

Quick Start Guide

M91 FastHall™ Analysis Kits for Quantum Design PPMS® DynaCool System



Safety Precautions

Observe these general safety precautions during all phases of instrument operation, service, and repair. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended instrument use. Lake Shore Cryotronics, Inc. assumes no liability for Customer failure to comply with these requirements.

The MeasureReady® M91 FastHall™ measurement controller protects the operator and surrounding area from electric shock or burn, mechanical hazards, excessive temperature, and spread of fire from the instrument. Environmental conditions outside of the conditions below may pose a hazard to the operator and surrounding area.

- Indoor use
- Altitude to 2000 m
- 23 °C ± 5 °C at rated accuracy
- 10 °C to 35 °C at reduced accuracy, <65% relative humidity non-condensing
- Overvoltage category II
- Pollution degree 2
- Mains fluctuations up to ± 10%

Ground the Instrument

To minimize shock hazard, the instrument is equipped with a 3-conductor AC power cable. Plug the power cable into an approved 3-contact electrical outlet or use a 3-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) safety standards.

Ventilation

The instrument has ventilation holes in its side covers. Do not block these holes when the instrument is operating.

Do Not Operate in an Explosive Atmosphere

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Keep Away from Live Circuits

Operating personnel must not remove instrument covers. Refer component replacement and internal adjustments to qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them. Do not position the instrument so that it is difficult to disconnect the power cord.

Do Not Substitute Parts or Modify Instrument

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an authorized Lake Shore Cryotronics, Inc. representative for service and repair to ensure that safety features are maintained. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Cleaning

Do not submerge instrument. Clean only with a damp cloth and mild detergent. Exterior only.

Desktop Installation

When installing the instrument in a desktop environment, ensure it is mounted on a flat, level surface.

Improper Use

If the instrument is used in a manner that is not specified by Lake Shore, the safety protections provided by the instrument are no longer guaranteed, and may be impaired.

Child Safety

This equipment is not suitable for use in locations where children are likely to be present.

 Direct current (power line)

 Alternating current (power line)

 Alternating or direct current (power line)

 Three-phase alternating current (power line)

 Earth (ground) terminal

 Protective conductor terminal

 Frame or chassis terminal

 On (supply)

 Off (supply)

 Equipment protected throughout by double insulation or reinforces insulation (equivalent to Class II of IEC 536—see Annex H)

 CAUTION: High voltages; danger of electric shock; background color: yellow; symbol and outline: black

 CAUTION or WARNING: See included documentation; background color: yellow; symbol and outline: black

 CAUTION: Hot surface

 CAUTION: Electrostatic discharge sensitive (ESD) components

Instrument specifications

M91 FastHall™ measurement controller, when operating in the Quantum Design PPMS® system

Resistance range (R)

Standard: 10 mΩ to 10 MΩ source current

High resistance*: Up to 200 GΩ source voltage

Mobility range (μ)

0.001 cm²/(V s) to 10⁶ cm²/(V s)

Parameters

Current source range: 1 μA to 100 mA

(lowest settable: 10 nA)

Current measurement range: 100 mA to 10 nA

(lowest measurable: 1 pA)

Voltage source range*: 10 mV to 10 V

Voltage measurement range: 1 mV to 10 V

Size

216 mm wide × 87 mm high × 369 mm deep
(8.5 in × 3.4 in × 14.5 in), half rack

Weight

3.2 kg (7 lb)

**Only available with M91-HR (high resistance)*

NOTE: For more details on the M91, please see:

<https://www.lakeshore.com/m91>

Introduction

This guide provides basic information for getting started with your analysis kit. For further information, see: <https://www.lakeshore.com/m91-ppms-kit/>.

