4200-3-DOC001_1.0

Option User Manual

The Rook™

Fully Integrated 3-Axis Cryogenic Nanopositioner

CryoAdvance 50 | CryoAdvance 100 | s200

Table of Contents

Section 1 - Preface

WARNING
Read all instructions before using this product. All users must read and understand this manual and all other safety instructions before using the equipment. Retain these instructions for future reference.

This manual is intended for users of the Montana Instruments products and systems described herein. Users include anyone who may physically interact with the system or peripheral equipment, including installing, setting up, or configuring the system, or anyone who may operate system components via operating panels, the supplied user interface, or remote interfaces.

This manual may be used by facilities personnel for determining infrastructure requirements in the room or building where the equipment will be installed.

This manual should be referenced by authorized service personnel for important safety and hazard information and other product restrictions.

1.1 Conventions Used in this Manual

The following style conventions are used in this document:

- Vertical bar (|)
  - Indicates alternative selections. The bar may be used in place of "and" or "or".
- Alphanumeric List (1., 2., 3…| a., b., c…)
  - Indicates instructions or actions which should be completed in a specific ordered sequence.
- Bulleted List (• | ◦ | -)
  - Indicates instructions, commands, or additional information about an action.
  - May alternatively be used for unordered lists of materials or additional reference notes.
- `Courier Font`
  - Indicates a label or indicator on a physical product or part.
  - Indicates a system output, such as a display reading.
  - May also be used for URLs, file paths, file names, scripting language, prompts, or syntax.

1.1.1 Abbreviations

The following abbreviations may be used:

- ACM: Ancillary Control Module
- CAN: Controller Area Network
- DMM: Digital Multimeter
- HDMI: High-Definition Multimedia Interface
- MI: Montana Instruments
- PCB: Printed Circuit Board
- TCM: Temperature Control Module
- UI: User Interface
- UPS: Uninterruptible Power Supply
- USB: Universal Serial Bus
- VNC: Virtual Network Computing

1.1.2 Explanation of Safety Warnings

Safety and hazard information includes terms, symbols, warnings, and instructions used in this manual or on the equipment to alert users to precautions in the care, use, and handling of the system. The following hazard levels and information are considered:

⚠ DANGER
Serious personal injury Imminent hazards, if not avoided, will result in serious injury or death.

⚠ WARNING
Serious personal injury Potential hazards which, if not avoided, could result in serious injury or death.

⚠ CAUTION
Possible personal injury Potential hazards which, if not avoided, could result in minor or moderate injury.

NOTICE
Command or Product Safety Notice Potential hazards which, if not avoided, could result in product damage.

» NOTE
Points of particular interest for more efficient or convenient equipment operation; additional information or explanation.

1.1.3 Graphical Symbols

The following symbols may be used in diagrams, supporting text, and physical parts:

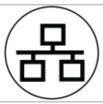
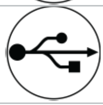
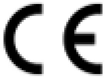
	Hazard Alert: General Warning		Hazard Alert: High Voltage
	Hazard Alert: Laser Radiation		HDMI port
	CAN bus module		USB port
	Hazard Alert: Hot Surface		Hazard Alert: Magnetic Field
	Waste Electrical and Electronic Equipment (WEEE)		Conformité Européenne (CE)
	Multimeter Required		Hand Push Button

Figure 1: Table of Graphical Symbols.

1.2 General Hazard Information

The following descriptions are of general hazards and unsafe practices that may result in product damage, severe injury, or death.

- The products, parts, and components in this manual are to be serviced by authorized Montana Instruments service representatives only. Failure to do so will void the warranty and may damage the product and/or create a safety hazard.
- Only use all components provided for the intended purpose described herein.
- If the equipment or any component is used or modified in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

The following hazards may be typical for this product:

⚠ WARNING
Risk of tripping and entanglement from poor cable management. System components pose tripping and entanglement hazards. • Recommended cable management is to group cables where possible without reducing systems performance. • Ensure cables are visible in high-traffic areas.

WARNING
Risk of injury when lifting or moving system components. System components, including standalone equipment and installed assemblies, may be heavy. • Use caution when lifting or moving equipment or assemblies. Ensure proper lifting principles are used to avoid injury. • Equipment or assemblies >20 kg should always be lifted by two or more people or with a suitable lifting device.

WARNING
High voltage: danger of electric shock. Electric shocks and burns from capacitor discharge or power circuits could lead to serious injury or death. • Before turning on any power supply, the ground prong of the power cord plug must be properly connected to the ground connector of the wall outlet. The wall outlet must have a third prong or must be properly connected to an adapter that complies with these safety requirements. • Only use replacement power cords or power plugs with the same polarity and power rating as those of the original ones. Do NOT use inadequately rated cables. If the equipment or the wall outlet is damaged, the protective grounding could be disconnected. • Do NOT use damaged equipment until its safety has been verified by authorized personnel. • Do NOT disconnect or tamper with the operation of the protective earth terminal inside or outside the apparatus.

NOTICE
Only clean exterior surfaces with acceptable fluids. • Only use deionized water, glass cleaner, or isopropyl alcohol to clean the exterior surfaces of any enclosure. Do NOT use any volatile chemicals other than isopropyl alcohol. • Apply fluid to a clean, lint-free cloth and wipe the surface with a cloth. Do NOT apply fluid directly to any surfaces or enclosures.

Section 2 - Option Overview

2.1 Rook™ Nanopositioner

Compatible Cryostation Models	Configuration
CryoAdvance 50	One positioner, open- & closed-loop
CryoAdvance 50 – CryoOptic	One positioner, open- & closed-loop
CryoAdvance 50 – MagnetoOptic	One positioner, **open loop only**
CryoAdvance 100	Up to two positioners, open- & closed-loop
CryoAdvance 100 - CryoOptic	Up to two positioners, open- & closed-loop
s200	Up to four positioners, open- & closed-loop

Figure 1: Table of Rook™ Nanopositioner configurations.

Figure 2: Rook™ Nanopositioner.

2.1.1 Intended Use

Montana Instruments has set a new standard of positioning reliability by delivering the only nanopositioner available today with critical motion performance specified at the top of the 3-axis stack. Bi-directional repeatability and bi-directional runout are measured and specified while integrated into an operational Cryostation set to 4 K base temperature. The Rook™ stands up to everyday handling and operation using Montana Instruments' Galaxy software and touchscreen control architecture for ease and simplicity of use.

The Rook™ positioning system seamlessly integrates with other Montana Instruments equipment, allowing for a single source of control for your cryogenic environment and making experimental automation simpler. Scripting examples are available onboard your touchscreen and in this user manual.

2.1.2 Components

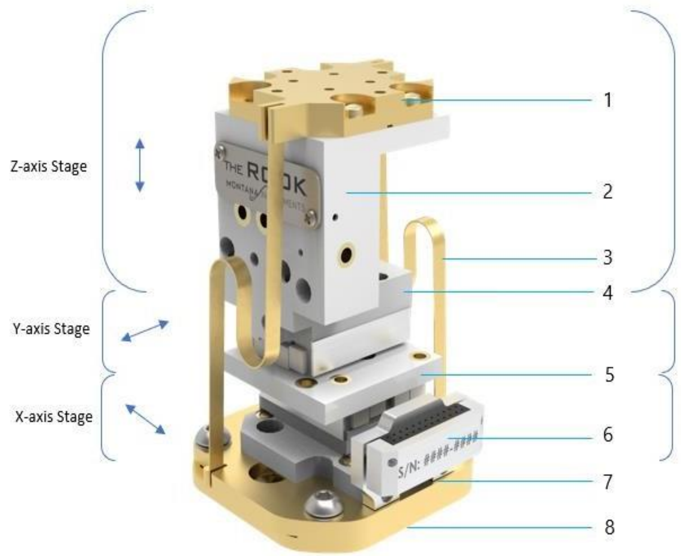
The nanopositioner module consists of a 3-axis (X-Y-Z) positioner stack, rack-mountable motion controller, and power supply. The Cryostation user interface touchscreen provides operational control of the nanopositioner.

The Rook™ Nanopositioner

Ceramic body with motion powered by piezo slip-stick mechanisms on each axis. The positioner kit includes flexible thermal links for the best possible conduction to your sample, and the whole assembly is removable from the Cryostation sample chamber for added flexibility. The Rook™ nanopositioner is capable of operation atcryogenic temperatures down to <3 Kelvin.

Features:

- Travel range of 5mm x 5mm x 5mm.
- 50 nm closed loop encoder resolution.
- The load capacity of up to 0.4 kg (with spring).
- Complete ceramic construction.



1. Cryogenic Mounting Plate
2. Z-axis Stage (Carriage)
3. Flexible Thermal Link
4. Y-axis Stage (Carriage)
5. X-axis Stage (Carriage)
6. Terminal Block Connector
7. Mounting Plate
8. Adaption Plate

Figure 3: Rook™ Nanopositioner components.

2.1.3 Nanopositioner Mounted to Sample Chamber Base

The nanopositioner module consists of a 3-axis (X-Y-Z) positioner stack, rack-mountable motion controller, and power supply. The Cryostation user interface touchscreen provides operational control of the nanopositioner.

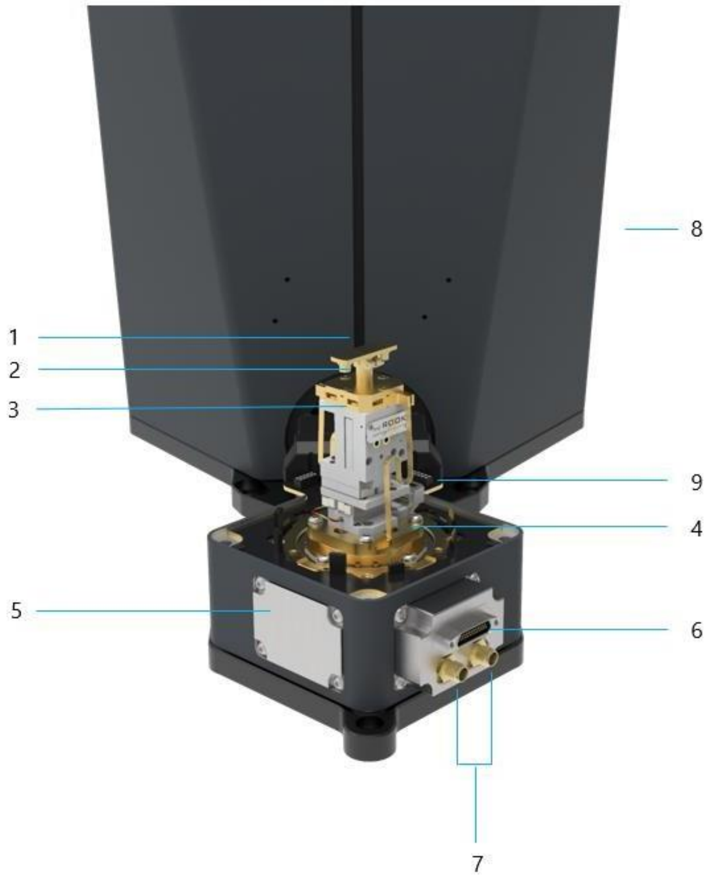


Figure 4: Nanopositioner mounted to sample chamber base.

1. Sample Mount
2. Adapter
3. Cryogenic Mounting Plate
4. Flexible Thermal Link
5. Side-Panel
6. Micro-D 25 Adapter
7. Coaxial Connectors
8. Foundation
9. Terminal Block Connector

2.1.4 Cryostation, Nanopositioner, and Housing

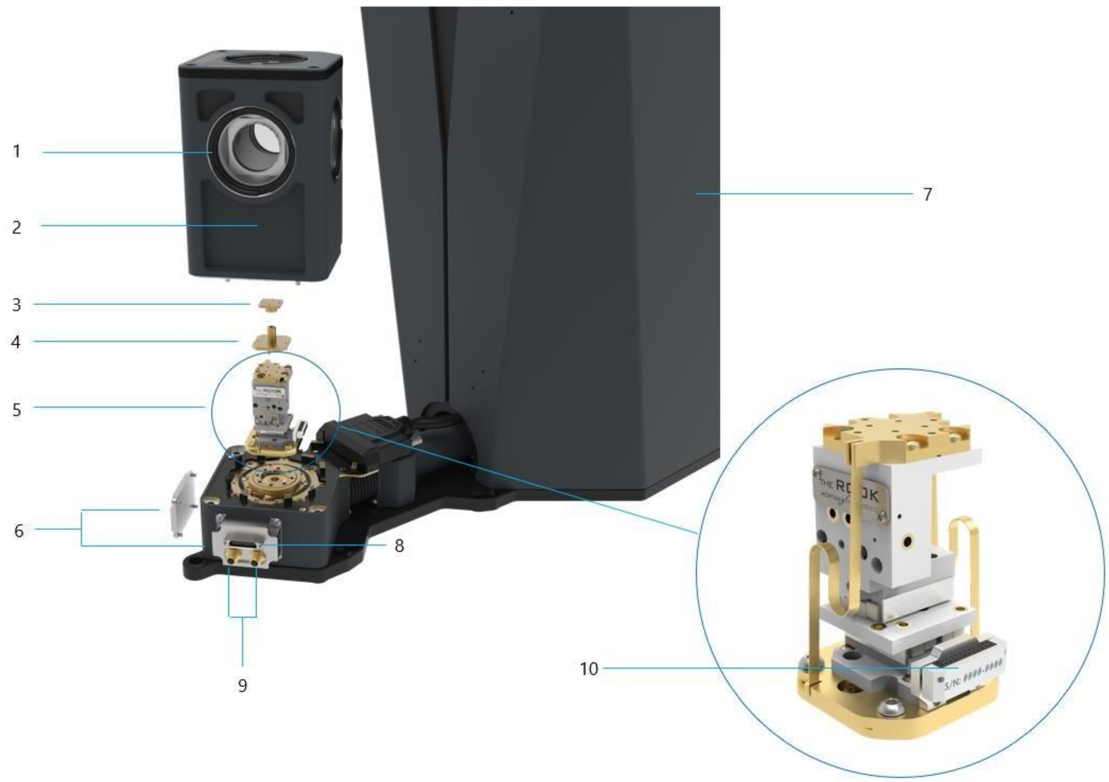


Figure 5: Cryostation, nanopositioner, and housing.

