

# PPMS

PHYSICAL PROPERTY MEASUREMENT SYSTEM

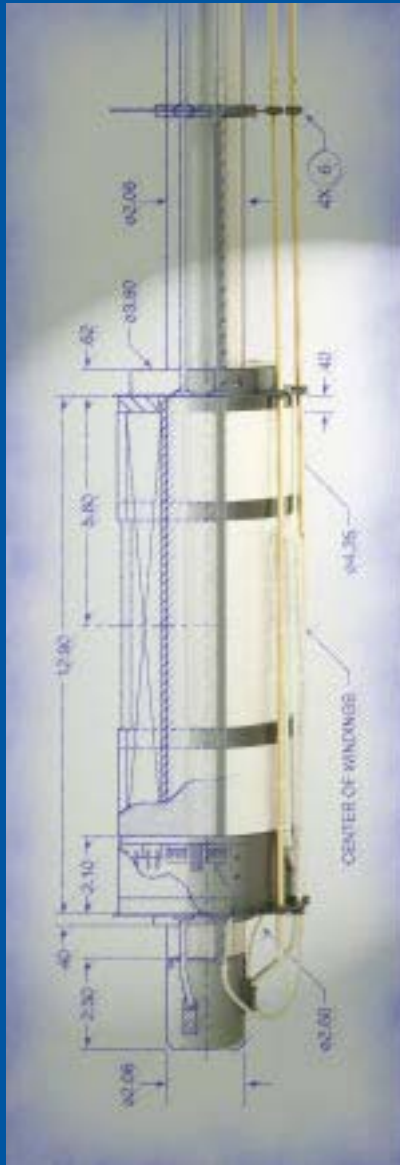


physical  
property  
measurement  
PPMS system

Quantum Design



## SYSTEM FEATURES



Much of the versatility of the PPMS is based on the design of the PPMS probe. The probe incorporates the magnet, the temperature control, and the sample puck connector.

THE QUANTUM DESIGN PHYSICAL PROPERTY MEASUREMENT SYSTEM (PPMS) REPRESENTS A UNIQUE CONCEPT IN LABORATORY EQUIPMENT. IT IS AN OPEN ARCHITECTURE, VARIABLE TEMPERATURE-FIELD SYSTEM THAT IS OPTIMIZED TO PERFORM A VARIETY OF AUTOMATED MEASUREMENTS. AT QUANTUM DESIGN WE KNOW YOUR TIME IS VALUABLE, SO WE BROUGHT LABORATORY AUTOMATION TO A NEW LEVEL. WHILE THE PPMS AUTOMATICALLY RUNS YOUR MEASUREMENTS, YOU CAN BE ANALYZING DATA FROM PREVIOUS MEASUREMENTS, PLANNING YOUR NEXT EXPERIMENT, AND CREATING NEW MATERIALS.

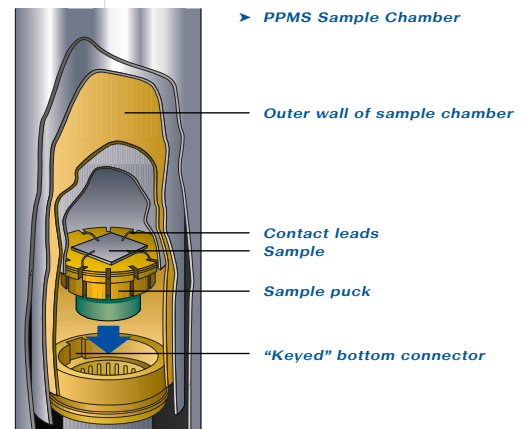
THE PPMS WORKS LIKE A DEDICATED SYSTEM, BUT ITS TREMENDOUS FLEXIBILITY LETS YOU PERFORM DIFFERENT TYPES OF MEASUREMENTS. PLUS, YOU CAN EASILY INTEGRATE YOUR OWN UNIQUE EXPERIMENT WITH THE PPMS. THE FOLLOWING PAGES LIST SPECIALLY CONFIGURED PPMS INSTRUMENTS FOR HEAT CAPACITY, MAGNETOMETRY, AND ELECTRO-TRANSPORT APPLICATIONS. HOWEVER, ANY OF THE CAPABILITIES CAN BE COMBINED TO CONFIGURE A SYSTEM SUITABLE FOR YOUR PARTICULAR RESEARCH NEEDS.

