Application Brief

How To Simplify Isolated 24-V PLC Digital Input Module Designs

TEXAS INSTRUMENTS

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Digital Input Modules

Digital Input (DI) modules are used in Programmable Logic Controllers (PLCs) and Motor Drives to receive 24-V digital inputs from field sensors and switches. Isolation is used to manage ground potential differences. The input signal is interpreted as a logic high or low using a voltage comparator with hysteresis. Some form of current limit is also implemented to avoid excess current draw from the 24-V inputs; power dissipation is a critical concern in high-density compact multi-channel designs.

The IEC 61131-2 standard for programmable controllers specifies three different types of digital input receivers: Types 1, 2 and 3. Ideal implementations for Type 3 should draw as close to 2 mA as possible in the ON-state, and have voltage transition thresholds between 5 V and 11 V.

Figure 1. Traditional DI modules a) Basic current limit b) More accurate but complex current limit

Common Digital Input Implementations

Figure 1 shows the two most common implementations of Digital Input receivers in use today. In the first case shown in Figure 1 (a), the voltage thresholds are set by resistors R1 and R2, and R2 serves as a basic current limit. Such an implementation for Type 3 inputs can easily draw up to 12 mA at 32-V input. The second implementation shown in Figure 1 (b) uses several discrete components (9 to 15) to implement a better current limit and controlled voltage thresholds. In this

case, for Type 3, the current draw can be as high as 6 mA across temperature depending on the design. In both cases, the current limit is much higher than the ideal current limit of 2 mA for type 3 inputs. A Schmitt trigger buffer is usually needed after the optocoupler to provide hysteresis for noise immunity.
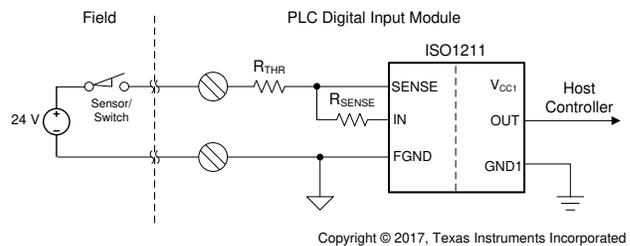
Figure 2. One channel of a Digital Input Module with ISO1211

New Solutions for Digital Input Modules

Texas Instruments' ISO1211 and ISO1212 devices are isolated digital input receivers with integrated current limit, compliant to IEC 61131-2 Type 1, 2 and 3 characteristics. The ISO1211 is suitable for channel-to-channel isolation and the ISO1212 is suitable for multi-channel designs. Figure 2 shows the implementation of one channel of a Digital Input module with ISO1211. The resistor R_{SENSE} controls the current limit, and the resistor R_{THR}, the voltage transition thresholds. The recommended values of R_{SENSE} and R_{THR} and application circuits for multi-channel and other scenarios are provided in the ISO121x product datasheet. The ISO121x simplifies system design by integrating an accurate current limit, voltage comparator with hysteresis, reverse polarity protection and isolation, while not needing field-side power. For Type 3 characteristics, ISO121x limits the input current draw to < 2.5 mA, a factor of 5x lower than traditional approaches.
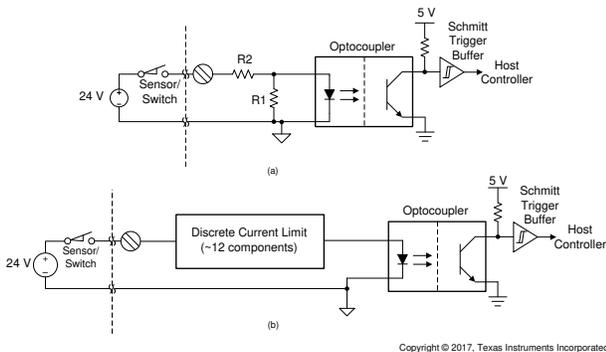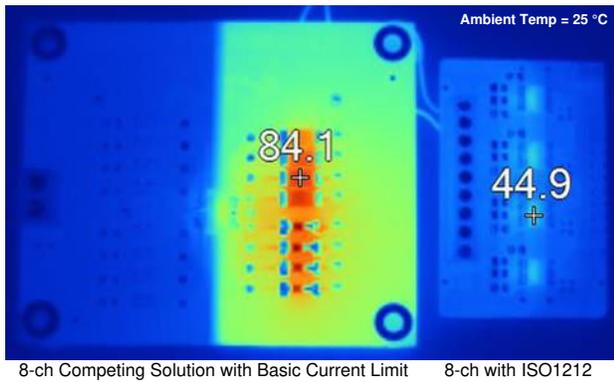
8-ch Competing Solution with Basic Current Limit   8-ch with ISO1212
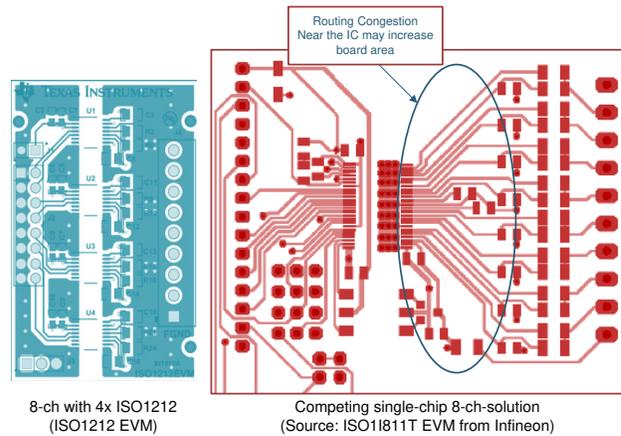
Figure 3. Board temperature comparison: Traditional solution vs ISO1212

