Complete, low-cost, software programmable ohmmeter measures micro-ohms

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Numerous applications require the measurement of very low resistances, including but not limited to fuse integrity analysis, relay characterization, and superconductor evaluation. There is a wide range of commercially available equipment designed for this task, but these units are prohibitively expensive and cannot be practically integrated into many applications outside the laboratory. A common low-cost and compact method of measuring resistance is to inject a known dc current into the unknown resistor, measure the resulting voltage and calculate the resistance using Ohm's law. Unfortunately, for very low resistances, the current required to generate a voltage sufficiently distinguishable from the surrounding noise becomes impractically large.

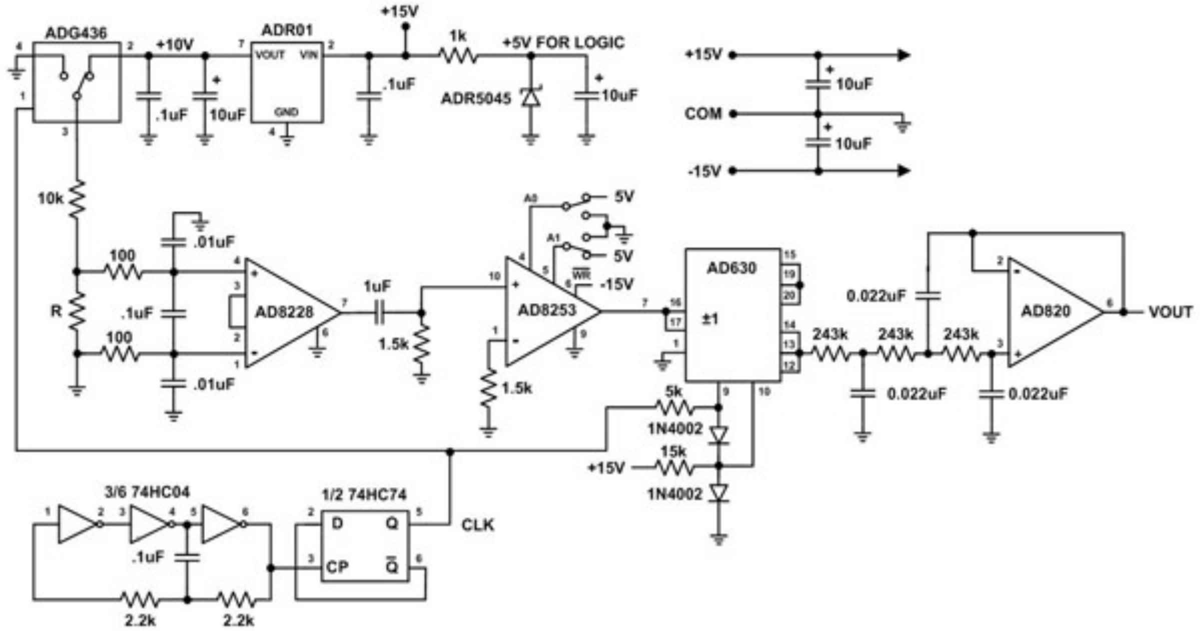

Figure 1 The AD8253 is configured in transparent gain mode, allowing the gain to be manually set by the user according to Table 1.

Figure 1 is a schematic of a complete, low-cost, software-programmable lock-in amplifier designed to measure resistances in the micro-Ohm range. An ac voltage is generated by switching current into the unknown resistance. The 1 mA current pulse is generated by using an analog switch (ADG436) to alternately apply 10V (from the ADR01 precision reference) and ground to the series connection of 10 kΩ and the unknown resistance. The resulting ac voltage, which is imperceptibly small, is then applied to an AD8228 instrumentation amplifier configured in a gain of 100. The low noise of the AD8228 make it well-suited for a first gain stage. Following the AD8228 is an AD8253 software-programmable gain instrumentation amplifier which can be configured in gains of 1, 10, 100, or 1000 depending on the size of the resistance being measured. In **Figure 1**, the AD8253 is configured in transparent gain mode, allowing the gain to be manually set by the user according to **Table 1**. The system gain is extremely stable over temperature due to the low

TABLE 1 LOGIC LEVELS FOR AD8253 TRANSPARENT

WR	A1	A0	GAIN
$-V_S$	LOW	LOW	1
$-V_S$	LOW	HIGH	10

$-V_S$	HIGH	LOW	100
$-V_S$	HIGH	HIGH	1000

gain drift of the AD8228 and AD8253. To extract its amplitude information, a balanced demodulator (AD630) synchronously rectifies the amplified signal. An active three-pole low-pass filter using an AD820 then rejects all out-of-band frequencies, while passing the in-band signal of interest with a transfer function of 50 mV/mΩ at maximum system gain.

The system is completely self-contained, and the user only needs to provide a +/-15V supply. A 1 kHz oscillator, constructed from common low-cost digital ICs, creates the CLK signal that controls the excitation and demodulation sections of the system, where the 5V supply for these ICs is obtained from the 15V rail using an ADR5045 shunt regulator.