Items included with the analysis kits:

M91-PPMS-KIT1	M91-PPMS-KIT2	PPMS-INSERT-HALL
M91/PPMS integration: Breakout box	M91-HR/PPMS integration: PPMS-INSERT-HALL	PPMS insert with 8 triaxial guarded connections
M91	M91-HR	User supplied
Resistance up to 10 MΩ	Resistance up to 200 GΩ	Resistance up to 200 GΩ
PPMS sample puck	Lake Shore sample board	Lake Shore sample board
Signal path: Semi-guarded, guarding stops at the breakout box. Standard twisted pair wiring.	Signal path: Fully guarded (internal coaxial) from instrument to sample.	Signal path: Fully guarded (internal coaxial) from instrument to sample.
Triaxial cables	Triaxial cables	Triaxial cables
MeasureLINK™-MCS software	MeasureLINK™-MCS software	Purchase MeasureLINK separately

Benefits

M91-PPMS-KIT1	M91-PPMS-KIT2	PPMS-INSERT-HALL
Add M91 measurement benefits to a PPMS system.	Add M91 measurements benefits AND improved signal quality to a PPMS system. Main benefit of insert is the signal path is fully guarded from the instrument to the sample.	Add improved signal quality to a PPMS system. The customer can use any instrumentation to insert. Main benefit of insert is the signal path is fully guarded from the instrument to the sample.

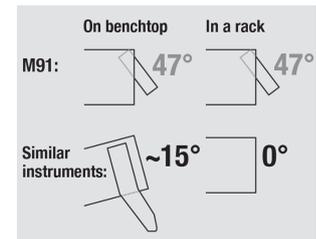
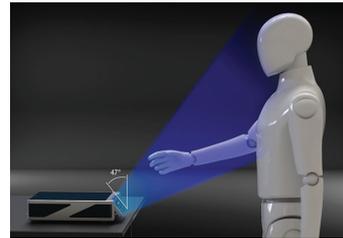
- Faster measurement with reduced setting time
- Best performance for low-noise, low-current measurement
- Fully guarded from instrument to sample for ultra-low noise measurements (PPMS-INSERT-HALL)
- Measure up to 200 GΩ with the M91-HR (high resistance) controller
- 3-year standard warranty

Unpacking

1. Inspect all items for both visible and hidden damage that occurred during shipment. If there is visible damage to the contents, contact the shipping company and Lake Shore immediately.
NOTE: Procedures vary with shipping companies. Keep all damaged shipping materials and contents until instructed to either return or discard them.
2. Keep the container and shipping materials until all contents have been accounted for. The insert is shipped in a permanent case.
3. Check off each item on the packing list as it is unpacked.

Placement

The M91 FastHall™ measurement controller is an out-of-the-box benchtop instrument with an adjustable TiltView™ screen for an improved viewing angle. The screen adjusts from a 0° to a 47° viewing angle, whether mounted in a rack or on a bench top.



Rack mounting

The M91 can be installed in an instrumentation rack using the optional Lake Shore RM-1/2 rack mount kit. See <http://www.lakeshore.com/rack-kit/> for full details.

NOTE: Ensure that there is 1 in (25 mm) clearance on both sides of the instrument after rack mounting.

Kit components: M91-PPMS-KIT1

M91 FastHall™ measurement controller



FastHall eliminates the need for field reversal Up to 100× faster for low-mobility materials Lower mobilities can be measured using lower fields.

Includes MeasureLINK™-MCS software for Hall measurement control. Integrates with Quantum Design PPMS® MultiVu™ application software.

For further information about the FastHall measurement controller, refer to the documentation included with the product.

Breakout box

The M91-TRIAx-DB25 adapter connects the M91 FastHall™ measurement controller to the PPMS system.

- Semi-guarded, guarding stops at the breakout box. Standard twisted pair wiring
- M91 resistance measurements up to 10 MΩ
- Samples mount to PPMS sample puck

Back
(1) DB25 connection

Front
(8) triaxial connections



Kit components: M91-PPMS-KIT2

M91-HR FastHall™ measurement controller



FastHall eliminates the need for field reversal Up to 100× faster for low-mobility materials Lower mobilities can be measured using lower fields.

Includes MeasureLINK™-MCS software for Hall measurement control. Integrates with Quantum Design PPMS® MultiVu™ application software.

For further information about the FastHall measurement controller, refer to the documentation included with the product.

