

## REPLACING TRADITIONAL OPTOCOUPPLERS WITH Si87XX DIGITAL ISOLATORS

### 1. Introduction

Opto-couplers are a decades-old technology widely used for signal isolation, typically providing safety isolation, signal level shifting, and ground loop mitigation. They are commonly used in a wide range of end applications, including data communication circuits, switch mode power systems, measurement and test systems, and isolated data acquisition systems. Optocouplers have several weaknesses, including parametric instability with temperature and device aging, significant internal parasitic couplings, long propagation delay times, narrow operating temperature ranges, and relatively low reliability. Optocouplers have been the “go-to” isolation device of choice for the past 30+ years because they were the only integrated solutions to the problem of signal isolation. Today’s advanced CMOS signal isolation products offer better timing performance, higher reliability, and lower power consumption compared to optocouplers and are capturing sockets traditionally held by optocouplers. However, converting to CMOS isolation devices has, most often, required circuit changes and PCB modifications that cost money and create design risks, until now.

The Si87xx family can be used as a pin-compatible optocoupler upgrade in existing systems or as a design-in component for new product designs. Package and pin compatibility allow the Si87xx to replace optocouplers without PCB modifications, with substantial gains in device performance and reliability. Device operation is simple: the Si87xx output is held low when anode current is above the turn-on current threshold and pulled high by an internal or external pull-up resistor when anode current is below the turn-off current threshold. (For more information about current thresholds and hysteresis values, see the Si87xx data sheet.)

### 2. Si87xx Operation

Figure 1 shows an Si87xx block diagram in which the input-side circuit contains a diode emulator, high-frequency transmitter, and galvanic isolator, all of which are powered by the voltage present on the anode pin. The diode emulator mimics the behavior of an optocoupler LED to ensure compatibility with existing optocoupler input circuits. Device operation is straightforward: the diode emulator enables the transmitter when anode current is above its turn-on threshold. This action causes the transmitter to propagate a high-frequency carrier across the isolation barrier to the receiver, which, in turn, forces the output driver low. Conversely, an anode current below the turn-off threshold disables the transmitter, causing the receiver to release the output pin to be pulled high by the pull-up resistor.

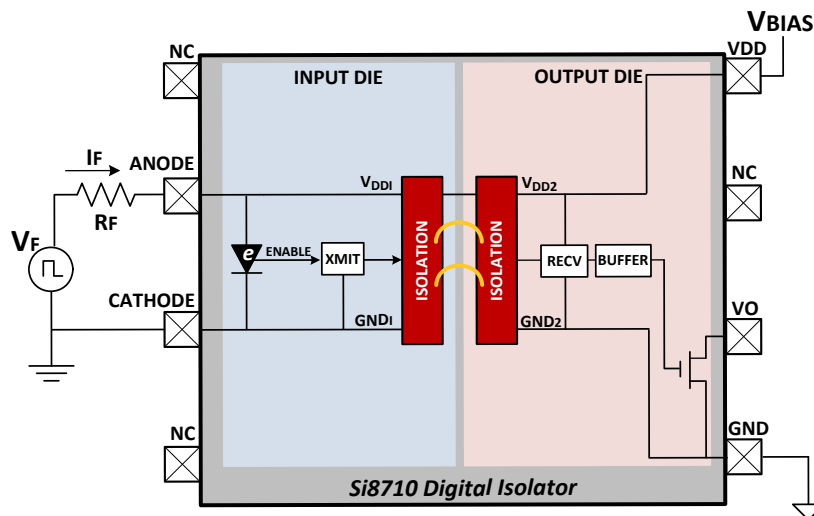


Figure 1. Si8710 Digital Isolator Block Diagram

This simple architecture provides numerous advantages over optocouplers:

