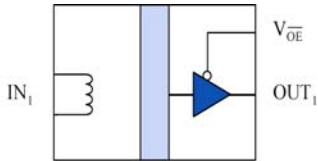
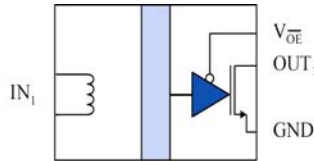


## Passive Input Digital Isolators

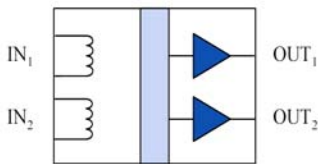
### Functional Diagram



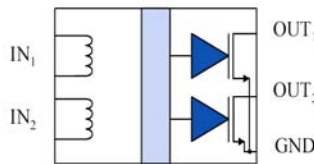
**IL610**



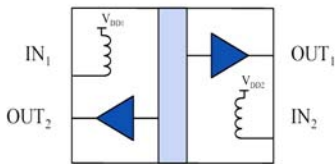
**IL610A**



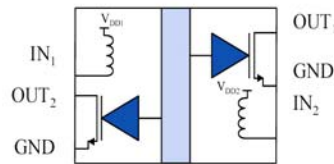
**IL611**



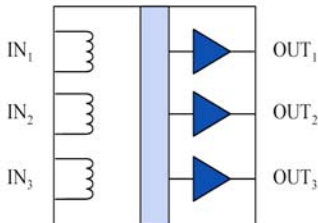
**IL611A**



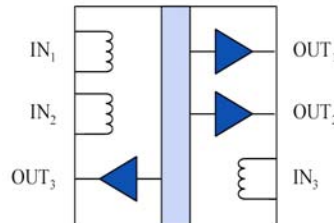
**IL612**



**IL612A**



**IL613**



**IL614**

### Features

- 40 Mbps Data Rate
- Very Wide Input Voltage Range
- Open Drain or CMOS Outputs
- Failsafe Output (Logic high output for zero coil current)
- Output Enable
- 3.3 V or 5 V Power Supply
- 2500 V<sub>RMS</sub> Isolation (1 Minute)
- Low Power Dissipation
- -40°C to 85°C Temperature Range
- 20 kV/μs Typical Common Mode Rejection
- UL1577 & IEC61010 Approval (pending)
- Available in MSOP, SOIC, and PDIP Packages and as Bare Die

### Applications

- CAN Bus/ Device Net
- General Purpose Opto Replacement
- Wired-OR Alarms
- SPI interface
- I<sup>2</sup>C
- RS 485, RS422, RS232
- Digital Fieldbus
- Size critical multi-channel applications

### Description

The IL600 series are isolated signal couplers with CMOS or open drain transistor outputs which can be used to replace opto-couplers in many standard isolation functions. The devices are manufactured with NVE's patented IsoLoop<sup>®</sup> GMR sensor technology giving exceptionally small size and low power dissipation.

A single resistor is used to set maximum input current for input voltages above 0.5 V. The devices are available in SOIC, PDIP and MSOP packages and as bare die.

### Absolute Maximum Ratings<sup>(1)</sup>

| Parameters                    | Symbol   | Min. | Typ. | Max.         | Units | Test Conditions |
|-------------------------------|----------|------|------|--------------|-------|-----------------|
| Storage Temperature           | $T_S$    | -55  |      | 150          | °C    |                 |
| Ambient Operating Temperature | $T_A$    | -55  |      | 125          | °C    |                 |
| Supply Voltage                | $V_{DD}$ | -0.5 |      | 7            | V     |                 |
| Input Current                 | $I_{IN}$ | -25  |      | 25           | mA    |                 |
| Output Voltage                | $V_O$    | -0.5 |      | $V_{CC}+0.5$ | V     |                 |
| Maximum Output Current        | $I_O$    | -10  |      | 10           | mA    |                 |
| ESD                           |          |      | 2    |              | kV    | HBM             |

### Recommended Operating Conditions

| Parameters                       | Symbol           | Min. | Typ. | Max. | Units         | Test Conditions |
|----------------------------------|------------------|------|------|------|---------------|-----------------|
| Ambient Operating Temperature    | $T_A$            | -40  |      | 85   | °C            |                 |
| Supply Voltage                   | $V_{DD}$         | 3.0  |      | 5.5  | V             |                 |
| Input Current                    | $I_{IN}$         | 0    |      | 10   | mA            |                 |
| Output Current                   | $I_{OUT}$        | -4   |      | 4    | mA            |                 |
| Open Drain Reverse Voltage       | $V_{SD}$         | -0.5 |      |      | V             |                 |
| Open Drain Voltage               | $V_{DS}$         |      |      | 6.5  | V             |                 |
| Open Drain Load Current          | $I_{OD}$         |      |      | 4    | mA            |                 |
| Input Signal Rise and Fall Times | $t_{IR}, t_{IF}$ |      |      | 50   | ms            |                 |
| Common Mode Input Voltage        | $V_{CM}$         |      |      | 400  | $V_{AC\ RMS}$ |                 |

### Insulation Specifications

| Parameters                   | Symbol | Min.  | Typ.            | Max. | Units             | Test Conditions              |
|------------------------------|--------|-------|-----------------|------|-------------------|------------------------------|
| Creepage Distance (external) |        |       |                 |      |                   |                              |
| MSOP                         |        | 3.010 |                 |      | mm                |                              |
| 0.15" SOIC                   |        | 4.026 |                 |      | mm                |                              |
| 0.30" SOIC                   |        | 8.077 |                 |      | mm                |                              |
| 0.30" PDIP                   |        | 7.077 |                 |      | mm                |                              |
| Internal Isolation Distance  |        |       | 9               |      | μm                |                              |
| Leakage Current              |        |       | 0.2             |      | μA <sub>RMS</sub> | 240 V <sub>RMS</sub> , 60 Hz |
| Barrier Impedance            |        |       | $>10^{14}    7$ |      | Ω    pF           |                              |

