Logic gates form high-impedance voltmeter

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You can use the circuit described in this Design Idea to estimate voltages across 10- to 100-MΩ resistances. It also works for reverse-biased diodes.

ESTIMATE THE UNKNOWN VOLTAGE USING A GRAPH OF THRESHOLD VERSUS SUPPLY VOLTAGE.

The common CMOS gates in **Figure 1** have an input threshold voltage in which the output swings from logic zero to logic one, and vice versa. The threshold voltage depends on the supply voltage (**Figure 2**). Because of each CMOS gate's high input impedance, input currents are approximately 0.01 nA. If you apply 5V to 100 MΩ, you get 50 nA. Thus, you can connect the gate input at a point at which it draws a negligible amount of current.

You can vary the CMOS gate's supply voltage to attain the desired threshold voltage for the gate input. If you apply the unknown voltage to one of the gate's inputs and then connect the other input to the positive-voltage supply, you can vary the supply voltage, V_S, until you reach a point at which the threshold voltage at the input becomes equal to the unknown voltage.

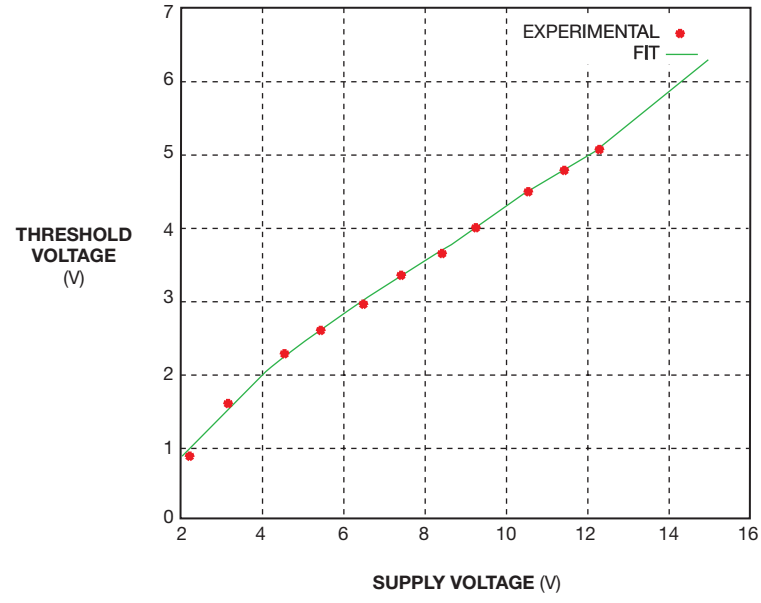
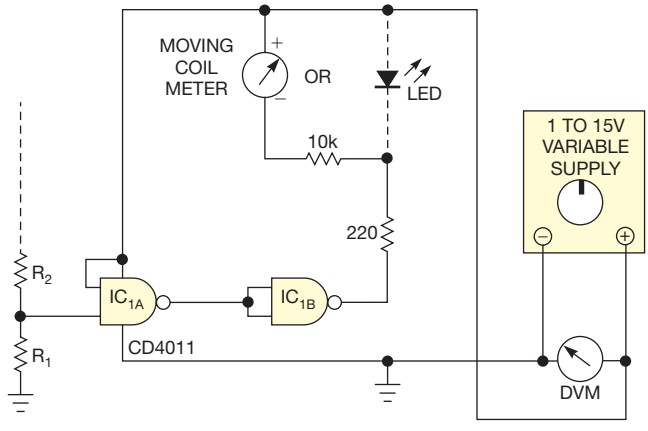


Figure 2 The gate's threshold voltage is nearly linear respective to the power-supply voltage. Download this plot from the online Design Idea at www.edn.com/4368072.



NOTE: R_1 AND R_2 ARE IN TENS OR HUNDREDS OF MEGOHMS.

Figure 1 Use CMOS gates and a variable power supply to find an unknown voltage.

At this point, the output of the sense gate, IC_{1A}, changes from logic zero to logic one. When this event happens, the threshold of the gate passes the unknown voltage. You can estimate the unknown voltage using a graph of threshold voltage versus supply voltage, such as the one in **Figure 2**. By fitting a parabola or a polynomial to the experimentally obtained points—say, some 20 points lying in the supply-voltage range of 2 to 15V—you can estimate the threshold voltage, V_T, for any supply voltage.

This circuit has been built and tested. The online version of this Design Idea includes Octave/Matlab code that you can view at www.edn.com/4368072. EDN