Technical White Paper

Upgrading Your Designs With TI's Pin-to-Pin Opto-Emulator Switch: ISOM8610

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ABSTRACT

The last few years have seen a tremendous increase in electrification of systems to increase system performance, modularity and reliability. System modularity and reliability is critical to reduce system downtime, flexibility, design reuse and enabling minimal manual intervention. There are different implementations that enable system configurability using isolated switches, each of which provide different levels of insulation and system ruggedness.

This technical white paper explains various types of isolated switches from mechanical- to light-based switches. The paper covers various challenges over system reliability and lifetime deration while using traditional opto-switches, which can be addressed with TI's isolated switches (ISOMOS). Finally, the paper goes over different application scenarios that use ISOM8610 to enable system configurability and simply system designs to enhance performance.

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Trademarks

1 Introduction

Isolated switches are critical for a wide range of applications that require a part of the circuit to be engaged or disengaged in the signal chain based on a control signal. Some of the applications where isolated switches are used include home automation, factory automation, fleet telematics, semiconductor test boards and so forth. Historically, electromechanical relays have been used to realize isolated switching in circuits.

As the name suggests, electromechanical relays leverage mechanical movements induced by electricity to establish a connect or disconnect. Essentially, a finite control current energizes an electromagnetic coil on the primary side to generate a magnetic field, which in-turn attracts the armature to establish a contact. The electromagnetic coil and contacts are galvanically isolated from one another.

Electromechanical relays do have a good isolation performance, however tend to be bulky as the assembly requires a coil and an armature, power hungry due to large magnetizing current, noisy due to physical movement of relay contacts and chatter prone from debounce during contact establishment. Electromechanical relays have limited lifetime of about 100k cycles for rated loads due to mechanically switching elements and need to be replaced often based on the rate of switching per application.

Reed relays do help reduce the chatter and size to a certain extent, however still have a limited lifetime and are bulky and power hungry.

Another implementation of isolated switching is by using OptoMOS's. OptoMOS is a galvanically isolated, current controlled switch. Epoxy (dielectric) is sandwiched between a Light Emitting Diode (LED) and Photo detector array and two back-to-back FETs as shown in Figure 1-1. Control current is used to turn on the LED, which generates enough light to be detected by the photo detector array. The photodetector array then generates enough voltage to turn on the switch, thereby establishing the contact.

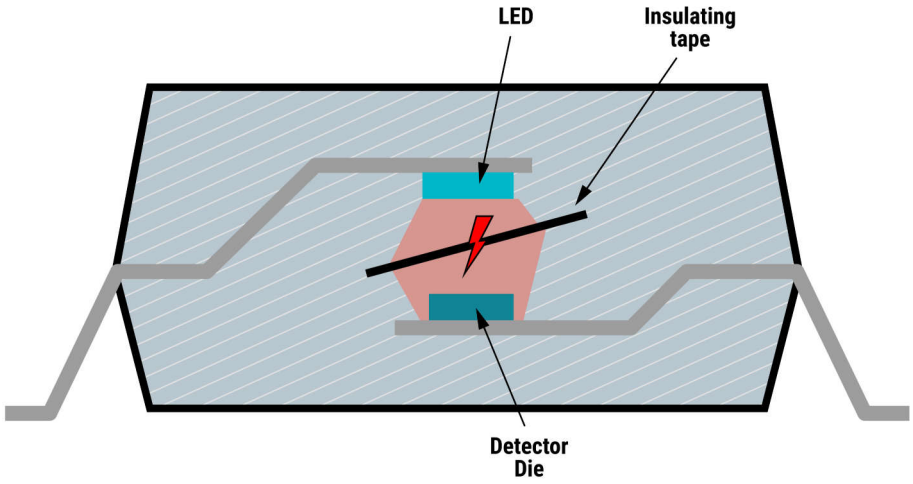

Figure 1-1. Cross-Section of an Opto-Coupler

1.1 OptoMOS Usage and Considerations

OptoMOS's are a great alternative to the earlier isolated switching options. OptoMOS's are compact, generate no noise and have a clean switching without any chatter. However, OptoMOS's tend to have a limited lifetime due to the associated aging of the LEDs over use. This means that one needs to bias the forward LED with higher current to compensate for LED lifetime aging. This factor further increases if the usage is at higher temperatures. As depicted in Figure 1-2, light output within an optically-isolated switch reduces by about 10% across devices after just one year of use. This leads to higher power consumption long-term as the initial bias current needs to be higher to compensate for this degradation.