1. Window
2. Housing
3. Sample Mount
4. Adapter
5. Nanopositioner
6. Side Panels
7. Foundation
8. Micro-D 25 Feedthrough.
9. Coaxial Connectors
10. Terminal Block Connector

2.1.5 Nanopositioner Stage Dimensions

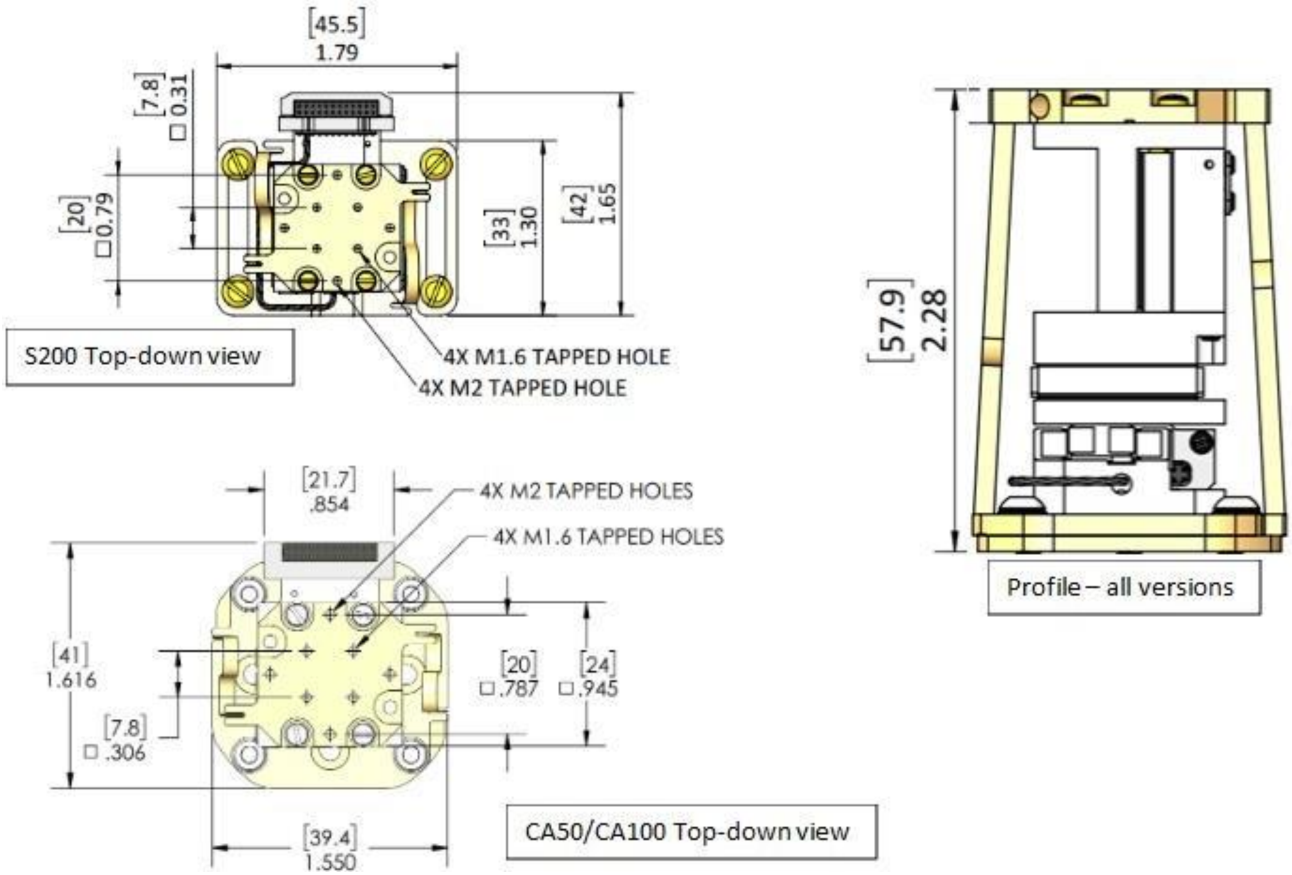


Figure 6: Nanopositioner stage dimensions.

2.1.6 Technical Specifications

Environmental Specifications

Temperature of Environment	5 – 25 °C
Humidity	5 – 80% non-condensing
Altitude	<2000 m

Power Specifications

Model		**Motion Controller**
Mains Power Connector on Unit		IEC 60320 C14
Line Voltage		100 – 240 VAC
Frequency		50 – 60 Hz
Maximum Current Draw		1.9 A
Maximum Power Consumption		190 W
Wall Outlet / Receptacle	N. America & non-EU	Standard NEMA 1-15P
	CEE Europe (non-UK)	NEMA 1-15P is supplied and IEC 320-C8 available for region-specific adapters
	UK	NEMA 1-15P is supplied and IEC 320-C8 available for region-specific adapters
	Israel	NEMA 1-15P is supplied and IEC 320-C8 available for region-specific adapters

Physical Dimensions

Component	**L x W x H**	**Mass**
	19″ x 15″ x 1.75″	7.5 lbs

2.1.7 Safety Information

The following hazards may be typical for this product:

⚠ WARNING
Risk of injury due to sharp edges The interior of the enclosure contains sheet metal parts that may have sharp edges. • When working inside the enclosure (authorized service personnel only), exercise caution to avoid getting cut by these edges.

WARNING
High voltage: danger of electric shock Electric shocks and burns from capacitor discharge or power circuits could lead to serious injury or death. • Prior to accessing the enclosure or when otherwise servicing the unit (authorized service personnel only), completely power down the system and unplug the power cable. • If power must be applied to diagnose issues or otherwise, a grounding strap must be applied to the arm-interfacing internal components.

2.2 Touchscreen Monitor

The Cryostation user interface touchscreen provides operational control of the nanopositioner.

2.2.1 Intended Use

A 10-inch touchscreen display provides the main user interface control for the system. The software can alternatively be monitored and controlled via a VNC interface or remote scripting.

2.2.2 Touchscreen Monitor Inputs

The touchscreen monitor has HDMI, USB 3.0, and Power input ports located on the back near the lower center of the device.

Figure 7: Touchscreen monitor inputs.

2.2.3 Control Console

The console located on the back near the top-center of the device contains basic display controls.

Figure 8: Display monitor control console.

2.2.4 Safety Information

The following hazards may be typical for this product:

WARNING
High voltage: danger of electric shock Electric shocks and burns from capacitor discharge or power circuits could lead to serious injury or death. • Prior to accessing the enclosure or when otherwise servicing the unit (authorized service personnel only), completely power down the system and unplug the power cable. • If power must be applied to diagnose issues or otherwise, a grounding strap must be applied to the arm-interfacing internal components.

2.3 Motion Control Unit

2.3.1 Intended Use

The motion control unit is a device used for interfacing with and controlling the nanopositioner. It provides both the electronic hardware and software interface for communicating with the nanopositioner and controlling the stages within the stack.

2.3.2 Components

The nanopositioner module consists of a 3-axis (X-Y-Z) positioner stack, rack-mountable motion controller, and power supply. The Cryostation user interface touchscreen provides operational control for the nanopositioner.

2.3.3 Motion Controller Inputs/Outputs (I/O)

The Nanopositioner I/O ports are located at the back of the unit.

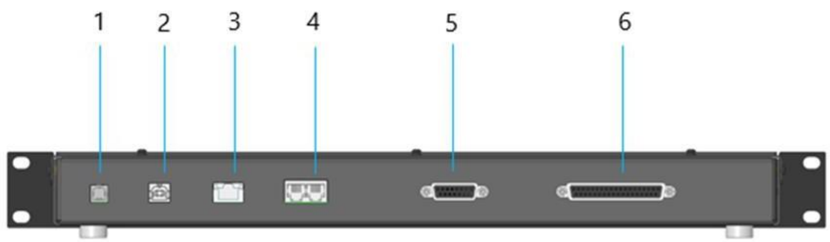


Figure 9: Motion controller (back) inputs/outputs (I/O).

1. Power Input HIROSE P/N: RP34-8R-3DL 24 VDC/50 W
2. USB 2.0 Receptacle
3. Ethernet 10/00/1000 MBPS
4. RS485 IN/OUT
5. Digital Input/Output D-SUB 25 Pin Female Connector
6. Motor and Encoder D-SUB 37 Pin Female Connector

2.3.4 Motion Controller Power Button

The Nanopositioner power button is located on the front panel. When the unit is powered on the button will glow.

Figure 10: Motion controller (front) power button location.

2.3.5 Safety Information

The following hazards may be typical for this product:

⚠ WARNING
High voltage: danger of electric shock Electric shocks and burns from capacitor discharge or power circuits could lead to serious injury or death. • Prior to accessing the enclosure or when otherwise servicing the unit (authorized service personnel only), completely power down the system and unplug the power cable. • If power must be applied to diagnose issues or otherwise, a grounding strap must be applied to the arm-interfacing internal components.

Section 3 - Option Installation & Handling

3.1 Packaging Contents

The motion controller comes packed with Cryostation.

3.1.1 Unpacking the Motion Controller

1. Locate the control unit boxes and remove the box wrap and cut the bands securing the box to the pallet. Carefully lift the box off the pallet and set it on the floor or a nearby surface.
2. Open the top of the box and remove the top piece of foam.
3. Reach inside and grasp the underside of the unit. Lift the unit up and out of the box. Keeping the unit in the same orientation, set onto an adjacent surface.
4. Carefully remove the plastic wrap around the enclosure.
5. Move the unit to the desired location.

» NOTE
The Nanopositioner is installed in the Cryostation system prior to shipping. Refer to the Cryostation system manual for additional details.

3.2 Connecting System Cables and Power

NOTICE
Only use cables and hoses provided or approved by the manufacturer Only use the cables and hoses in the manner described below.

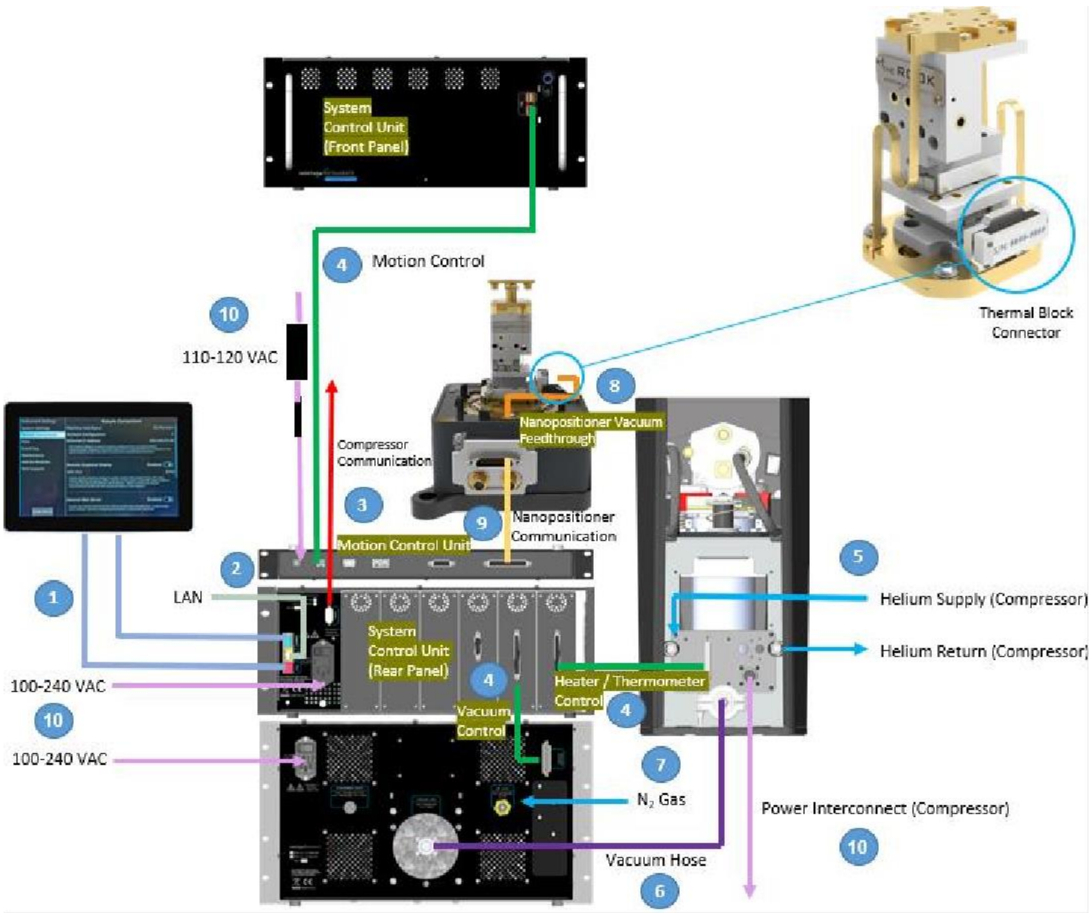


Figure 11: Cryostat interconnect diagram containing The Rook™.

1. User Interface
2. LAN
3. Compressor Communication
4. System Control Cables
5. Helium Line
6. Vacuum Hose
7. Nitrogen (N2 Gas)
8. Nanopositioner Vacuum Feedthrough
9. Nanopositioner Communication
10. Nanopositioner System Power / Power Interconnect

NOTICE

Only use cables and hoses provided or approved by the manufacturer
Remove any plastic covers from the connector locations on the back of the compressor, the cryostat, the system control unit, and the vacuum control unit.

1. User Interface:

Locate the USB and HDMI cables. Connect these cables from the back of the system control unit to the user interface touchscreen display.

2. LAN:

Locate the LAN cable (if applicable). Connect LAN cables from the back of the system control unit to the dedicated facility LAN socket.

3. Compressor Communication:

Locate the DSUB9 M-M series cable. Connect one end to the DSUB9 location on the back of the compressor. Connect the other end to the COMM PORT location on the back of the system control unit. Tighten both connections with the thumbscrews to secure them.

4. Control Cables:

Locate the DSUB37 F – split cable. Connect the DSUB37 F end to the `HEATER/THERMOMETER CONTROL` location on the TCM peripheral card in the system control unit. Where the cable splits, attach the DSUB25 F end to the `SAMPLE CONTROL` location, the DSUB25 M end to the `CORE CONTROL` location, and the MDR26 to the `USER INPUT` locations on the back panel of the cryostat. Tighten connections with the thumbscrews to secure.

Locate the DSUB25 M-M series cable. Connect one end to the `VACUUM CONTROL` location on the back of the vacuum control unit. Connect the other end to the `VACUUM CONTROL` location on the ACM peripheral card in the system control unit.

Locate the USB 2.0 Cable- A-Male to B-Male. Plug the USB-A 2.0 Connector into the USB-A 2.0 Panel Mounted Socket located on the front panel of the System Control Unit. Plug the USB-B 2.0 Connector into the USB-B 2.0 Panel Mounted Socket located on the rear panel. Refer to Section 3.2 (Connecting the System Control Unit to the Motion Control Unit).

5. Helium Hoses:

Helium hoses should first be tightened by hand. Use a crescent wrench to continue to tighten the fitting, stopping as soon as force is required. Do not over-tighten.

- Locate the helium hose labeled `SUPPLY`. Connect one end to the `SUPPLY` location on the front of the compressor. Connect the other end to the `SUPPLY` location on the back panel of the cryostat.
- Locate the helium hose labeled `RETURN`. Connect one end to the `RETURN` location on the front of the compressor. Connect the other end to the `RETURN` location on the back panel of the cryostat.

6. Vacuum Hose:

Locate the vacuum hose. Connect one end to the `VACUUM LINE` location on the back of the vacuum control unit. Connect the other end to the `VACUUM LINE` location on the back panel of the cryostat. The O-ring seal only needs to be compressed, so take care not to overtighten.

7. Nitrogen (optional):

To keep the sample space clean, a dry clean nitrogen connection is highly recommended, especially in humid climates. Nitrogen will help rid the system of moisture and decrease the initial pump downtime.

- Connect a ¼ in (6mm) tube to your nitrogen source (this tubing is not supplied).
- Start the nitrogen supply at a low flow rate.
- Verify that the nitrogen is flowing through the tube and does not contain any water vapor. Allow some nitrogen to flow through the tube to remove impurities.
- Connect this tube to the `N2 INLET` fitting on the back of the vacuum control unit by pressing in.
- Set the nitrogen pressure to approximately 15 psi.

To disconnect the tubing, push the green circle on the fitting inwards and pull the tubing out.

» NOTE
The system uses nitrogen during a `VENT` operation or during a `COOLDOWN` or `PULL VACUUM` operation if a "dry nitrogen purge" is enabled.

8. Nanopositioner Vacuum feedthrough:

The Nanopositioner feedthrough cable should already be connected. This connection is made during the assembly of the Cryostation.

