground.
3. Test the ground rods using a ground resistance tester specifically designed for that purpose.

Do not use a common ohmmeter.

4. After verifying that a good earth ground has been achieved, connect the rods together using solid copper straps at least 76 mm (3 in.) wide and approximately 0.9 to 1.3 mm (0.05 in.) thick, keeping the strap as short as possible.

Do not use braided wire. Use a solid copper strap.

5.6 Rack Mount

The procedure below provides instructions for installing the IMC300 rack mount kit. IMC300 is designed to mount in a standard 48.3 cm (19 in.) rack, using optional rack mount kits, or can be used on a benchtop.

2 rack mount kits are available:

- Full rack extender (PN 786-023-G1)
- Rack adapter (PN 786-023-G2)

5.6.1 Full Rack Extender

The optional Full Rack Extender mounts a single IMC300 into a full-width 48.3 cm (19 in.) rack space.

5.6.1.1 Inventory

- 2 - rack mount ears
- 2 - large aluminum panels
- 2 - small aluminum panels
- 2 - hex shoulder screws
- 8 - small flat head screws
- 4 - large flat head screws

5.6.1.2 Installation

1 Assemble the extender. Use the eight small flat head screws to connect the two small aluminum panels and two large aluminum panels.

2 Install hex shoulder screws. From inside the extender, thread two hex shoulder screws on one side, closest to the front of IMC300. Continue to thread the screws until the threads are completely exposed.

3 Attach the extender. Align the extender with IMC300 to fit the rack. The hex shoulder screws installed in step 2 should align with the two large threaded holes in IMC300. Tighten the hex shoulder screws to secure the extender to IMC300.

4 Install the rack mount ears. Using the four large flat head screws provided, install the rack mount ears on the outer ends of the controller assembly. Install one rack mount ear to IMC300, and the other to the extender.

5 Mount IMC300. Slide the entire assembly into an empty 3U rack-mount space (8.9 cm [3.5 in.] H x 48.3 cm [19 in.] W). Secure the assembly with four rack screws (not provided).

5.6.2 Rack Adapter

The optional Rack Adapter (PN 786-023-G2) mounts two IMC300 controllers side-by-side in a full-width 48.3 cm (19 in.) rack space.

5.6.2.1 Inventory

- 2 - rack mount ears
- 1 - rear mount coupler
- 2 - M3 button head screws and washers
- 4 - 10-32 flat head screws

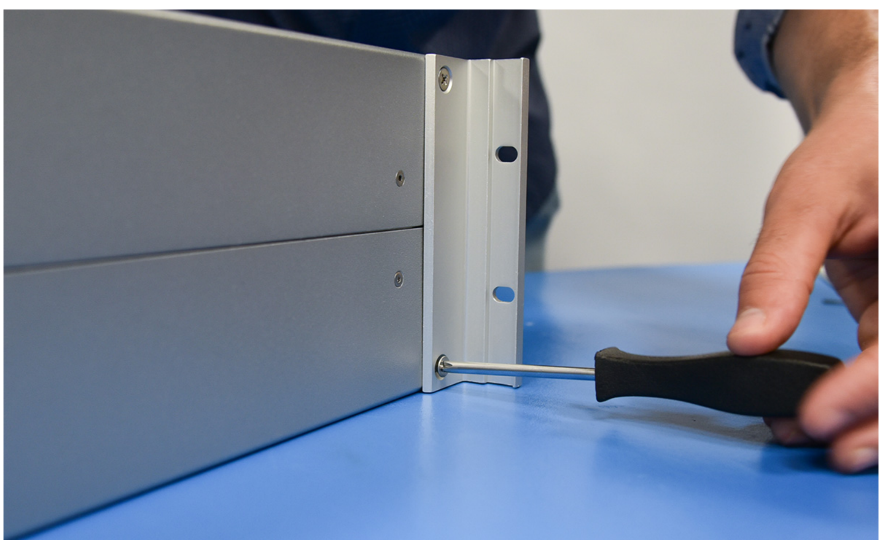
5.6.2.2 Installation

1 Align the two controllers side by side, as though installed in the rack. Remove the two adjacent screws on the rear panel of each IMC300.

These screws are no longer needed for the rack adapter. However, screws will be needed if the IMC300 is ever switched to mounting a single unit with the adapter.

2 Install the rear mount couplers. Using the two button head screws and washers provided, install one side of the rear mount coupler to each IMC300. Do not fully tighten the screws until both screws are installed.

3 Install the rack mount ears. Using the four flat head screws provided, install the rack mount ears on the outer ends of the controller assembly. One rack mount ear should be installed on each IMC300.



4 Mount the IMC300 assembly. Slide the assembly into an empty 3U rack-mount space (8.9 cm [3.5 in.] H x48.3 cm [19 in.] W). Secure the assembly with four rack screws (not provided).

5.7 I/O Connections

A 25-pin, D-sub connector, located on the IMC300 rear panel, provides Input/Output connections.

Inputs can be activated by connecting to a switch and shorting to ground, or they can be driven by a TTL compatible signal. TTL signals can be programmed to be either active high or active low, as needed.

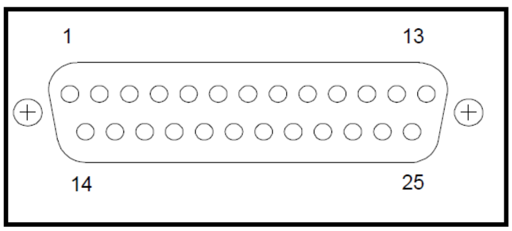
⚠ CAUTION

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

⚠ WARNING

Output relays are rated for 24 V (dc) or 30 ac, 2 A maximum.

The pin assignments for the rear panel mounted I/O connector are displayed in the figure and table below.



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

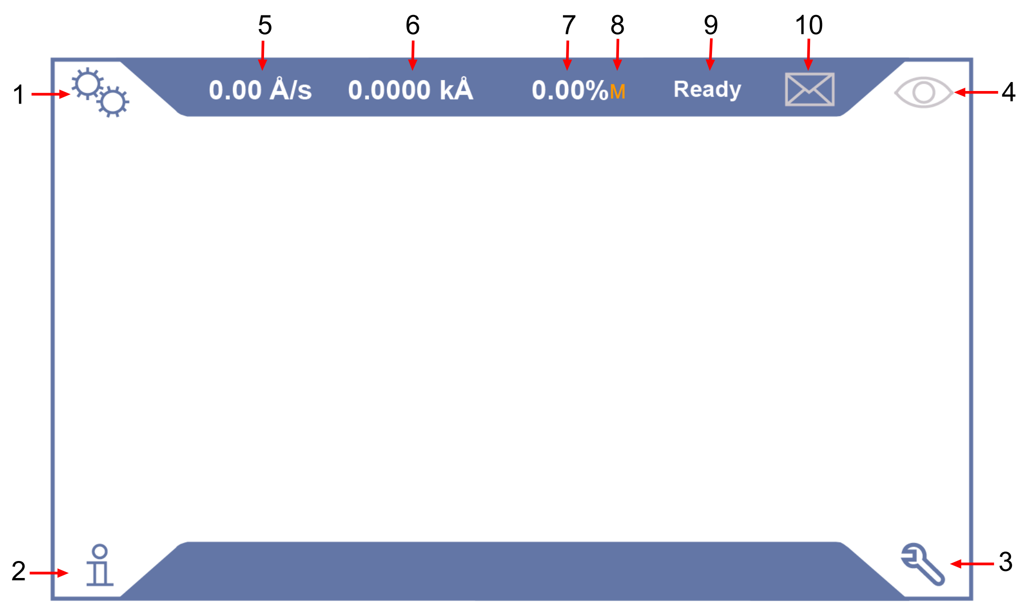
NOTE: The following relays and TTL outputs are only available when the option card is installed.

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

6 Operation

6.1 Menu Overview

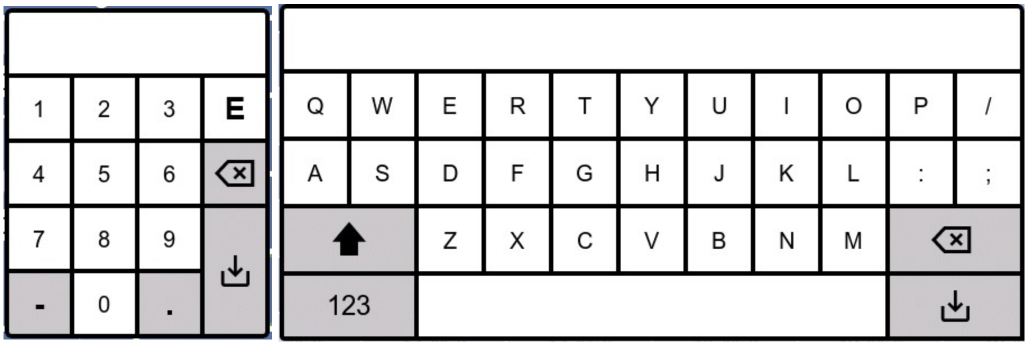
When IMC300 is turned on, the Operate screen is displayed. There are 10 main screens that control IMC300 operation, as well as, a skeleton screen that is always shown. This section describes the function of each screen and their respective settings.



1	Settings	Takes the user to the Settings screen.
2	Materials	Takes the user to the User Materials screen.
3	General settings	Takes the user to the General Settings screen.
4	Operate	Takes the user to the Operate screen.
5	Rate*	Current rate is displayed here.
6	Thickness*	Current thickness is displayed here.
7	Power*	Current power level is displayed here.
8	Manual power	When manual power is selected, an "M" appears next to the power level in orange.
9	State	Current state is displayed here.
10	Messages	Messages are displayed here. If there are no messages, the icon appears dimmed. If there is a warning message, the icon is orange. If there is an error message, the icon is red.

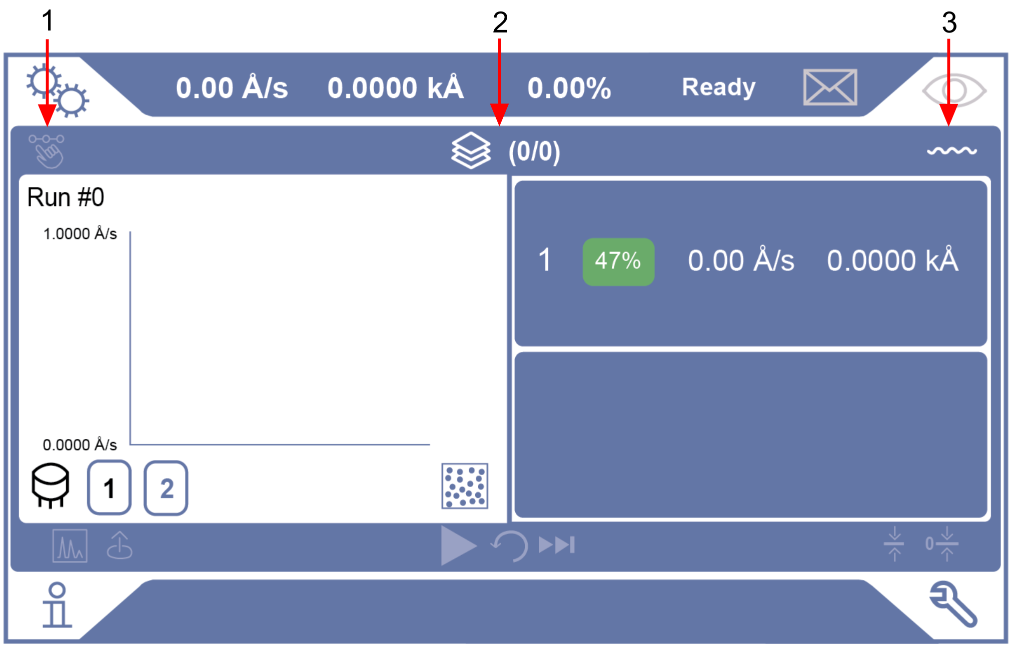
*These update once per second. When multiple sensors are present, the rate and thickness are shown as the average of all sensors.

IMC300 touch screens have two available keyboards, shown below, depending on the field the user selects.



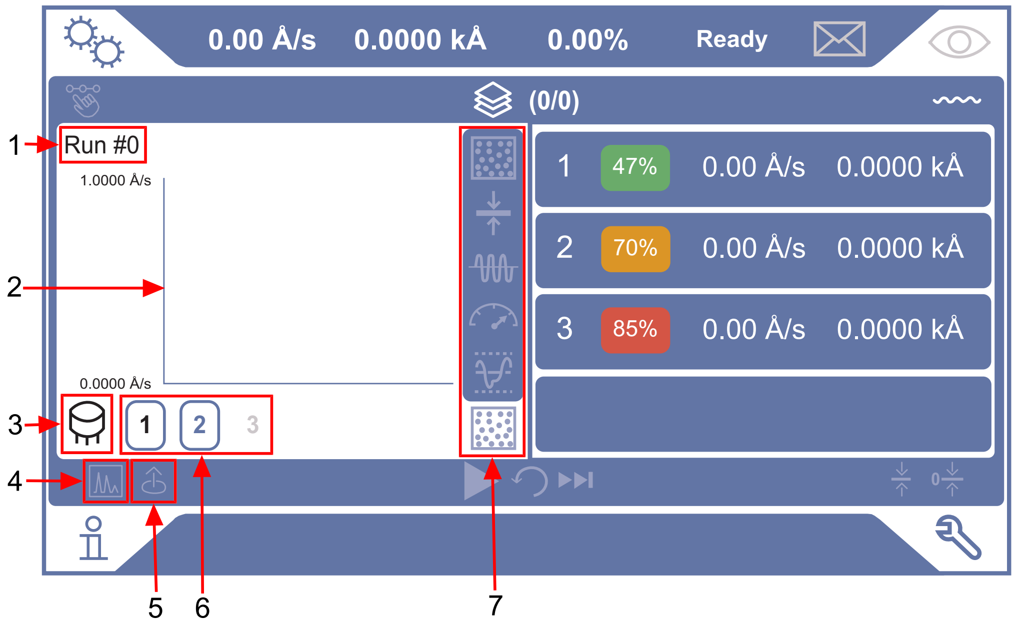
6.2 Operate Screen

The Operate screen is shown below.



1	Process	Displays the current process. Pressing this icon brings the user to the Process screen. See Process Screen [▸ 90].
2	Layer	Displays the current layer name and layer number, as well as total number of layers.
3	Film	Displays the current film.

6.2.1 Left Panel



The left panel of the Operate screen displays either a graph or the source settings while a process is running. Pressing either the Graph icon or Source icon located on the bottom left corner toggles between the two screens.

1	Run #	Displays the run number.
2	Graph or source settings	The area where either the graph or source settings are displayed. Clicking the graph icon or source icon changes the content in this area.
3	Sensor icon	This icon is displayed for all data types except for power data, where the Source icon is displayed. This is not a clickable icon.
4	Graph icon	Pressing this icon displays the graph. This is the default state.
5	Source icon	Pressing this icon displays the source settings.
6	Graph data selection	Pressing these buttons tells IMC300 which sensor/source data to draw on the graph. When a sensor is selected, its number will be highlighted with a border. When a sensor is deselected, the border is removed. (e.g. sensor 3).
7	Graph selection	When this button is pressed, a pop-up bar appears showing the different graph options. The buttons from top to bottom are **Rate**, **Thickness**, **Frequency**, **Power**, and **Rate Deviation**.

6.2.1.1 Graphs

IMC300 draws data for five graphs: Rate, Thickness, Frequency, Power, and Rate Deviation. Examples are provided below.

Rate

The rate graph draws rate data from the selected sensors. Range of the graph is calculated using the following formula:

Upper Range = RoundUp (Max + 1)

Lower Range = RoundDown (Min - 1)

Thickness

The thickness graph draws thickness data from the selected sensors. Range of the graph is calculated using the following formula:

Upper Range = RoundUp (Max + 0.1 kÅ)

Lower Range = RoundDown (Min - 0.1 kÅ)

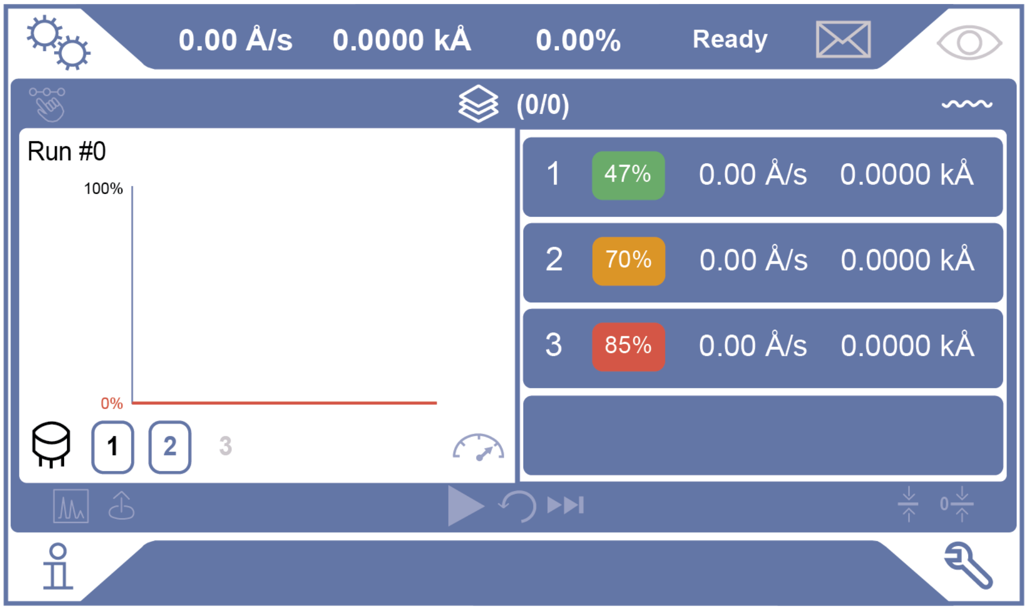
Frequency

The frequency graph draws data from the selected sensors. Range of the graph is calculated using the following formula:

Upper Range = RoundUp ((Max + 1 KHz)/1000)

Lower Range = RoundDown ((Min - 1 KHz)/1000)

Power



The power graph draws data from the selected sensors. This graph does not auto scale, it is always 0% to 100%. If maximum and/or minimum power levels are set, they are displayed as a red line.

Rate Deviation

The deviation graph draws rate deviation data from the selected sensors. This graph does not auto scale, the upper and lower scales are set by the user. If the values are outside of the scales, the value clamps to the top or bottom of the screen.

6.2.1.2 Source Settings

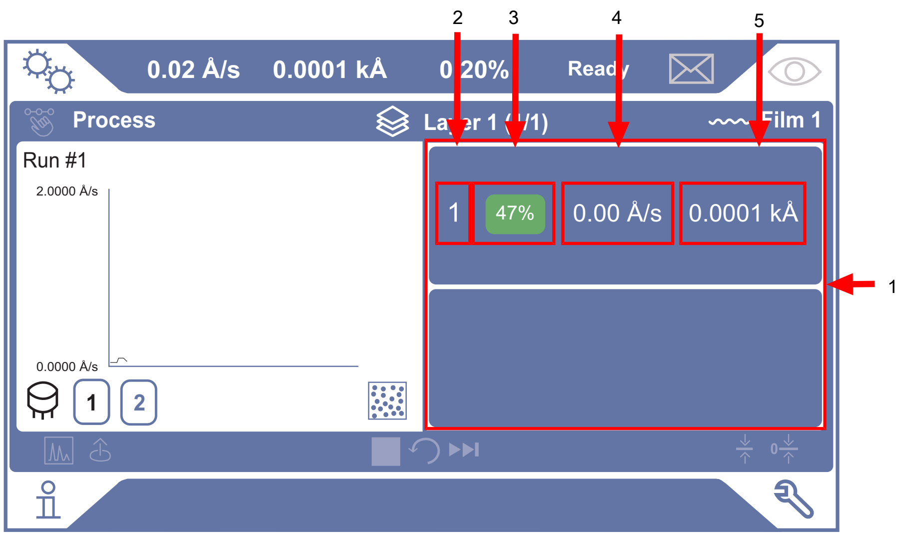
The Source Settings screen is shown below. Once in the source settings, users have the ability to choose between **PID** (proportional integral derivative) or **Manual Power** control. When PID is selected, the manual power will update with the power output allowing the user to easily switch to **Manual Power** at the same level.

1	Source tabs	The four tabs allow the user to select which film source to modify.
2	Final soak power	Final Soak Power is changed by either pressing on the text field, which brings up a numerical keypad the user can enter a value between 0.00% and 100.00%, or pressing the "-" or "+" buttons, which changes the power by 1%.
3	PID toggle	The default power setting is PID. When the toggle is on PID, PID text boxes are enabled and Manual Power entry text box and buttons are disabled. When the toggle is on Manual Power, PID text boxes are disabled and Manual Power entry text box and buttons are enabled.
4	PID edit	When PID is selected, three text boxes are enabled. When text box for "**P**" is pressed, a numerical keypad appears for input of a value between 1 and 9999. When the text box for "**I**" and "**D**" are pressed, a numerical keypad appears for input of a value between 0.0 and 99.9.
5	Source button	Pressing the **Source** icon switches the left panel to display the source settings.

6	Manual power edit	When Manual Power is selected, the text box and buttons are enabled. When the text box is pressed, a numerical keypad appears for the input of a value between 0.00% and 100.00%. When the "**-**" or "**+**" buttons are pressed, the value changes by 0.1%.
7	Sensor	The sensor related to the selected source is highlighted in green.
8	Manual power	When Manual Power is selected, an "**M**" appears next to the power level in orange.

6.2.2 Right Panel

The right panel displays sensor information. If a sensor is not connected, it is displayed as a blank dark blue rectangle as shown in the image below.



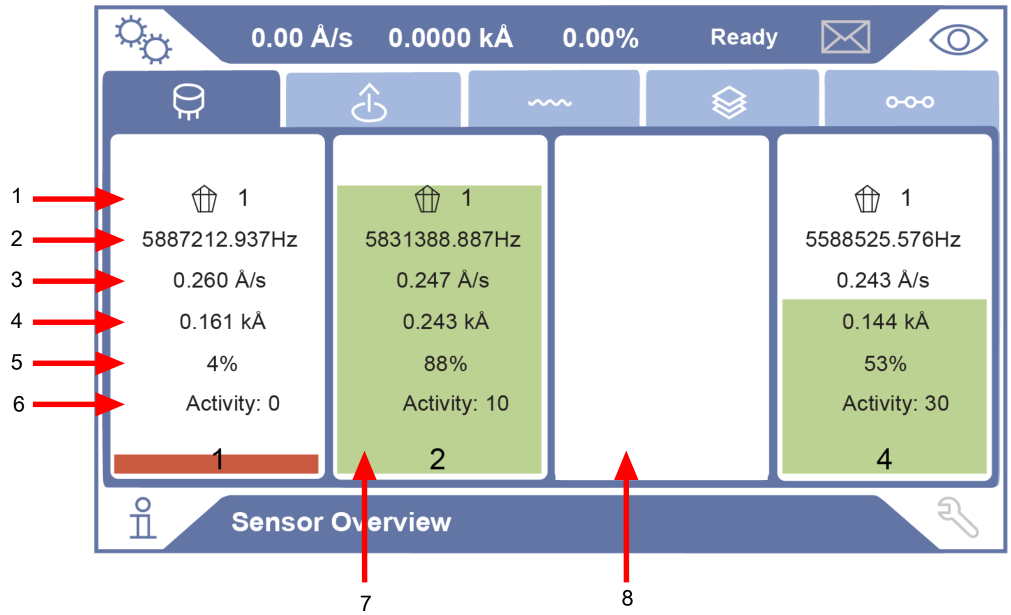
1	Right panel	Displays sensor information.
2	Sensor number	Displays the number of the corresponding sensor. These numbers are static and do not change.
3	Crystal health	Crystal health indicates the percent of crystal life consumed. A crystal that has not reached its crystal life warning limit or crystal life error limit is shown in green. A crystal that has reached its crystal life warning limit (a default value of 70%) shown in orange. A crystal that has reached its crystal life error limit (a default value of 85%) shown in red.
4	Rate	Displays the rate of the sensor. This updates once per second.
5	Thickness	Displays the thickness of the layer on the sensor. This updates once per second.

6.2.3 Bottom Bar

1	Start/stop	Pressing the triangle icon starts the process and changes the triangle to a square. Pressing the square icon stops the process.
2	Reset	Pressing this icon resets the current layer. NOTE: This icon is disabled when a process is running.
3	Next layer	Pressing this icon activates the next layer. NOTE: This icon is disabled when a layer is in progress or when it is on the last layer.
4	Final thickness	Pressing this icon populates the final thickness of the current layer in a text box. A numerical keypad appears for values between 0.00 kÅ to 9999 kÅ to be entered. Pressing anywhere on the screen removes the keypad. Pressing the "-" or "+" buttons changes the thickness by 1Å. NOTE: This icon is only enabled when a process is running.
5	Zero thickness	Pressing this icon sets all sensor's thicknesses to zero.

6.3 Sensor Screen

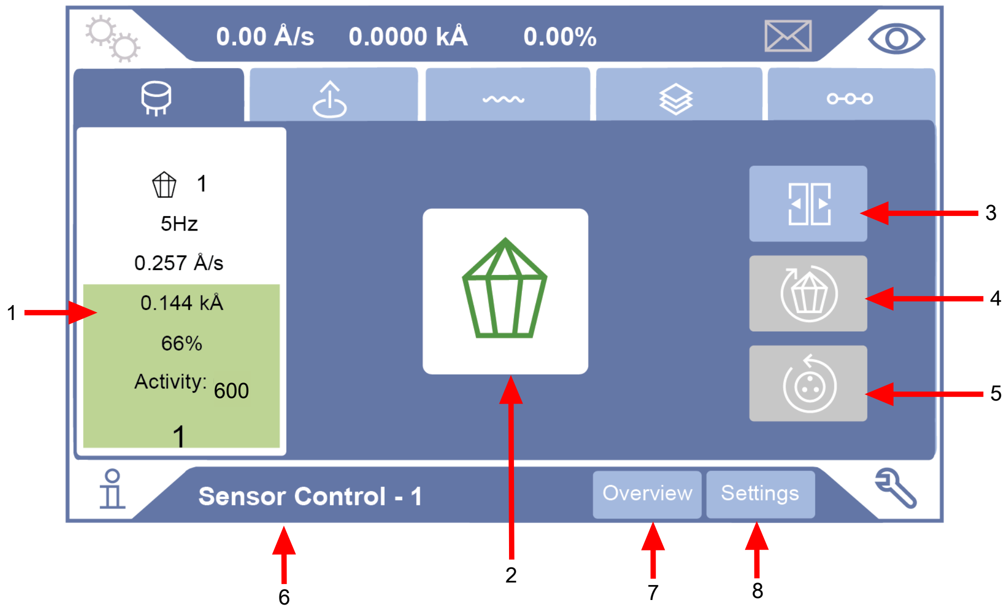
The Sensor screen is shown below.



1	Crystal index	Displays the current position in the Crystal Carousel.
2	Frequency	Displays the frequency in Hertz with three digits after the decimal point.
3	Rate	Displays the rate in Å/s with three digits after the decimal point.
4	Thickness	Displays the thickness in kÅ with three digits after the decimal point.
5	Crystal health	Displays the crystal health in percentage. Green indicates a good crystal, yellow indicates a crystal warning and red indicates a crystal failure.
6	Activity	Measures the sensor's ability to conduct current. This value is useful for predicting when a crystal needs to be replaced. The closer the activity level is to zero, the more imminent a crystal failure.
7	Crystal health vertical bar	A bar showing crystal health is shown. Crystal health indicates the percent of crystal life consumed. A crystal that has not reached its crystal life warning limit or crystal life error limit is shown in green. A crystal that has reached its crystal life warning limit (a default value of 70%) shown in orange. A crystal that has reached its crystal life error limit (a default value of 85%) shown in red.
8	Sensor not connected	When a sensor is not connected, the corresponding rectangle is empty.

6.3.1 Sensor Control

When one of the sensor rectangles is pressed from the Sensor Info screen, the Sensor Control screen is displayed for that sensor.



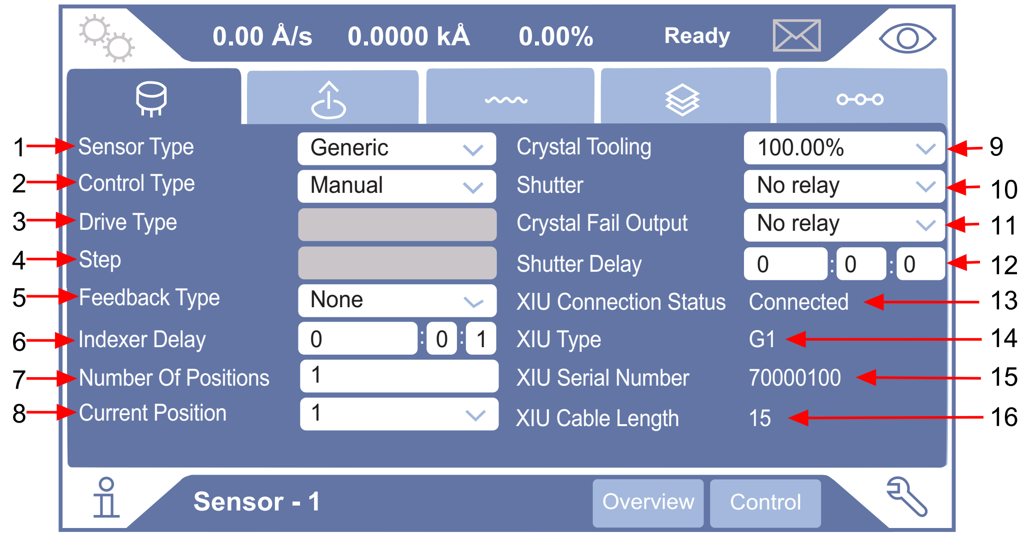
1	Sensor info	The sensor information is displayed the same way it appears on the Sensor Screen [42]. In this screen, the rectangle is not a button.
2	Crystal display	The crystal status is displayed in the same color as its health. If the crystal health is unknown, the crystal is gray. This will also show how many crystals are attached to the sensor. Between 1 to 32 crystals can be attached to the sensor.
3	Shutter control	When this icon is pressed, the crystal shutter opens or closes. If the crystal shutter is not available, the button appears dimmed and disabled.
4	Switch crystal	When this icon is pressed, the crystal is marked as failed and switched.
5	Rotate carousel	When this icon is pressed, the crystal status is checked for each available position and the carousel is rotated.
6	Screen name	Displays what screen the user is on and the sensor that is being used.
7	Overview	When this button is pressed, it takes the user back to the Sensor Overview screen.
8	Settings	When this button is pressed, it takes the user to the settings for the selected sensor.

6.3.2 Sensor Settings

This screen is used to setup the sensors.

NOTICE

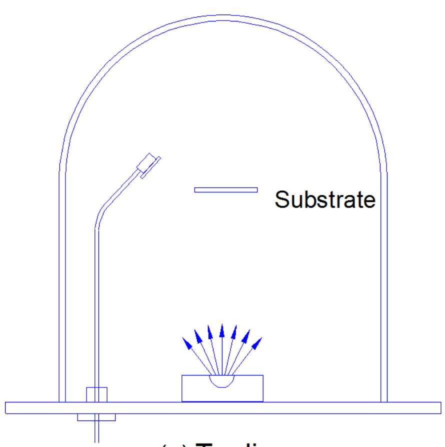
When Sensor Type is "Single," Crystal Switch Out is disabled.



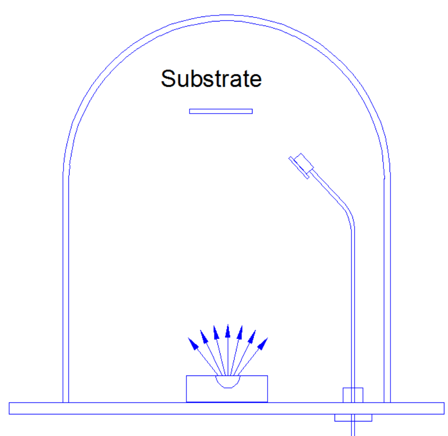
1	Sensor Type	Choose the sensor type using the drop-down menu, which contains Single, XtalTwo, XtalSix, Crystal12, and Generic sensor options. The default is Single.
2	Control Type	Choose the control type using the drop-down menu, which contains Manual, Direct, BCD, and Individual control options.
3	Drive Type	Defines the drive direction for Direct Control.
4	Step	This field is only enabled when the control type is Direct. Choose between Single Step and Double Step with the drop down menu.
5	Feedback Type	Chose the feedback type using the drop down menu, which contains None, Individual, BCD, Single Home, and In Position.
6	Indexer Delay	Set the Indexer Delay by hour, minute, and second. Pressing the hour text box generates a numerical keypad for values between 0 and 999 to be entered. Pressing the minute or second text boxes generates a numerical keypad for values between 0 and 59 to be entered.
7	Number of Positions	Set the number of positions by pressing the text box. A numerical keypad appears for values between 1 and 32 to be entered.