### Safety & Approvals

#### IEC61010-1

TUV Certificate Numbers:

*Approval Pending*

#### Classification

| Model   | Package      | Pollution Degree | Material Group | Max. Working Voltage |
|---|--------------|------------------|----------------|----------------------|
| IL610-1, IL610A-1, IL611-1, IL611A-1  | MSOP         | II               | III            | 100 V <sub>RMS</sub> |
| IL610-2, IL610A-2, IL611-2, IL611A-2, IL612-2, IL612A-2                     | PDIP         | II               | III            | 300 V <sub>RMS</sub> |
| IL613, IL614  | SOIC (0.3")  | II               | III            | 300 V <sub>RMS</sub> |
| IL610-3, IL610A-3, IL611-3, IL611A-3, IL612-3, IL612A-3<br>IL613-3, IL614-3 | SOIC (0.15") | II               | III            | 150 V <sub>RMS</sub> |

#### UL 1577

Component Recognition program. File #: *Approval Pending*

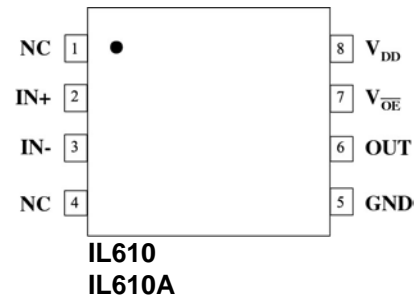
Rated 2500V<sub>RMS</sub> for 1 minute (SOIC, PDIP), 1000V<sub>RMS</sub> for 1 minute (MSOP)

### Electrostatic Discharge Sensitivity

This product has been tested for electrostatic sensitivity to the limits stated in the specifications. However, NVE recommends that all integrated circuits be handled with appropriate care to avoid damage. Damage caused by inappropriate handling or storage could range from performance degradation to complete failure.

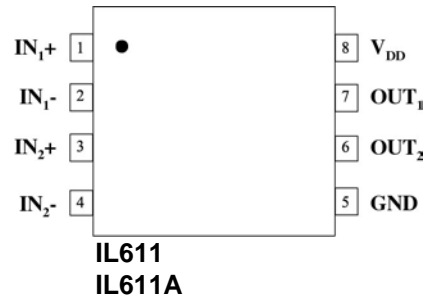
**IL610 and IL610A Pin Connections**

|   |          |  |
|---|----------|--|
| 1 | NC       | No internal connection                                 |
| 2 | IN+      | Coil connection  |
| 3 | IN-      | Coil connection  |
| 4 | NC       | No internal connection                                 |
| 5 | GND      | Ground return for $V_{DD}$                             |
| 6 | OUT      | Data out   |
| 7 | $V_{OE}$ | Output enable. Internally held low with 100 k $\Omega$ |
| 8 | $V_{DD}$ | Supply Voltage   |



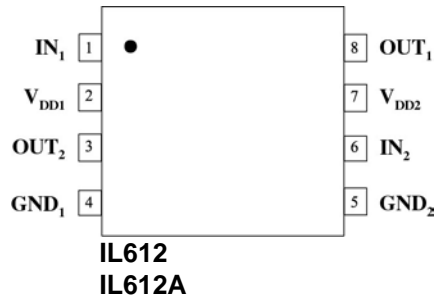
**IL611 and IL611A Pin Connections**

|   |                   |                            |
|---|-------------------|----------------------------|
| 1 | IN <sub>1</sub> + | Channel 1 coil connection  |
| 2 | IN <sub>1</sub> - | Channel 1 coil connection  |
| 3 | IN <sub>2</sub> + | Channel 2 coil connection  |
| 4 | IN <sub>2</sub> - | Channel 2 coil connection  |
| 5 | GND               | Ground return for $V_{DD}$ |
| 6 | OUT <sub>2</sub>  | Data out channel 2         |
| 7 | OUT <sub>1</sub>  | Data out channel 1         |
| 8 | $V_{DD}$          | Supply Voltage             |



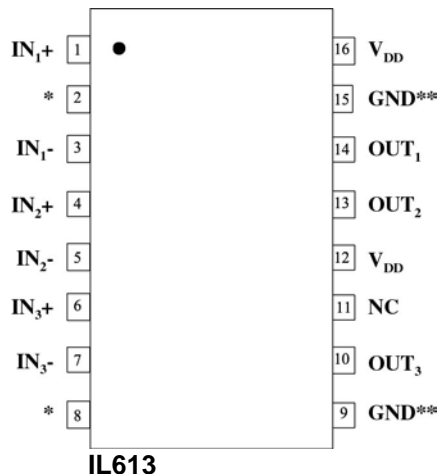
**IL612 and IL612A Pin Connections**

|   |                  |                             |
|---|------------------|-----------------------------|
| 1 | IN <sub>1</sub>  | Data in, channel 1          |
| 2 | $V_{DD1}$        | Supply Voltage 1            |
| 3 | OUT <sub>2</sub> | Data out, channel 2         |
| 4 | GND <sub>1</sub> | Ground return for $V_{DD1}$ |
| 5 | GND <sub>2</sub> | Ground return for $V_{DD2}$ |
| 6 | IN <sub>2</sub>  | Data in, channel 2          |
| 7 | $V_{DD2}$        | Supply Voltage 2            |
| 8 | OUT <sub>1</sub> | Data out, channel 1         |