9. Nanopositioner Communication:

- Carefully plug the nanopositioner communication cable into the back of the motion controller **(A)**. Locate the MicroD 25 socket (female) on the side panel of the sample chamber base section of the cryostation foundation **(B)**. Plug the remaining nanopositioner cable into the Micro D 25 socket on the side panel of the sample chamber base section of the cryostation foundation **(C).**

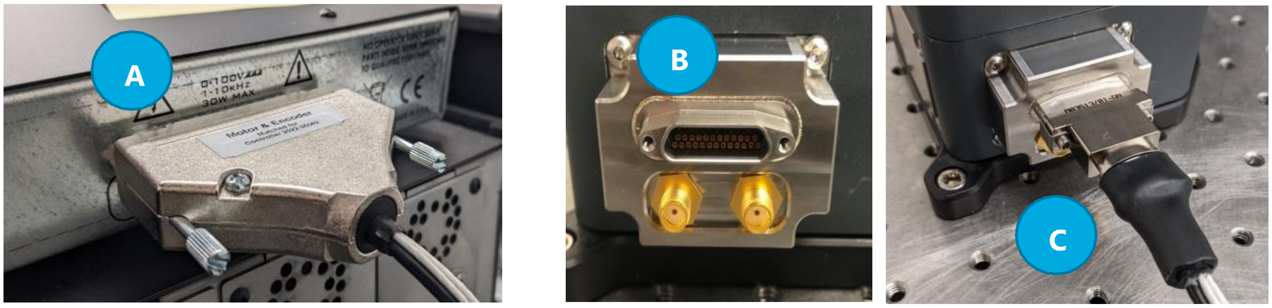


Figure 12: Side-view of nanopositioner communication connector plugged into the side panel (right image) to the motion controller (left image).

10. Nanopositioner System Power / Power Interconnect:

Be sure to connect all other cables and hoses prior to connecting system power.

- Locate one of the C13 main power cords. Ensure the rocker switch on the back of the system control unit is off (o).
- Connect the main power cord to the C14 inlet located on the rear of the enclosure.
- Connect the power plug to the appropriate 100 – 240 VAC wall outlet power source.
- Locate the other C13 main power cord. Ensure the rocker switch on the back of the vacuum control unit is off (o).
- Connect the main power cord to the C14 inlet located on the rear of the enclosure.
- Connect the power plug to the appropriate 100 – 240 VAC wall outlet power source.
- Ensure the rocker switch on the front of the compressor is off (o).
- Ensure that the 50/60 Hz toggle switch is in the correct position.
- Ensure that the circuit breaker on the compressor is open (handle in the down position).
- Uncoil the “output to cryocooler” cable and connect it to the Accessory port located on the front of the compressor.
- Connect the compressor power cable to the appropriate 208 – 240 VAC wall outlet power source.

» NOTE
Once all cables and hoses are connected, use the Velcro straps provided to neatly bundle the cables, but do NOT include the helium hose. The helium hoses should never be strapped down in any location.

11. Installing the Rook™ Nanopositioner into an Existing System

The following section provides general installation instructions for the Rook™ (both open and closed loop versions) on CryoAdvance 50, 100, and s200 systems. The diagram in Figure 11 provides an overview of how the Rook™ integrates into a system. Note that installation will vary slightly from system to system depending on system size and other installed accessories/equipment.

1.) With the system off and while wearing clean latex or nitrile gloves, remove the vacuum housing and radiation shield.

2.) Align the Rook™ base holes up with holes on the sample space platform (hole locations will vary based on the desired positioner location and size of the sample chamber). Figure 13 demonstrates a Rook installed in a CryoAdvance 50 Cryostation. Note: Cryostation configurations can vary and may include additional features including coax, DC wires, fiber optics, etc. For questions about installation on your exact configuration please contact Montana Instruments.

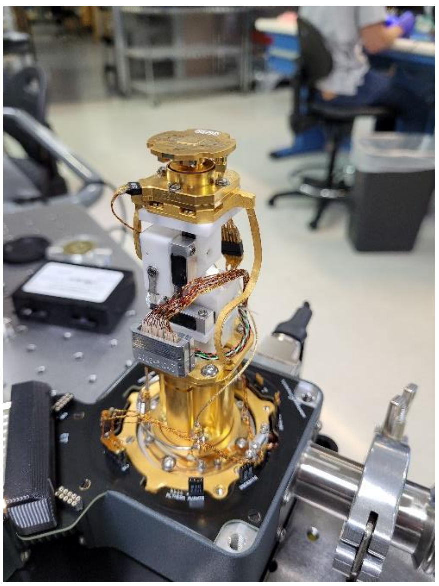


Figure 13: Example of the Rook™ installed on a CryoAdvance 50 Cryostation.

3.) Using provided hardware (M3 screws and Belleville washers), fasten the Rook™ to the platform. Do not over tighten. Refer to section 6.2 for hardware torque specifications.

4.) Ensure the MD25 side panel connector is installed. An example of an installed connector is shown in Figure 12B.

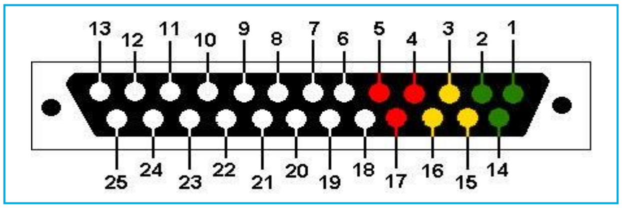
5.) Connect the Rook™ wire connector to the connector on the inside of the sample chamber (inside connector of MD25 panel). Do not tighten wires in the thermal clamp until motion is confirmed.

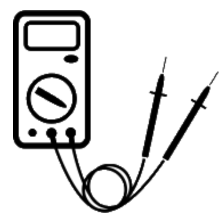
6.) Connect the communication cable to the back of the motion controller and side MD25 connector as seen in Figure 12A, C on the previous page. CLOSED LOOP: Note that for closed loop operation, communication cables and the positioner stack are paired. Check serial numbers on both to make sure they match before continuing with the installation.

    - Motor Capacitance

i. To verify the correct installation of the control cable and evaluate the nanopositioner motors, confirm that each axes motor phase measures a resistance of >1-2 MΩ and a capacitance of 150 nF ±15% (at room temperature) to its corresponding axis motor ground. See Figure 14 for pin numbering/assignment.

- Encoder (Supplied Voltage)
  i. The voltage supplied to the encoders should be 5 V.



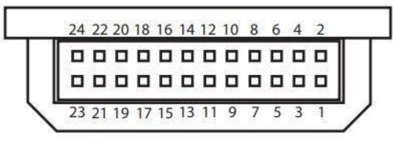


External side panel view

1 ● X Motor Phase 1
2 ● X Motor Phase 2
14 ● X Motor Ground

3 ● Y Motor Ground
15 ● Y Motor Phase 1
16 ● Y Motor Phase 2

4 ● Z Motor Phase 1
5 ● Z Motor Phase 2
17 ● Z Motor Ground



Description:	Color	Female Mill-Max24	
X Motor Phase 1	Red	1	A1
X Motor Phase 2	White (Green TP)	2	
X Motor Ground 1	Black	3	
X Motor Ground 2	Green	3	
Y Motor Ground 1	Black	4	A2
Y Motor Ground 2	Green	4	
Y Motor Phase 1	Red	5	
Y Motor Phase 2	White (Green TP)	6	
Z Motor Phase 1	Red	7	A3
Z Motor Phase 2	White (Green TP)	8	
Z Motor Ground 1	Black	9	
Z Motor Ground 2	Green	9	
Motor Shield	N/A	N/A	

Nanopositioner connector view

Figure 14: Pin assignment and testing.

7.) After all connections have been made power on Motion Controller and System Control Unit.
- If necessary, activate the positioner in settings on the User Interface touchscreen.
- Ensure User Touchscreen Interface is on and connected to the System Control Unit (HDMI and USB connections).

8.) Allow updates to install (approx. 20-30 minutes)

9.) Once updates are installed, select “Instruments” in bottom left corner of the User Interface touchscreen and navigate to the positioner.

10.) Test motion and closed/open loop operation, depending on which mode will be used.

11.) Once optimal motion is confirmed, unscrew a selected thermal clamp and lead wires from the Rook™ to the MD25 connector underneath the clamp. See Figure 15 for an example.
- Make sure to not over tighten the thermal clamp down on the wires, as it could damage them. If multiple sets of wires are held by the same thermal clamp, try to ensure that all wires lay as flat as possible and that they do not overlap to avoid potential damage to them.

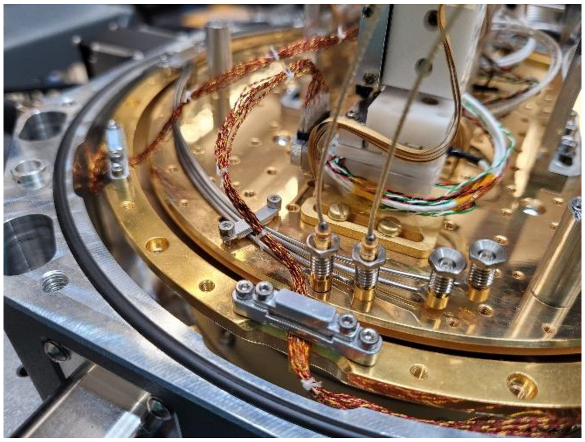


Figure 15: Example of wiring and use of thermal clamp with a Rook™ on an s200 system.

12.) FOR CLOSED LOOP ONLY: It is recommended that closed loop Rook™ nanopositioners be tested at both room temp and at cryogenic temperatures. With the Rook™ installed, perform a standard system cooldown (time to cooldown varies depending on system size). After cooldown, test the Rook™ at the stabilized cryogenic temperature (temperature can vary slightly depending on other installed accessories). Once motion is confirmed, the system can be warmed back up.

13.) Check to make sure wires do not make contact with the radiation shield once it is put back on, as this can cause higher temperatures in the sample chamber. If it is unavoidable that wires will be in contact with the shield, try to minimize the contact as much as possible.

Section 4 – Sample Mount Installation

- The top plate of the flex link is the same as the top plate of the attocube flex link and the MI standard sample mounts can be shared.
- Do not apply a torque greater than 1.33 in-lbs. to any screw attaching a mount to the flex link or any otherattachment above the flex link.
- Always brace the positioner stack with one hand while torquing screws to further guarantee no damage tothe positioner stack.

4.1 Magnetic Fields

The Rook's encoders are magnetically encoded so the presence of external magnetic fields will interact with the position feedback, causing the position to be inaccurate. It is advised that positioner encoders not be relied upon when in the presence of a magnetic field.

According to the magnetic encoder manufacturer, a field of 25 mT or larger applied to the encoder may cause permanent damage. Testing done by Product Development has not been proven to cause permanent damage, so it is believed these encoders are not overly sensitive to non-direct magnetic fields.

It is still prudent for users to be mindful not to place positioners in proximity to large fields (>0.7 T) or even to place small permanent magnets (>0.25 T) directly on or next to encoders. Permanent magnets can still be placed on top of the positioner stack near a sample. At the time of this writing, it is unknown the exact field strength that will permanently damage encoders. Distance, angle, and duration may all play a role in the interaction between the encoder and magnetic field.

4.2 Payload

The full positioner XYZ stack will operate with loads ranging from 0-100 grams without the addition of the preload spring to the Z-axis. The mass of the flex link is already accounted for, and the load listed in the table below is in addition to the flex link.

The preload spring is only added to the Z-axis since it must also overcome gravity; heavy loads of 100 g or more require an assist from this spring-loaded plunger. The X-axis and Y-axis will remain operational with all these loads and do not require any modification to translate loads up to 400 g. Please note, heavy loads may reduce the max velocity of the positioner stack, especially at base temperature.

With the addition of the preload spring, we cannot guarantee that stack motion will still comply with published specifications.

For optimal performance with the spring installed, the sample center of mass should be designed to be as close to the center axis of the positioner stack as possible.

Load (g)	**Spring Plunger**
0-100	Do Not Install a Spring Plunger
100-250	Low Force Spring Plunger
250-400	High Force Spring Plunger

Important: Only use the preload spring when mass is on the positioner stack (following the table above). If a spring is used with less mass than specified above, the positioner will not be able to counteract the expansion force loss of travel moving down (-Z).

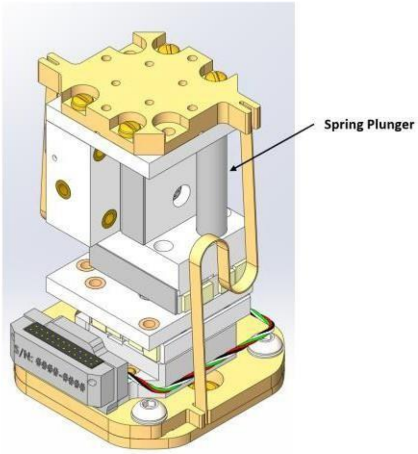


Figure 16: Rook™ with "spring Plunger" installed.

The spring is easily installed & removed from the Z-axis by hand – simply translate the Z-axis to the end of its positive travel, grab the spring plunger at its base, position the smaller end on the top plate of the positioner, and push up to compress the spring. Then insert into or remove from the boreholes in the stage.

Section 5 - User Interface (UI) Usage & Operation

The following section explains and describes the basic functions of the user interface. The UI is a primary function of Montana Instruments' Galaxy software architecture.

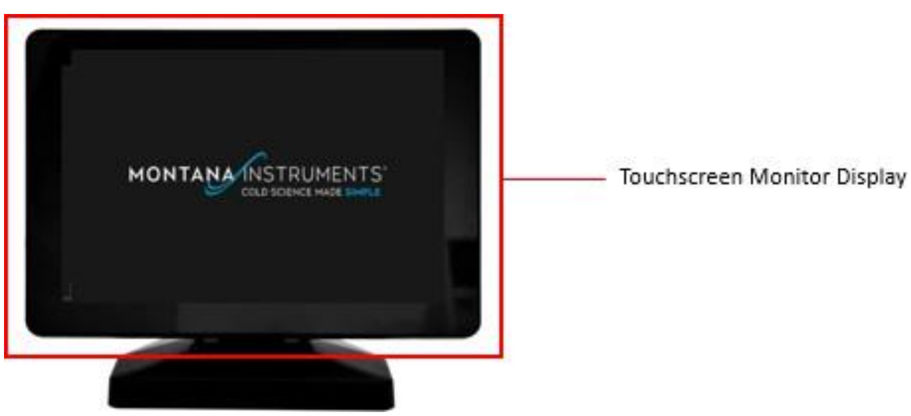
5.1 Open Loop Stack

5.1.1 Powering on Touchscreen Monitor

If the touchscreen monitor does not power up, locate, and depress the power button on the back of the unit.

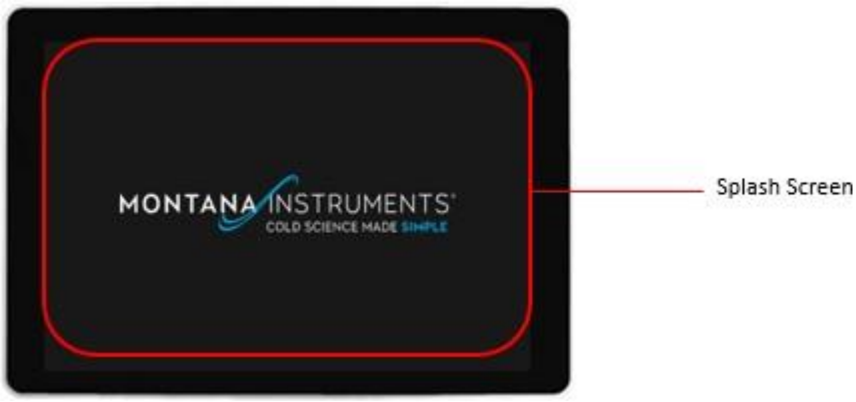
5.1.2 Touchscreen Monitor Display

Upon powering up the touchscreen monitor the Montana Instruments splash screen will appear.



