MPMS® 3

Product Description

Magnetic Property Measurement System

Quantum Design's MPMS 3 represents the culmination of more than 30 years of development and design in the world of SQUID Magnetometry. Providing users with the sensitivity of a SQUID (Superconducting QUantum Interference Device) magnetometer and the choice of multiple measurement modes, the MPMS 3 offers new levels of performance in magnetic research while including those aspects of past Quantum Design SQUID magnetometers that customers have grown to appreciate and depend on.

The MPMS 3 incorporates major advances in data acquisition, temperature control and magnetic field control with $\leq 10^{-8}$ emu sensitivity. The award-winning design of Quantum Design's MPMS 3 also provides expanded software functionality within its user-friendly MultiVu interface. Combining the highest level of system performance with the possibility of using all previously available MPMS measurement options, the Quantum Design MPMS 3 truly represents the next generation of advanced SQUID magnetometry.

Data Acquisition

The MPMS 3 provides three possible measurement modes: DC Scan Mode (standard), VSM Mode (optional) and AC Susceptibility Mode (optional).

DC Scan Mode: Provides continual plotting and capture of raw data points at various fields and temperatures. This mode of data capture is similar to, but faster than, Quantum Design's historic MPMS XL measurement modes.

VSM Mode: Combines Quantum Design's dc SQUID sensor with Vibrating Sample Magnetometer (VSM) technology, providing the ability to achieve $<1 \times 10^{-8}$ emu sensitivity at zero magnetic field. Further noise reduction in the design allows this system to achieve an unprecedented $<8 \times 10^{-8}$ emu sensitivity at the full field of 7 tesla.

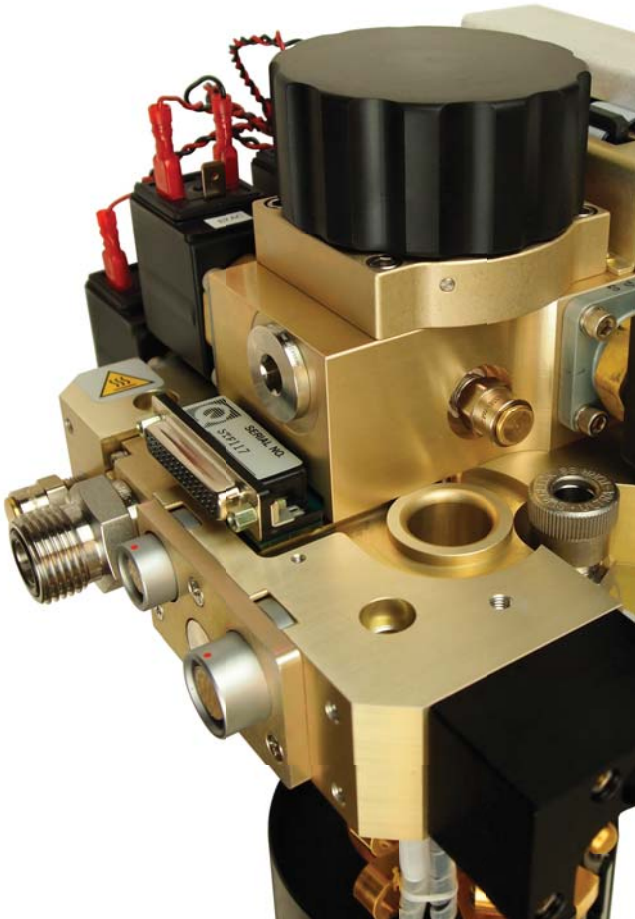
AC Susceptibility Mode: Using an oscillating magnetic field, this measurement uses the MPMS 3's SQUID and VSM linear motor to measure the AC Susceptibility of a sample. Fully integrated functionality and scripting are available within the MultiVu interface.