Guarded insert with Lake Shore probe

- Fully guarded from instrument to sample for ultra-low noise measurements
- M91-HR low-noise measurements and high resistance measurements up to 200 GΩ
- Samples mount to consumable Lake Shore sample carrier boards (also pin compatible with Quantum Design sample carrier boards), 12 included



Specifications summary*

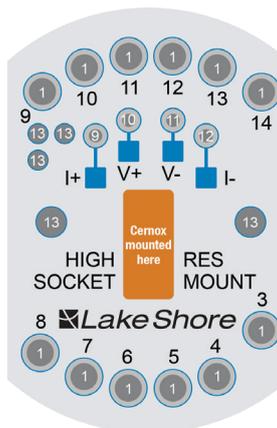
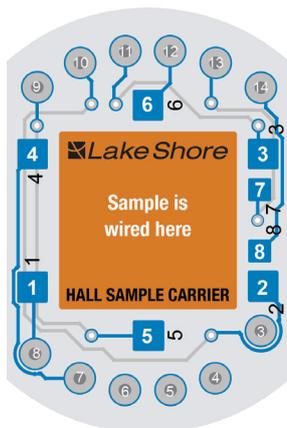
Triax center conductor leakage current	<500 fA at 10 V
Maximum current per pin	100 mA
Maximum voltage between any 2 pins and insert body	50 V DC, 25 VAC RMS, 35.3 V peak
Operating temperature range	1.8 K to 400 K

* All insert specifications assume guarded configuration

Connections and Installation

Sample connections

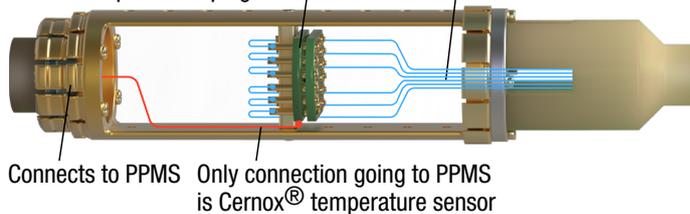
1. Connect the Quantum Design PPMS® system to the M91 FastHall™ measurement controller with the Lake Shore probe.
2. The M91 supports both van der Pauw (4-connection) and Hall bar (6-connection) geometries. These samples are wired to the Lake Shore sample board. The sample board then snaps into the sample insert board located on the probe.



3. When the probe is loaded into the PPMS, these sample connections are fully guarded up to the M91 via triaxial cables (included in the kit). The integrated Cernox® sensor connections go to the PPMS enabling temperature readings directly through MultiVu. The figure below zooms in on the working end of the probe.

Board that accepts all connections to the M91—sample board plugs into this

Connections to the M91



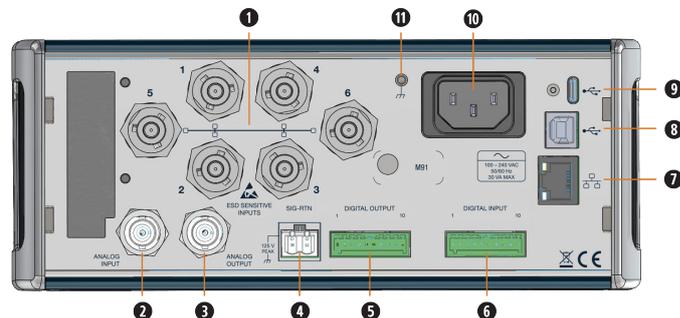
4. Two additional leads are provided for auxiliary purposes to the sample (for example, gate bias applications). Contacts 7 and 8 are internally connected from the Hall sample carrier to the triaxial connectors 7 and 8 on the top of the insert.
NOTE: Instrumentation to connect to these two connections is not included with these kits.

Installing the M91 FastHall™ measurement controller

The recommended communication interface to the M91 is the USB connector (labeled as #7 in the diagram). In order to use this interface, the current Lake Shore USB driver should be downloaded and installed on the PC used to run the M91 measurements. If this is completed properly, then when the M91 is connected, the PC will recognize the instrument as an M91. The driver can be downloaded here:

<https://www.lakeshore.com/resources/software/drivers>.