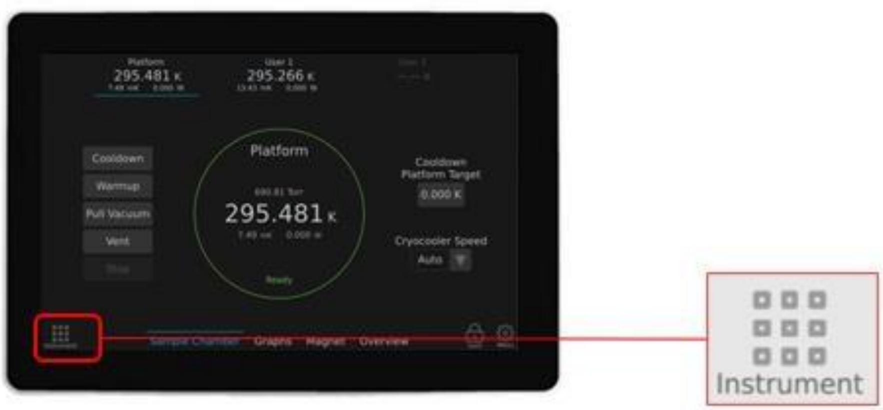
5.1.3 Splash Screen

The appearance of the splash screen verifies that the touch screen is powering up.



5.1.4 Startup Screen

Tap on the “Instrument” icon on the lower left of the display screen to access connect instruments.



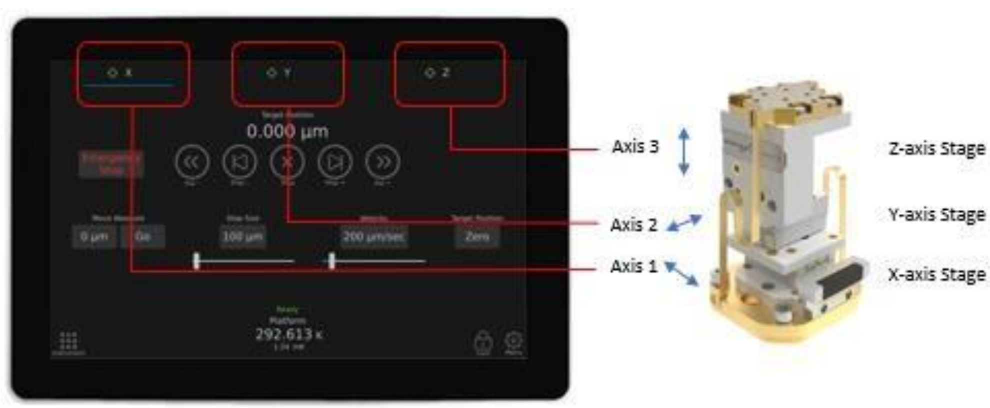
An amber-colored Indicator message may be displayed upon startup of the user interface.

5.1.5 Axis Selection

The selected axis is underscored with a blue line. The green target indicates that the axis is at the target position. The spinning blue dots indicates that the axis is attempting to acquire the target.

5.1.6 Axis Assignment

"Axis 1" is the "X-axis" (bottom stage). "Axis 2" is the "Y-axis" (middle stage). "Axis 3" is the "Z-axis" (upper stage).



5.1.7 Target Position

"Target Position" is the position of the enabled axis that the controller is attempting to achieve.

5.1.8 Emergency Stop

This operation will stop all axes and set all axes' “Target Position” to their current position.

5.1.9 Manual Position Controls (Jog±)

Touch and hold to move the enabled axis in the positive (Jog +) or negative (Jog -) direction.

5.1.10 Manual Position Controls (Step±)

Touch to step the enabled axis in the positive (Step +) or negative (Step -) direction.

5.1.11 Manual Position Controls (Stop)

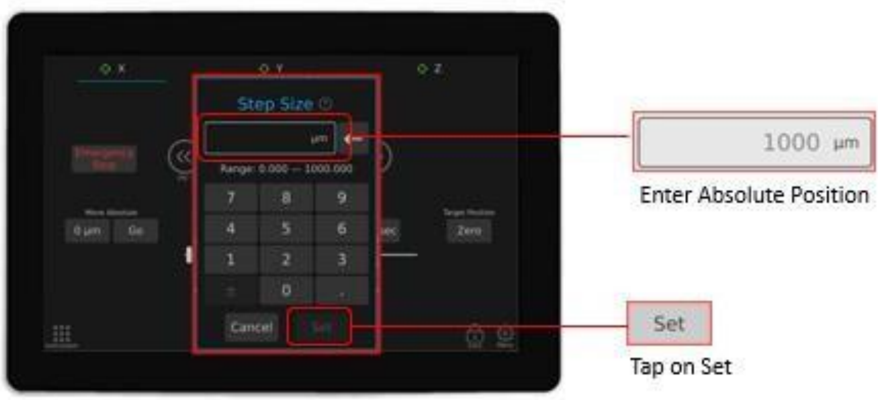
Touch to stop the motion of the currently enabled axis.

5.1.12 Move Absolute Setting

Move Absolute is a function that moves the enabled axis to a set position.

5.1.13 Entering Move Absolute Value

Tap on the “Move Absolute” value.



5.1.14 Move Absolute

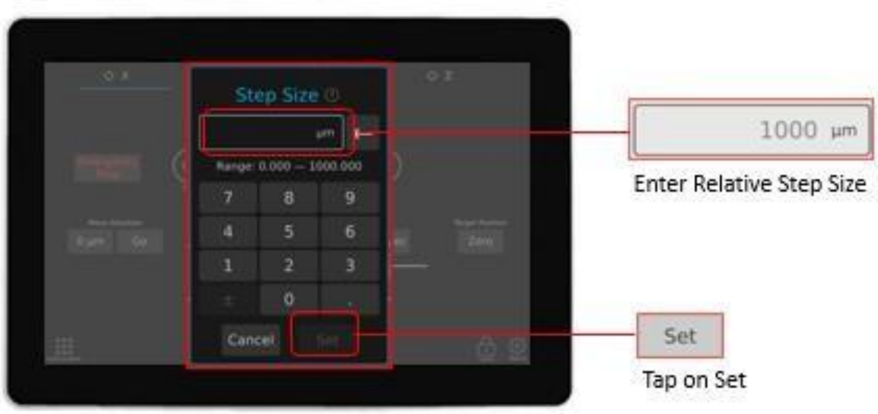
Tap on the “Go” button.

5.1.15 Enter "Step Size" Using Slider

Move the slider to adjust the value. This value dictates the step size taken when using the "Step +" or "Step -" buttons.

5.1.16 Enter "Step Size" Using Key Entry

Touch the step size box and enter the desired step size.

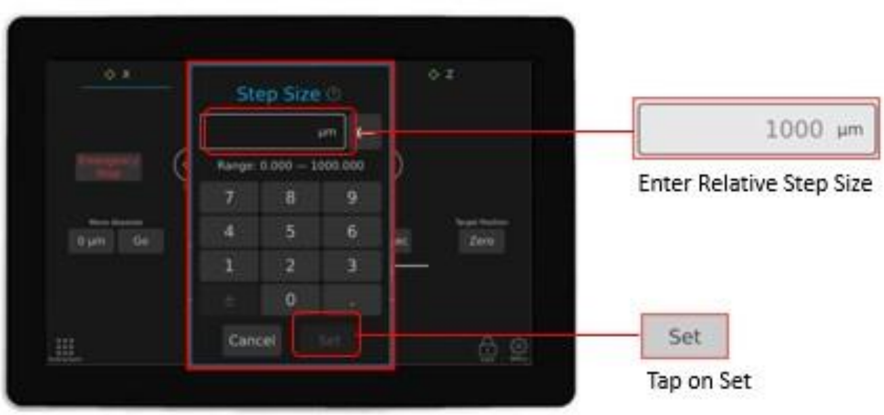


5.1.17 Enter "Velocity" Using Slider

The slider can be moved to set the velocity value. This value dictates the velocity of the "Jog" and "Step" motion.

5.1.18 Enter "Velocity" Using Key Entry

Touch the velocity box and enter the desired axis movement velocity.

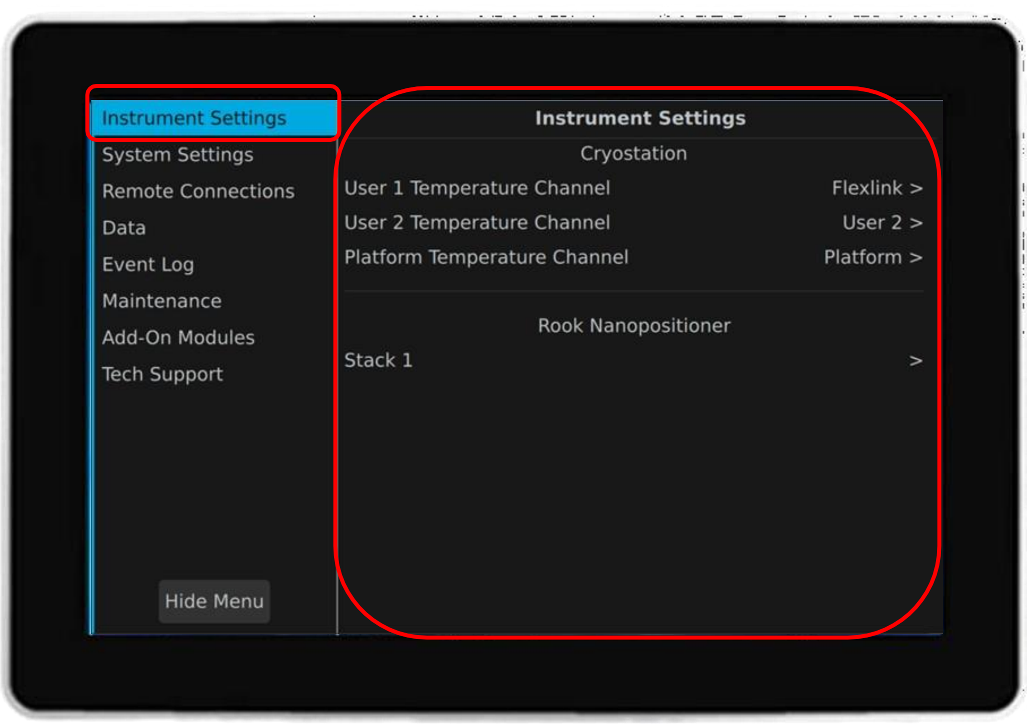


5.1.19 System Menus

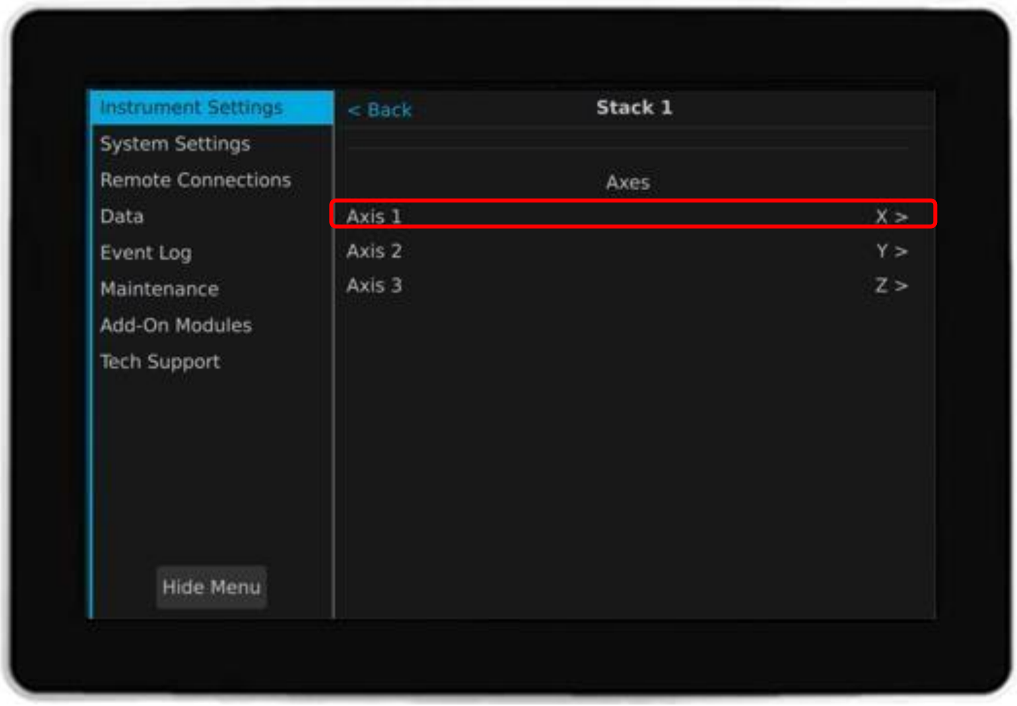
Tap on the “Menu” icon to access the instrument's settings.

5.1.20 Instruments Settings

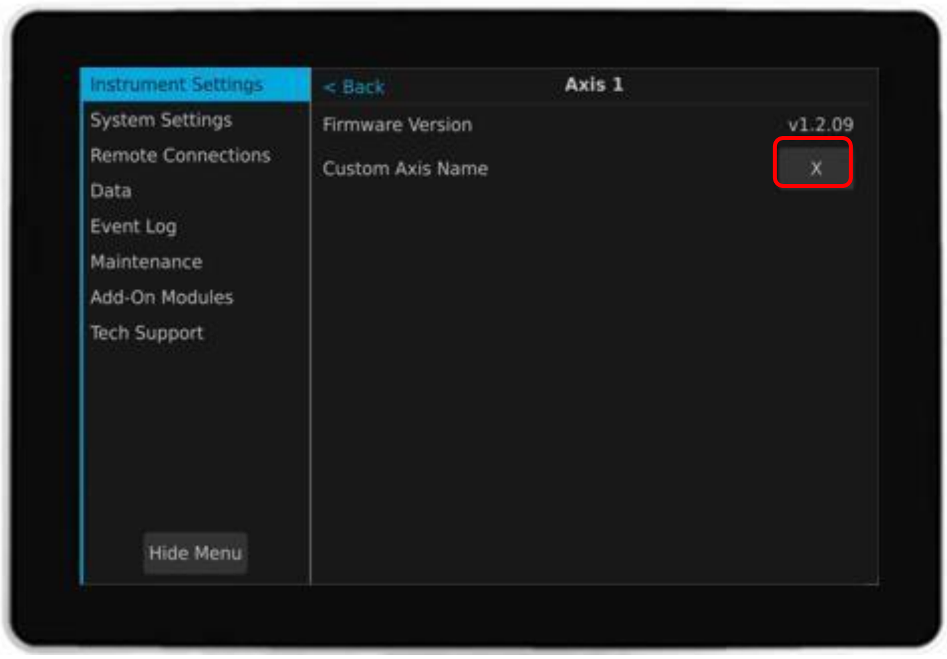
The side menu will highlight whatever was recently accessed. In this case, Instrument settings are displaying both the Cryostation and stack, i.e., connected devices.



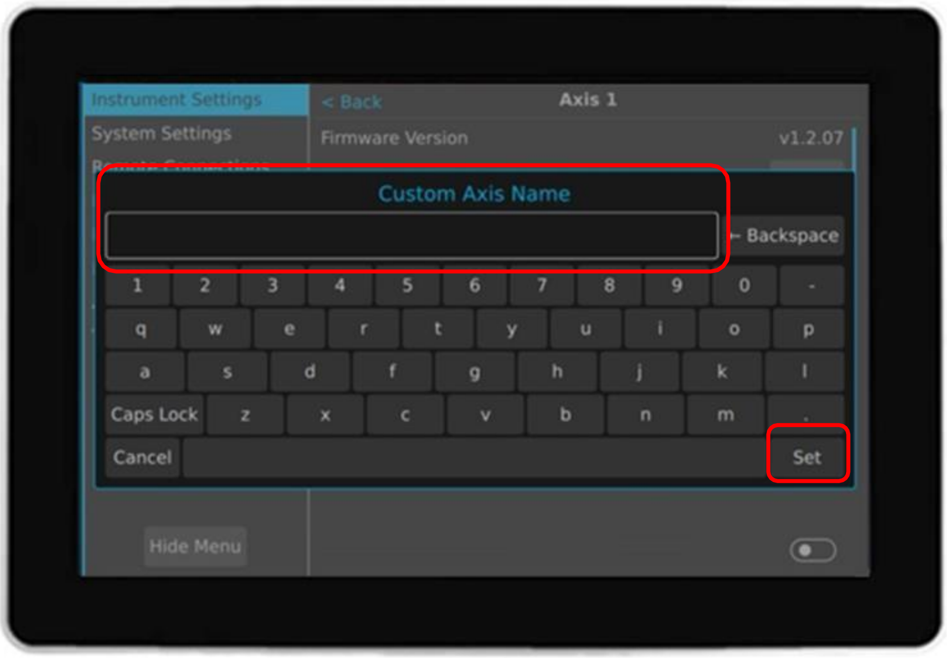
The stack settings screen will display the axes.
Tapping on "Axis 1" (in this case) will display Axis 1 settings.



