Application Brief

How to Design Isolated Digital Input Modules for Surge Immunity

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Introduction: Understanding Typical Surge Protection

Protection against surge events defined by IEC 61000-4-5 is often a key point in the design of digital input modules. TVS diodes exist to help provide protection against such surge events. The ISO121x family is a solution for digital input modules and who's particular configuration and choice of input resistors can offer a base level of surge protection. This level of protection can be taken even further with the implementation of TVS diodes that can protect against surge events of up to 3 kV.

Input Resistor Choice and Configuration: How far will resistors alone take you?

The ISO1212 requires a resistor(R_{THR}) to set the desired input voltage threshold. An additional resistor can be used when the input voltage is expected to exceed 60 V. The two resistors combined form a voltage divider with R_{SHUNT} limiting any inrush current from transients. These resistors alone can accomplish some amount of surge protection. However, the type of resistors makes a significant impact on surge performance.

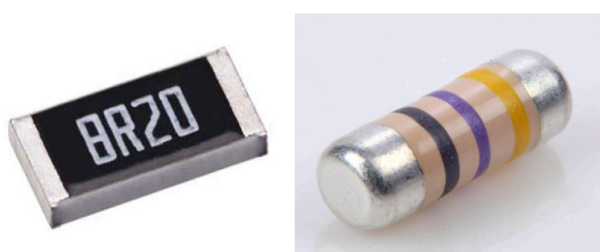

Figure 1. Thin Film Resistor (left) vs Carbon MELF Resistor (right)

Figure 1 above depicts two different types of resistors used in electronics. Metal Thin film resistors are the most commonly used resistors with the widest availability of resistance and power ratings. While these types of resistors can generally satisfy normal operation requirements, they are not suited for handling surge events nearly as well as Metal Electrode Leadless Face (MELF) resistors.

MELF resistors, specifically carbon MELF resistors, are superior in handling surge events in comparison to typical metal thin film resistors. Table 1 below shows their difference in surge performance. Testing was conducted on the ISO1211 EVM without any TVS diodes present.

Table 1. Thin Film Resistor Surge vs Carbon MELF Resistor Surge

		Surge Level (Volts)					
Resistor Type	**Rthr (ohms)**	**500**	**1 k**	**1.5 k**	**2 k**	**2.5 k**	**3k**
Thin Film	2.49 k	√	√	×			
MELF	2.49 k	√	√	√	√	×	
Thin Film	1 k	√	√	×			
MELF	1 k	√	√	√	√	√	×

You can MELF resistors can withstand significantly higher surge voltage. This also highlights how much surge protection one can achieve with resistors alone.

Increasing Surge Protection Even Further: Implementing TVS diodes

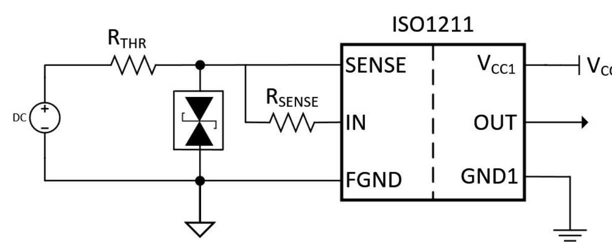

Figure 2. Typical TVS placement on Input

TVS diodes are known as a common way to improve protection against transients. Figure 2 above shows a common way of implementing a TVS diode for the ISO1211. Choosing a TVS component for surge protection requires consideration of the working voltage, clamping voltage, and surge current in order to select the correct device. Finding a suitable TVS diode could present a challenge when operating close to the ISO121x's max input voltage of 60 V.

Table 2. Thin Film Resistor Surge vs Carbon MELF Resistor Surge

			Surge Level (Volts)					
Resistor Type	**Rthr (ohms)**	**TVS Diode**	**500**	**1 k**	**1.5 k**	**2 k**	**2.5 k**	**3k**
Carbon MELF	1 k	GSOT36C	√	√	√	√	√	×
Carbon MELF	1 k	EZJP0V420WM	√	√	√	√	×	
Carbon MELF	2.49 k	EZJP0V420WM	√	√	√	√	√	√
Carbon MELF	1 k	VCAN26A2	√	√	√	√	×	
Carbon MELF	2.49 k	VCAN26A3	√	√	√	√	√	×

Table 1 shows the surge performance of a few different TVS diodes with different values of R_{THR}. We can see that compared to resistors alone, the addition of TVS diodes significantly improves the surge tolerance of the ISO121x solution.