For further connection information for the M91, refer to the documentation included with the product or <https://www.lakeshore.com/m91>.

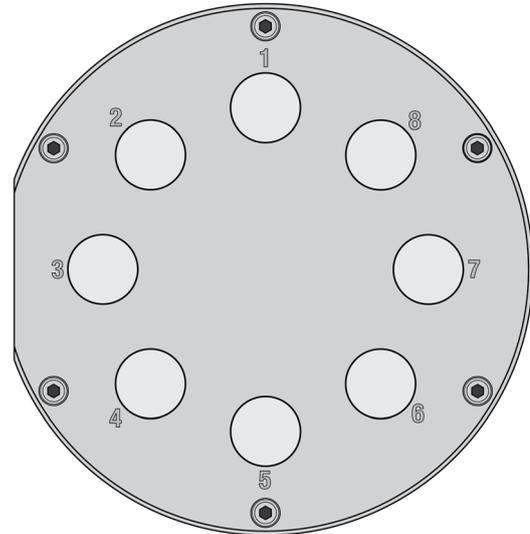


1. Triaxial sample connectors
2. Analog input
3. Analog output
4. Signal return
5. Digital output
6. Digital input
7. RJ-45 Ethernet interface
8. USB Type-B communications interface
9. USB Type-C™ interface
10. Line input assembly
11. Chassis ground connection

PPMS sample insert connections

The PPMS Sample Insert has eight numbered triaxial connectors on the top of the insert. The M91 and the sample insert will be connected using the provided triax bundle using contacts 1 to 6, matching the number on the insert to the rear panel of the M91 insert. See the table below for the complete list of connections.

NOTE: The auxiliary connections are extra connections used for other applications, such as gate bias. Instrumentation for contacts 7 and 8 are not included with the M91-PPMS-KIT2 or PPMS-INSERT-HALL.



Sample contact	Signal
1	Van der Pauw or Hall Bar (M91)
2	Van der Pauw or Hall Bar (M91)
3	Van der Pauw or Hall Bar (M91)
4	Van der Pauw or Hall Bar (M91)
5	Hall Bar (M91)
6	Hall Bar (M91)
7	Auxiliary connection
8	Auxiliary connection

Installing MeasureLINK™-MCS software

To install and activate MeasureLINK, please refer to the MeasureLINK software manual and quick start guide, available from the Downloads page at: <https://www.lakeshore.com/measurelink>.

Application packs

MeasureLINK includes a number of optional application packs that extend the functionality of MeasureLINK software. These packs include the drivers needed to communicate with the instruments, prewritten scripts for running all of the Hall measurements and reporting the results of the measurements, measurement examples, and documentation.

For this application, the following two application packs should be installed (which can be completed by navigating to the Application Packs tab in the Utilities window):

- MeasureLINK QD MultiVu application pack
- MeasureLINK M91 FastHall application pack

Once the application packs are installed, restart MeasureLINK software to complete the application pack installation process.

Configuring the MultiVu driver

After the MultiVu driver has been installed and configured, MeasureLINK can directly control the temperature and field by communicating with MultiVu. MeasureLINK measurements will seamlessly control field and temperature for any of the standard MeasureLINK M91 sequences.

Installing the guarded insert into the Quantum Design PPMS® DynaCool system

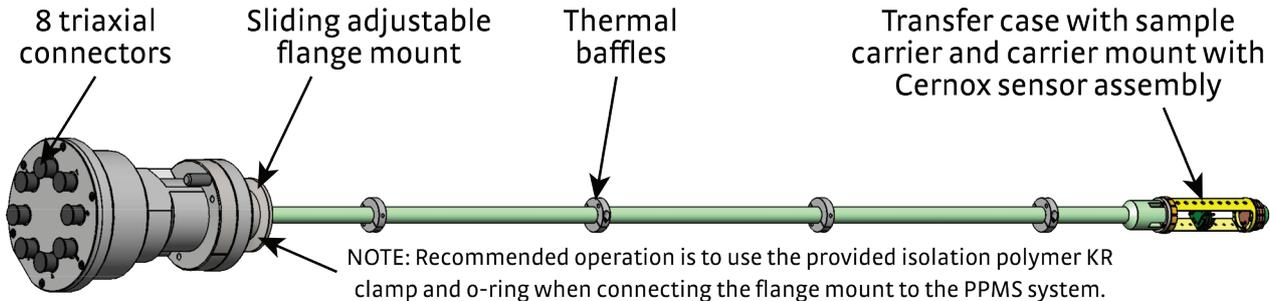
Sample chamber access port and chamber baffles

