Read isolated digital signals without power drain

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Although optocouplers offer designers a straightforward method of establishing galvanic isolation between circuits that operate at different ground potentials, they do not provide an ideal approach. An optocoupler draws power from the isolated circuit, switches relatively slowly, and loses current-transfer ratio as its light emitter ages.

The circuit in **Figure 1** overcomes these limitations by replicating a digital signal's state, drawing no power from the isolated input, and consuming only modest power on the nonisolated side. As **Figure 2** shows, the circuit imposes only a 20-nsec input-to-output delay from the positive edge of SENSE_CLK to DATA_OUT.

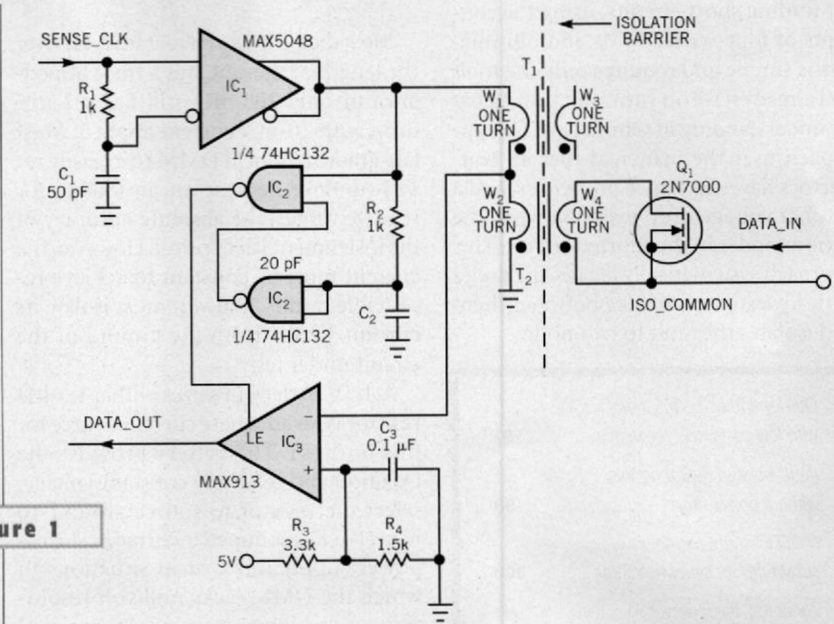

Figure 1

You can use a simple ferrite-bead transformer to isolate logic-level signals.

MOSFET transistor Q_1 operates in either of two states—high resistance between source and drain ($R_{DS/OFF}$), or low resistance ($R_{DS(ON)}$) when a control signal drives Q_1 into conduction. When conducting, Q_1 imposes a low resistance across T_1's secondary winding, W_3. The remainder of the circuit senses the state of T_1's secondary resistance. Resistor R_1, capacitor C_1, and the complementary inputs of MOSFET-driver IC_1 differentiate the SENSE_CLK signal's positive-going input edge, producing a positive-going 5V pulse at IC_1's output and driving one end of winding W_1. **Figure 2** shows the relationship among the circuit's signals.

Connected in series-aiding mode, the two primary windings W_1 and W_2 of T_1

form a 2-to-1 inductive voltage divider whose center tap drives the inverting input of IC_3, a high-speed comparator. With Q_1 off and thus presenting an open circuit across the secondary of T_1, the junction of windings W_1 and W_2 applies a pulse of approximately 2.5V to comparator IC_3's inverting input and drives IC_3's internal state low. Meanwhile, IC_2's two gates, resistor R_2 and capacitor C_2 generate a short strobe pulse in the middle of IC_1's output pulse and applied to IC_3's LE (latch-enable) input.

Latching IC_3's internal state to its external output (DATA_OUT) produces a logic-low output that follows DATA_IN. If DATA_IN goes sufficiently positive to bias Q_1 on, Q_1's low resistance across W_3 reflects a low impedance to windings W_1 and W_2 of T_1. The reduced pulse amplitude at the junction of W_1 and W_2 and IC_3's inverting input of approximately 0.5V is insufficient to trigger IC_3, and IC_3's internal state goes high. The latching pulse at LE forces IC_3's DATA_OUT high, again following the state of DATA_IN.