- **Pin and Package Drop-In Opto-Coupler Upgrade**  
Faster propagation time, better parametric stability over voltage and temperature, 2x to 3x lower internal parasitic coupling compared to optocouplers.
- **Standard CMOS Process Technology**  
CMOS is a well understood process technology with 40+ years of learning and offers 5.5 times lower failures-in-time (FIT) rate than GaAs-based optocouplers, a time dependent dielectric breakdown (TDDB) of 60 years, and a mean time-to-failure (MTTF) of 87 years. CMOS also provides an operating temperature range of  $-40$  to  $+125$  °C compared to  $-40$  to  $+85$  °C for optocouplers, greater parametric stability over voltage and temperature, and lower operating power versus optocouplers.
- **Precise Current Thresholds with Hysteresis**  
The Si826x output is either low or high, with no ambiguous output states and excellent threshold stability over voltage and temperature. There are no current transfer ratio (CTR) issues to address.
- **Improved Performance**  
Shorter propagation delay time and PWD, wider operating temperature range, and greater parametric operating stability than optocouplers.
- **Silicon Dioxide Based Capacitive Isolation Barrier**  
Silicon dioxide is an ultra-stable material enabling an unparalleled lifetime of over 60 years, compared to less than 15 years in optocouplers.
- **Superior Surge Tolerance**  
Withstands 10 kV surge per IEC 60065
- **Wide Product Range**  
The Si87xx digital isolators are available in gull-wing PDIP8, SOIC8, LGA8, and SDIP6 packages and offer optional internal pull-up resistor and external enable. (For more information, see the Si87xx Digital isolator data sheet.)

### 3. Applications

#### 3.1. Replacing an Existing Optocoupler with the Si87xx

- Use the Si87xx data sheet or online guide to select the correct, pin-compatible Si87xx product for the application at hand.
- Desolder the existing optocoupler from the board and discard it.
- Solder the selected Si87xx device into the site previously occupied by the optocoupler.
- Adjust the value of  $R_F$  to achieve a maximum current of 3 mA for the Si87xx A-grade and Si87xx C-grade devices or 6 mA for the B-Grade device (see Equation 1 below).
- Connect power and verify proper system operation.

Note that the Si87xx is also compatible with typical external devices that improve optocoupler CMTI performance, such as shorting switches, reverse diode clamps, and others. Components of this type can be left in place or removed at the user's option.

#### 3.2. Using the Si87xx in New Designs

Typically, the only calculated value is that of the current limiting resistor,  $R_F$ . The first step is deciding if the application benefits more from low anode current (A-Grade or C-Grade) or from high common-mode transient immunity (B-Grade). Once this decision is made and the anode current threshold and optimum ON current values are known, values for calculating  $R_F$  (see Equation 1) are straightforward.

$$R_F = \frac{V_F - 2.0}{I_F}$$

Where:

$R_F$  is the value of the anode current limit resistor ( $\Omega$ )

$V_F$  is the input-side forward voltage (V)

$I_F$  is the Anode forward input current (mA)

#### Equation 1.

Note that it is best to keep the values of both  $V_F$  and  $R_F$  low because this offers greater resistance against CMT events. For example, a B-Grade Si87xx with  $V_F = 5$  V and  $R_F = 833 \Omega$  exhibits higher CMTI than the same device with  $V_F = 10$  V and  $R_F = 1.6$  k $\Omega$ .

## 4. Evaluation Board

The Si87xx package and pin-compatibility makes upgrading existing optocoupler circuits quick and easy. Simply look-up the closest replacement to the incumbent optocoupler and replace the optocoupler with the appropriate Si87xx (it may also be necessary to adjust the value of Anode input resistor  $R_F$  for optimum operation). The PCB of Figure 2 exercises an Si87xx digital isolator and a competing optocoupler simultaneously. The external digital input signal is buffered and fed into the inputs of both devices while the output signals are observed on an oscilloscope. Figure 3 shows the outputs of both devices at room temperature, while Figure 4 shows the outputs at 80 °C. Note the faster propagation delay rise times provided by the Si87xx device.