The sample chamber is accessed through the KF-40 flange mounted to the cryostat top plate manifold. In order to seal the flange and prevent thermal radiation from reaching your sample, use the baffle set which is attached to the KF blank flange as shown in the figure, below. In order to prevent leaks into the sample chamber, be sure to keep the sealing surfaces of the KF flange and baffle set clean. Also, be sure not to damage the o-ring used to seal this flange.

NOTE: Some DynaCool options seal the sample chamber differently and do not use the components shown in the figure.

Before setting a temperature below 295 K, make sure that the sample chamber is sealed and contains only clean gas. This is completed by executing a purge and seal operation after sealing the KF flange at room temperature.

WARNING: Be sure to properly seal the sample chamber flange before setting temperatures below 295 K. Failure to do so will cause ice to build up in the chamber, which is hazardous and may damage the DynaCool sample chamber due to excessive pressures resulting from an ice plug. Even a small leak can cause ice to build up, so be sure to keep the KF flange surfaces clean and to not damage the o-ring used to seal the flange.



Handling the sample cards

- Always wear gloves when handling sample cards to avoid contamination that can affect sensitive measurements.
- If contamination is suspected, contact Lake Shore Customer Support for cleaning and debugging guidance.
- For installation, use the two pins with the wider spacing for alignment, and ensure the card is fully inserted before use.
- To remove the card, gently rock it back and forth. If needed, use a plastic flat-edged tool to carefully pry each side of the card from the holder.

Finding the serial number of the Cernox® sensor on the PPMS sample insert

Every PPMS sample insert has a Cernox® sensor installed on the sample carrier board. During installation of a new insert, locate the serial number of the Cernox sensor to download the curve.

There are two ways to find the Cernox sensor serial number for a specific PPMS insert kit:

1. Inside the case that the insert case, there is a black box labeled “841-095 Assy, PPMS Cernox card.” The serial number is located on the back side of this box.
2. Under the sample insert, there is a label that lists both the part of the Cernox sensor and the serial number (see the image, below).

For more information on how to download calibration data and for installation information, please see <https://www.lakeshore.com/sensors>.



Confirming Operation of the Insert

The M91 FastHall analysis kit comes with four samples for confirming the operation of your system. These samples are a 0.01 Ω resistor, a 10 M Ω resistor, a 100 G Ω resistor and an InAs sample. These samples are mounted on Hall sample carrier boards.

The three resistors are used to confirm operation of the insert over the resistance range. The InAs sample is used to confirm proper magnetic field orientation of the PPMS. This section explains how to use MeasureLINK™-MCS software to confirm the operation of the insert.

Measuring the resistors

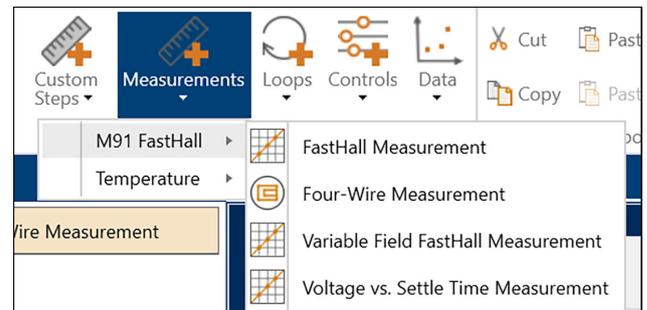
The resistor values provided are nominal values and are not precision resistors. The precision of the resistors is listed in the table below.

Resistor value	Precision (%)
0.01 Ω	0.1%
10 M Ω	1%
100 G Ω	20%

These resistors are only used to confirm operation of the insert and not to confirm accuracy specifications of the M91 FastHall analysis kit. During quality check, similar measurements to those described here were performed using precision resistors to confirm the accuracy of your M91 FastHall analysis kit.

