Reimagining today's isolation solutions for tomorrow's technologies

As today's world of digital electronics and technology progresses, circuit designs keep pushing the boundaries of speed, performance, and reliability. Isolation is one tool that designers use to overcome obstacles created by noise and stability. More specifically, isolation is used to transfer signals or power between two circuits, or two power domains, while preventing current from flowing between them. Typical applications consist of reducing noise or electromagnetic interference (EMI) by removing ground loops, providing protection for low-voltage circuits or human operators from potentially hazardous voltages, and preventing corrupt data causing unsafe conditions in safety- or operation-critical applications.

Indeed, isolation is the key to making a safer, more reliable design, and the CMOS digital isolation portfolio by Silicon Labs offers perhaps the most reliable, flexible, and cost-effective solution to this growing need.

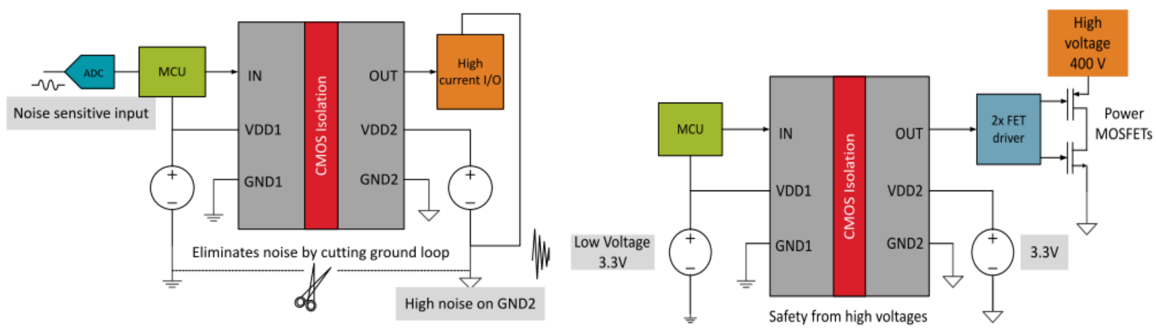

Figure 1: Isolation used for noise/EMI reduction and safety from high voltages[1]

Opto-isolation

Opto-isolation has existed for decades and has been the benchmark isolation method since the 1960s. However, it has its shortcomings, including LED aging over time as well as thermal stress; additionally, there is the issue of inherently low switching rates. Over the years, designs have required special compensation to deal with these issues, such as careful attention to operating life, diode current, ambient temperature, and peak transient currents.

Digital isolation

Digital isolation technology differs from traditional opto-isolation in a number of ways, but the core difference is that it incorporates magnetics or capacitive coupling to transfer the signal instead of LEDs and light-sensitive devices such as phototransistors.

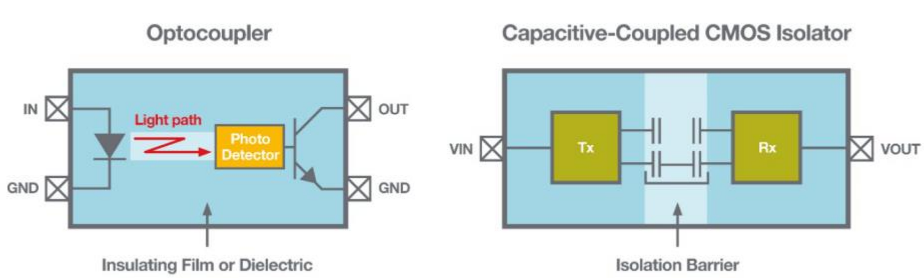

Figure 2: Basic operation of an optocoupler versus a capacitive-coupled CMOS isolator[3]

A digital isolator consists of a transmitter and receiver separated by a differential capacitive isolation barrier, with its output logic state determined by the presence or absence of a high-frequency (HF) carrier instead of light. This isolation barrier can better withstand high-voltage stress and has improved immunity to large, common-mode transients, resulting in higher reliability and data integrity.

Overcome the frustrations of yesterday's solutions

Compared to gallium arsenide (GaAs) processes used in optocouplers, CMOS process technology and construction allows for higher performance and superior timing due to its high rejection of common-mode transients and a narrow receiver pass band providing tight frequency discrimination.[4] The signal isolation path is fully differential from transmitter to receiver, providing maximum common-mode rejection. The receiver's active differential gain causes it to recognize only the difference between its V+ and V– input signals. Any common-mode voltages, such as RF interference or common-mode transients, appear on both the V+ and V– inputs and are cancelled at the differential input,[5] as shown in Figure 3.

