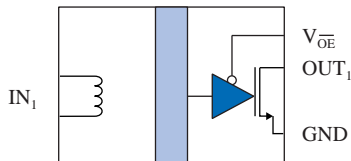
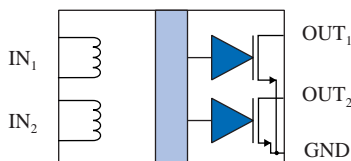


## Passive-Input Digital Isolators – Open Drain Outputs

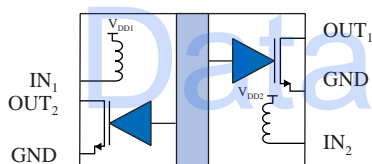
### Functional Diagrams



**IL610A**



**IL611A**



**IL612A**

### Features

- 10 Mbps Data Rate
- Flexible Inputs with Very Wide Input Voltage Range
- 5 mA Input Current
- Failsafe Output (logic high output for zero coil current)
- 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 Transient Immunity
- Low EMC Footprint
- UL1577 and IEC61010-2001 Approval
- 8-Pin MSOP, SOIC, and PDIP Packages

### Applications

- General Purpose Optocoupler Replacement
- Wired-OR Alarms
- SPI Interface
- I<sup>2</sup>C
- RS-485, RS-422, or RS-232
- Space-Critical Multi-Channel Applications
- Isolated Relays and Actuators

### Description

The IL600A-Series are isolated signal couplers with open-drain outputs. They have a similar interface but better performance and higher package density than optocouplers.

The devices are manufactured with NVE's patented\* IsoLoop<sup>®</sup> spintronic Giant Magnetoresistive (GMR) technology for small size, high speed, and low power.

A resistor sets the input current; a capacitor in parallel with the current-limit resistor provides improved dynamic performance.

These versatile components simplify inventory requirements by replacing a variety of optocouplers, functioning over a wide range of data rates, edge speeds, and power supply levels. The devices are available in MSOP, SOIC, and PDIP packages, as well 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	
DC Input Current	$I_{IN}$	-25		25	mA	
AC Input Current (Single-Ended Input)	$I_{IN}$	-35		35	mA	
AC Input Current (Differential Input)	$I_{IN}$	-75		75	mA	
Output Voltage	$V_o$	-0.5		$V_{DD}+1.5$	V	
Maximum Output Current	$I_o$	-10		10	mA	
ESD			2		kV	HBM

Note 1: Operating at absolute maximum ratings will not damage the device. Parametric performance is not guaranteed at absolute maximum ratings.

## 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	
Open Drain Reverse Voltage	$V_{SD}$	-0.5			V	
Open Drain Voltage	$V_{DS}$			6.5	V	
Open Drain Load Current	$I_{OD}$			7	mA	
Common Mode Input Voltage	$V_{CM}$			400	$V_{RMS}$	

## Insulation Specifications

Parameters	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Creepage Distance (external)						
MSOP		3.01			mm	
0.15" SOIC		4.03			mm	
PDIP		7.08			mm	
Internal Isolation Distance			9		$\mu\text{m}$	
Leakage Current			0.2		$\mu\text{A}$	240 $V_{RMS}$ , 60 Hz
Barrier Impedance			$>10^{14}  7$		$\Omega    \text{pF}$	
Rated Voltage (1minute; MSOP)	$V_{ISO}$	1,000			$V_{AC}$	50 Hz to 60 Hz
Rated Voltage (1 min.; SOIC & PDIP)	$V_{ISO}$	2,500			$V_{AC}$	50 Hz to 60 Hz

## Safety and Approvals

### IEC61010-2001

TUV Certificate Numbers: N1502812, N1502812-101

### Classification: Reinforced Insulation

Model	Package	Pollution Degree	Material Group	Max. Working Voltage
IL610A-2, IL611A-2, IL612A-2	PDIP	II	III	300 $V_{RMS}$
IL610A-3, IL611A-3, IL612A-3	SOIC (0.15")	II	III	150 $V_{RMS}$

### UL 1577

Component Recognition Program File Number: E207481

Rated 2,500 $V_{RMS}$  for 1 minute (SOIC, PDIP)

## Soldering Profile

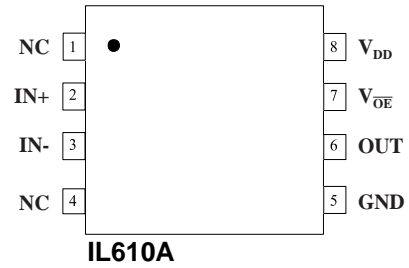
Per JEDEC J-STD-020C

## 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.

## IL610A Pin Connections

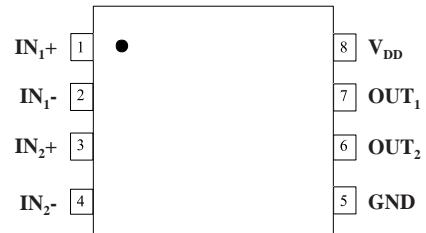
1	NC	No internal connection
2	IN+	Coil connection
3	IN-	Coil connection
4	NC	No internal connection
5	GND	Ground return for $V_{DD}$
6	OUT	Data out
7	$V_{OE}$	Output enable. Internally held low with 100 k $\Omega$
8	$V_{DD}$	Supply Voltage