The resistors are measured using MeasureLINK™-MCS software and the M91 FastHall Four-Wire Measurement method. To complete this method:

1. Configure MeasureLINK.
2. Click **Sequence** from the ribbon.
3. Click **Measurements** from the Sequence ribbon.
4. From the drop down list, select M91 FastHall, and then Four-Wire Measurement.



The figure below shows the configuration for a Four-Wire Measurement. Most of the selections are the same for each resistor. The selections that vary are summarized in the table below.

Device

Instrument: M91

Contacts

Excitation low 1

Excitation high 2

Sense low 4

Sense high 3

Compliance

Source
 Source current
 Source voltage

Blanking time 2 ms

Source current 10 mA

Compliance voltage 10V

Source voltage 1 V

Current limit 100 mA

Use reversal

Target signal to noise ratio (SNR)
 Turn off SNR
 Default (30)
 Value

Minimum SNR 30

Maximum number of samples: 2

Ranges

Auto range

Voltage range 1 V

Current range 10 mA

Resistor value	Contacts	Source	Blanking time	Source current/ source voltage
0.01 Ω	42-13	Current	2 ms	100 mA
10 MΩ	24-24	Current	1 s	800 nA
10 MΩ	24-24	Voltage	1 s	10 V
100 GΩ	43-12	Voltage	100 s	10 V

All resistors should be run at room temperature and do not require any magnetic field. The resistor board mounts directly onto the PPMS insert sample, and all testing should be done with the PPMS insert inside the PPMS system. When ready, click **Start** on the ribbon.

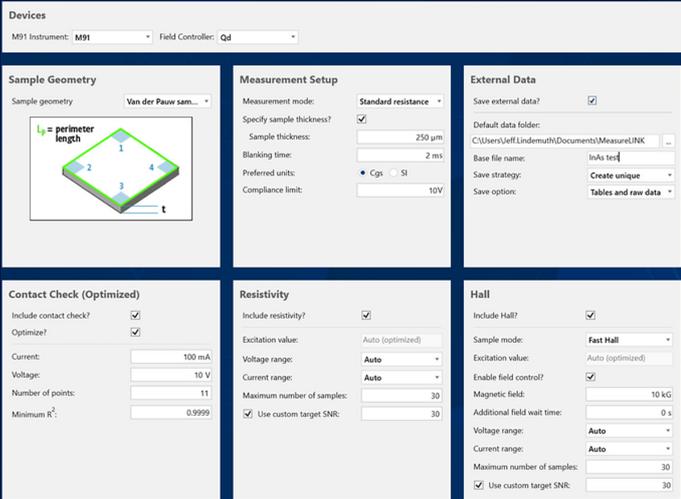
When the measurement is complete, confirm the resistance value on the Summary tab.

When removing the sample, the board should be carefully rocked back and forth to prevent damage to the pins.

Measuring the InAs sample

The InAs sample requires the magnet field for the PPMS system. Please consult pages 18 to 20 of this guide for more information on how to use the system.

To complete a Hall measurement with the InAs sample, mount the sample on the insert, insert it into the PPMS, and set the temperature to 295 K. In MeasureLINK, select a new sequence, select M91 FastHall, and then FastHall Measurement.



The screenshot displays the MeasureLINK software interface for configuring a measurement. The 'Devices' section at the top shows 'M91 Instrument: M91' and 'Field Controller: Qd'. The interface is organized into several panels:

