

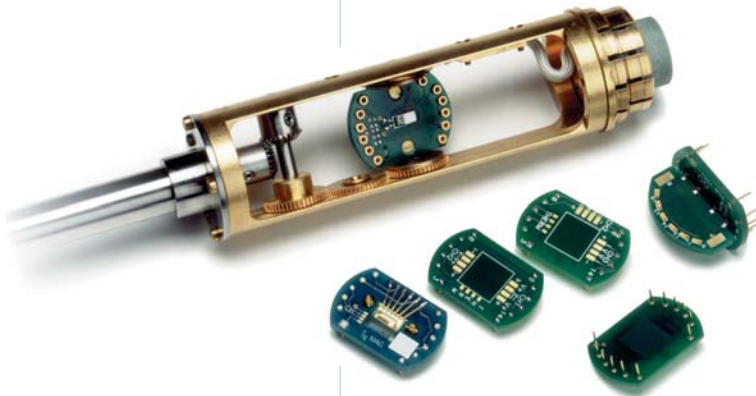
# application note

Quantum Design



## ELECTRO-TRANSPORT

ACCURATE RESULTS COMBINED WITH EASY SAMPLE MOUNTING, WHETHER ON REMOVABLE PUCKS OR PLATFORMS, IS THE THEME OF THE PPMS ELECTRO-TRANSPORT SYSTEM.



### AC RESISTIVITY

The Model P600 AC Transport Measurement System (ACT) supplies four transport property measurement techniques (AC Resistivity, 5-wire AC Hall Effect, I-V Curve, and Critical Current) in a single add-on package. Two independent channels are available to measure multiple samples in a single sequence. To protect delicate samples, software selectable parameters include current, voltage, and power limits. Plus, precision resistors are used to ensure system calibration.

#### AC RESISTIVITY:

Sine wave excitation

Voltage detection utilizes shielded, high-precision electronics and Digital Signal Processor (DSP) technology

Low resistance optimization mode

Calculation of higher harmonic contribution

Electronic phase shift preset into phase of demodulating waveform



#### HALL EFFECT:

Separate balance pot control for each channel

Configurable as 4- or 5-wire measurements

Turn-counting dial enables user to quantify balance changes

Software displays the balancing voltage for improved performance

#### I-V CURVE TRACING:

Discrete current steps avoid the smearing of features

Rejects common environmental noise sources

#### CRITICAL CURRENT:

Smooth current ramping with discrete steps

Ramp rate is automatically optimized

Inductive voltage is subtracted

#### PREAMP SPECIFICATIONS:

Noise: HGA\*: 0.5 nV/√Hz @ 1kHz (typ.), 1 nV/√Hz (maximum)

PGA: 5 nV/√Hz @ 1kHz (typ.), 10 nV/√Hz (maximum)

Voltage Input Range: ± 5 V @ x 1 Gain

Common Mode Rejection:

-120 dB @ 1 kHz for HGA

-100 dB @ 1 kHz for PGA

#### ON-BOARD CALIBRATED RESISTORS:

10 Ω and 1 k Ω

#### CURRENT SOURCE SPECIFICATIONS:

Current Range: 10 μA to 2 A (500 mA continuous operation, pulses to 2 A) (typ.)

For certain applications the current from the AC Transport is limited to protect system wiring from damage and self-heating. The following applications have the associated current limitation:  
p825 Helium-3 System: 20 mA  
P310 Horizontal Rotator: 500 mA  
Frequency Range: DC, 1 Hz to 1 kHz AC

\* HGA – High Gain Amplifier

PGA – Programmable gain Amplifier

# electro-transport

## RESISTANCE SPECIFICATIONS:

Absolute Accuracy: 0.2% (maximum);  
0.03% (typ.) for  $R < 100 \Omega$   
Relative Sensitivity:  $\pm 1 \text{ n}\Omega$  (typ.)

## DC RESISTIVITY

The Model P400, DC Resistivity, provides four channels that you can use for 4-wire resistivity (up to three samples in a single sequence) and van der Pauw measurements.