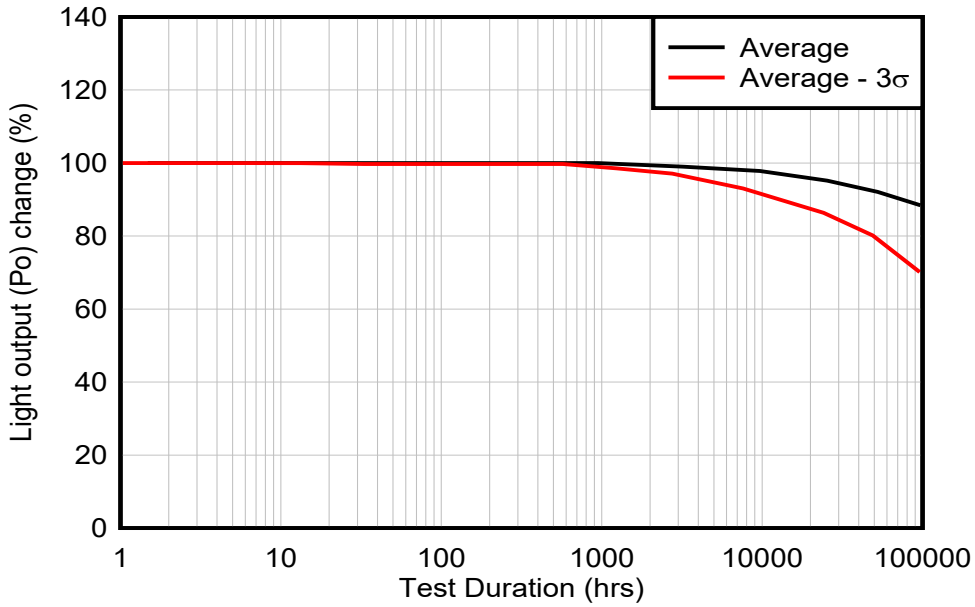

Figure 1-2. LED Deration Over Lifetime Usage (Representational)

TI's Isolated switches (ISOMOS) use Silicon Dioxide (SiO_2)-based isolation with electrical signaling across the barrier for communication, as shown in Figure 1-3. As all the circuits are realized in silicon, there is no associated aging on the circuits. There is no need to compensate for lifetime usage of the device, as one must with traditional LED-based OptoMOS's. This enables easier and cooler designs that work reliably over system lifetime.

	OptoMOS Switches	ISOMOS Switches
Dielectric	Epoxy	Silicon Dioxide
Signaling Scheme	Light based	Electrical
Aging	Some (based on system temperature and bias current)	None
Current consumption over device lifetime	Mid-High	Low

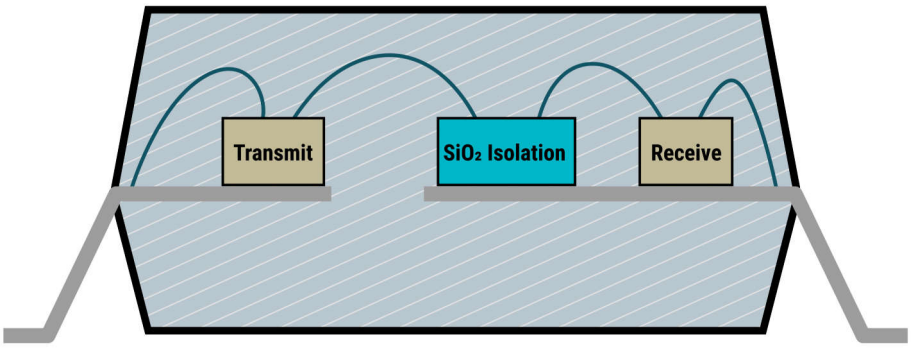

Figure 1-3. Cross Section of an Opto-Emulator

Isolated switches are commonly used in various applications across industrial and automotive sectors where one can safely connect/disconnect a part of the circuit based on a control signal. Some of the key applications for ISOM8610 in different end-equipments like Factory automation, Building automation, and Intrusion alarms are discussed in the following section.

