HIGH-SPEED LEVEL SHIFTING USING Si8xxx ISOLATORS

1. Introduction

Voltage level shifting is common in analog and mixed-signal system applications. While several technologies implement level shifting (e.g., HVIC processes, discrete circuits, dedicated level shifting ICs), recent advances in CMOS isolation technology enables fast, reliable, and highly-integrated ICs that are ideal for a broad range of level shifting applications. This application note discusses precision high-speed level shifting techniques using Silicon Labs' Si8xxx Digital isolators and ISOdrivers. Specifically, this application note covers common-mode voltage level shifting, logic threshold voltage level shifting, and gate driver common-mode inversion.

2. Addressing Common Mode Level Shifting

Many industrial applications require measurements of very low-level analog signals from sensors, such as thermo-couples and pressure transducers. These sensors often ride on very high common-mode voltages (VCM) and, as a result, have differential outputs. Typically, an instrumentation amplifier applies differential gain to amplify the sensor output signal (typically <100 mV), amplifying the signal to a level compatible with the analog-to-digital converter (ADC) input range (typically >1 V). Since the digitized signal is typically processed by an earth-ground-based MCU or other controller, galvanic isolation is required between the ADC output and ground-based controller input to prevent the high common-mode voltage from entering low-voltage, ground-based circuitry.

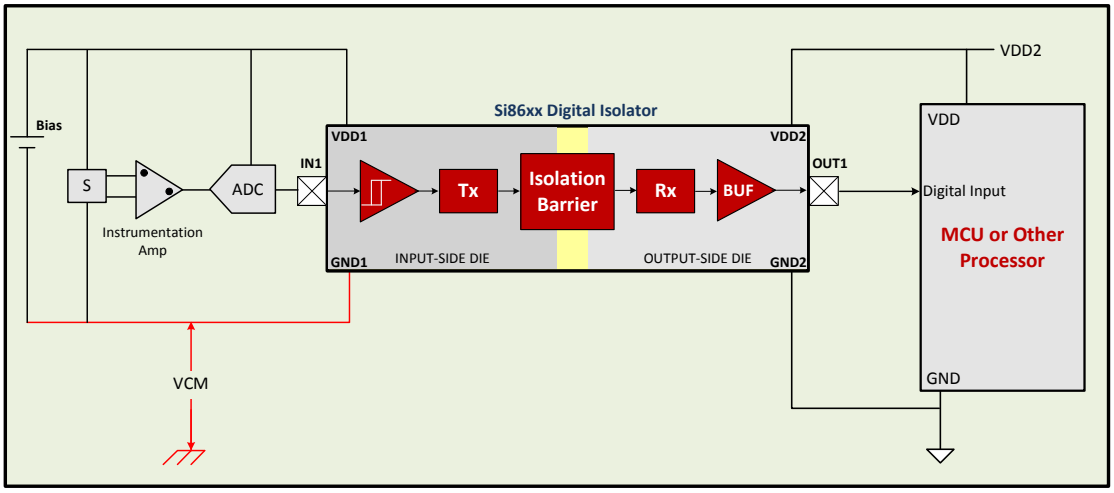


Figure 1. Example Industrial Application

Figure 1 shows a Silicon Labs Si86xx digital isolator providing isolation and level-shifting between an analog data acquisition circuit (riding on a high common-mode voltage) and a ground-referenced controller. The Si86xx isolator operates by enabling its input-side transmitter when IN1 is logic high, causing the transmitter to generate a carrier wave that propagates through the isolation barrier to the output-side receiver. The receiver asserts a logic high on OUT1 when sufficient in-band energy is detected. Conversely, a logic low at IN1 results in no carrier, which, in turn, results in a logic low at OUT1. This simple architecture carries with it industry-leading performance, reliability, power savings, integration, cost effectiveness, and space savings. These isolators are very easy to use; the designer need only choose the isolation working voltage rating, speed, and dc bias. (Note the difference between working voltage and rated voltage; rated voltage is a component-level specification that specifies the isolator's voltage withstand capability at 2500 V_{RMS} or 5000 V_{RMS} for one minute.) In Figure 1, the VCM is 560 V (peak or dc) and is also the working voltage for the system, i.e. the voltage that the barrier must withstand continuously throughout the system's lifetime. As shown in Figure 2, the mean time-to-failure for these isolators at a working voltage of 396 V_{RMS} (560 Vpk) is 60 years.