8	Current Position	Choose the current position by selecting a value in the drop down list, between 1 and the "Number of Positions" entered above.
9	Crystal Tooling	Set the crystal tooling by pressing the text box, a numerical keypad appears for values between 1.0% and 10000% to be entered.
10	Shutter	The shutter output and which relay number are assigned for controlling the sensor shutter function appear here. Any relays that appear dimmed in the selection box are not assigned to another function and are not available. The default value is No relay.
11	Crystal Fail Output	The assigned output that is triggered if the all of the crystals in the sensor have failed. The default value is No relay.
12	Shutter delay	Set the Shutter Delay by hour, minute, and second. Pressing the hour text box generates a numerical keypad for values between 0 and 150 to be entered. Pressing the minute or second text boxes generates a numerical keypad for values between 0 and 59 to be entered. The default value is 00:00:00.
13	XIU connection status	Displays the connection status of the XIU.
14	XIU type	Displays which XIU type is being used.
15	XIU serial number	Displays the XIU serial number.
16	XIU cable length	Displays the length of the cable (in feet) from IMC300 to the XIU.

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



(a) Tooling Over 100%



(b) Tooling Under 100%

In figure (a), the sensor will measure less rate or thickness than is actually deposited on the substrate due to the positioning of the sensor above the substrate. In figure (b), the sensor will measure more rate or thickness than is actually deposited on the substrate due to the positioning of the sensor below the substrate.

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, increase the tooling value. If the rate or thickness reading is high, decrease the tooling value.

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 a relay to control the shutter.

Shutter Delay: If the Yes option is selected for shutter, enter the time required for the shutter to open and the rate to 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, 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 required for a multi-crystal sensor.

Manual: Not under control of IMC300. With manual control, IMC300 will stop the process upon the completion of the current layer. If the next layer requires a different crystal position, a message is displayed requesting the number of the crystals required. Once the position has been changed, press the **Continue** button.

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 used 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 up and down outputs. IMC300 will then determine the fastest direction to the target crystal position by activating the appropriate output. The Inline drive type informs IMC300 that continuous travel in one direction is not possible. Therefore to get from position 6 to 1, the direction must be down until 1 is reached.

NOTE: Fast and Inline are not available at first release of this product.

Single Step and Double Step: Used when multi-crystal sensor heads are actuated by pulsing a pneumatic value. CrystalSix rotary sensor uses Double Step. Crystal 12 and RSH-600 rotary sensors use Single Step.

BCD: Select when position control is through an external rotation controller, which accepts Binary Coded Decimal (BCD) inputs for position selection. BCD inputs are common because they require only a few signal lines to select several positions. IMC300 automatically creates the number of relay outputs required to interface with the external controller.

Individual (discrete): Select when position control requires a unique signal line for each position. IMC300 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 IMC300 identifies the current crystal position.

NOTE: Generic feedback is not available at first release of this product.

None: No crystal feedback is provided. IMC300 tracks crystal position from the current position setting (above). This setting is used for the CrystalSix and Crystal 12 rotary sensors.

Individual (discrete): 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 RSH-600 rotary sensor.

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 selected as None, IMC300 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, IMC300 will wait this time for the pocket to reach the target position. If it does not receive the feedback signal, a Pocket Wait Timeout error is issued.

***** Not available at this time.

6.3.3 Crystal Switching

IMC300 offers a choice of Single, XtalTwo (CrystalTwo), XtalSix (CrystalSix), Xtal12 (Crystal 12®), or Generic sensors. The CrystalTwo, CrystalSix, Crystal 12, and Generic sensors provide one or more backup crystals in case a crystal fails during deposition. Sensor types are specified on the Sensors screen.

The XtalTwo option requires the 779-220-G1 or 779-220-G2 CrystalTwo Switch. The CrystalTwo Switch is connected to any sensor input through an XIU package. A Dual Sensor head can also be used by configuring it as two single sensors with the second Dual Head Sensor configured as Backup Sensor by using an XIU in place of the 779-220-Gx CrystalTwo Switch. The normally uncovered crystal is connected to Sensor x, the backup crystal normally covered by the shutter is connected to Sensor y (where y is any available sensor channel). Sensor y is configured as Backup Sensor for Sensor x in the Sensor page of the Material screen and must have a shutter output assigned in the Sensor page of the Sensor screen. The manual Switch Crystal function is not available in this configuration. To calibrate the Backup Sensor, temporarily set it to be the Sensor.

All multi-position and shuttered sensors require the Pneumatic Actuator Control Valve, part number 750-420-G1, and a feedthrough with an air tube.

A crystal switch automatically occurs when:

- IMC300 is configured for a XtalTwo (CrystalTwo) sensor type, a layer is STARTed or running and there is another good crystal available when the active crystal fails.
- IMC300 is configured for a XtalSix, Xtal12 or Generic, a layer is STARTed or running, and there is at least one good crystal left in the carousel when the active crystal fails.
- A layer is configured with a Backup sensor, a layer is running on the primary sensor, and the last crystal of the primary sensor fails.
- IMC300 is configured for a XtalTwo or single head with Backup, a START is executed and the designated primary sensor is different from the last sensor run.
- Using a XtalSix or Xtal12 and pressing START if the current position is not within the First/Last Xtal position range listed on the Sensor page of the Material screen.
- S and Q levels are exceeded while in deposit.

A crystal switch does **NOT** *automatically* occur:

- During a state of STOP, READY, or IDLE.
- When the designated primary sensor and backup sensor fail during pre-deposit. (A SUSPEND occurs if the failure action is configured for Time Power.)
- During deposition if the secondary crystal of a XtalTwo switch fails, or the Backup sensor, or the last good crystal of a XtalSix, Xtal12 or Generic fails. (In either case a TIME-POWER, SUSPEND, POST DEPOSIT, or STOP occurs, depending on the failure option chosen.)

A crystal switch can be manually executed via the front panel, handheld controller, remote communications, or logic statements when the system is configured for a multi-position sensor.

NOTICE

When crystal switching with the handheld controller, IMC300 must be on the Sensor screen and the cursor on the appropriate sensor number. Only the active sensor, the one defined in the current process or sensor 1, can be switched using the handheld controller.

6.3.3.1 XtalTwo (CrystalTwo)

In the case of the XtalTwo (a Dual Sensor head with a 779-220-G1 or 779-220-G2 CrystalTwo Switch), the CrystalSwitch output must be wired so that it simultaneously energizes the Pneumatic Shutter Actuator Control Valve which applies the air pressure to actuate the dual sensor shutter mechanism and the RF relay in the CrystalTwo Switch, exposing crystal #2 while covering crystal #1 and rerouting the RF signal. This allows the dual sensor to be operated with only one oscillator kit and requires only one sensor connection at IMC300.

Power-up initialization is performed on a dual sensor to verify that the back-up crystal is good.

If a crystal fail occurs while in Deposit, IMC300 switches to the second crystal and continue. IMC300 runs the next layer using the last crystal position it switched to. While in Ready, the Failed Crystal list can also be cleared by executing a crystal switch with the handheld controller or by pressing the Switch Crystal function key in the Sensor screen or via communications command RN**18 (Switch Crystal). A good crystal must be available to switch to in the case of using the crystal switch method.

6.3.3.2 XtalSix (CrystalSix)

On power-up, all crystals are read to determine how many good and bad crystals are present. IMC300 uniquely identifies and tracks all six positions in the CrystalSix.

During deposition, when there is a crystal failure, IMC300 automatically switches to the next position with a good crystal. When the last good crystal fails and a backup sensor is not available, the Xtal Fail message is displayed, the Xtal Fail state becomes true and IMC300 goes directly to Time Power, POST DEP, SUSPEND or STOP, as appropriate.

When the sensor selected is a XtalSix, the relay contacts are pulsed closed for one second, opened for one second, closed for one second, then opened for each position. The first one second closure advances the CrystalSix carousel into an intermediate position between two crystals. Opening the closure for one second allows the ratchet mechanism to relax whereupon the second contact closure advances the next crystal into the proper position.

Make sure that all positions have a crystal since XtalSix will not be able to rotate the carousel past an empty position.

6.3.3.3 Xtal12 (Crystal 12)

On power-up, IMC300 rotates the sensor until position 1 is detected. It continues to rotate through the other 11 positions to determine the state of all crystals. At the conclusion of the sequence, the Sensor screen shows the sensor in position 1 and the position number of any failed crystals. The Crystal 12 has resistors electrically in parallel for each of the 12 positions. IMC300 verifies that the resistance value is correct at each position. If the value is not as expected, IMC300 pulses again and rechecks the position. If position 1 is not detected, or after 13 pulses of the wrong value, IMC300 reports a Crystal Sw Fail message. In that case, all crystals are also marked as failed, except for current position status.

A Crystal Switch or Rotate Sensor function must be initiated in the Sensor screen or via Remote Communication to enable IMC300 to catalog the state of all crystals and to return to position 1. This must also be done after the sensor type has been changed to Xtal12. The Rotate Head Function is permitted only if IMC300 is in Ready, Stop, or all active layers are in Idle or Suspend.

During deposition, IMC300 automatically switches to the next position with a good crystal when there is a crystal failure. When the last good crystal fails, and no backup sensor is available, the Crystal Fail message is displayed, the Xtal Fail state becomes true and IMC300 goes directly to Time Power or STOP, POST DEP, SUSPEND, as appropriate.

When configured for a Xtal12, the relay contacts are only pulsed closed for one second then opened again once for each position. There is no intermediate position.

Make sure that all positions have a crystal since Xtal12 will not be able to rotate the carousel past an empty position.

6.3.3.4 Generic Sensor Crystal Switching

Selecting Generic as the sensor type enables sequential crystal switching for the Number of Positions selected (maximum of 32). Upon a crystal switch, the Switch Output first closes for 1 second pulse on and 1 second pulse off. The setting step determines how many On/Off pulse sequences will occur for each movement to the next crystal position. IMC300 tracks the position and which are good and failed, it cannot detect what position it is in at start.

After a crystal switch sequence, IMC300 attempts to find the resonant frequency for the crystal in this position. If IMC300 does not find a good resonant frequency for this crystal, it again pulses the Crystal Switch Output and attempts to find a resonant frequency at the next position. The maximum number of attempts to find a good resonant frequency is one less than the Number of Positions value. If a good resonant frequency is not found after all attempts, IMC300 enters the Time Power, POST DEP, SUSPEND or STOP state depending on the Sensor / Option Action chosen in the Material/Sensor display.

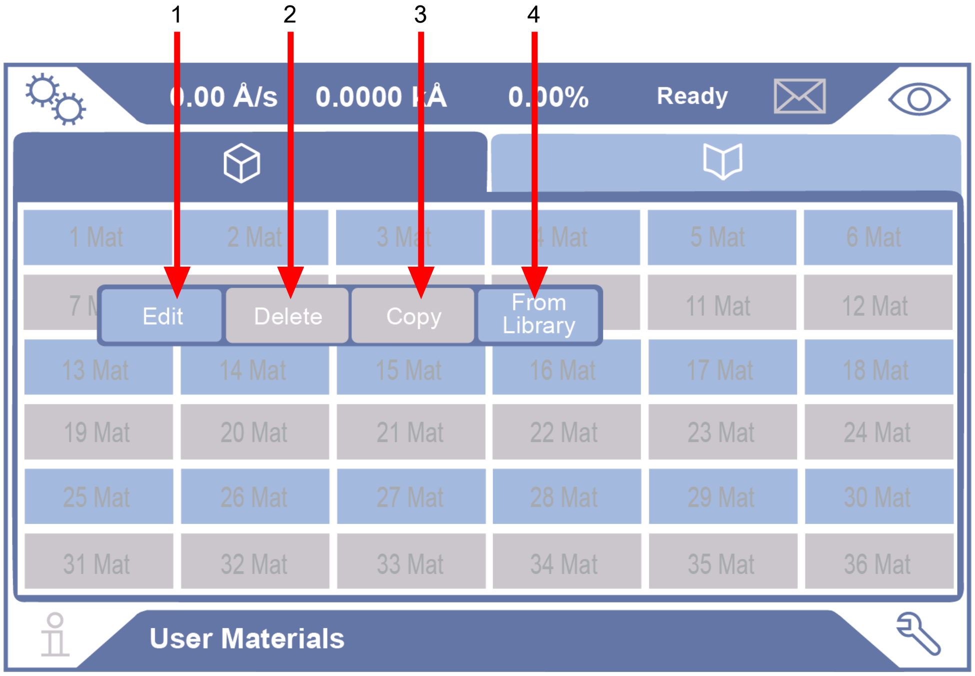
6.4 Material Screen

Pressing the on the bottom left corner of the screen brings you to the Material Screen, shown below.

Materials that have been defined by the user appear in black. Materials that have not been defined by the user appears dimmed. This screen is scrollable to view more materials.

6.4.1 Material Edit

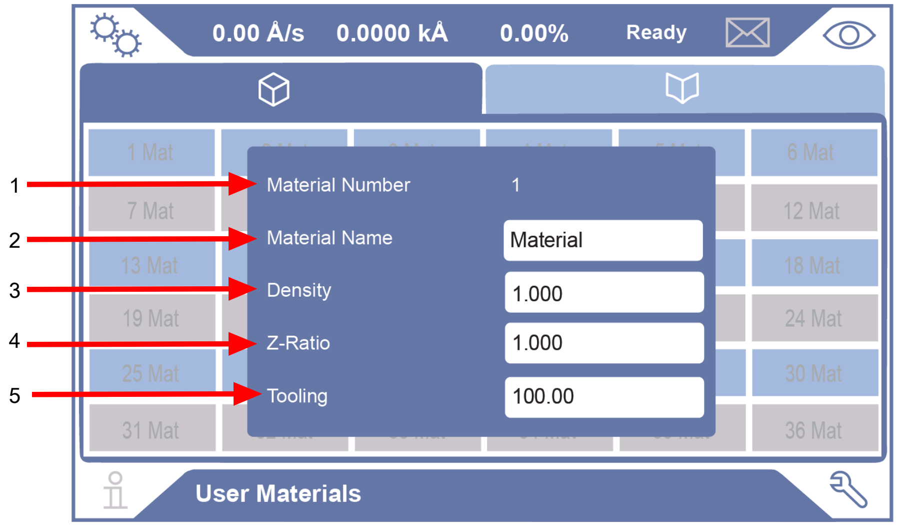
Selecting a material highlights the material and brings up the edit menu, shown below. Pressing anywhere else on the screen removes the menu.



1	Edit	Pressing the Edit button brings up the Edit Menu to alter the Material configuration. This menu has five fields: Material Number, Material Name, Density, Z-ratio, and Material Tooling. See Edit Screen [▸ 53].
2	Delete	Pressing the Delete button deletes the selected material.
3	Copy	Pressing the Copy button copies the selected material. Selecting another material changes Copy to Paste (not shown), allowing users to paste the copied material.
4	From library	Pressing the From Library button brings up the Material Library. See Material Library [▸ 54].

6.4.1.1 Edit Screen

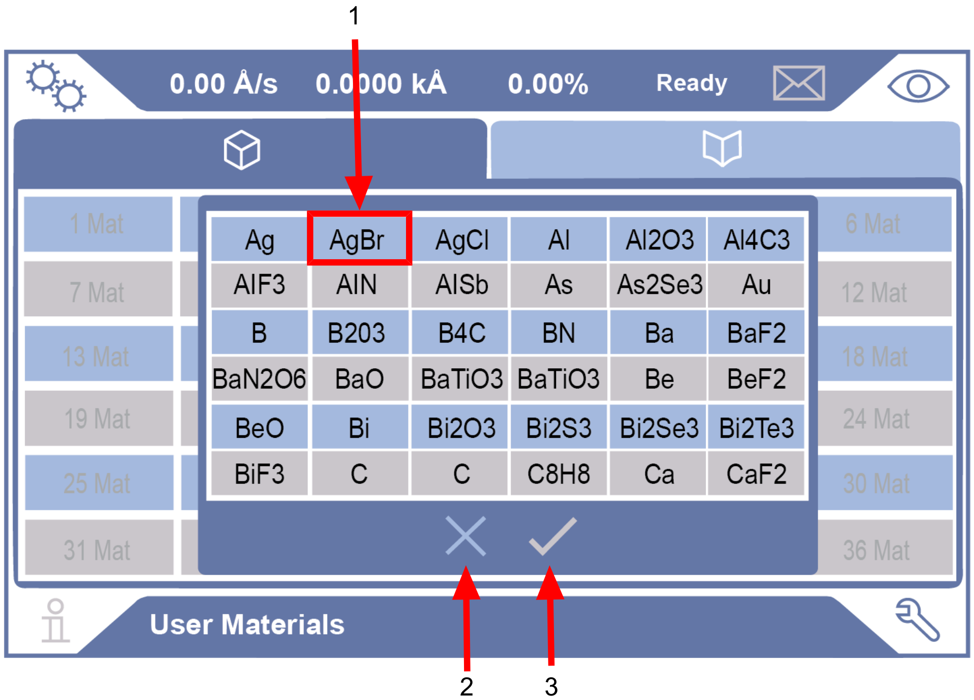
Pressing the Edit button brings up the Edit screen, shown below.



1	Material number	This is a label that cannot be changed.
2	Material name	Pressing this text box brings up an alphanumerical keyboard that accepts up to 30 characters. The default name is Material.
3	Density (g/cm^3)	Pressing this text box brings up a numerical keypad that accepts values between 0.100 to 99.999. The default value is 1.00.
4	Z-Ratio	Pressing this text box brings up a numerical keypad that accepts values between 0.100 to 15.000. The default value is 1.00.
5	Tooling	Pressing this text box brings up a numerical keypad that accepts values between 1.00 and 10000.00. The default value is 100.00.

6.4.1.2 Material Library

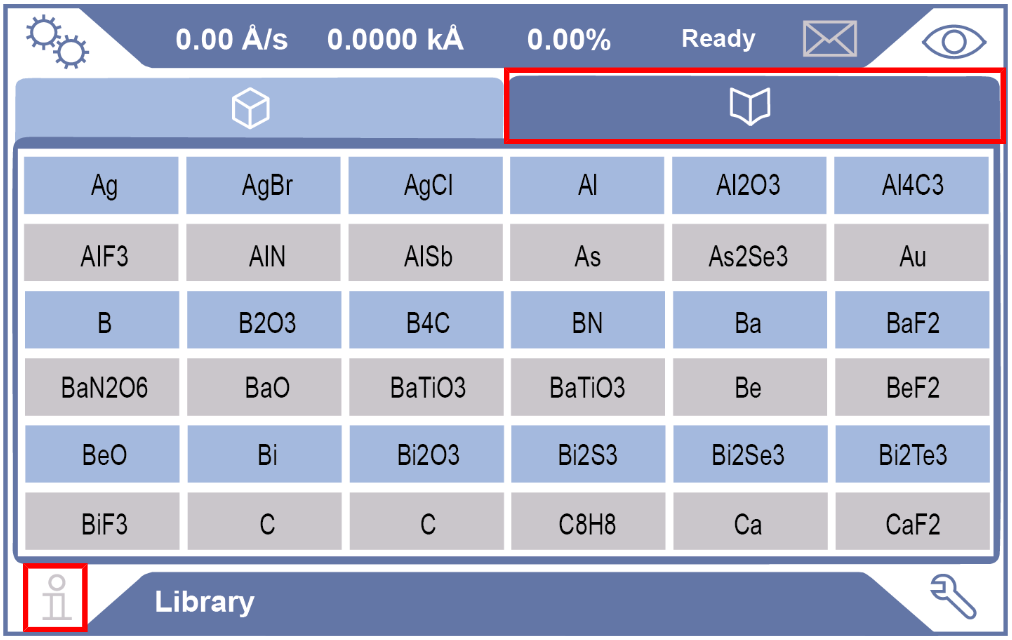
Pressing the From Library button brings up the Material Library, shown below.



1	Selected material	Selecting a material highlights it.
2	Cancel	Pressing this button closes the library and does not make any changes to the materials.
3	Select	Pressing this button saves that material over the selected material.

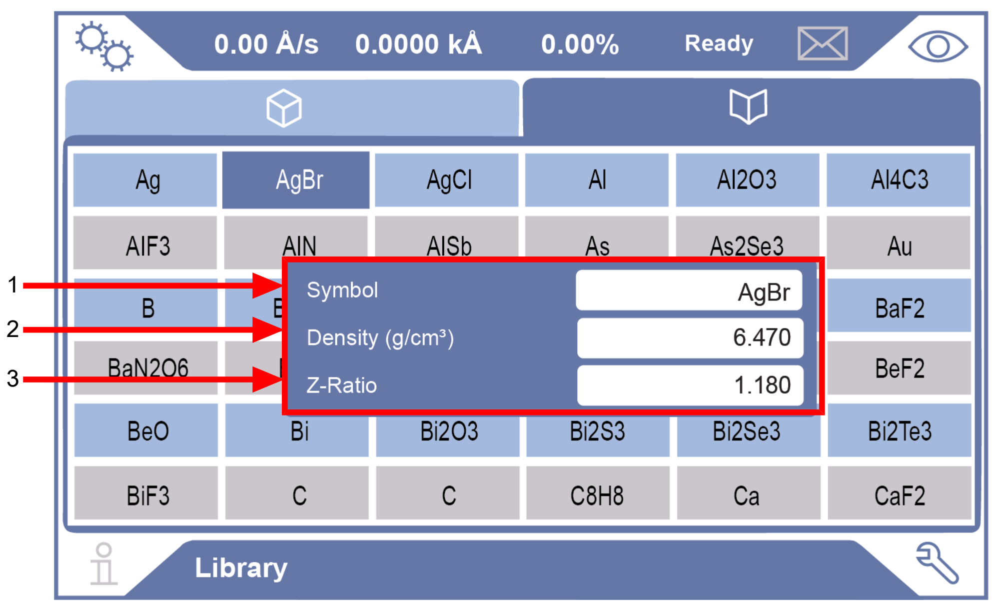
6.5 Library Screen

The Library Screen, shown below, is accessed by first pressing the icon on the bottom left corner of the screen, followed by the icon.



6.5.1 Material Edit

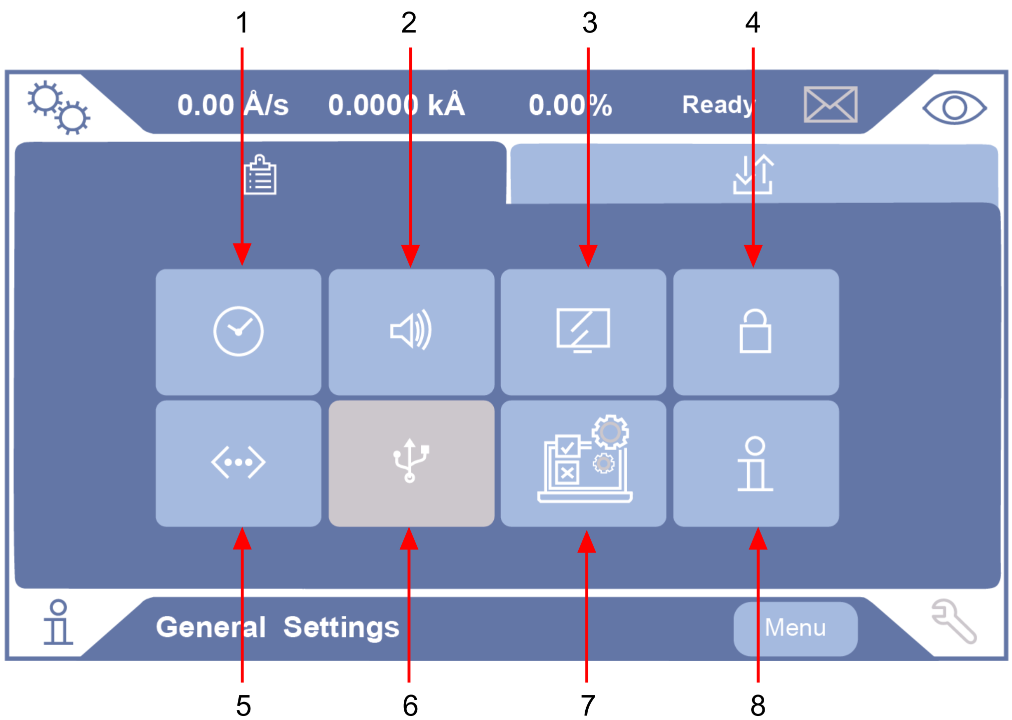
The Library screen displays the material library. When a material is selected, it is highlighted and a menu pops up with three fields that are not user editable.



1	Symbol	The elemental symbol for the selected material.
2	Density (g/cm^3)	The density for the selected material.
3	Z-Ratio	The Z-ratio for the selected material.

6.6 Settings Screen

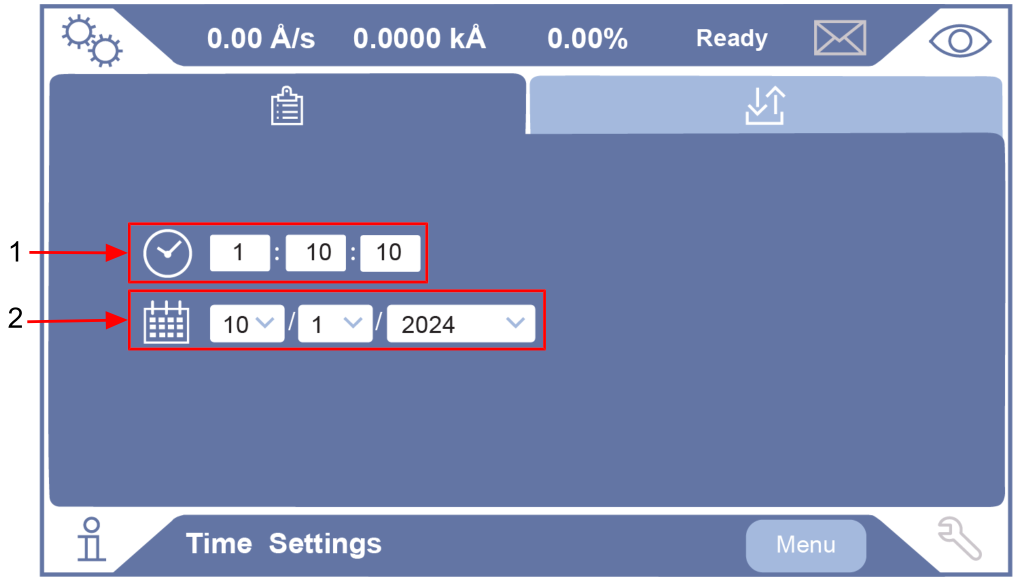
Pressing the 🔧 on the bottom right corner of the screen brings you to the Settings Screen, shown below.



1	Time	Pressing the time button brings the user to the Time Settings screen. See Time Settings [▸ 57].
2	Sound	Pressing the audio button brings the user to the Audio Settings screen. See Sound Settings [▸ 57].
3	Screen	Pressing the display button brings the user to the Display Settings screen. See Screen Settings [▸ 58].
4	Lock	Pressing the lock button brings the user to the Lock Settings screen. See Lock Settings [▸ 59].
5	Communication	Pressing the communication button brings the user to the Communication Settings screen. See Communication Settings [▸ 60].
6	File	File Settings screen is not available at first release of this product.
7	Graph	Pressing the graph button brings the user to the Graph Settings screen. See Test Settings [▸ 62].
8	System information	Pressing the system information button brings the user to the System Information screen. See System Information [▸ 63].

6.6.1 Time Settings

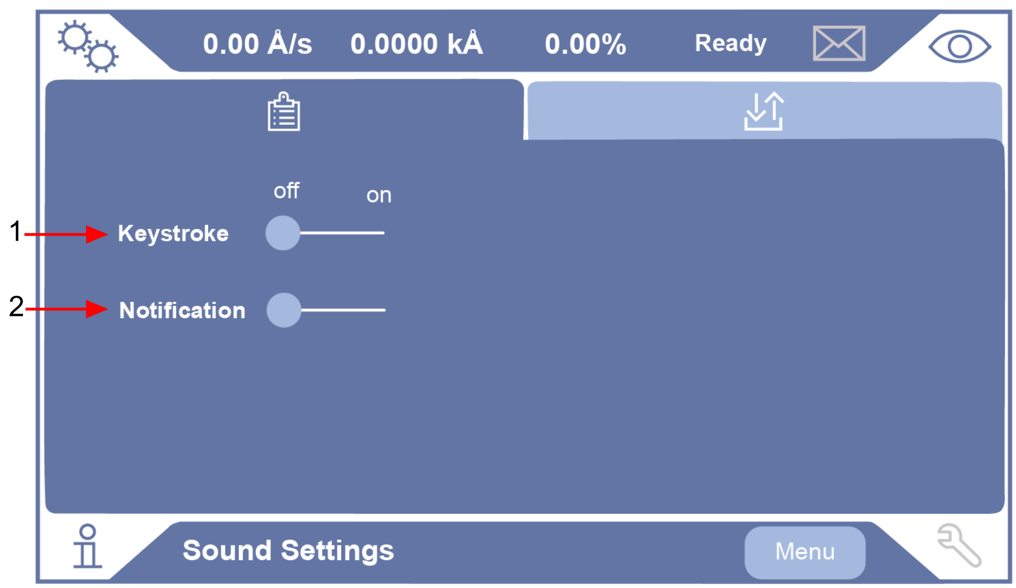
Pressing the ⏲ icon brings the user to the Time Settings screen, shown below.



1	Time	Allows the user to set the time on the instrument. Format is shown as hh:mm:ss, 24-hour configuration.
2	Date	Allows the user to set the date on the instrument. Format is shown as month day year.

6.6.2 Sound Settings

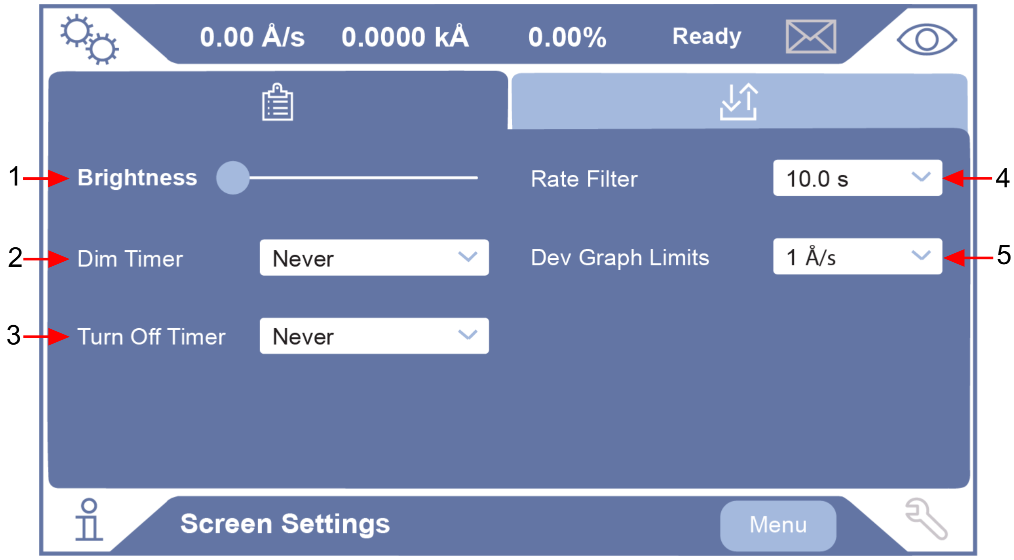
Pressing the 🕪 icon brings the user to the Sound Settings screen, shown below.



1	Keystroke	Activates keystroke sound. The default value is off.
2	Notification	Activates notification sounds. The default value is off.

6.6.3 Screen Settings

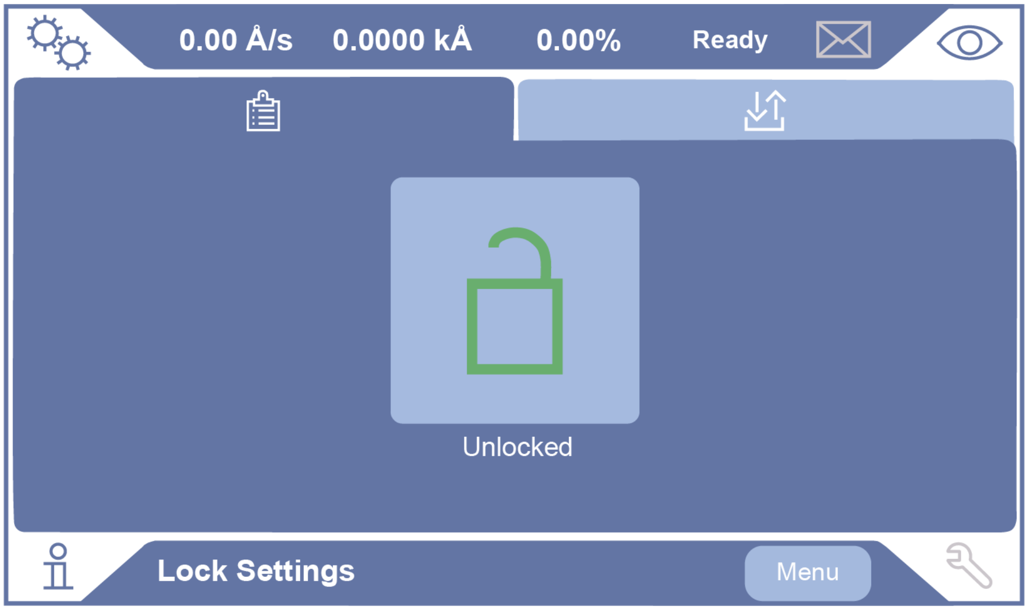
Pressing the icon brings the user to the Screen Settings screen, shown below.



