

COMMON-MODE TRANSIENT IMMUNITY

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Common-Mode Transient Immunity (CMTI) is one of three key characteristics associated with isolators such as *iCoupler* digital isolators as well as optocouplers. The other key characteristics are isolation rating and working voltage. This article discusses how ADI measures CMTI for our transformer-based *iCoupler* digital isolators and shows comparisons to competing digital isolators based on capacitors.

CMTI is important because high-slew-rate (high-frequency) transients can corrupt data transmission across the isolation barrier. Understanding and measuring the susceptibility to these transients is critical. The capacitance across the barrier (i.e., between the isolated ground planes) provides the path for these fast transients to cross the isolation barrier and corrupt the output waveform.

Figure (1) shows a typical setup for performing the CMTI test of a 4-channel digital isolator. During CMTI testing, a pulsed transient is applied across the isolated ground planes and the outputs of the device are monitored for data disruptions. The key characteristic of this transient is its slew rate. In the case shown in Figure 1, a transient pulse is applied to the ground on the left-hand side of the isolation barrier while the outputs of the DUT on the right hand side of the barrier are monitored. The CMTI test is performed for both positive and negative transients and is also done with the inputs of the DUT tied both HIGH and LOW.

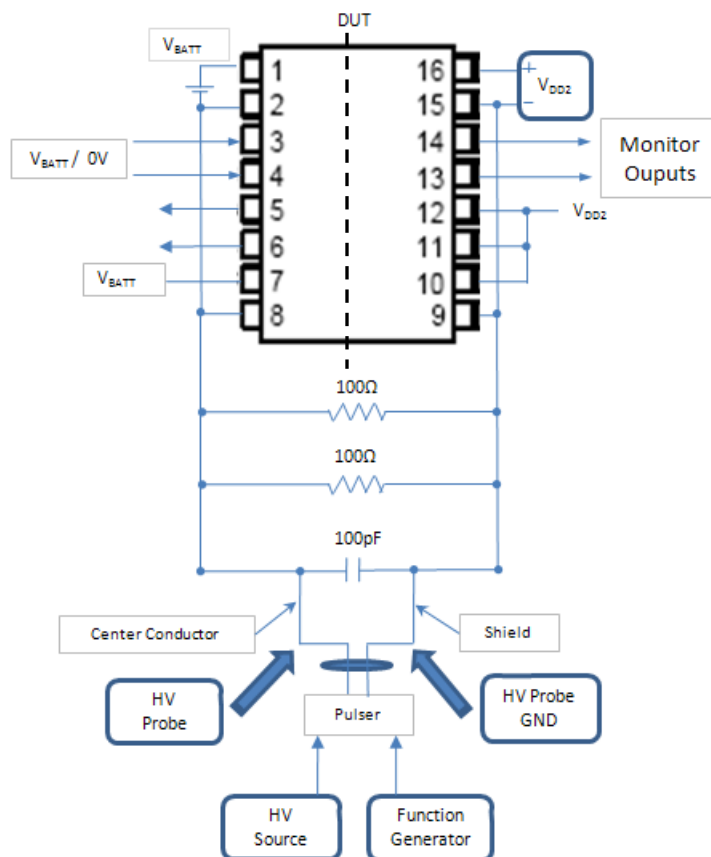


Figure 1 : Typical CMTI Setup of a 4-Channel Digital Isolator

Transformer-Based Isolation vs. Capacitor-Based Isolation

The ADuM1402, 4-channel digital isolator from ADI relies on a transformer based isolation method and uses on-chip, air-core transformers to provide the isolation barrier. The primary and secondary coils are separated by a thick polyimide layer that provides thousands of volts of isolation. Through inductive coupling and a changing magnetic field between the two coils of the transformer, data is transmitted across the isolation barrier.

An alternative to transformer-based isolation employs capacitors for both isolation and data transmission across the isolation barrier. The dielectric material between the capacitor plates acts as the galvanic isolation barrier. Similar to the transformer case, capacitive coupling uses a changing electric field to transmit information across the isolation barrier.

In our testing, we have demonstrated that transformer-based isolation has inherent advantages over capacitor-based isolation with respect to CMTI. As the following table demonstrates, transformer isolation is less sensitive to CMTI.

Test	Transient Polarity	Output State	Transformer Pass Level	Capacitive Pass Level	Transformer Fail Level	Capacitive Fail Level
CM _H	Positive	High	100 kV/μs	9 kV/μs	> 100 kV/μs	10 kV/μs
CM _L	Positive	Low	100 kV/μs	100 kV/μs	> 100 kV/μs	> 100 kV/μs
CM _H	Negative	High	100 kV/μs	18 kV/μs	> 100 kV/μs	20 kV/μs
CM _L	Negative	Low	100 kV/μs	100 kV/μs	> 100 kV/μs	> 100 kV/μs

(All testing performed @ V_{BATT} = V_{DD2} = 4.50V, +25C)

The CM_H test parameter is the maximum common-mode voltage slew rate that can be sustained while still maintaining V_{OUT} > 0.8*V_{DD2}. CM_L is the maximum common-mode voltage slew rate that can be sustained while still maintaining V_{OUT} < 0.8V.

Figure 2 shows a positive going common-mode transient of 10 kV/μs and its adverse effect on the capacitive-based digital isolator when the output state is High (CM_H). Whereas, Figure 3 shows the ADuM1402 is immune to positive common-mode transients as high as 100 kV/μs.