**IL613 Pin Connections**

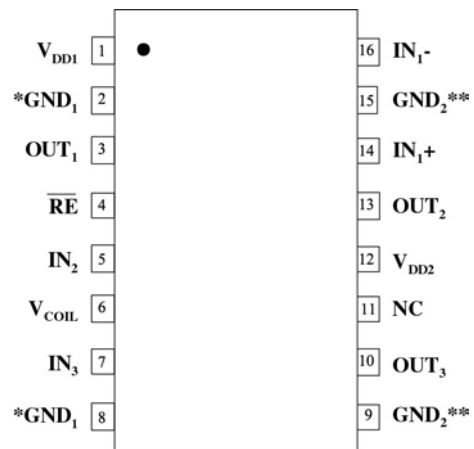
|    |                   |  |
|----|-------------------|--|
| 1  | IN <sub>1</sub> + | Channel 1 coil connection                                      |
| 2  | *                 | Internally connected to pin 8                                  |
| 3  | IN <sub>1</sub> - | Channel 1 coil connection                                      |
| 4  | IN <sub>2</sub> + | Channel 2 coil connection                                      |
| 5  | IN <sub>2</sub> - | Channel 2 coil connection                                      |
| 6  | IN <sub>3</sub> + | Channel 3 coil connection                                      |
| 7  | IN <sub>3</sub> - | Channel 3 coil connection                                      |
| 8  | *                 | Internally connected to pin 2                                  |
| 9  | GND               | Ground return for $V_{DD}$ (Internally connected to pin 15)    |
| 10 | OUT <sub>3</sub>  | Data out channel 3   |
| 11 | NC                | No connection  |
| 12 | $V_{DD}$          | Supply Voltage. Pin 12 and pin 16 must be connected externally |
| 13 | OUT <sub>2</sub>  | Data out channel 2   |
| 14 | OUT <sub>1</sub>  | Data out channel 1   |
| 15 | GND               | Ground return for $V_{DD}$ (Internally connected to pin 9)     |
| 16 | $V_{DD}$          | Supply Voltage. Pin 12 and pin 16 must be connected externally |



\* Pins 2 and 8 internally connected  
\*\* Pins 9 and 15 internally connected

**IL614 Pin Connections**

|    |                        |   |
|----|------------------------|---|
| 1  | V <sub>DD1</sub>       | Supply Voltage 1  |
| 2  | GND <sub>1</sub>       | Ground return for V <sub>DD1</sub> (Internally connected to pin 8)    |
| 3  | OUT <sub>1</sub>       | Data out channel 1  |
| 4  | $\overline{\text{RE}}$ | Channel 1 data output enable. Internally held low with 100 k $\Omega$ |
| 5  | IN <sub>2</sub>        | Data in channel 2   |
| 6  | V <sub>coil</sub>      | Supply connection for channel 2 and channel 3 coils                   |
| 7  | IN <sub>3</sub>        | Data in channel 3   |
| 8  | GND <sub>1</sub>       | Ground return for V <sub>DD1</sub> (Internally connected to pin 2)    |
| 9  | GND <sub>2</sub>       | Ground return for V <sub>DD2</sub> (Internally connected to pin 15)   |
| 10 | OUT <sub>3</sub>       | Data out channel 3  |
| 11 | NC                     | No connection   |
| 12 | V <sub>DD2</sub>       | Supply Voltage 2  |
| 13 | OUT <sub>2</sub>       | Data out channel 2  |
| 14 | IN <sub>1+</sub>       | Coil connection   |
| 15 | GND <sub>2</sub>       | Ground return for V <sub>DD2</sub> (Internally connected to pin 9)    |
| 16 | IN <sub>1-</sub>       | Coil connection   |



**IL614**

- \* Pins 2 and 8 internally connected
- \*\* Pins 9 and 15 internally connected

### Electrical Specifications

Electrical Specifications are  $T_{min}$  to  $T_{max}$  unless otherwise stated.