Drive Type: DC 7.5/8.3 Hz Square wave  
Current Range: 5.0 nA to 5 mA  
Current Step Size: 1% of range or 10 nA  
Current Stability: 0.1% over 6 hours  
from 295 K to 297 K  
Sensitivity: 20 nV (typ.)  
Compliance Voltage: 95 mV  
Maximum Resistance: 4 M $\Omega$   
Precision: 0.01% at 2 readings per sec..  
Detection Stability: 0.1% over 6 hours  
from 295 K to 297 K

## HORIZONTAL AND VERTICAL ROTATORS

The PPMS rotators are designed to measure the angular dependence of electro-transport properties such as resistivity, Hall Effect, I-V characteristics, and critical current.

Samples are mounted on easily removable printed circuit boards. Each board provides gold pads for making up to eight electrical connections to one or two samples in either 4-wire or 5-wire configurations. Various boards are available for different measurements and geometries and are designed to plug into a platform on the rotator for easy sample installation and removal. A nonmagnetic thermome-

ter is incorporated onto the rotator platform and is in direct thermal contact with the installed sample board.

sample Area Size: 8 mm x 9 mm  
sample-mounting area

Two interchangeable stepper motors are available for standard (Model A) and high-resolution (Model B) angular rotation.

**Model P310 A/B, the PPMS Horizontal Sample Rotator** (pictured), uses specially selected materials to minimize magnetic effects. And, it uses sapphire bushings to avoid problems typically encountered during temperature cycling. An index switch on either stepper motor assembly allows physical verification of the position of the motor, allowing for consistent initialization. The base of the rotator is configured with the standard 12-wire PPMS puck interface.

Range:  $-10^\circ$  to  $370^\circ$   
Angular Step Size:  $0.05^\circ$  (P130A);  
 $0.0045^\circ$  (P310B) (typ.)  
Reproducibility:  $<1.0^\circ$  with  $6^\circ$  (typ.)  
backlash  
Speed:  $10^\circ$  per sec. (P310A);  $1^\circ$  per sec.  
(P310B)

**Model P305 A/B, the PPMS Vertical Sample Rotator**, measures the angular dependence of electro-transport properties in a transverse magnetic field. Electrical leads run up the rotator to a connector at the top which mates with the standard PPMS cables. This rotator also allows for easy, non-destructive modification by users. This internal wiring of the rotator can be removed, allowing you to install your own sample-mounting

stages or sample-wiring methods. The sample height within the PPMS sample chamber is also easily adjustable.

Range:  $380^\circ$   
Angular Step Size:  $0.013^\circ$  (P305A);  
 $0.002^\circ$  (P305B)  
Reproducibility:  $<0.2^\circ$  (unidirectional)  
with  $<0.5^\circ$  backlash ( $0.2^\circ$  backlash typ.)  
Speed:  $2.8^\circ$  per sec. (P305A);  $0.25^\circ$  per sec.  
(P305B)

## MODEL P450 A/B/C PPMS MULTI-FUNCTION PROBE

The Multi-function Probe simplifies custom experiments the involve optics, microwaves or extra electrical leads. The eight-faceted probe head provides ample room for electrical or coaxial lead feed-throughs. Plus, the probe head and baffles include three direct axial ports that allow you to instal light pipes, fiber optic cables, or microwave guides.

Three models are available. Model A includes the puck connector and a sample housing at the bottom of the prob, which provide access to the internal PPMS wiring. Samples may be mounted to a plug-in platform assembly which includes a calibrated thermometer. Model B is similar to Model A; however, its sample stage is a standard 16-pin DIP socket. This model does not include a thermometer. Model C does not include the bottom sample housing and puck connector.

*Cause and Effects of Common-Mode Leakage technical bulletin available upon request.*

Quantum Design



WORLD HEADQUARTERS

10307 Pacific Center Court, San Diego, California, USA 92121-3733  
800-289-6996 • 858-481-4400 • fax 858-481-7410  
email: info@qdusa.com • http://www.qdusa.com