**IL610A**

## IL611A Pin Connections

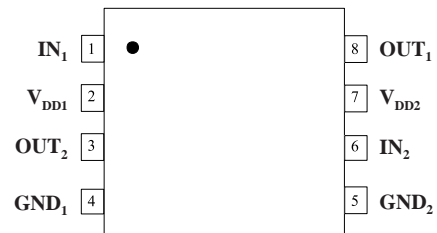
1	IN <sub>1+</sub>	Channel 1 coil connection
2	IN <sub>1-</sub>	Channel 1 coil connection
3	IN <sub>2+</sub>	Channel 2 coil connection
4	IN <sub>2-</sub>	Channel 2 coil connection
5	GND	Ground return for $V_{DD}$
6	OUT <sub>2</sub>	Data out, channel 2
7	OUT <sub>1</sub>	Data out, channel 1
8	$V_{DD}$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



**IL611A**

## 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



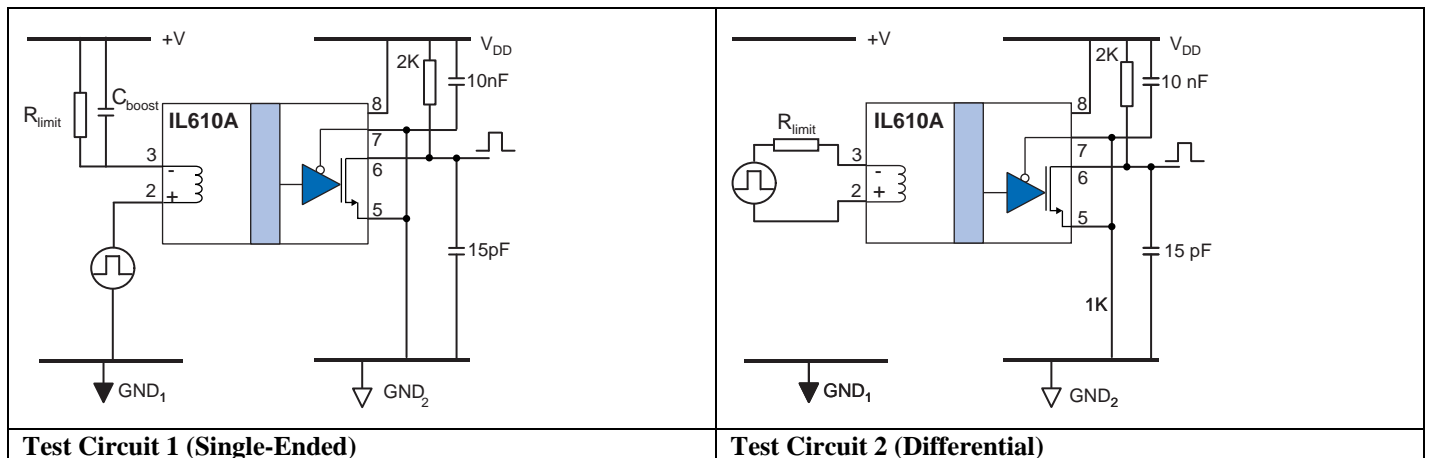
**IL612A**

## Operating Specifications

Input Specifications ( $V_{DD} = 3\text{ V} - 5.5\text{ V}$ ; $T = -40^{\circ}\text{C} - 85^{\circ}\text{C}$ unless otherwise stated)						
Parameters	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Coil Input Resistance	$R_{COIL}$	47	85	112	$\Omega$	$T = 25^{\circ}\text{C}$
		31	85	128	$\Omega$	$T = -40^{\circ}\text{C} - 85^{\circ}\text{C}$
Coil Resistance Temperature Coefficient	$TC R_{COIL}$		0.2	0.25	$\Omega/^{\circ}\text{C}$	
Coil Inductance	$L_{COIL}$		9		nH	
DC Input Threshold (5 V)	$I_{INH-DC}$	0.5	1		mA	Test Circuit 1; $V_{DD} = 4.5\text{ V} - 5.5\text{ V}$
	$I_{INL-DC}$	5	3.5		mA	
DC Input Threshold (3 V)	$I_{INH-DC}$		0.5	0.3	mA	Test Circuit 1; $V_{DD} = 3\text{ V} - 3.6\text{ V}$ ; no boost cap
	$I_{INL-DC}$	8	5		mA	
Dynamic Input Threshold (3 V)	$I_{INH-BOOST}$	0.5	1		mA	$V_{DD} = 3\text{ V} - 3.6\text{ V}$ ; $t_{IR} = t_{IF} = 3\text{ ns}$ ; $C_{BOOST} = 16\text{ pF}$
	$I_{INL-BOOST}$	5	3.5		mA	
Differential Input Threshold	$I_{INH-DIFF}$	0.5	1		mA	Test Circuit 2; $V_{DD} = 3\text{ V} - 5.5\text{ V}$ ; input current reverses; boost cap not required
	$I_{INL-DIFF}$	5	3.5		mA	
Failsafe Input Current <sup>(1)</sup> (5 V)	$I_{FS-HIGH}$	-25		0.5	mA	Test Circuit 1; $V_{DD} = 4.5\text{ V} - 5.5\text{ V}$
	$I_{FS-LOW}$	5		25	mA	
Failsafe Input Current <sup>(1)</sup> (3 V)	$I_{FS-HIGH}$	-25		0.3	mA	Test Circuit 1; $V_{DD} = 3\text{ V} - 3.6\text{ V}$
	$I_{FS-LOW}$	8		25	mA	
Input Signal Rise and Fall Times	$t_{IR}, t_{IF}$			1	$\mu\text{s}$	
Common Mode Transient Immunity	$ CM_H ,  CM_L $	15	20		kV/ $\mu\text{s}$	$V_T = 300\text{ V}_{peak}$

### Notes:

- Failsafe Operation is defined as the guaranteed output state which will be achieved if the DC input current falls between the input levels specified (see Test Circuit 1 for details). Note if Failsafe to Logic Low is required, the DC current supplied to the coil must be at least 8 mA using 3.3 V supplies versus 5 mA for 5 V supplies.