### EASE OF USE

The hallmarks of the PPMS are automation and ease of use. You can quickly and easily configure the PPMS to perform different types of measurements. In a matter of minutes you can install a measurement application, set up an automated sequence, and start collecting meaningful data. And, the PPMS is designed to run 24 hours a day, 7 days a week.

### PPMS MULTIVU SOFTWARE

PPMS MultiVu is Windows™-based control software that contains all the functions essential for each measurement application. With it you can create measurement sequences that automate system operation, and you can control system parameters, such as magnetic field and temperature, manually. Plus, you can review saved data and monitor data as the PPMS collects it. All systems come complete with remote capability.



**SAMPLE MOUNTING**

The PPMS sample-mounting system is the most interesting and unique feature of this instrument. At the bottom of the sample chamber is a 12-pin connector pre-wired to the system electronics. This connector allows you to plug in a removable sample insert or sample “puck” and offers convenient access to electrical leads for application hardware and electronics. This connector provides the foundation for all of the PPMS measurement inserts.



► Specialized pucks, 2.4 cm in diameter, are used for different measurement applications.

**OPEN ARCHITECTURE**

The tremendous flexibility of the PPMS lets you create your own experiments and easily interface your own third-party instruments to the PPMS hardware. The PPMS MultiVu software supports linking capabilities, so you can write your own programs in Delphi, C++, or Visual Basic to synchronize PPMS functions with the activity of other instruments to perform your custom experiment. The Model 6000 PPMS Controller houses and controls all the critical components of the instrument to provide direct communication with the application electronics for rapid data acquisition.

**TEMPERATURE CONTROL OPERATION**

To control the temperature, a vacuum pump draws helium into the annular region where heaters warm the gas to the correct temperature. This design reduces thermal gradients and increases system flexibility by making the sample chamber a controllable

environment. For example, the sealed sample chamber may hold a high vacuum without the need for additional inserts. This is significant for the design of the Heat Capacity and Helium-3 capabilities.

The temperature control system offers the following features:

- Temperature sweep capability allows measurements to be taken while sweeping the temperature at a user-defined rate (0.01–6 K/min.).
- Continuous Low-Temperature Control (CLTC) ensures precise temperature control, uninterrupted operation below 4.2 K, and smooth transitions through the 4.2 K helium boiling point.

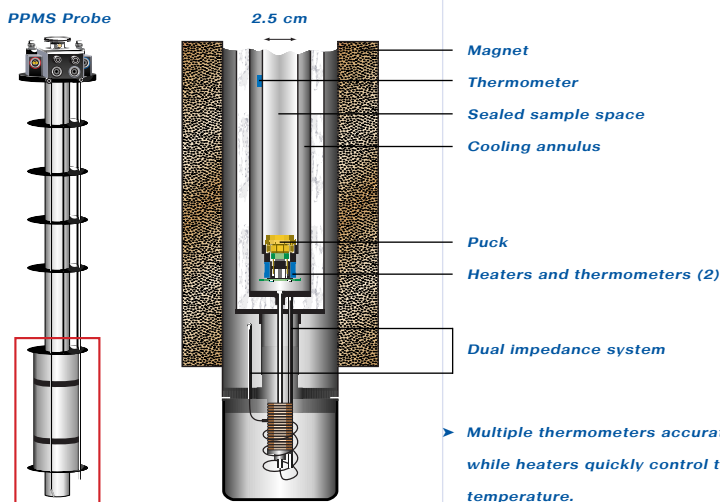
- Temperature range of 1.9–400 K accommodates many different types of measurements.