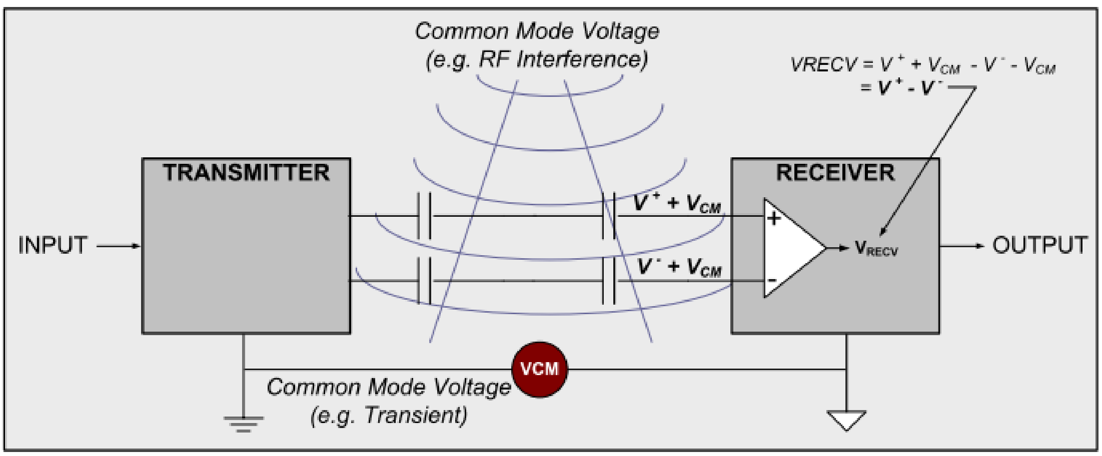

Figure 3: Single-channel representation of CMOS isolator differential signal isolation path[6]

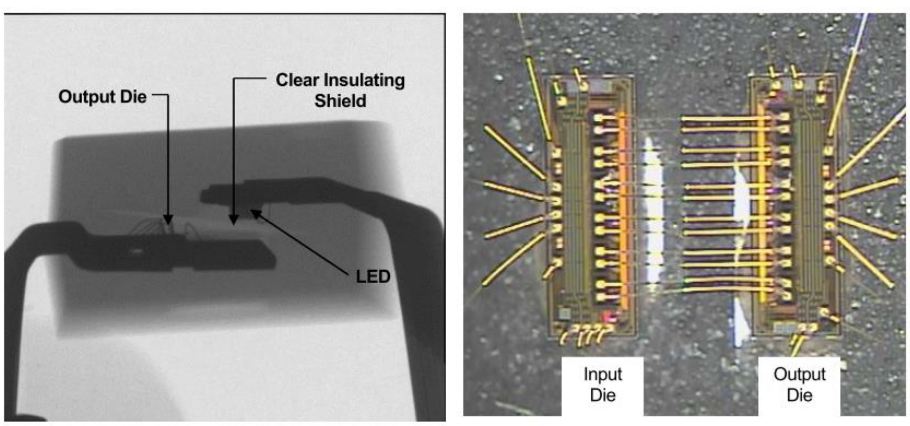

Figure 4: Comparison of an optocoupler assembly (X-ray) and decapsulated CMOS digital isolator[7]

As seen in Figure 4, an optocoupler's cost and physical complexity can increase with channel count, making higher channel count optocouplers more difficult to realize than high channel count CMOS digital isolators. And these die areas are very little compared to the optocoupler, which allows it to be more cost-effective for higher channel count isolators and easier to integrate inside of other semiconductor functions and integrated circuits (ICs) requiring built-in isolation. Multi-channel digital isolators come in a variety of configurations and channel counts and can easily be integrated into chipsets with increased functional capabilities, lower cost, and lower power consumption.

Creating modern solutions for tomorrow's technologies

Three major chipsets from Silicon Labs that offer CMOS digital isolation are Si823x, Si86xx, and Si87xx. If you are looking to replace your previous opto-isolators with digital isolation without the burden of too much design work and printed circuit board (PCB) edits, the Si87xx CMOS digital isolator allows for a direct, pin-compatible replacement that provides significant gains in performance and reliability as well as faster and tighter timing. It provides a convenient drop-in upgrade for designs needing higher reliability and longer service life. Several ordering options exist with a variety of input/output configurations.