Electrical Specifications ( $V_{DD} = 3\text{ V} - 5.5\text{ V}$ ; $T = -40^{\circ}\text{C} - 85^{\circ}\text{C}$ unless otherwise stated)						
Parameters	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Quiescent Supply Current (5 V)						
IL610A	$I_{DD}$		2	3	mA	$V_{DD} = 5\text{ V}$ , $I_{IN} = 0$ $R_{pullup} = \text{open circuit}$
IL611A	$I_{DD}$		4	6	mA	
IL612A	$I_{DD1}$		2	3	mA	
IL612A	$I_{DD2}$		2	3	mA	
Quiescent Supply Current (3.3 V)						
IL610A	$I_{DD}$		1.3	2	mA	$V_{DD} = 3.3\text{ V}$ , $I_{IN} = 0$ $R_{pullup} = \text{open circuit}$
IL611A	$I_{DD}$		2.6	4	mA	
IL612A	$I_{DD1}$		1.3	2	mA	
IL612A	$I_{DD2}$		1.3	2	mA	
Logic High Output Voltage <sup>(1)</sup>	$V_{OH}$		$V_{DD}$		V	Off State
Logic Low Output Voltage	$V_{OL}$		0	0.1	V	$I_O = -20\ \mu\text{A}$
			0.4	0.8	V	$I_O = -4\text{ mA}$
Logic Output Current	$ I_O $	7	10		mA	

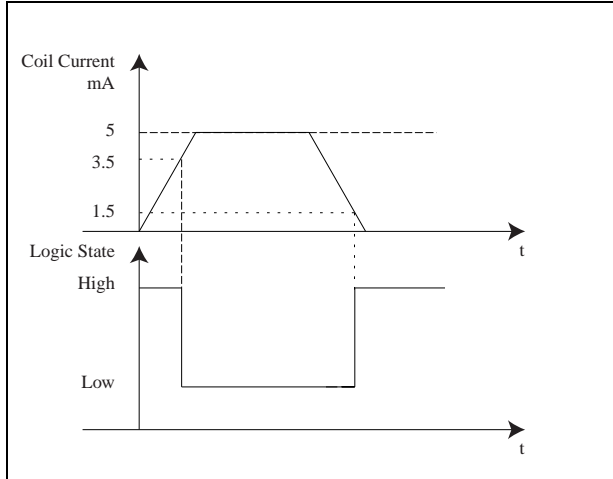
Switching Specifications ( $V_{DD} = 3\text{ V} - 5.5\text{ V}$ ; $T = -40^{\circ}\text{C} - 85^{\circ}\text{C}$ unless otherwise stated)						
Parameters	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Input Signal Rise and Fall Times	$t_{IR}$ , $t_{IF}$			10	$\mu\text{s}$	Test Circuit 1; $t_{IR} = t_{IF} = 3\text{ ns}$ ; $C_{BOOST} = 16\text{ pF}$
Data Rate		10			Mbps	
Minimum Pulse Width	PW	100			ns	
Propagation Delay Input to Output (High to Low)	$t_{PHL}$		20	25	ns	
Propagation Delay Input to Output (Low to High)	$t_{PLH}$		50	75	ns	

**Notes:**

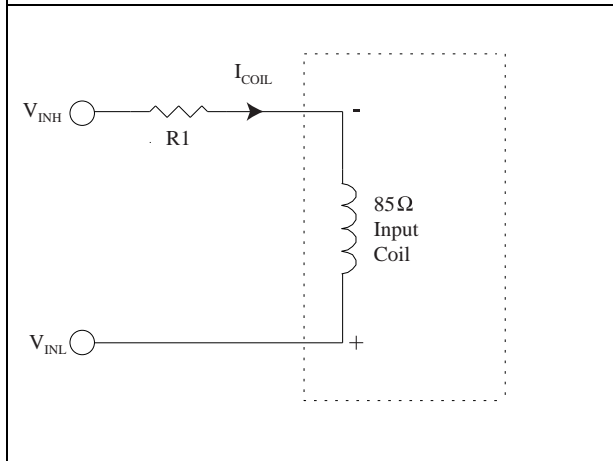
- $V_{DD}$  refers to the supply voltage on the output side of the isolated channel.
- Failsafe Operation is defined as the guaranteed output state which will be achieved if the DC input current falls between the input levels specified (see Test Circuit 1 for details). Note if Failsafe to Logic Low is required, the DC current supplied to the coil must be at least 8 mA using 3.3 V supplies versus 5 mA for 5 V supplies.

## Applications Information

IL600-Series Isolators are current mode devices. Changes in current flow into the input coil result in logic state changes at the output. As shown in Figure 1, output logic high is the zero input current state.



**Figure 1. Typical IL600-Series Transfer Function**



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

coil metals under constant current flow. In single ended mode, long-term DC current flow above 25 mA can cause erosion of the coil metal. In differential mode, erosion takes place in both directions as each current cycle reverses and has a net effect of zero up to the absolute maximum current.

An advantage over optocouplers and other high-speed couplers in differential mode is that no reverse bias protection for the input structure is required for a differential signal.