2 Application Use Cases

2.1 Software Controllable Termination on CAN Nodes

ISOMOS enables a software configurable termination on the CAN bus, needed in networks where new nodes can be continually added. This design can enable or disable termination across CANH-CANL by driving TERM high or low with appropriate current limiting series resistor on LED emulator pins via MCU GPIO, as illustrated in Figure 2-1. Farthest terminals on the CAN Bus must be driving TERM = High to enable 120Ω resistor across the bus, while all other nodes drive TERM = Low.

ISOM8610 easily supports ±70V common mode with no distortion of CAN signals on the bus, with minimal loading on the bus with <1uA off-state leakage across temperature at blocking voltage of 70V. With a possibility of multiple nodes being added on the CAN bus, low off-state leakage and capacitance becomes more important for proper system functionality.

Additionally, ISOM8610 also does not require a bulky secondary side isolated power supply, to perform the switching operation. The TERM control is also galvanically isolated from the exposed CAN lines, enabling system protection. With this architecture, 60Ω effective termination across the CAN bus can be achieved with flexibility on enabling or disabling a node, with no hardware change.

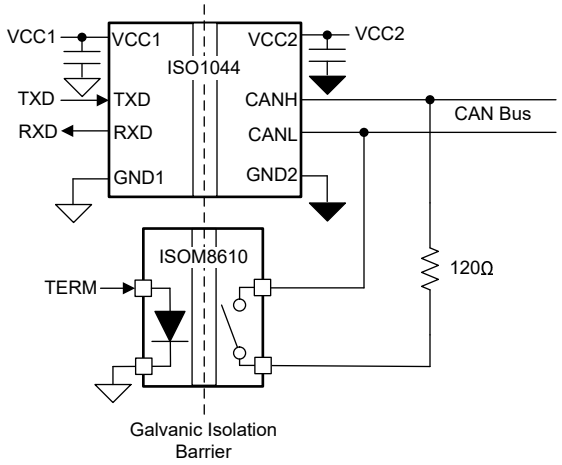

Figure 2-1. ISOM8610 for Software Controllable Switchable Termination on CAN Bus

2.2 Analog Current/Voltage Drivers to Load Isolation in a Programmable Logic Controller

Analog current and voltage output drivers are used to signal 4-20mA current signals or -10V to 10V voltage signals per IEC 61131-2 Industrial process standard. ISOMOS can be employed to achieve output isolation and glitch-free power ups as illustrated in Figure 2-2.

In a normal use case, while forcing analog signals either voltage or current, ISOMOS is enabled by setting V_{EN_SW} = High to establish the path to the load, thereby closing the signal path to load for communication. ISOM8610 supports 150mA on state current, sufficient for analog output signaling.

During scenarios where Drive (DRV) output is disabled, the output for Analog output IC gets tri-stated. Any small change in the driver input couples to the analog output line, sending across an unintended signal to the load. During these scenarios, ISOMOS can be used to truly isolate the load by simply turning off the LED emulator input by setting V_{EN_SW} = Low. ISOMOS output stage when OFF has a blocking voltage of 70V, which can easily support the signal common mode in analog output modules.

Additionally, ISOM8610 supports 3750Vrms isolation rating, an excellent choice for realizing analog voltage/ current outputs with load isolation, with control signals on the cold side.