| Parameters  | Symbol   | Min.                     | Typ.                     | Max.   | Units   | Test Conditions                             |
|---|--|--------------------------|--------------------------|--|---|---|
| Coil Input Impedance                                      | $Z_{COIL}$   | 47  8                    | 55  9                    | 67  10   | $\Omega  nH$  | $T_{AMB} = 25^{\circ}C$                     |
| Temperature Coeff of Coil Resistance                      | $TC R_{COIL}$  |                          | 0.16                     | 0.165  | $\Omega/^{\circ}C$  |   |
| Input Threshold for Logic High                            | $I IN_H$   |                          |                          | 2  | mA  |   |
| Input Threshold for Logic Low                             | $I IN_L$   | 10                       |                          |  | mA  |   |
| Quiescent Current   | IL610, $I_{DD1}$<br>IL610, $I_{DD2}$<br>IL611, $I_{DD1}$<br>IL611, $I_{DD2}$<br>IL612, $I_{DD1}$<br>IL612, $I_{DD2}$<br>IL613, $I_{DD1}$<br>IL613, $I_{DD2}$<br>IL614, $I_{DD1}$<br>IL614, $I_{DD2}$ |                          | 2                        | 0<br>3<br>0<br>4<br>2<br>2<br>0<br>6<br>2<br>4           | $\mu A$<br>mA<br>$\mu A$<br>mA<br>mA<br>mA<br>$\mu A$<br>mA<br>mA<br>mA | $V_{DD} = 5 V, I_{IN} = 0$                  |
| Quiescent Current   | IL610, $I_{DD1}$<br>IL610, $I_{DD2}$<br>IL611, $I_{DD1}$<br>IL611, $I_{DD2}$<br>IL612, $I_{DD1}$<br>IL612, $I_{DD2}$<br>IL613, $I_{DD1}$<br>IL613, $I_{DD2}$<br>IL614, $I_{DD1}$<br>IL614, $I_{DD2}$ |                          | 1.3                      | 0<br>2<br>0<br>2.6<br>1.3<br>1.3<br>0<br>4<br>1.3<br>2.6 | $\mu A$<br>mA<br>$\mu A$<br>mA<br>mA<br>mA<br>$\mu A$<br>mA<br>mA<br>mA | $V_{DD} = 3.3 V, I_{IN} = 0$                |
| Logic High Output Voltage <sup>(4)</sup>                  | $V_{OH}$   | $V_{DD}-0.1$<br>$V_{DD}$ | $V_{DD}$<br>$V_{DD}-0.5$ |  | V   | $I_O = -20 \mu A$<br>$I_O = -4 mA$          |
| Logic Low Output Voltage                                  | $V_{OL}$   |                          | 0<br>0.5                 | 0.1<br>0.8   | V   | $I_O = 20 \mu A$<br>$I_O = 4 mA$            |
| Logic Output Current                                      | $I_O$  | 4                        | 7                        |  | mA  |   |
| Switching Specifications CMOS Outputs                     |  |                          |                          |  |   |   |
| Data Rate   |  | 40                       |                          |  | Mbps  | 50% Duty Cycle                              |
| Minimum Pulse Width                                       | PW   | 25                       |                          |  | ns  | 50% Points, $V_o$                           |
| Propagation Delay Input to Output (High to Low)           | $t_{PHL}$  |                          | 20                       | 25   | ns  | $C_L = 15 pF$ ,<br>$I_{COIL} = 10 mA$       |
| Propagation Delay Input to Output (Low to High)           | $t_{PLH}$  |                          | 20                       | 25   | ns  | $C_L = 15 pF$ ,<br>$I_{COIL} = 10 mA$       |
| Average Propagation Delay Drift                           |  |                          | 50                       |  |   | ps/ $^{\circ}C$                             |
| Pulse Width Distortion $ t_{PHL}-t_{PLH} $ <sup>(2)</sup> | PWD  |                          | 7                        | 10   | ns  | $C_L = 15 pF$                               |
| Propagation Delay Skew <sup>(3)</sup>                     | $t_{PSK}$  |                          | 10                       | 20   | ns  | $C_L = 15 pF$                               |
| Output Rise Time (10-90%)                                 | $t_R$  |                          | 2                        | 4  | ns  | $C_L = 15 pF$                               |
| Output Fall Time (10-90%)                                 | $t_F$  |                          | 2                        | 4  | ns  | $C_L = 15 pF$                               |
| Common Mode Transient Immunity                            | $ CM_H ,  CM_L $   | 15                       | 20                       |  | kV/ $\mu s$   | $V_T = 300 V_{peak}$                        |
| Switching Specifications Open Drain Outputs               |  |                          |                          |  |   |   |
| Parameters  | Symbol   | Min.                     | Typ.                     | Max.   | Units   | Test Conditions                             |
| Data Rate   |  | 10                       |                          |  | Mbps  | 50% Duty Cycle,<br>$R_{pullup} = 1 k\Omega$ |
| Minimum Pulse Width                                       | PW   | 100                      |                          |  | ns  | 50% Duty Cycle,<br>$R_{pullup} = 1 k\Omega$ |
| Propagation Delay Input to Output (High to Low)           | $t_{PHL}$  |                          | 20                       | 25   | ns  | $C_L = 2 k\Omega    15 pF$                  |
| Propagation Delay Input to Output (Low to High)           | $t_{PLH}$  |                          | 50                       | 75   | ns  | $C_L = 2 k\Omega    15 pF$                  |
| Common Mode Transient Immunity                            | $ CM_H ,  CM_L $   | 15                       | 20                       |  | kV/ $\mu s$   | $V_T = 300 V_{peak}$                        |

**Notes:**

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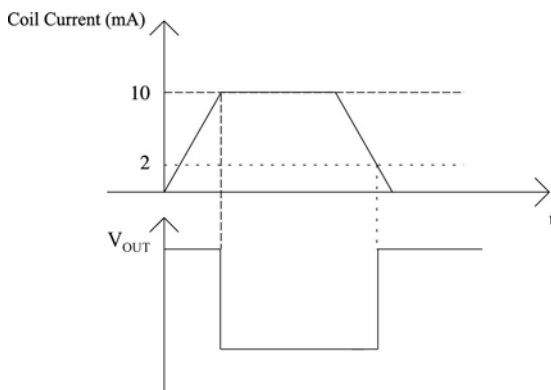
1. Absolute Maximum ambient operating temperature means the device will not be damaged if operated under these conditions. It does not guarantee performance.
2. PWD is defined as  $|t_{PHL} - t_{PLH}|$ . %PWD is equal to the PWD divided by the pulse width.
3.  $t_{PSK}$  is equal to the magnitude of the worst case difference in  $t_{PHL}$  and/or  $t_{PLH}$  that will be seen between units at 25°C.
4. The term  $V_{DD}$  refers to the supply voltage on the output side of the isolated channel.

**Operation**

The IL600 series are current mode devices. Changes in current flow into the input coil result in logic state changes at the output. One of the great advantages of the passive coil input is that both single ended and differential inputs can be handled without the need for reverse bias protection. The internal GMR sensor switches the output to logic low if current flows from (In-) to (In+). Only a single resistor is required to limit the input coil to the recommended 10 mA. This allows large input voltages to be used since there is no semiconductor structure on the input.

The absolute maximum current through the coil of the IL600 series is 25 mA DC. However, it is important to limit input current to levels well below this in all applications. The worst case logic threshold current is 10 mA. While typical threshold currents are substantially less than this, NVE recommends designing a 10 mA logic threshold current in each application. In all cases, the current must flow from In- to In+ in the coil to switch the output low. This is true regardless of true or inverted data configurations. Output logic high is the zero input current state.

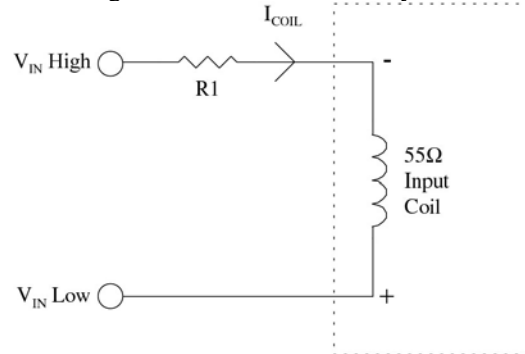
Figure 1 shows the response of the IL600 series. The GMR bridge structure is designed such that the output of the isolator is logic high when no field signal is present. The output will switch to the low state with 10 mA of coil current and the output will switch back to the high state when the input current falls below 2 mA. This allows glitch-free interface with low slew rate signals.



