

Differential Data Transfer: What's the Difference?

By David Carr

The primary function of an isolator is to pass some form of information across an electrical barrier while preventing current flow. Isolators are constructed from an insulating material that blocks the current flow, with a coupling element on both sides of the barrier. Information is typically encoded before being transmitted across the barrier by the coupling elements.

iCoupler[®] digital isolators from Analog Devices use chip-scale micro-transformers as the coupling element to transfer data across a high quality polyimide insulation barrier. Two primary methods of data transfer have been used in *iCoupler* isolators: single-ended and differential. Selection of a data transfer scheme involves engineering trade-offs to optimize the desired characteristics of the end product.

In a single-ended data transfer, the transformer is utilized with one side of the primary winding grounded. Logic transitions in the input signal are encoded into pulses that are always a positive polarity, with respect to ground, on the transmitter die. This is also referred to as “one pulse two pulse” because a rising edge is encoded as two successive pulses, while a falling edge is represented by a single pulse (see top of Figure 1). The receiver on the other side of the isolation barrier receives the signals and determines if one or two pulses were sent; then, it reconstructs the output accordingly.

Differential data transfer uses the transformer in a truly differential fashion. In this case, a single pulse is always sent when an input edge is detected, but the polarity of the pulse determines if the transition was rising or falling (bottom half of Figure 1). The receiver is truly differential and updates the output based upon the pulse polarity.

One of the main benefits of the single-ended approach is lower current consumption at low data rates. This is because the differential receiver requires more dc bias current than the CMOS Schmitt trigger used in the single-ended receiver. However, the differential approach has lower power at higher throughput rates for two reasons: drive level and number of pulses. The drive level to the transformer can be reduced because the receiver only needs to determine polarity rather than the presence of a single or dual pulse. On average, a single-ended system requires 1.5 pulses per edge, while differential transfer requires one pulse per edge (a 33% reduction).

Reduced drive level and fewer pulses also reduce RF emissions. Emissions are generated when current pulses in the power supplies cause radiation of printed circuit board structures. Since there are fewer pulses, and the energy of each pulse is lower, the resultant RF emissions are dramatically lower.

Differential transfer has two other advantages over single-ended: propagation delay and noise immunity. In the single-ended approach, the single and dual pulses must be created with a specific timing relationship and the receiver must analyze the pulses within a certain time window. These requirements impose constraints on the encoding and decoding that ultimately limit the propagation delay through the device. This, in turn, limits the overall throughput that the part can achieve. The differential approach has fewer constraints since a single pulse is always used, so propagation delays are lower and throughput is higher.

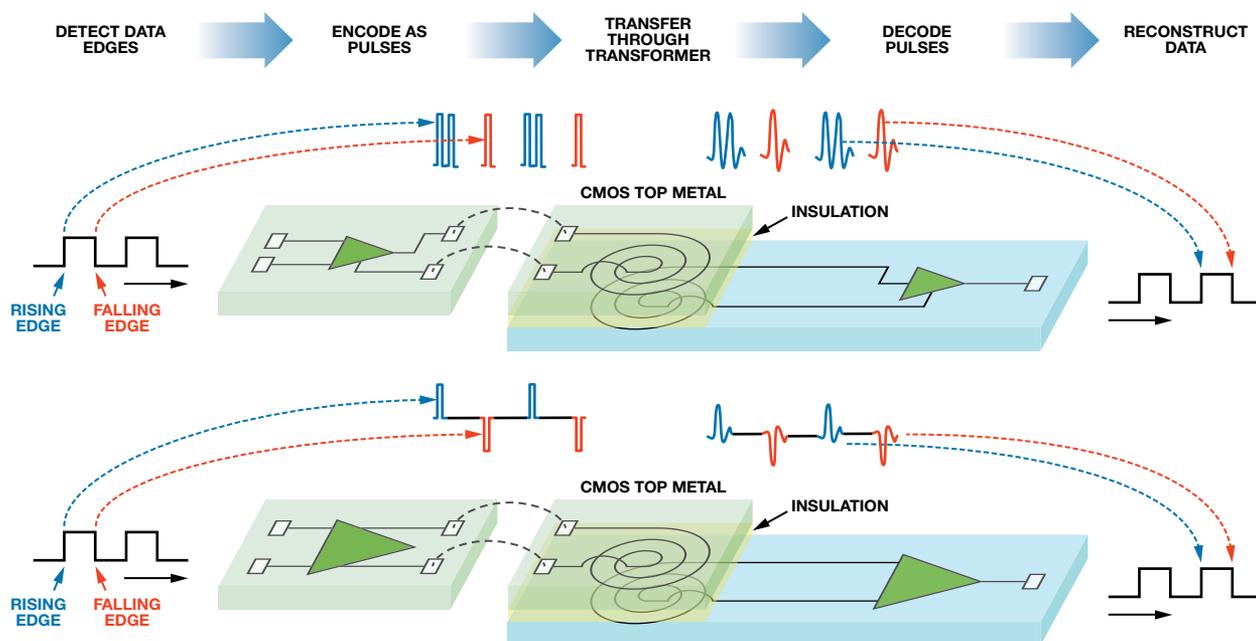


Figure 1. Single-ended vs. differential data transfer.

While the differential receiver reliably detects the differential signals sent by the transmitter, it rejects unwanted common-mode noise typically present in an isolated system, leading to much higher common-mode transient immunity (CMTI). The differential receiver is also less susceptible to power supply noise, leading to higher noise immunity. The LEDs used in optocoupler designs are single-ended in nature, which contributes to the poor CMTI performance generally exhibited by optocouplers. Differential data transfer provides an additional performance boost for *i*Coupler digital isolators over optocouplers.

Data transfer methodology is one option in the designer's toolbox when optimizing digital isolator performance. Having a truly differential coupling element as the basis of *i*Coupler technology provides great flexibility in this regard, which optocouplers and capacitive coupling devices typically can't match.

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