Tapping on the grayed box allows the user to provide a custom axis name (X).



A keyboard will display upon tapping on the "X" button. Enter "Custom Axis Name" and then tap on the "Set" button in the lower left of the keyboard display.


Instrument Settings
System Settings
< Back
Axis 1
Firmware Version
v1.2.07
Custom Axis Name
← Backspace
1
2
3
4
5
6
7
8
9
0
-
q
w
e
r
t
y
u
i
o
p
a
s
d
f
g
h
j
k
l
Caps Lock
z
x
c
v
b
n
m
.
Cancel
Set
Hide Menu

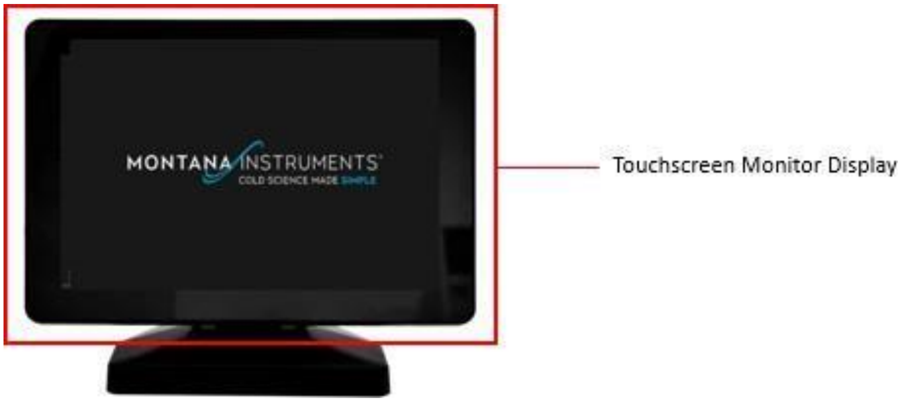
5.2 Closed Loop Stack

5.2.1 Powering on Touchscreen Monitor

If the touchscreen monitor does not power up, locate, and depress the power button on the back of the unit.

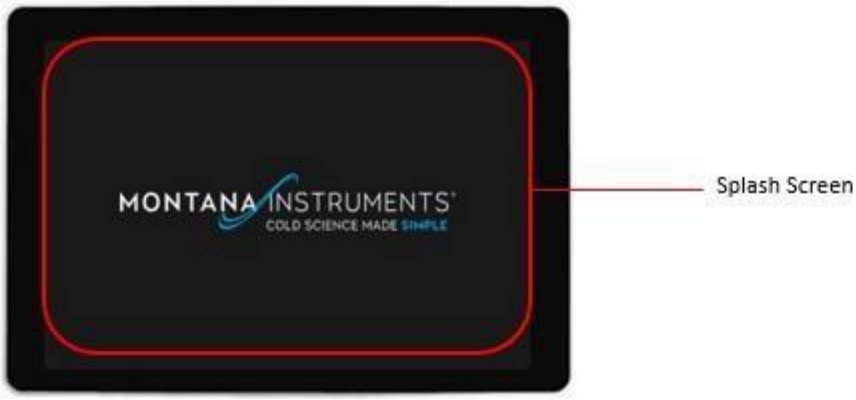
5.2.2 Touchscreen Monitor Display

Upon powering up the touchscreen monitor the Montana Instruments splash screen will appear.



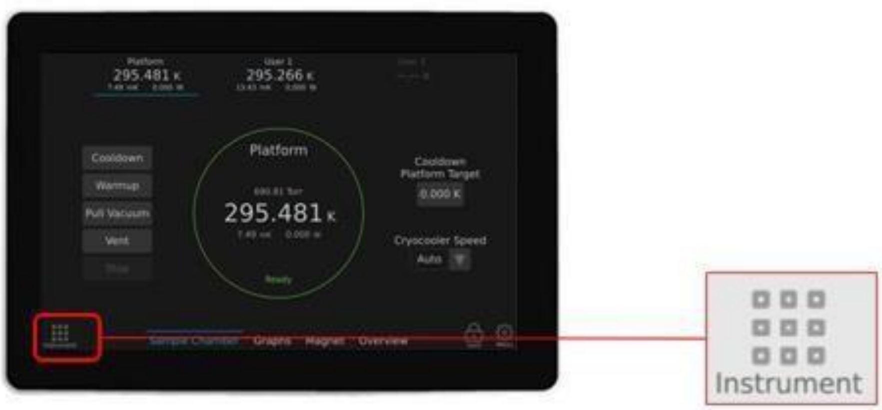
5.2.3 Splash Screen

The appearance of the splash screen verifies that the touch screen is powering up.



5.2.4 Startup Screen

Tap on the “Instrument” icon on the lower left of the display screen to access connect instruments.



An amber-colored Indicator message may be displayed upon startup of the user interface.

5.2.5 Closed Loop Mode

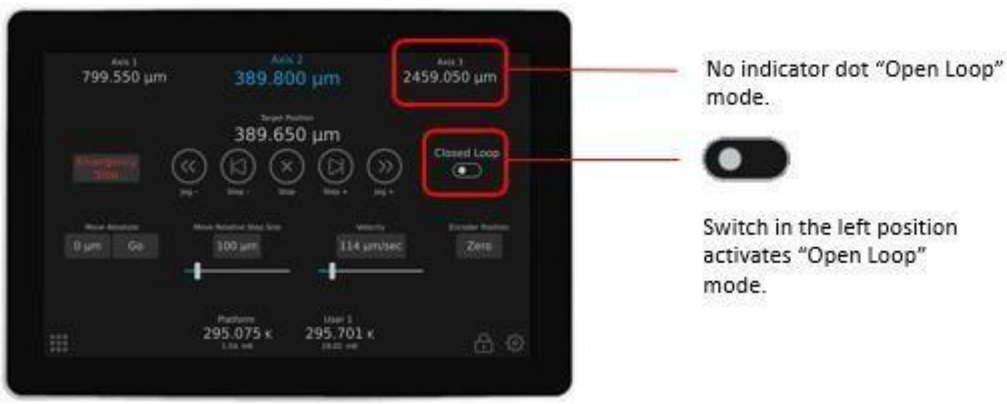
Closed loop nanopositioners have integrated positional feedback. This allows the positioners to move to specific locations, return to previous locations, and aid users in experimental setups and scripting. They also have the option to operate in open loop mode, where encoder positional feedback is not used.

When closed loop mode is enabled the switch will turn blue and a blue indicator dot will appear next to the enabled axes' names.

5.2.6 Open Loop Mode

Open loop positioners do not have integrated active positional feedback. The open loop positioner system maintains the other key performance specifications providing the user with a stable, reliable, and accurate nanopositioning system. Feedback to the user indicates positioner movement.

When open loop mode is enabled, the switch will turn white and there will be no indicator dot next to the axis names.



5.2.7 Axis Enable and Position

The selected axis is underscored with a blue line. The "Target position" value indicates the encoder position (Closed Loop).

5.2.8 Axis Assignment

"Axis 1" is the "X-axis" (bottom stage). "Axis 2" is the "Y-axis" (middle stage). "Axis 3" is the "Z-axis" (upper stage).

5.2.9 Target Position

"Target Position" is the position of the enabled axis that the controller is attempting to achieve.

5.2.10 Emergency Stop

This operation will stop all axes, set all axes' “Target Position” to their current position, and place all axes in open loop mode. If closed loop operation is desired after initiating the emergency stop, each desired axis must be manually set to closed loop via the “Closed Loop” switch.

5.2.11 Manual Position Controls (Jog±)

Touch and hold to move the enabled axis in the positive (Jog +) or negative (Jog -) direction.

5.2.12 Manual Position Controls (Step±)

Touch to step the enabled axis in the positive (Step +) or negative (Step -) direction.

5.2.13 Manual Position Controls (Stop)

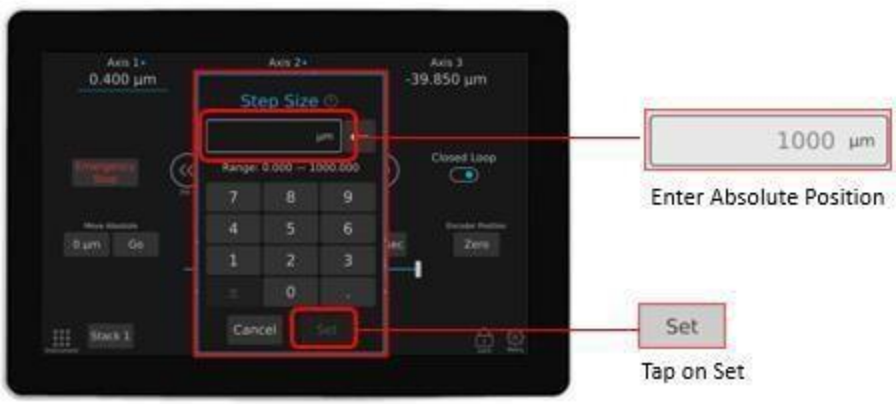
Touch to stop the motion of the currently enabled axis.

5.2.14 Move Absolute

Move Absolute is a function that moves the enabled axis to a set position.

5.2.15 Entering Move Absolute Value

Enter the value and tap the "Set" button.



5.2.16 Move Absolute

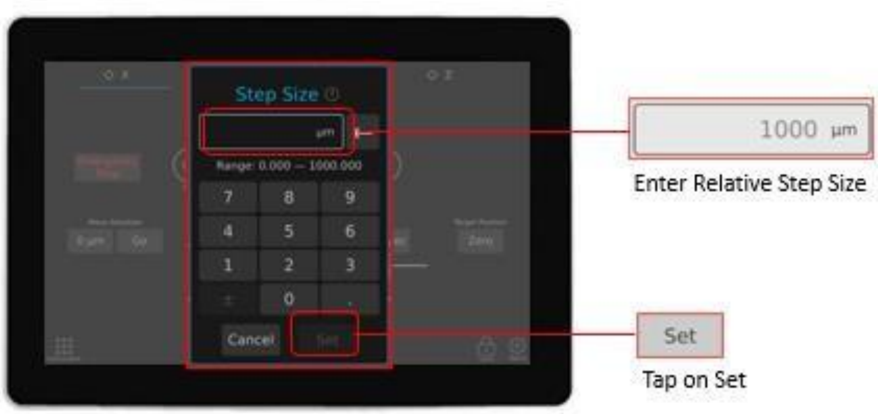
Tap on the Go button.

5.2.17 Enter "Step Size" Using Slider

Move the slider to adjust the value. This value dictates the step size taken when using the "Step +" or "Step - " buttons.

5.2.18 Enter "Step Size" Using key Entry

Touch the step size box and enter the desired step size.



5.2.19 Enter "Velocity" Using Slider

The slider can be moved to set the velocity value. This value dictates the velocity of the "Jog" and "Step" motion.

5.2.20 Enter "Velocity" Using Key Entry

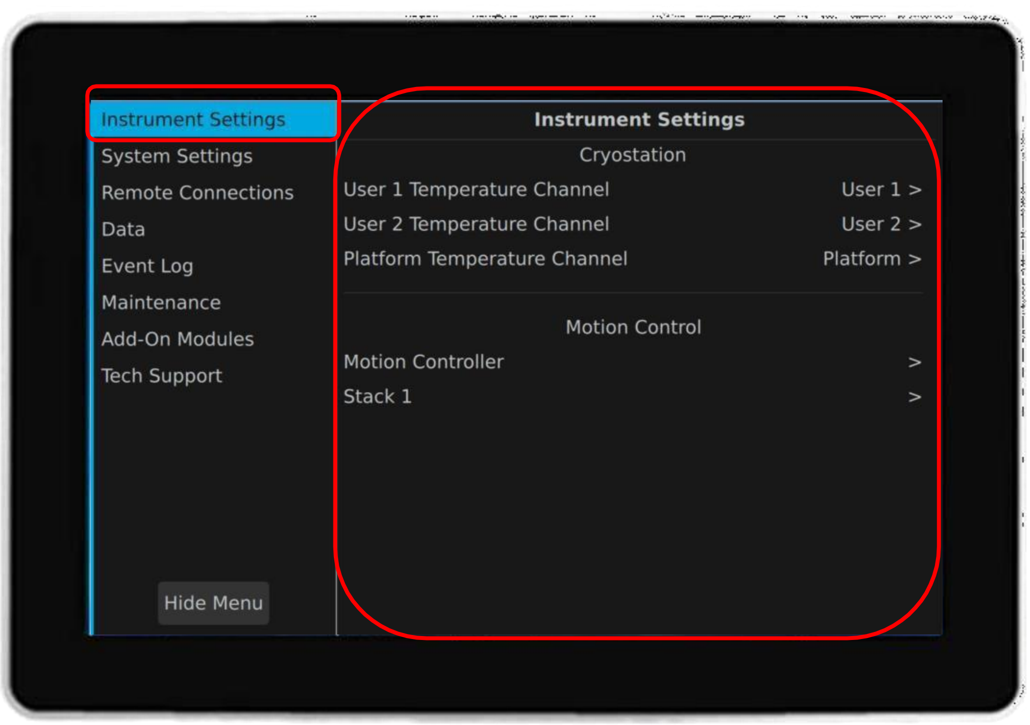
Touch the velocity box and enter the desired axis movement velocity.

5.2.21 System Menus

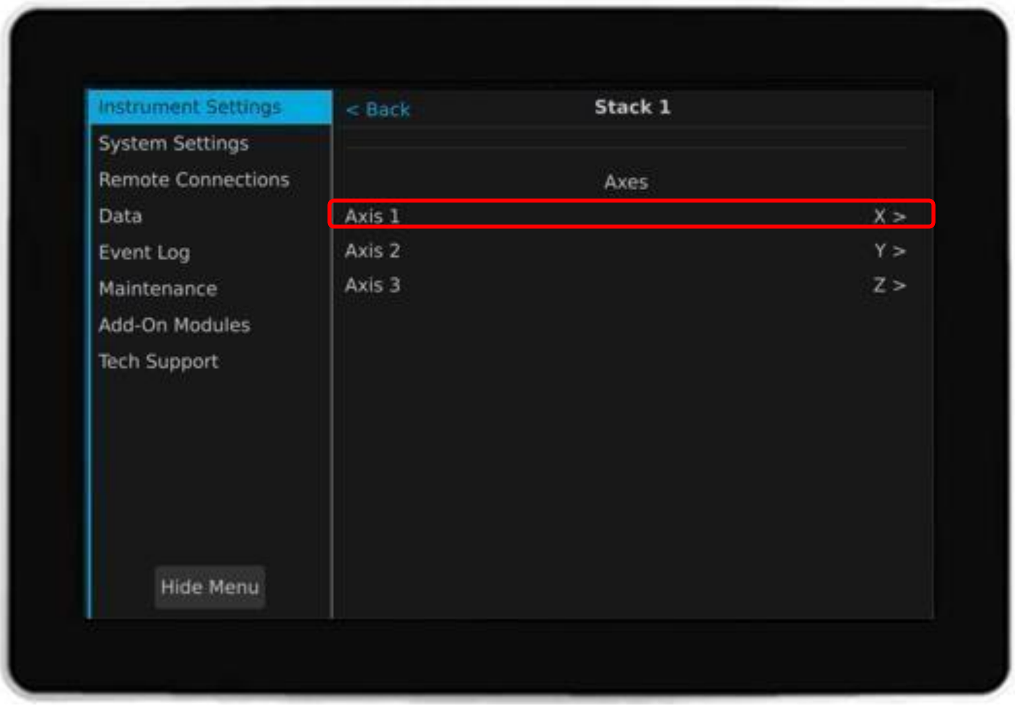
Tap on the “Menu” icon to access the instrument's settings.