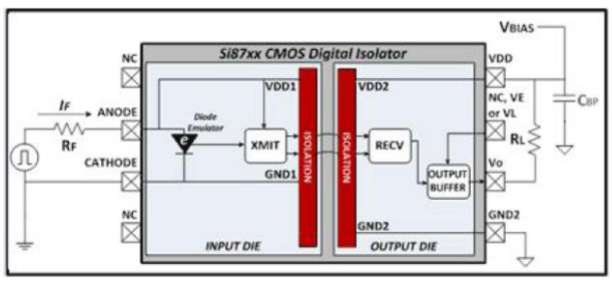

Figure 5: Si87xx optocoupler replacement CMOS digital isolators[9]

The Si823x isolated driver family, meanwhile, consists of a wide variety of dual, independent, high-drive strength drivers in a single package and provides up to 5-kV$_{RMS}$ isolation per UL1577. These drivers have very low propagation times and are ideal for applications requiring gate drive for MOSFETs and IGBTs. The Si8230/1/3/4 chips offer high-side and low-side drivers, while the Si8232/5/7/8 chips include dual drivers. Refer to Application Note AN486 for details on high-side bootstrapping.

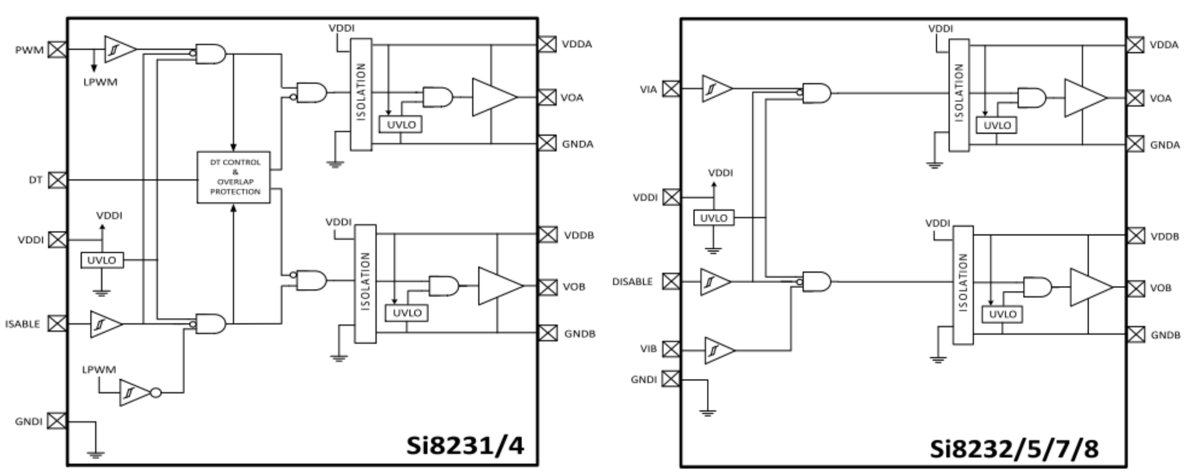

Figure 6: Si823x isolated driver family[10]

Figure 7 shows an example of a high-side/low-side configuration driving a half-bridge interfaced to a DC motor. The isolated FET drivers are an ideal method for low logic levels to interface with high voltage switches. The isolation adds a barrier to protect the sensitive digital domain from noise. Bootstrap circuitry allows AOUT to operate as the high-side driver for the high-side FET whose source varies throughout the switching cycle.

