How To Improve Speed and Reliability of Isolated Digital Inputs in Motor Drives

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Digital Input Receivers in Motor Drives

Digital Input receivers are used in AC and servo motor control to interface various 24-V signals to the control module of the drive. These signals include inputs from field sensors and switches, position and speed feedback encoded as 24-V signals, clock or PWM inputs for speed control, and emergency stop signals, such as Safe Torque Off (STO). Isolation is used to manage ground potential differences.

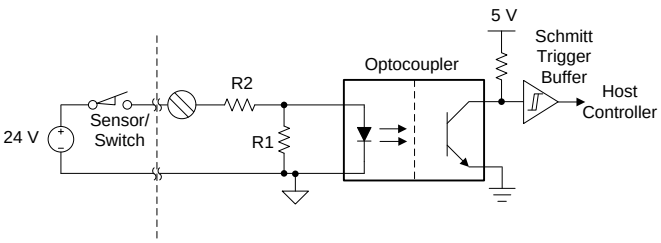

Figure 1. Traditional implementation of Digital Input Receivers in Motor Drives

Common Implementations

Figure 1 shows the most common implementation of Digital Input receivers in motor drive applications in use today. The voltage thresholds and the receiver input current are set by the resistors R1 and R2, in combination with the optocoupler's input characteristics. A Schmitt trigger buffer is usually needed after the optocoupler to provide hysteresis for noise immunity.

New Digital Input Solutions for Motor Drive Applications

Texas Instruments' ISO1211 and ISO1212 devices are high-speed isolated digital input receivers with integrated current limit, voltage comparator with hysteresis and reverse polarity protection. The ISO1211 can be used for channel-to-channel isolation and the ISO1212 is ideal for multichannel designs. Figure 2 shows the implementation of one channel of a Digital Input receiver with ISO1211. The resistor R_{SENSE} controls the current limit, and the resistor R_{THR}, the voltage transition thresholds. This allows the systems designer to independently adjust these parameters. The ISO121x can reduce power dissipation by a factor of 5x compared to traditional approaches, as shown in the *How To Simplify Isolated 24-V PLC Digital Input Module Designs* TI Tech Note.

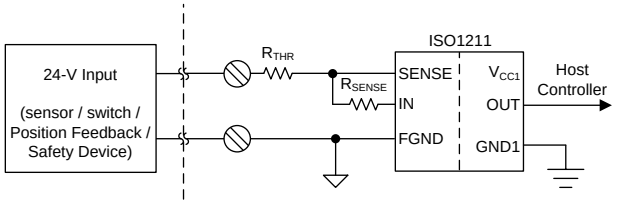

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Figure 2. Digital Input Module with ISO1211

A CMOS based integrated solution such as the ISO121x offers several advantages over traditional optocoupler solutions for motor drive digital inputs.

Higher Speed and Lower Response Times

Standard optocouplers have a response time of tens of micro-seconds, and are not capable of high speed operation. ISO121x devices offer much higher speed and response time, and are ideal for high speed digital inputs such as for position and speed feedback and control signals in motor drives.

Device	Max. Response Time / Propagation Delay	Maximum Clock Frequency
Optocoupler	20 µs	20 kHz
ISO121x	140 ns	2 MHz

Controlled Thresholds and Noise Immunity

Motor drives are noisy systems, and it is imperative to design interfaces including digital inputs for noise immunity. Optocoupler input response and current transfer ratio varies greatly from device to device, and with temperature. Over a period of time, the LEDs used in the optocoupler also age, resulting in a further shift in input and transfer characteristics. Keeping these factors in mind, digital inputs designed with optocouplers have a wide variation in input voltage transition thresholds. To keep the current draw low, often the system designer is forced to design the digital input receiver to draw the minimum required current at a higher input voltage (i.e. the maximum threshold is pushed higher, beyond the desired

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specification). In comparison, as shown in Figure 3, an ISO121x based solution has controlled thresholds and hysteresis, and sufficient margin to the low and high levels, to account for noise, variation in the 24-V supply and voltage drop in the input wiring.