1	Brightness	Allows the user to set the screen brightness. The default value is the lowest brightness, with the slider to the left.
2	Dim Timer	When the drop-down menu is selected, users can choose timers between 1, 2, 3, 5, 10, 15, or 30 minutes, 1, 2, or 5 hours, and Never to dim the screen. The default value is Never.
3	Turn Off Timer	When the drop-down menu is selected, users can choose timers between 1, 2, 3, 5, 10, 15, or 30 minutes, 1, 2, or 5 hours, and Never to turn off the screen. The default value is Never.
4	Rate Filter	When the drop-down menu is selected, users can choose between 0.1, 0.4, 1.0, 4.0, 10.0, 20.0, or 30.0 seconds. The default value is 10.0 s.
5	Dev Graph Limits	When the drop-down menu is selected, users can choose between 1, 2, 3, 4, 5, 10, or 15 Å/s. The default value is 1 Å/s.

6.6.4 Lock Settings

Pressing the icon brings the user to the Lock Settings screen, shown below.

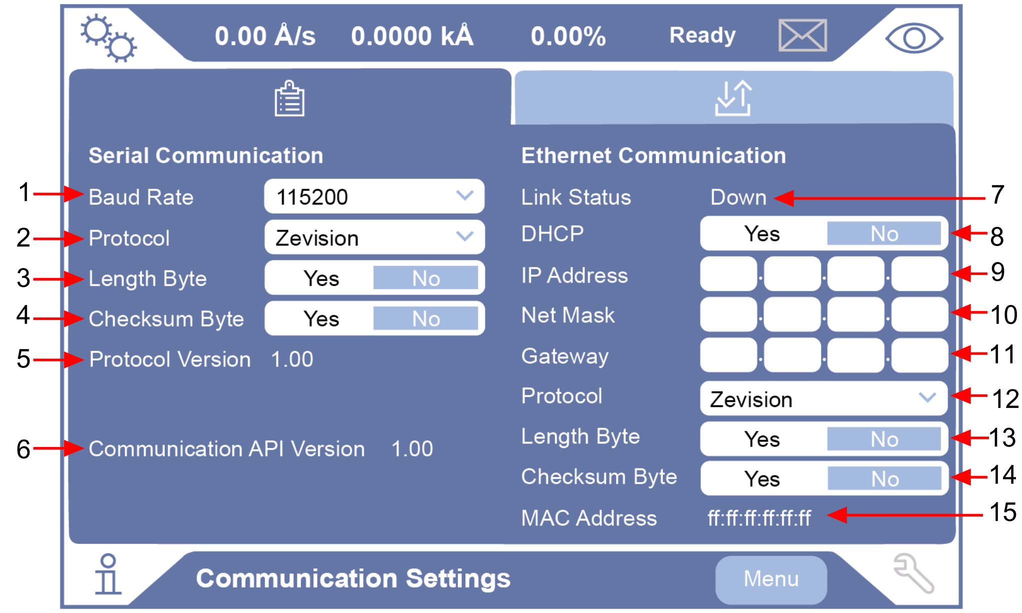


The lock settings screen allows the user to prevent changes to the configurations by setting a four digit pin. Pressing the lock icon populates a numeric keypad. Locking the instrument only allows the user the ability to start/stop a process and enter manual power. The default state is unlocked.

NOTE: Issuing this command UG0E02:0 will clear the lock screen if the pin is not available. See Communication [104] for more information.

6.6.5 Communication Settings

Pressing the <-> icon brings the user to the Communication Settings screen, shown below.



1	Baud Rate	Choose the baud rate using the drop-down menu, which contains 115200. The default value is 115200.
2	Protocol	Choose the communication protocol using the drop-down menu, which contains Zevision and XTC3.* The default value is Zevision.
3	Length Byte	Specifies whether commands/responses will have two length bytes at the beginning of the command/response. See Communication [▸ 104] for more information. The default value is No.
4	Checksum Byte	Specifies whether commands/responses will have a checksum byte at the end of the command/response. See Communication [▸ 104] for more information. The default value is No.
5	Protocol Version	This label shows the current version of the protocol to maintain compatibly.
6	Communication API Version	This label shows the current version of the Commands supported to maintain compatibly.
7	Link Status	Indicates the status of the Ethernet Communication link, Up or Down.
8	DHCP	This field allows you to enable or disable DHCP. The default value is Yes.

9	IP Address	Sets the Static IP address when DHCP is disabled. Displays the IP Address when DHCP is enabled. This field brings up a numerical keypad that accepts input between 0 and 255, when DHCP is disabled.
10	Net Mask	Sets the Net Mask when DHCP is disabled. Displays the Net Mask when DHCP is enabled. This field brings up a numerical keypad that accepts input between 0 and 255, when DHCP is disabled.
11	Gateway	Sets the Gateway when DHCP is disabled. Displays the Gateway when DHCP is enabled. This field brings up a numerical keypad that accepts input between 0 and 255, when DHCP is disabled.
12	Protocol	Ethernet Interface: Choose the communication protocol using the drop-down menu, which contains Zevision and XTC3. The default value is Zevision.
13	Length Byte	Ethernet Interface: Specifies whether commands/ responses will have a length byte at the beginning of the command/response. See Communication [▸ 104] for more information. The default value is No.
14	Checksum Byte	Ethernet Interface: Specifies whether commands/ responses will have a checksum byte at the end of the command/response. See Communication [▸ 104] for more information. The default value is No.
15	MAC Address	A MAC address is a unique identifier assigned to a network interface controller for use as a network address in communications within a network segment.

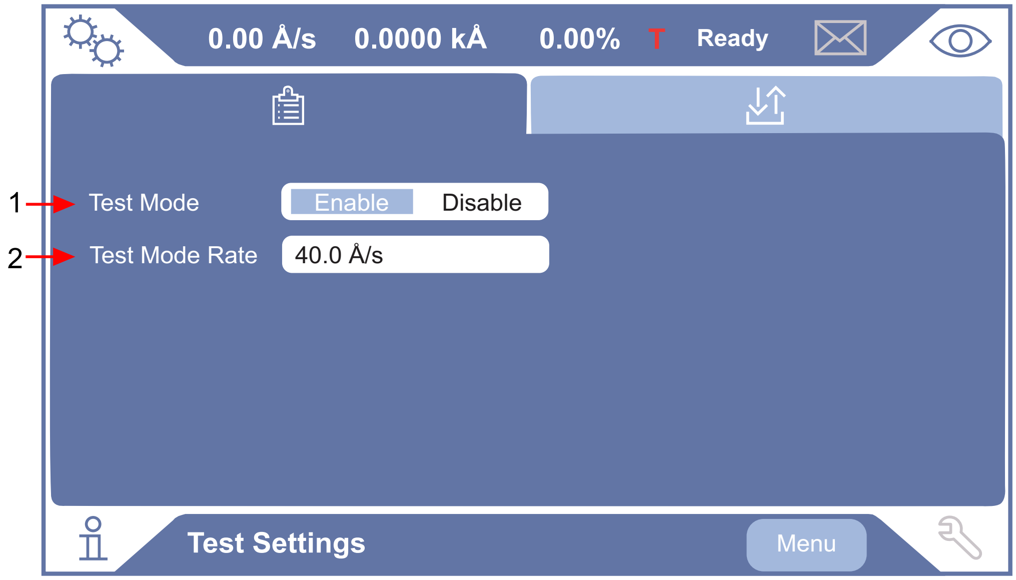
* UG commands are not available in the XTC/3 protocol.

6.6.6 File System

File System is not available for the first release of this product.

6.6.7 Test Settings

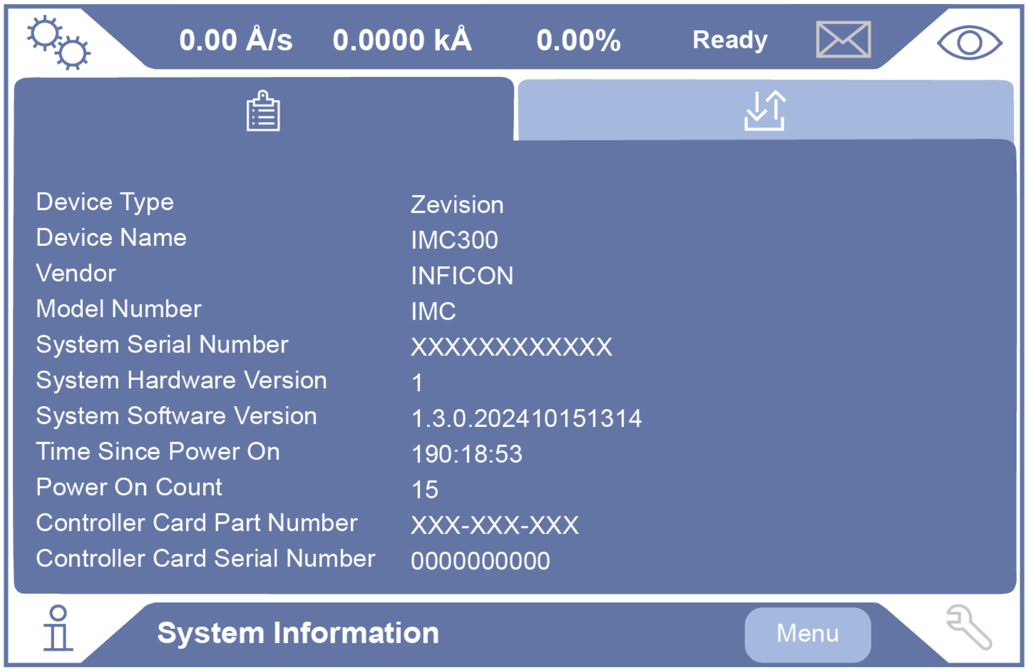
Pressing the icon brings the user to the Graph Settings screen, shown below.



1	Test Mode	This field allows you to enable or disable Test Mode. When enabled, a red T will appear on the top bar to indicate the system is in test mode as shown above. Test mode can only be enabled when the system is in the ready state. The default value is Disable. Test Mode allows the system to operate without a sensor attached to allow the configuration to be tested. The sensor will be spoofed and an artificial rate will be injected into the simulation.
2	Test Mode Rate	This field allows you to select what the rate will be set to while in test mode. The default value is 40 Å/s. Test Mode Rate can be updated at any time.

6.6.8 System Information

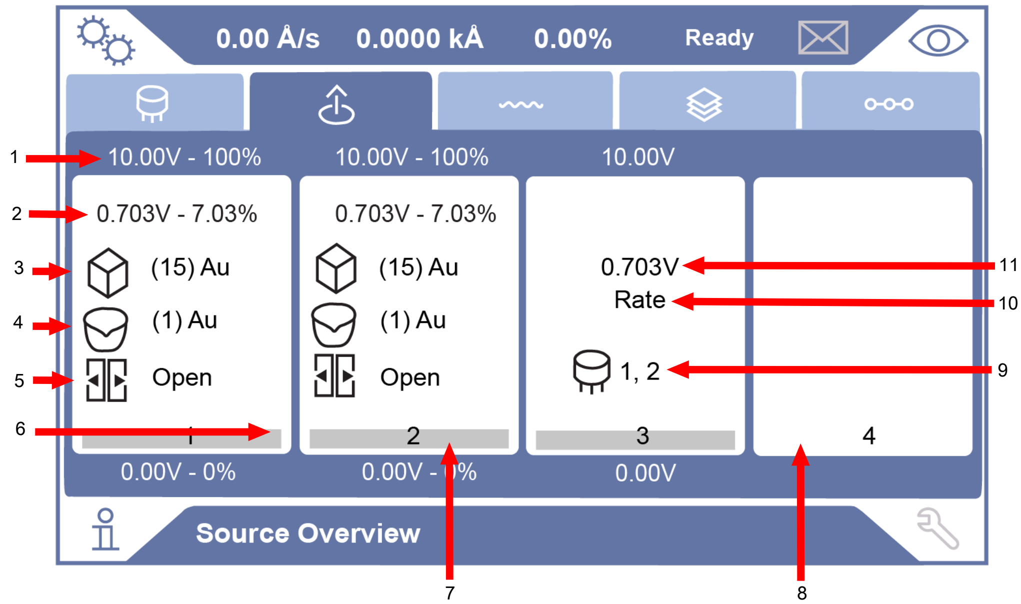
Pressing the ℹ icon brings the user to the System Information screen, shown below.



The System Information screen displays the user information pictured above.

6.7 Source Screen

The source overview screen is shown below.



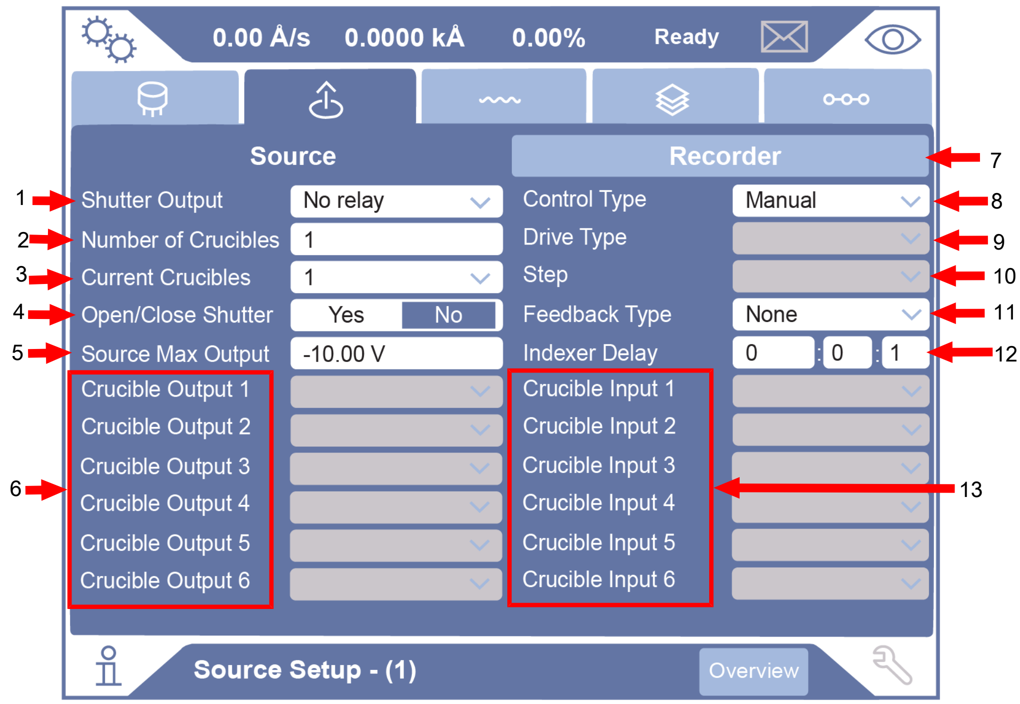
1	Output range	Displays the upper output range at the top of the source/ recorder output bar and the lower output range at the bottom of the source/recorder output bar.
2	Source power output	Displays the source voltage and percent power.
3	Material	Displays the current source material.
4	Crucible	Displays the current crucible position.
5	Source shutter status	Indicates the source shutter position.
6	Output number	Displays the source/recorder output number.
7	Percent output vertical bar	A vertical bar is displayed corresponding to the percent power.
8	Output not configured	When a source or recorder output is not configured, the corresponding rectangle is empty.
9	Recorder output assigned sensor(s)	Displays which sensors are selected for recorder output.
10	Recorder data type	Displays the data type being recorded.
11	Recorder output voltage	Displays the recorder output voltage.

6.7.1 Source Setup

IMC300 provides the capability to configure the four source control channels. Each source control channel is treated as an individual device.

When one of the source/recorder output rectangles is pressed from the Source Overview screen, the Source Setup screen is displayed for the selected source.

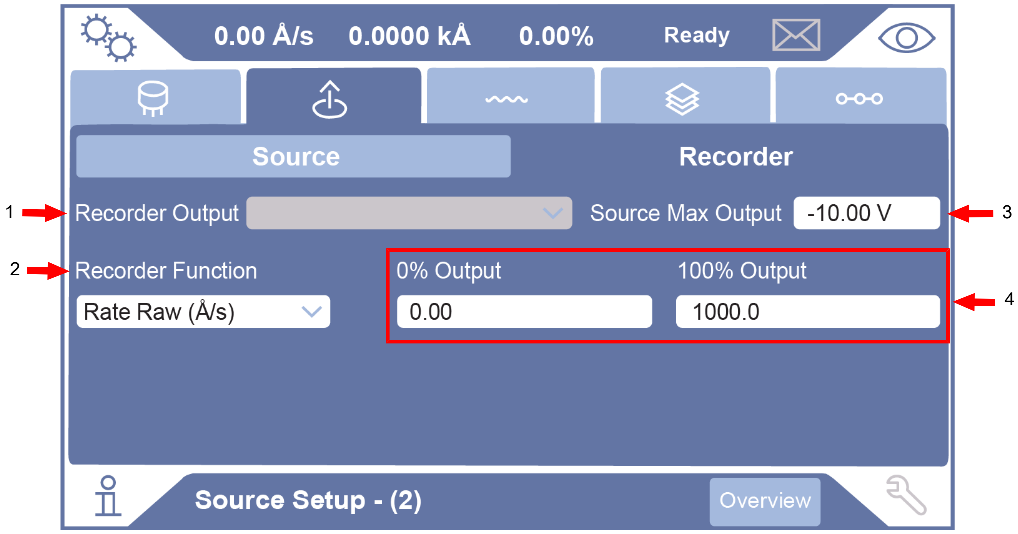
Source



1	Shutter Output	The relay assigned for the source shutter function appears here. Clicking the drop down menu will show the available relays to be assigned to this function. The default value is No relay.
2	Number of Crucibles	0-32 crucibles can be entered. The number of crucibles populates the number of materials under the crucible material list. The default value is 1.
3	Current Crucible	This field allows you to identify what crucible position is physically in position for the source. The default value is 1.
4	Open/Close Shutter	This field allows you to identify if the source has a source shutter. The default value is No.
5	Source Max Output	Maximum source output voltage. Output voltage range is from -10.00 V to +10.00 V. The default value is -10.00 V.

6	Crucible Output	A list of the Relay ID's of the crucible outputs appears here. The number changes depending on the configuration. These outputs control the crucible switcher. The default value is No relay.
7	Recorder	Displays the Recorder Setup screen.
8	Controller Type	Source control type can be setup as manual, direct, individual, or BCD. When manual is selected, the crucible output, drive type, and step parameters are disabled. When individual or BCD control type is selected, the drive type and step parameters are disabled. When direct is selected, the crucible output, drive type, and step parameters are all enabled. The default value is Manual.
9	Drive Type	Defines the drive direction for Direct Control.
10	Step	Single Step and Double Step: Used when multi-crystal sensor heads are actuated by pulsing a pneumatic value. This is the number of pulses needed by the pneumatic valve to rotate the carousel one position. A pulse is one second on and one second off. CrystalSix rotary sensor uses Double Step. Crystal 12 and RSH-600 rotary sensors use Single Step. NOTE: When changing to Crystal 12 or CrystalSix the system will select the correct step value and not allow it to be changed.
11	Feedback Type	Defines the type of feedback for a multi-crystal sensor head. This is how the IMC300 identifies the current crystal position. The default value is None.
12	Indexer Delay	This parameter has two different functions. If the Feedback Type is selected as None, IMC300 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, IMC300 will wait this time for the pocket to reach the target position. If it does not receive the feedback signal, a Pocket Wait Timeout error is issued. The default value is 0 : 0 : 1.
13	Crucible Input	A list of the Feedback Input ID's for the crucible switcher appears here. The number changes based on the configuration. The default value is No relay.

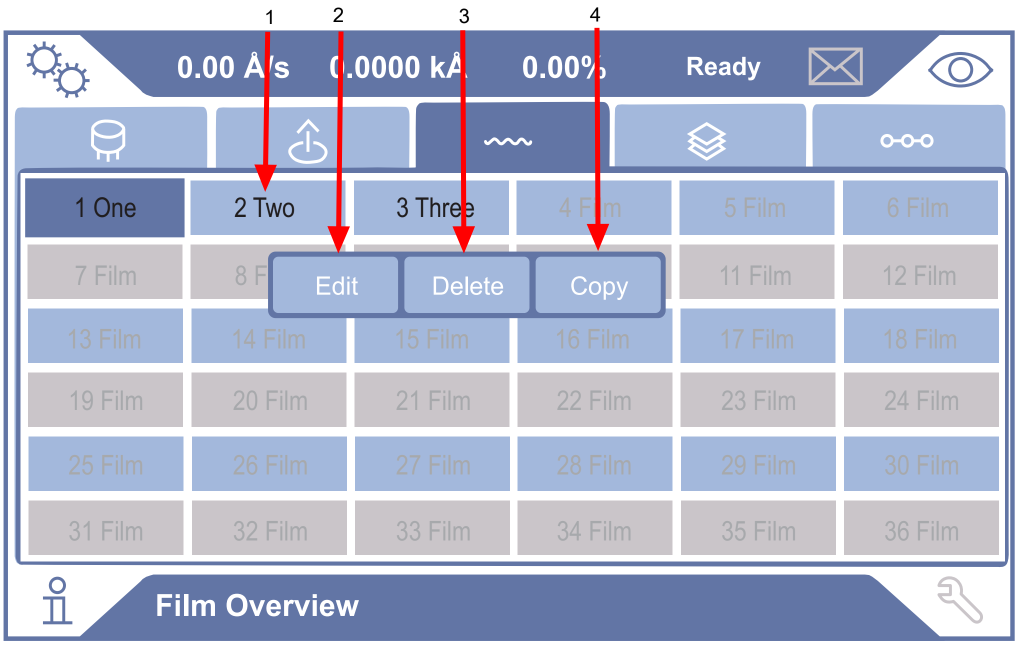
Recorder



1	Recorder Output	This parameter designates which Active Layer Film Index or Sensor Index will be used.
2	Recorder Function	Selects what data to be output. Rate, thickness, rate deviation, thickness deviation, power, or frequency can be chosen. The default value is Rate Raw (Å/s).
3	Source Max Output	Maximum source output voltage. Output voltage range is from -10.00 V(dc) to +10.00 V(dc). The default value is -10.00 V.
4	Recorder Output Range	This is where the upper and lower limits of the recorder output are entered. The units and valid input range corresponds to the recorder data selected. Rate Raw is 0-100000 Å/s, thickness is 0-999999 kÅ, rate deviation and thickness deviation is -100-100, and frequency is 4500000-6000000 Hz. If the Recorder Function is Rate Raw, Rate Filtered, or Thickness, the default value for 0% Output is 0.0, while the default value for 100% Output is 1000.0. If the Recorder Function is Rate Deviation or Power, the default value for 0% Output is 0.0 and the default value for 100% Output is 100.0. If the Recorder Function is Frequency, the default 0% Output is 4000000.0 and the default value for 100% output is 6000000.0.

6.8 Film Screen

The Film screen, shown below, is accessed by first pressing the icon in the top left corner of the screen, followed by the icon in the third tab over.



1	Selected film	Selecting a film highlights that film dark blue and the edit menu appears.
2	Edit	Pressing the Edit button brings you to the Film Settings screen. See Film Settings [▸ 69].
3	Delete	Pressing the Delete button deletes the selected film.
4	Copy	Pressing the Copy button copies the selected film. Selecting another film changes Copy to Paste.

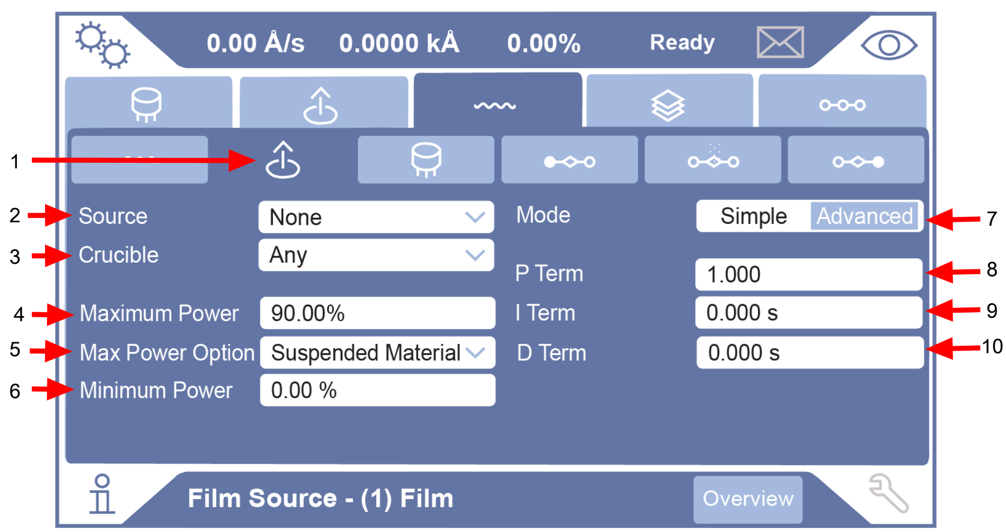
6.8.1 Film Settings

Pressing the Edit button on the Film screen takes the user to the Film Settings screen below.

1	Film settings	This is the first tab under Film Screen.
2	Film number	This label is static and cannot be changed.
3	Film name	Pressing this field brings up a keyboard that accepts up to 30 characters. The default name is Film.
4	Material	Select from the list of user defined materials from the drop down menu. The default value is None.

6.8.2 Film Source Settings

Film Source Settings is the second tab under Film Settings. There are two versions of this screen: Simple and Advanced.



1	Film source settings	This is the second tab under the Film screen.
2	Source	This field populates a drop-down list of sources and their availabilities. This parameter determines which of the four sources is to be used for the film being defined. This parameter cannot be changed while a process is running. The default value is None.
3	Crucible	This field populates a drop-down list of crucibles. Selecting a crucible other than None will request a crucible switch to the specified position before the preconditioning of the source. Crucible defines which crucible position contains the film on a given source. The default value is Any.
4	Maximum power	This field brings up a numerical keypad that accepts input between 0.00% and 100.00%. This parameter is used to set the maximum permissible % power level. The control voltage output will not exceed this limit. The default value is 90.00%.
5	Max Power option*	This field populates a drop-down list with the following options: Continue, Post Deposition, Stop Process, and Suspend Material. Continue (0), Post-Dep (1), Stop Proc (2), Suspend Mat (3) This parameter provides a safety feature. 0 = Continue. Allows the layer to continue in its current state. 1 = PostDeposit. The layer will proceed to the programmed post deposit state(s). 2 = Stop. Stop resets the process. 3 = Suspend. Suspend Material stops the process. The default setting is Stop Proc (2). The default value is Suspend Material.
6	Minimum power*	This field brings up a numerical keypad that accepts input between 0.00% and 99.99%. This parameter is used to set the minimum permissible % power level. The control voltage output will not exceed this limit. The default value is 0.00%.
7	Mode	This toggles the Film Source Settings screen between Simple and Advanced modes. The default mode is Simple.
8	P term	This field brings up a numerical keypad that accepts input between 0.1 and 1000. The default value is 1.000.
9	I term	This field brings up a numerical keypad that accepts input between 0.000 s and 10000.000 s. The default value is 0.000 s.

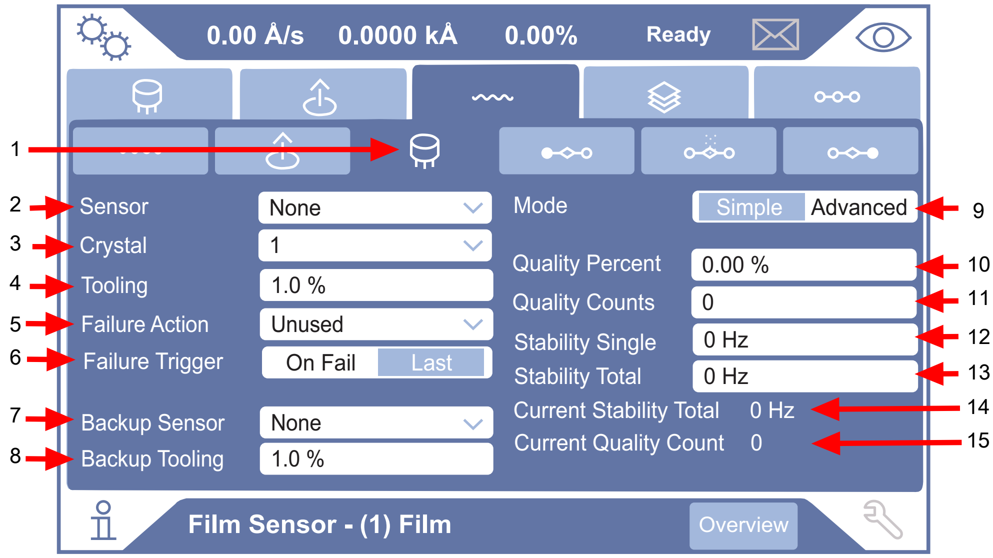
10	D term	This field brings up a numerical keypad that accepts input between 0.000 s and 10000.000 s. The default value is 0.000 s.

*These options are only available in Advanced mode.

NOTE: IMC300 uses a dead time controller PID loop, where P is the gain, I is the time constant, and D is the dead time

6.8.3 Film Sensor Settings

The Film Sensor settings screen is the third tab under the Film screen. There are simple and advanced versions of this screen. The section below is the Simple screen.

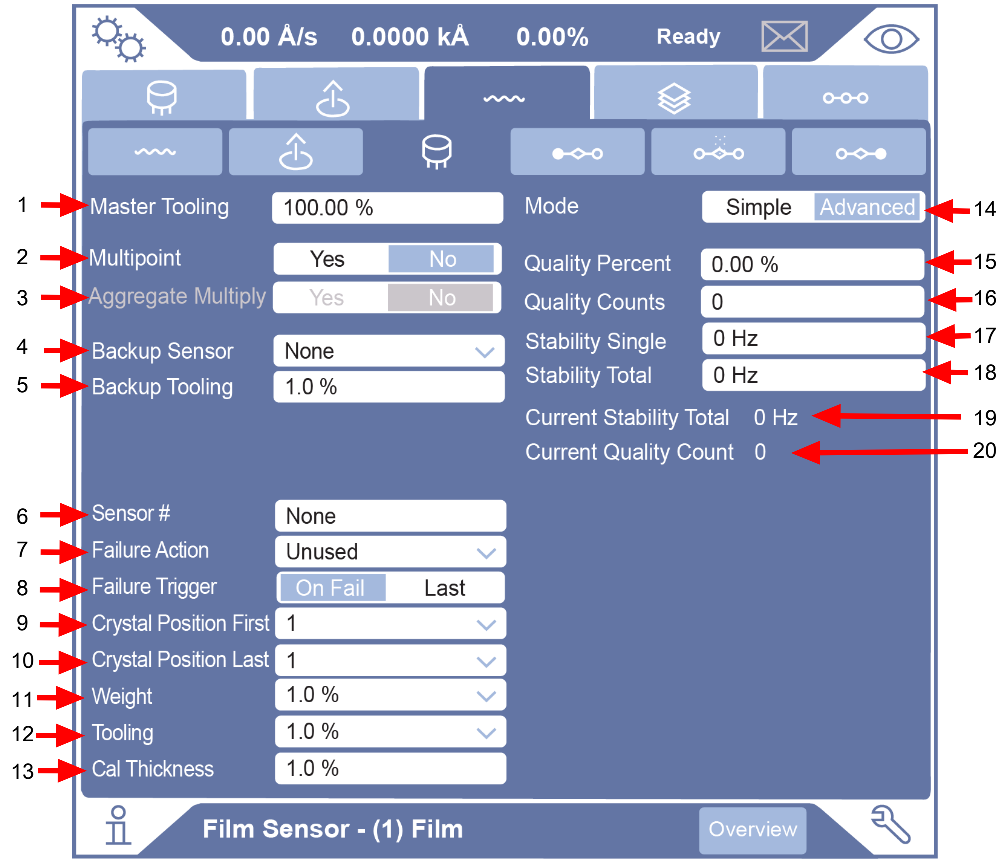


1	Film Sensor Settings	This is the third tab under the Film screen.
2	Sensor	Pressing this field populates a drop down list of sensors and their availabilities. Sensor defines which sensor is to be used to monitor the film. The default value is None.
3	Crystal	Pressing this field populates a drop down list of crystals and their availabilities. Crystal defines which crystal position in the sensor should be used to monitor the film. The default value is Any.
4	Tooling	Compensates for sensor sensitivity to the selected material. Pressing this field brings up a numerical keypad that accepts input between 1.00% and 10000.00%. The default value is 100.00%.

5	Failure Action	Pressing this field populates a drop down menu with the following options of the desired process change when the sensor fails: Unused, Post Deposition, Stop, Suspend, and Time Power. The default value is Unused. Post Deposition: The sensor continues into post-deposit states. Stop: All source control voltages are set to zero and goes to the Ready state. Suspend: Only the associated layer enters the suspend state. Its source control voltage will be set to zero. Time Power: The sensor continues to final thickness using the stored average power and ratel.
6	Failure Trigger	This field identifies when the Failure Action should take place if this all of the crystals in this sensor fail. The default is Last. On Fail: The failure action takes place if this sensor fails. Last: The failure action takes place only if this sensor fails and there are no other sensors being used by the film.
7	Backup Sensor	This is a drop down list of sensors. Backup sensor defines which sensor to use if all of the crystals in the first sensor fail. The default value is None.
8	Backup Tooling	Sets the Tooling factor for the backup sensor if one has been select. Pressing this field brings up numerical keypad that accepts input between 1.00% and 10000.00%. The default value is 100.00%.
9	Mode	This toggles the Film Sensor screen between Simple and Advanced modes. The default mode is Simple.
10	Quality Percent	The maximum allowed deviation, from the rolling average of the previous 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 1 minimum). If the counter reaches Quality Counts during a layer, the process is aborted. Setting to zero disables the parameter. Pressing this field brings up a numerical keypad that accepts input between 0.0% and 99.0%. The default value is 0.00%.

