How to Design Isolated Comparators for ±48V, 110V and 240V DC and AC Detection

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Isolated Voltage Monitoring in Industrial Applications

Many industrial applications need to monitor DC and AC voltages in the range of 48V to 300V. Examples include power supply and battery monitors, and receivers of status signals from sensors, switches and relays. Isolation is needed to handle ground potential differences and to protect against high voltage. The traditional solution for AC detection is to use a bridge rectifier followed by a Zener diode and an optocoupler as shown in Figure 1. For DC detection, the same circuit is used without the bridge rectifier.

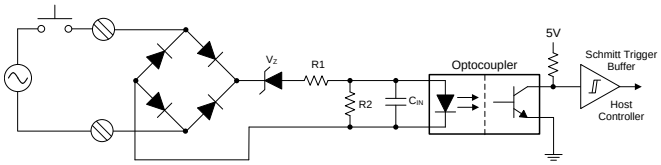

Figure 1. Traditional AC Voltage Detection

ISO121x for 48V to 300V DC Detection

Texas Instruments' ISO1211 and ISO1212 devices provide a reliable and low-power alternative to optocouplers for 48-V to 300-V DC and AC detection. ISO121x devices integrate a 60-V hysteresis comparator, current limit and galvanic isolation. The ISO1211 is ideal for channel-to-channel isolation and the ISO1212 is ideal for multichannel designs.

ISO121x devices offer many performance benefits vs. optocouplers: precise voltage thresholds, low input current draw, higher speed, lower Failures In Time (FIT), higher reliability and operation up to 125°C. ISO121x devices draw current from the signals they are monitoring and do not need a separate field side power supply.

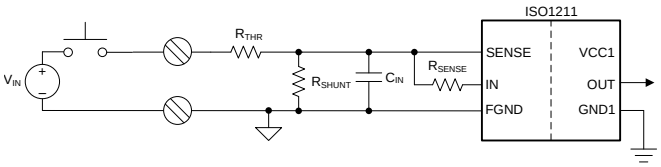

Figure 2. DC Voltage Detection with ISO1211

Figure 2 shows an implementation of DC voltage detection with ISO1211. The resistor R_{SENSE} controls the input current into the ISO1211. The typical voltage threshold at the SENSE pin is 8.25V. The transition threshold at the module input is 8.25V plus the voltage drop across R_{THR}. The ISO121x devices are rated for 60-V operation. For use with voltages greater than 60-V an additional resistor R_{SHUNT} is used. The current through R_{SHUNT} increases with input voltage, increasing the voltage drop across R_{THR}, and preventing the voltage on the ISO121x pins from exceeding 60V. A capacitor C_{IN} > 1 nF is used to prevent overshoot on the SENSE pin beyond 60V during transitions.

The following equations describe the input current through the ISO1211, the voltage transition threshold at the module input (V_{IT}), and the maximum allowed voltage at the module input (V_{IN_MAX}).

$$I_{ISO121x} = 2.25\ mA \times \left(\frac{562\ \Omega}{R_{SENSE}} \right)$$

$$V_{IT} = 8.25\ V + R_{THR} \times \left(\frac{8.25\ V}{R_{SHUNT}} + 2.25\ mA \times \left[\frac{562\ \Omega}{R_{SENSE}} \right] \right)$$

$$V_{IN\_MAX} = 60\ V + R_{THR} \times \left(\frac{60\ V}{R_{SHUNT}} + 2.25\ mA \times \left[\frac{562\ \Omega}{R_{SENSE}} \right] \right)$$

Voltage Threshold Calculator

Texas Instruments offers an xls based calculator that solves the equations described in the previous section: ISO121x Threshold Calculator for 9V to 300V DC and AC Voltage Detection. The calculator also provides the peak current drawn for a given module input voltage. The calculator has separate sheets for DC and AC operation.

AC Voltage Detection Using ISO121x

Figure 3 shows the application circuit for AC voltage detection. Low cost diodes such as the BAT54CLT1G can be used for the bridge rectifier. The equations for determining the values of the different resistors are same as for DC detection, except that the equations will yield peak voltages. The results must be divided by $\sqrt{2}$ to obtain the r.m.s. values.

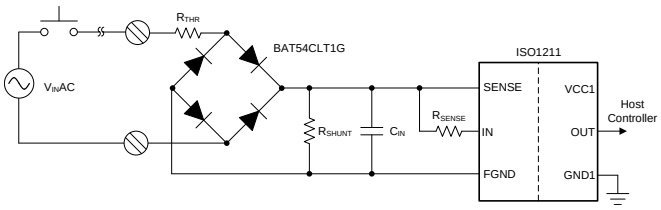

Figure 3. AC Voltage Detection with ISO1211

For AC inputs, a suitable value for C_{IN} should be chosen to ensure low ripple on the SENSE pin.