One of the more common applications is for an isolated Differential Line Receiver. For example, RS-485 can drive an IL610 directly for a fraction of the cost of an isolated RS-485 node (see *Illustrative Applications*).

### Coil Polarity

The device switches to logic low if current flows from (In-) to (In+). Note that the designations “In-“ and “In+” refer to logic levels, not current flow. Positive values of current mean current flow into the In- input.

### Input Resistor Selection

Resistors set the coil input current (see Figure 2). There is no limit to input voltages because there are no semiconductor input structures.

Worst-case logic low threshold current is 8 mA, which is for single-ended operation with a 3 V supply. In differential mode, where the input current reverses, the logic low threshold current is 5 mA for the range of supplies. A “boost capacitor” creates current reversals at edge transitions, reducing the input logic low threshold current to the differential level of 5 mA.

### Typical Resistor Values

$V_{COIL}$	<b>0.125W, 5% Resistor</b>
3.3 V	510 $\Omega$
5 V	820 $\Omega$

The table shows typical values for the external resistor for 5 mA coil current. The values are

approximate and should be adjusted for temperature or other application specifics. If the expected temperature range is large, 1% tolerance resistors may provide additional design margin.

### Single-Ended or Differential Input

The IL610, IL611, IL613, and channel 1 of the IL614 can be run with single-ended or differential inputs (see Test Circuits on page 5). In the differential mode, current will naturally flow through the coil in both directions without a boost capacitor, although the capacitor can still be used for increased external field immunity or improved PWD.

Absolute Maximum recommended coil current in single-ended mode is 25 mA while differential mode allows up to  $\pm 75$  mA to flow. The difference in specifications is due to the risk of electromigration of

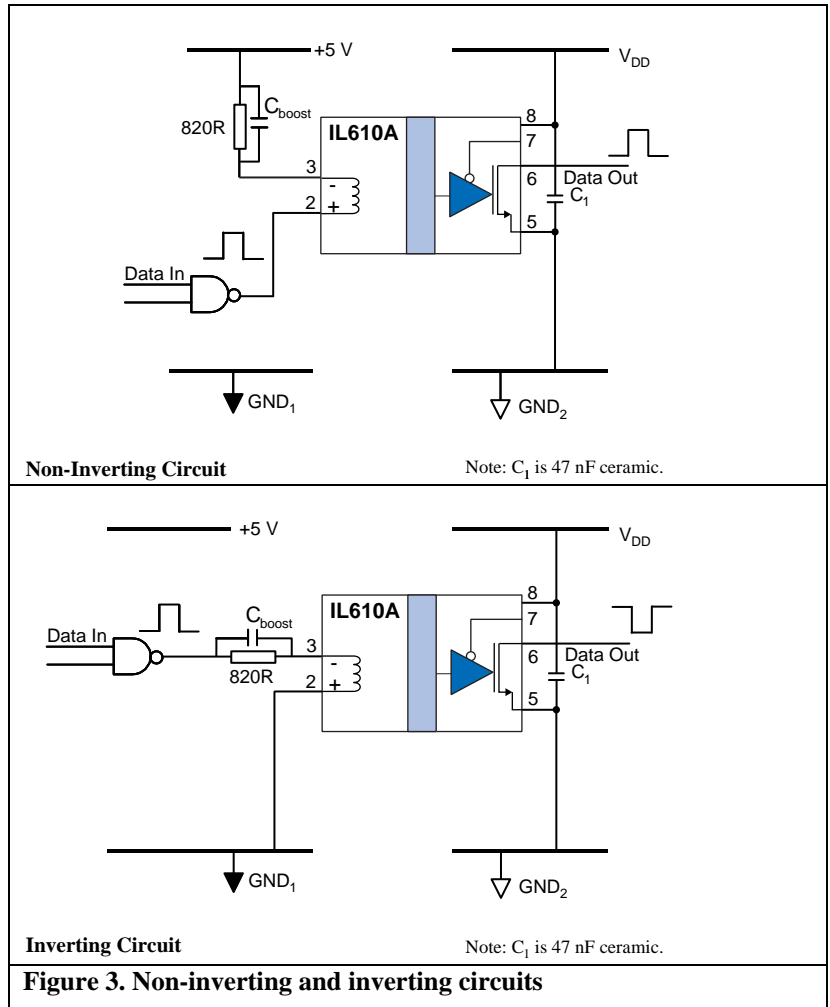
## Non-inverting and Inverting Configurations

IL600-Series Isolators can be configured in non-inverting and inverting configurations (see Figure 3). In a typical non-inverting circuit, the In<sup>-</sup> terminal is connected via a 1 kΩ input resistor to the supply rail, and the input is connected to the In<sup>+</sup> terminal. The supply voltage is +5 V and the input signal is a 5 V CMOS signal. When a logic high (+5 V) is applied to the input, the current through the coil is zero. When the input is a logic low (0 V), at least 5 mA flows through the coil from the In<sup>-</sup> side to the In<sup>+</sup> side.

The inverting configuration is similar to standard logic. In the inverting configuration, the signal into the coil is differential with respect to ground. The designer must ensure that the difference between the logic low voltage and the coil ground is such that the residual coil current is less than 0.5 mA.

The IL612 and IL614 devices have some inputs that do not offer inverting operation. The IL612 coil In<sup>-</sup> input is hardwired internally to the device power supply; therefore it is important to ensure the isolator power supply is at the same voltage as the power supply to the source of the input logic signal. The IL614 has a common coil In<sup>-</sup> for two inputs. This pin should be connected to the power supply for the logic driving channels 2 and 3, and the channels run should be run in non-inverting mode.