11	Quality Counts	This sets the number of measurements that must be outside the allowed Quality Percent before the crystal is declared failed. Quality Percent selects the permissible rate deviation in percent of the measured rate relative to the desired rate. A counter is incremented each time quality percent is exceeded, then decremented each time a reading is within the rate deviation. If the counter reaches Quality Counts during a layer, the process is aborted. Setting to zero disables this parameter. Pressing this field brings up a numerical keypad that accepts input between 0 and 99. The default value is 0.
12	Stability Single	This sets the maximum permissible increase in frequency from one measurement to the next that will cause a crystal fail. As a material is deposited, the frequency decreases. However, arcing, mode hoping, or external stresses can cause a positive shift in the crystal frequency. If a single large positive frequency shift exceeds the inputed value, a crystal fail is indicated. Pressing this field brings up a numerical keypad that accepts input between 25 Hz and 9999 Hz, or 0 Hz to indicate that it is unused. The default value is 0 Hz.
13	Stability Total	This sets the maximum total permissible increase in frequency accumulated during the active layer that will cause a crystal fail. As a material is deposited the frequency decreases. However, arcing, mode hoping, or external stresses can cause a positive shift in the crystal frequency. If the accumulated value of these positive frequency shifts exceeds the inputed value, a crystal fail is indicated. Pressing this field brings up a numerical keypad that accepts input between 25 Hz and 9999 Hz, or 0 Hz to indicate that it is unused. The default value is 0 Hz.
14	Current Stability Total	The value currently accumulated in the Crystal Quality counter when active. The Crystal Quality counter will become active five seconds after entering DEPOSIT and if the Crystal Quality parameter is non-zero.
15	Current Quality Count	Indicates the current quality count.

The section below is the Advance screen.



1	Master Tooling	The master tooling is used as a global tooling factor. This parameter is used to affect all the sensors' tooling together and calibrate the aggregate rate and thickness to the thickness measured on the substrate. This field brings up a numerical keypad that accepts input between 1.0% and 10000%. The default value is 100%.
2	Multipoint *	This enables the averaging of up to 4 sensors when set to Yes. The default is No. Up to four sensors may be used to control an "aggregate" rate. The aggregate rate is determined from averaged rate information at each sensor scaled by the sensor tooling and sensor weight parameters. The standard IMC300 includes sensor channels 1 and 2. IMC300 will support two additional sensor channels with the addition of optional measurement cards.

3	Aggregate Multiply*	When Multipoint is set to Yes, this option determines whether a multiplier is calculated for a crystal's rate information if a crystal fail occurs during deposition. This multiplier is used only during the layer in which the crystal failure occurs. After this layer is finished, the multiplier is cleared. The default value is No.
4	Backup Sensor	This is a drop down list of sensors to use if the primary sensor fails. This parameter is only accessible when Multipoint is set to No. The default value is None.
5	Backup Tooling	This field brings up a numerical keypad that accepts input between 1.00% and 10000.00%. The default value is 100.00%. This parameter is only accessible when Multipoint is set to Yes.
6	Sensor #	This is a drop down list of sensors and their availability. The default value is None.
7	Failure Action	Pressing this field populates a drop down menu with the following options of the desired process change when the sensor fails: Unused, Post Deposition, Stop, Suspend, and Time Power. The default value is None.
8	Failure Trigger	This field identifies when the Failure Action should take place if this all of the crystals in this sensor fail. The default is Last. On Fail: The failure action takes place if this sensor fails. Last: The failure action takes place only if this sensor fails and there are no other sensors being used by the film.
9	Crystal Position First	This is a drop down list of available crystal positions. Crystal Position First sets the range of allowed crystals for a film. Crystal position first defines which crystal number should be used first for the Sensor # when this film is deposited. The default value is Any.
10	Crystal Position Last	This is a drop down list of available crystal positions. Crystal Position Last sets the range of allowed crystals for a film. Crystal position last defines which crystal number should be used last for the Sensor # when this film is deposited. The default value is Any.

11	(Sensor) Weight	This field brings up a numerical keypad that accepts input between 1.00% and 400.0%. This parameter is used to gauge the relative importance of each sensor's measured rate in calculating a weighted average aggregate rate. The default value is 100.0%. If the weight parameter for a sensor is changed, the new weight for this sensor will be used for subsequent calculations of the aggregate rate, if the sensor's Failure Action is not "Unused."
12	(Sensor) Tooling	Compensates for sensor sensitivity to the selected material. This field brings up a numerical keypad that accepts input between 1.00% and 10000.00%. The default value is 100.00%.
13	Cal Thickness	This feature will be used when co-deposition becomes available in a future update.
14	Mode	This toggles the Film Sensor screen between Simple and Advanced modes. The default mode is Simple.
15	Quality Percent	The maximum allowed deviation, from the rolling average of the previous 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 1 minimum). If the counter reaches quality counts during a layer, the process is aborted. Setting to zero disables the parameter. This field brings up a numerical keypad that accepts input between 0.00% and 99.0%. The default value is 0.00%.
16	Quality Counts	A counter is incremented each time quality percent is exceeded, then decremented each time a reading is within the rate deviation. If the counter reaches quality counts during a layer, the process is aborted. Setting to zero disables this parameter. This field brings up a numerical keypad that accepts input between 0 and 99. The default value is 0.

17	Stability Single	As a material is deposited, the frequency decreases. However, arcing, mode hopping, or external stresses can cause a positive shift in the crystal frequency. If a single large positive frequency shift exceeds the inputted value, a crystal fail is indicated. This field brings up a numerical keypad that accepts input between 25 Hz and 9999 Hz, or 0 Hz to indicate that it is unused. The default value is 0 Hz.
18	Stability Total	As a material is deposited, the frequency decreases. However, arcing, mode hopping, or external stresses can cause a positive shift in the crystal frequency. If the accumulated value of these large positive frequency shift exceeds the inputted value, a crystal fail is indicated. This field brings up a numerical keypad that accepts input between 25 Hz and 9999 Hz, or 0 Hz to indicate that it is unused. The default value is 0 Hz.
19	Current Stability Total	Indicates the current stability total.
20	Current Quality Count	Indicates the current quality count.

* Multipoint and Aggregate Multiply are not available in first release.

Condition of the deposition	Sensor #1 Rate (Å/s)	Sensor #2 Rate (Å/s)	Sensor #3 Rate (Å/s)	Sensor #4 Rate (Å/s)	Aggregate Rate (Å/s)	Aggregate Multiplier
Beginning	10	10	10	10	10	1
Later in the Deposition	16	10	10	4	10	1
If #1 fails, notice what happens to the aggregate rate if the aggregate multiplier is not calculated.	Xtal Fail	10	10	4	8	1
An AGGREGATE MULTIPLIER is calculated as the ratio of the aggregate rate before the sensor failure (using an average rate for the failed sensor prior to failure) divided by the aggregate rate after the sensor failure (without the failed sensor's rate information).	With: 10 Without: 8 Ratio 1.25					
Applying the multiplier to all future aggregate rate results:	Xtal Fail	10	10	4	10	1.25
If during the deposition the use of the aggregate multiplier is turned off, the aggregate rate reverts back to:	Xtal Fail	10	10	4	8	not used
If the layer has not finished, the use of AGGREGATE MULTIPLY may be turned back on and the previously calculated multiplier (in this case 1.25) will continue to be used.						

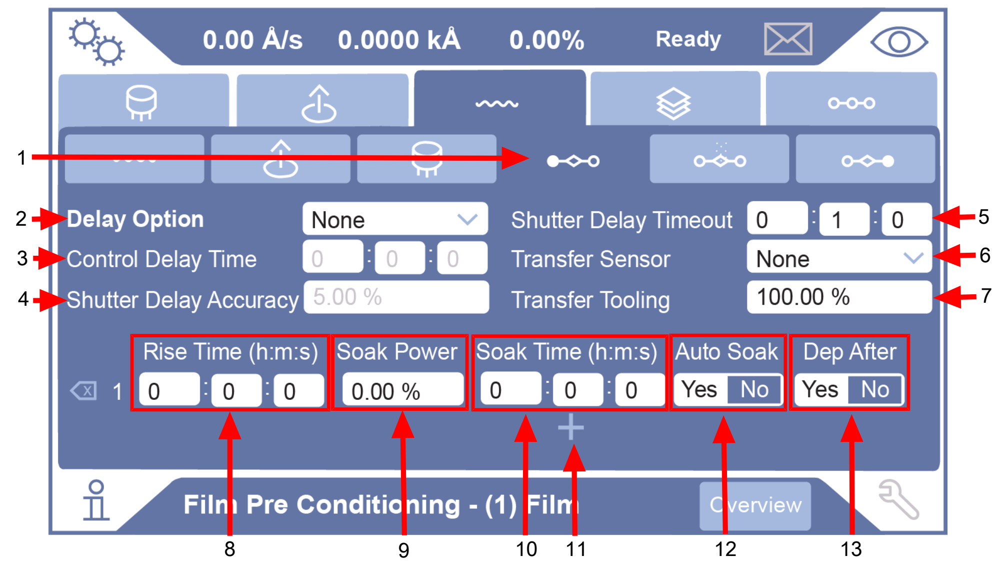
An AGGREGATE MULTIPLIER is calculated as the ratio of the aggregate rate before the sensor failure (using an average rate for the failed sensor prior to failure) divided by the aggregate rate after the sensor failure (without the failed sensor's rate information).

With: 10 Without: 8 Ratio 1.25

Condition of the deposition	Sensor #1 Rate (Å/s)	Sensor #2 Rate (Å/s)	Sensor #3 Rate (Å/s)	Sensor #4 Rate (Å/s)	Aggregate Rate (Å/s)	Aggregate Multiplier
Applying the multiplier to all future aggregate rate results:	Xtal Fail	10	10	4	10	1.25
If during the deposition the use of the aggregate multiplier is turned off, the aggregate rate reverts back to:	Xtal Fail	10	10	4	8	not used
If the layer has not finished, the use of AGGREGATE MULTIPLY may be turned back on and the previously calculated multiplier (in this case 1.25) will continue to be used.						

Sensor	1	2	3	4	Unit
Applied rate	2	4	2.667	1	Å/s
Master tooling	200				%
Sensor tooling	100	50	75	200	%
Displayed rate	4	4	4	4	Å/s
Sensor weight	50	100	75	25	%
Σ weights	250				%
Relative weight	0.2	0.4	0.3	0.1	N/A
Contribution rate	0.8	1.6	1.2	0.4	Å/s
Aggregate rate	4				Å/s

6.8.4 Film Pre-Conditioning Settings

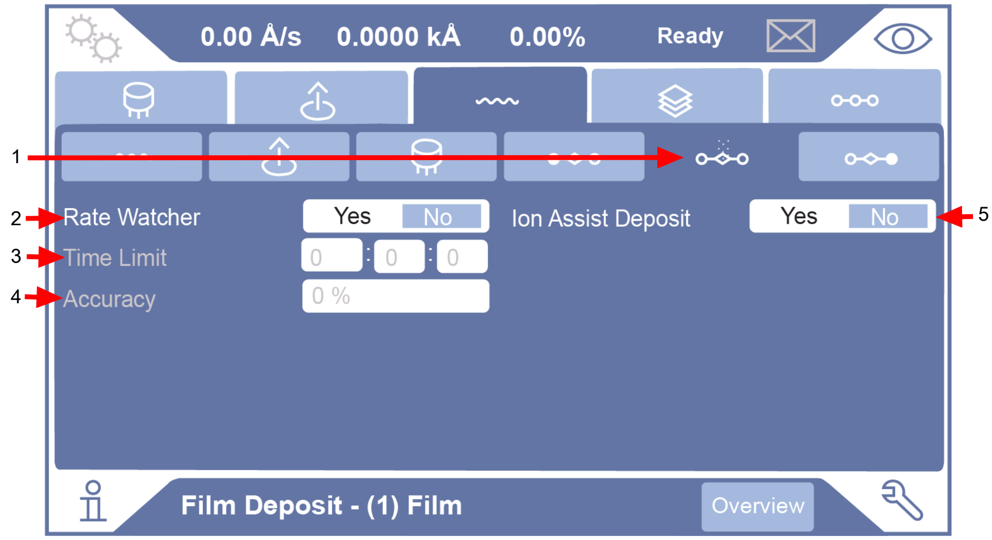


1	Pre conditioning	This is the fourth tab under Film Settings.
2	Delay Option	A list of Delay Options appears here. The options are None, Shutter, Control, or Both. Depending on the option selected, the Control Delay Time and Shutter Delay Accuracy fields are enabled/disabled. The default is None.

3	Control Delay Time	At the beginning of a deposition, there is a large rate spike due to the sudden heat load on the crystal. Control delay suspends the action of the control loop on the source control power for a set time to prevent the control from responding to the temporary spike. This field is only enabled when Delay Option is set to Control or Both. The hour text box accepts values between 0-999. The minute and second text boxes accept values between 0-59. The default is 00:00:00.
4	Shutter Delay Accuracy	Shutter delay happens during preconditioning and suspends deposition until the crystal reaches the desired rate range within the shutter delay accuracy. It specifies how close the rate must be to the setpoint value for 5 seconds before opening the source shutter. This field is only enabled when Delay Option is set to Shutter or Both. The text box accepts values between 1.00%-99.0%. The default value is 5.00%.
5	Shutter Delay Timeout	Shutter Delay Timeout is how long the unit will stay in the shutter delay state before triggering an error. Shutter delay state is only exited if the rate stays within the acceptable shutter delay accuracy for 5 seconds or if shutter delay time is reached. The default value is 1 minute.
6	Transfer Sensor	The tooling factor for the transfer sensor. Default value is 100.0%. This parameter is only enabled when the Transfer Sensor is enabled.
7	Transfer Tooling	This field accepts values between 1.00% and 10000.00%. Transfer tooling is a tooling factor that is only applied to the transfer sensor. The default value is 100.00%.
8	Rise Time	Rise time is set up here. The hour text box accepts values between 0-999. The minute and second text boxes accept values between 0-59. Rise time defines how long it should take to transition from the current power value to the next Soak Power value. The default value is 00:00:00.
9	Soak Power	This field brings up a keypad that accepts between 0.00%-100.0%. Soak power defines the % power for a given preconditioning step. The default value is 0.00%. If Soak Power and Soak Time are 0, then the preconditioning step is skipped.

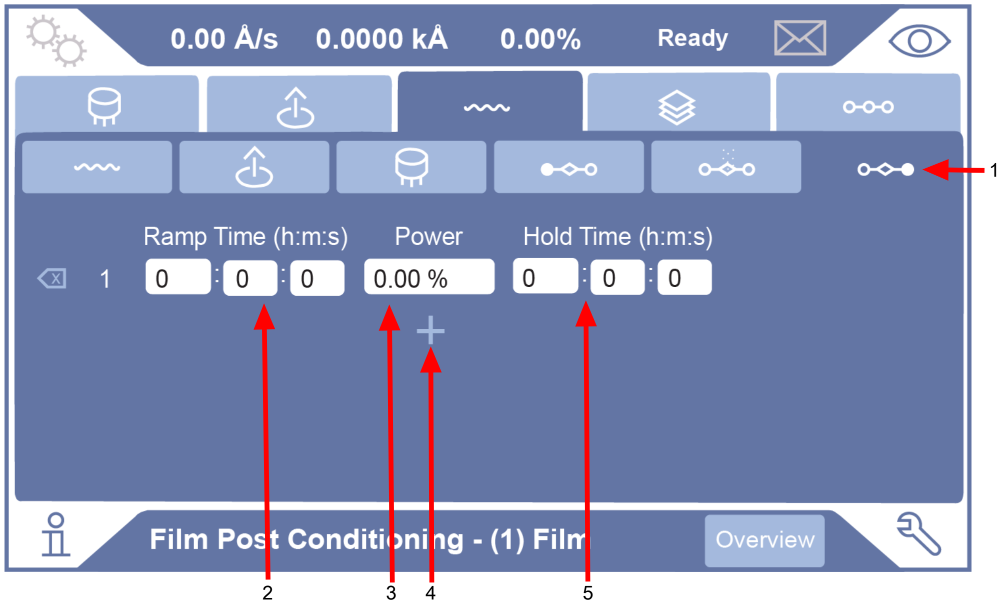
10	Soak Time	Soak time is set up here. The hour text box accepts values between 0-999. The minute and second text boxes accept values between 0-59. Soak time defines how long to stay at the soak power value before going to the next step in the layer using this film. The default value is 00:00:00.
11	Add Rise/Soak Cycle	Pressing the "**+**" button adds a new rise/soak cycle. When a new row is added, a delete button appears on the left hand side.
12	Auto Soak	This field is only available for the last rise/soak cycle. When selected, the deposit state power information is collected. The next time the material is selected, the last soak step uses the collected power information to set a power level closer to what is needed. The default value is No.
13	Dep After	This field is only available for the last rise/soak cycle. This allows the deposition step to start automatically instead of requiring the "Next" button to be pressed. The default value is No.

6.8.5 Film Deposit Settings



1	Film Deposit	This is the fifth tab under Film Settings.
2	RateWatcher	This controls the rate of deposition when enabled. Time limit and accuracy are disabled when RateWatcher is set to "No." The default value is No.
3	Time Limit	Time Limit determines the time interval between sample periods. The crystal shutter relay is in its normal state during this time. The hour text box accepts values between 0-150. The minute and second text boxes accept values between 0-59. The default value is 00:00:00, which disables the function. During a Rate Ramp, the Sample and Hold feature is inactive; the crystal shutter is open and the rate is controlled by the crystal. The default value is 00:00:00.
4	Accuracy	This field accepts values between 1%-99%. The default value is 5%.
5	Ion Assist Deposit	This can be used with the logic functions to apply features when Ion Assist Deposit is set to On. The default value is No.

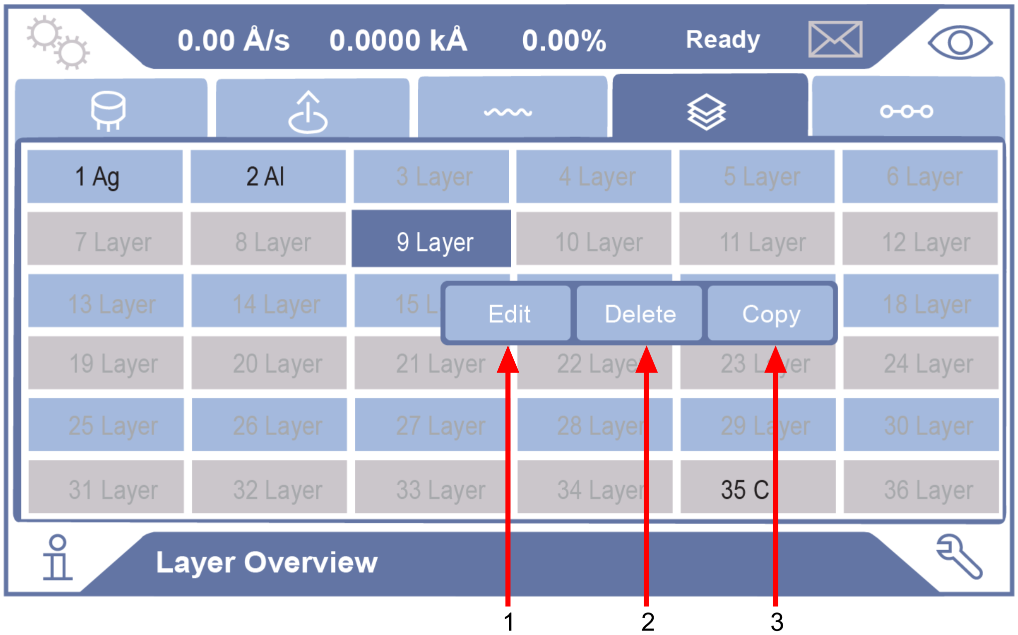
6.8.6 Film Post-Conditioning Settings



1	Post Deposition Settings	This is the sixth tab under Film Settings.
2	Ramp Time	The hour text box accepts values between 0-999. The minute and second text boxes accept values between 0-59. The default value is 00:00:00.
3	Power	This field accepts values between 0.00%-100.00%. The default is 0.00%.
4	Hold time	The hour text box accepts values between 0-150. The minute and second text boxes accept values between 0-59. The default value is 00:00:00. If the hold time is zero then the post deposition step is skipped.
5	Add Ramp/Hold Cycle	This adds a new ramp/hold cycle row. Once a new row is added, a "-" button appears to delete the row.

6.9 Layer Screen

The layer screen, shown below, is accessed by first pressing the icon on the top left corner of the screen, followed by the icon in the fourth tab over.



1	Selected Layer	Selecting a layer highlights that layer dark blue and the edit menu appears.
2	Edit	Pressing the edit button brings you to the Layer Overview screen. See Layer Overview [87].
3	Delete	Pressing the delete button deletes the selected layer.
4	Copy	Pressing the copy button copies the selected layer. Selecting another layer changes Copy to Paste.

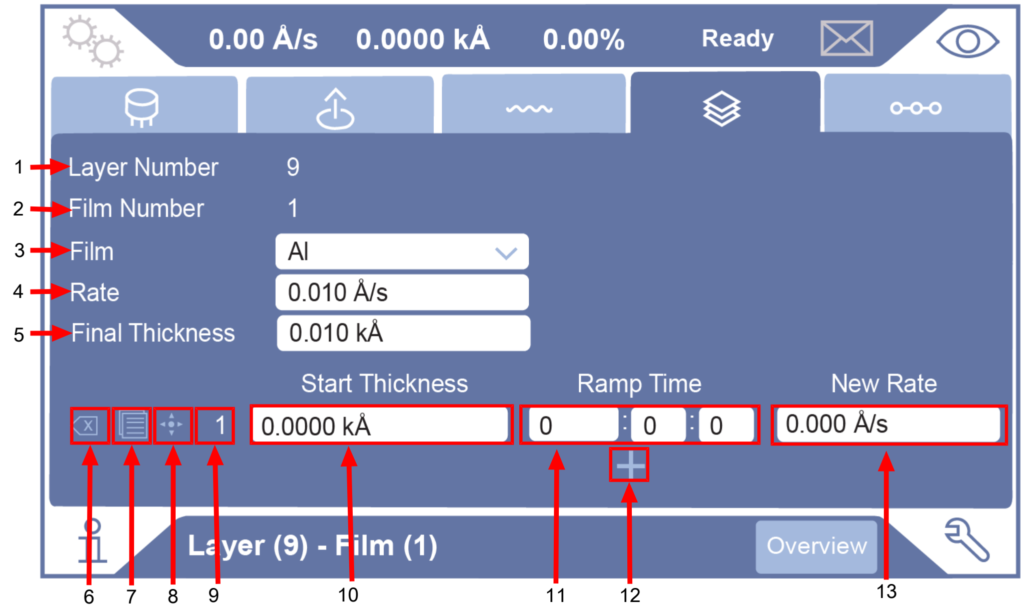
6.9.1 Layer Overview

Pressing the Edit button on the Layer screen takes the user to the Layer Overview screen, shown below.

1	Layer Number	This is static and cannot be changed.
2	Layer Name	Pressing this field displays an alphanumerical keyboard, which accepts up to 32 characters. The default name is Layer.
3	Delete	This deletes the selected layer. A confirmation pop-up appears once pressed.
4	Move	To move a film, press the move button and drag the selected film.
5	Film Index Number	The film index number is displayed here.
6	Film	This field populates a drop down list of defined films. The default film is None. Do not modify this field while a process is running.
7	Rate	This field brings up a numerical keypad that accepts input between 0.01 and 999.9 Å/s. Rate defines the initial rate when depositing this layer. The default value is 0.000 Å/s.
8	Add Film	Unavailable for first release.
9	Final Thickness	This field displays a numerical keypad that accepts input between 0.001 and 1000 kÅ. Final thickness defines the thickness desired to stop depositing this layer on the substrate. Final thickness defines at what thickness to stop depositing this layer on the substrate. The default value is 0.000 kÅ.
10	Edit	Pressing the edit button takes the user to the Layer-Film Edit menu. See Layer-Film Edit Screen [▸ 88].

6.9.2 Layer-Film Edit Screen

Pressing the Edit button on the Layer Overview screen brings the user to the Layer-Film Edit screen, shown below.

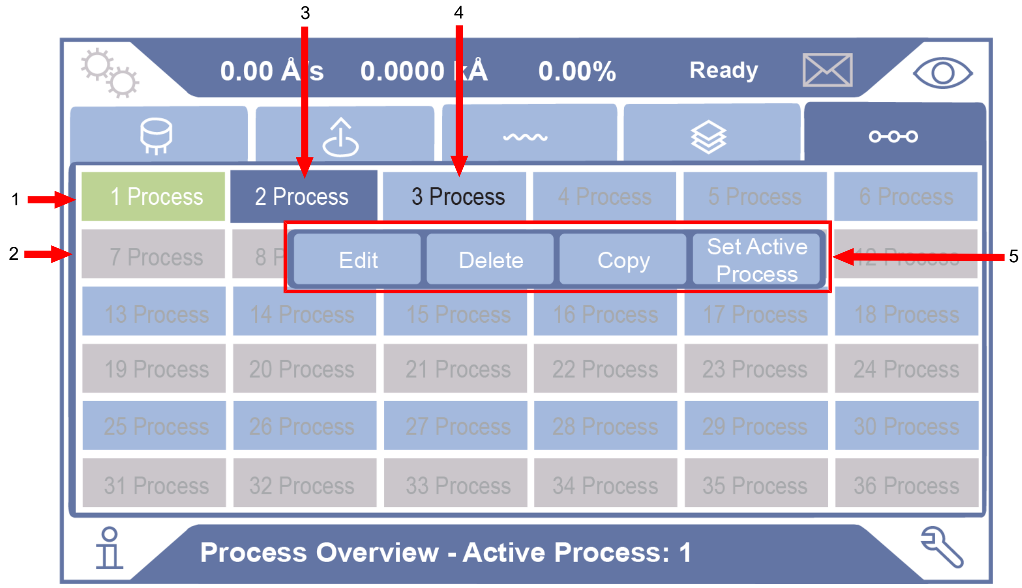


1	Layer Number	Displays the layer number. This is a static label and cannot be changed.
2	Film Number	Displays the film number. This is a static label and cannot be changed.
3	Film	This field populates a drop-down list of defined films. The default value is None.
4	Rate	This field brings up a numerical keypad that accepts input between 0.000 and 999.9 Å/s. The default value is 0.000 Å/s.
5	Final Thickness	This field brings up a numerical keypad that accepts input between 0.000 and 1000 kÅ. The default value is 0.000 kÅ.
6	Delete	This deletes the selected layer. A confirmation pop-up appears once pressed.
7	Duplicate	Pressing this makes a copy of the rate ramp and pastes it below.
8	Move	To move a film, press the move button and drag the selected film.
9	Film Index Number	The film index number is displayed here.
10	Start Thickness	This field brings up a numerical keypad that accepts input between 0.00 and 999.9999 kÅ. The default value is 0.000 kÅ.

11	Ramp Time	Set the Ramp Time by hour, minute and second. Pressing the hour text box generates a numerical keypad for values between 0 and 150 to be entered. Pressing the minute or second text boxes generates a numerical keypad for values between 0 and 59 to be entered. Ramp time defines how long it should take to go from the current rate to the new rate after start thickness is reached. The default value is 00:00:00.
12	Add Rate	Pressing the "+" button adds up to 10 rate ramps that can be defined. When a new ramp is added, a "-" button becomes available to delete the ramp.
13	New Rate	This field brings up a numerical keypad that accepts input between 0.000 and 999.999 Å/s. New rate defines the rate you want to transition to after reaching start thickness. The default value is 0.000 Å/s. If the new rate is set to zero, then the rate ramp is skipped.

6.10 Process Screen

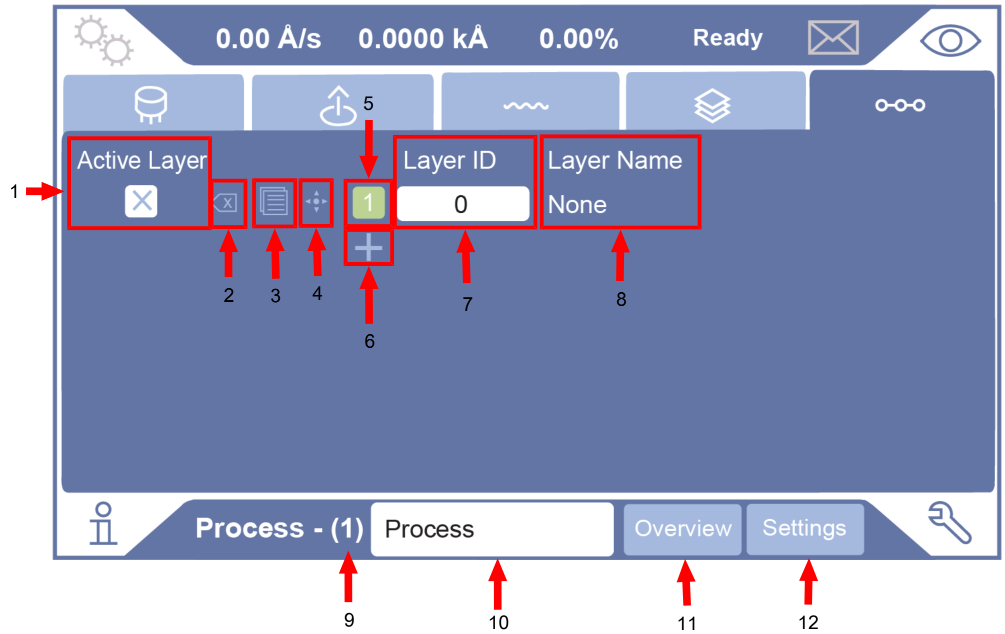
The process overview screen is shown below.



1	Active Process	The active process is highlighted green with a white font.
2	Undefined Process	Processes that have not been defined are displayed with a gray font.
3	Selected Process	When a process is selected, it is highlighted dark blue with a white font and a menu appears.
4	Defined Process	Defined processes are displayed with a black font.
5	Process Menu	From the process menu, you can enter the process edit screen, delete a process, copy and paste a process, or make the process active. When pressed anywhere outside of the process menu, it disappears.

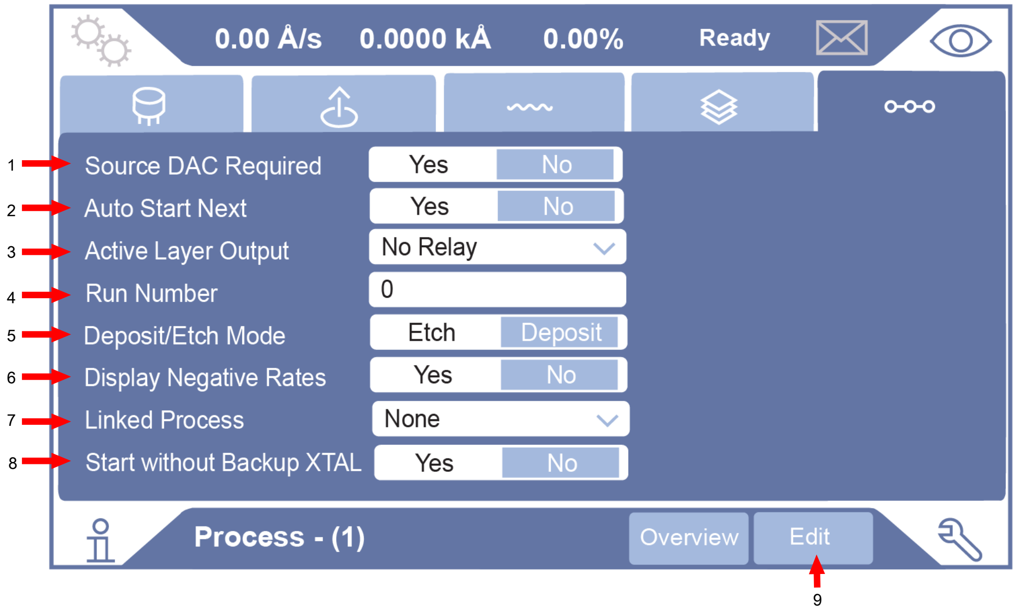
6.10.1 Process Edit

After selecting a process to edit, the process edit screen is displayed.



1	Active Layer	When the active layer box is selected, the layer becomes active.
2	Delete	Deletes the layer.
3	Copy	Copies the layer to a new layer that appears below the layer that is copied.
4	Move Layer	Allows the user to change the order of the layers by pressing and dragging the icon.
5	Layer Number	The layer number is displayed here. Active layers are green.
6	Add Layer	Pressing the "+" button adds a layer to the bottom of the list.
7	Layer ID	When the layer ID box is selected, a numerical keyboard appears. The number indicates which layer ID is to be used for this layer in the process. The default value is 0.
8	Layer Name	Once a layer ID is entered, the layer name is automatically populated. This field displays the layer name assigned to the selected Layer ID.
9	Process Number	Displays the process number currently being edited.
10	Process Name	When the process name box is selected, an alphanumerical keyboard appears and accepts up to 30 characters for the process name.
11	Process Overview	Returns to the process overview screen.
12	Process Settings	Opens the process settings screen.