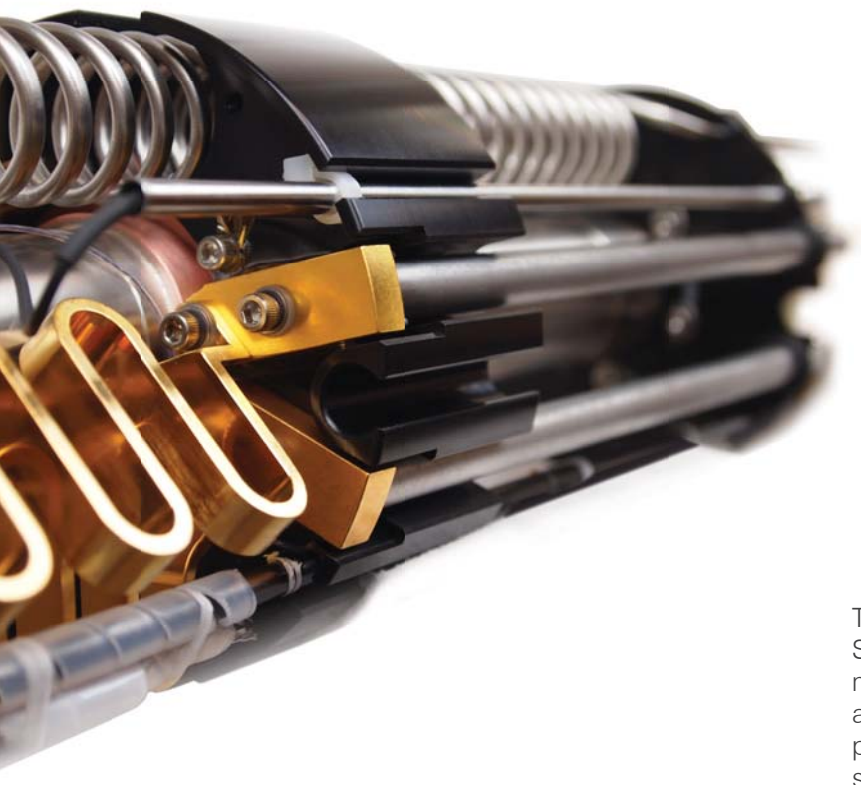
Temperature Control

The MPMS 3 uses an innovative temperature control design that allows you to cool samples from room temperature to a stable 1.8 K in typically less than 30 minutes.

The temperature control insert of the MPMS 3 is a vacuum-insulated chamber into which cold helium is drawn through a variable flow valve, for the purpose of cooling the sample chamber with pumped helium to temperatures as low as 1.8 K. A finely tuned flow impedance and sophisticated temperature control software allow continuous operation at 1.8 K as well as smooth temperature control through the 4.2 K liquid helium boiling point. Heaters on the sample chamber can raise the temperature as high as 400 K. A thermal shield, anchored to a liquid nitrogen tank, intercepts heat from a warm sample chamber and minimizes liquid helium consumption when operating at higher temperatures. By flattening the thermal gradient along the cold end of the temperature control insert, this shield also allows the entire insert to be constructed with a relatively short geometry, minimizing heat capacitance and enabling rapid temperature control.

The diameter of the temperature control insert was selected to allow a 9 mm sample bore and to provide the smallest diameter pickup coils possible to optimize the magnetometer's sensitivity.





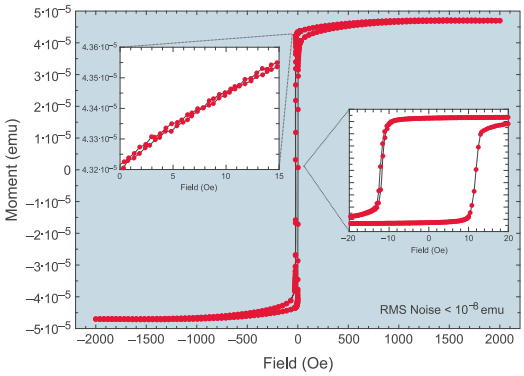


Figure 1. The quality of moment versus field data, at 5 K, is shown for a thin film ferromagnetic sample provided by Professor Eckert of Harvey Mudd College. The left inset illustrates the reproducibility in coming from 2 kOe to zero field. The right inset demonstrates in particular the small field setting resolution of the new MPMS®3 magnet power supply.