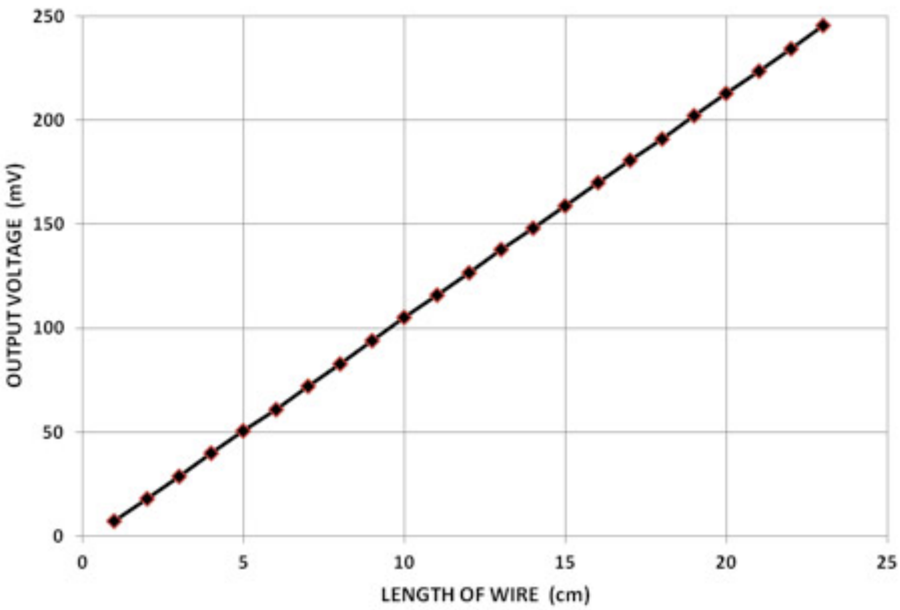

Figure 2 The output voltage of the system for various lengths of 18 AWG copper wire has a resistance of 213.58 μΩ/cm, as measured in the laboratory

The output voltage of the system is linear over the entire range as can be seen above in Figure 2.

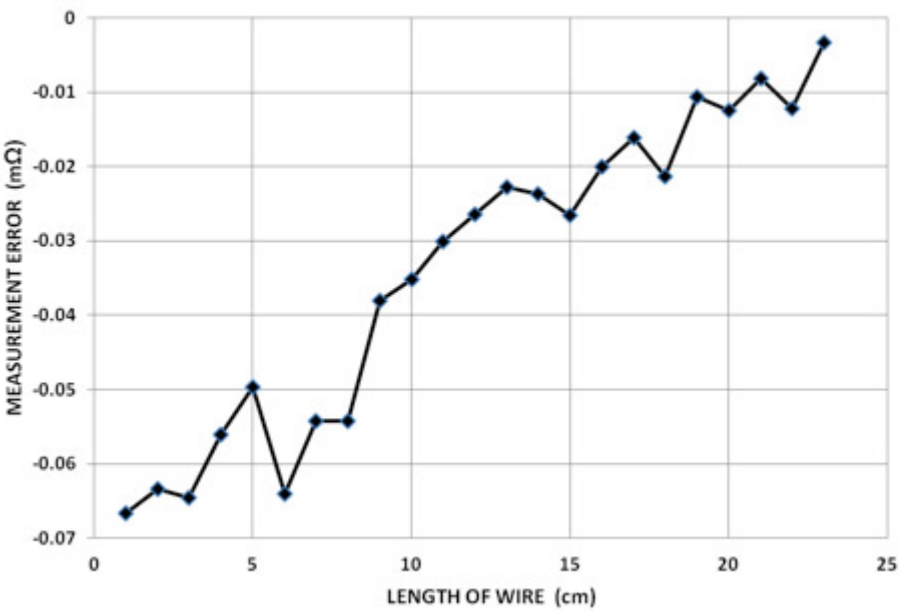

Figure 3 The measurement error of the system, where the noise in the curve is due to the human error in placing the measurement leads, and the slope of the curve is due to a slight system gain error.

The linearity of the system is further demonstrated by **Figure 4**.

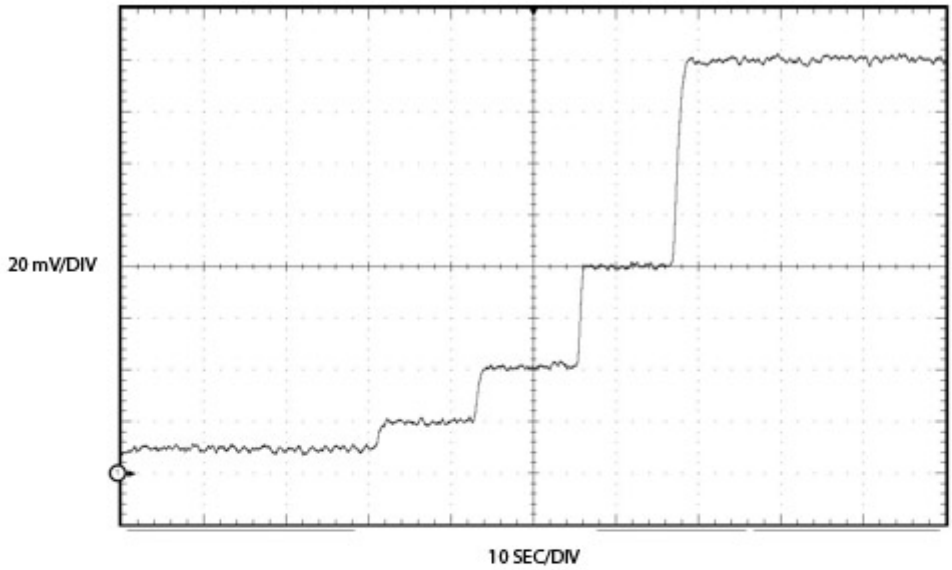

Figure 4 The linearity of the system is demonstrated by the output voltage of the system as the measurement leads are placed across 1, 2, 4, 8, and 16 cm lengths of wire.