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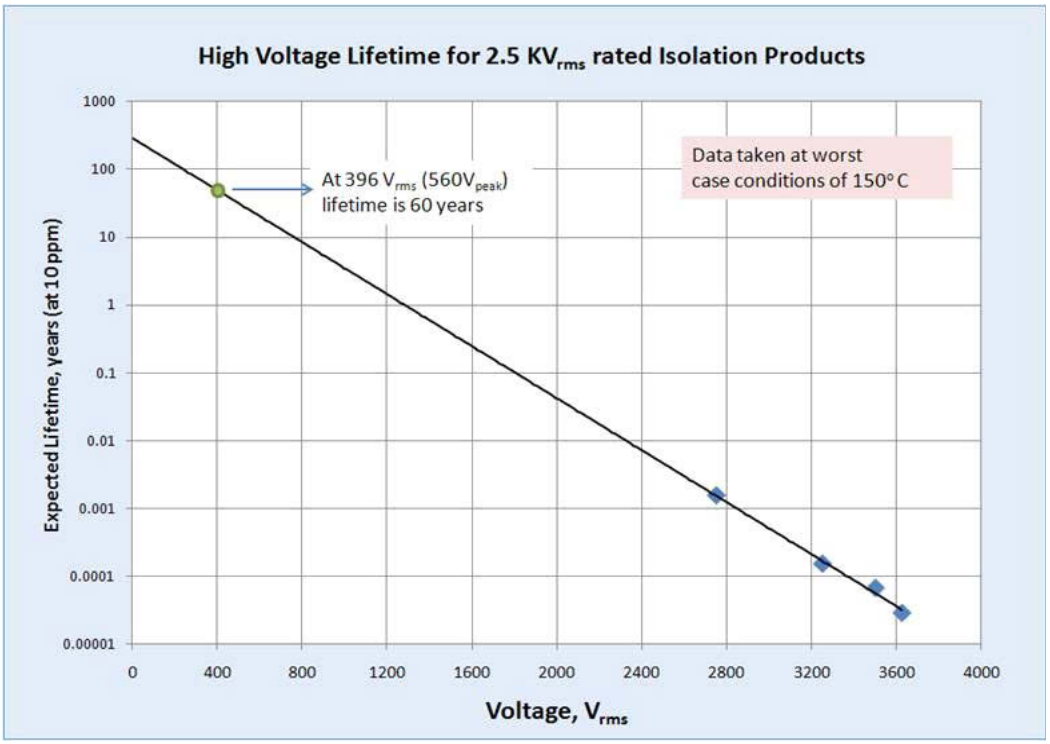


Figure 2. Si84xx Time-Dependent Dielectric Breakdown

3. Logic Level Shifting

To reduce overall system power consumption, many of today's high-speed logic devices (e.g. FPGAs) operate from supplies of 3V or less. Lower bias voltages (and consequently lower logic thresholds) complicate interface with 5 V devices, creating a need for a fast and robust logic level shifter. The “minimalist” approach of Figure 3A provides compatible logic thresholds, but the maximum 4.8 V VOH of the 5 V logic device can negatively impact the performance or damage the 2.5 V logic device. Figure 3B eliminates the over-voltage problem of Figure 3A using an open drain (or open collector) buffer with a pull-up to 2.5 V. While this is a good solution for low-speed logic circuits, the pull-up resistor can significantly slow the rising edge of the output waveform, creating timing problems in high-speed circuits. Figure 3C shows the Si86xx isolator used as a logic threshold level shifter where each side of the isolator is biased to match the local logic rails. Note the common ground on both sides of the isolator since all logic supplies are assumed to be connected to a common ground.