Both single ended and differential inputs can be handled without reverse bias protection.



**Non-Inverting Circuit**

Note: C<sub>1</sub> is 47 nF ceramic.

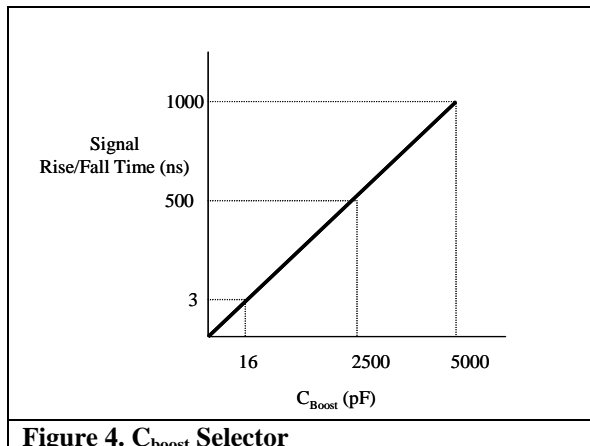
**Inverting Circuit**

Note: C<sub>1</sub> is 47 nF ceramic.

**Figure 3. Non-inverting and inverting circuits**

## Boost Capacitor

The boost capacitor in parallel with the current-limiting resistor boosts the instantaneous coil current at the signal transition. This ensures switching and reduces propagation delay and reduces pulse-width distortion.



**Figure 4. C<sub>boost</sub> Selector**

**Select the value of the boost capacitor based on the rise and fall times of the signal driving the inputs.** The instantaneous boost capacitor current is proportional to input edge speeds ( $C \frac{dV}{dt}$ ). Select a capacitor value based on the rise and fall times of the input signal to be isolated that provides approximately 20 mA of additional “boost” current. Figure 4 is a guide to boost capacitor selection. For high-speed logic signals ( $t_r, t_f < 10$  ns), a 16 pF capacitor is recommended. The capacitor value is generally not critical; if in doubt, choose a higher value.

## Dynamic Power Consumption

Power consumption is proportional to duty cycle, not data rate. The use of NRZ coding minimizes power dissipation since no additional power is consumed when the output is in the high state. In differential mode, where the logic high condition may still require a current to be forced through the coil, power consumption will be higher than a typical NRZ single ended configuration.

## Power Supply Decoupling

47 nF low-ESR ceramic capacitors are recommended to decouple the power supplies. The capacitors should be placed as close as possible to the appropriate  $V_{DD}$  pin.

## Electromagnetic Compatibility and Magnetic Field Immunity

Because IL600-Series Isolators are completely static, they have the lowest emitted noise of any non-optical isolators.

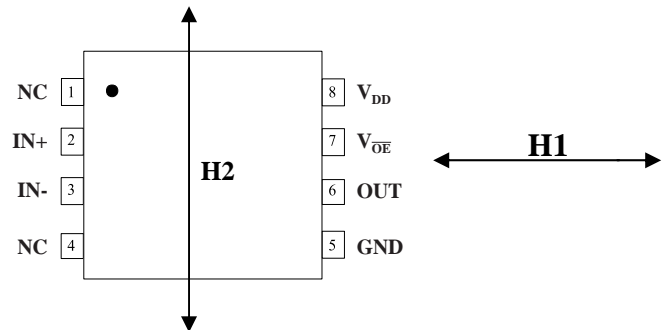
IsoLoop Isolators operate by imposing a magnetic field on a GMR sensor, which translates the change in field into a change in logic state. A magnetic shield and a Wheatstone Bridge configuration provide good immunity to external magnetic fields.

Immunity to external magnetic fields can be enhanced by proper orientation of the device with respect to the field direction, the use of differential signaling, and boost capacitors.

### 1. Orientation of the device with respect to the field direction

An applied field in the “H1” direction is the worst case for magnetic immunity. In this case the external field is in the same direction as the applied internal field. In one direction it will tend to help switching; in the other it will hinder switching. This can cause unpredictable operation.

An applied field in direction “H2” has considerably less effect and results in higher magnetic immunity.



### 2. Differential Signaling and Boost Capacitors

Regardless of orientation, driving the coil differentially improves magnetic immunity. This is because the logic high state is driven by an applied field instead of zero field, as is the case with single-ended operation. The higher the coil current, the higher the internal field, and the higher the immunity to external fields. Optimal magnetic immunity is achieved by adding the boost capacitor.

