Applications Newsletter
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Six Things to Consider when Making Electrical Transport Measurements

1. Choosing the right transport option: QD offers three transport options which all perform resistance (magnetoresistance), Hall effect and I-V curve tracing. QD also makes it easy to integrate outside electronics and control (e.g., using LabVIEW). Here is a brief comparison of our three transport offerings where strong points of each are highlighted:

Option	Number of Channels	Min R [Ω]	Max R [Ω]	Max Current [mA]	Van der Pauw?	Comments
ETO	2	$< \mu\Omega$	10 MΩ	100	NO	AC lock-in; 2-wire resistance 1 MΩ - 5 GΩ
ACT	2	$< \mu\Omega$	20 kΩ	2000	YES	AC lock-in; only on PPMS; optimized for low R samples
Resistivity	3	10 $\mu\Omega$	1 MΩ	5	YES	DC resistance bridge

2. Sample and the puck: Thermally contacted but electrically isolated: The sample needs to be in good thermal contact with the "puck" sample mount so that heat generated in transport measurements can be carried away. However, when using the standard metallic pucks, the sample must be electrically isolated from this ground (the system ground for the dewar). To meet this thermal/electrical challenge for bulk samples, we usually put a thin layer of cigarette paper on the puck and paint both sides with a small amount of 7031 varnish or vacuum grease.

3. Choosing the correct measurement frequency: Our equipment measures the DC resistance of a material, but uses low frequency modulation to improve the signal/noise. The resistance SHOULD not depend on frequency, but you need to prove this by trying different frequencies. Advice:

ACT: often prime values like 17 Hz or 103 Hz are good targets. Avoid line frequency (50 or 60 Hz) and its multiples. Stay above 10 Hz for best amplifier noise performance. For small signal measurements, stay below 100 Hz to avoid inductive cross-talk (see application note 1584-202) and features in 25-35 K region (see below)

ETO: some basic guidelines that will work most of the time:

- Use f ~ 18-21 Hz for ANY 4-wire measurements where gain>= 300 (low resistance samples). Pick a favorite frequency and stick with it! Why is higher frequency needed? There is a servo in gain = 300 stage that will attenuate signals slower than ~5 Hz resulting in hysteresis in I-V and phase shift in resistance measurements. See ETO user manual for more discussion.
- Use f ~ 0.4-0.5 Hz for 4-wire measurements with gain <300 OR any 2-wire measurements (high resistance samples): this avoids RC attenuation effects (C~100 pF per lead in wires)

4. Testing the contacts: Ohmic and low resistance contacts are essential in producing sensible transport data, even for 4-wire measurements. Checking for shorts between sample and system ground (i.e., the puck, see #2 above) is essential and can explain strange noise issues, especially at low temperatures. Sample mounting advice is found in seminars on Pharos here.

5. Small resistance samples and common mode leakthrough: This electronics term is important to understand whenever you are measuring small resistances. Resistance at the current (I+/I-) contacts produces symptoms like residual resistance or negative resistance in superconductors.
Please read application note 1584-201.

6. Features in reported resistance in 25-35 K region: The Inconel feedthrough in the sample chamber can produce an artifact in low level measurements in this temperature region. See application note AR04.