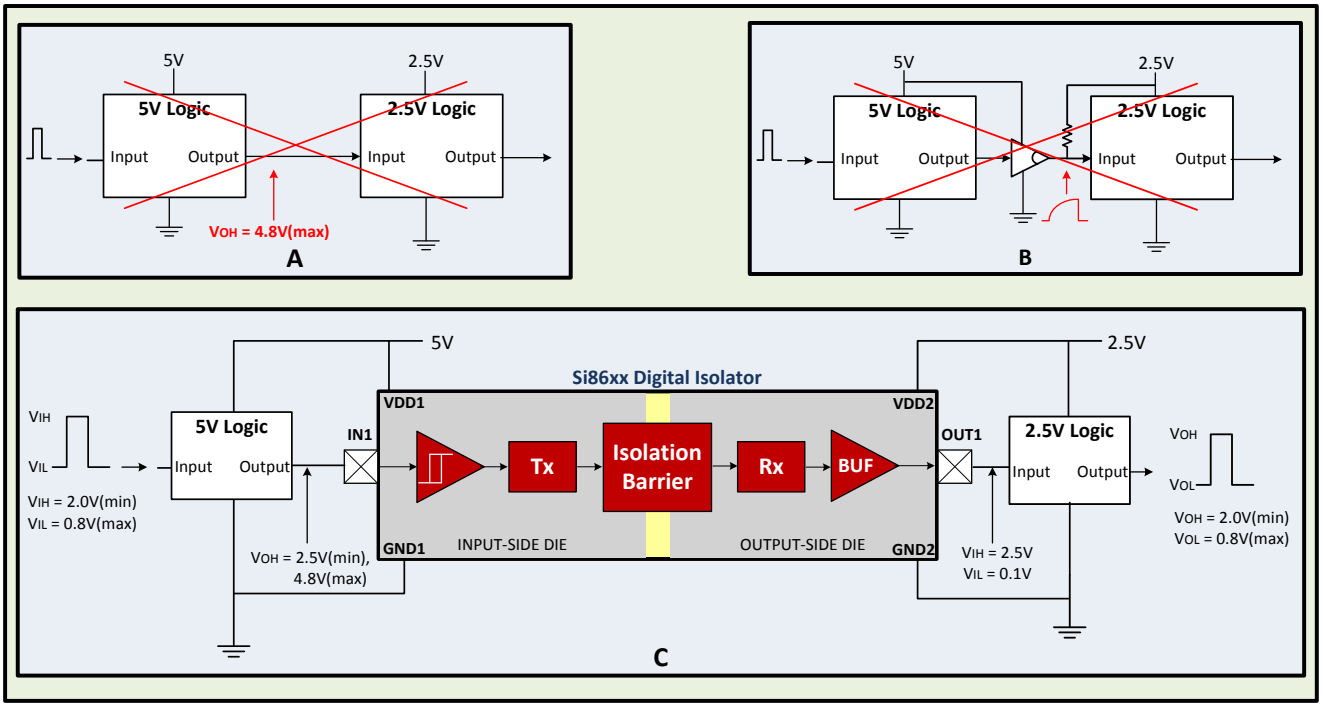


Figure 3. Logic Level Shift Approaches

4. Isolated Gate Driver Common Mode Inversion

The Si823x ISOdrivers are isolated dual 0.5 A and 4.0 A MOSFET/IGBT gate drivers based on the same proprietary Silicon Labs CMOS isolation technology used in the Si86xx digital isolators. ISOdrivers provide up to 5 kVRMS withstand voltage per UL1577 and have fast 60 ns propagation delay time. Their high integration, flexibility, and performance allow these drivers to be used in a number of switch mode power system (SMPS) applications. For more information, please see Silicon Labs application note “AN441: Using the Si8232/5/6 Dual ISODrivers in Power Delivery Systems”. The Dual ISOdrivers have no built-in overlap protection or dead time generator, enabling the state of each driver output to unconditionally follow that of its input as long as both sides of the device are powered. A block diagram of the Si8232/5/6 Dual ISOdriver is shown in Figure 4.