**CONFIGURABLE THERMOMETRY**

The UserTemp feature makes it extremely easy for you to incorporate your own calibrated thermometer into the hardware so that your thermometer can control the system temperature. UserTemp not only reads the thermometer but also controls the helium gas flow and heaters to minimize the time required to stabilize at each selected temperature. Many of the PPMS options utilize this feature to monitor the temperature close to the sample.

**FIELD CONTROL**

The PPMS can be configured with a 7 to 16 T longitudinal magnet or a 7 T transverse magnet. The low noise, bi-polar power supply allows continuous charging through zero field with current compensation and over-voltage protection.



► Multiple thermometers accurately monitor while heaters quickly control the system temperature.

## HEAT CAPACITY



A new concept in refrigeration design, this self-contained <sup>3</sup>He Refrigerator lowers the minimum sample temperature to < 0.4 K.

THE FOCUS OF THE PPMS HEAT CAPACITY SYSTEM IS TO PERFORM QUALITY HEAT CAPACITY MEASUREMENTS ON A VARIETY OF SAMPLES OVER A WIDE RANGE OF TEMPERATURES. THE UNIQUE USER-FRIENDLY ARCHITECTURE PROVIDES COMPLETE AUTOMATION OF ALL MEASUREMENT PARAMETERS AND COMPLEX MEASUREMENT ANALYSIS.

### HEAT CAPACITY

The Heat Capacity measurement system performs fully automated relaxation heat capacity measurements. Each measurement is analyzed using a sophisticated *two-tau model*<sup>™</sup> to accurately simulate the effect of the heat flow between the microcalorimeter platform and the sample (tau2) as well as the heat flow between the platform and puck stage (tau1). The Heat Capacity measurement system includes a high-vacuum system.

#### FEATURES:

- Advanced heat capacity algorithms calculate the actual thermal coupling of the sample to the microcalorimeter platform, curve fit the data, and then compensate for this coupling when determining the heat capacity of the sample.
- A built-in data subtraction feature automatically removes the background heat capacity of the sample platform and adhesive.
- All calculated fitting parameters, including a  $\partial^2$  quality value, are saved in the data file.
- Application software automatically acquires, analyzes, and displays data.

#### SPECIFICATIONS:

Temperature Range: 1.9–400 K  
Sample Size: 1–500 mg  
Resolution: 10 nJ/K @ 2 K

### HELIUM-3 SYSTEM

To reach temperatures below 1.9 K, an optional <sup>3</sup>He refrigerator is available. This probe provides a minimum temperature of less than 0.4 K. A new concept in refrigeration design, this self-contained helium-3 refrigerator operates by continuously circulating <sup>3</sup>He in a closed-cycle, sealed system, eliminating the need for low-temperature seals and manual valves. The Helium-3 System provides fully automated control of the pumps to support measurement capability up to 350 K. This option is specifically designed to provide lower temperatures for heat capacity and electrotransport measurements. Cooldown time from 300 K to 0.5 K is less than three hours.



► To use the Heat Capacity option, you mount the sample on an easy-to-install, plug-in microcalorimeter sample mount using a special sample-mounting fixture.

BECAUSE MAGNETOMETRY APPLICATIONS ARE USED IN CONJUNCTION WITH THE AUTOMATED TEMPERATURE AND FIELD CONTROL CAPABILITY OF THE PPMS, THE RESULT IS A POWERFUL, FULLY AUTOMATED MAGNETIC MEASUREMENT WORKSTATION THAT INCLUDES INTEGRATED SOFTWARE.

### AC/DC MAGNETIZATION

The AC Measurement System (ACMS) provides you with the capability to perform both AC susceptibility and extraction DC magnetization measurements without changing hardware.

#### FEATURES:

- A single automated measurement sequence can perform both AC and DC magnetization measurements.
- Direct measurement of the instrumental phase shift, not available on any other AC susceptometer: This feature uses integrated, low inductance calibration coils to measure and subtract background phase shifts prior to every AC measurement point.