The MPMS 3 features an integrated Environmental Magnet Shield. This shield allows sensitive measurements to be made by creating a locally quiet environment. It also serves as a return path for the system's superconducting magnet, permitting use of the system in close proximity to other sensitive devices.

Quantum Design is proud of its 30+ years of contributions to HTS research, development and design. We are excited to offer this newest incarnation of the MPMS platform — to the benefit of future researchers.

Magnet Control

The MPMS 3 utilizes a 7 tesla, superconducting, helium-cooled magnet and a hybrid digital/analog magnet controller designed specifically for the MPMS 3 to achieve precise, quiet control of the magnetic field. SQUID precision in a magnetic measurement requires a stable magnetic field. The MPMS 3 accomplishes rapid switching between charging and discharging states and stable fields with a unique, patented superconducting switching element, which changes between superconducting and normal states in less than one second. This allows rapid collection of high precision data.

The high open state resistance and low thermal mass of the MPMS 3's QuickSwitch™ also help to minimize liquid helium consumption when ramping magnetic field, as compared to more traditional superconducting persistent switch technology. Further aiding the instrument's low helium consumption is the use of high temperature superconductor (HTS) magnet leads anchored to a liquid nitrogen tank. The nitrogen shield in this design absorbs a large amount of room temperature heat that would otherwise be conducted to the helium bath.

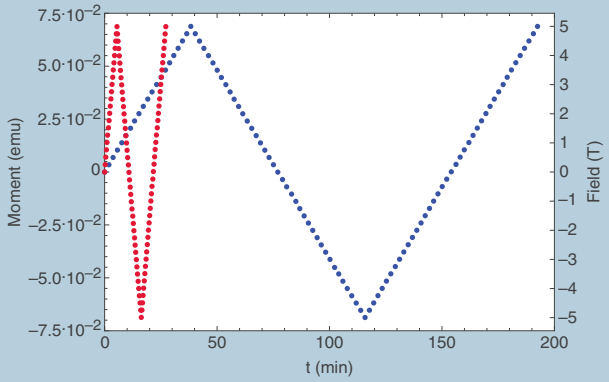


Figure 2. The MPMS 3's unique, patented superconducting switching element provides increased speed and performance of magnet ramping and stabilization. This leads to faster measurement frequency with decreased time lags between measurements.

MPMS®3

A History of Innovation
Industry Leading Sensitivity
Award Winning Design
Automated Operation
Precision & Speed

Measurement Options

- VSM Measurement
- AC Susceptibility
- Horizontal Rotator
- Oven (up to 1000 K)
- Ultra-Low Field
- Magneto-Optic Measurement
- High Pressure Cell
- Manual Insertion Utility Probe

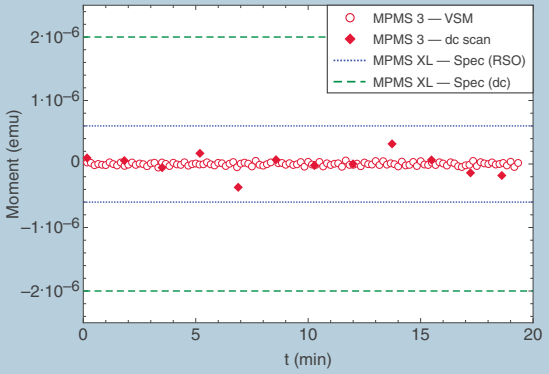


Figure 3. The MPMS 3 provides the lowest noise floor ever available in a Quantum Design SQUID magnetometer (both for DC Scan and VSM measurement modes). [MPMS 3 noise data was collected at full field on an EverCool equipped system with the cold head running.]