5.2.22 Instruments Settings

The side menu will highlight whatever was recently accessed. In this case, Instrument settings are displaying both the Cryostation and stack, i.e., connected devices.

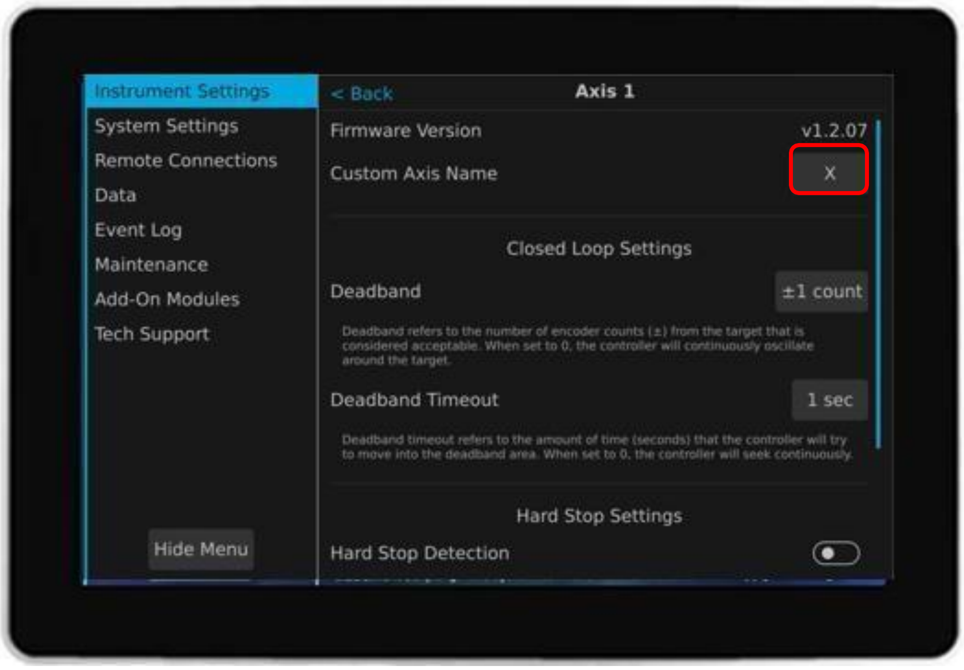


The stack settings screen will display the axes.
Tapping on “Axis 1” (in this case) will display Axis 1 settings.

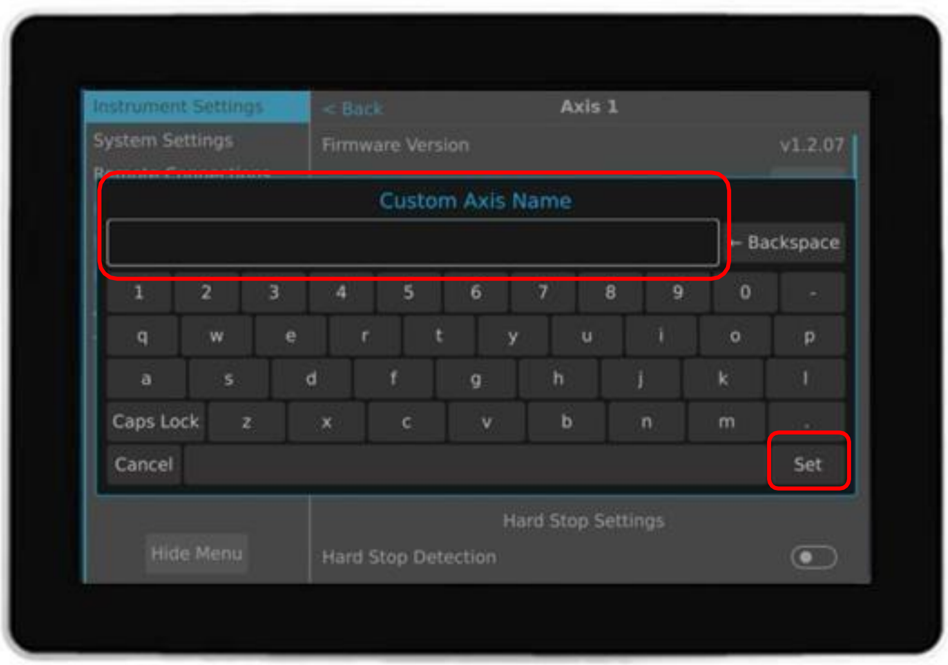


Axis settings allow the user to customize and configure the axis.
Tapping on the grayed boxes allows the user to provide a custom axis name (X), change the “Closed Loop Settings” and to toggle “Hard Stop Settings" on or off.

Tap on the “X” button to customize the axis name.

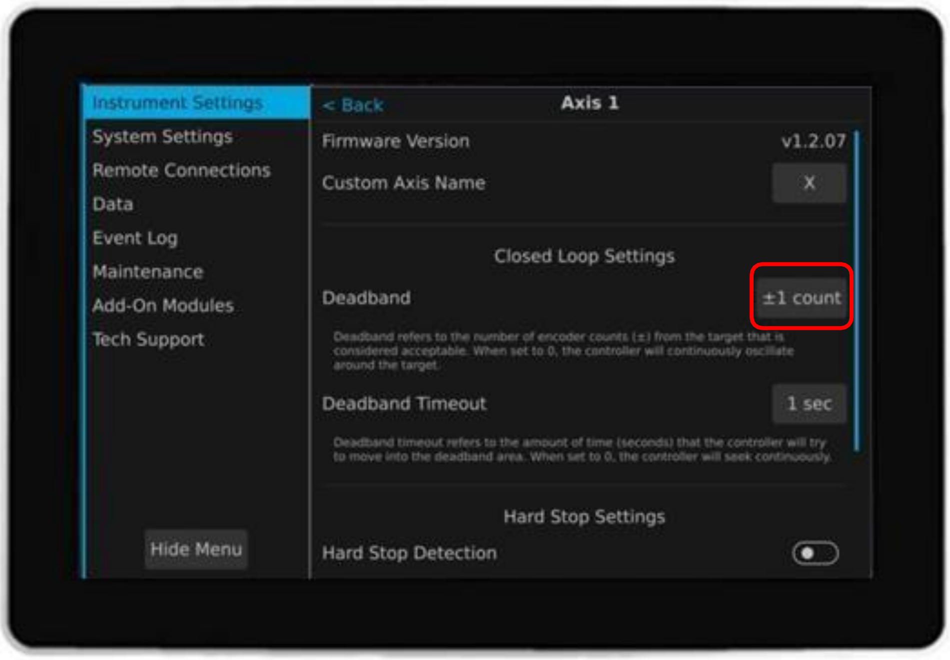


A keyboard will display upon tapping on the “X” button. Enter “Custom Axis Name” and then tap on the “Set” button in the lower left of the keyboard display.

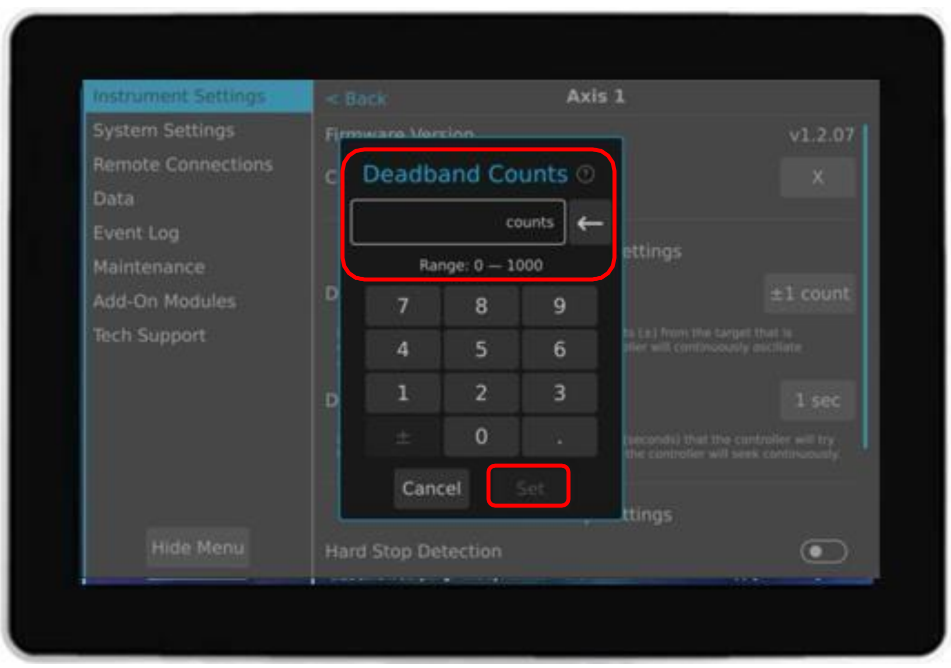


“Closed Loop Settings” will automatically display and allow the user to enter or select a “Deadband”

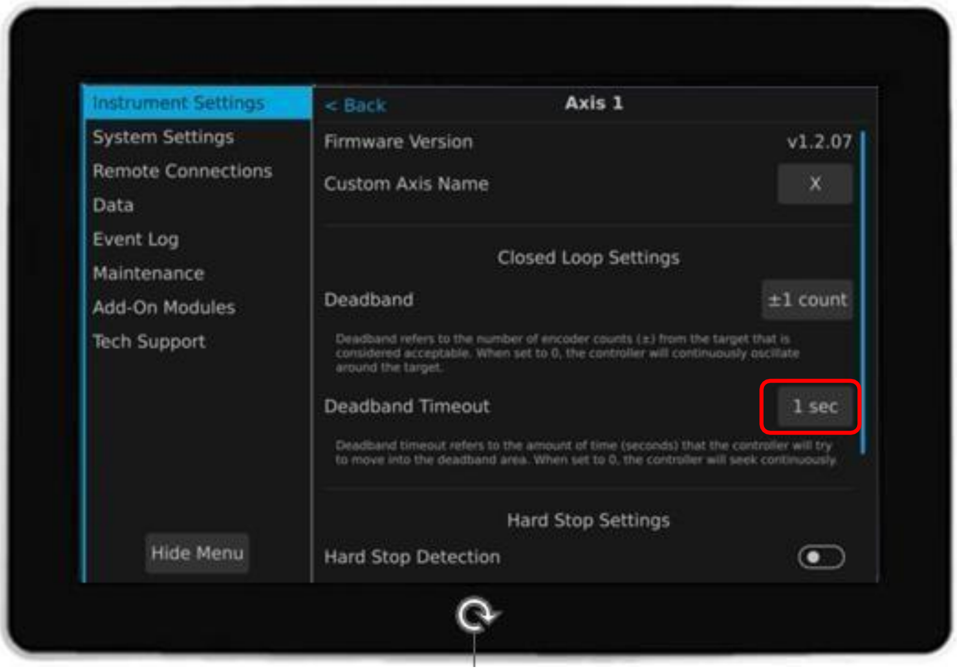
and “Deadband Timeout” values.
Tap on the “Deadband” button to change the “Deadband” value.



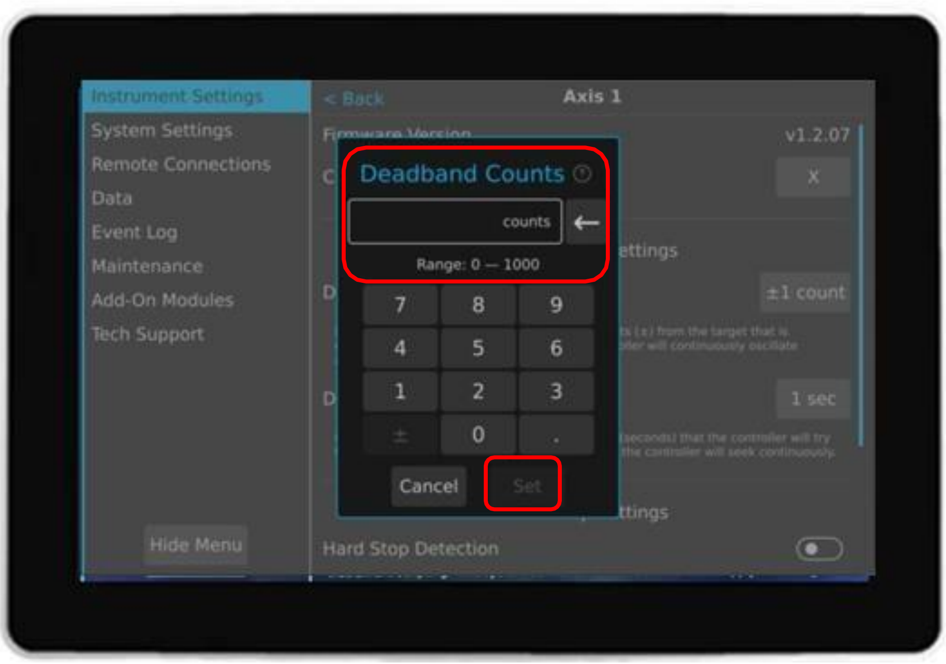
Enter the “Deadband” value (count) and then tap on “Set.”



Tap on the “Deadband Timeout” value (Sec) button to change the “Deadband Timeout” value.

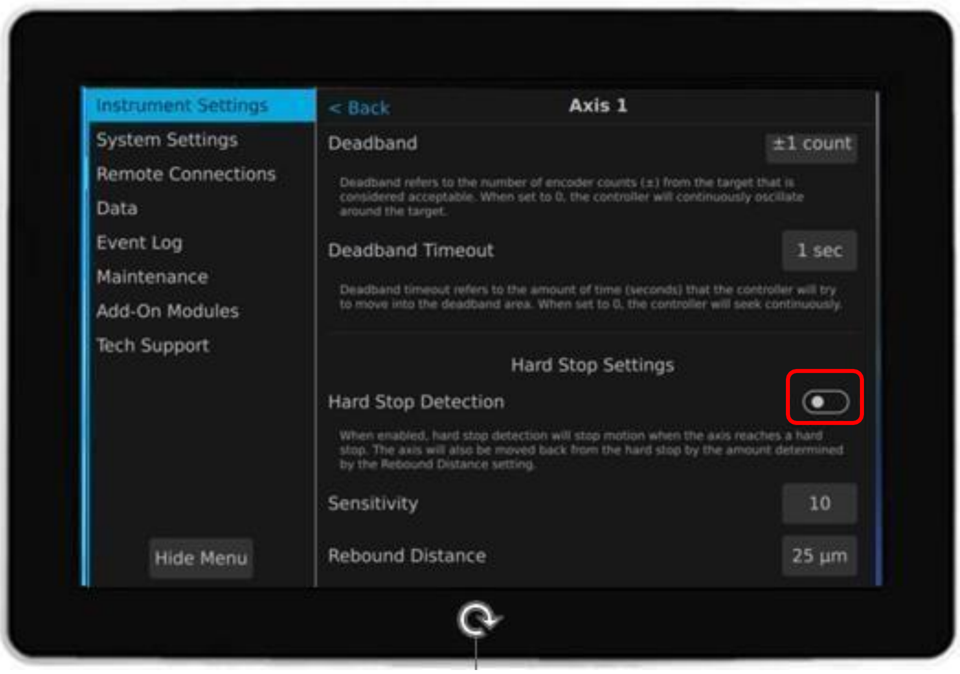


Enter the “Deadband Timeout” value and then tap on “Set.”