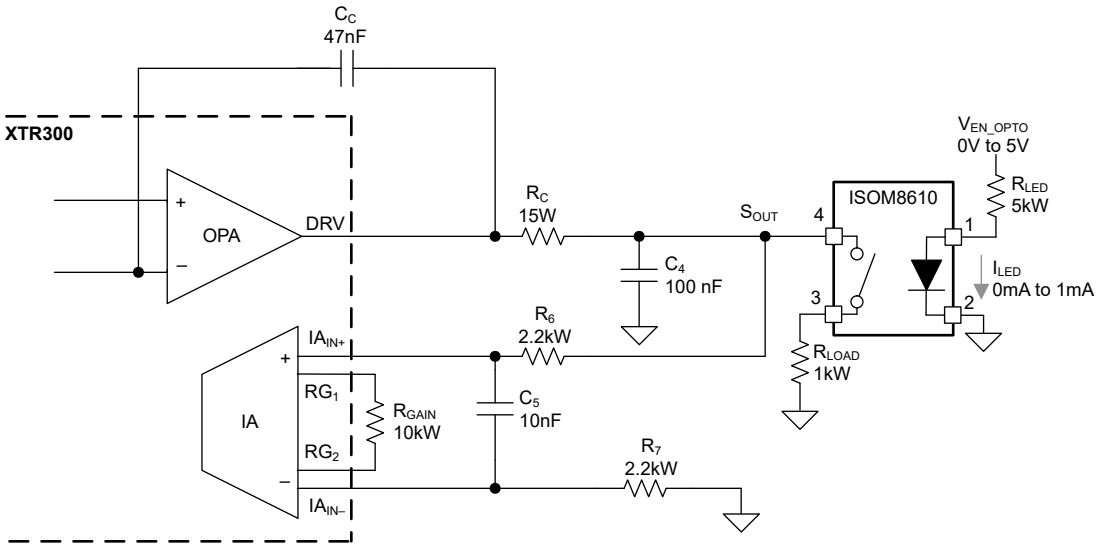

Figure 2-2. ISOM8610 for Analog Voltage/Current Driver Output Isolation

2.3 Channel to Channel Isolated Universal Analog Input Module

A universal analog input module can accept either an analog voltage or a current input. This enables real-time analog input configurability and unified hardware development for different analog input conditions. Multiple measurement modes supported in an RTD 4-wire scenario can be internally switched using ISOMOS. Each path is individually controllable using GPIO signal from MCU, or using a GPIO expander to reduce the number of control signals needed for exclusive configurability for multi-channel designs. Figure 2-3 illustrates the architecture for a channel to channel isolated analog input module using ISOM8610.

In the proposed architecture, each differential pair gets sampled serially. Each input pair can be sampled individually by setting the control signals for the corresponding ISOMOS pair to High. During this time, the control signals for the rest of the pairs are set to Low. ISOM8610 supports blocking voltage of up to 70V without a secondary side isolated high voltage supply to enable robust channel-to-channel isolated designs.

For voltage inputs, ISOM8610 on state resistance of 7Ω (typ.) comes in series with the input impedance of the measuring ADC, with input impedance generally >100MΩ, minimally impacting the measurement accuracy. Once the digitization for the pair is complete, the switch pair is turned off, and the next pair is turned on. ISOM8610 offers best in class switching performance of turn-on and turn-off time of < 200µs, enabling faster switching. ISOM8610 offers galvanic isolation across the barrier, which protects the sensitive circuitry like the MCU from the noisy field side.

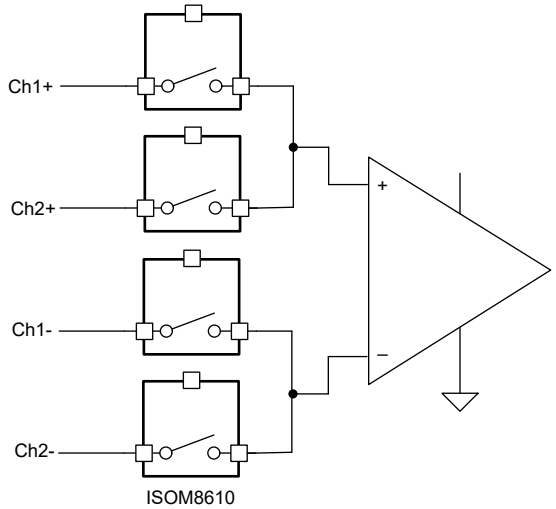

Figure 2-3. ISOM8610 for Channel to Channel Isolated Analog Voltage Input Module

2.4 Switching Precision Burden Resistor in Universal Analog Input Modules

In continuation to the above usage, ISOMOS can also be used to set or un-set the precision burden resistor that can range between 50Ω to 250Ω as shown in Figure 2-4. As the front end typically accepts voltage input, 4-20mA current input needs to be converted into voltage for post processing. For this reason, a precision burden resistor is used to convert the 4-20mA current signal to a proportional voltage that is fed to the ADC input.