Compared to traditional approaches using optocouplers, designing with ISO121x has the following advantages:

1. **Lower Power Dissipation:** The precise current limit in the ISO121x can reduce the current drawn from digital inputs by up-to a factor of 5 reducing power dissipation and board temperature. As shown in Figure 3, a traditional solution can heat up to 84°C during a room temperature test, where as ISO121x based solution is much cooler at 45°C.
2. **Smaller boards and modules :** ISO121x based solutions reduce component count leading to smaller boards. Lower power dissipation also allows packing more channels in a smaller module.
3. **Simplified System Design :** With ISO121x, the IEC 61131-2 input characteristics, current limit and isolation are guaranteed by the datasheet. No additional Schmitt trigger buffer is needed. This simplifies system design.
4. **High Speed Operation :** ISO121x offers 4 Mbps data rate and 150 ns latency - allowing much faster interfaces than general purpose optocouplers.

Multi-channel single-chip solutions

Figure 4 compares the layout of a design with four ISO1212 devices with a competing 8-channel single-chip solution. The Y-dimension of the board is limited by the placement of the input screw terminals/connectors. However, the X-dimension is higher for the 8-channel single-chip solution. This is because of additional space taken due to routing congestion close to IC. On the other hand, since ISO1212 has only two channels there is more flexibility in placing the IC closer to the input terminals resulting in much simpler routing, leading to a smaller solution.

8-ch with 4x ISO1212 (ISO1212 EVM)   Competing single-chip 8-ch-solution (Source: ISO1I811T EVM from Infineon)

Figure 4. Layout of ISO1212 based design vs competing 8-channel single-chip solution

Other advantages of ISO121x based solution over some multi-channel serializer devices include:

1. **No need for field side power supply:** This saves cost on connectors/terminal for the 24-V field side supply as well as the corresponding surge protection.
2. **Channel independence:** Damage to one channel on the field side (say, due to short circuit) does not impact any of the other channels.
3. **Higher speeds:** Serialization in multi-channel devices limits speeds to <20 kHz, while ISO121x devices can support up-to 2 MHz clocking.

Design for Surge, EFT and ESD Immunity

The ISO121x devices have been designed for Surge, EFT and ESD immunity according to IEC 61000-4-x standards. Please refer to the application section of the product datasheet for design, and layout guidelines to achieve the best transient immunity.

Conclusion

The ISO1212 and ISO1211 devices bring a modern solution to Digital Input Modules, integrating IEC 61131-2 input characteristics, voltage comparator with hysteresis, a precise current limit and galvanic isolation in a small package. Modules designed with ISO121x have lower power dissipation, allow higher channel density, are compact and simple to design compared to traditional solutions.

Table 1. Alternative Device Recommendations

Device	Optimized Parameters	Performance Trade-Off
SN65HVS880	8-channel digital input serializer	Non-isolated, 3.6mA current limit, Needs field side supply
SN65HVS885	8-channel digital input serializer	Non-isolated, 3.6mA current limit, Needs isolated DC-DC

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