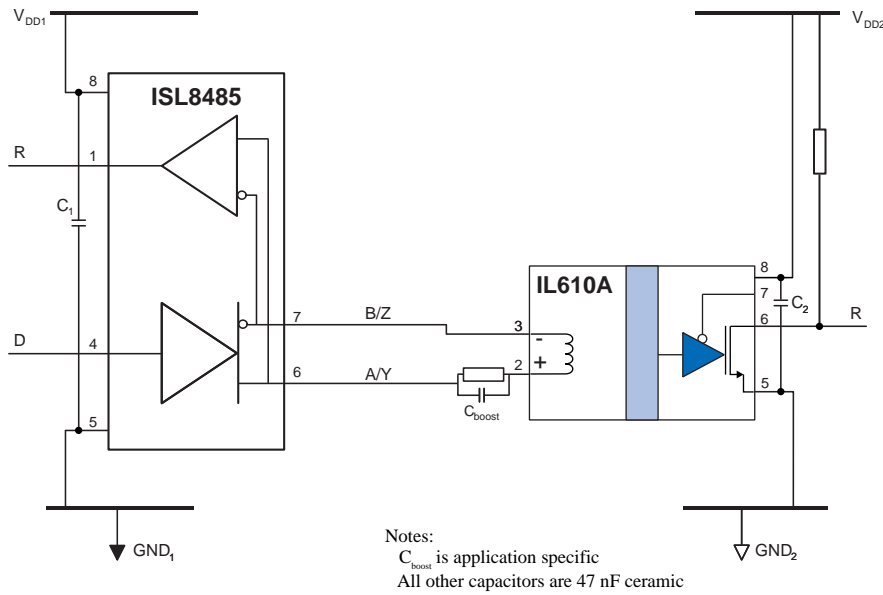
Method	Approximate Immunity	Immunity Description
Field applied in H1 direction	$\pm 20$ Gauss	A DC current of 16 A flowing in a conductor 1 cm from the device could cause disturbance.
Field applied in H2 direction	$\pm 70$ Gauss	A DC current of 56 A flowing in a conductor 1 cm from the device could cause disturbance.
Field applied in any direction but with boost capacitor (16 pF) in circuit	$\pm 250$ Gauss	A DC current of 200 A flowing in a conductor 1 cm from the device could cause disturbance.

## Data Rate and Magnetic Field Immunity

It is easier to disrupt an isolated DC signal with an external magnetic field than it is to disrupt an isolated AC signal. Similarly, a DC magnetic field will have a greater effect on the device than an AC magnetic field of the same effective magnitude. For example, signals with pulses longer than 100  $\mu$ s are more susceptible to magnetic fields than shorter pulse widths.



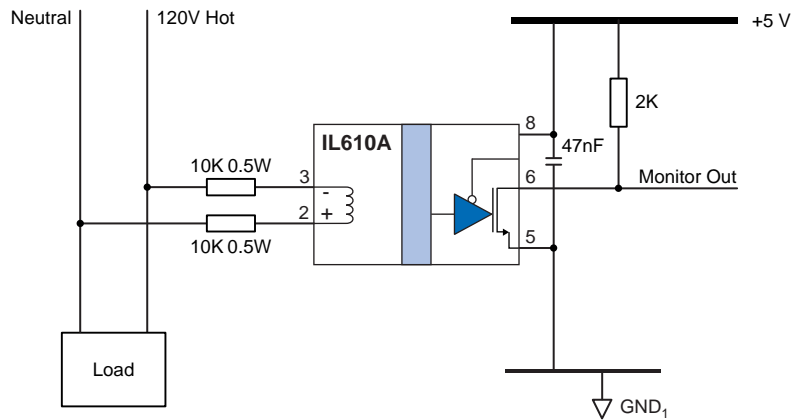
## Illustrative Applications



### Isolated RS-485 and RS-422 Receivers Using IL610As

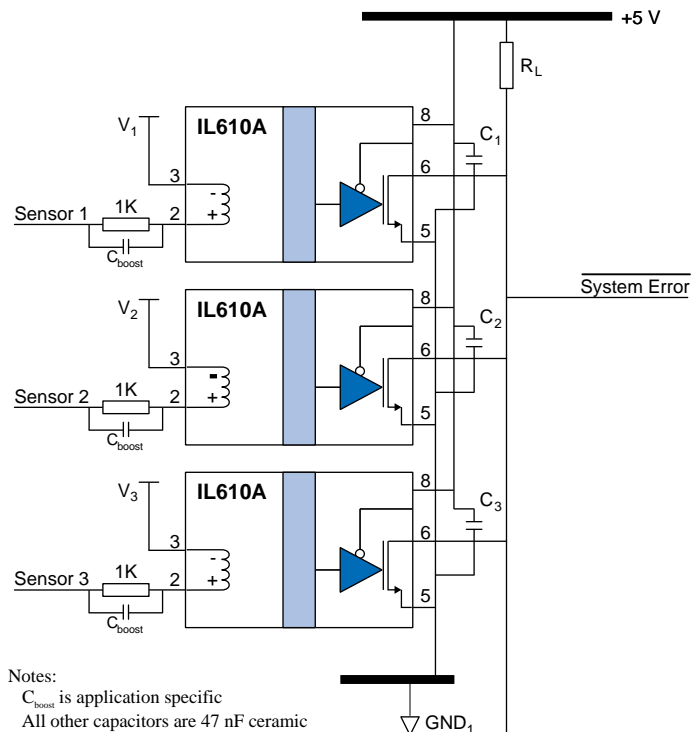
IL610As can be used as simple isolated RS-485 or RS-422 receivers, terminating signals at the IL610A for a fraction of the cost of an isolated node. Cabling is greatly simplified by eliminating the need to power the input side of the receiving board. No current-limiting resistor is needed for a single receiver because it will draw less current than the driver maximum. Current limiting resistors allow at least eight nodes without exceeding the maximum load of the transceiver chip. Placement of the current-limiting resistors on both lines provides better dynamic signal balance. There is no need for line termination resistors because the IL610A coil resistance of approximately 85  $\Omega$  is close to the characteristic impedance of most cables. The circuit is intrinsically open circuit failsafe because the IL610A is guaranteed to switch to the high state when the coil input current is less than 500  $\mu$ A. For higher speed, a faster output device (such as the CMOS-output IL600-Series Isolators) are needed as well as possibly better impedance matching.