**Figure 1. IL600 Series Transfer Function**

To calculate the value of the protection resistor (R1) required, use Ohm’s law as shown in the examples below. It

should be noted that we are concerned only with the magnitude of the voltage across the coil. The absolute values of V<sub>in High</sub> and V<sub>in Low</sub> are arbitrary.



**Figure 2. Series Resistor Calculation Equivalent Circuit.**

**Example 1.** In this case, T<sub>nom</sub> = 25°C, V<sub>in High</sub> is 24 V, V<sub>in Low</sub> is 1.8 V, and I<sub>coil</sub> minimum is specified as 10 mA. Total loop resistance is

$$(R1 + R_{coil}) = \frac{(V_{in High} - V_{in Low})}{I_{coil}} = \frac{22.2}{0.01} \Omega = 2220 \Omega$$

Therefore,

$$R1 = (2220 - 55) \Omega = 2145 \Omega$$

**Example 2.** At a maximum operating temperature of 85°C, T<sub>max</sub> = 85°C, T<sub>nom</sub> = 25°C, V<sub>in High</sub> = 5 V, V<sub>in Low</sub> = 0 V, and nominal R<sub>coil</sub> = 55 Ω. At T<sub>max</sub> = 85°C

$$R_{coil} = 55 + (T_{max} - T_{min}) \times TCR_{coil} = 55 + (85 - 25) \times 0.165 = 55 + 9.9 = 65 \Omega$$

Therefore, the recommended series resistor is

$$R1 = \frac{(V_{in High} - V_{in Low})}{I_{coil}} - R_{coil} = \frac{5 - 0}{0.01} - 65 = 435 \Omega$$

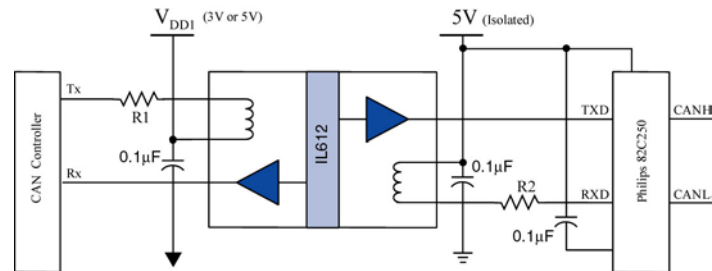
Allowance should also be made for the temperature coefficient of the current limiting resistor to ensure that I<sub>coil</sub> is 10 mA at maximum operating temperature.

**Power Supplies**

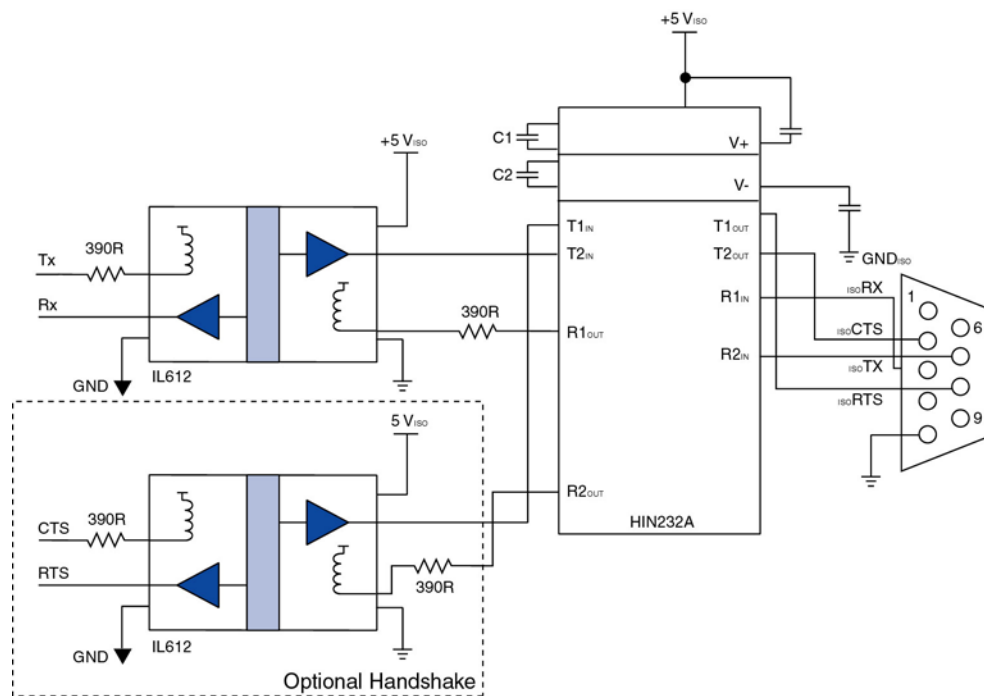
It is recommended that 47 nF ceramic capacitors be used to decouple the power supplies. The capacitors must be placed as close as possible to V<sub>DD</sub> for proper operation.