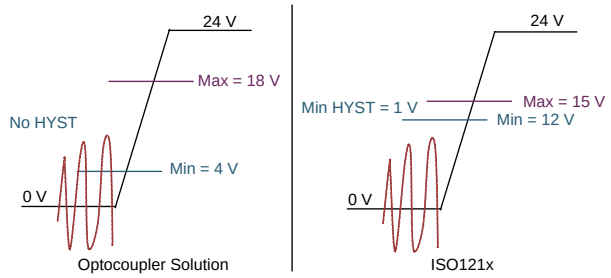

Figure 3. ISO121x Based Receivers Have Higher Noise Margin to the High and Low Levels

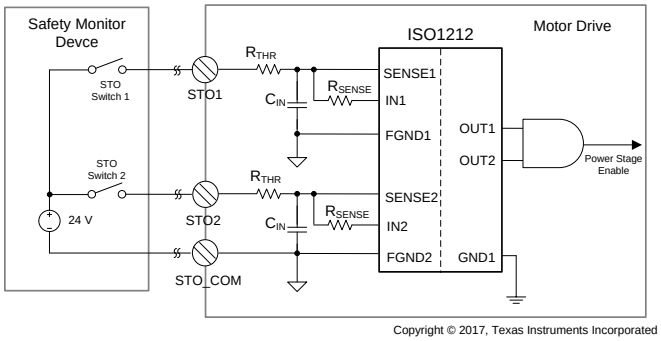

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Figure 4. Safe Torque Off (STO) Signals Implemented with ISO1212

Increased Reliability

The ISO121x devices, like other digital isolation products from Texas Instruments are manufactured using a well-controlled CMOS semiconductor manufacturing process. These devices have a very low Failure in Time (FIT) rate of <0.3 per 1 billion hours of operation. In comparison, optocouplers have a FIT rate of 10 to 30 per 1 billion hours of operation, orders of magnitude worse. The ISO121x devices also do not age with time, unlike optocouplers.

Device	FIT rate	Aging
Optocoupler	20	Significant
ISO121x	0.3	Negligible

Critical signals such as Safe Torque Off (STO) that are active-low, and hence operate at a continous high-level in normal operation can cause accelerated aging in optocouplers. Safe Torque Off (STO) when implemented with ISO121x as shown in Figure 4 benefits from a lower FIT rate, and negligible impact from aging.

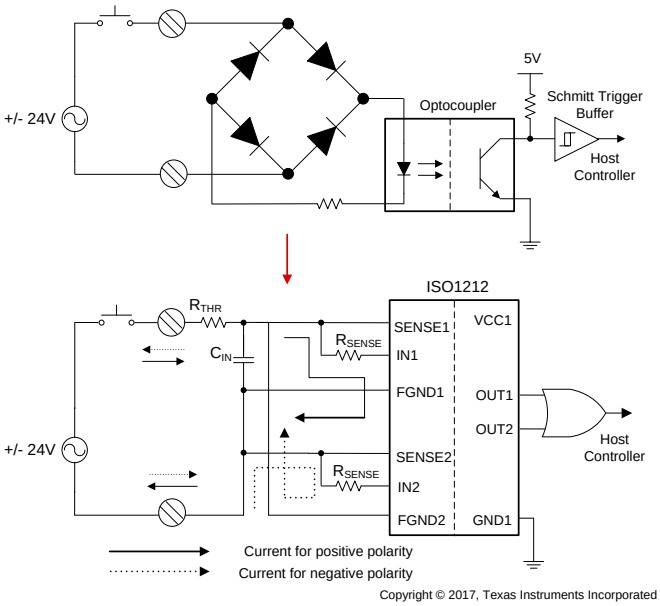

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Figure 5. Implementing Bipolar, AC or Sink-Source Configuration using ISO1212

Bipolar, AC or Sink-Source Operation

Digital inputs for motor drives are sometimes implemented in bipolar or sink-source configuration. To implement bipolar operation, usually a full-bridge rectifier using four diodes is used ahead of an optocoupler. The ISO1212 device can be used to create an input module that can be used for bipolar, AC or sink-source operation, as shown in Figure 5, resulting in a compact solution, while maintaining the benefits of current limit, and precise voltage thresholds.

Conclusion

The ISO1212 and ISO1211 devices bring a modern solution for Digital Input receivers in motor drive applications offering higher speed, well controlled voltage thresholds, better noise immunity and increased reliability and longevity compared to traditional solutions with optocouplers.

Table 1. Alternative Device Recommendations

Device	Optimized Parameters	Performance Trade-Off
ISO1211	Single-channel isolated digital input receiver	For channel to channel isolation
ISO1212	Dual-channel isolated digital input receiver	For group isolated inputs. Lower cost per channel
SN65HVS880	8-channel digital input serializer	Non-isolated, Lower Speed, Needs field side supply

Table 2. Adjacent Tech Notes

SLLA370	*How To Simplify Isolated 24-V PLC Digital Input Module Designs*

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