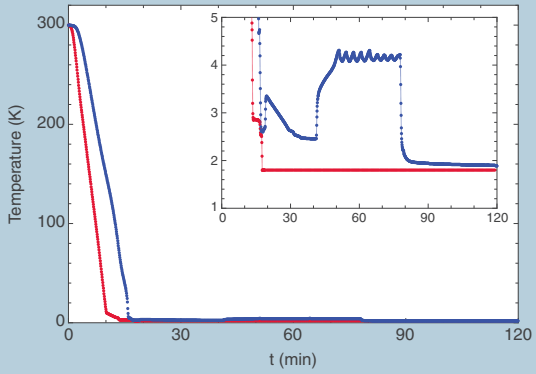


Figure 4. Cooling performance from room temperature of the MPMS 3 compared to the MPMS XL obtained by directly setting the system's base temperature at a fast rate. Note that in addition to reaching temperature stability much faster, the temperature history is completely monotonic for the MPMS 3 (see inset).

MPMS®3 Specifications

Temperature control	
Feature:	New TCI design, Rapid Temp™
Operating Range:	1.8 K to 400 K
Cooling Rate:	30 K/min (300 K to 10 K stable in 15 min., typical); 10 K/min (10 K to 1.8 K stable in 5 min., typical)
Temperature Stability:	+/- 0.5%
Temperature Accuracy:	lesser of +/- 1% or 0.5 K
Sample Chamber I.D.:	9 mm
Magnetic field control	
Feature:	QuickSwitch™
Magnetic Field Range:	-70 kOe to +70 kOe
Field Uniformity:	0.01% over 4 cm
Field Charging Rate:	4 Oe/sec to 700 Oe/sec
Field Charging Resolution:	0.33 Oe
Remanent Field:	~5 Oe (typical) when oscillating from full field back to zero
Magnetization measurements	
Feature:	SQUID-based Magnetometry/Susceptibility
Maximum DC moment:	10 emu
Sensitivity:	≤ 2,500 Oe: ≤ 5 x 10^{-8} emu (DC scan) ≤ 1 x 10^{-8} emu (VSM, less than 10 second averaging)* > 2,500 Oe: ≤ 6 x 10^{-7} emu (DC scan) ≤ 8 x 10^{-8} emu (VSM, less than 10 second averaging)*
Variable drive amplitude:	0.1 to 8 mm (peak)
General System Details**	
Power Requirements:	200 VAC - 230 VAC, 50/60 Hz, 10A Max.
Liquid Helium Usage:	4 liters/day (typical) + 0.05 liters per sample cooldown***
Liquid Helium Capacity:	65 liters
Liquid Nitrogen Usage:	5 liters/day (typical)
Liquid Nitrogen Capacity:	60 liters
Maximum Hold Time:	12 days (typical)

** When VSM option installed. ** Specifications apply to non-EverCool® base configuration.*
**** Liquid Helium consumption increases with oven use.*

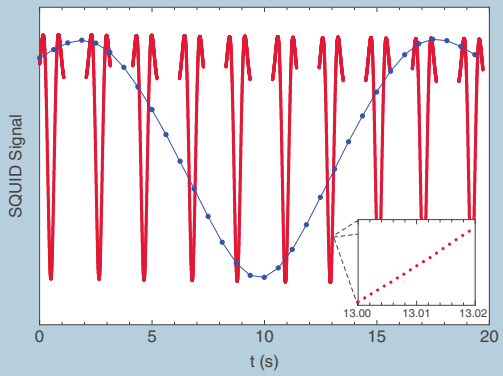


Figure 5. Significantly increased speed and point density of the new DC Scan Measurement Mode of the MPMS 3 compared to a standard DC scan acquired on the MPMS XL. The increased point density and shorter acquisition time allow for better rejection of noise and SQUID drifts as well as more data points for analysis of the raw data.