6.10.2 Process Settings



1	Source DAC Toggle	Specifies whether a source DAC for source power control is required for a layer. The default value is No.
2	Auto Start Next Toggle	Specifies whether the next layer will start automatically when this layer reaches idle. The default value is No.
3	Active Layer Output	Specifies the first of 8 consecutive outputs to indicate the number of the layer that will be executed when Start is executed. All 8 consecutive outputs must be unassigned upon selecting the first output and BCD logic is used to indicate which layer is active. The default value is No relay.
4	Run Number	Increments at the start of a process. When selected the run number can be changed from 0-99999. The default value is 0.
5	Deposit/Etch Mode	When **Deposit** is selected, it allows the user to show deposition rate and accumulated thickness. When **Etch Mode** is selected, it allows the user to show etch rate and etch depth. The default mode is Deposit.
6	Display Negative Rates	This field determines whether negative rate values will be shown. Selecting **Yes** shows the negative rate values, selecting **No** shows negative rates as 0.0 Å/s. The default value is No.
7	Linked Process	This field allows the user to link another process. A linked process ID of 0 or None indicates that the instrument will transition to the **Ready** state once the current process is complete. The default value is None.

8	Start without Backup Xtal	This field defines if the film used by the active layer can be started without additionally having a backup sensor assigned to the film. This parameter is ignored if the sensor type assigned to the layer = single. The default value for Start without Backup Xtal is No.
9	Process Edit	Returns to the process edit screen.

6.11 Changing Parameters While a Process is Running

While a process is running, the following is true:

1. The following cannot be deleted until the active process ends or is completed:
   - ⇨ Any layers in the active process that have already been completed
   - ⇨ The layer currently running (active) in the active process
   - ⇨ Films associated with a layer that is running or was completed in the active process
2. Any layer in the active process which has not yet started can be deleted before the layer has been started.
3. Any film assigned to the active layer cannot have the sensor number, crystal first/last number, source number, and crucible number change until the active process ends or is completed
4. The ion assist parameter cannot be changed for the film assigned to the active layer until the active process ends or is completed.
5. Preconditioning and post conditioning steps for the active film cannot be changed until the active process ends or is completed.
6. All sensor and source parameters cannot be changed while any process is running.

Specific items that can be changed while running a process:

- Any deposition rate
- Any final thickness*
- Any P Term
- Any I Term
- Any D Term
- Any max power value
- Material (density, z-ratio, tooling)
- Rate filter
- Rate ramps (setpoint thicknesses, new rates minimally)
- Recorder output function and range

*Setting the active layer's final thickness to be lower than the current final thickness while in the deposit stop causes IMC300 to move to the layer's postconditioning steps.

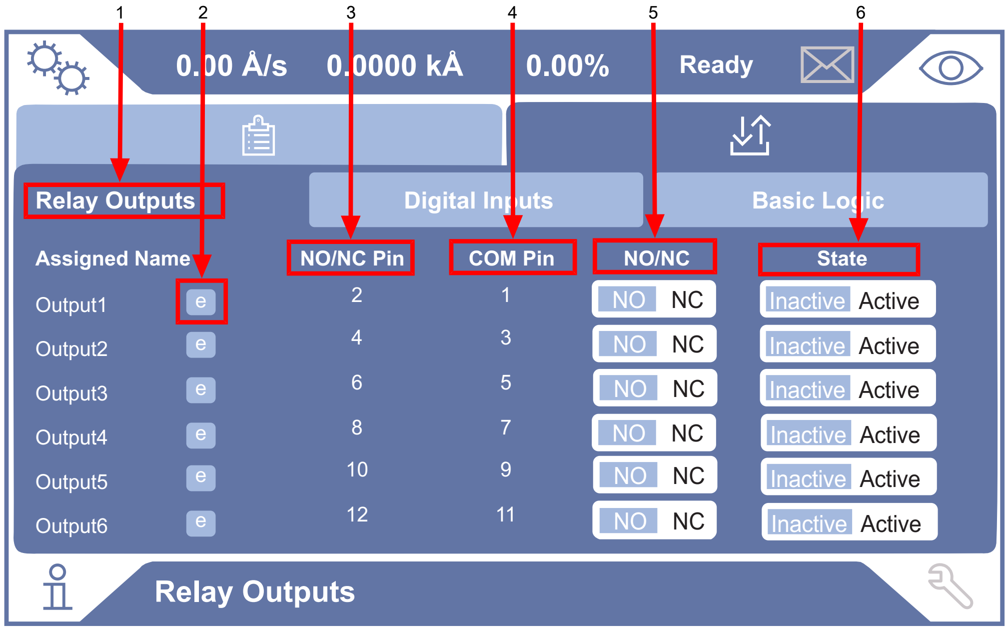
Settings that can be changed while a process is running:

Process Control	C01	Q/U	Start/Stop Process
	C03	R	Zero Thickness
	C05	R	Clear S and Q Counts
	C06	Q/U	Layer Control
	C07	Q/U	Manual Power Setup
	C1E	R	Trigger Final Thickness
Rate	C1D	Q/U	Test Mode Rate (Å/s)
	L**02**02	Q/U	Rate
Final Thickness	L**02**03	Q/U	Final Thickness
PID Terms	F**0903	Q/U	P Term
	F**0904	Q/U	I Term
	F**0905	Q/U	D Term
Max Power Values	F**0906	Q/U	Maximum Power
	F**0907	Q/U	Max Power Option
Rate Filter	G1201	Q/U	Rate Filter
Rate Ramps	L**02**06**01	Q/U	Start Thickness
	L**02**06**02	Q/U	Ramp Time
	L**02**06**03	Q/U	New Rate

Recorder Control	S**12	Q/U	Recorder Output Select
	S**13	Q/U	Recorder Function
	S**14	Q/U	Rate 0 Percent Output
	S**15	Q/U	Rate 100 Percent Output
	S**16	Q/U	Thickness 0 Percent Output
	S**17	Q/U	Thickness 100 Percent Output
	S**18	Q/U	Rate Deviation 0 Percent Output
	S**19	Q/U	Rate Deviation 100 Percent Output
	S**1A	Q/U	Power 0 Percent Output
	S**1B	Q/U	Power 100 Percent Output
	S**1C	Q/U	Frequency 0 Percent Output
	S**1D	Q/U	Frequency 100 Percent Output

6.12 I/O Screen

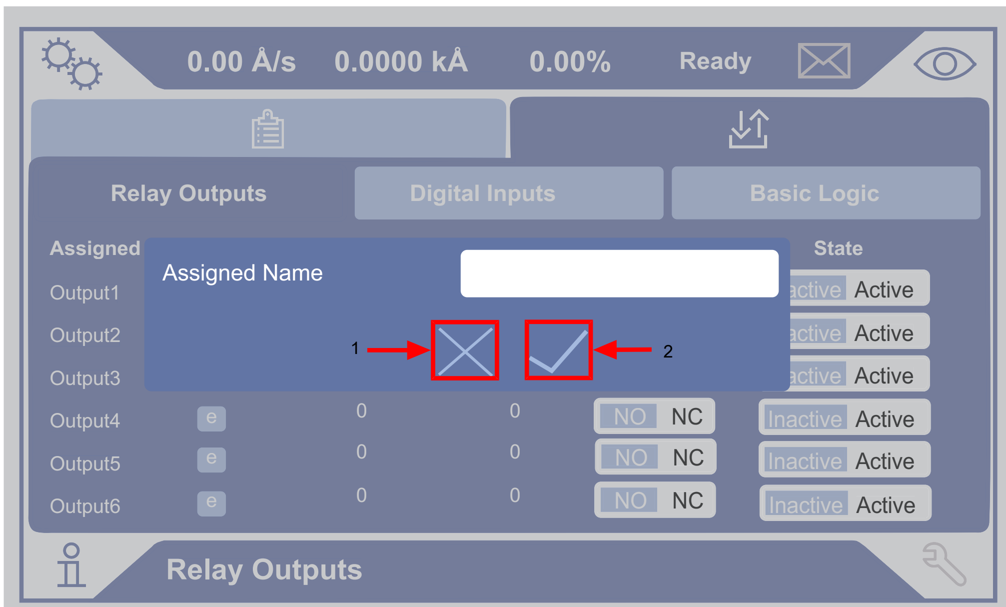
Relay Ouputs



1	Relay Outputs	Select the **Relay Outputs** tab to configure the relays.
2	Name the Relay	Selecting the **e** allows the relay name to be updated.
3	NO/NC Pin	Displays the pin assignment for the rear panel mounted I/O connector. When the relay closes, a connection is made between this pin and the COM pin.
4	COM Pin	Displays the common relay pin for the rear mounted I/O connector. When the relay closes, a connection is made between this pin and the NO/NC pin.
5	NO/NC	Each relay can be selected to be NO, normally open, or NC, normally closed. The default value is NO.
6	State	Opens or closes the relay. The default state is Inactive.

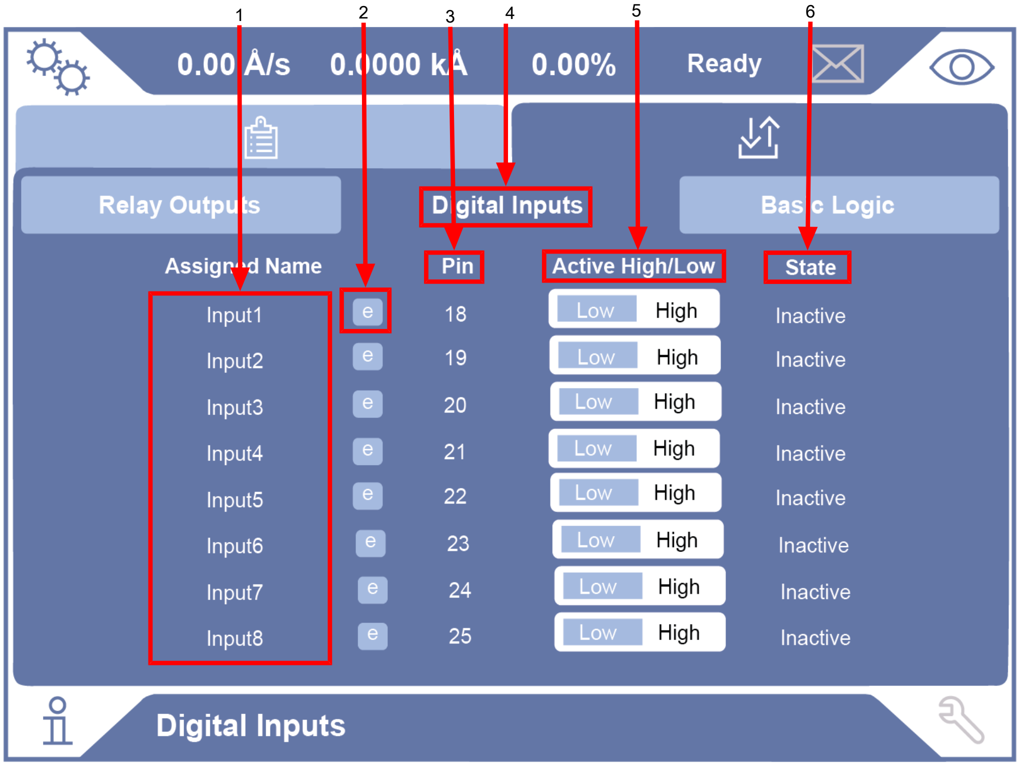
NOTE: The remote commands in the XTC/3 protocol R0x11 and R0x12 set the relay to Active or Inactive respectively.

Selecting the **e** next to the relay of interest opens the **Assigned Name** window. This field accepts up to 32 characters.



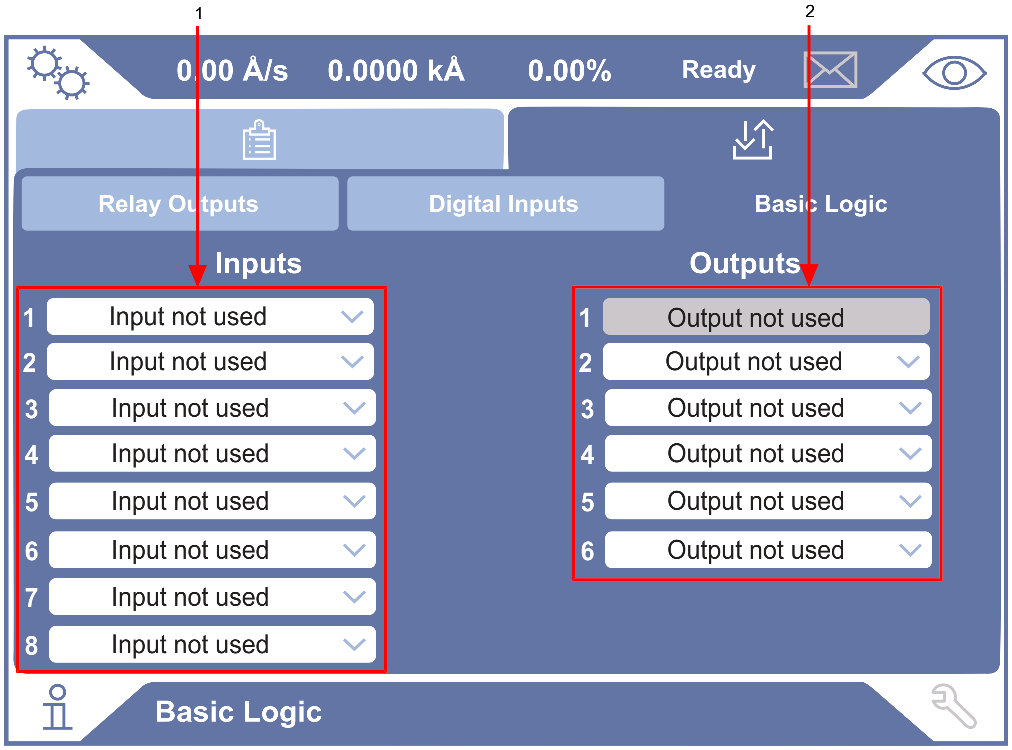
1	Cancel	Selecting **X** cancels the relay name assignment.
2	Confirm	Selecting the **check** confirms the relay assignment.

Digital Inputs



1	Assigned Name	Displays the name of the relay. The default name is Input.
2	Name the relay	Selecting the **e** allows the relay name to be updated.
3	Pin	Displays the pin assignment for the rear panel mounted I/O connector.
4	Digital Inputs	Select the **Digital Inputs** tab to configure the inputs.
5	Active High/Low	This allows configuration of the active state. An **Active Low** setting triggers an event when the state of the pin is low, **Active High** triggers an event when the state of the pin is high. The default value is Low.
6	State	Displays the active/inactive state of the input on the rear panel mounted I/O connector.

Basic Logic



1	Inputs	For input list see T0101** Settings table below.
2	Outputs	For output list see T0102**Setting table below.

T0101** Settings

0	Blank (input not used)	Input not used.
1	Start	START if a layer is not already running.
2	Stop	STOP.
3	End Deposit	Terminates the Deposit state just as if the Final Thickness were achieved.
4	Rate Watcher Hold Initiate	Initiates the Rate Watcher sample if the film is programmed for this feature.
5	Rate Watcher Hold Inhibited	Maintains the Rate Watcher in the Hold condition.
6	Crystal Fail Inhibit	Prohibits the closure of the Crystal Fail Output and the associated stop.
7	Zero Thickness	Zeroes the Thickness.

8	Soak X Hold	Extends the SOAK X state until the signal/closure is removed. Specify the specific Hold with a comma and the hold number. Example: T010103:8,2 (to set input 3 to hold Soak 2) The Range of X is 1-10 to specify the specific hold the event should trigger on.
9	Reset	Reset the process. Reset is processed while the unit is in Ready or Idle of the last layer.
10	Process Selection Bit 1	Select a specific process ID.
11	Process Selection Bit 2	
12	Process Selection Bit 3	
13	Process Selection Bit 4	
14	Process Selection Bit 5	
15	Process Selection Bit 6	
16	Process Selection Bit 7	
17	Process Selection Bit 8	
18	Switch Crystal on Sensor X	Do a Crystal Switch on the specified sensor.
19	Non-Deposit Hold	Hold the power in a non-deposit state, such as Pre/Post conditions.
20	Start Inhibit	Prevents starting a layer as long as the input remains active.

T0201** Settings

ID	Output	Active State	Inactive State
0	Blank	Output not used	
1	Stop	In Stop	Not in Stop
2	End of Process	When entering idle if this is last film in the process.	When Stop or Reset is done.

ID	Output	Active State	Inactive State
3	Thickness Setpoint	In Deposit or Time Power state and thickness setpoint is reached.	When Start or Reset is done. When idle is entered.
4	Crystal Fail	When a crystal fail is triggered on any sensor.	When good crystal life reading is detected.
5	Alarms	On Rate Deviation error On Shutter Delay Error When Max power is reached On Crucible Switch Error	As each error is cleared and no other error is set. When Start or Reset is done. When Idle ramp is entered
6	Source X in use	When Source X is active. Example: T010204:5,2 (to set Output 4 to trigger on when Source 2 is active) The Range of X is 1-2 to specify the specific the specific active source.	When Source X is not active.
7	Final Thickness	Final thickness is reached.	When Start or Reset done.
8	End of Film	Initiate Idle state.	When Start or Reset done.
9	In Layer	When Process is started.	Enter Idle or Stop.
10	Ion Assisted Deposition	Enter any deposit state and Ion Assist Deposit is enabled.	Enter Idle ramp Enter Stop.
11	Ready	When each State starts, the old and new state output are set or cleared as necessary. Specify the specific a Rise or Soak with a comma and the number. Example:T010204:11,2 (to set Output 4 to trigger on Rise 2) The Range of X is 1-10 to specify the specific rise or soak the event should trigger on.	When each State starts, the old and new state output is set or cleared as necessary.
12	Rise X		
13	Soak X		
14	Shutter Delay		
15	Deposit		
16	Rate Ramp		
17	Manual		
18	Time Power		
19	Idle Ramp		
20	Idle		
21	Max Power	When power reaches max power.	When power is not at max power.

ID	Output	Active State	Inactive State
22	Rate Deviation Error	When the rate deviation is greater than 5% or 0.5Å of the desired rate for 60 seconds or 20 times the time constant if the time constant is greater than 3 seconds.	When rate deviation is within test limits. When Idle Ramp is entered.
23	Crystal Switcher Fail	When an attempted crystal switch fails.	When another crystal switch is started.
24	Crystal Switching	Whenever a crystal switch is active.	When the crystal switch is done.
25	Crucible Switcher Fail	No crucible valid input within 30 seconds of a crucible switch.	When Start or Reset is done. If Stop on Alarms is set to No, XTC/3 will give the error message but will not do anything else, it stays in Crucible Switch. If the Crucible Valid input becomes set, the output is cleared.
26	Shutter Delay Error	Shutter delay is enabled and the rate deviation is greater than 5% or 0.5 Å of the desired rate for 60 seconds.	When Start or Reset is done. If Stop on alarms is set to No, the unit will give the error but will not do anything else. It stays in Shutter Delay and controls power to acquire correct rate. If rate comes into specified range, then the output is cleared. When Idle Ramp is entered.

6.13 Handheld Controller

An optional Handheld Controller (PN 035-0225) is available as an accessory with IMC300. The handheld controller serves as a wireless remote to manually control power, switch crystals and produce a STOP. The Handheld Controller connects wirelessly via its USB WIFI adapter to the IMC300's front panel USB port.

To operate the controller:

- Pressing the bottom stop button will have the same effect as pressing STOP on the front panel of IMC300.
- Pressing the top play button will perform a crystal switch, if crystal switching is available for the selected sensor.
- Pressing the left arrow button will decrease power by 1% while in manual power.
- Pressing the right arrow button will increase power by 1% while in manual power.
- The ON/OFF switch on the side determines if the Handheld Controller is powered on or off respectively.

7 Communication

7.1 Introduction

IMC300 offers the following types of data communications hardware ports:

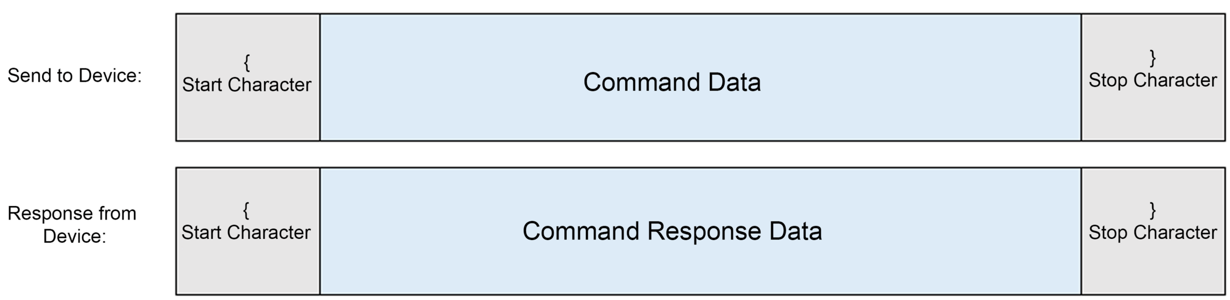
- RS-232: 115200 bps baud rate, 8 data bits, and no parity (standard) (8-N-1 word format)
- Ethernet: Port 2101, address DHCP or static IP (optional)

Both the host and server must have the same form of communications equipment and complementary setup. For serial communications, the baud rates and data word format must match.

The word format for bit serial lines (RS-232) is comprised of ten signal bits: eight data bits, one start bit, one stop bit, and no parity. The eight data bits contain a byte of information or character whose ASCII value ranges from 0 to 255.

7.2 INFICON Zevision Protocol

7.2.1 Overview



7.2.2 Sending Data to the Device

Start Character

All transmissions begin with a start character. The start character helps synchronize the send and receive state machines, allowing for quicker recovery of lost data. Any characters received before the start character will be ignored.

Start character: "{"

Command

See INFICON Zevision Command [▸ 106] for command formatting and specific commands.

Stop Character

All transmissions end with a stop character. The stop character signals to the sender or receiver that the transmission is finished and helps decoding of the transmission.

Stop character: "}"

7.2.3 Sending and Receiving Data from the Device

Start Character

All responses begin with a start character. The start character signals to the sender or receiver that a new transmission has begun and helps decode the transmission.

Start character: "{"

Command

See INFICON Zevision Command [▸ 106] for command response formatting and specific commands.

Stop Character

All transmissions end with a stop character. The stop character signals to the sender or receiver that the transmission is finished and helps decode the transmission.

Stop character: "}"

7.2.4 Protocol Options

Options can be enabled to make the protocol more robust and reduce the chance for errors during transmission.

Send to Device:	{ Start Character	**Data Length** 2 bytes High/ Low	Command Data	**Checksum** 1 byte, sum, modulo 256, data only	} Stop Character
Response from Device:	{ Start Character	**Response Data Length** 2 bytes High/ Low	Command Response Data	**Checksum** 1 byte, sum, modulo 256, data only	} Stop Character

Length

The length of the transmission is defined as two bytes of data (high/low). The length includes all of the command data within the message (blue shaded), excluding the **Start**, **Stop**, **Length** and **Checksum** bytes. The length bytes are a numeric value from 1 to 57,000. For the {H01} command, the length would be 3 in hexadecimal format (the length modifier would be 00 03).

Checksum

The checksum is a single byte. The checksum is calculated by summing all the command data within the message (blue shaded), excluding the **Start**, **Stop**, **Length,** and **Checksum** bytes (same as the length). The checksum is one byte long and supports unsigned modulo 256.

The checksum helps ensure that the message content is valid and a bit did not get lost during transmission. For example, the checksum for {H02} would be AA in hexadecimal or ª when converted to ASCII. The full checksum command is {H02ª}.

7.2.5 Multi Packets

Should the response exceed 57,800, the response is split up into multiple transmissions.

When **Length** and **Checksum** are disabled, each packet is transmitted without a header or footer. The total response is always marked with a start and end character.

Length

If length is enabled, each packet includes a header containing a start marker symbol ("<"), followed by the length.

Header Marker	Length High	Length Low	Data
<	HIGH length byte	LOW length byte	.....

Checksum

If checksum is enabled, each packet includes a footer containing an ending marker symbol (">"), proceeded by the checksum.

Data	Checksum	Footer Marker
.....	Checksum byte	>

7.3 INFICON Zevision Command

7.3.1 Command Formation

Actions U-Update, Q-Query A-Add, D-Delete, S-Status H-Hello	**Command Group** (L/M/S/..)	**Command ID** (Level 1)	**Command ID** (Level 2...)	**:** Data Separator	**Data** (Optional from Sets) (2.567, 100)	**;** (optional) Command Seperator

7.3.1.1 Action Types

Actions define what the command will do. Actions are a single ASCII character.

- U: Update - Set the value of a configuration setting
- Q: Query - Read the value of a configuration setting
- A: Add - Add a command to a list
- D: Delete - Delete a command from a list
- ?: Help - Display setting information
- S: Status - Get the value of a runtime variable along with a synchronization byte to identify when a measurement was taken in relation to other measurements.
- R: Remote - Execute an action

7.3.1.2 Command Group

Command groups define how the settings are organized. Command groups are a single ASCII character.

7.3.1.3 Command IDs

Command IDs define a specific setting. Depending on the command, command IDs can have multiple levels. Command IDs are 2 ASCII characters coded in HEX format: **00** - **FF**

Command level examples:

Actions	Command Group	Command ID
U-Update, Q-Query, S-Status	(L/M/S/..)	00-FF (Level 1)

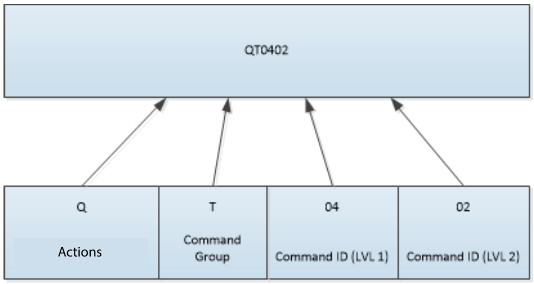
Actions	Command Group	Command ID	Command ID
U-Update, Q-Query, S-Status	(L/M/S/..)	00-FF (Level 1)	00-FF (Level 2)

Actions	Command Group	Command ID	Command ID	Command ID
U-Update, Q-Query, S-Status	(L/M/S/..)	00-FF (Level 1)	00-FF (Level 2)	00-FF (Level 3)

Actions	Command Group	Command ID	Command ID	Command ID	Command ID
U-Update, Q-Query, S-Status	(L/M/S/..)	00-FF (Level 1)	00-FF (Level 2)	00-FF (Level 3)	00-FF (Level 4)

Actions	Command Group	Command ID	Command ID	Command ID	Command ID	Command ID
U-Update, Q-Query, S-Status	(L/M/S/..)	00-FF (Level 1)	00-FF (Level 2)	00-FF (Level 3)	00-FF (Level 4)	00-FF (Level 5)

Example:



7.3.1.4 Data

Some commands, such as the **Updates** and **Action** commands require additional data. Data is separated from the command by a colon **":"** ASCII character.

The data in the data field is command specific, but can take the form of:

- Numeric Data - ASCII numbers forming a number or a float. For example, numeric 78 or float 68.553.
- String Data - an ASCII String. For example, **My Name**. (No quotation marks are needed.) Special characters @#$%^&*()+!\"':/?,\\`~; are not available.
- Time Data - Hours:Minutes:Seconds, All ASCII numbers with colons ':' separating the values. Hours can be any length 0-8760 (max) and can be omitted if zero, Minutes and Seconds must be between 0-59.

7.3.1.5 Multiple Commands

Multiple commands can be sent by separating them with a semicolon (**;**). There is no limit to the number of commands to be sent as long as the total response message length is not more than 57,000 bytes. For example: **{SC11;SC12}** would ask status of current rate and current power.

7.3.2 Response

Every command sent to the device will get a response.

Command Echoed (Type, Group, ID...)	**Response Status** (+ or -)	**Response Error Code** (optional) (if Error) (A,B,C...)	**:** Data Separator (Optional from Queries)	**Response Data** (Optional from Queries)	**;** (optional) Command Separator

7.3.2.1 Command

The full command is echoed in the response. This includes everything before the data separator. This allows individual command responses.

7.3.2.2 Response Status

The response status is an acknowledgment of how the command performed. The response status can be "**+**" for success or "**-**" for failure.

Error Response Code

If the system returned a failure response, an error code is returned to give some insight into why the command failed.

All error codes are ASCII letters:

Error Code	Description
A	Illegal command, the command is not supported
B	Illegal parameter value
C	Checksum error (only when checksum is enabled)
D	Illegal format
F	State error, the system is in the wrong state
L	Length error (only when length is enabled)
T	Time out, the start character has been received but stop character has not been received and 200 ms has passed since the last character received

7.3.2.3 Data Separator

The data separator is used to mark the end of a command and differentiate any data associated with a command. The data separator is useful when identifying commands, as the command length can vary in size.

Data Separator: "**:**"

7.3.2.4 Data

The **Data** field is only transmitted when querying configurations or status. The data in the data field is command specific, but can take the form of:

- Numeric data - ASCII numbers forming a number or float. For example, numeric 78 or float 68.553.
- String data - an ASCII string. For example, **My Name**. (No quotation marks are needed.) Special characters @#$%^&*()+!\'":/?,\\`~; are not available.
- Time Data - Hours:Minutes:Seconds, All ASCII numbers with colons ':' separating the values. Hours can be any length 0-8760 (max) and can be omitted if zero, Minutes and Seconds must be between 0-59.

7.3.2.5 Status Commands

A status command (S Action Type) will include a sync count. The sync count is 0-255 and increments every time a measurement is taken (every 100mS). It rolls over when the maximum count is reached. The sync count is provided to ensure data new.

7.3.2.6 Multiple Commands

When multiple commands are sent in the same message, the response is separated by a semicolon (**;**). Each command receives a response.

For example, a response to the two commands in Multiple Commands [▸ 108] might look like this: SC11+:C7,35.01;SC12+:C7,2.36. The status index, power and rate values depend on the deposition parameters.

7.3.3 Command Set

Commands supported in the system are as follows:

Letter	**Command**
C	Process Control
E	Echo
F	Film
G	General
H	Hello
I	Inputs
L	Layer
M	Materials
N	Sensors
O	Outputs
P	Process
S	Sources
T	Logic

7.3.3.1 Help

The Help command responds with a human-readable list of commands supported by the system. This command does not need a command action character.

Command	Description	Example Command	Example Response
?	Display commands supported by the system.	{?}	*

NOTE: The Help command can be added to the front of lists to view a smaller section of data, Example: {?S} to see just the sources, or {?S01} to see source 1.

7.3.3.2 Hello Commands

Hello commands allow a simple interaction with the device. They allow the unit to communicate basic configuration data and validate, send, and receive transmissions. These commands do not need a command action character.

Command	Description	Example Command	Example Response
H01	String containing the product name and the software version number.	{H01}	{H01+:Zevision IMC300 1.2.2.202403080045}
H02	String containing the software version number, with each of the values separated by commas.	{H02}	{H02+:01,02,02,2024,03,08,00,45}

7.3.3.3 Echo Command

The Echo command is used to test the communication interface. All data passed into the command is sent back as a response. This command does not need a command action character.

Command	Description	Example Command	Example Response
E	Echo data from the input to the output	{E:example}	{E+:example}

7.3.3.4 General Commands

General commands allow the configuration of the system.

