Quantum Design

Application Note 1084-403

Format of AC Transport Measurement Data Files

This document expands on the information in the AC Transport User Manual. Below is a description of the quantities that are reported in the *.DAT file created by the ACT option.

NOTES:

- Some quantities are specific to particular measurements, e.g., Hall effect and critical current, and will only be reported when those measurements are executed.
- In discussion below, "A.C. Measurements" are Resistivity and Hall effect while "D.C. Measurements" are Critical Current and I-V.
- Only channel 1 quantities are discussed below, but the same information applies to channel 2.
- In discussions below on A.C. Measurements:
  - $V_{resistive}$ = measured peak A.C. voltage which is in phase with the applied current, and hence represents resistive properties of the sample.
  - $V_{reactive}$ = measured peak A.C. voltage which is 90 degrees out of phase with the applied current. This is also called the quadrature voltage. **NOTE**: AC Transport does not calibrate this portion of the signal. Emphasis is placed on accurately reporting the in-phase voltage.

1. **Comment :** PPMS text comment.
2. **Time Stamp (sec):** Time stamp from the Model 6000, reported in seconds.
3. **Status (code):** General PPMS status.
4. **Temperature (K):** Average temperature of the PPMS block thermometer during the measurement.
5. **Magnetic Field (Oe):** Average magnetic field during the measurement.
6. **Sample Position (deg):** If using this option in conjunction with either the horizontal or vertical rotator, this value will reflect the position of the rotator motor.
7. **Excitation (mA):** Peak amplitude of the *requested* excitation current. See PPMS Application Note (AC Transport section) 1084-402 for more discussion of the reported vs. the real excitation current.
8. **Frequency (Hz):** Frequency of excitation.
9. **Volts ch1:** In A.C. Measurements, this is equal to $|V_{resistive}|$, the absolute value of the in-phase voltage. **NOTE**: It is always positive in this case! In D.C. Measurements, this is simply the D.C. voltage and can be negative. Units are volts.
10. **V Std.Dev. ch1:** Error bar on the measurement of "Volts ch1". In A.C. Measurements, this is determined by the standard error of the regression of the composite data waveform to a reference sine wave. In D.C. Measurements, it is simply the standard error of the measured D.C. voltage. Units are volts.

11. **Res. ch1 (ohm-cm):** Channel 1 sample resistivity

$$\rho = \frac{V_{resistive}}{I} \times (A/L) \times C$$

where *A/L* is the user-specified ratio of the sample cross-section to voltage lead separation and C is a correction which depends on frequency, amplitude, current range, and voltmeter gain.

12. **Res. Std.Dev. ch1:** Error bar on the measurement of "Res. ch1". See discussion above on "V. Std.Dev. ch1".
13. **Hall ch1 (cm^3/coul):** This is merely the resistivity divided by the magnetic field – one data point is NOT a trustworthy measure of the Hall coefficient due to voltage offsets that are inevitable in Hall measurements. See Appendix C of the ACT User's Manual for more information.

$$HallCh1(cm^3/Coul) = \frac{\rho(\Omega \cdot cm)}{H(Oe)} \times 10^8$$

14. **Hall Std.Dev. ch1:** Error bar on the measurement of "Hall ch1". See discussion above on "V. Std.Dev. ch1". Units are cm^3/C.
15. **Crit.Cur. ch1 (mA):** Critical current as determined by the current at which the voltage crosses the user-input voltage criterion.
16. **C.Cur. Std.Dev. ch1:** Error bar on the measurement of "Crit.Cur. ch1", determined as the standard error obtained by making repeated measurements. Thus, a value is only reported here when the "Measures" value in the measurement dialog is greater than 1.
17. **ACT Status (code):** Indicates errors in ACT measurement; zero indicates no errors were encountered.
18. **ACT Gain:** Total gain which is product of gain in ACT preamp (1,10,100,1000) and ACMS board gain (1,5,25,125). See Chapter 3 of *ACT User's Manual*.
19. **2nd Harm. ch1 (dB):** Magnitude of the 2nd harmonic content (voltage signal at 2*Frequency) in the reported voltage in A.C. Measurements. Phase information is not conveyed. It is expressed in dB relative to the fundamental, so that –20 dB, -40 dB, -60 dB means that the 2f signal is 10x, 100x, 1000x smaller than the fundamental, respectively.
20. **3rd Harm. ch1 (dB):** Similar analysis, but for the 3rd harmonic (3*Frequency) component.
21. **Quad.Error ch1 (ohm-cm-rad):** This is the estimate of the error in the reported resistivity due to the quadrature component of the resistivity. It is defined as $\frac{V_{reactive}}{I} \times (A/L) \times \delta\phi$

where $\delta\phi$ is the tolerance in the phase calibration of the lock-in, typically 0.0017 radians (0.1 degrees). It is a statement of the magnitude of the quadrature signal and expressed in units of the resistivity so that it can be compared directly with "Res. Ch1".

22. **Drive Signal ch1 (V):** Total magnitude of the sample response on channel 1.

$$\sqrt{(V_{resistive})^2 + (V_{reactive})^2}$$

23. **Map 23 ():** Reports user thermometer temperature if rotator is in use.