*Pictured are the servo-motor, coil set, and sample rod for the ACMS.*



- High-speed digital filtering: By using a DSP chip, the ACMS improves the signal-to-noise ratio over analog filters to offer excellent performance over a wide frequency range.
- A compensation coil reduces environmental noise in AC susceptibility measurements.

#### SPECIFICATIONS:

Temperature Range: 1.9-350 K

AC Frequency Range: 10 Hz to 10 kHz

AC Field Amplitude Range: 2 mOe to 15 Oe

Sensitivity Range: DC magnetization measurements:  $2.5 \times 10^{-5}$  emu to 5 emu ( $2.5 \times 10^{-8}$  Am<sup>2</sup> to  $5 \times 10^{-3}$  Am<sup>2</sup>)

AC Susceptibility Measurements:  $2 \times 10^{-8}$  emu ( $2 \times 10^{-11}$  Am<sup>2</sup> @ 10 kHz)

The ACMS cannot be used with the 7-T Transverse & 16T systems. Performance is reduced in the 14-T system due to lower field homogeneity. Temperature stability may be reduced at low temperatures due to sample movement.

### ULTRA LOW FIELD†

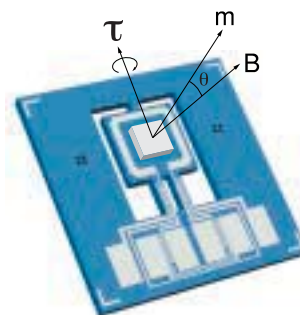
The Ultra Low Field (ULF) capability is also available on the PPMS and provides fully automated remanent field profiling and nulling. Using a fluxgate magnetometer, a superconducting low-field magnet coil, magnet-reset heater, and the ACMS hardware, the ULF option actively nulls the remanent field so you may perform zero-field cooled measurements.

#### SPECIFICATIONS:

Residual Field: < 0.1 Oe at any point

Residual Field Uniformity: < ±0.1 Oe along 4 cm at the center of the coil set

† Not available for the 7-T Transverse, 14-T, or 16-T systems.



*Tq-Mag chip with integrated Wheatstone bridge.*

### TORQUE MAGNETOMETRY\*

The Torque Magnetometer (Tq-Mag) is specifically designed to measure small, anisotropic samples, such as single crystals and thin films. It performs fully automated, high-sensitivity, angular-dependent measurements of magnetic torque over the full range of magnetic fields and temperatures.

#### SPECIFICATIONS:

Sample Size: Up to 2 x 2 mm<sup>2</sup>

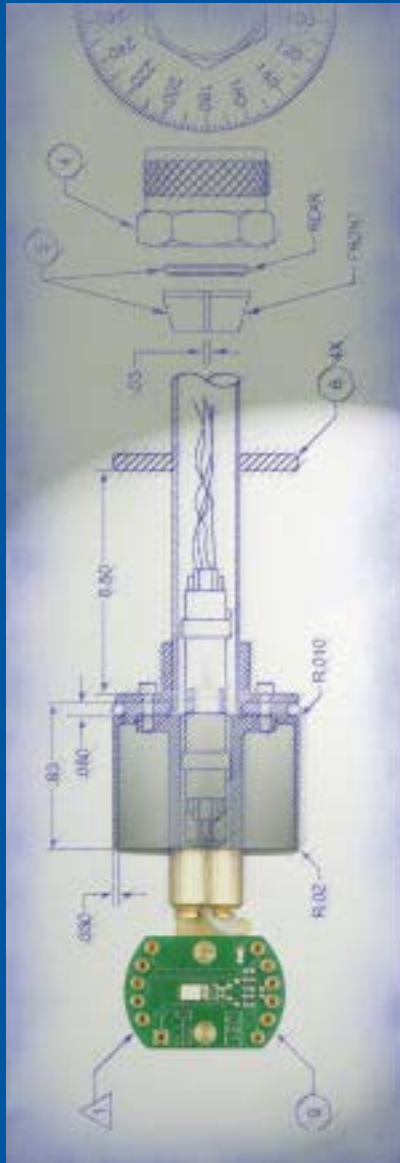
RMS Torque Noise Level:  $1 \times 10^{-9}$  Nm for 40 sec. sampling time

\* Quantum Design developed the Torque Magnetometer in collaboration with the IBM Research Division, Zürich Research Laboratory, and the Physik-Institut der Universität Zürich, Switzerland.