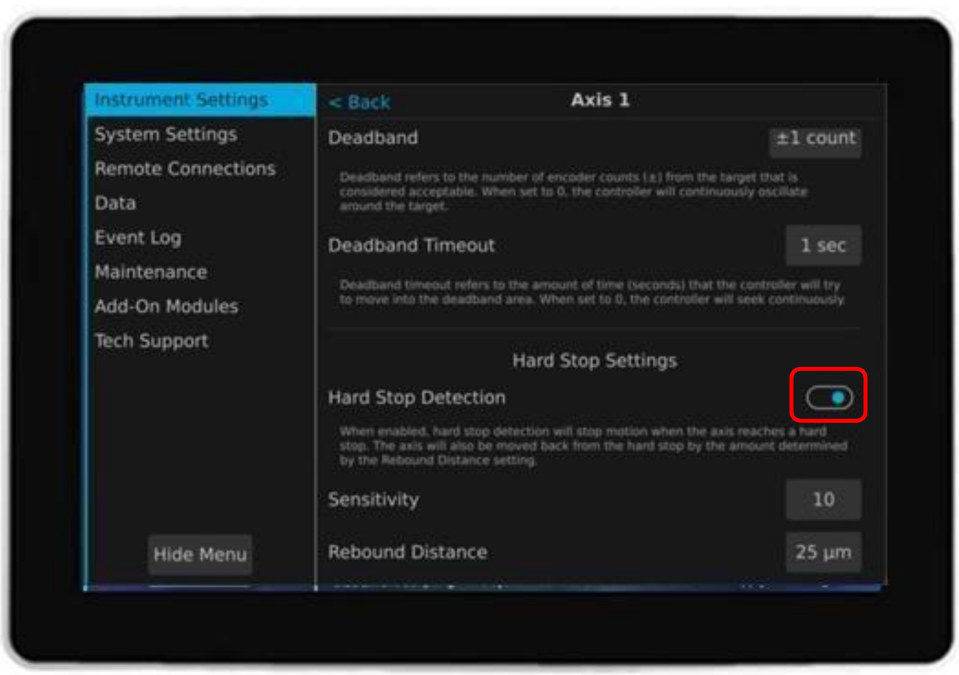


5.2.23 Hard Stop Settings

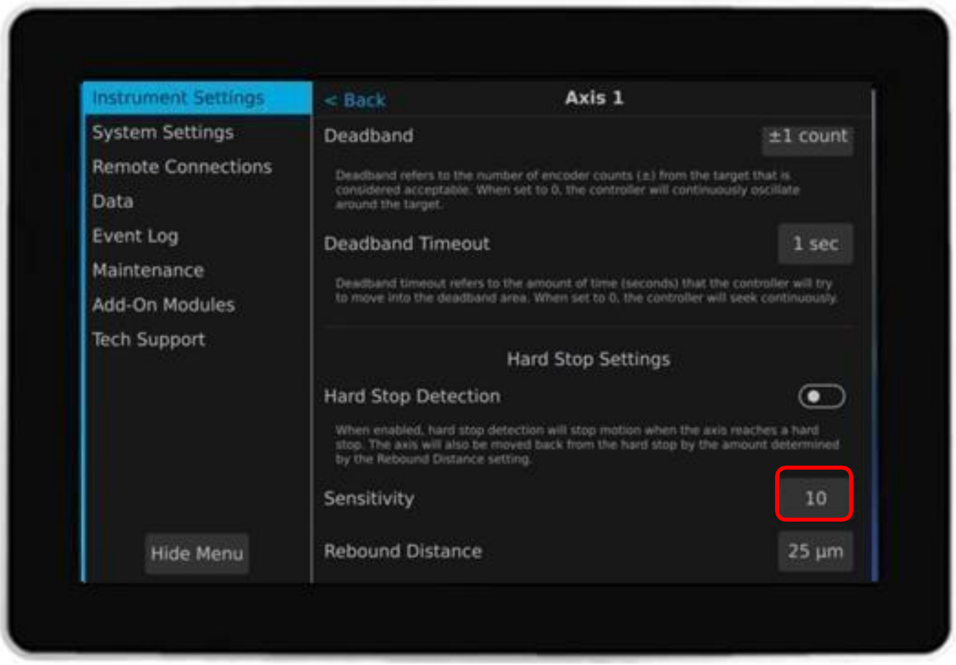
Toggle “Hard Stop Detection” ON or OFF.
Toggling the “Hard Stop” selection to OFF (left) will grey out the toggle button.



Toggling the “Hard Stop” selection to ON (right) will illuminate the toggle button (blue). When enabled, hard stop detection will stop motion when the axis reaches a hard stop.

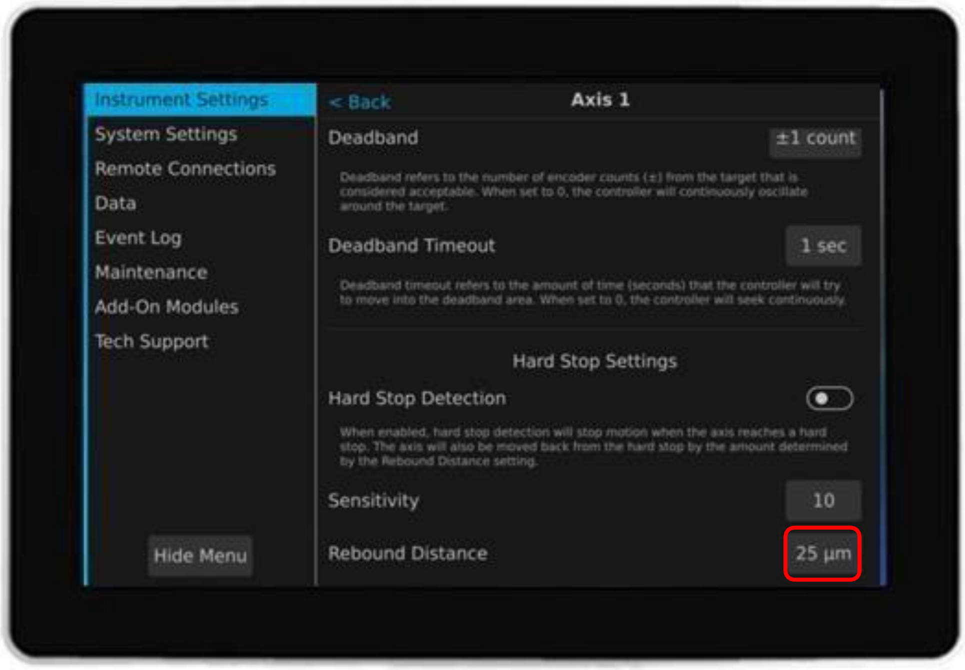


Tap on the “Sensitivity” button to change the “Sensitivity” value.

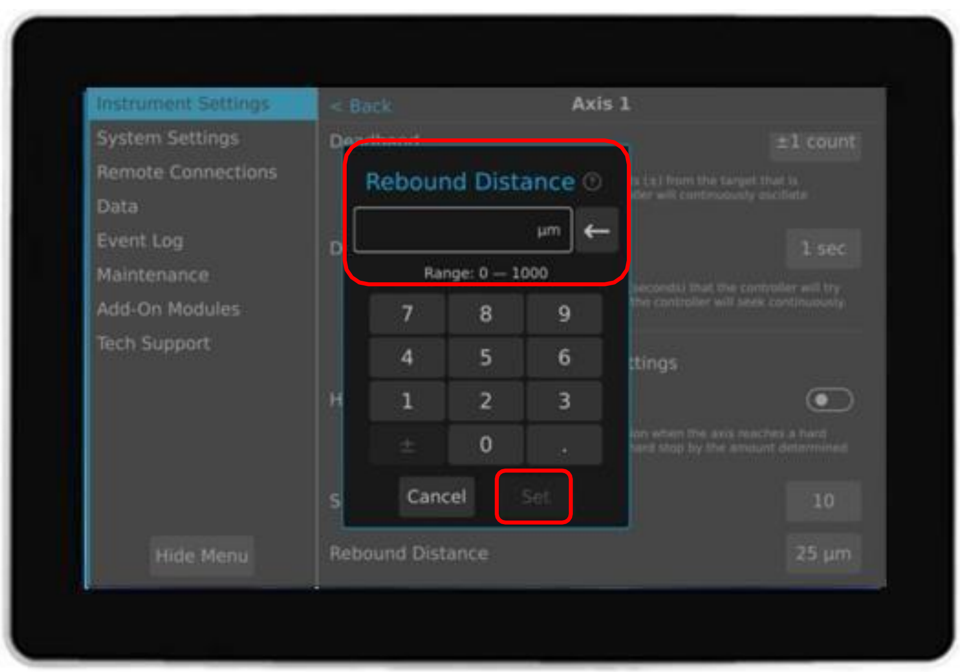


Enter the “Sensitivity” value and then tap on “Set.” Please be advised that the range is 1-100, with 100 being the most sensitive. We recommend that the sensitivity value be set to 5. Higher sensitivities can lead to “false stops.”

Tap on the “Rebound Distance” button to change the “Rebound Distance” value.



Enter the “Rebound Distance” value and then tap “Set.”



Section 6 - Care & Maintenance

6.1 System Care

Recommended system care procedures should be followed by any users of the system. For further information on any of these procedures, contact an authorized service representative for assistance. When handling the stage for cryogenic environments, take the necessary precautions when handling the stage, such as wearing clean latex gloves, clean room clothing, etc. Avoid any contaminants. Maximum cryogenic temperature is down to <4 Kelvin. Montana Instruments optionally supplies the stage with cryogenic-compatible connectors, see the chart below.

6.1.1 Maintenance of Nanopositioner Stack

- The Rook™ linear stage utilizes a maintenance-free design. Do not modify the stage or perform anymaintenance unless specifically instructed to do so by Montana Instruments personnel. If the stageis not performing up to the original specifications, please contact Montana Instruments.
- The Rook™ linear stage is a precision mechanical device and should be handled with care. Do notdrop or mishandle the stage.
- Follow the Installation Preparation requirements and use proper cable management to ensure aclean and safe operating environment.

6.1.2 When Working in the Sample Chamber

- Keep surfaces clean. Avoid touching any surfaces inside the sample space with your fingers as oils orother foreign contaminants can easily be transferred to the surfaces, the sample, or the optics. **Always wear clean gloves.**
- Use proper grease and adhesives in the sample chamber. The accessory kit includes Apiezon® L-grease, N-grease, and the adhesive GE Varnish (VGE).
- Avoid using too much grease – a thin layer (just enough so the surface is shiny) is best for metal-to-metal surfaces and O-rings. Too much grease can outgas and contaminate other surfaces in the sample chamber.
- Do not apply N-grease anywhere above the positioner stack assembly e.g. flex link top plate or above: N-grease tends to run when the system is baked out and can contaminate the bearings, rails,and encoders which will render the positioners non-operational at cryogenic temperatures.
- Inspect, wipe, and grease O-rings. Make sure that the O-rings are clean with a thin layer of L-grease.The exposed surface should be wiped with a dry Kimwipe or lens tissue and re-greased every 10-15 uses.
- Check to ensure wires are preserved. Make sure wires do not overlap under thermal clamps and ensure the clamps are not too tight. Make sure wires do not touch the radiation shield or contactthe sample mount directly after the thermal clamp.
- Do not operate or move positioner when platform temperature is above 300 K (do not move positioners during bakeout procedure).

6.1.3 When You are Using Your Cryostat

- Keep the lid on the sample chamber to keep it free from dust.
- Supply a slight amount of nitrogen to keep the system clean and dry.
    i. Use the `VENT` command with "Vent Continuously" enabled to keep nitrogen flowing through the chamber at atmospheric conditions.
- Keep the sample chamber under a vacuum. Use the `PULL VACUUM` command button to pull andkeep the chamber under a medium vacuum state.

6.2 Hardware Torque Specifications

All hardware in a Montana Instruments cryostat is torqued to specifications that ensure optimal and safe system operation. Over time, however, hardware can become loose, so it may be necessary for users to tighten hardware themselves. The following tables show the torque specifications for screws used in the cryostat system, with values in in*lbs and N*m. The torque specifications are based on the material of the screw, the size of the screw and the temperature environment the screw is present in. By following the instructions below, users can ensure their cryostats continue to operate at peak performance. For further questions or help, please contact our Customer Service team.

		Torque (in*lbs)[1]							
Application	**Screw Material**	**M1.6**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**
Room Temp	Brass	0.5	1.1	3.9	9.0	18.1	30.8	51.6	74.8
	Stainless Steel	1.2	2.5	9.0	20.9	42.2	71.8	120.2	174.2
Cold, clamping aluminum	Brass	0.6	1.3	4.6	10.8	21.8	37.0	62.0	89.9
	Stainless Steel[2,3]	1.7	3.4	12.4	29.0	58.5	99.6	166.6	241.5
Cold, clamping copper	Brass	0.3	0.6	2.3	5.4	10.8	18.4	30.8	44.6
	Stainless Steel[2]	1.4	2.9	10.4	24.1	48.7	83.0	138.8	201.2

Notes:
1. Based on target of 70% of fastener yield stress (when cold) unless noted
2. Belleville washer recommended
3. Based on target of 50% of fastener yield stress

		Torque (N*m)[1]							
Application	**Screw Material**	**M1.6**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**
Room Temp	Brass	0.06	0.1	0.4	1.0	2.0	3.5	5.8	8.4
	Stainless Steel	0.14	0.3	1.0	2.4	4.8	8.1	13.6	19.7
Cold, clamping aluminum	Brass	0.07	0.1	0.5	1.2	2.5	4.2	7.0	10.2
	Stainless Steel[2,3]	0.19	0.4	1.4	3.3	6.6	11.2	18.8	27.3
Cold, clamping copper	Brass	0.04	0.1	0.3	0.6	1.2	2.1	3.5	5.0
	Stainless Steel[2]	0.16	0.3	1.2	2.7	5.5	9.4	15.7	22.7

Notes:
1. Based on target of 70% of fastener yield stress (when cold) unless noted
2. Belleville washer recommended
3. Based on target of 50% of fastener yield stress

Figure 17: Hardware torque specifications.

How to Torque Screws to Specification

1. Identify screw material, screw size, and temperature environment the screw is in.
2. Obtain a torque screwdriver of appropriate size for the screw. Units in either in*lbs or N*m
3. Set torque screwdriver value to the correct specification from the chart. NOTE: Ensure units match between chart and screwdriver to avoid damage to screws or screws being too loose.
4. Tighten screw (clockwise) using torque screwdriver. The screwdriver will click once the set torque value is achieved.

Section 7 - Best Practices

7.1 General Handling

The top plate of the flex link is the same as the top plate of the attocube flex link and the MI standard sample mounts can be shared.

Do not apply a torque greater than 1.33 in-lbs. to any screw attaching a sample mount to the flex link or any other attachment above the flex link.

Always brace the positioner stack with one hand while torquing screws to further guarantee no damage to the positioner stack.

7.2 Multiple-Positioner Configurations

When more than one Rook™ unit is installed in a sample chamber, the nanopositioner controllers will daisy-chain together as seen in Figure 18 via an RJ11 connector for RS485 communication between each other. The unit connected to the system controller is considered the "master controller." The Galaxy software will automatically detect each connected controller, with only the master controller directly connected to the MIEC by USB connection.