Positive Transients

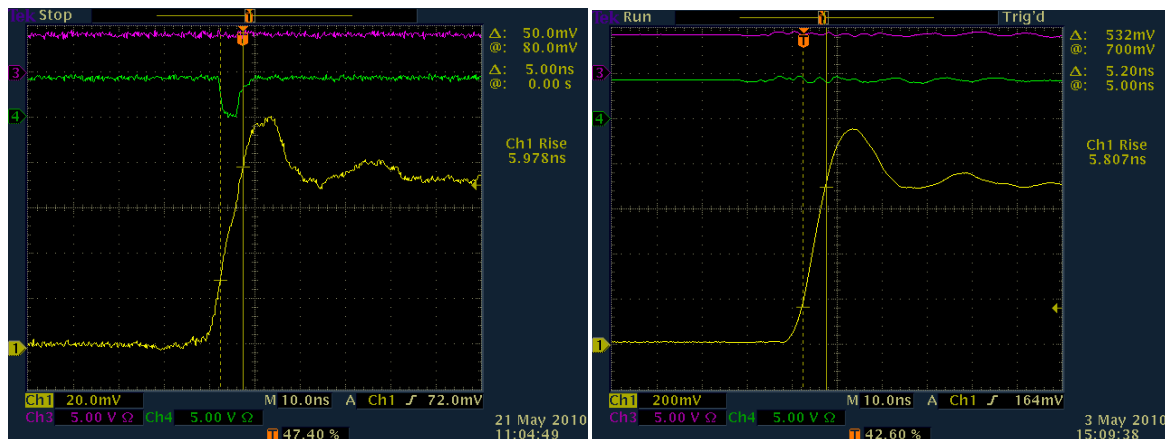


Figure 2 : Capacitive-based isolator $CM_H \sim 10 \text{ kV}/\mu\text{s}$

Figure 3 : ADuM1402, $CM_H \sim 100 \text{ kV}/\mu\text{s}$, V_{OA} , V_{OB}

As is the case for positive going transients, Figure 4 indicates that a capacitive-based digital isolator is also susceptible to negative going common-mode transients when the output state is High (CM_H). However, Figure 5 shows the ADuM1402 is immune to negative common-mode transients as high as 100 $\text{kV}/\mu\text{s}$. *iCoupler* data sheets often specify a guaranteed CMTI level much lower than 100 $\text{kV}/\mu\text{s}$, typically guaranteed to be at least 25 $\text{kV}/\mu\text{s}$; however, this is to ensure that rating over all process and operating conditions.

Negative Transients

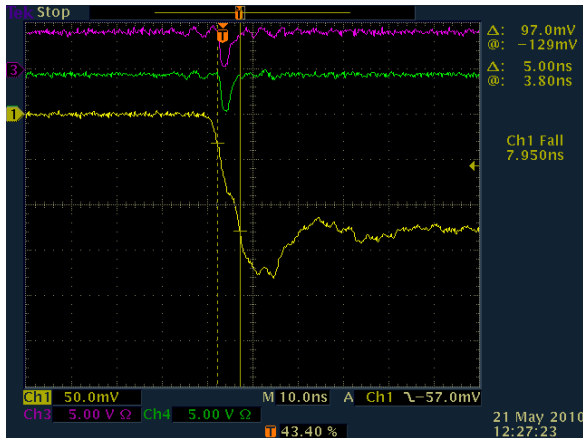


Figure 4 : Capacitive-based isolator $CM_H \sim 20 \text{ kV}/\mu\text{s}$

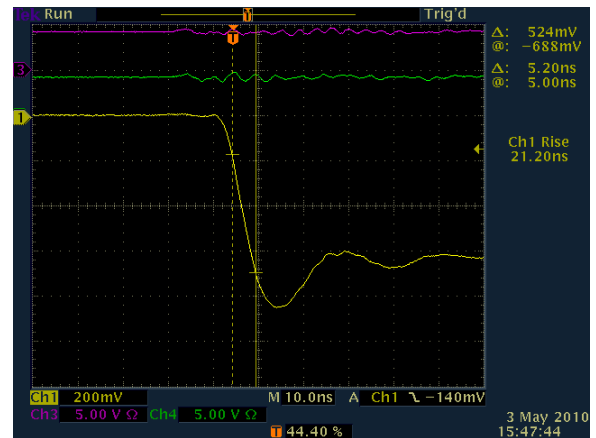


Figure 5 : ADuM1402, $CM_H \sim 100 \text{ kV}/\mu\text{s}$, V_{OA} , V_{OB}

Conclusion

Based on the measurements above, it can be seen that capacitor-based digital isolators may be more susceptible to common-mode transients when their output state is High (CM_H). However, in the case when the output state is Low (CM_L), capacitive-based digital isolators can provide CMTI comparable to that of inductive-based digital isolators. The advantage of inductive coupling is that it provides high common-mode impedance to the noise and low differential impedance to the signal. However, unlike the transformer-based isolator, in the capacitor-based isolator there is no differential signal and the noise and the signal share the same transmission path. Therefore, this requires that the signal frequencies be well above the expected frequency of the noise so that the barrier capacitance presents low impedance to the signal and high impedance to the noise.