- Sample Geometry:** Shows a diagram of a diamond-shaped sample with four contacts labeled 1, 2, 3, and 4. The perimeter length is labeled L_p and the thickness is labeled t . The sample geometry is identified as 'Van der Pauw sam...'. A dropdown menu is set to 'Van der Pauw sam...'.
- Measurement Setup:** Includes 'Measurement mode: Standard resistance', 'Specify sample thickness? ', 'Sample thickness: 250 µm', 'Blanking time: 2 ms', 'Preferred units: Cgs (SI)', and 'Compliance limit: 10V'.
- External Data:** Includes 'Save external data? ', 'Default data folder: C:\Users\Jeff.Lindemuth\Documents\MeasureLINK', 'Base file name: InAs test', 'Save strategy: Create unique', and 'Save option: Tables and raw data'.
- Contact Check (Optimized):** Includes 'Include contact check? ', 'Optimize? ', 'Current: 100 mA', 'Voltage: 10 V', 'Number of points: 11', and 'Minimum R^2 : 0.9999'.
- Resistivity:** Includes 'Include resistivity? ', 'Excitation value: Auto (optimized)', 'Voltage range: Auto', 'Current range: Auto', 'Maximum number of samples: 30', and 'Use custom target SNR: 30'.
- Hall:** Includes 'Include Hall? ', 'Sample mode: Fast Hall', 'Excitation value: Auto (optimized)', 'Enable field control? ', 'Magnetic field: 10 kG', 'Additional field wait time: 0 s', 'Voltage range: Auto', 'Current range: Auto', 'Maximum number of samples: 30', and 'Use custom target SNR: 30'.

The following values should be changed from the default values:

- Check the Specify sample thickness? checkbox
- Sample thickness: 0.25 mm
- Base file name: InAs test
- Magnetic field: 10 kG (1 T)
- If you are testing an InAs sample without the magnet, deselect the **Include Hall?** checkbox to run only Contact Check and Resistivity

Start the measurement. When complete, confirm on the Summary tab that the Type is n-type. The mobility should be on the order of $24000 \text{ cm}^2/(\text{V s})$.

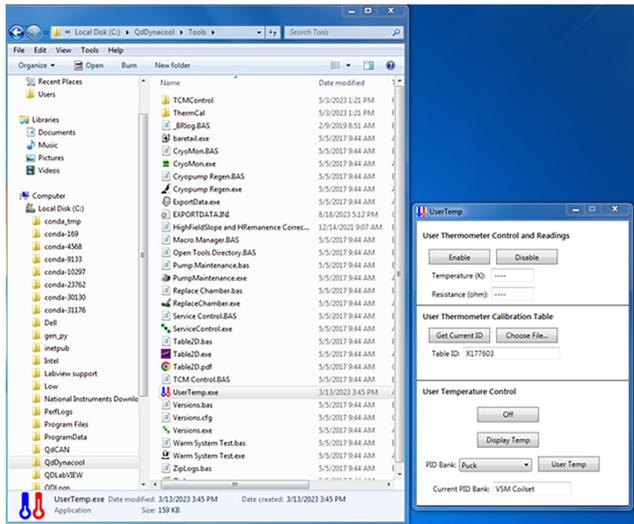
If the Type is p-type, confirm the proper connection between the M91 and the insert. Make sure that the triaxial cables on the back of the M91, numbered 1-6, are connected to the same numbered triaxial connectors on the top on the insert. If the Type is still p-type, contact Quantum Design (see “Customer Support” on the last page of this document).

This completes the setup of your M91 FastHall analysis kit. You are now ready to begin measurements.

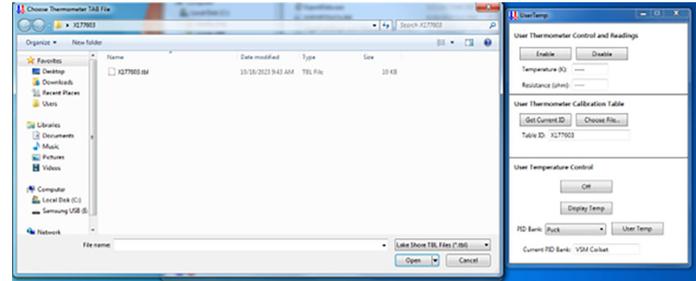
Setting Up the Sensor on the Insert

For temperature reading and control on the PPMS, set up the sensor on the guarded insert as shown below.

1. Download QdDynacool from Quantum Design's Pharos portal (see "Customer Support" on the last page of this document).
2. From the QdDynacool Tools directory, select the UserTemp.exe file.