Command	Actions	Description	Type	Range	Example (Command):	Example (Response):
G01	Q	Communication API version	Float	1.00	{QG01}	{QG01+:1.00}
G02	Q	Device type	String	"Zevision"	{QG02}	{QG02+:Zevision}
G03	Q	Device name	String	"IMC300"	{QG03}	{QG03+:IMC300}
G04	Q	Vendor	String	"INFICON"	{QG04}	{QG04+:INFICON}
G05	Q	Model number	String	"IMC"	{QG05}	{QG05+:IMC}
G06	Q	System serial number	String	"00000000"	{QG06}	{QG06+:00000000}
G07	Q	System hardware version	Numeric	1	{QG07}	{QG07+:1}
G08	Q	System software version	String	"XX.XX.XX.YYYYMMDDHHMM"	{QG08}	{QG08+:1.2.2.202403080045}
G09	None	Option cards				
G09**	None	Option card slot				
G09**01	Q	Type/Name	String	"Sensor Source" "Input/Output"	{QG090201}	{QG090201+:Input/Output}
G09FE	Q	Number of option cards in the system	Numeric	0-2		
G0A	Q/U	System time	String	Date time string format: "YYYY-MM-DD HH:MM:SS"	{QG0A}	{QG0A+:03-02-2024 08:34:38}
G0B	Q	Time since power on	String	"HHHH:MM:SS"	{QG0B}	{QG0B+:0:23:01}
G0C	Q	Power on count	Numeric		{QG0C}	{QG0C+:5}
G0D	R	Reset command			{RG0D}	{RG0D+}
G0E	None	Display info				
G0E01	Q/U	Turn On/Off display	Numeric	0 = Off 1 = On	{QG0E01} Turn on display {UG0E01:1}	{QG0E01+:0} {QG0E01+}

Command	Actions	Description	Type	Range	Example (Command):	Example (Response):
G0E02	Q/U	Front panel lockout	Numeric	0 = Disable Updates from Screen 1 = Enable Updates from Screen	{QG0E02} Screen Updates Enabled {UG0E02:0}	{QG0E02+:0} {UG0E02+}
G0E03	Q/U	Brightness	Numeric	20%-100%	{QG0E03} Brightness = 20% {UG0E03:20}	{QG0E03+:20} {UG0E03+}
G0E04	Q/U	Dim timer	Numeric	1-300 minutes	{QG0E04} Dim Timer = 0 minutes {UG0E04:0}	{QG0E04+:0} {UG0E04+}
G0E05	Q/U	Off timer	Numeric	1-300 minutes	{QG0E05} Off Timer = 0 minutes {UG0E05:0}	{QG0E05+:0} {UG0E05+}
G0F	None	Sound settings				
G0F01	Q	Keystroke off/on	Numeric	0 = Off 1 = On	{QG0F01} Keystroke = Off {UG0F01:0}	{QG0F01+:0} {UG0F01+}
G0F02	Q/U	Notification off/on	Numeric	0 = Off 1 = On	{QG0F02} Notification = Off {UG0F020}	{QG0F02+:0} {UG0F02+}
G11	Q/U	Com lockout	Number	0 = Unlocked 1 = Locked	{QG0F02} Notification = Off {UG0F020}	{QG0F02+:0} {UG0F02+}
G12	None	Graph info				
G1201	Q/U	Rate filter	Float	0.1-30.0 seconds	{QG1201} Rate Filter = 10.0 seconds {UG1201:10.0}	{QG1201+:10.0} {UG1201+}

Command	Actions	Description	Type	Range	Example (Command):	Example (Response):
G1202	Q/U	Dev graph limits	Numeric	1-15 Å/s	{QG1202} Dev Graph Limit = 1 A /s {UG1202:1}	{QG1202+:1} {UG1202+}
G1203	Q/U	Mix max power lines	Numeric	0 = Off 1 = On	{QG1203} Min Max Power Lines= On {UG1203:1}	{QG1203+:1} {UG1203+}
G1204	Q/U	Crystal life warning limit	Numeric	1%-99%	{QG1204} Crystal Life Warning = 70% {UG1204:99}	{QG1204+:70} {UG1204+}
G1205	Q/U	Crystal life error limit	Numeric	1%-99%	{UG1205} {QG1205:99}	{UG1205+:99} {QG1205+}
G13	None	RS232 communication				
G1301	Q	RS232 protocol type	Numeric	0 = Zevision (default) 1 = XTC3	{QG1301} Protocol Type = Zevision {UG1301:0}	{QG1301+:0} {UG1301+}
G1302	Q	RS232 protocol version	Float	1.00	{QG1302}	{QG1302+:1.00}
G1303	Q	RS232 baud (bps)	Numeric	115200	{QG1303}	{QG1303+:115200}
G1304	Q/U	RS232 enable checksum	Numeric	0 = Disable (default) 1 = Enable	{UG1304} Disable Checksum {UG1304:0}	{UG1304+:0} {QG1304+}
G1305	Q/U	RS232 enable length checking	Numeric	0 = Disable (default) 1 = Enable	{UG1305} Disable Length Check {UG1305:0}	{UG1305+:0} {QG1305+}
G1306	Q/U	RS232 enable/ disable file transfer	Numeric	0 = Disable (default) 1 = FTP Enable	{UG1306} Disable File Transfer {UG1306:0}	{UG1306+:0} {QG1306+}

Command	Actions	Description	Type	Range	Example (Command):	Example (Response):
G14	None	Ethernet communication				
G1401	Q/U	DHCP	Numeric	0 = Static IP address (default) 1 = DHCP enabled	{QG1401}	{QG1401+:0}
G1402	Q/U	IPv4 address	String	xxx.xxx.xxx	{QG1402} {UG1402:192.168.1.100}	{UG1402+} {QG1402} {QG1402+:192.168.1.100}
G1403	Q/U	IPv4 NetMask	String	xxx.xxx.xxx	{QG1403} {UG1403:255.255.255.0}	{UG1403+} {QG1403} {QG1403+:255.255.255.0}
G1404	Q/U	IPv4 gateway	String	xxx.xxx.xxx	{QG1404} {UG1404:192.168.1.1}	{UG1404+} {QG1404+:192.168.1.1}
G1405	Q	Ethernet MAC address	String	xx:xx:xx:xx:xx:xx	{QG1405}	{QG1405+:00:a0:41:ff:ff:19}
G1406	Q/U	Ethernet protocol type	Numeric	0 = Zevision (default) 1 = XTC3	{QG1406} {UG1406:1}	{QG1406} {QG1406+:0} {UG1406+}
G1407	Q/U	Ethernet enable checksum	Numeric	0 = Disable (default) 1 = Enable	{QG1407} {UG1407:1}	{QG1407+:0} {UG1407+}
G1408	Q/U	Ethernet enable length checking	Numeric	0 = Disable (default) 1 = Enable	{QG1408} {UG1408:1}	{QG1408+:0} {UG1408+}
G140A	Q	Ethernet link Status	Numeric	0 = Down 1 = Up	{QG140A}	{QG140A+:0}
G16	R	Trigger beeper		RG16 or RG16:1 = User Tone RG16:2 = Error Tone RG16:3 = Keypress Tone	Tone Error {RG16:1}	{RG16+}

Command	Actions	Description	Type	Range	Example (Command):	Example (Response):
G18	None	Hardware info				
G1801	None	Controller card				
F180101	Q	Board Serial Number	String	"0000000000"	{G180101}	{QG180101+:1122410014}
G180102	Q	Board part number	String	"XXX-XXX-XXX"	{QG180102}	{QG180102+:786-102-G1U}

7.3.3.5 Materials

The user material list is shown. Materials in the material list can be added or deleted. Each material contains additional settings for the material. Materials can have IDs 01 to C8 (1 to 250) that replace the **'s in the command.

The material list is defaulted to zero, users must add materials with the M00 command. Once a material is added, it must be updated with specific values.

Command	Actions	Description	Type	Range	Example Command	Example Response
M00	A/D	Add or delete material from the end of the list	Command		{AM00} {DM00}	{AM00+} {DM00+}
M**	None	Material				
M**01	Q/U	Material name	String	a-z, A-Z, 0-9	{UM0101:Material 1} {QM0101}	{UM0101+} {QM0101+:Material 1}
M**03	Q/U	Density	Float	0.100 to 100.000 g/cm^3	{UM0103:5} {QM0103}	{UM0103+} {QM0103+:5.000}
M**04	Q/U	Z-ratio	Float	0.100 to 15.000	{UM0107:2} {QM0107}	{UM0107+} {QM0107+:2.00}
M**07	Q/U	Tooling	Float	1.0% to 1000.0%	{UM0107:110} {QM0107}	{UM0107+} {QM0107+:110.00}
MFE	Q	Number of material	Numeric	1 - Number of material in the list	{QMFE}	{QMFE+:1}

7.3.3.6 Process Control Status

Command	Actions	Description	Type	Range	Example Command	Example Response
C01	Q/U	Stop/start process	Numeric	0 = Stop running process. On query 0 indicates process is not running. 1 = Start process if not running. Resume paused process. On query 1 indicates process is running.	{UC01:1} {QC01}	{UC01+} {QC01+:1}
C02	Q/U	Stop on alarm	Numeric	0 = Do not stop on alarm 1 = Stop on alarm	{UC02:1} {QC02}	{UC02+} {QC02+:1}
C03	R	Zero thickness		Set the thickness for all sensors to 0.0 kÅ	{RC03}	{RC03+}
C04	R	Reset process		Return the system to the Ready state to prepare for running a process. Accessible from the Stopped, Idle, and Ready states.	{RC04}	{RC04+}
C05	R	Clear S and Q counts		Clears S and Q counts	{RC05}	{RC05+}
C06	Q/U	Layer control	Numeric	0 = PID 1 = Manual	{UC06:1} {QC06}	{UC06+} {QC06+:1}
C07	Q/U	Manual power setpoint	Float	0.00 - 100.00%	{UC07:30} {QC07}	{UC07+} {QC07+:30.00}

Command	Actions	Description	Type	Range	Example Command	Example Response
C08	Q/U	Run number	Numeric	0 - 4294967295	{UC08:15} {QC08}	{UC08+} {QC08+:15}
C09	Q	Current State	String	Name of the currently executing State or Substate in the active process	{QC09}	{QC09+:DepRateHold 1}
C0A	Q	Active process	String	Name of the active process	{QC0A}	{QC0A+:Process 1}
C0B	Q	Active layer	String	Active layer name	{QC0B}	{QC0B+:Layer 1}
C0C	Q	Active film	String	Active film name	{QC0C}	{QC0C+:Film 1}
C0D	Q	Active sensor	String	Active sensor name, may be single or a list	{QC0D}	{QC0D+:Sensor 1}
C0E	Q	Active power source	String	Active power source name, may be single or a list	{QC0E}	{QC0E+:Source 1}
C0F	S	Active power output voltage	Numeric	-10.0-10.0 V	{SC0F}	{SC0F+:82,23.61}
C10	Q	Max power	Float	0.0&-100.0%	QC10	QC10+:0
C11	S	Current power	Float	0.0%-100.0%	{SC11}	{SC11+:93,23.82}
C12	S	Current rate	Float	Filtered deposition rate (Å/s)	{SC12}	{SC12+:22,3.05}
C13	S	Raw rate	Float	Raw deposition rate (Å/s)	{SC13}	{SC13+:78,3.74}
C14	S	Rate rolling average	Numeric	(Å/s)	{SC14}	{SC14+:97,3.0523}
C15	S	Current thickness	Float	kÅ	{SC15}	{SC15+:CC,0.0375}
C16	S	Raw frequency	Float	Hz	{SC16}	{SC16+:FE,5499639.2049}
C17	Q	Active crystal life	Numeric	0%-100%	QC17	{QC17+:47}
C18	Q	Active crystal fail	Numeric	0 = Good 1 = Failed	QC18	{QC18+:0}

Command	Actions	Description	Type	Range	Example Command	Example Response
C19	Q	Alarm state	Numeric	0 = No Alarm, 1 = Alarm	QC19	{QC19+:0}
C1A	Q	Current process time	Time	0 - 8000:00:00 (HHHH:MM:SS)	QC1A	{QC1A+:0:12:33}
C1B	Q	Last process error	String	Last error output, (clears process start)	QC1B	{QC1B+:None}
C1C	Q/U	Test mode	Numeric	0 = Test Mode Disabled 1 = Test Mode Enabled	{UC1C:1} {QC1C}	{UC1C+} {QC1C+:1}
C1D	Q/U	Test Mode Rate (Å/s)	Float	0.000 - 999.9 Å/s	{UC1D:50.5} {QC1D}	{UC1D+} {QC1D+:50.500}
C1E	R	Trigger Final Thickness				
C1F	Q	Stop Reason	Numeric	0 = No stop 1 = Keyboard 5 = Crystal Fail 6 = Max Power 7 = Hand Controller 8 = Communications 9 = Digital Input 10 = Power Loss 11 = Rate Dev Error 12 = Crystal Switcher fail	{QC1F}	{QC1F+:0}
C20	Q	Current Stability Total	Numeric	25 - 9999	{QC20}	{QC20+:0}
C21	Q	Current Quality Count	Numeric	0 - 99	{QC21}	{QC21+:0}

7.3.3.7 Process

Command	Actions	Description	Type	Range	Example Command	Example Response
P01	Q/U	Set active process	Numeric	P0201 - P02C8 Note: Set this to define the active process	{UP01:1} {QP01}	{UP01+} {QP01+:1}
P02	None	Process list				
P0200	A/D	Add/remove process	Command		{AP0200} {DP0200}	{AP0200+} {DP0200+}
P02**		Process				
P02**01	Q/U	Name	String	a-z, A-Z, 0-9	{UP020101:Process 1} {QP020101}	{UP020101+} {QP020101+:Process 1}
P02**02	Q/U	Active layer	Numeric	1 = Number of layers in the list	{UP020102:1} {QP020102}	{UP020102+} {QP020102+:1}
P02**04	Q/U	Auto start next	Numeric	0 = No 1 = Yes	{UP020104:1} {QP020104}	{UP020104+} {QP020104+:1}
P02**06	Q/U	Run number	Numeric	1 - 4,294,967,295	{UP020106:10} {QP020106}	{UP020106+} {QP020106+:10}
P02**07	None	Layer list				
P02**0700	A/D	Add/remove layer	Command		{AP02010700} {DP02010700}	{AP02010700+} {DP02010700+}
P02**07**	Q/U	Layer ID	Numeric	0-250 (0 = no layer selected)	{UP02010701:1} {QP02010701}	{UP02010701+} {QP02010701+:1}
P02**07FE	Q	Number of layers	Numeric	1 = Number of layers in the list	{QP020107FE}	{QP020107FE+:2}
P02**08	Q/U	Deposit/etch mode	Numeric	0 = Deposit 1 = Etch	{UP020108:1} {QP020108}	{UP020108+} {QP020108+:1}
P02**09	Q/U	Display negative rates	Numeric	0 = No (negative displayed as 0) 1 = Yes	{UP020109:1} {QP020109}	{UP020109+} {QP020109+:1}

Command	Actions	Description	Type	Range	Example Command	Example Response
P02**0A	Q/U	Linked process ID	Numeric	0-250	{UP02010A:2} {QP02010A}	{UP02010A+} {QP02010A+:2}
P02**0B	Q/U	Start without Backup Xtal	Numeric	0 = No (default) 1 = Yes	{QP02010B} {UP02010B:0}	{QP02010B+:1} {UP02010B+}
P02FE	Q	Number of processes	Numeric	1 = Number of processes in the list	{QP02FE}	{QP02FE+:2}

7.3.3.8 Layer

Command	Actions	Description	Type	Range	Example Command	Example Response
L00	A/D	Add/remove layer	Command		{AL00} {DL00}	{AL00+} {DL00+}
L**	None	Layer setting				
L**01	Q/U	Layer name	String	a-z, A-Z, 0-9	{UL0101:Layer 1} {QL0101}	{UL0101+} {QL0101+: Layer 1}
L**02	None	Film list				
L**0200	A/D	Add/remove film from film list	Command		{AL010200} {DL010200}	{AL010200+} {DL010200+}
L**02**	None	Film setting	Setting			
L**02**01	Q/U	Film ID	Numeric	0-250 (0 = none selected)	{UL01020101:1} {QL01020101}	{UL01020101+} {QL01020101+:1}
L**02**02	Q/U	Rate	Float	0.000 to 999.9 Å/s	{UL01020102:50} {QL01020102}	{UL01020102+} {QL01020102+:50.000}
L**02**03	Q/U	Final thickness (kÅ)	Float	0.0000 to 1000.000 kÅ	{UL01020103:10} {QL01020103}	{UL01020103+} {QL01020103+:10.000}

Command	Actions	Description	Type	Range	Example Command	Example Response
L**02**06	None	Rate ramp list				
L**02**0600	A/D	Add/remove rate ramp	Command		{AL0102010600} {DL0102010600}	{AL0102010600+} {DL0102010600+}
L**02**06**	None	Rate ramp in rate ramp list				
L**02**06**01	Q/U	Start thickness	Float	0.0000 to 999.9999 kÅ	{UL010201060101:3} {QL010201060101}	{UL010201060101+} {QL010201060101+:3.0000}
L**02**06**02	Q/U	Ramp time	Float	0:00:00 to 150:00:00 (HHH:MM:SS)	{UL010201060102:1:30} {QL010201060102}	{UL010201060102+} {QL010201060102+:0:01:30}
L**02**06**03	Q/U	New rate	Float	0.000 to 999.999 Å/s	{UL010201060103:40} {QL010201060103}	{UL010201060103+} {QL010201060103+:40.000}
L**02**06FE	Q	Number of rate ramps	Numeric		{QL01020106FE}	{QL01020106FE+:1}
L**02FE	Q	Number of films	Numeric	0 to 4	{QL0102FE}	{QL0102FE+:1}
LFE	Q	Number of layers	Numeric	1 = Number of layers in the list	{QLFE}	{QLFE+: 1}

7.3.3.9 Film

Command	Actions	Description	Type	Range	Example Command	Example Response
F00	A/D	Add or delete film from the end of the list	Command		{AF00} {DF00}	{AF00+} {DF00+}
F**	None	Film				
F**01	Q/U	Film name	String	a-z, A-Z, 0-9	{UF0101:Film 1} {QF0101}	{UF0101+} {QF0101+:Film 1}

Command	Actions	Description	Type	Range	Example Command	Example Response
F**02	Q/U	Material ID	Numeric	0-250 (0 = no material selected)	{UF0102:1} {QF0102}	{UF0102+} {QF0102+:1}
F**03	None	Pre-condition list				
F**0300	A/D	Add or remove pre-condition	Command		{AF010300} {DF010300}	{AF010300+} {DF010300+}
F**03**	None	Pre-condition step				
F**03**01	Q/U	Start ramp/rise time	Float	0:00:00 - 150:00:00 (HHH:MM:SS)	{UF01030101:1:30} {QF01030101}	{UF01030101+} {QF01030101+:0:01:30}
F**03**02	Q/U	Ramp power	Float	0.00% to 99.99%	{UF01030102:50} {QF01030102}	{UF01030102+} {QF01030102+:50.00}
F**03**03	Q/U	Hold time	Float	0:00:00 to 150:00:00 HHH:MM:SS	{UF01030103:1:30} {QF01030103}	{UF01030103+} {QF01030103+:0:01:30}
F**03FE	Q	Number of pre-conditions	Numeric	1 - Number of pre-conditions in the list	{QF0103FE}	{QF0103FE+:1}
F**04	None	Delay settings				
F**0401	Q/U	Delay option	Numeric	0 = None 1 = Shutter 2 = Control 3 = Both	{UF010401:3} {QF010401}	{UF010401+} {QF010401+:3}
F**0402	Q/U	Control delay time	Time	0:00:00 - 150:00:00 (HHH:MM:SS)	{UF010402:1:30} {QF010402}	{UF010402+} {QF010402+:0:01:30}
F**0403	Q/U	Shutter delay accuracy	Numeric	1% to 99%	{UF010403:15} {QF010403}	{UF010403+} {QF010403+:15.00}
F**0404	Q/U	Shutter delay timeout	Time	0:00:01 - 3:00:00 (H:MM:SS)	{UF010404:1:30} {QF010404}	{UF010404+} {QF010404+:0:01:30}

Command	Actions	Description	Type	Range	Example Command	Example Response
F**0405	Q/U	Transfer sensor ID	Numeric	0-4 (0 = none sensor selected)	{UF010405:1} {QF010405}	{UF010405+} {QF010405+:1}
F**0406	Q/U	Transfer tooling	Float	1.0%-10000.0%	{UF010406:110} {QF010406}	{UF010406+} {QF010406+:110.00}
F**05	None	Post condition				
F**0500	A/D	Add or remove post condition	Command		{AF010500} {DF010500}	{AF010500+} {DF010500+}
F**05**	None	Post condition				
F**05**01	Q/U	Ramp/rise time	Time	0:00:00 - 150:00:00 (HHH:MM:SS)	{UF01050101:1:30} {QF01050101}	{UF01050101+} {QF01050101+:0:01:30}
F**05**02	Q/U	Ramp power	Float	0.00% to 99.99%	{UF01050102:50} {QF01050102}	{UF01050102+} {QF01050102+:50.00}
F**05**03	Q/U	Hold time	Time	0:00:00 to 150:00:00 (HHH:MM:SS)	{UF01050103:1:30} {QF01050103}	{UF01050103+} {QF01050103+:0:01:30}
F**05FE	Q	Number of post conditions	Numeric	1 - Number of post conditions in the list	{QF0105FE}	{QF0105FE+:1}
F**06	Q/U	Deposit settings				
F**0601	Q/U	RateWatcher enabled	Numeric	0 = Disabled 1 = Enabled	{UF010601:1} {QF010601}	{UF010601+} {QF010601+:1}
F**0602	Q/U	RateWatcher time	Time	0:00:00 - 150:00:00 (HHH:MM:SS)	{UF010602:1:30} {QF010602}	{UF010602+} {QF010602+:0:01:30}
F**0603	Q/U	RateWatcher accuracy	Numeric	1%-100%	{UF010603:10} {QF010603}	{UF010603+} {QF010603+:10}
F**0604	Q/U	Ion assisted deposit	Numeric	0 = No 1 = Yes	{UF010604:1} {QF010604}	{UF010604+} {QF010604+:1}
F**07	None	Sensor list				

Command	Actions	Description	Type	Range	Example Command	Example Response
F**0700	A/D	Add/remove sensor			{AF010700} {DF010700}	{AF010700+} {DF010700+}
F**07**	None	Sensor				
F**07**01	Q/U	Sensor number	Numeric	1-4	{UF01070101:1} {QF01070101}	{UF01070101+} {QF01070101+:1}
F**07**02	Q/U	Crystal position	Numeric	1 - Number of crystals	{UF01070102:2} {QF01070102}	{UF01070102+} {QF01070102+:2}
F**07**03	Q/U	Sensor film tooling	Float	1.0% to 9999.0%	{UF01070103:110} {QF01070103}	{UF01070103+} {QF01070103+:110.00}
F**07**04	Q/U	Crystal position last	Numeric	0 = Disabled 1 = Number of crystals	{UF01070104:10} {QF01070104}	{UF01070104+} {QF01070104+:10}
F**07**05	Q/U	Failure action	Numeric	0 = Unused 1 = PostDp 2 = Stop 3 = Suspnd 4 = TimePw	{UF01070105:2} {QF01070105}	{UF01070105+} {QF01070105+:2}
F**07**06	Q/U	Failure trigger	Numeric	0 = On fail 1 = On last	{UF01070106:1} {QF01070106}	{UF01070106+} {QF01070106+:1}
F**07FE	Q	Number of sensors	Numeric	1 = Number of sensor in the list	{QF0107FE}	{QF0107FE+:1}
F**08	Q/U	Sensor config				
F**0801	Q/U	Mode	Numeric	0 = Simple 1 = Advanced	{UF010801:1} {QF010801}	{UF010801+} {QF010801+:1}
F**0805	Q/U	Backup sensor ID	Numeric	0-4 (0 = no sensor selected)	{UF010805:2} {QF010805}	{UF010805+} {QF010805+:2}

Command	Actions	Description	Type	Range	Example Command	Example Response
F**0806	Q/U	Backup tooling	Float	1.0%-10000.0%	{UF010806:110} {QF010806}	{UF010806+} {QF010806+:110.00}
F**0807	Q/U	Quality percent	Numeric	0-99	{UF010807:10} {QF010807}	{UF010807+} {QF010807+:10.00}
F**0808	Q/U	Quality counts	Numeric	0-99	{UF010808:15} {QF010808}	{UF010808+} {QF010808+:15}
F**0809	Q/U	Stability single	Numeric	25-9999	{UF010809:100} {QF010809}	{UF010809+} {QF010809+:100}
F**080A	Q/U	Stability total	Numeric	25-9999	{UF01080A:500} {QF01080A}	{UF01080A+} {QF01080A+:500}
F**09	Q/U	Source settings				
F**0901	Q/U	Source ID	Numeric	0-2 (0 = no source selected)	{UF010901:1} {QF010901}	{UF010901+} {QF010901+:1}
F**0902	Q/U	Crucible	Numeric	0 = disabled 1 - number of crucibles in source	{UF010902:1} {QF010902}	{UF010902+} {QF010902+:1}
F**0903	Q/U	P term	Float	0.010 10000.00 Å/s/% power	{UF010903:5} {QF010903}	{UF010903+} {QF010903+:5.000}
F**0904	Q/U	I term	Float	0.000-10000.000 seconds	{UF010904:2} {QF010904}	{UF010904+} {QF010904+:2.000}
F**0905	Q/U	D term	Float	0.000-10000.000 seconds	{UF010905:2} {QF010905}	{UF010905+} {QF010905+:2.000}
F**0906	Q/U	Maximum power	Float	0.0% to 100.0%	{UF010906:80} {QF010906}	{UF010906+} {QF010906+:80.00}

Command	Actions	Description	Type	Range	Example Command	Example Response
F**0907	Q/U	Max power option	Numeric	0 = Continue with the layer deposition 1 = Post deposit, enter post deposit state 2 =End the process 3 = Enter stop mode to suspend process	{UF010907:1} {QF010907}	{UF010907+} {QF010907+:1}
F**0908	Q/U	Min power	Float	0.0% to 100.0%	{UF010908:20} {QF010908}	{UF010908+} {QF010908+:20.00}
FFE	Q	Number of films	Numeric	1 - Number of films in the list	{QFFE}	{QFFE+:1}

7.3.3.10 Outputs

Command	Actions	Description	Type	Range	Example Command	Example Response
O**	None	Output number		1 - Number of relays in the system		
O**01	Q/U	Name	String	a-z, A-Z, 0-9	{UO0101:Output 1} {QO0101}	{UO0101+} {QO0101+:Output 1}
O**02	Q/U	Normal (inactive) state	Numeric	0 = Open 1 = Closed	{UO0102:1} {QO0102}	{UO0102+} {QO0102+:1}
0**03	Q	Assigned	Numeric	See table below.	{QO0103}	{QO0103+:0}
O**04	Q/U	Active state	Numeric	0 = Inactive 1 = Active	{UO0104:1} {QO0104}	{UO0104+} {QO0104+:1}
O**05	Q	Raw state	Numeric	0 = Open/Low 1 = Closed /High	{QO0105}	{QO0105+:0}
OFE	Q	Number of outputs in the system	Numeric	1 - Number of ouptuts in the system	{QOFE}	{QOFE+:6}

0**3 Ranges

Output	Range
0	Output not assigned
1	Source Shutter 1
2	Source Shutter 2
3	Sensor Shutter 1
4	Sensor Shutter 2
5	Stop
6	End of process
7	Thickness setpoint
8	Crystal fail
9	Alarms
10	Source in use (open = 1; closed = 2)
11	Final Thickness
12	End of Film
13	In layer
14	Ion Assisted Deposition
15	Crystal Switcher 1
16	Crystal Switcher 2
17	Ready
18	Crucible Switching
19	Rise 1
20	Soak 1
21	Rise 2
22	Soak 2
23	Shutter Delay
24	Deposit
25	Rate Ramp
26	Manual
27	Time Power
28	Idle Ramp
29	Idle
30	Max Power
31	Rate Deviation Error
32	Crystal Switcher Fail
33	Crystal Switching

Output	Range
34	Crucible Switcher Fail
35	Shutter Delay Error
36	Computer Control
37	Crucible Select Source 1 Binary (8 outputs required, one / position)*
38	Crucible Select Source 1 Binary, bit 2
39	Crucible Select Source 1 Binary, bit 3
40	Crucible Select Source 1 Binary, bit 4
41	Crucible Select Source 1 Binary, bit 5
42	Crucible Select Source 1 Binary, bit 6
43	Crucible Select Source 1 Binary, bit 7
44	Crucible Select Source 1 Binary, bit 8
45	Crucible Select Source 1 BCD (3 outputs required BCD)*
46	Crucible Select Source 1 BCD, bit 2
47	Crucible Select Source 1 BCD, bit 3
48	Crucible Select Source 2 Binary (8 outputs required, one / position)*
49	Crucible Select Source 2 Binary, bit 2
50	Crucible Select Source 2 Binary, bit 3
51	Crucible Select Source 2 Binary, bit 4
52	Crucible Select Source 2 Binary, bit 5
53	Crucible Select Source 2 Binary, bit 6
54	Crucible Select Source 2 Binary, bit 7
55	Crucible Select Source 2 Binary, bit 8
56	Crucible Select Source 2 BCD (3 outputs required BCD)*
57	Crucible Select Source 2 BCD, bit 2
58	Crucible Select Source 2 BCD, bit 3
60	Not implemented for XTC3 backwards compatibility

7.3.3.11 Inputs

Command	Actions	Description	Type	Range	Example Command	Example Response
I**	None	Input number		1 - Number of inputs in the system		

Command	Actions	Description	Type	Range	Example Command	Example Response
I**01	Q/U	Name	String	a-z, A-Z, 0-9	{UI0101:Input 1} {QI0101}	{UI0101+} {QI0101+:Input 1}
I**02	Q/U	Active high/low	Numeric	0 = Low 1 = High	{UI0102:1} {QI0102}	{UI0102+} {QI0102+:1}
I**03	Q	Assigned	Numeric	See table below.	{QI0103}	{QI0103+:0}
I**04	Q	Active state	Numeric	0 = Inactive 1 = Active	{QI0104}	{QI0104+:1}
I**05	Q	Raw state	Numeric	0 = Low 1 = High	{QI0105}	{QI0105+:0}
IFE	Q	Number of inputs in the system	Numeric	1 - Number of inputs in the system	{QIFE}	{QIFE+:8}

I**3 Ranges

Input	Range
0	Input not assigned
1	Start
2	Stop
3	End Deposit
4	Rate Watcher Hold Initiate
5	Rate Watcher Hold Inhibit
6	Crystal Fail Inhibit
7	Zero Thickness
8	Soak 2 Hold
9	Crucible 1 Valid
10	Crucible 2 Valid
11	Reset
12	Select Process 1-4, 2 bits*
13	Select Process 1-4, 2 bits, bit 2
14	Select Process 1-16, 4 bits*
15	Select Process 1-16, 4 bits, bit 2
16	Select Process 1-16, 4 bits, bit 3
17	Select Process 1-16, 4 bits, bit 4

Input	Range
18	Select Process 1-64, 6 bits*
19	Select Process 1-64, 6 bits, bit 2
20	Select Process 1-64, 6 bits, bit 3
21	Select Process 1-64, 6 bits, bit 4
22	Select Process 1-64, 6 bits, bit 5
23	Select Process 1-64, 6 bits, bit 6
24	Select Process 1-99, 7 bits*
25	Select Process 1-99, 7 bits, bit 2
26	Select Process 1-99, 7 bits, bit 3
27	Select Process 1-99, 7 bits, bit 4
28	Select Process 1-99, 7 bits, bit 5
29	Select Process 1-99, 7 bits, bit 6
30	Select Process 1-99, 7 bits, bit 7
31	Switch Crystal
32	Non-Deposit Hold
33	Zero Film Time
34	Start Inhibit
35	Soak 1 Hold
37	Not implemented for XTC3 backwards compatibility

7.3.3.12 QCM Sensor

Command	Actions	Description	Type	Range	Example Command	Example Response
N**	None	Sensor number		1 - Number of sensors in the system		
N**01	Q/U	Name	String	a-z, A-Z, 0-9	{UN0101:Sensor 1} {QN0101}	{UN0101+} {QN0101+:Sensor 1}
N**02	Q/U	Sensor type	Numeric	0 = Single 1 = Dual 2 = Crystal2 3 = Crystal6 4 = Crystal12 5 = Generic	{UN0102:3} {QN0102}	{UN0102+} {QN0102+:3}

Command	Actions	Description	Type	Range	Example Command	Example Response
N**03	Q/U	Control type	Numeric	0 = Manual 1 = Direct 2 = Individual 3 = BCD	{UN0103:1} {QN0103}	{UN0103+} {QN0103+:1}
N**04	Q/U	Drive type	Numeric	0 = Up 1 = Down	{UN0104:1} {QN0104}	{UN0104+} {QN0104+:1}
N**05	Q/U	Step	Numeric	0 = Step single 1 = Step double	{UN0105:1} {QN0105}	{UN0105+} {QN0105+:1}
N**06	Q/U	Feedback type	Numeric	0 = None	{UN0106:2} {QN0106}	{UN0106+} {QN0106+:2}
N**07	Q/U	Indexer delay	Time	0:00:00 - 999:0:0 (HHH:MM:SS)	{UN0107:0:15} {QN0107}	{UN0107+} {QN0107+:0:00:15}
N**08	Q	Number of positions	Numeric	1-32	{UN0108:12} {QN0108}	{UN0108+} {QN0108+:12}
N**09	Q/U	Current position	Numeric	1-32	{UN0109:3} {QN0109}	{UN0109+} {QN0109+:3}
N**0A	Q/U	Crystal tooling	Float	1.00%-10000.00 %	{UN010A:110} {QN010A}	{UN010A+} {QN010A+:110.00}
N**0B	None	Crystal switch output	None			
N**0B01	Q/U	Output	Setting	1 - X (Number of Outputs in the system)	{UN010B01:1} {QN010B01}	{UN010B01+} {QN010B01+:1}
N**0B02	Q/U	Output	Setting	1 - X (Number of Outputs in the system)	{UN010B02:1} {QN010B02}	{UN010B02+} {QN010B02+:1}
N**0B03	Q/U	Output	Setting	1 - X (Number of Outputs in the system)	{UN010B03:1} {QN010B03}	{UN010B03+} {QN010B03+:1}
N**0B04	Q/U	Output	Setting	1 - X (Number of Outputs in the system)	{UN010B04:1} {QN010B04}	{UN010B04+} {QN010B04+:1}
N**0B05	Q/U	Output	Setting	1 - X (Number of Outputs in the system)	{UN010B05:1} {QN010B05}	{UN010B05+} {QN010B05+:1}