Quantum Design

Quantum Design, Inc.
10307 Pacific Center Court, San Diego, CA 92121
Tel: 858.481.4400 Fax: 858.481.7410
www.qdusa.com

CE

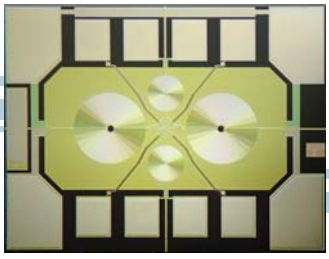
MPMS®3 EverCool® Option

The Quantum Design MPMS 3 EverCool Dewar eliminates the need for liquid helium transfers and virtually eliminates all helium loss from the Quantum Design MPMS 3 magnetometer system. For the user, this integrated pulse-tube cryocooler dewar system can be considered cryogen free, as it not only recondenses the liquid helium directly within the EverCool Dewar but also accomplishes its initial cool-down directly from helium gas, thereby eliminating the need to use any liquid cryogens for the operation of the MPMS 3.

MPMS 3 EverCool system advantages:

- Minimal additional space requirements for the cryocooler compressor
- Production of initial operating charge of liquid helium from helium gas in as little as 30 hours
- Full integration of all EverCool functions within the MPMS 3 MultiVu software, allowing virtually automatic system operations, including helium level control in the MPMS 3 EverCool dewar
- Little or no service requirements for the pulse-tube cryocooler

The MPMS 3 EverCool Dewar is available as an option for the Quantum Design MPMS 3. It requires the use of a water chiller for the water-cooled compressor, as well as the hook up of an external He gas supply for the purpose of automatically replenishing He gas that is lost under certain conditions (e.g., purging the sample space or using the system under extreme conditions).



MPMS®3 EverCool® Specifications

Model:	C060 MPMS 3 EverCool
Helium Liquefaction Capacity:	~ 9 liquid liters/day. This is the net liquefaction rate while the system is running and represents the amount of liquid helium that can be generated in excess of the normal daily system usage.
Nominal LHe Capacity:	~ 16 liters. Full capacity is defined when level reaches bottom of magnet.
Estimated Cool-Down Time:	~ 30 hours to reach thermally steady state, ready for normal system operation. No liquid helium is required for cool-down. An additional 20 hours are necessary to reach the normal helium level.
Potential Effect on System Sensitivity:	The EverCool configuration has a permanently running cryocooler, which has no influence on the system specifications. The noise performance standard is identical to the MPMS 3 base system.
Physical Configuration:	• EverCool Dewar with integrated cold head housed in existing standard MPMS 3 cabinet; • Pumping module, gas handling control and integrated EverCool controller housed in existing standard MPMS 3 pump console; • Compressor with stainless steel hoses connecting to main cabinet.
Physical Dimensions: Main Cabinet (excl. keyboard arm and compressor hoses): Pump Console: Compressor: Compressor hoses (pair):	 ~ 84 x 104 x 199 cm3 (L x W x H); Weight: ~ 400 kg. ~ 71 x 61 x 61 cm3 (L x W x H); Weight: ~ 65 kg. ~ 46 x 48 x 62 cm3 (L x W x H); Weight: ~120 kg. ~ 20m length; Weight: ~ 35 kg (pair)
Water-Cooled Compressor Configurations & Power Requirements: Compressor configurations:	 3 Phase 220/230VAC 33A max @ 60 Hz; 3 Phase 460VAC 13A max @ 60Hz; 3 Phase 380/420VAC 16 A max @ 50 Hz; 3 Phase 200/220VAC 33A max @ 50Hz; Power requirement of 9 kW max with a typical consumption of 7.2 kW
Cooling Water Requirement:	≥9 liters/min @ 28 °C and ≥3 liters/min @ 10 °C (non-condensing)
Maintenance Time on Compressor:	After 20,000 operational hours (recorded by timer on compressor)
Maintenance Time on Cold Head:	After ~ 30,000 operational hours

Note: Detailed configuration information available in the "MPMS 3 EverCool Configuration Worksheet."