Power Reduction and Multi-Level, Multi-Channel Implementation

Figure 4 shows how ISO1212 can be used for a multi-channel application, while reducing average current draw from the high voltage input pins. The phototransistor (ex. TLP388, 350V) can be turned on by the microcontroller for only a short duration when the measurement is needed, avoiding continous power dissipation. Also, in this example, IN_1 is sampled by two ISO1212 channels. This enables multi-level detection with different thresholds.

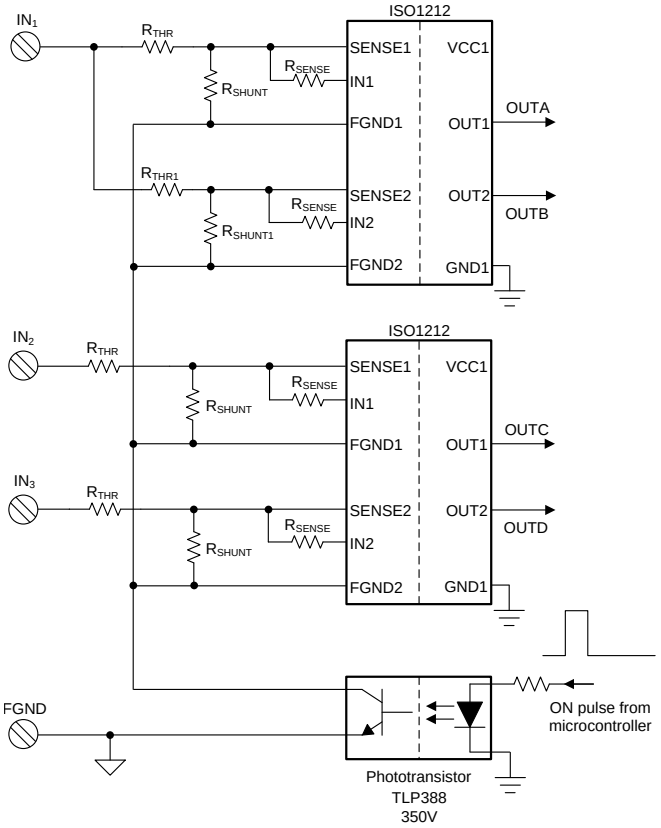

Figure 4. Reducing Power Consumption in High Voltage Detection

Table 1. Suggested Values for DC Applications

VDC System (V)	V_{IN_MAX} (V)	R_{THR} (kΩ)	R_{SHUNT} (kΩ)	R_{SENSE} (Ω)	Transition Threshold (V)			I_{IN} (mA)
					Min	Typ	Max	
48	77	8.5	—	560	24	27	30	2.3
110	137	22	40	560	54	62	70	3.3
240	250	38	22	560	100	113	126	4.7

Table 2. Suggested Values for AC Applications

VAC System (V_{RMS})	V_{IN_MAX} (V_{RMS})	R_{THR} (kΩ)	R_{SHUNT} (kΩ)	R_{SENSE} (Ω)	Transition Threshold (V_{RMS})		
					Min	Typ	Max
110	148	33	24	560	58	66	73
240	300	60	15	560	109	124	138

Test Results

Table 1 and Table 2 provide suggested component values for different values of DC and AC detection. Figure 5 shows test results from an implementation for 240V DC. A transition threshold of 110V is obtained, and V_{SENSE} remains below 60V (limit for ISO121x) for V_{IN} up to 250V. The module input current is less than 5 mA at 250V.

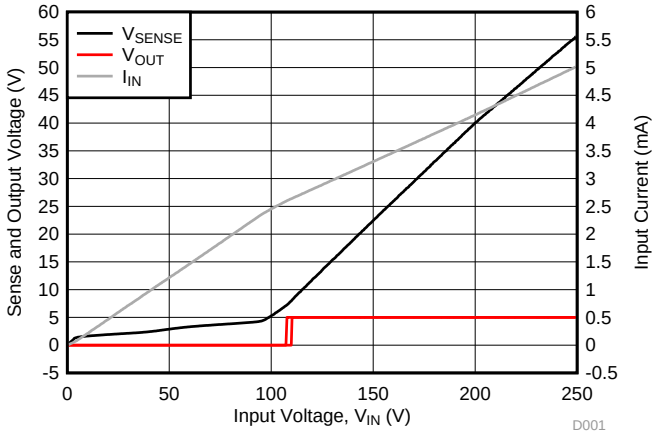

Figure 5. Test Results for 240V DC Detection

Table 3. 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

Table 4. Adjacent Tech Notes

SLLA370	*How To Simplify Isolated 24-V PLC Digital Input Module Designs*
SLLA379	*How To Improve Speed and Reliability of Isolated Digital Inputs in Motor Drives*

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