Performance Study: the Model 370 AC Resistance Bridge with the Model 3708 Preamp/Scanner

The Lake Shore Model 370 AC resistance bridge is a state of the art instrument for measuring resistances ranging from $<10^{-6}$ Ω to $>10^{6}$ Ω. To cover this resistance range with maximum efficiency, several scanner options are available. The standard inputs on the Model 370 with the original 3716S scanner are optimized for measurement of negative temperature coefficient (NTC) resistance temperature sensors to temperatures as low as 10 mK. In this temperature range, the resistance of the sensors are typically 10^{3} Ω or higher. When measuring materials with very low resistances such as superconductors, or the Kondo effect in metals where the resistance diverges as T → 0 K, the measurement can be optimized further for the low resistance range by selecting the appropriate scanner.

The latest scanner option for the Model 370 AC resistance bridge is the Model 3708 8-channel ultra-low resistance preamp/scanner. The Model 3708 input noise is conservatively estimated at 2 nV/√Hz RMS and can achieve measurement resolution to 10 nΩ. It is optimized specifically for low-noise resistance measurements from 100 nΩ to 500 Ω, with total resistance measurement range extending to 2 μΩ. The Model 3708 is a significant improvement over the Model 3716L low resistance scanner, which only limits input noise to 4 nV/√Hz RMS and achieves measurement resolution of 20 nΩ. When combined with the exclusive design attributes of the Lake Shore Model 370 AC resistance bridge, the low noise measurement performance of the Model 3708 has been demonstrated to be equivalent to the low noise measurement performance previously only available with the Linear Research Model LR-700 AC resistance bridge.

To compare the performance of the Lake Shore Model 370 AC resistance bridge with Model 3708 preamp/scanner to the Linear Research Model LR700 AC resistance Bridge, Dr. T. Onimaru and Dr. T. Takabatake of Hiroshima University recorded electrical resistivity measurements for the Kondo lattice antiferromagnet $CePd_5Al_2$. The results, shown in figure 1, are typical of data showing a Kondo effect at low temperatures. The same sample was measured using both the Lake Shore and Linear Research instruments. The resistance range was 2 mΩ, and the excitation current was 10 mA. The data were recorded using filter settings of 1, 3 and 10 s for both instruments and also using no filtering for the Model 370 with 3708. Each scan is offset from the previous scan by 1 μΩ for clarity.

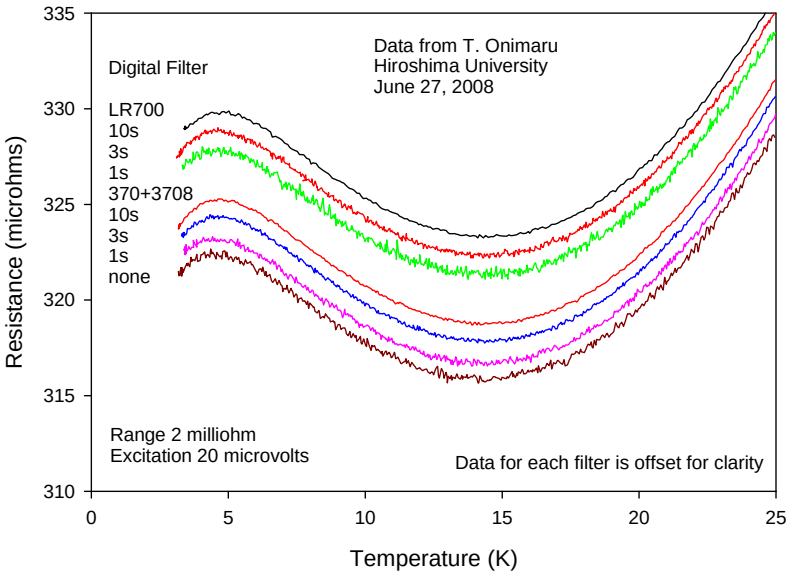

Figure 1: Comparison of Lake Shore Model 370 AC resistance bridge with Model 3708 preamp/scanner and Linear Research Model LR700 AC resistance bridge

From this data the RMS noise in the measurement was estimated, and the results are tabulated in table 1.

	Filter (s)	RMS Noise (μΩ)
Model 370 and Model 3708	None	0.136
	1	0.109
	3	0.073
	10	0.038
	20	0.034
LR700	1	0.163
	3	0.094
	10	0.057

Table 1: Estimated RMS noise from figure 1

The performance of the Model 3708 was also compared against other instruments such as a high sensitivity DC nanovoltmeter and a commercial lock-in amplifier. For this comparison, measurements were conducted on a 0.1 Ω resistor using different excitation currents. The results are summarized in table 2. Note that this measurement was performed on the 200 mΩ range as compared to the 2 mΩ range of the previous data.

	Model 370/3708	DC nanovoltmeter	Commercial lockin
Current (mA)	**RMS noise with 0.1 Ω resistor (μΩ)**		
31	0.2		
10	0.28	0.4	
3	0.4	1.3	1.3

Table 2: Comparison of Model 3708 with DC nanovoltmeter and a commercial lock-in

These results clearly demonstrate that the Model 3708 scanner, coupled with the numerous integrated features of the Model 370 AC resistance bridge, is a very effective instrument for measuring very low resistance materials.

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