**Application Diagrams**

*CAN Bus*

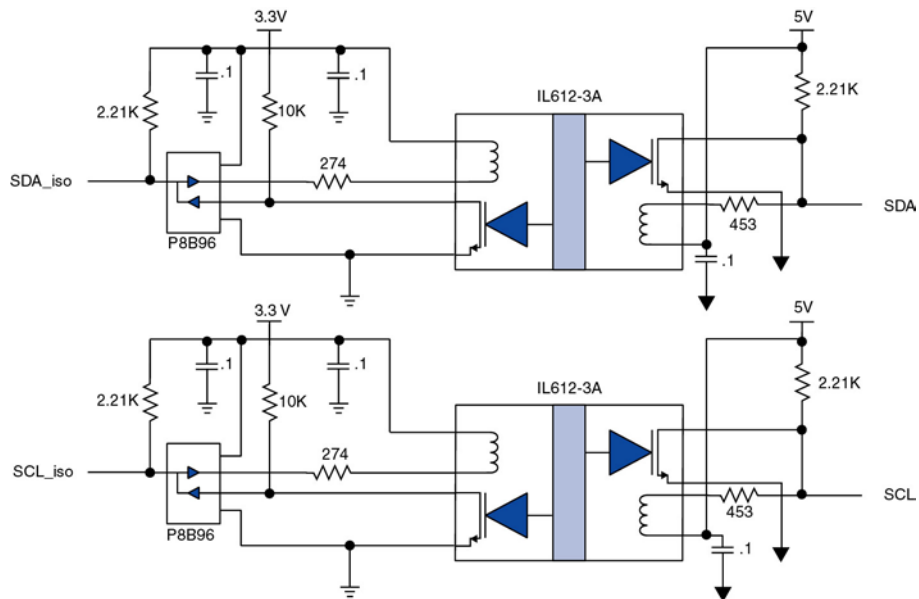


*RS232*

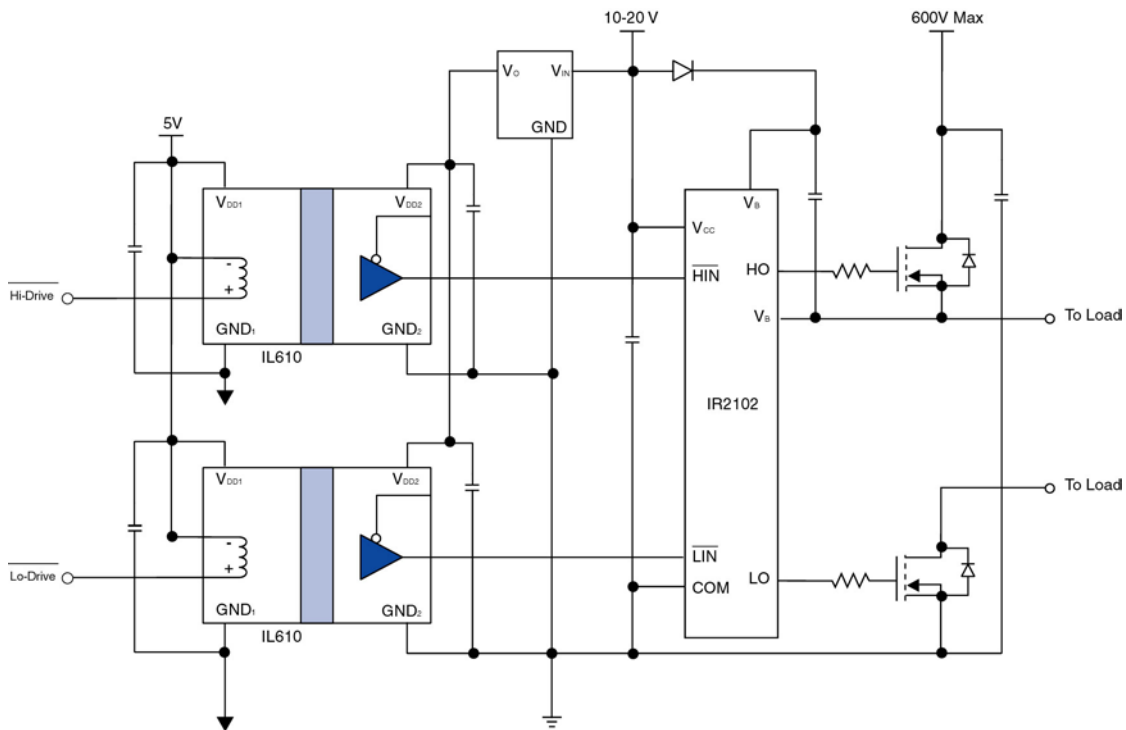




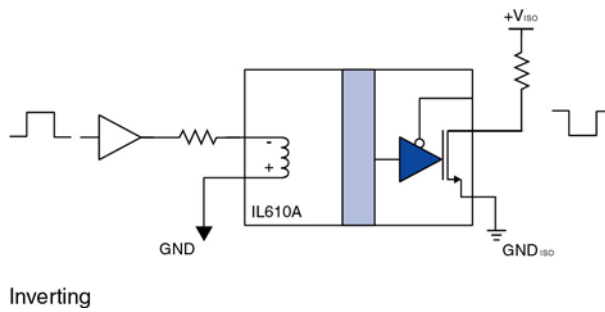
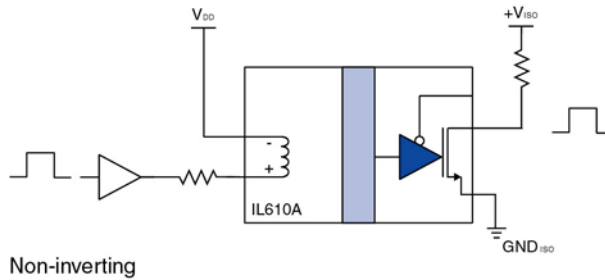
*I<sup>2</sup>C*



