

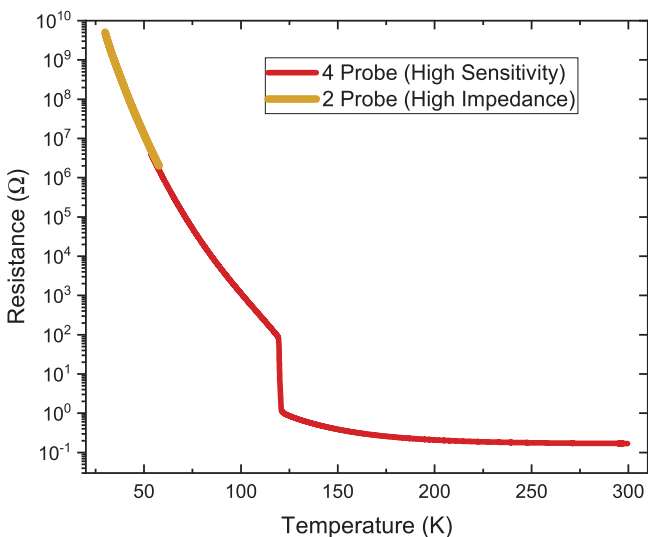
## AC Resistance (ETO)

DynaCool (D605) / PPMS (P605) / VersaLab (V605)

The Electrical Transport Option (ETO) leverages a digital lock-in technique to measure resistance in a traditional Kelvin sensing (4-probe) configuration across a wide dynamic range; this is extended further by the special 2-probe high-impedance mode for a total range spanning nearly fifteen full decades. The two modes feature 8 MΩ of overlap so data can be normalized for a complete curve across both ranges. Additional functions like I-V curve profiling and differential resistance measurements extend the utility of the ETO to non-ohmic materials as well as device characterization and screening.

### Key Features:

- Simultaneous measurement of resistance on up to two channels with phase angle and quadrature voltage reported for diagnostics
- Pre-selected frequencies for channels 1 and 2 prevent cross-talk and maximize signal-to-noise
- Two measurement modes: current sourced in standard 4-probe configuration; voltage sourced in high-impedance 2-probe configuration
- I-V curve collection can be used to screen for ohmic contacts
- Preamp is mounted as close to the electrical access point of the PPMS as possible to minimize degradation of small signals occurring before amplification



Temperature dependence of the resistance of a magnetite ( $\text{Fe}_3\text{O}_4$ ) mineral sample. The high-resistance data is collected using the 2-probe (high impedance) mode, while the rest of the range is covered by the more conventional 4-probe configuration for increased sensitivity. Note that the Verwey transition can be resolved near 120 K.

## Electrical Transport (ETO) Specifications (for zero-field)

(Values refer to the standard 4-probe configuration unless otherwise noted)

### Resistance [R]

Excitation Mode:	AC
Range:	10 $\mu\Omega$ to 10 M $\Omega$ 2 M $\Omega$ to 5 G $\Omega$ (high-impedance 2-probe)
Accuracy*:	$\pm 0.1\%$ typical, $\pm 0.2\%$ maximum; $R < 200$ k $\Omega$ $\pm 0.2\%$ typical; $R \approx 1$ M $\Omega$ $\pm 2.0\%$ typical; $R < 1$ G $\Omega$ (high-impedance) $\pm 5.0\%$ typical; $R = 5$ G $\Omega$ (high-impedance)
Sensitivity:	10 n $\Omega$ RMS typical

### Drive Parameters

Frequency Range:	0.1 to 200 Hz (nominal)
Current Amplitude Range**:	10 nA to 100 mA
Current Amplitude Accuracy:	$\pm 0.4\%$ , 100 nA drive; improves for larger amplitudes
Voltage Amplitude Range:	10 mV to 10 V (high-impedance 2-probe)

**Operational Range** 1.8 to 400 K; 0 to 16 T

\*Accuracy specification depends on sourced current and selected preamp range; stated values describe typical performance for a majority of possible measurement configurations.

\*\*Stated available current range applies to operation at temperatures of 1.8 K and above.

Specifications are subject to change without notice.



ETO Preamp Head