Command	Actions	Description	Type	Range	Example Command	Example Response
N**0B06	Q/U	Output	Setting	1 - X (Number of Outputs in the system)	{UN010B06:1} {QN010B06}	{UN010B06+} {QN010B06+:1}
N**0C	Q/U	Open/close shutter	Numeric	0 = Close 1 = Open	{UN010C:1} {QN010C}	{UN010C+} {QN010C+:1}
N**0E	Q/U	Shutter output	Setting	1 - X (Number of Outputs in the system)	{UN010E:1} {QN010E}	{UN010E+} {QN010E+:1}
N**0F	Q/U	Crystal fail output	Setting	1 - X (Number of Outputs in the system)	{UN010F:1} {QN010F}	{UN010F+} {QN010F+:1}
N**10	Q/U	QCMs	None			
N**10**	None	QCM	None			
N**10**02	Q	Health	Numeric	0%-100% (estimated % used, 100% = crystal fail)	{QN01100102}	{QN01100102}
N**10FE	Q	Number of QCMs	Numeric	1 - Number of QCMs	{QN0110FE}	{QN0110FE+:12}
N**11	Q	Active QCM ID	Numeric	1 - Number of QCMs	{QN0111}	{QN0111+:0}
N**12	S	Active QCM frequency	Float	Hz	{SN0112}	{SN0112+:D6,5499639.1840}
N**13	S	Active QCM rate	Float	Å/s	{SN0113}	{SN0113+:59,13.05}
N**14	S	Active QCM thickness	Float	0.0000 to 999.99 kÅ	{SN0114}	{SN0114+:3D,2.1532}
N**15	S	Active QCM status	Numeric	0 = Good 1 = Failure	{SN0115}	{SN0115+:5B,0}
N**16	S	Active QCM life	Numeric	0%-100%	{SN0116}	{SN0116+:A9,47.00}
N**17	S	Active QCM activity	Numeric		{SN0117}	{SN0117+:A1,1008}
N**18	R	Switch crystal			{RN0118}	{RN0118+}
N**19	R	Rotate carousel			{RN0119}	{RN0119+}
N**1A	None	Crystal switch input				

Command	Actions	Description	Type	Range	Example Command	Example Response
N**1A01	Q/U	Input	Setting	1 - X (Number of Inputs in the system)	{UN011A01:I01} {QN011A01}	{UN011A01+} {QN011A01+:I01}
N**1A02	Q/U	Input	Setting	1 - X (Number of Inputs in the system)	{UN011A02:I01} {QN011A02}	{UN011A02+} {QN011A02+:I01}
N**1A03	Q/U	Input	Setting	1 - X (Number of Inputs in the system)	{UN011A03:I01} {QN011A03}	{UN011A03+} {QN011A03+:I01}
N**1A04	Q/U	Input	Setting	1 - X (Number of Inputs in the system)	{UN011A04:I01} {QN011A04}	{UN011A04+} {QN011A04+:I01}
N**1A05	Q/U	Input	Setting	1 - X (Number of Inputs in the system)	{UN011A05:I01} {QN011A05}	{UN011A05+} {QN011A05+:I01}
N**1A06	Q/U	Input	Setting	I01 - I** (Number of inputs in the system)	{UN011A06:I01} {QN011A06}	{UN011A06+} {QN011A06+:I01}
N**1B	R	Clear crystal status			{RN011B}	{RN011B+}
N**1C	Q	XIU connected	Numeric	1 = Connected 0 = Disconnected	{QN011C}	{QN011C+:1}
N**1D	Q	XIU type	String	"G1" or "G2"	{QN011D}	{QN011D+:G1}
N**1E	Q	XIU serial number	String	Serial number	{QN011E}	{QN011E+:04921915}
N**1F	Q	XIU cable length (ft)	String	15, 30, 50, 100	{QN011F}	{QN011F+:15}
N**20	S	Rate deviation (Å)	Float	Limited by G1202 -1-1 Å -15-15 Å	{SN0120}	{SN0120+:59,0.0000000000}
NFE	Q	Number of Sensors in the system	Numeric	1 - Number of sensors in the system	{QNFE}	{QNFE+:2}

7.3.3.13 Sources

Command	Actions	Description	Type	Range	Example Command	Example Response
S**	None	Source number		1 - Number of sources in the system		
S**01	Q/U	Name	String	a-z, A-Z, 0-9	{US0101:Source 1} {QS0101}	{US0101+} {QS0101+:Source 1}
S**02	Q/U	Source output configuration	Numeric	0 = Source 1 = Recorder	{US0102:1} {QS0102}	{US0102+} {QS0102+:1}
S**03	S	Current voltage	Float	-10 V - Max voltage	{SS0103}	{SS0103+:97,-5.000}
S**04	S	Current percent power	Float	0.0 % - 100.0 %	{SS0104}	{SS0104+:BA,50.000}
S**05	Q/U	Shutter output	Setting	1 - X (Number of Outputs in the system)	{US0105:O01} {QS0105}	{US0105+} {QS0105+:O01}
S**06	Q/U	Open/close shutter	Numeric	0 = Close 1 = Open	{US0106:1} {QS0106}	{US0106+} {QS0106+:1}
S**07	Q/U	Number of crucibles	Numeric	0-32	{US0107:8} {QS0107}	{US0107+} {QS0107+:8}
S**08	Q/U	Current crucible number	Numeric	1 - Max (set by S**07)	{US0108:3} {QS0108}	{US0108+} {QS0108+:3}
S**09	None	Crucible material list				
S**0900	A/D	Add or delete crucible material from the end of list			{AS010900} {DS010900}	{AS010900+} {DS010900+}
S**09**	Q/U	Material ID	Numeric	0 - Material max entry	{US010901:1} {QS010901}	{US010901+} {QS010901+:1}
S**09FE	Q	Number of crucible materials	Numeric	0 - Number of crucibles	{QS0109FE}	{QS0109FE+:1}
S**0A	Q/U	Max output	Float	-10 V - +10 V	{US010A:10} {QS010A}	{US010A+} {QS010A+:10.00}

Command	Actions	Description	Type	Range	Example Command	Example Response
S**0B	Q/U	Control type	Numeric	0 = Manual 1 = Direct 2 = Individual 3 = BCD	{US010B:1} {QS010B}	{US010B+} {QS010B+:1}
S**0C**	None	Crucible output	None			
S**0C01	Q/U	Relay	Setting	1 - X (Number of Outputs in the system)	{US010C01:O01} {QS010C01}	{US010C01+} {QS010C01+:O01}
S**0C02	Q/U	Relay	Setting	1 - X (Number of Outputs in the system)	{US010C02:O01} {QS010C02}	{US010C02+} {QS010C02+:O01}
S**0C03	Q/U	Relay	Setting	1 - X (Number of Outputs in the system)	{US010C03:O01} {QS010C03}	{US010C03+} {QS010C03+:O01}
S**0C04	Q/U	Relay	Setting	1 - X (Number of Outputs in the system)	{US010C04:O01} {QS010C04}	{US010C04+} {QS010C04+:O01}
S**0C05	Q/U	Relay	Setting	1 - X (Number of Outputs in the system)	{US010C05:O01} {QS010C05}	{US010C05+} {QS010C05+:O01}
S**0C06	Q/U	Relay	Setting	1 - X (Number of Outputs in the system)	{US010C06:O01} {QS010C06}	{US010C06+} {QS010C06+:O01}
S**0D**	None	Crucible input	None			
S**0D01	Q/U	Relay	Setting	1 - X (Number of Outputs in the system)	{US010D01:I01} {QS010D01}	{US010D01+} {QS010D01+:I01}
S**0D02	Q/U	Relay	Setting	1 - X (Number of Outputs in the system)	{US010D02:I01} {QS010D02}	{US010D02+} {QS010D02+:I01}
S**0D03	Q/U	Relay	Setting	1 - X (Number of Outputs in the system)	{US010D03:I01} {QS010D03}	{US010D03+} {QS010D03+:I01}

Command	Actions	Description	Type	Range	Example Command	Example Response
S**0D04	Q/U	Relay	Setting	1 - X (Number of Outputs in the system)	{US010D04:I01} {QS010D04}	{US010D04+} {QS010D04+:I01}
S**0D05	Q/U	Relay	Setting	1 - X (Number of Outputs in the system)	{US010D05:I01} {QS010D05}	{US010D05+} {QS010D05+:I01}
S**0D06	Q/U	Relay	Setting	1 - X (Number of Outputs in the system)	{US010D06:I01} {QS010D06}	{US010D06+} {QS010D06+:I01}
S**0E	Q/U	Drive type	Numeric	0 = Up 1 = Down	{US010E:1} {QS010E}	{US010E+} {QS010E+:1}
S**0F	Q/U	Step	Numeric	0 = Single 1 = Double	{US010F:1} {QS010F}	{US010F+} {QS010F+:1}
S**10	Q/U	Feedback type	Numeric	0 = None 1 = Individual 2 = BCD 4 = In position	{US0110:2} {QS0110}	{US0110+} {QS0110+:2}
S**11	Q/U	Indexer delay	Time	0:00:01 - 150:00:00 (HHH:MM:SS)	{US0111:1:30} {QS0111}	{US0111+} {QS0111+:0:01:30}
S**12	Q/U	Recorder output select	Numeric	0 = Active Layer Film Index 1	{US0112:1} {QS0112}	{US0112+} {QS0112+:1}
S**13	Q/U	Recorder function	Numeric	0 = Rate (Raw) 1 = Rate (Filtered) 2 = Thickness 3 = Rate Deviation 4 = Power 5 = Frequency	{US0113:1} {QS0113}	{US0113+} {QS0113+:1}
S**14	Q/U	Rate 0 Percent Output	Float	0 - 100000 Å/s (default: 0)	{US0114:1} {QS0114}	{US0114+} {QS0114+:1}
S**15	Q/U	Rate 100 Percent Output	Float	0 - 100000 Å/s (default: 1000)	{US0115:1} {QS0115}	{US0115+} {QS0115+:1}

Command	Actions	Description	Type	Range	Example Command	Example Response
S**16	Q/U	Thickness 0 Percent Output	Float	0 - 100000 Å (default: 0)	{US0116:2} {QS0116}	{US0116+} {QS0116+:2}
S**17	Q/U	Thickness 100 Percent Output	Float	0 - 100000 Å (default:1000)	{US0117:10} {QS0117}	{US0117+} {QS0117+:10.000}
S**18	Q/U	Rate Deviation 0 Percent Output	Float	-100.0 - +100.0	{US0118:10} {QS0118}	{US0118+} {QS0118+:10}
S**19	Q/U	Rate Deviation 100 Percent Output	Float	-100.0 - +100.0	{US0119:30} {QS0119}	{US0119+} {QS0119+:30}
S**1A	Q/U	Power 0 Percent Output	Float	0.0 - +100.0 % (default: 0)	{US011A:1} {QS011A}	{US011A+} {QS011A+:1.000}
S**1B	Q/U	Power 100 Percent Output	Float	0.0 - +100.0 % (default: 100)	{US011B:50} {QS011B}	{US011B+} {QS011B+:50.000}
S**1C	Q/U	Frequency 0 Percent Output	Float	4000000 - 6000000	{US011C:-10} {QS011C}	{US011C+} {QS011C+:-10.0}
S**1D	Q/U	Frequency 100 Percent Output	Float	4000000 - 6000000 The DAC output voltage increments in steps of 0.1V (20 KHz) for the output range 0 to 10V.	{US011D:10} {QS011D}	{US011D+} {QS011D+:10.0}
S**1E	R	Switch Crucible			{RS011E}	{RS011E+}
SFE	Q	Number of Sources in the system	Numeric		{US011F:50} {QS011F}	{US011F+} {QS011F+:50.0}

8 Maintenance and Calibration Procedures

8.1 Importance of Density, Tooling, and Z-Ratio

A quartz crystal microbalance is capable of precisely measuring mass added to the face of an oscillating quartz crystal sensor. Conversion of the mass information into thickness is achieved when the user enters the material density and Z-Ratio into the conversion equation. In some instances, where highest accuracy is required, it is necessary to make a density calibration as outlined in Determine Density [▸ 139]. Because flow of material from a deposition source is not uniform, it is necessary to account for the different amount of material arriving at the sensor compared to the substrate. This difference is accounted for in the tooling parameter. The tooling factor can be experimentally established by following the guidelines in Determine Tooling [▸ 140]. In the conversion equation, if the Z-Ratio is not known it can be estimated from the procedure outlined in Laboratory Determination of Z-Ratio. [▸ 140]

8.2 Determine Density

The bulk density values retrieved in Appendix A: Material Table are sufficiently accurate for most applications.

Follow the steps below to determine density value.

1. Place a substrate (with proper masking for film thickness measurement) adjacent to the sensor, so that the same thickness will be accumulated on the crystal and substrate.
2. Set the density to the bulk value of the film material or to an approximate value.
3. Set the Z-Ratio to 1.000 and set tooling to 100%.
4. Place a new crystal in the sensor and make a short deposition (1000–5000 Å) using manual control.
5. After deposition, remove the test substrate and measure the film thickness with either a multiple beam interferometer or a stylus-type profilometer.
6. Determine the new density value with equation [1].

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

Density (g/cm^3) = D_1 (T_x/T_m)   [1]

where: D_1 = Initial density setting, T_x = Thickness reading on the instrument, T_m = Measured thickness

Slight adjustment of density may be necessary in order to achieve $T_x = T_m$

8.3 Determine Tooling

1. Place a test substrate in the system substrate holder.
2. Make a short deposition and determine the actual thickness.
3. Calculate tooling from the relationship shown in equation [2].
4. Round off percent tooling to the nearest 0.1%.
5. When entering the new value for tooling into the program, T_m equals T_x if calculations are done properly.

Tooling (%) = TF_i (T_m/T_x) [2]

where T_m = Actual thickness at substrate holder T_x = Thickness reading in TF_i = Initial tooling factor

It is recommended that a minimum of three separate evaporations be made when calibrating tooling. Variations in source distribution and other system factors will contribute to slight thickness variations. An average value tooling factor should be used for final calibrations.

8.4 Laboratory Determination of Z-Ratio

A list of Z-Ratio values for materials commonly used is available in Appendix A: Material Table. For other materials, Z-Ratios can be calculated from the following formula:

$Z = (d_q \mu_q / d_f \mu_f)^{1/2}$ [3]

$Z = 9.378 \times 10^5 (d_f \mu_f)^{-1/2}$ [4]

where:

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

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

d_q = density of quartz (crystal) (2.649 g/cm^3)

μ_q = shear modulus of quartz (crystal) (3.32×10^{11} dynes/cm^2)

The densities and shear moduli of many materials can be found in a number of handbooks listing physical properties of materials.

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

1 Establish the correct density value as described in the section titled Determine Density [139].

2 Install a new crystal and record its starting frequency (F_{co}).

3 Make a deposition on a test substrate such that the percent crystal life reads approximately 50%, or near the end of crystal life for the particular material, whichever is smaller. Monitor the crystal life value.

4 Stop the deposition and record the ending crystal frequency (F_c).

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

6 Using the density value from step 1 and the recorded values for F_{co} and F_c, adjust the Z-Ratio value in thickness equation [5] to bring the calculated thickness value into agreement with the actual thickness. If the calculated value of thickness is greater than the actual thickness, increase the Z-Ratio value. If the calculated value of thickness is less than the actual thickness, decrease the Z-Ratio value.

$$T_f = (Z_q x10^4/2\pi Zp)((1/F_{co}) \arctan (Z \tan(\pi F_{co})/F_q)) - (1/F_c) \arctan (Z \tan(\pi F_c)/F_q))) \quad [5]$$

where:

T_f = thickness of deposited film (kÅ)

F_{co} = starting frequency of the sensor crystal (Hz)

F_c = Final frequency of the sensor crystal (Hz)

F_q = Nominal blank frequency = 6045000 (Hz)

Z = Z-Ratio of deposited film material

Z_q = Specific acoustic impedance of quartz = 8765000 (MKS units)

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

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

1. If the thickness of material 1 is large compared to material 2, use material 1 Z-Ratio value for both materials.
2. If the thickness of material 1 is thin compared to material 2, use material 2 Z-Ratio value for both materials.
3. If the thickness of both materials is similar, use the Z-Ratio value of material 1 for material 1 and then use a value for Z-Ratio which is the weighted average of the two Z-Ratio values for deposition of material 2 and subsequent materials.

8.5 Determining Soak Power with the Handheld Controller

The Handheld Controller is a useful tool that can be used to determine the appropriate Soak Power levels. Below is an example of how a typical process Soak 1 and Soak 2 can be determined using the Handheld Controller.

Determining Soak 1

Use the Handheld Controller to slowly increase power, a few percent-per-minute. Watch the rate until some rate increase is detected. Depending on the type of source used, this may take several minutes. Once a non-zero rate is achieved, note the current percent power. Use a percent or more lower than this for the Soak Power 1 parameter.

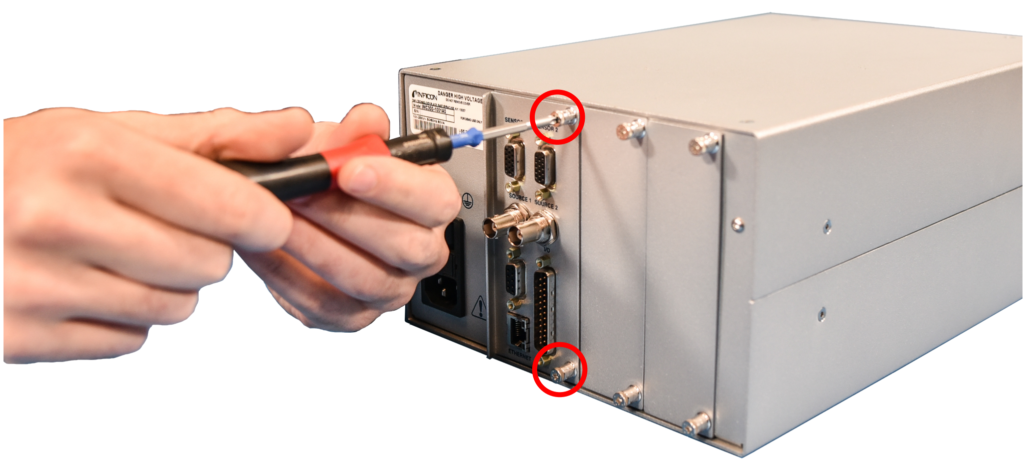
Determining Soak 2

After ~30 - 60 seconds of Soak 1, using the Handheld Controller, again slowly increase the power a percent at a time until the desired Deposition Rate is reached. Use a percent or two less than this number for the Soak Power 2 parameter.

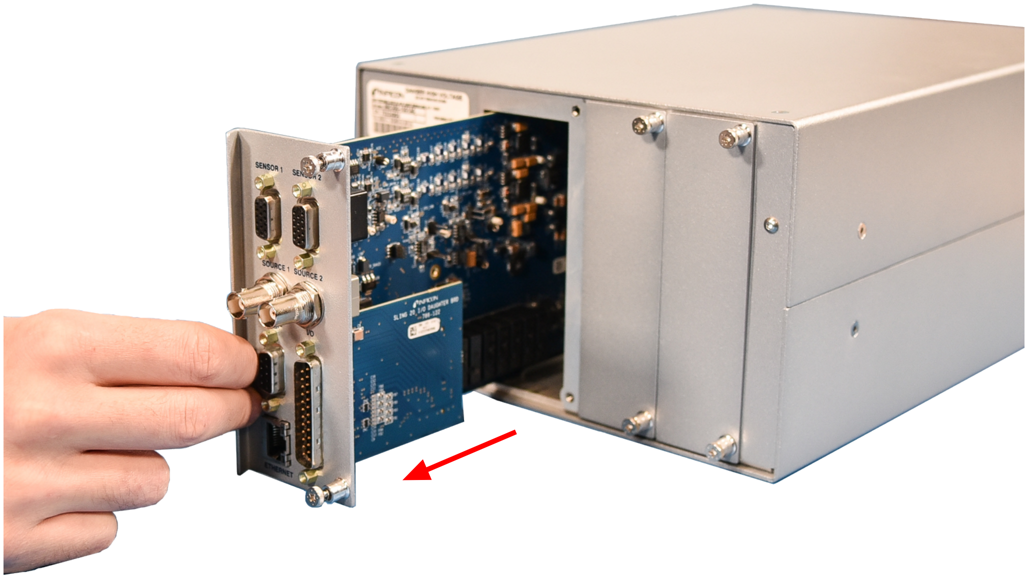
8.6 Replacement Procedures

8.6.1 Controller Board Replacement

1. Begin by turning the mains power switch off and disconnecting the power cord from the unit.
2. Using a Phillips head screwdriver, unfasten the two captive screws on the controller board.



3. Carefully slide the controller board assembly out from the welded chassis.



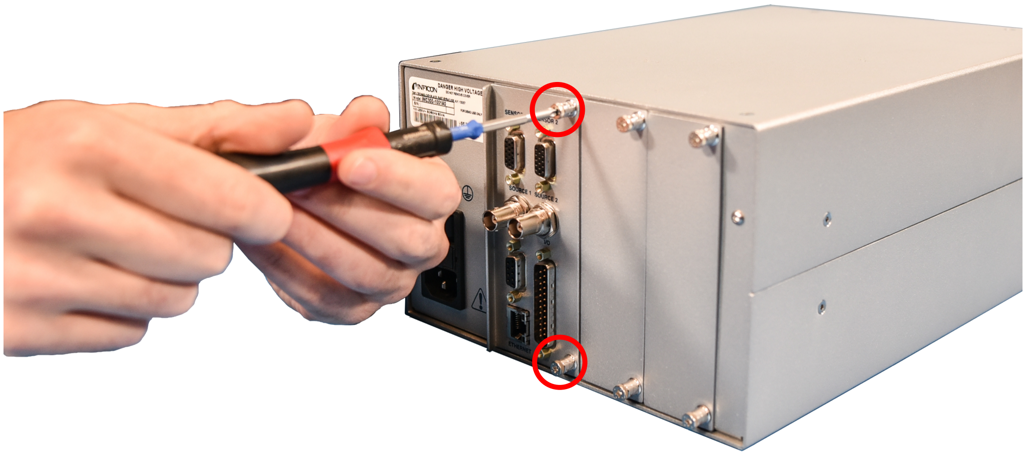
4. Slide the controller board assembly into the left most slot on the welded chassis and fasten the two captive screws using a Phillips head screwdriver.

8.6.2 Routine Maintenance

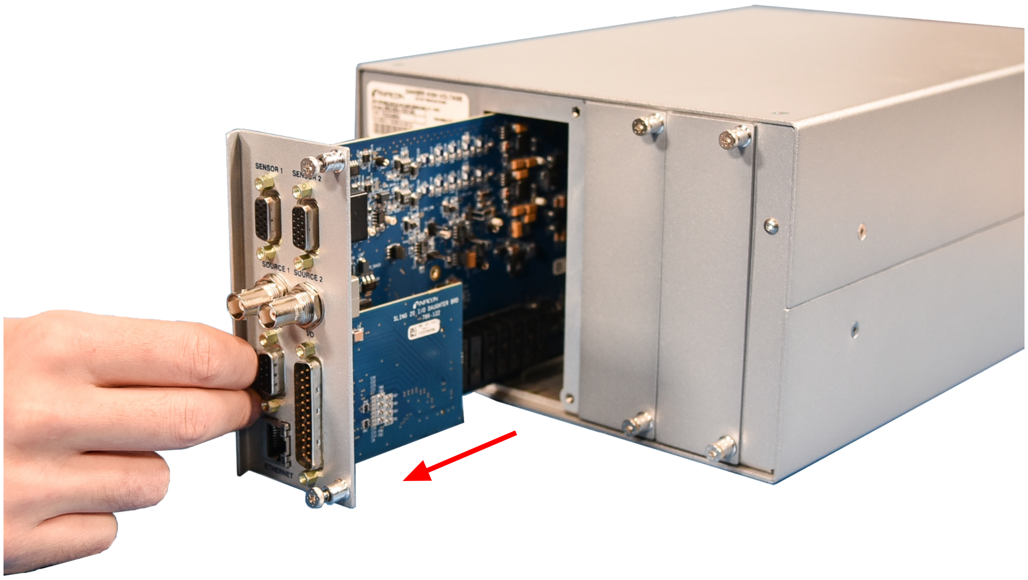
Lithium Battery

1. Begin by turning the mains power switch off and disconnecting the power cord from the unit.

2. Using a Phillips head screwdriver, unfasten the two captive screws on the controller board.



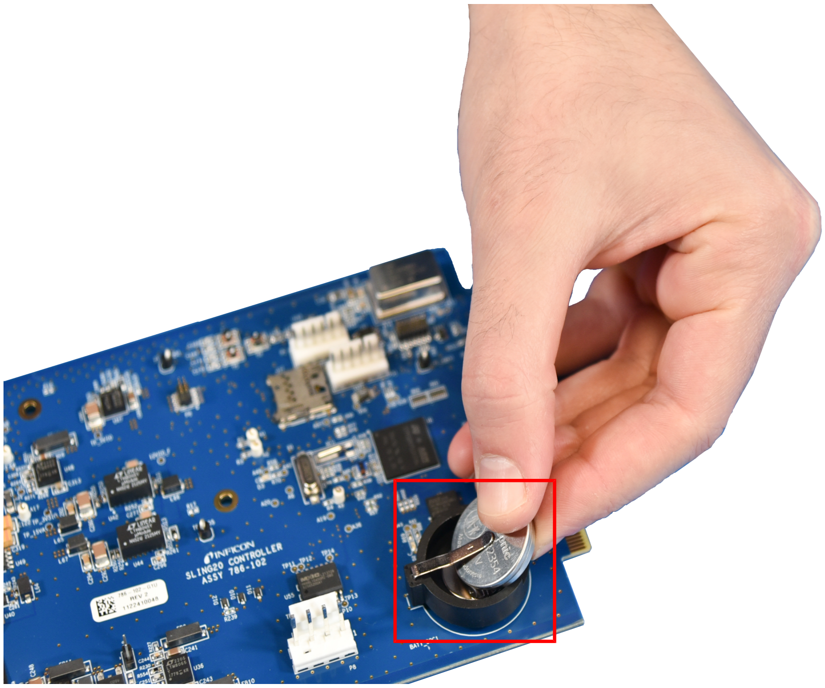
3. Carefully slide the controller board assembly out from the welded chassis.



4. Remove the old battery and insert new battery on the control board.

⚠ CAUTION

Battery tab may be easily bent. When replacing battery confirm tab placement and ensure it makes contact with the battery.



5. Slide the controller card assembly into the left most slot on the welded chassis and fasten the two captive screws using a Phillips head screwdriver.

9 Troubleshooting and Error Messages

9.1 Troubleshooting

If the instrument fails to work or appears to have diminished performance, the following Symptom/Cause/Remedy charts may be helpful.

⚠ DANGER

Risk of Electric Shock

Potentially lethal voltages are present. Refer all maintenance to qualified personnel.

⚠ CAUTION

The instrument contains delicate circuitry that is susceptible to transient power line voltages. Disconnect power whenever making any interface connections. Refer all maintenance to qualified personnel.

Symptom	Cause	Remedy
The power ON LED is not illuminated.	A circuit breaker is tripped.	Have qualified personnel reset the circuit breaker.
	The power cord is unplugged from the wall or the back of the instrument.	Reconnect the power cord.
	There is incorrect voltage.	Have qualified personnel verify the voltage.
	The mains switch is off.	Turn the rear mains switch on.
	The mains fuse is blown.	Replace the mains fuse.

Symptom	Cause	Remedy
The instrument "locks" up.	There is a high electrical noise environment.	Route the cables to reduce noise pickup (30 cm [1 ft.] away from high power conducting lines make a sizable reduction in the amount of noise entering the instrument). Keep all ground wires short with a large surface area to minimize ground impedance (a solid copper strap with 5 to 1 length to width ratio is recommended).
	There is poor ground or a poor grounding practice.	Verify there is proper earth ground. Use an appropriate ground strap, (solid copper strap with 5 to 1 length to width ratio is recommended). Eliminate any ground loops by establishing the correct system grounding. Verify proper instrument grounding.
The instrument does not retain parameters on power down (or there is a loss of parameters on power up).	There is a power supply problem.	Contact the service department, refer to How to Contact Us [▸ 13].

Symptom	Cause	Remedy
The **crystal fail** message is always on.	There is a defective cable from the feedthrough to the instrument.	Use an ohmmeter or DVM (digital voltmeter) to check the electrical continuity or isolation, as appropriate.
	There is poor electrical contact in the transducer, the feedthroughs, or the in-vacuum cable.	Use an ohmmeter or DVM to check the electrical continuity or isolation, as appropriate. See Sensor Operating Manual for more details.
	There is a failed crystal.	Replace the crystal.
	There is no crystal.	Insert a crystal.
	Two crystals are placed into the crystal holder.	Remove one of the crystals.
	The frequency of the crystal is out of range.	Verify that the crystal frequency is within the required range or replace the crystal.
	There is incorrect cable length from the oscillator to the sensor head.	Correct the cable length to meet the specification.
	The stability and quality factors have been exceeded.	Clear the stability and quality factors.
	There is an incorrect sensor number programmed for the active film.	Assign the appropriate sensor to the active film.

9.2 Troubleshooting Sensors

Many sensor head problems can be diagnosed with a DMM (digital multimeter). Disconnect the short oscillator cable from the feedthrough and measure the resistance from the center pin to ground. If the reading is less than 10 MΩ, the source of the leakage should be found and corrected. Likewise, with the vacuum system open, check for center conductor continuity. A reading of more than one Ω from the feedthrough to the transducer contact indicates a problem. Cleaning contacts or replacing the in-vacuum cable may be required.

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

Symptom	Cause	Remedy
There are large jumps of thickness reading during deposition.	Stress causes the film to peel from the crystal surface.	Replace the crystal or use an alloy crystal. Consult the factory.
	Particulate or "spatter" from a molten source is striking the crystal.	Thermally condition the source thoroughly before deposition. Use a shutter to protect the crystal during source conditioning.
	There are scratches or foreign particles on the crystal holder seating surface (improper crystal seating).	Clean and polish the crystal seating surface on the crystal holder. Refer to the appropriate sensor manual.
	Small pieces of material fell on the crystal (for a crystal facing-up situation).	Check the crystal surface and blow it off with clean air.
	Small pieces of magnetic material are being attracted by the sensor magnet and contacting the crystal (sputtering sensor head).	Check the sensor cover aperture and remove any foreign material that may be restricting full crystal coverage. Refer to the appropriate sensor manual.
The crystal ceases to oscillate during deposition before it reaches its normal life.	The crystal is struck by particulate or spatter from the molten source.	Thermally condition the source thoroughly before deposition. Use a shutter to protect the crystal during source conditioning.
	Material on the crystal holder partially masks the crystal cover aperture.	Clean the crystal holder. Refer to the appropriate sensor manual.
	There is an electrical short or an open condition.	Using an ohmmeter or DMM, check for electrical continuity in the sensor cable, connector, contact springs, connecting wire inside sensor, and feedthroughs.
	Check for thermally induced electrical shorts or open conditions.	Using an ohmmeter or DMM, check for electrical continuity in the sensor cable, connector, contact springs, connecting wire inside sensor, and feedthroughs.

Symptom	Cause	Remedy
The crystal does not oscillate or oscillates intermittently (both in vacuum and in air).	There is intermittent or poor electrical contact (the contacts are oxidized).	Use an ohmmeter or DMM to check electrical continuity. Replace the ceramic retainer.
	The leaf spring has lost retentivity (ceramic retainer, center insulator).	Bend the leaves to approximately 45°. Refer to the appropriate sensor manual.
	There is RF interference from the sputtering power supply.	Verify earth ground. The ground strap should be adequate for RF ground (solid copper strap with a 5:1 length:width ratio is recommended). Change the location of the instrument and move the oscillator cabling away from RF power lines. Connect the power supply to a different power line.
	The cables are not connected or are connected to the wrong input.	Verify that there are proper connections.
The crystal oscillates in vacuum, but stops oscillation after it is opened to air.	The crystal is near the end of its life. Opening to air causes film oxidation which increases film stress.	Replace the crystal.
	Excessive moisture accumulates on the crystal.	Turn off the cooling water to the sensor prior to venting. Flow warm water through sensor while the chamber is open.

Symptom	Cause	Remedy
There are large changes in the thickness reading during source warm-up. (This usually causes the thickness reading to decrease.)	There is inadequate cooling water or the cooling water temperature is too high.	Check the cooling water flow rate. The cooling water temperature must be less than 30ºC. Refer to the appropriate sensor manual.
There is thermal instability after the termination of deposition. (This usually causes the thickness reading to increase.)	There is excessive heat input to the crystal.	If there is heat due to radiation from the evaporation source, move the sensor further away from the source and use sputtering crystals for better thermal stability. Install a radiation shield.
	The crystal holder is not seated properly in the sensor body.	Clean or polish the crystal seating surface on the crystal holder. Refer to the appropriate sensor manual.
	There is crystal heating caused by a high-energy electron flux (often found in RF sputtering).	Use a sputtering sensor head.
	There is poor thermal transfer from the water tube to the body (CrystalSix).	Use a new water tube when the clamping assembly has been removed from the body. If a new water tube is not available, use a single layer of aluminum foil between the cooling tube and sensor body, if the process allows.
	There is poor thermal transfer.	Use an aluminum or gold foil washer between the crystal holder and the sensor body.