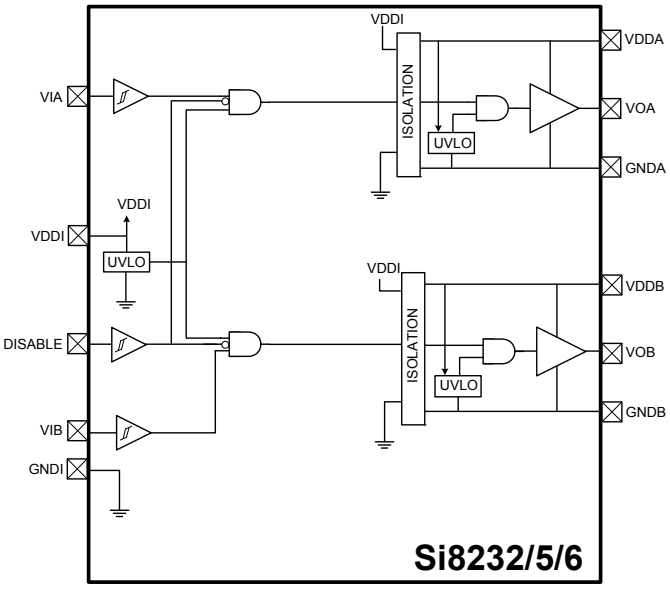


Figure 4. Common Mode Inversion

For example, in a given application, GNDA might have a common-mode voltage of 100 V while GNDB has a common-mode voltage of 200 V. These two common-mode voltages can reverse (i.e., GNDA can change to 200 V, and GNDB can change to 100 V as in Figure 5) without damaging or upsetting the driver. The Si8232/5/6 drivers can therefore be used in dual-low-side, dual-high-side, or high-side/low-side configurations in systems where common-mode voltages vary greatly.