3. Click the **Choose File...** button. Select the .tbl file from Lake Shore Cryotronics containing the calibration curve for your sensor.



4. On the User Temperature Control panel, select Rotator from the PID Bank drop down list, then click **User Temp.**
5. Enable User Temperature Control by clicking **Display Temp.**

An adapter box with a rotator is required to measure the offset sensor. This adapter box allows connection of the Cernox sensor to the electronics of the PPMS system. The adapter box, rotator/MFP experiment cable (3084-010-02), is available from Quantum Design. (See “Customer Support” on the last page of this document.)



Quantum Design PPMS® DynaCool system startup and cool down

This section covers cooling down the cryostat from a completely warm state to normal operating temperature.

- 1. Turn on the power to the electronics.**

Make sure all the breakers on the back of the cabinet are turned on and the computer is on. MultiVu software should be running.

 - Make sure the breakers in the back of the cabinet are turned on. The power light on the back of the cabinet should be lit.
 - Make sure the power switch on the back of the CAN Module Bay is set to on. The PWR indicator should be illuminated on the temperature control module in the CAN Module Bay.
 - Make sure the computer is on. Observe that the PWR light from the USB-based CAN Network transceiver is lit. This is located in the back of the CAN module bay.
- 2. Check cooling water and power to the compressor.**

Make sure the chilled cooling water is flowing through the compressor, and the circuit breaker is switched to the ON position.

NOTE: Do not press the green start button.

3. **Launch the startup procedure.**

Follow the steps below to begin the cool down procedure:

- Launch the MultiVu software. Verify that there are no red indicators in the status bar at the bottom of the MultiVu window. If there are any messages indicating that a service is stopped, then start the services by double-clicking the DynaCool Services Control icon in the lower right corner of the screen, and pressing **Start All Services** from the DynaCool Services Window.
- Open the Cryostat Monitor from the “Instrument > Cryostat...” menu item . Press the **Startup** button on the left and follow the brief instructions.

4. **Wait for cool down.**

After the startup procedure has been launched, you can close the Cryostat Monitor window, or leave it open to track the progress of the cool down. A typical cool down time for a 9 T DynaCool is about 16 hours. During this time, the system performs several operation; including:

- Purging the cryostat vacuum space with air to flush out any residual helium gas.
- Evacuating the cryostat vacuum space.
- Purging and filling the circulation loop with a clean charge of helium from the bottle
- Regenerating the chamber cryopump.
- Starting the cryocooler compressor and cooling the system to its base temperature of about 4 K.
- Condensing 100 to 200 cc of liquid helium into the cooler reservoir.

Upon completion of the startup procedure, the Cryostat Monitor status will read “Cold Cryostat” and the Cryostat Status panel will indicate “Cold.”

5. **Shutting down the system and other tasks.**

It may be necessary to shut the system down from time to time or perform system-level control tasks.

NOTE: Please refer to documentation provided with the DynaCool system.

6. Temperature, field, and chamber commands.

With the system now ready to be used, you can perform various control tasks immediately:

- To set temperature, select the “Instrument > Temperature...” menu item, enter a setpoint of 300 K and a rate of 20 K/min. Click **Set** to bring the sample to room temperature.
- To set magnetic field, select the “Instrument > Field...” menu item, then enter a setpoint of 10000 Oe, and a rate of 200 Oe/s. Click **Set** to bring the magnetic field to 1 T.
- Once the sample chamber is stable at room temperature, select “Instrument > Chamber...”, and click **Vent and Seal** to vent the chamber with helium gas. You can then remove the KF flange cover at the top of the cryostat to open the sample chamber. After closing the sample chamber, click **Purge/Seal** to vent and flush the chamber with helium gas from the bottle.

NOTE: You may also access these instrument control dialogs by clicking the corresponding panel in the status bar at the bottom of the DynaCool MultiVu window.

Customer Support

For support, please contact Quantum Design USA, or your local Quantum Design office worldwide.

10307 Pacific Center Court

San Diego, CA USA 92121

Phone: 800-289-6996

Email: service@qdusa.com

Web: www.qdusa.com