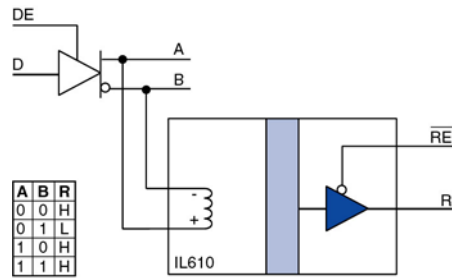
*Single Phase Power Control*



*Inverting and Non-Inverting Circuits*

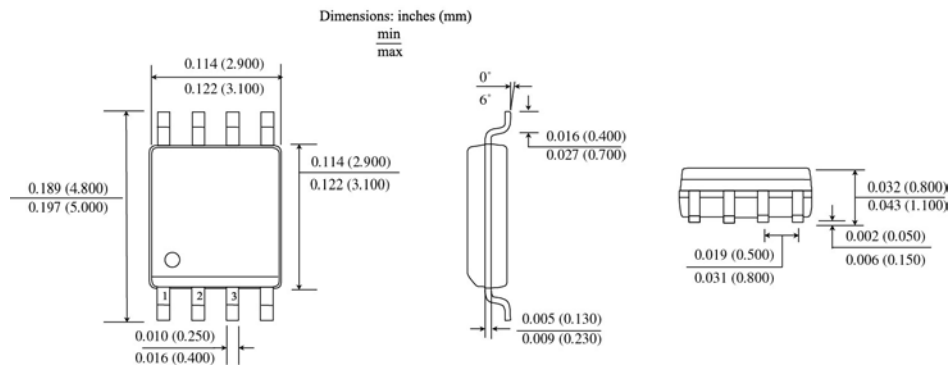


*Differential to Single Ended Conversion*

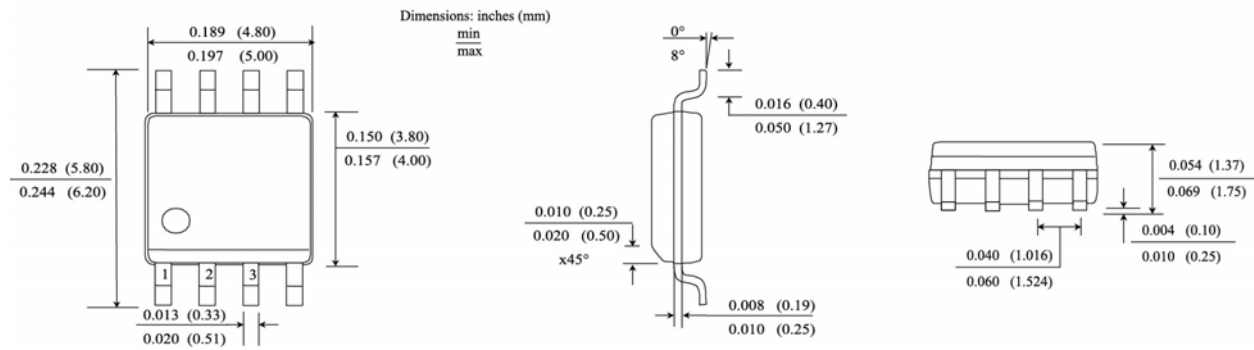


**Package drawings, dimensions and specifications**

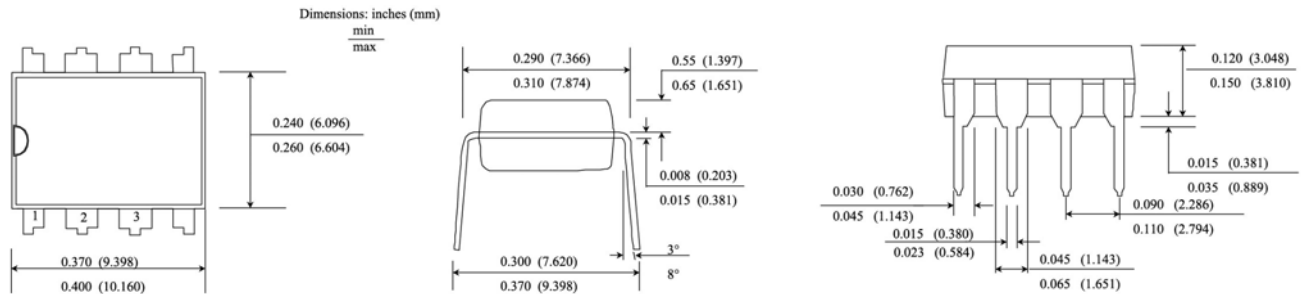
**8-pin MSOP Package**



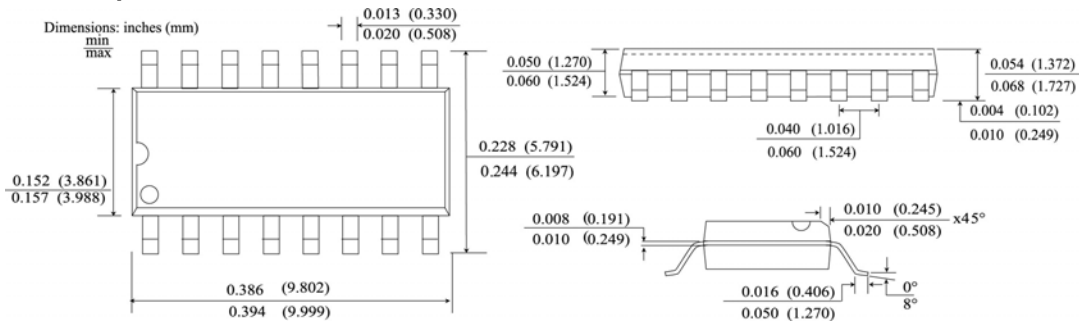
**8-pin SOIC Package**



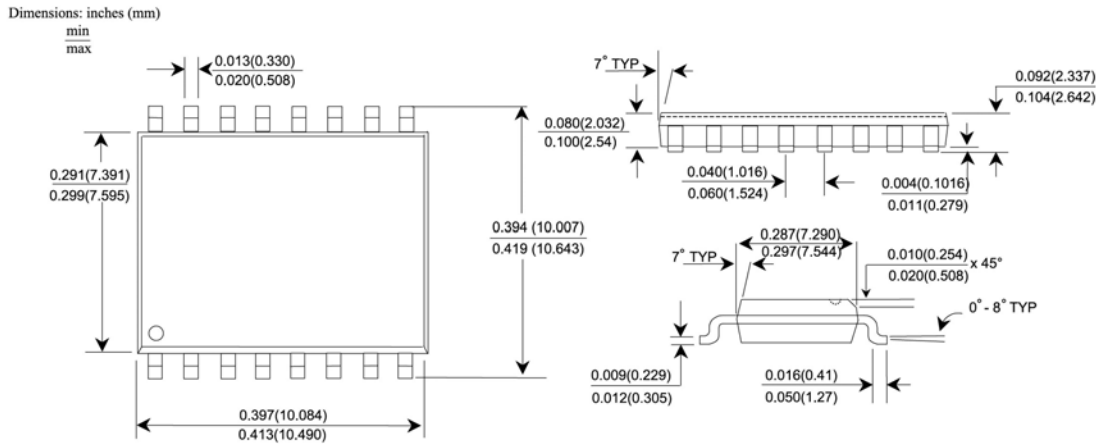
**8-pin PDIP Package**



**0.15" 16-pin SOIC**

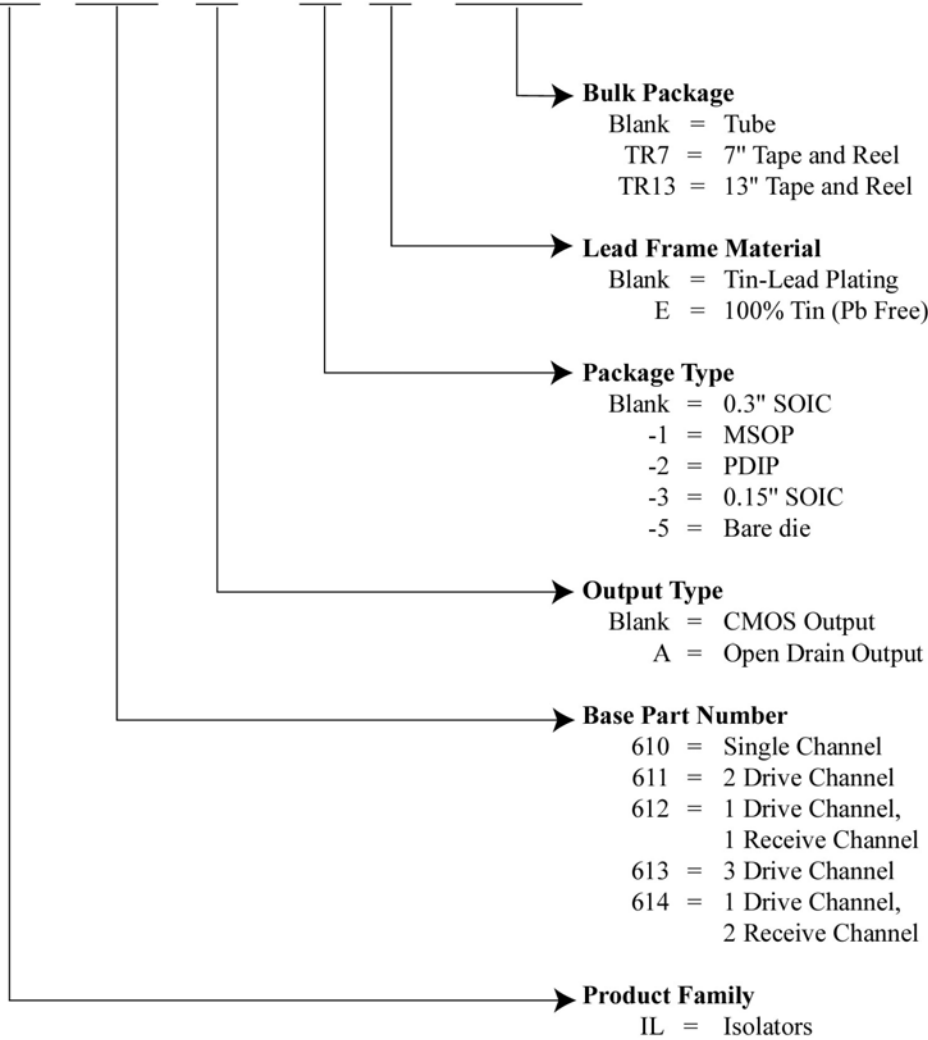


**0.30" 16-pin SOIC**



**Ordering information and valid part numbers.**

**IL 610 A - 1 E TR13**



**IL610 Valid  
Part Numbers**

IL610-1  
 IL610A-1  
 IL610-2  
 IL610A-2  
 IL610-3  
 IL610A-3  
 IL610-5  
 IL610A-5  
 IL610-1TR7  
 IL610A-1TR7  
 IL610-3TR7  
 IL610A-3TR7  
 IL610-1TR13  
 IL610A-1TR13  
 IL610-3TR13  
 IL610A-3TR13

**IL611 Valid  
Part Numbers**

IL611-1  
 IL611A-1  
 IL611-2  
 IL611A-2  
 IL611-3  
 IL611A-3  
 IL611-5  
 IL611A-5  
 IL611-1TR7  
 IL611A-1TR7  
 IL611-3TR7  
 IL611A-3TR7  
 IL611-1TR13  
 IL611A-1TR13  
 IL611-3TR13  
 IL611A-3TR13

**IL612 Valid  
Part Numbers**

IL612-2  
 IL612A-2  
 IL612-3  
 IL612A-3  
 IL612-3TR7  
 IL612A-3TR7  
 IL612-3TR13  
 IL612A-3TR13

**IL613 Valid  
Part Numbers**