Symptom	Cause	Remedy
There is poor thickness reproducibility.	There is a variable source flux distribution.	Move the sensor to a more central location to reliably sample the evaporant. Ensure there is a constant relative pool height of melt. Avoid tunneling into the melt.
	The sweep, dither, or position where the electron beam strikes the melt has been changed since the last deposition.	Maintain consistent source distribution by maintaining consistent sweep frequencies, sweep amplitudes and electron beam position settings.
	The material does not adhere to the crystal.	Make certain the crystal surface is clean. Avoid touching the crystal with fingers. Make use of an intermediate adhesion layer.
	There is a cyclic change in rate.	Make certain the source sweep frequency is not "beating" with the measurement frequency.
There is a large drift in thickness (greater than 200 Å for a density of 5.00 g/cm^3) after the termination of sputtering.	There is crystal heating due to poor thermal contact.	Clean or polish the crystal seating surface on the crystal holder. Refer to the appropriate sensor manual.
	The external magnetic field is interfering with the sensor's magnetic field (sputtering sensor).	Rotate the sensor magnet to the proper orientation with the external magnetic field. Refer to the sputtering sensor manual.
	The sensor magnet is cracked or demagnetized (sputtering sensor).	Check the sensor magnetic field strength. The maximum field at the center of the aperture should be 700 gauss or greater.

Symptom	Cause	Remedy
There is a rotary sensor crystal switch problem. (The sensor does not advance or is not centered in aperture.)	There is no relay or an incorrect relay output programmed (for instruments having outputs).	Program a relay.
	There is a loss of pneumatic supply or the pressure is insufficient for operation.	Ensure the air supply is regulated at 80-90 psi.
	Operation has been impaired as a result of material accumulation on the cover.	Clean material accumulation as needed.
	There is an improper alignment.	Refer to the sensor operating manual for the alignment procedure.
	A 0.057 mm (0.00225 in.) diameter orifice is not installed on the supply side of the solenoid valve assembly (CrystalSix or Crystal12 sensors).	Install the orifice as shown in the CrystalSix or Crystal 12 Operating manual.

9.3 Troubleshooting Computer Communication

Symptom	Cause	Remedy
Communication cannot be established between the computer and the instrument.	There is an improper communication cable connection.	Ensure that the cables are connected to the correct ports on the instrument and the computer.
	There is a defective communication cable.	Verify that the cable is plugged in and is not damaged. Replace the communication cable.
	The incorrect IP address or submask is being used.	Verify that the IP address and submask in the instrument match the information in the computer.
	An incorrect communication port number or baud rate is being used.	Verify that the baud rate for the instrument matches the baud rate used by the computer. Verify that the communication port number used in the computer is assigned to the RS-232 port connected to the instrument.
There is an incomplete or erroneous response.	There is an incorrectly formatted message.	Verify that the communication message is formatted correctly.

9.4 Error Messages

Error Message	Cause/Trigger
APP_PROCESS_ERROR_DELAY_FAIL	When the rate deviation is outside of the defined accuracy window for more than 60 seconds.
APP_PROCESS_ERROR_SWITCHER_FAIL	When a crucible/crystal switching does not receive feedback information before the indexer delay timeout.
APP_PROCESS_ERROR_NO_OUTPUT_FOR_SWITCH	When a crystal or crucible switch is requested with no relay assigned for control.
APP_PROCESS_ERROR_RATE_DEV_ERROR	When the rate deviation is outside of the 5% accuracy window for more than 60 seconds.
APP_PROCESS_ERROR_CRYSTAL_FAIL	When a crystal fails. Crystals can fail in the following ways: • failing a crystal with the "Switch Crystal" command or button • disconnecting the crystal from the sensor or XIU (or otherwise unable to detect frequency) • exceeding allowed S and Q stat thresholds
APP_PROCESS_ERROR_MAX_POWER	If the active source's power is equal to the Max Power setting for 5 seconds or more.
APP_PROCESS_ERROR_NO_SENSOR_CONNECTED	When trying to start a process or switch crystals with no sensor connected to IMC300
APP_PROCESS_ERROR_CONFIGURATION	Any of the necessary settings to run a process are missing. Mandatory settings include: • a material • a film configured with that material • a sensor/source being used in that film • a layer to deposit that film • a process to run the layer • having an active process set to run

Error Message	Cause/Trigger
APP_PROCESS_ERROR_TRANSFER_SENSOR	If the selected transfer sensor is the same as the primary sensor (i.e. Sensor 1 is being used for the deposition and you select Transfer Sensor = Sensor 1).
APP_PROCESS_ERROR_PROCESS_LOOP	If an infinite loop is detected when linking processes (i.e. process 1 goes to process 2 goes back to process 1).
APP_PROCESS_ERROR_START_INHIBIT	If an input is assigned to the fixed IO function "Start Inhibit" and a user starts to try the process, the "Start Inhibit" error will be posted.

GUI Error Message	Cause/Trigger
Crucible switch fail	Feedback timeout - switch cannot complete, no feedback was received in the programmed time period, Indexer Delay Timeout - Switch did not complete within the programmed indexer delay period.
Delay fail	IMC300 was unable to achieve rate control within the Shutter Delay Timeout period.
No output for switch	The output pin for Crucible Switching and Crystal Switching has not been set.
Switcher fail	Feedback timeout - switch cannot complete, no feedback was received in the programmed time period, Indexer Delay Timeout - Switch did not complete within the programmed indexer delay period, Unknown position (defect with Crystal6 or Crystal12 resistor grid).
Rate deviation error	IMC300 was unable to achieve rate control within 60 seconds or 20 times the time constant (I term) if the time constant is greater than 3 seconds.
Crystal fail	The active crystal at the current position has failed.
Max power reached	The active source reached the programmed max power level (default 90%).
No sensor connected	Attempted to start a layer with no good crystals on the sensor. This message can also indicate that the XIU is disconnected.
Error loading rate ramp during deposition	Unable to load rate ramp due to film configuration error.
Error loading postcondition during process advance event	Unable to load subsequent postconditions due to film configuration error.

GUI Error Message	Cause/Trigger
Error loading postcondition during start layer	Unable to load first postcondition due to film configuration error.
Error loading postcondition during begin from stopped state	Unable to load postcondition when resuming process. Film configuration error.
Error loading postcondition during ramp step complete	Unable to load postcondition hold due to film configuration error.
Error loading postcondition during hold step complete	Unable to load postcondition ramp due to film configuration error.
Error loading precondition during start layer	Unable to load precondition due to film configuration error.
Error loading precondition during begin from stopped state	Unable to load precondition due to film configuration error.
Error loading precondition during ramp step complete	Unable to load precondition hold due to film configuration error.
Error loading precondition during hold step complete	Unable to load precondition ramp due to film configuration error.
No active process	Attempted to start a process without an active process selected.
No layer in process	Attempted to start a process with no layers to deposit.
Film material not set	The film used by the active layer in the active process is missing material information.
Film sensor not set	The film used by the active layer in the active process has no sensor assigned.
Film source not set	The film used by the active layer in the active process has no source assigned to control the deposition.
Layer film not set	The active layer in the active process does not have a film assigned.
Transfer sensor error	Failed to switch to transfer sensor.
Multi-process loop	Attempted to start a sequence of linked processes that result in a loop.
Start inhibit enabled	The Start command was not processed because the Start Inhibit input is set.
Option card config	Communication with the Option Card was lost or the option card restarted.
Option card slot	The Option Card was removed or inserted while the IMC300 was running. The unit should be restarted.
Recorder conflict	Attempted to start a layer where the active film's source is configured as a recorder instead of a source.

GUI Error Message	Cause/Trigger
USB fault	The Current Limit on the USB port was reached and the USB port was turned off. The unit should be powercycled.
Power loss	Deposition ended due to unexpected power loss.
No backup XTAL	Attempted to start a layer without a known good backup crystal. This message will only appear if Start without Backup XTAL is disabled.
SD card missing	SD card was not detected when powering on the IMC300. The unit should be power cycled, when the SD card is reinserted.
Crystal fail inhibit	The Crystal Fail was not processed because the Crystal Fail inhibit input is set.

10 Measurement Theory

10.1 Basics

A quartz crystal deposition monitor, or QCM, uses the converse piezoelectric properties of a quartz crystal to detect added mass. The QCM uses this mass sensitivity to measure the deposition rate and final thickness of a vacuum deposition. When a voltage is applied across the faces of a properly shaped piezoelectric crystal, the crystal is distorted and changes shape in proportion to the applied voltage. At certain discrete frequencies of applied voltage a condition of very sharp electro-mechanical resonance is encountered. When mass is added to the face of a resonating quartz crystal, the frequency of these resonances is reduced. This change in frequency is very repeatable and is precisely understood for specific oscillating modes of quartz. This easy to understand phenomenon is the basis of an indispensable measurement and process control tool that can easily detect the addition of less than an atomic layer of an adhered foreign material.

In the late 1950s, it was noted by Sauerbrey[1,2] and Lostis[3] that the change in frequency, $\Delta F = F_q - F_c$, of a quartz crystal with coated (or composite) and uncoated frequencies, F_c and F_q respectively, is related to the change in mass from the added material, M_f , as follows:

$M_f / M_q = \Delta F / F_q$ [1]

where M_q is the mass of the uncoated quartz crystal. Simple substitutions lead to the equation that was used with the first “frequency measurement” instruments:

$T_f = K (\Delta F) / d_f$ [2]

where the film thickness, T_f, is proportional (through K) to the frequency change, ΔF, and inversely proportional to the density of the film, d_f. The constant, $K = N_{at} d_q / F_q^{\,2}$, where d_q (= 2.649 g/cm^3) is the density of single crystal quartz and N_{at} (=166100 Hz cm) is the frequency constant of AT-cut quartz. A crystal with a starting frequency of 6.0 MHz will display a reduction of its frequency by 2.27 Hz when 1 Å of aluminum (density of 2.77 g/cm^3) is added to its surface. In this manner the thickness of a rigid adlayer is inferred from the precise measurement of the crystal’s frequency shift. The quantitative knowledge of this effect provides a means of determining how much material is being deposited on a substrate in a vacuum system, a measurement that was not convenient or practical prior to this understanding.

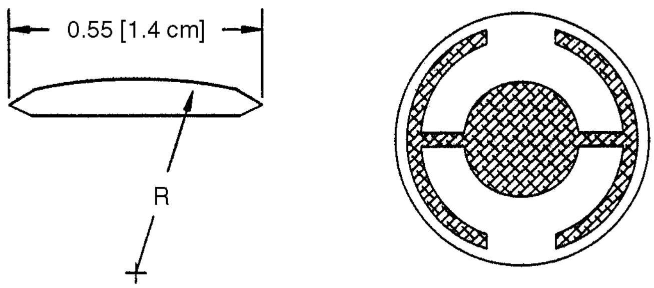
1.G. Z. Sauerbrey, Phys. Verhand .8, 193 (1957)

2.G. Z. Sauerbrey, Z. Phys. 155,206 (1959)

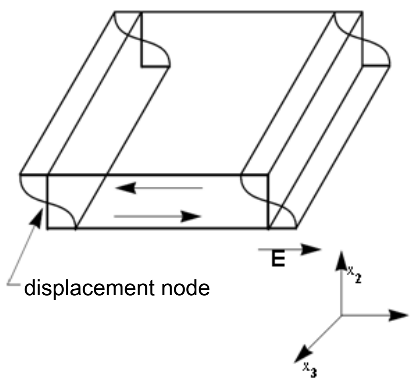
3. P. Lostis, Rev. Opt. 38,1 (1959)

10.2 Monitor Crystals

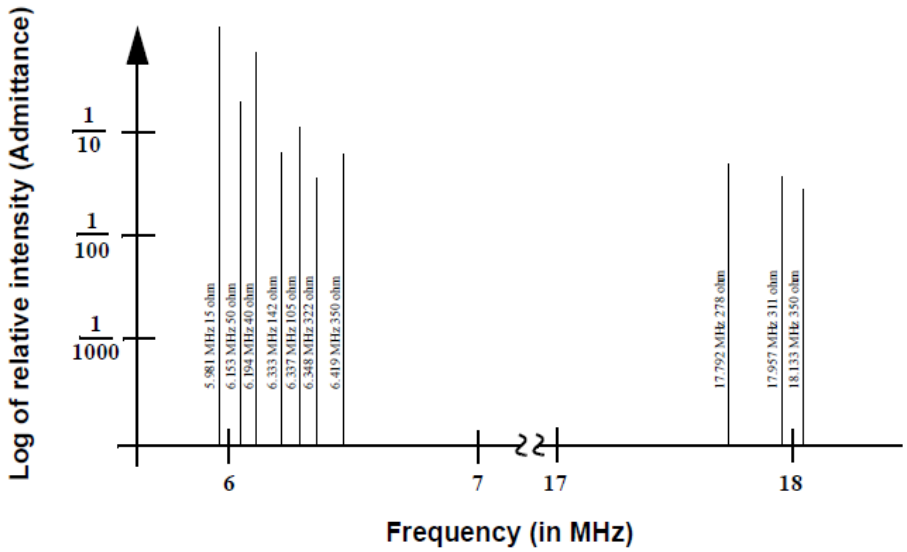
No matter how sophisticated the electronics surrounding it, the essential device of the deposition monitor is the quartz crystal.



The lowest frequency response is primarily a “thickness shear” mode that is called the fundamental. The characteristic movement of the thickness shear mode is for displacement to take place parallel to the major monitor crystal faces. In other words, the faces are displacement antinodes.



The responses located slightly higher in frequency are called anharmonics; they are a combination of the thickness shear and thickness twist modes. The response at about three times the frequency of the fundamental is called the third quasiharmonic. There are also a series of anharmonics slightly higher in frequency associated with the quasiharmonic. The monitor crystal design depicted above is the result of several significant improvements from the square crystals with fully electroded plane parallel faces that were first used. The first improvement was to use circular crystals. This increased symmetry greatly reduced the number of allowed vibrational modes. The second set of improvements was to contour one face of the crystal and to reduce the size of the exciting electrode. These improvements have the effect of trapping the acoustic energy. Reducing the electrode diameter limits the excitation to the central area. Contouring dissipates the energy of the traveling acoustic wave before it reaches the edge of the crystal. Energy is not reflected back to the center where it can interfere with other newly launched waves, essentially making a small crystal appear to behave as though it is infinite in extent. With the crystal’s vibrations restricted to the center, it is practical to clamp the outer edges of the crystal to a holder and not produce any undesirable effects. Contouring also reduces the intensity of response of the generally unwanted anharmonic modes; hence, the potential for an oscillator to sustain an unwanted oscillation is substantially reduced.



The use of an adhesion layer has improved the electrode-to-quartz bonding, reducing “rate spikes” caused by micro-tears between the electrode and the quartz as film stress rises. These micro-tears leave portions of the deposited film unattached and therefore unable to participate in the oscillation. These free portions are no longer detected and the wrong thickness is consequently inferred. The “AT” resonator is usually chosen for deposition monitoring because at room temperature it can be made to exhibit a very small frequency change due to temperature changes. Since there is presently no way to separate the frequency change caused by added mass (which is negative) from the frequency changes caused by temperature gradients across the crystal or film induced stresses, it is essential to minimize these temperature-induced changes. It is only in this way that small changes in mass can be measured accurately.

10.3 Period Measurement Technique

Although instruments using equation [2] were very useful, it was soon noted they had a very limited range of accuracy, typically holding accuracy for ΔF less than 0.02 F_q.

In 1961, it was recognized by Behrndt[4] that:

$M_f / M_q = (T_c - T_q) / T_q = \Delta F / F_q$ [3]

where T_c and T_q are the periods of oscillation of the crystal with film (composite) and the bare crystal, respectively. The period measurement technique was the outgrowth of two factors; first, the digital implementation of time measurement, and second, the recognition of the mathematically rigorous formulation of the proportionality between the crystal's thickness, l_q, and the period of oscillation, $T_q = 1/F_q$. Electronically, the period measurement technique uses a second crystal oscillator, or reference oscillator, not affected by the deposition and usually much higher in frequency than the monitor crystal. This reference oscillator is used to generate small precision time intervals which are used to determine the oscillation period of the monitor crystal. This is done by using two pulse accumulators. The first is used to accumulate a fixed number of cycles, m, of the monitor crystal. The second is turned on at the same time and accumulates cycles from the reference oscillator until m counts are accumulated in the first. Since the frequency of the reference is stable and known, the time to accumulate the m counts is known to an accuracy equal to $\pm 2/F_r$ where F_r is the reference oscillator's frequency. The monitor crystal period is $(n/F_r)/m$, where n is the number of counts in the second accumulator. The precision of the measurement is determined by the speed of the reference clock and the length of the gate time (which is set by the size of m). Increasing one or both of these parameters leads to improved measurement precision. Having a high frequency reference oscillator is important for rapid measurements (which require short gating times), low deposition rates, and low density materials. All of these require high time precision to resolve the small, mass-induced frequency shifts between measurements. When the change of a monitor crystal's frequency between measurements is small, that is, on the same order of size as the measurement precision, it is not possible to establish quality rate measurement. The uncertainty of the measurement injects more noise into the control loop, which can be counteracted only by longer control loop time constants. Long time constants cause the correction of rate errors to be very slow, resulting in relatively long term deviations from the desired rate. These deviations may not be important for some simple films, but can cause unacceptable errors in the production of critical films such as optical filters or very thin layered superlattices grown at low rates. In many cases the desired properties of these films can be lost if the layer-to-layer reproducibility exceeds one or two percent. Ultimately, the practical stability and frequency of the reference oscillator limits the precision of measurement for conventional instrumentation.

4. K. H. Behrndt, J. Vac. Sci. Technol. 8, 622 (1961)

10.4 Z-Match Technique

After learning of fundamental work by Miller and Bolef[5], which rigorously treated the resonating quartz and deposited film system as a one-dimensional continuous acoustic resonator, Lu and Lewis[6] developed the simplifying Z-match® equation in 1972. Advances in electronics taking place at the same time, namely the development of the micro-processor, made it practical to solve the Z-match equation in "real-time." Most deposition process controllers sold today use this sophisticated equation, which takes into account the acoustic properties of the resonating quartz and film system as shown in equation [4].

$T_f = (N_{at}d_q / \pi d_f F_c Z) \arctan (Z \tan(\pi(F_q-F_c)/F_q))$ [4]

where $Z=(d_q\mu_q/d_f\mu_f)^{1/2}$ is the acoustic impedance ratio and μ_q and μ_f are the shear moduli of the quartz and film, respectively. Finally, there was a fundamental understanding of the frequency-to-thickness conversion that could yield theoretically correct results in a time frame that was practical for process control. To achieve this new level of accuracy it requires only that the user enter an additional material parameter, Z, for the film being deposited. This equation has been tested for a number of materials, and has been found to be valid for frequency shifts equivalent to $F_f = 0.4F_q$. Keep in mind that equation [2] was valid to only $0.02F_q$ and equation [3] was valid only to approximately $0.05F_q$.

5. J. G. Miller and D. I. Bolef, J. Appl. Phys. 39, 5815, 4589 (1968)

6. C. Lu and O. Lewis, J Appl. Phys. 43, 4385 (1972)

11 Control Loop Theory

The instrumental advances in measurement speed, precision and reliability would not be complete without a means of translating this improved information into improved process control. For a deposition process, this means keeping the deposition rate as close as possible to the desired rate. The purpose of a control loop is to take the information flow from the measurement system and to make power corrections that are appropriate to the characteristics of the particular evaporation source. When properly operating, the control system translates small errors in the controlled parameter, or rate, into the appropriate corrections in the manipulated parameter, power. The controller's ability to quickly and accurately measure and then react appropriately to the small changes keeps the process from deviating very far from the set point.

The controller model most commonly chosen, for converting error into action is called PID. In the PID, P stands for proportional, I stands for integral and D stands for derivative action. Certain aspects of this model will be examined in detail a little further on. The responsiveness of an evaporation source can be found by repetitively observing the system response to a disturbance under a particular set of controller settings. After observing the response, improved controller parameters are estimated and then tried again until satisfactory control is obtained. Control, when it is finally optimized, essentially matches the parameters of the controller model to the characteristics of the evaporation source.

Techniques for calculating optimum source control parameters can be classified by the type of data used for tuning. They fall into basically three categories:

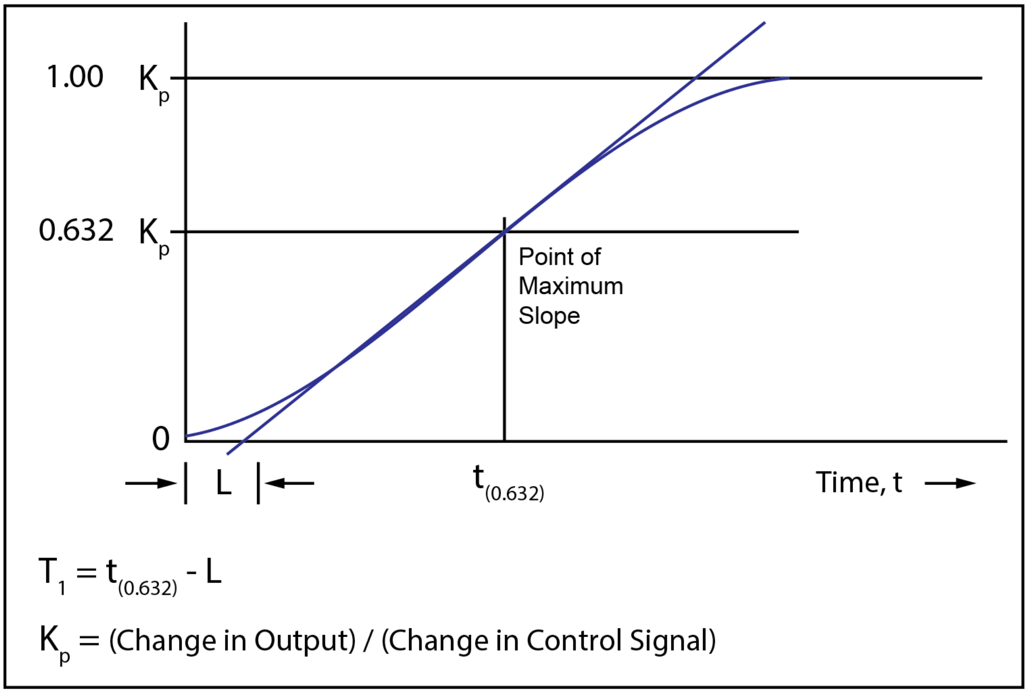
- Closed Loop Methods
- Open Loop Methods
- Frequency Response Methods

Of these categories, the open loop methods are considered superior. They are considered superior because of the ease with which the necessary experimental data can be obtained and because of the elimination (to a large extent) of trial and error when the technique is applied. The important response characteristics are determined as shown in the following graph.

In general, it is not possible to characterize all processes exactly; some approximation must be applied. The most common is to assume that the dynamic characteristics of the process can be represented by a first-order lag plus a dead time. The Laplace transform for this model (conversion to the s domain) is approximated as:

$$\frac{\text{Output}}{\text{Input}} = \frac{K_p \exp(-Ls)}{T_1 s + 1}$$

Three parameters are determined from the process reaction curve. They are the steady state gain, K_p, the dead time, L, and the time constant, T_1. Several methods have been proposed to extract the required parameters from the system response as graphed below. These are: a one point fit at 63.2% of the transition (one time constant); a two point exponential fit; and a weighted least-square-exponential fit. From the above information a process is sufficiently characterized so that a controller algorithm may be customized.



A controller model used extensively is the PID type, shown in Laplace form in the following equation.

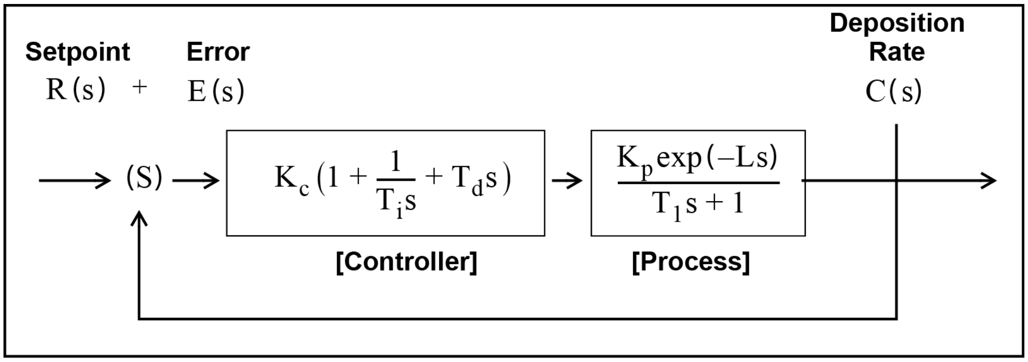
$$M(s) = K_c\left(1 + \frac{1}{T_i s} + T_d s \;\; Es\right)$$

Where

- M(s) = manipulated variable or power
- K_c = controller gain (the proportional term)
- T_i = integral time
- T_d = derivative time
- E(s) = process error

The following figure represents the controller algorithm and a process with first order lag plus a dead time. The process block implicitly includes the dynamics of the measuring devices and the final control elements, in our case the evaporator power supply.

R(s) represents the rate setpoint. The feedback mechanism is the error generated by the difference between the measured deposition rate, C(s), and the rate set point, R(s).



The key to using any control system is to choose the proper values of K_c, T_d and T_i. Optimum control is a somewhat subjective quantity as noted by the presence of several mathematical definitions as shown below.

The integral of the squared error (ISE) is a commonly proposed criterion of performance for control systems.

It can be described as:

$$ISE = \int e^2(t)\,dt$$

where error = e = setpoint minus the measured rate. The ISE measure is relatively insensitive to small errors, but large errors contribute heavily to the value of the integral. Consequently, using ISE as a criterion of performance will result in responses with small overshoots but long settling times, since small errors occurring late in time contribute little to the integral.

The integral of the absolute value of the error (IAE) has been frequently proposed as a criterion of performance:

$$IAE = \int |e(t)|\,dt$$

This criterion is more sensitive to small errors, but less sensitive to large errors, than ISE.

Graham and Lathrop7 introduced the integral of time multiplied by the absolute error (ITAE) as an alternate criterion of performance:

$$ITAE = \int t|e(t)|\,dt$$

ITAE is insensitive to the initial and somewhat unavoidable errors, but it will weight heavily any errors occurring late in time. Optimum responses defined by ITAE will consequently show short total response times and larger overshoots than with either of the other criteria. It has been found that this criteria is generally most useful for deposition process control.

The most satisfactory performance criterion for deposition controllers is the ITAE. There will be overshoot, but the response time is quick, and the settling time is short. For all of the above integral performance criteria, controller tuning relations have been developed to minimize the associated errors. Using manually entered or experimentally determined process response coefficients, ideal PID controller coefficients can be readily calculated for the ITAE criteria as shown below.

$$K_c = (1.36/K_p)\,(L/T_1)^{-0.947}$$

$$T_i = (1.19T_1)\,(L/T_1)^{0.738}$$

$$T_d = (0.381T_1)\,(L/T_1)^{0.995}$$

For slow systems, in order to help avoid controller windup (windup is the rapid increase in control signal before the system has the chance to respond to the changed signal), the time period between manipulated variable (control voltage) changes is lengthened. This allows the system to respond to the previous controller setting change, and aggressive controller settings can be used.

A secondary advantage is that immunity to process noise is increased since the data used for control is now comprised of multiple readings instead of a single rate measurement, taking advantage of the mass integrating nature of the quartz crystal.

With process systems that respond quickly (short time constant) and with little to no measurable dead time, the PID controller often has difficulty with the deposition process noise (beam sweep, fast thermal shorts of melt to crucible, etc.). In these situations a control algorithm used successfully is an integral/reset type of controller. This type of controller will always integrate the error, driving the system towards zero error. This technique works well when there is little or no dead time. If this technique is used on a process with measurable lag or dead time, then the control loop will tend to be oscillatory due to the control loop over-compensating the control signal before the system has a chance to respond.

12 Appendix A: Material Table

The following represents the density and Z-Ratio for various materials. The list is alphabetical, by chemical formula. The Z-Ratio values shown are normalized for AT-cut quartz crystals.

⚠ WARNING

Some of these materials are hazardous. 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.

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_2O_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
BaN_2O_6	3.244	1.261	barium nitrate
BaO	5.720	*1.000	barium oxide
$BaTiO_3$	5.999	0.464	barium titanate (tetragonal)

Formula	Density	Z-Ratio	Material Name
$BaTiO_3$	6.035	0.412	barium titanate (cubic)
Be	1.820	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 trisulfide
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
CoO	6.440	0.412	cobalt oxide
Cr	7.200	0.305	chromium
Cr_2O_3	5.210	*1.000	chromium (III) oxide

Formula	Density	Z-Ratio	Material Name
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 sulfide
Ga	5.930	0.593	gallium
Ga_2O_3	5.880	*1.000	gallium oxide (beta)
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
Ge	5.350	0.516	germanium
Ge_3N_2	5.200	*1.000	germanium nitride
GeO_2	6.240	*1.000	germanium oxide

Formula	Density	Z-Ratio	Material Name
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	holmium
Ho_2O_3	8.410	*1.000	holmium oxide
In	7.300	0.841	indium
In_2O_3	7.180	*1.000	indium 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	lanthanum 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
$LiNbO_3$	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

Formula	Density	Z-Ratio	Material Name
$MgAl_2O_6$	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 trioxide
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	32.00	*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
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	neodymium
Nd_2O_3	7.240	*1.000	neodymium oxide
NdF_3	6.506	*1.000	neodymium fluoride
Ni	8.910	0.331	nickel
NiCr	8.500	*1.000	nichrome
NiCrFe	8.500	*1.000	Inconel

Formula	Density	Z-Ratio	Material Name
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	rubidium 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	sulfur
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
Se	4.810	0.864	selenium
Si	2.320	0.712	silicon
Si_3N_4	3.440	*1.000	silicon nitride

Formula	Density	Z-Ratio	Material Name
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 fluoride
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_2O_3	4.600	*1.000	titanium sesquioxide
TiB_2	4.500	*1.000	titanium boride
TiC	4.930	*1.000	titanium carbide
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

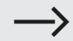
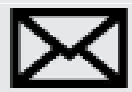
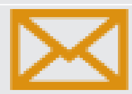
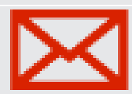
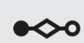
Formula	Density	Z-Ratio	Material Name
TlBr	7.560	*1.000	thallium bromide
TlCl	7.000	*1.000	thallium chloride
TlI	7.090	*1.000	thallium iodide (beta)
U	19.050	0.238	uranium
U_3O_8	8.300	*1.000	tri uranium octoxide
U_4O_9	10.969	0.348	uranium oxide
UO_2	10.970	0.286	uranium dioxide
V	5.960	0.530	vanadium
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 disulfide
WSi_2	9.400	*1.000	tungsten silicide
Y	4.340	0.835	yttrium
Y_2O_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
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

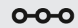
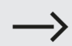
Formula	Density	Z-Ratio	Material Name
ZrN	7.090	*1.000	zirconium nitride
ZrO_2	5.600	*1.000	zirconium oxide

13 Appendix B: Definitions of Icons

The following table defines all icons shown in IMC300. The list is alphabetical and states which screen the icons are located.

Icon Name	Location	Icon
Add	Process screen/ layer screen/ pre conditioning screen/ post conditioning screen	
Calendar	Time settings	
Clock	General settings/ time settings	
Close shutter	Source screen/ sensor screen	
Communication	Settings screen	
Copy	Process screen	
Crystal	Sensor screen	
Delete	Process screen	
Deposit	Film screen	
Display	Settings screen	
Double arrow	File system settings	
Film	Film screen	
Frequency	Operate screen	
Graph	Operate screen / sensor screen	
High brightness	Screen settings	
Info	All screens	

Icon Name	Location	Icon
Layers	Operate screen	
Library	Library screen	
Lock	Settings screen	
Low brightness	Screen settings	
Manual power	Source settings	
Maintenance	All screens	
Material	Source screen	
Message	Top bar	
Mail notification		
Mail warning		
Mail error		
No mail		
Move	Process screen	
Mute	Settings screen	
Next	Operate screen	
Open shutter	Source screen / sensor screen	
Operate	All screens	
Preconditioning	Film screen	

Icon Name	Location	Icon
Post conditioning	Film screen	
Power	Source screen	
Process	Process screen	
Rate	Operate screen	
Rate deviation	Operate screen	
Reset	Operate screen	
Rotate carousel	Sensor screen	
Rotate sensor	Sensor screen	
Selection	Operate screen	
Sensor	Graph panel	
Settings	All screens	
Single arrow	File system settings	
Source	Operate screen	
Speaker	Settings screen	
Start	Operate screen	
Stop	Operate screen	
Switch crystal	Sensor screen	
Thickness	Operate screen	

Icon Name	Location	Icon
Unlocked	Lock settings	
USB	Settings screen	
Zero thickness	Operate screen	

14 Appendix C: How to Update Application Firmware on IMC300

Prerequisites

- Flash drive.
- The Application Update contains two files, fw-app.efw and tgfx_ext.ebin. See INFICON Service Engineer for update files.

Procedure

1. Copy the two encrypted files (fw-app.efw and tgfx_ext.ebin) to the USB flash drive.
2. Power OFF the IMC300.
3. Plug the USB flash drive into the slot on the front panel.
4. Power ON the IMC300 unit. The firmware update process will begin (notice the blinking amber LED on the front panel) and once it’s finished, the GUI operating screen will appear on the LCD. You may also verify the update by viewing the software version command using the external serial interface or the Info Menu screen.

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