# versatile

## ELECTRO-TRANSPORT



Different sample-mounting structures for the rotators are available for each type of measurement. These platforms hold the sample parallel or perpendicular to the field. Vertical Rotator is pictured.

THE PPMS OFFERS AUTOMATION AND CONVENIENT SAMPLE MOUNTING FOR ALL TYPES OF ANGULAR-DEPENDENT ELECTRO-TRANSPORT MEASUREMENTS, INCLUDING RESISTIVITY, HALL EFFECT, I-V CURVES, AND YOUR OWN EXPERIMENTAL DESIGN. LET QUANTUM DESIGN SIMPLIFY YOUR TRANSPORT MEASUREMENTS.

### AC TRANSPORT MEASUREMENT SYSTEM

The AC Transport measurement system (ACT) option is a precision current source and voltage detector that supports four different types of automated, electrical transport measurements: AC resistivity, five-wire Hall effect, I-V curve, and critical current. A PPMS integrated with ACT provides fast data acquisition and the convenience of measuring up to two samples on a single sample mount.

#### SPECIFICATIONS:

Current Range: 10  $\mu$ A to 2 A  
Sensitivity: 1 nV @ 1 kHz  
Frequency Range: 1 Hz to 1 kHz

### DC RESISTIVITY

The DC Resistivity option adds resistance bridge capability to the Model 6000 PPMS Controller. This bridge provides four independent channels that you can use for van der Pauw and four-wire resistance measurements (up to three samples in a single sequence).

#### SPECIFICATIONS:

Current Range: 5 nA to 5 mA  
Sensitivity: 20 nV



Horizontal Rotator with various sample-mounting platforms.

### HORIZONTAL AND VERTICAL ROTATORS

You may also take advantage of the Horizontal and Vertical Rotators to obtain information about angular dependence. Samples are mounted on removable platforms. A thermometer, in direct contact with the platform, accurately determines the sample temperature. Both rotators are available with standard or high-resolution motors.

The Horizontal Rotator option rotates the sample about the horizontal axis.

#### SPECIFICATIONS:

Range:  $-10^{\circ}$  to  $370^{\circ}$   
Angular Step Size:  $0.053^{\circ}$  for standard resolution;  $0.0045^{\circ}$  for high resolution

The Vertical Rotator option rotates the sample about the vertical axis.

#### SPECIFICATIONS:

Angular Step Size:  $0.013^{\circ}$  for standard resolution;  $0.002^{\circ}$  for high resolution

### MULTI-FUNCTION PROBE

The Multi-Function Probe option extends measurement capabilities of the PPMS by allowing you to easily add hardware such as fiber optics, microwave guides, and external electrical leads to customize your experiment. This probe incorporates the PPMS sample space electrical connections and can utilize the electro-transport accessories.

## BASE SYSTEM SPECIFICATIONS

### MAGNET OPTIONS

Longitudinal:  $\pm 7$ ,  $\pm 9$ ,  $\pm 14$  T,  $\pm 16$  T  
 Transverse:  $\pm 7$  T split coil

#### FIELD UNIFORMITY

7 and 9 T Longitudinal:  $\pm 0.01\%$   
 over 5.5 cm x 1 cm diameter  
 cylindrical volume (typ.)  
 7 T Transverse:  $\pm 0.1\%$  over 1 cm  
 DSV  
 14 T Longitudinal:  $\pm 0.1\%$  over  
 5.5 cm  
 16 T Longitudinal:  $\pm 0.1\%$  over 1 cm  
 DSV

#### BI-POLAR POWER SUPPLY

7, 9 T: 50-A  
 Slew Rate: 1–19 mT/sec. (typ.)  
 7 T Transverse: 50A  
 Slew Rate: 0.3–5 mT/sec. (typ.)  
 14 T: 100-A  
 Slew Rate: 0.8–13 mT/sec. (typ.)  
 16 T: 120A  
 Slew Rate: 1–22 mT/sec. (typ.)