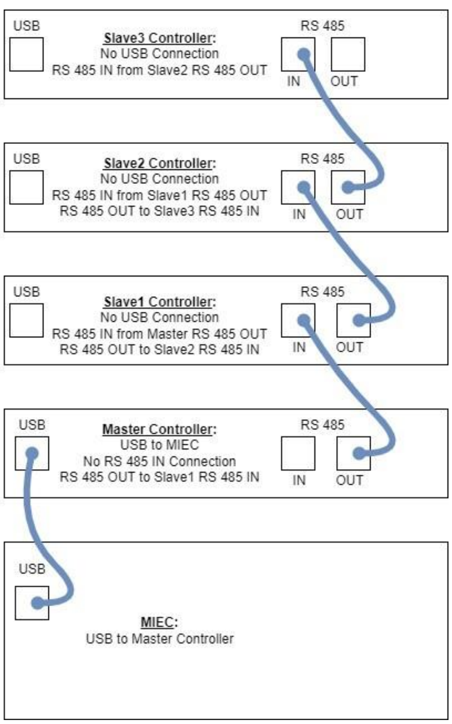


Figure 18: Daisy chain of motion controllers when using multiple nanopositioners.

When turning on the system from a full shut down we recommend powering up motion controllers first and then the main system controller. This will perform a soft reset of the controllers to properly assign the master controller.

If only the motion controllers were shut down, when powering back up, turn on the master controller last.

If one of the stacks is not showing up in the GUI, then there may be a communication error between the motion controllers resulting from a bad RJ11 cable (ECD-21). To determine whether or not the cable is malfunctioning:

a. Turn off motion controllers and MIEC.
b. Replace the cable with a different RJ11 cable.
c. Turn all controllers back on.
d. Check to see if all axes are showing up in the GUI.
e. If all axes are showing up in the GUI, the issue is the RJ11 cable causing communicationerrors between motion controllers.

7.3 Magnetic Fields

The Rook's encoders are magnetically encoded so the presence of external magnetic fields will interact with the position feedback, causing the position to be inaccurate. It is advised that positioner encoders not be relied upon when in the presence of a magnetic field.

According to the magnetic encoder manufacturer, a field of 25 mT or larger applied to the encoder may cause permanent damage. Testing done by Product Development has not been proven to cause permanent damage, so it is believed these encoders are not overly sensitive to non-direct magnetic fields.

It is still prudent for users to be mindful not to place positioners in proximity to large fields (>0.7 T) or even to place small permanent magnets (>0.25 T) directly on or next to encoders. Permanent magnets can still be placed on top of the positioner stack near a sample. At the time of this writing, it is unknown the exact field strength that will permanently damage encoders. Distance, angle, and duration may all play a role in the interaction between the encoder and magnetic field.

7.4 Thermometer Mounting

It is recommended to have a thermometer installed above the nanopositioner. This can be installed in the cryogenic mounting plate or installed in/on a sample mount (if installed on top of the nanopositioner).

This thermometer will allow the system to monitor the temperature above the nanopositioners which more accurately represents the temperature of the ceramic body and will prevent the system from venting before the ceramic body is warm.

Due to the ceramic material each axis is constructed from, there is a significant lag in temperature between the system platform temperature and the temperature of the nanopositioner stack. Venting before the ceramic body if warm can lead to condensation on the body of the nanopositioners if the system is vented with air from a humid environment. **It is highly recommended to vent the system with dry nitrogen if available.**

In a multi-stack scenario, mount a thermometer above at least one of the nanopositioner stacks. It is not necessary to mount a thermometer above every single nanopositioner stack as they will all warm up at relatively the same rate and a single thermometer will serve as a proxy for the others.

7.5 Payload

The full positioner XYZ stack will operate with loads ranging from 0-100 grams without the addition of the preload spring to the Z-axis. The mass of the flex link is already accounted for, and the load listed in the table below is in addition to the flex link.

The preload spring is only added to the Z-axis since it must also overcome gravity; heavy loads of 100 g or more require an assist from this spring-loaded plunger. The X-axis and Y-axis will remain operational with all these loads and do not require any modification to translate loads up to 400 g. Please note, heavy loads may reduce the max velocity of the positioner stack, especially at base temperature. With the addition of the preload spring, we cannot guarantee that stack motion will still comply with published specifications.

For optimal performance with the spring installed, the sample center of mass should be designed to be as close to the center axis of the positioner stack as possible.

Load (g)	**Spring Plunger**
0-100	Do Not Install a Spring Plunger
100-250	Low Force Spring Plunger
250-400	High Force Spring Plunger

Important: Only use the preload spring when mass is on the positioner stack (following the table above). If a spring is used with less mass than specified above, the positioner will not be able to counteract the expansion force and lose travel moving down (-Z).

The spring is easily installed & removed from the Z-axis by hand – simply translate the Z-axis to the end of its positive travel, grab the spring plunger at its base, position the smaller end on the top plate of the positioner, and push up to compress the spring. Then insert into or remove from the boreholes in the stage.

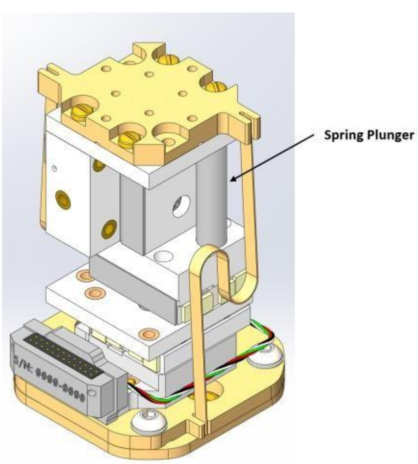


Figure 19: Rook™ with "Spring Plunger" installed.

Section 8 - Diagnostics and Troubleshooting

This section contains information for basic system diagnostics and troubleshooting advice. Diagnostics or repairs outside of the scope of this section should be completed by an authorized service representative.

The fast platform temperature decline seen at the end of the cooldown causes a large thermal gradient between Platform and stack as the stack temperature lags the Platform. i.e., When Platform first plummets to <10 K, the stack is typically still 100+ K. This may occasionally cause the temperature compensation algorithm for the encoders to falsely shift.

The recommendation is to give stack time to thermalize and reach temperatures closer to the Platform before operation. Encoders may need to be zeroed if large shifts occur. Slight shifts in the encoder readings will occur as temperature compensation is applied to the encoders when the temperature is changing significantly (more than a few degrees).

8.1 Troubleshooting Guide

If a degradation in performance or other failures are experienced, check for these common issues:

<table>
<tr><th>Problem/Symptom</th><th>Possible Cause</th><th>Solution/Suggestion</th></tr>
<tr><td rowspan="3">Axis not moving</td><td>Physical impediment.</td><td>Check the physical state of the positioner stack for:
Grease on the axis that isn’t moving.
Any other contamination on the axis.
Wire routing impediments.
Potential collisions preventing movement.</td></tr>
<tr><td>Control cabling issue.</td><td>Ensure all cables and wiring are connected/plugged in and do not have any shorts or breaks.
Check the thermal clamp where the In-Vacuum control cable is clamped and make sure it isn’t clamped too tight:
Remove the clamp and check to see if the axis becomes operational.
Re-install the clamp and do not torque screws to more than 0.5 in-lbs.</td></tr>
<tr><td>Incorrect settings (open loop only).</td><td>Confirm that the settings are correct.</td></tr>
<tr><td rowspan="2">No encoder feedback (incorrect feedback)</td><td>The cables are not properly connected.</td><td>Check cables and plugs to ensure everything is connected properly and does not have any shorts or breaks.</td></tr>
<tr><td>Nanopositioner is not paired with the correct controller (multi-stack configuration).</td><td>If in a multi-stack configuration confirm that the correct controller is being paired with the nanopositioner.</td></tr>
<tr><td rowspan="2">Z-axis not moving up</td><td rowspan="2">The mass on top of the positioner is too heavy (100g-250g)</td><td>Mass (>100g) on top of the positioner, you may have overloaded the z-axis. Reduce the mass on top of the positioner.</td></tr>
<tr><td>Install the Low Force Spring Plunger and see if the positioner can lift the mass.</td></tr>
</table>

Z-axis not moving down	The mass on top of the positioner is too light (>250g-400g)	• If the Low Force spring plunger is installed but the mass on top of the stage is under 100 g, it may not be able to move down:
		  ○ In this case, remove the Low Force spring plunger.
		  ○ Then check to see if full travel is achieved.
		• If the High Force spring plunger is installed but the mass on top of the stage is under 250 g, it may not be able to move down:
		  ○ Remove the High Force spring plunger.
		  ○ Check to see if full travel is achieved.

Communication issues	There are communication issues between the MIEC and the Motion Controller.	• Confirm that the controller is powered, "ON." • Check the USB cable and ensure it is connected. • If using a multi-stack configuration confirm that USB and RS 485 connections are correct. • Try plugging the USB cable into an alternate USB port on the front of the MIEC only. • Check the external control cable to ensure it is plugged into the sample chamber and back of the motion controller properly and is not too loose or partially plugged in.

Controller issues	The controller won't power on.	• Confirm 24V output from the power brick to the controller:
		  ○ Confirm 24V output from the power brick to the controller.
		• Verify connections.
		• If the number of stacks or axes is not as expected:
		  ○ Power off the MIEC and motion controllers then power on the motion controllers followed by the MIEC.
		  ○ NOTE: When using multiple stacks, the motion controllers must be powered on simultaneously.

High base temperature	Abnormal heat loads.	Accounting for wiring and encoder heat loads, consider the following:
		• The wiring goes through the thermal clamp.
		  ○ Is it well-lagged?
		  ○ Is the clamp tight or too loose?
		  ○ Are the wires spread out as much as possible to all for optimal thermalization of each wire?
		• Is the adaption plate secured to the cold platform and torqued to 8 in-lbs.?

<table>
<tr><td></td><td></td><td>Is the base of the flex link secured to the adaption plate and torqued to 5 in-lbs.?
Are there any burrs or deformities on the adaption plate or base of the flex link preventing good thermal contact?
Are any components touching the radiation shield or other warmer surfaces?</td></tr>
<tr><td rowspan="2">Vibrations</td><td>If experiencing greater than expected vibrations confirm that the following mechanical connections are within the specified torque.</td><td>Sample mount and exchange boss to the top of the flex links:
Flex-link top to the nanopositioner stack.
Flex-link bottom to the nanopositioner stack.
Flex-link to the platform adaptor plate.
Platform adaptor plate to the platform.</td></tr>
<tr><td>Nanopositioner is out of tolerance.</td><td>Carefully manually translate each axis through its travel range to feel for abnormal mechanical motion.</td></tr>
</table>

8.2 MIEC Troubleshooting Guide

The following faults are detected and displayed on the System Control Unit touchscreen and logged to the event log.

Warning Message	Description	Resolution
"Cannot change hard stop detection while axis is moving."	This will appear when the user attempts to change the hard stop detection while the axis is already in motion, performing a move command.	Wait for axis to stop moving before changing the hard stop detection.
"Cannot change the hard stop detection sensitivity while axis is moving."	This will appear when the user attempts to change the hard stop detection sensitivity while axis is already in motion, performing a move command.	Wait for axis to stop moving before changing the hard stop detection sensitivity.
"Cannot change the hard stop rebound distance while axis is moving."	This will appear when the user attempts to change the hard stop rebound distance while the axis is already in motion, performing a move command.	Wait for axis to stop moving before changing the hard stop rebound distance.
"Cannot use move absolute command while axis is moving."	This will appear when the user attempts to use the move absolute command while the axis is already in motion, performing a move command.	Wait for axis to stop moving before using the move absolute command.
"Cannot use jog command while axis is moving."	This will appear when the user attempts to use the jog command while the axis is already in motion, performing a move command.	Wait for axis to stop moving before using the jog command.
"Cannot change feedback mode while axis is moving."	This will appear when the user attempts to change the feedback mode while the axis is already in motion, performing a move command.	Wait for the axis to stop moving before changing the feedback mode.

Section 9 - Getting Help and Contacting Montana Instruments

9.1 Technical Support Information

Any technical questions or issues with the system that cannot be resolved with the information in this manual should be referred to an authorized Montana Instruments service representative.

9.1.1 Technical Support Information

- **Warranty and Repairs**

If the system or parts need to be returned to the Montana Instruments factory or an authorized service center for repair or service, contact an authorized service representative for a return merchandise authorization (RMA) number and instructions on returning the unit.
For a copy of the Limited Warranty Agreement, visit: www.montanainstruments.com/About/Warranty

- **Accessories and Replacement Parts**

Only use cables, hoses, accessories, and parts provided or approved by the manufacturer. Follow all instructions for proper installation or replacement.

i. To order spare or replacement parts, please contact your local service representative.
ii. To order new accessories or options, or for more information on other Montana Instrumentsproducts and technologies, please contact your local sales representative.

- **Contact Details**

For a complete list of sales and service centers visit: www.montanainstruments.com/Contact

North American Authorized Service

i. M-F 8:30 am-5 pm MST | Call: +1.406.551.2796
ii. Email: support@montanainstruments.com

North American Sales

iii. M-F 8:30 am-5 pm MST | Call: +1.406.551.2796
iv. Email: sales@montanainstruments.com

International Sales & Authorized Service

v. Visit www.montanainstruments.com/Contact/Sales-Offices for contact information for yourlocal representative.

Section 10 - Appendices

10.1 Related Documentation

For a copy of the associated documentation, see below:

Document Number	Document Title	Location
DOC102	General Terms and Conditions of Sale	www.montanainstruments.com/About/Terms
DOC103	Limited Warranty Agreement	www.montanainstruments.com/About/Warranty
DOC104	End User License Agreement	http://www.montanainstruments.com/about/EULA

10.2 General Terms and Definitions

Motion Control Coordinate System: In free space, an object is considered to have six degrees of freedom: three linear, along the x, y, and z-axes and three rotational around those (roll, pitch, and yaw respectively). All motions described here follow the right-hand coordinate system convention. The cross-product of the +X and +Y axes (pointer and middle fingers) is the +Z axis (thumb). Also, if the thumb of the right-hand points in the positive direction of an axis, the fingers will wrap around the axis in the direction of positive rotation about that axis. All movements are composed of translations along and/or rotations about the coordinate axes. Generally, the X and Y axes are on the horizontal plane, the direction of travel of the first or bottom stage is aligned with the X-axis, and the Z-axis is vertical. For parallel kinematic systems, cardan angles are used.

Linear Stage: A linear stage or translation stage (also axis), is a component of a precise motion system used to restrict an object to a single axis of motion.

Stack: A nanopositioner stack refers to linear stages being stacked on top of each to provide a moving foundation that can be controlled in multiple dimensions, commonly an xyz stack that provides control over the 3 linear degrees of freedom. The sample foundation at the top of a positioner stack is not to be confused with the Platform temperature in Cryostation systems.

Open-Loop Operation: In open-loop control, the control of the positioners is independent of the actual location of the stage. It does not use feedback to determine if the stage has achieved the desired movement goal of the input control command. Open-loop control is often used in simple applications because of its simplicity and lower cost, especially in systems where feedback is not critical.

Closed-Loop Operation: The term "closed-loop" in nanopositioning indicates that a sensor is used to monitor the position of a stage in real-time. The position readings are fed back to the controller and compared to the command positioner, which provides error correction for the system. The control technology is used to reach the optimum target position, for high position resolution, uniform feed velocity, and greater dynamic velocity and acceleration ranges.

10.3 Galaxy UI Screen Elements (Iconography)

10.3.1 Manual Controls

- Jog -
- Jog +
- Step -
- Step +
- Stop
- Closed Loop
- Open Loop
- Axis Enabled (Closed Loop)
- Emergency Stop

10.3.2 Main Navigation

- Instrument Selection
- Instrument Lock
- Instrument Unlock
- Menu

10.3.3 Status

- Target Acquired
- Hard Stop Detected