Low-cost autoranger scales DVM over four decades

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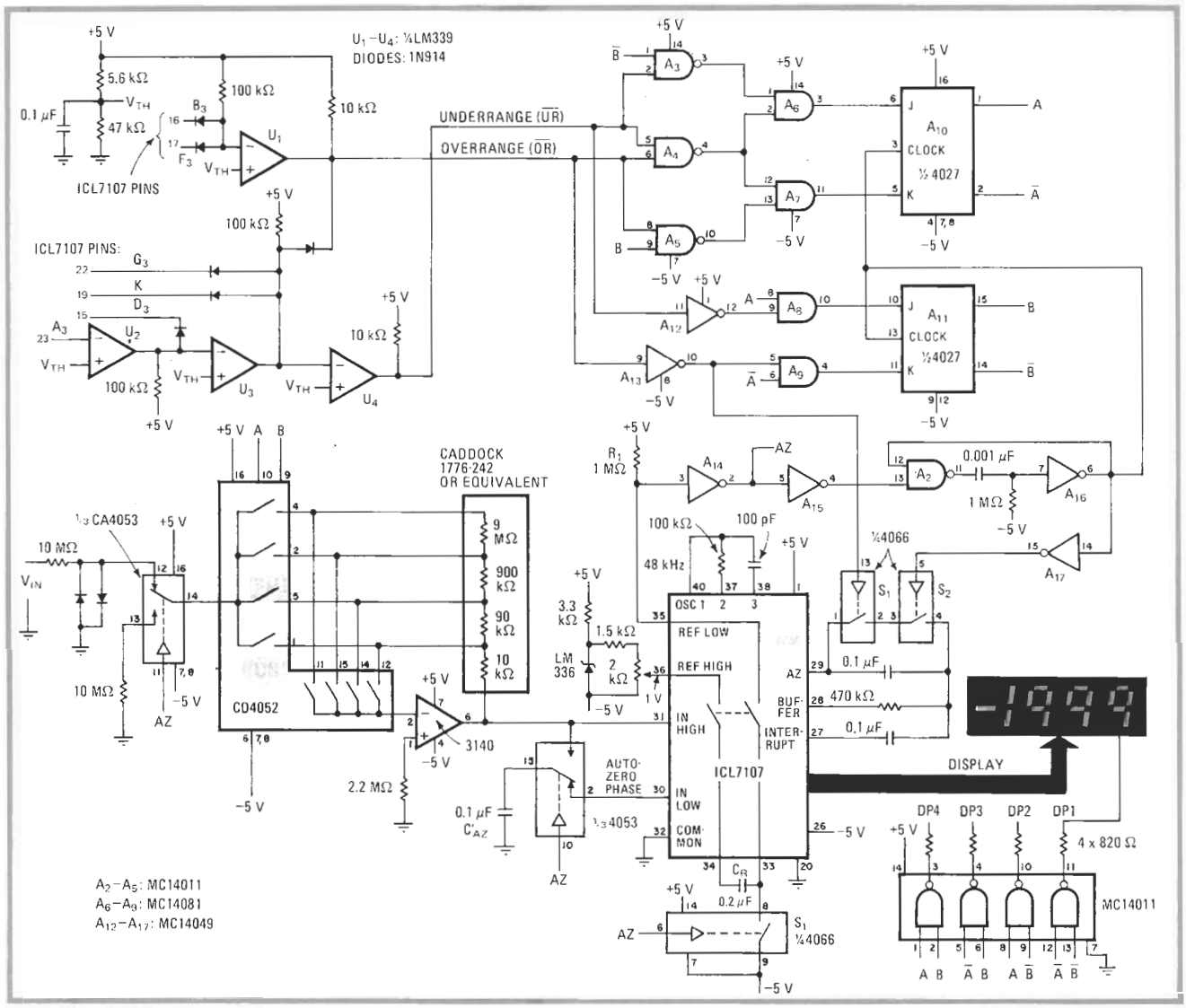
Autoranging capability can be added to a digital voltmeter with this circuit, which costs less than $25. Built around a dual-slope integrating analog-to-digital converter to ensure greatest measurement accuracy, the unit scales a 3½-digit voltmeter over a range of four decades (±1 to ±1,000 volts dc) without the need for complex feedback circuitry.

In operation (see figure), signals to the input are applied to the ICL7107 a-d converter through the range switch formed by the 4052 multiplexer and the attenuator that includes the CA3140 comparator and its accompanying decade resistor network. During each 333-millisecond measurement cycle, the converter proceeds to eliminate the error caused by the comparator's offset (autozero phase), stores the input voltage (integrating phase), and displays the difference, in terms of a voltage, between the integration time and the time required to discharge a reference potential from capacitor C_R (display phase). The autorange circuit (A_3–A_{13}) that follows tracks both underrange and overrange conditions with the aid of a suitable detection circuit. It generates the appropriate signals for controlling the range switch and thus the gain of the attenuation network.

The autorange circuit determines underflow or overflow at the initial portion of the autozero phase. During this time, the voltage on pin 35 of the converter drops momentarily. The drop switches gate A_{14} and thereby closes switch S_1, an action that brings pin 35 to logic 0 and completes the charging cycle for C_R. The rising edge of the AZ signal that clocks the range switch is delayed about 1 millisecond by A_2 and A_{16}, providing sufficient time to stabilize the display and to check for the underrange and overrange conditions.



Searching. DVM autorange circuit uses A_3–A_{14} to detect underflow and overflow conditions by examining the output state of ICL7107 a-d converter, then sets gain of input attenuator network over four decades through 4052 range switch. Circuit cost is under $25.

The range switch is an up-down counter. It will count down one state if an overrange signal is present and up one state if an underrange condition exists, over the binary range 00 to 11. The discharge path provided by switches S_2–S_3 reduces the residual charge on C_{AZ} during the de-integrating phase; otherwise continuous rocking between two adjacent scales may occur.

As for underrange and overrange detection, only one quad comparator need be connected to the ICL7107, as shown at the upper left. Both signals are derived from the converter's seven-segment outputs. Underranging occurs if the displayed number is less than 200; for overrange, the number must be greater than 1,999.

A blank display on digit 3 indicates the overrange condition. A blank output on digit 4 and either a 1 or a 0 on digit 3 signifies underrange. In equation form:

$$\overline{UR} = \overline{\overline{OV} \cdot G_3 \cdot \overline{K} \cdot (\overline{A}_3 + D_3)}$$

where A_3, D_3, and G_3 are the display segments of digit 3 and K is the converter's thousands multiplier. □