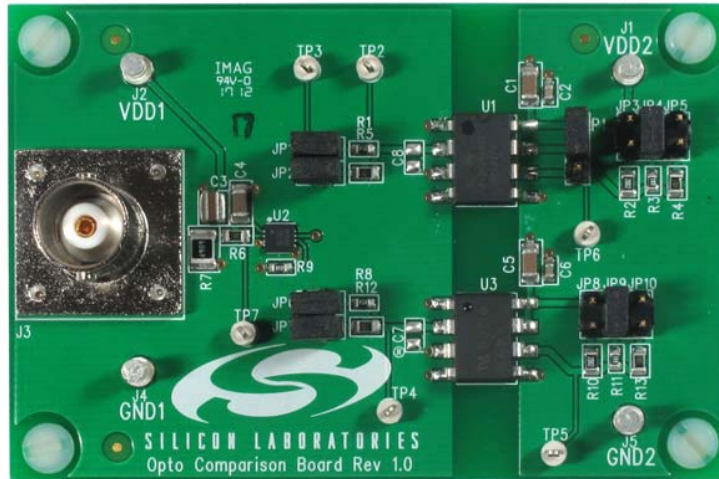


Figure 2. Opto Comparison EVB

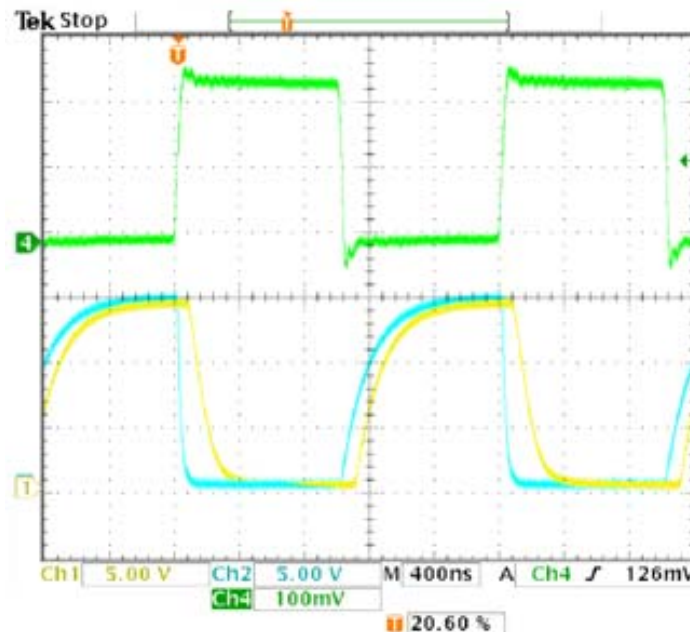
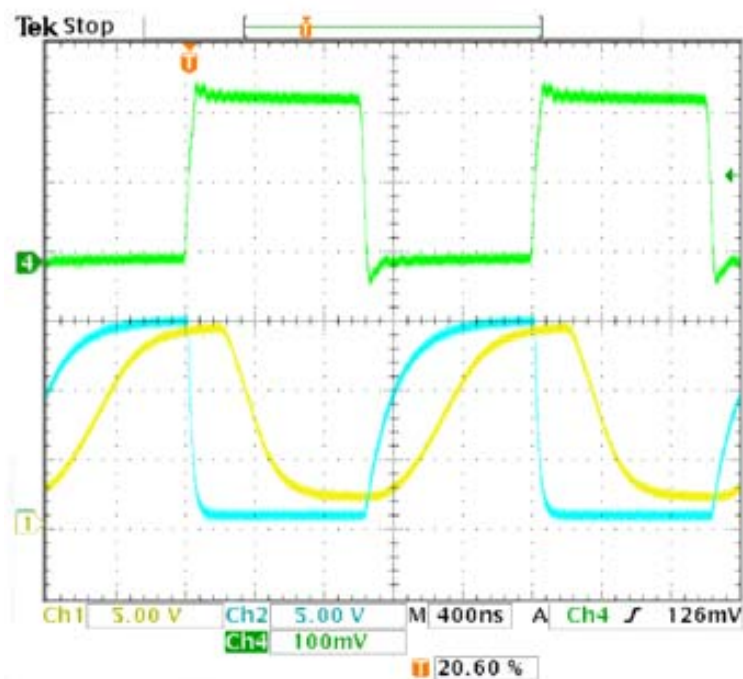


Figure 3. Optocoupler Comparison EVB at Room Temperature



**Figure 4. Optocoupler Comparison EVB at 80 °C**

Figure 4 uses the same setup as Figure 3, but, this time, operating at an elevated temperature. The blue waveform is the output of the Si8710A, and the yellow waveform is the output of the HCPL-4506. As operating temperature increases, the HCPL 4506 output falling edge is substantially slower, and the propagation delay worsens compared to Figure 3. Note that the Si8710A output performance is essentially the same, as shown in Figure 3.

## 5. Summary

The Si87xx digital optocoupler upgrade is the first and only enhanced optocoupler replacement technology available. This device family offers higher performance, greater reliability, increased ease-of-use, and more intuitive design than traditional optocouplers. The Si87xx easily retrofits into existing optocoupler circuits and requires no PCB changes. These devices are ideal for retrofit or new designs.

NOTES:

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