When ISOMOS is closed by setting it's corresponding control signal to High, the particular channel is in current input mode, otherwise in voltage input mode. In current input mode, ISOM8610 comes in series with the precision burden resistor and introduces variable resistance over temperature. Therefore, care must be taken to eliminate the variation by assigning an extra ADC channel to sense voltage across the burden resistor, which eliminates variable drop across the switch. If the number of ADC channels are limited, one can also eliminate the on-state resistance of ISOM8610 by compensating the voltage reading with $R_{ONDrift}$.

In voltage input mode, ISOM8610 is turned off by setting its control input to Low. ISOM8610 independently blocks the incoming analog voltage with ease and does not distort the incoming voltage signal due to minimal leakage of <1µA across temperature.

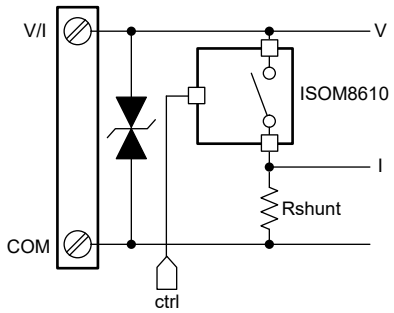

Figure 2-4. ISOM8610 for Switching Burden Resistor in Universal Analog Input Module

2.5 Switch Outputs for Intrusion Detection Systems

Intrusion alarm systems include motion detectors, used to catch intruders or unwanted movement in security systems. These battery powered alarms generally use Passive Infrared (PIR) sensors, which can detect position and motion. The intrusion systems generally have switch outputs, which are terminated using externally configurable end-of-line (EOL) resistors as shown in Figure 2-5.

To signal a motion detected, these modules that usually have a normally-closed outputs, release contact to signal intrusion through signals like Tamper, Alarm and so forth. Traditional normally-open OptoMOS's being used to signal the output alarm state tend to be power hungry as the bias current needs to be compensated for a lifetime of operation across system temperature. This compensation factor can be as high as 3 to 4 times of recommended operating currents.

ISOMOS eliminates the compensation factor as there is no physical LED, and ISOM8610 can be biased with as little as 1.2mA forward current across temperature for lifetime operation. This reduces the current budget for the switches, and in turn extends the lifetime of the battery powered Intrusion detection system.

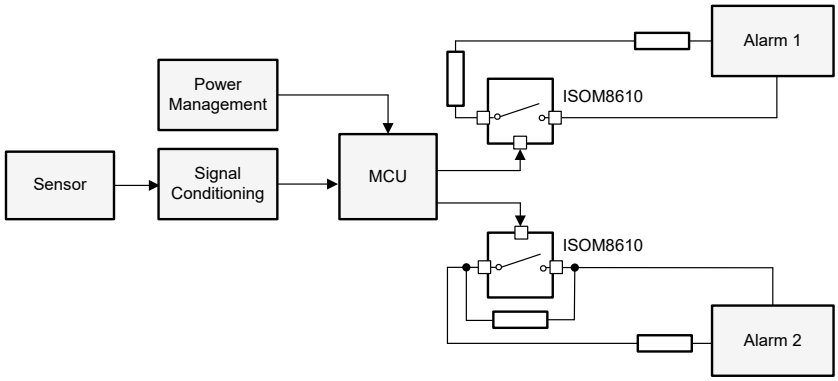

Figure 2-5. ISOM8610 for Switch Outputs in Intrusion Detection Systems

3 Summary

Optocoupler are commonly used in industrial applications to achieve galvanic isolation. Traditional optocouplers use optical based communication using Light-emitting diodes and tend to be power hungry and slow. TI's ISOMOS switches are pin to pin upgrades to traditional OptoMOS, which extend system lifetime and reliability with performance benefits like wider operating temperature and faster switching.

To find the best opto-emulator upgrade to the existing optocouplers used in your designs today, see TI's cross reference search tool!

4 References

- Texas Instruments: *Addressing High-Voltage Design Challenges With Reliable and Affordable Isolation Technologies*
- ISOM8610 product folder and data sheet.
- XTR300 product folder and data sheet.
- ISO1044 product folder and data sheet.
- Texas Instruments: *Replacing Optocouplers With Opto-emulators Product Overview*.
- TI Cross Reference Tool.

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