Number of Nodes	Current Limit Resistors ( $\Omega$ )
1	None
2	17
3	22
4	27
5	27
6	2
7	30
8	30



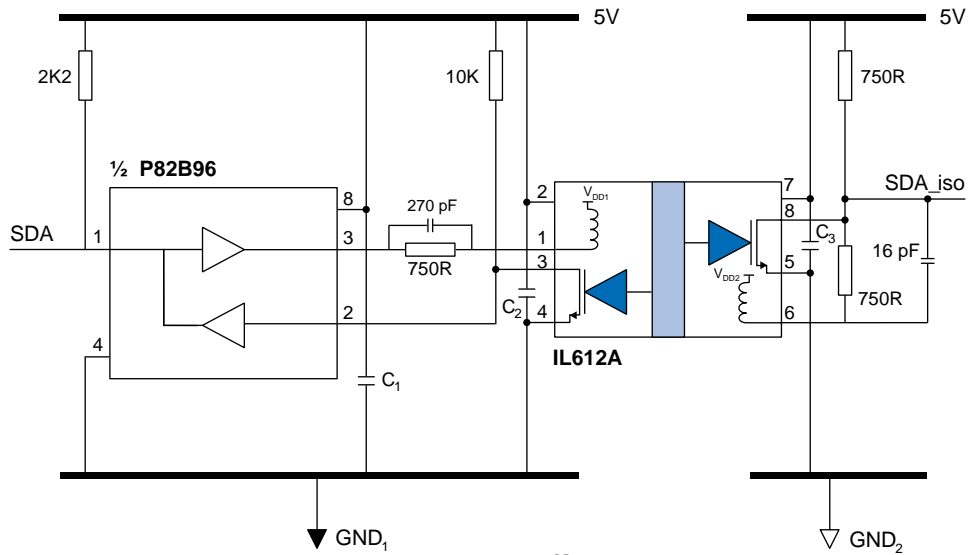
### Isolated 120 V Line Monitor

The wide input voltage range of IL600 Isolators allow connection to line voltage through current-limiting resistors. In this illustrative circuit, "Monitor Out" goes low when line voltage exceeds approximately 100 V, and high when line voltage drops below approximately 10 V.



### Multi-channel Isolated Alarm Monitor

The open-drain outputs of IL600A-Series Isolators allow wired-OR outputs. The inputs can be configured for inverting or non-inverting operation (see Applications Information), and a very wide input voltage range is possible. This illustrative circuit provides fail-safe output (logic high output for zero coil current) and typical logic output sink current of 10 mA for each isolator.



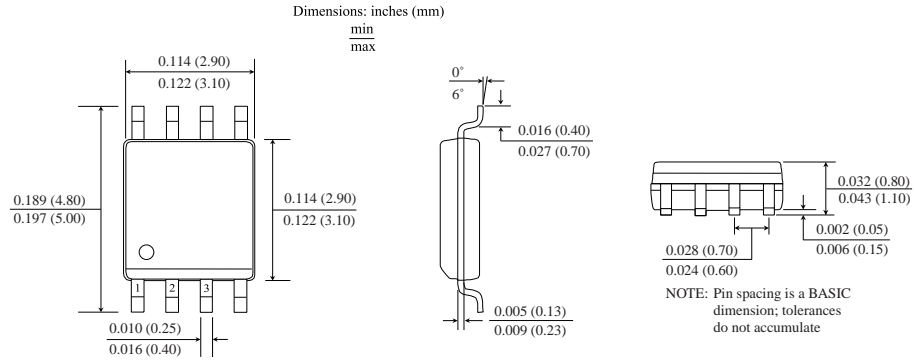
Notes:  
C1, C2, and C3 are 47nF ceramic  
Resistor values change for 3 V operation

### Isolation of I<sup>2</sup>C Nodes

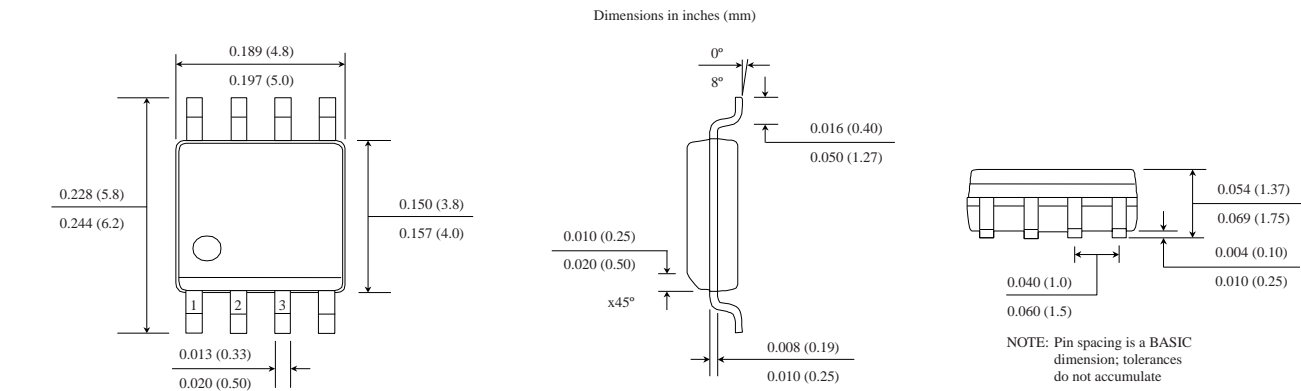
This circuit provides bidirectional isolation of I<sup>2</sup>C bus signals with no restrictions on data rate and none of the I<sup>2</sup>C bus latch-up problems common with other isolation circuits. The SCL section is similar as shown in the schematic using the other half of the P82B96.