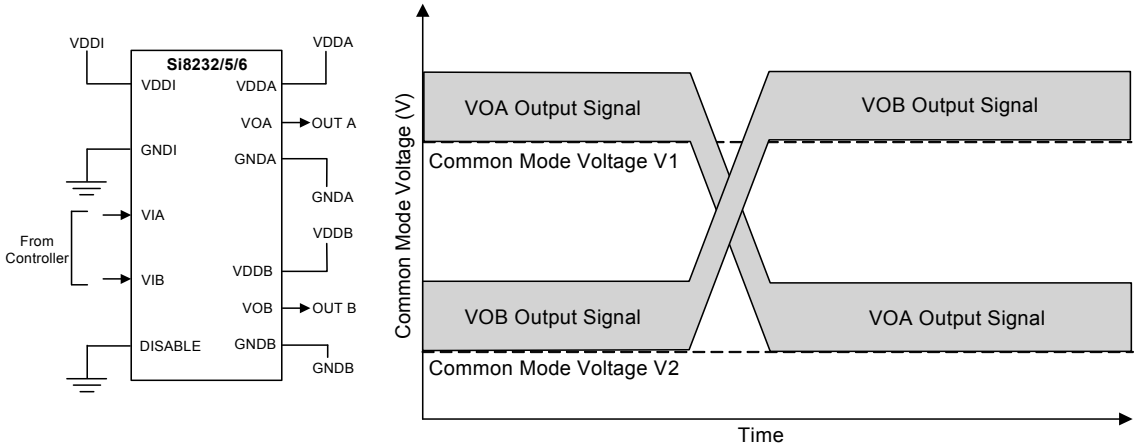
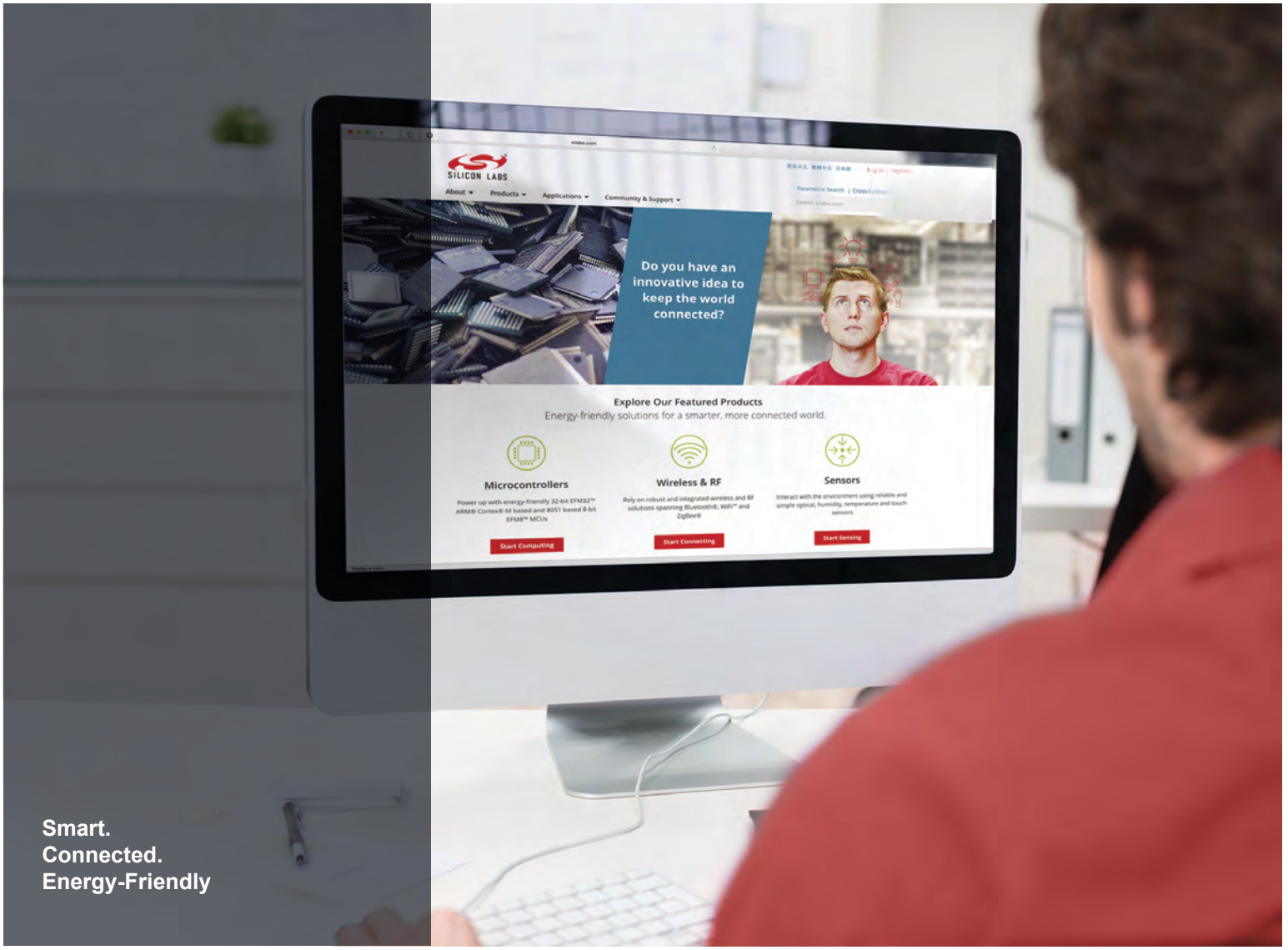


Figure 5. Common Mode Inversion

5. Summary

This application note discusses high-speed level shifting techniques using Silicon Labs' Si8xxx digital isolators and ISOdrivers. The underlying technology of Silicon Labs CMOS isolation technology offers high-speed and low-power operation, high reliability and integration, and ease-of-use for voltage level-shifting as well as other applications.



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