IC_1, IC_2, and IC_3 operate from a single 5V power supply. Separate bypass capacitors placed adjacent to each device's power pins minimize noise. Resistors R_3 and R_4 set IC_3's trigger-voltage threshold. Transformer T_1 provides a 1-to-1-to-1 turns ratio and comprises a single-hole ferrite bead (Fair-Rite part number 2673000101) with three identical single-turn windings. To minimize stray inductance, keep the connection to the junction of windings W_1, W_2, and IC_1 as short as possible. Also, the grounded end of W_2 should return to IC_1's ground connection.

The circuit's isolation capabilities depend on its pc-board layout and the properties of transformer T_1, whose type 73 ferrite core is moderately conductive. Thus, T_1's isolation properties depend on its windings' insulation. For example, Teflon or Kapton-insulated wire can withstand several kilovolts. If you carefully construct T_1 using the specified core and Teflon-insulated AWG #24 wire, the transformer can exhibit interwinding capacitances of 0.2 pF or less.□

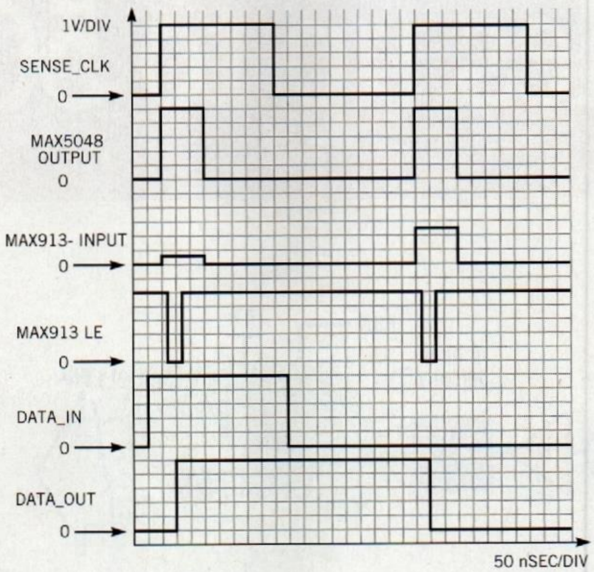

Figure 2 Each positive-going transition of SENSE_CLK transfers the state of the galvanically isolated digital signal at DATA_IN to DATA_OUT.

MOSFET shunt regulator substitutes for series regulator

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You would normally use a series linear regulator or a dc/dc converter to obtain 3V dc from a higher supply. However, when breadboarding a concept, you may be able to use a shunt regulator, especially if a series regulator of the correct voltage is unavailable. The MOSFET in **Figure 1** can replace a zener diode in a shunt regulator and provide lower output impedance than a zener diode.

The MOSFET is self-biased by connecting its drain to its source. The difference between the input voltage and the gate-to-source threshold voltage, V_{GS}, sets the current. The IRF521 in this example has a threshold voltage of 2 to 4V at 250 μA. The upper curve of **Figure 2** shows that the IRF521 achieves a gate-to-source voltage of 3V at a current of about 200 μA. MOSFETs can vary from device to device, but the typical MOSFET has a threshold at approximately the mean between the maximum and the minimum limits.

The lower curve in **Figure 2** is the output impedance, which you obtain from the upper curve by differentiating the upper curve. Although the output impedance, R_{OUT}, is near 800Ω at a current of 100 μA, it rapidly drops to less than 6Ω at 50 mA. Because you operate the MOSFET at or near threshold, its on-resistance spec doesn't apply, and the output impedance of this circuit is far higher than you would expect from the on-resistance. However, in general, the lower the on-resistance, the lower the output impedance at a specific current near threshold.

This circuit may require that R_2 and C_1 stop the oscillation in the MOSFET. Add a filter capacitor to the output to minimize the effect of load transients. Connecting a large filter capacitor from the gate to the source with short leads eliminates the need for R_2. You can use other