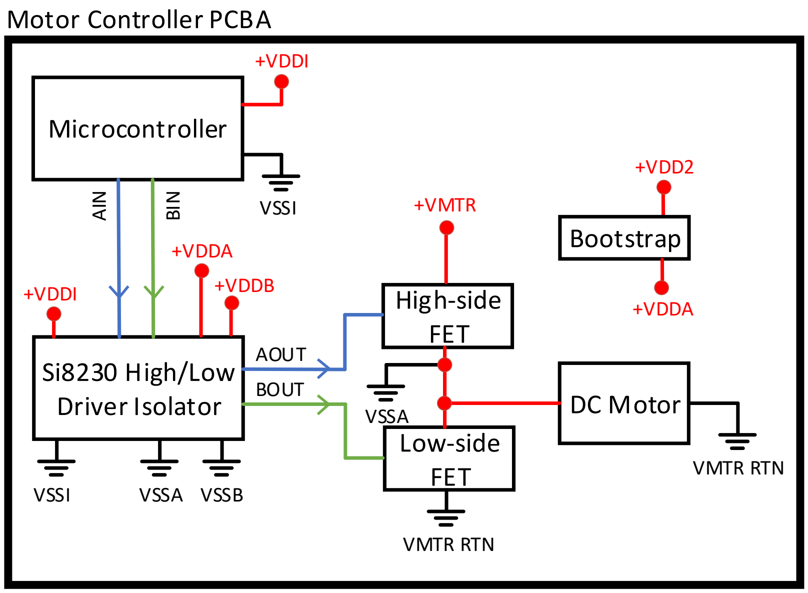

Figure 7: Si8230 DC motor example

The Si86xx family of digital isolators are meant for ultra-low-power and high-density applications needing high data rates and noise immunity. A number of input/output configurations exist with up to six channels, making for an easy integration.

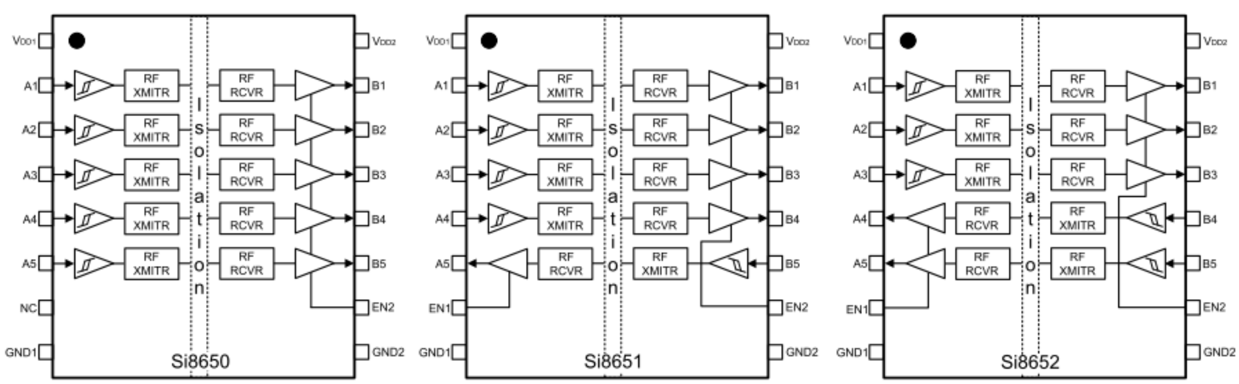

Figure 8: Si865x pin descriptions[11]

Within the Si86xx family are the highly flexible Si860x bidirectional I^{2}C (also called I2C) isolators meant to isolate I^{2}C and SMBus serial ports and also include additional unidirectional channels to support interrupts or resets. This makes it ideal for communications applications sensitive to ground loops, such as Power over Ethernet (PoE), that use an I^2C interface between the PoE power-sourcing equipment (PSE) and the earth-/ground-referenced system controller.[12] Another typical application could be a microcontroller hosting an I^2C or SMBus connected to several slave devices within a system that contains long cable lengths or interfaces that are prone to noise or interference.

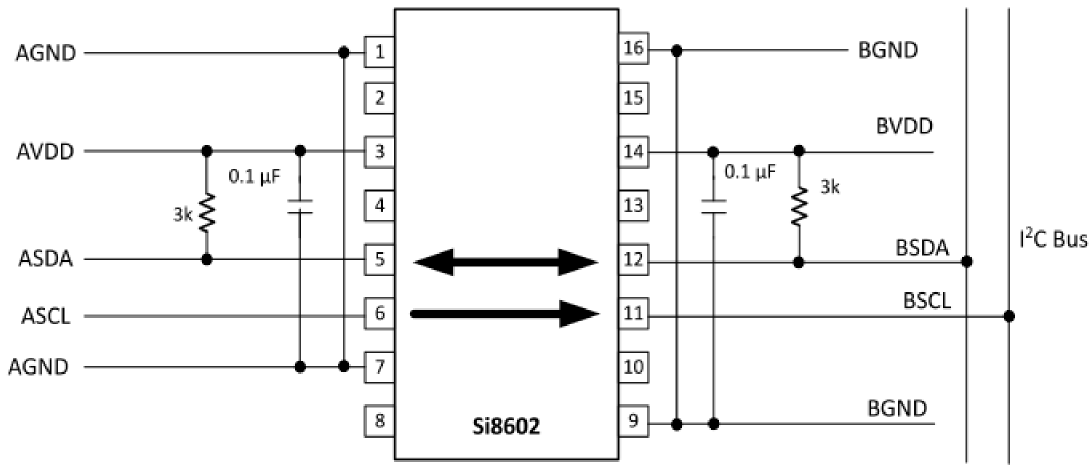

Figure 9: Typical Si8602 application diagram[13]