IL613  
 IL613TR13  
 IL613-3  
 IL613-3TR7  
 IL613-3TR13

**IL614 Valid  
Part Numbers**

IL614  
 IL614TR13  
 IL614-3  
 IL614-3TR7  
 IL614-3TR13

**Lead Free  
Part Numbers**  
 All part numbers  
 listed above are  
 available in the  
 Lead Free (E)  
 packages.

## **About NVE**

An ISO 9001 Certified Company

NVE Corporation is a high technology components manufacturer having the unique capability to combine leading edge Giant Magnetoresistive (GMR) materials with integrated circuits to make high performance electronic components. Products include Magnetic Field Sensors, Magnetic Field Gradient Sensors (Gradiometer), Digital Magnetic Field Sensors, Digital Signal Isolators and Isolated Bus Transceivers.

NVE is a leader in GMR research and in 1994 introduced the world's first products using GMR material, a line of GMR magnetic field sensors that can be used for position, magnetic media, wheel speed and current sensing.

NVE is located in Eden Prairie, Minnesota, a suburb of Minneapolis. Please visit our Web site at [www.nve.com](http://www.nve.com) or call 952-829-9217 for information on products, sales or distribution.

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***Specifications shown are subject to change without notice.***

ISB-DS-001-IL600-A  
January 28, 2005