

Application Brief

Protecting I/O modules from surge events



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I/O Modules

In most industrial applications, the system architecture consists of a central PLC that controls and communicates with peripherals like sensors, solenoids, and valves that are stationed all around the environment. The PLC communicates with these through digital signal outputs that are centralized in PLC Modules called I/O Modules. Ensuring the reliability of the I/O modules is critical to maintaining a safe and efficient industrial environment.

Design Challenges for Surge on I/O Modules

- Protection of outputs vs inputs (low impedance vs high impedance)
- Design considerations for clamping voltages variations over temp and devices

What is Surge?

Surge is a transient event that happens when a large energy source is coupled onto an electrical system that causes a large current and voltage spike. This event is defined in IEC61000-4-5 as a short circuit current pulse of 8- μ s rise time and 20- μ s time to half. The amount of surge current varies from what environment the equipment is in and what energy sources can couple onto the lines. I/O modules are used in industrial applications that can have surge events coupled onto them even though they are not directly touching a place that lightning can strike. For more information about the causes of surge check out [Demystifying Surge Protection](#).

What in I/O Modules needs protection?

Input-Output modules have all sorts of circuits that hang off of their lines. For instance, analog input modules are normally fed into comparators which, while they do sometimes have a series resistance that can limit current, during surge events these resistors will have to dissipate a lot of heat causing them to have to be bigger. Another similar example is analog output modules. These outputs can sometimes see large surge transients that can harm the small resistance outputs and especially damage the small internal ESD cells.

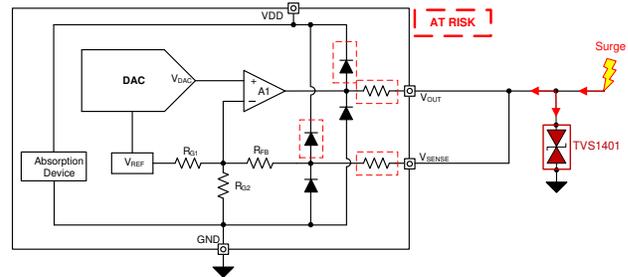


Figure 1. Analog Output Module Components

Digital Output modules need surge protection as their outputs are typically very low impedance. Digital Output modules can consist of power deliver modules like low R_{ON} switches that turn on and off relatively high currents. With these low impedance outputs, typically source of MOSFET, when a surge event is applied the current has a very easy path through the device and can break anything attached. In the figure below, the light red boxes show what is at risk for damage during a surge event.

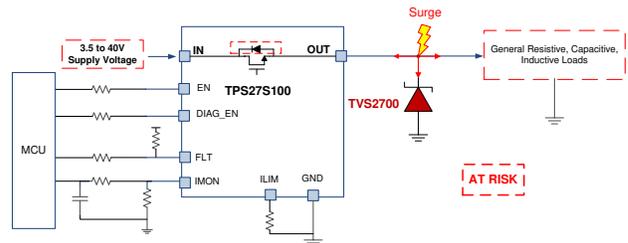


Figure 2. Digital Output Module Components

TI's Flat Clamp

Since these modules need protection, the question is what can TI's Flat Clamp devices offer for their protection? TI's Flat Clamp family of devices offer advantages in the way of clamping voltage, ultra low leakage, and package size.

Many of these I/O modules have absolute maximum voltage ratings that are close to the operating voltage. For instance, the ADS8689 has an input range of ± 12 V with an absolute maximum voltage of ± 20 V. Using TI's Flat Clamp TVS1401, during a typical 1-kV Surge event with 25 A needed to be dissipated, the clamping voltage would be 19.4 V. This is important for insuring the reliability of the input output module.

This is applicable for the entire Flat Clamp family as all of them have extremely low clamping voltage relative to their breakdown voltage. This means they will protect sensitive equipment at any voltage range.

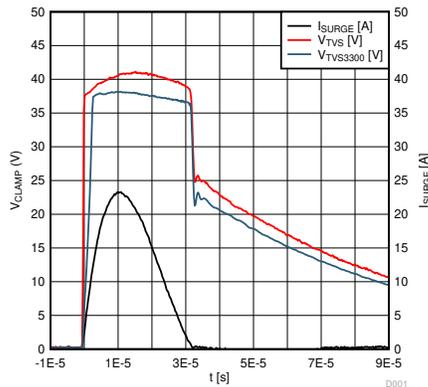


Figure 3. Surge Waveform for TVS3300 vs Conventional TVS

In analog modules, input or output, leakage is extremely important. These modules work by measuring the voltage at a certain pin and any leakage on that pin will change the value being read versus the actual value on the pin. TI's Flat Clamp device such as TVS0500 on analog input pins has a leakage of 0.07-nA versus a typical SMA TVS diode that would have a maximum of 1 to 10 μ A. A difference of up to 6 orders of magnitude.

Many of these modules have very strict constraints on the size of their boards, therefore it is beneficial to have the smallest footprint possible for each component. Using TI's Flat Clamp technology, board designers can get >70% area reduction for the TVS device. Shown below is the comparison of the DBV and DRB packages and the industrial standard SMA and SMB packages. Having these small packages allow the device to be placed closer to the connector. This means the surge pulse will be shunted immediately on the board instead of letting it travel through the PCB trace that could effect the pulse itself.

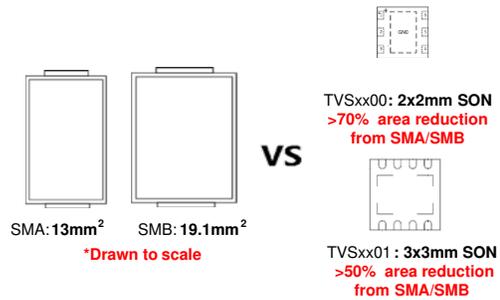


Figure 4. Flat Clamp Package Size Comparison

In conclusion, the environment where the I/O modules are found is susceptible to these surges and can cause serious damage to the system if not properly accounted for. TI's Flat Clamp family of devices can help protect most of the different analog or digital input and output modules from surge events.

Table 1. Alternative Device Recommendations

Device	Description
TVS0500, TVS0701	Unidirectional and Bidirectional Device for Surge Protection of 5-V I/O Modules
TVS1400, TVS1401	Unidirectional and Bidirectional Device for Surge Protection of 12-V I/O Modules
TVS2700, TVS2701	Unidirectional and Bidirectional Device for Surge Protection of 24-V I/O Modules

Table 2. Adjacent Resources

TVS Surge Rating: Power vs. Current	Demystifying Surge Protection Whitepaper
How to Select a Surge Diode	Demystifying Surge Protection Video Series
Flat-Clamp TVS Layout in SMA/SMB Footprint	TVS Surge Protection in High-Temperature Environments

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