Figure 10 shows an example of a system interfacing multiple I^2C devices together on a shared bus with isolation at the host printed circuit board assembly (PCBA). Figure 11 shows a system in which a host PCBA interfaces to two external devices, providing an isolated input and output meant for a camera system containing a button and flash.

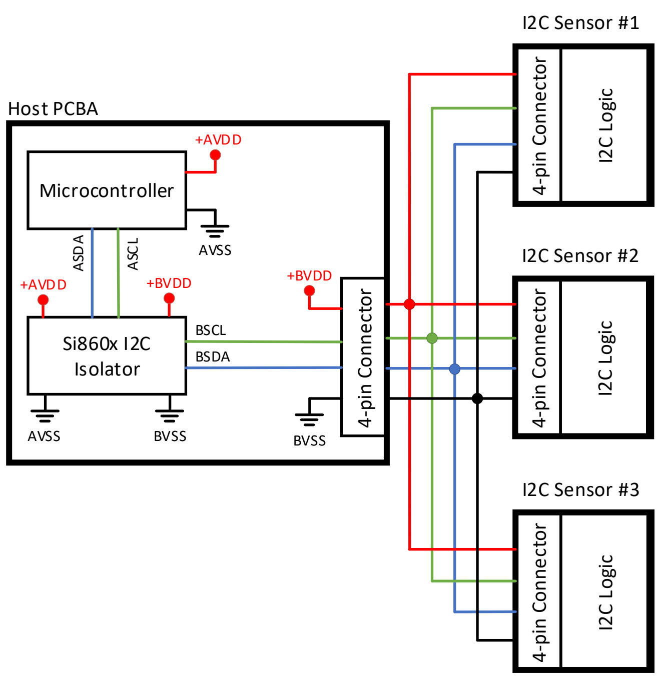

Figure 10: Example of system using I^2C isolation

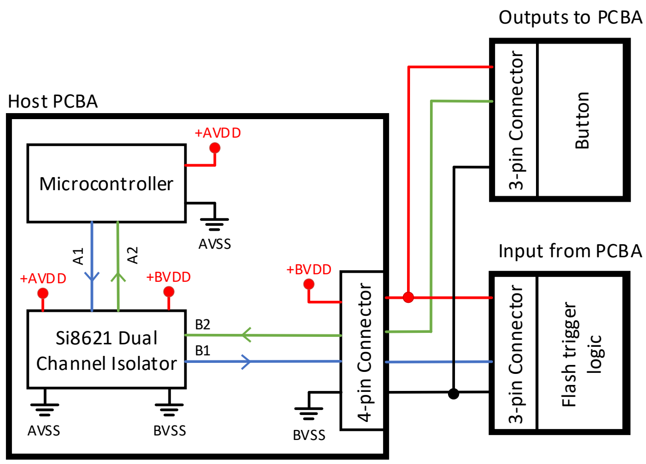

Figure 11: Example of system using input and output isolation

Conclusion

In summary, digital isolation enhances safety margin and reliability, is more compact, can be better-integrated with other chip requiring internal isolation, has better immunity to noise and nearby magnetic fields, and operates at a better efficiency, lower power, and at significantly higher data rates. The CMOS digital isolators offered by Silicon Labs not only allow for easy integration into current product design but also allow for seamless upgrading of older isolation technologies.

References

1: Silicon Labs Application Note AN1167: “Safety Considerations for Silicon Labs Series Capacitor Isolators.”

2,5,6,8: Silicon Labs White Paper: “CMOS Digital Isolators Supersede Optocouplers in Industrial Applications.”

3: Silicon Labs White Paper: “The Benefits of Opto-Coupled and Digital Isolators in Circuit Design Today.”

4,7,9: Silicon Labs White Paper: “Isolator vs. Optocoupler Technology.”

10: Silicon Labs Datasheet: “Si823x Data Sheet.”

11: Silicon Labs Datasheet: “Si8650/51/52/55 Data Sheet.”

12,13: Silicon Labs Datasheet: “Si860x Data Sheet.”