Surge Protection for 60 V Systems: Splitting R_{THR}

60-V systems impose a challenge when selecting a TVS diode with the appropriate clamping voltage that won't interfere with the working voltage. To address this challenge, the idea of splitting R_{THR} into two separate resistors is presented in Figure 3 below.

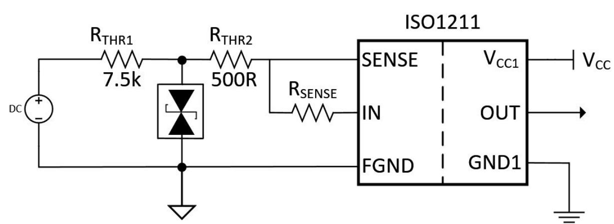

Figure 3. Modified TVS placement on ISO121x Input with Split R_{THR} Configuration

Splitting RTHR into two separate resistors (7.5 k and 500 R) allows for the TVS diode to be placed right in between them. This allows the selected TVS to clamp above 60 V, say 72 V, while still protecting the ISO121x thanks to the voltage drop across the 500 ohm resistor.

Table 3. Test Data of TVS with Split R_{THR} Configuration

				Surge Level (Volts)					
Resistor Type	**Rthr 1(ohms)**	**Rthr 2 (ohms)**	**TVS Diode**	**500**	**1 k**	**1.5 k**	**2 k**	**2.5 k**	**3k**
Thin Film	7.5 k	500 R	None	√	√	√	√	√	×
Thin Film	7.5 k	500 R	SMBJ 45A	√	√	√	√	√	×

Even having a split RTHR using metal thin film resistors and no TVS yields impressive surge performance. The addition of a TVS diode may still add protection for the ISO121x but that doesn't protect RTHR1 from experiencing the large surge current. RTHR1 succumbed to the surge current and strayed from its manufactured resistance.

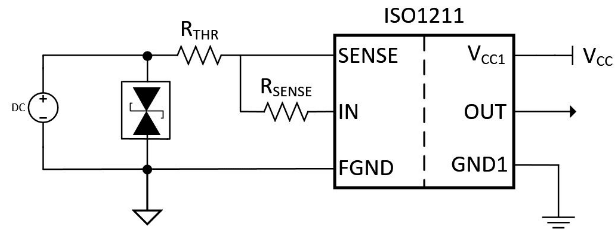

Figure 4. TVS placed on Raw Input

Another possible placement of the TVS diode is directly on the incoming communication line as shown in Figure 3. This option does not have the benefit of a resistor to limit current during a surge event does protect the ISO121x, R_{THR}, and R_{SENSE}. The physical size and ratings of the TVS diode required for this placement will be much larger than the other configurations and will most likely mean a more expensive TVS. Table 1 shows a few example TVS diodes that passed surge testing all the way up to 3 kV.

Table 4. Test Data of TVS on Raw Input

			Surge Level (Volts)					
Resistor Type	**Value(ohms)**	**TVS Diode**	**500**	**1 k**	**1.5 k**	**2 k**	**2.5 k**	**3k**
Thin Film	1 K	SMBJ28CA	√	√	√	√	√	√
Thin Film	1 K	1.5SMC30CA	√	√	√	√	√	√
Thin Film	1 K	SMBJ28CA	√	√	√	√	√	√

Since the TVS diode is the first to experience the surge event, even a thin film resistor easily survives. The TVS diode clamps the surge current to ground well before the resistors or the ISO121x take any damage.

Conclusion:

Protecting your digital inputs from surge events takes some consideration before deciding on both resistor and TVS diode types. Carbon MELF resistors provide superior protection compared to their thin film resistors and the addition of TVS diodes take the protection level to even greater heights. Plan your protection scheme wisely and choose the proper resistor/TVS configuration for your system. For more information visit TI Isolation Homepage.

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