#### CONTROL MODES

Persistent and Driven Modes:  
 Linear  
 Oscillating  
 No Overshoot

#### RESOLUTION

7 T: 0.02 mT to 1 T  
 0.2 mT to 7 T  
 9 T: 0.02 mT to 1 T  
 0.2 mT to 9 T  
 14 T: 0.03 mT to 1.5 T  
 0.3 mT to 14 T  
 16 T: 0.03 mT to 1.5 T  
 0.3 mT to 16 T  
 7 T Transverse: 0.02 mT to 0.75 T  
 0.2 mT to 7 T

### UPS REQUIREMENT

Maximum Current Load: 17 A

### TEMPERATURE CONTROL

1.9–400 K

#### ACCURACY

$\pm 1\%$  zero to full field (up to 16 tesla)

#### SLEW RATE

0.01–6 K/min.

#### CONTROL MODES

No Overshoot  
 Fast Settle  
 Temperature Sweep

#### STABILITY

$\pm 0.2\%$  for  $T \leq 10$  K (typ.)  
 $\pm 0.02\%$  for  $T > 10$  K (typ.)

#### SAMPLE SPACE SIZE

Clear Bore 2.5 cm (1 inch) diameter

### DEWAR OPTIONS

#### STANDARD DEWAR

LHe Capacity: 30 l  
 Static Boil-off w/Probe:  $< 5$  l/day  
 Max. Hold Time: 6 days

#### LN<sub>2</sub>-JACKETED DEWAR

LHe Capacity: 30 l  
 Static Boil-off w/Probe:  $< 4$  l/day  
 Max. Hold Time: 8 days  
 LN<sub>2</sub> Capacity: 40 l  
 Static Boil-off w/Probe:  $< 2$  l/day

#### HIGH-CAPACITY LN<sub>2</sub>-JACKETED DEWAR\*

LHe Capacity: 68 l  
 Static Boil-off w/Probe:  $< 3$  l/day  
 Max. Hold Time: 3 weeks  
 LN<sub>2</sub> Capacity: 48 l  
 Static Boil-off w/Probe:  $< 2$  l/day

\*7 & 9T longitudinal systems only



Different PPMS application inserts. From left to right: Helium-3, Horizontal Rotator, and ACMS.

All measurement capabilities mentioned in this brochure are available for any PPMS system.

All Quantum Design products are covered by a 1-year warranty.

Specifications subject to change without notice.

**CONTACT QUANTUM DESIGN FOR FURTHER INFORMATION ON ALL APPLICATIONS.**

**LOOK FOR MORE PPMS CAPABILITIES IN THE FUTURE.**

reliable

**QUANTUM DESIGN  
SUPPORT**



THE PPMS OFFERS THE RELIABILITY AND PRECISION YOU'VE COME TO EXPECT WITH ALL QUANTUM DESIGN PRODUCTS. OUR CUSTOMER SERVICE STAFF CAN HELP YOU EXPLORE THE FULL CAPABILITIES OF THE PPMS AND ANSWER ANY QUESTIONS YOU HAVE ABOUT ITS OPERATION. QUANTUM DESIGN'S STAFF OF PHYSICISTS AND ENGINEERS IS CONSTANTLY RESEARCHING NEW MEASUREMENT APPLICATIONS. PLEASE CONTACT US TO DISCUSS THE PPMS OR ANY OF THE PPMS MEASUREMENT APPLICATIONS. OUR GOAL IS TO HELP YOU PERFORM YOUR RESEARCH MORE EFFECTIVELY.

AT QUANTUM DESIGN, WE'VE CHANGED THE WAY INSTRUMENTS ARE DESIGNED.

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