## Package Drawings, Dimensions and Specifications

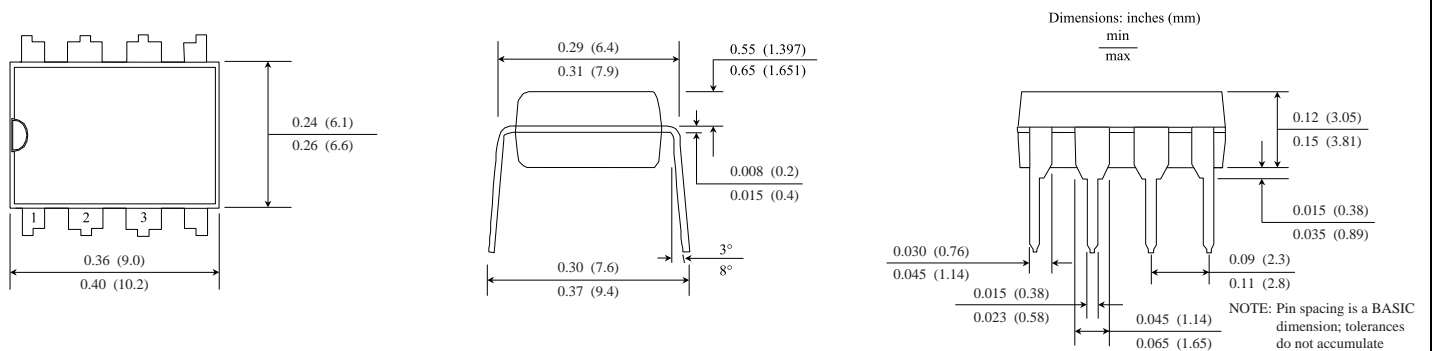
### 8-pin MSOP



### 8-pin SOIC Package

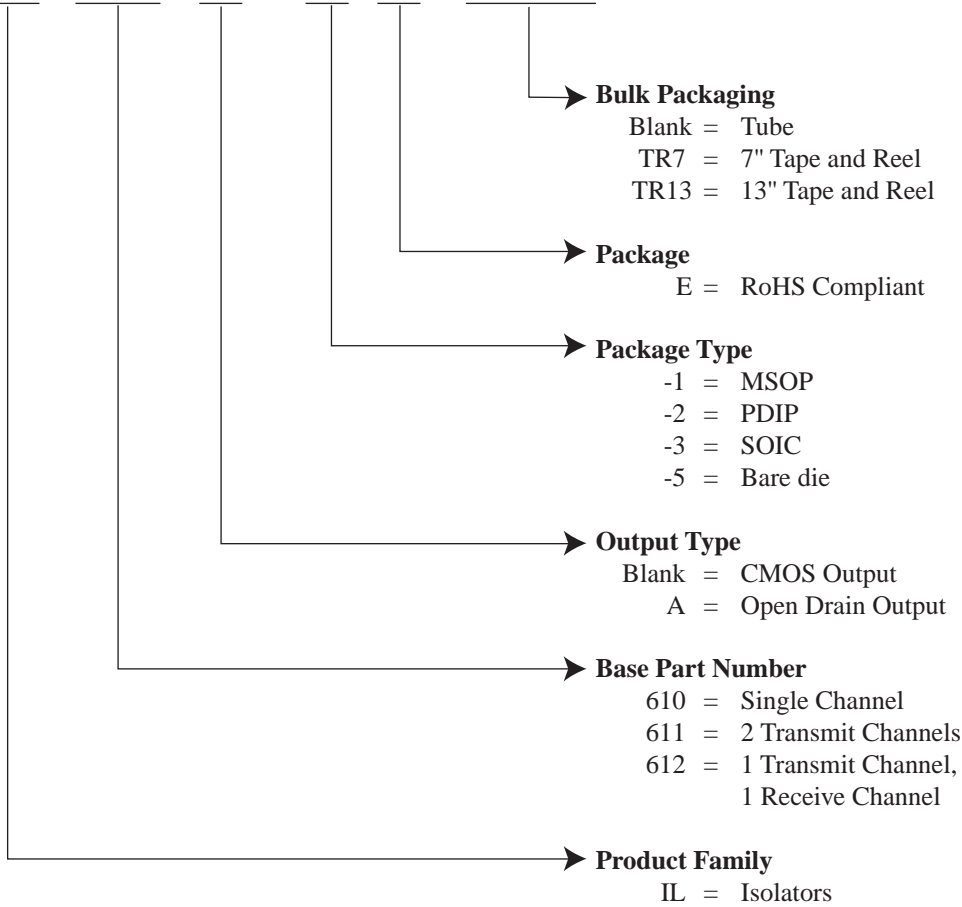


### 8-pin PDIP



## Ordering Information and Valid Part Numbers

IL 610 A - 1 E TR13



### IL610A Valid Part Numbers

IL610A-1E  
IL610A-2E  
IL610A-3E  
IL610A-5  
IL610A-1ETR7  
IL610A-3ETR7  
IL610A-1ETR13  
IL610A-3ETR13

### IL611A Valid Part Numbers

IL611A-1E  
IL611A-2E  
IL611A-3E  
IL611A-1ETR7  
IL611A-3ETR7  
IL611A-1ETR13  
IL611A-3ETR13

### IL612A Valid Part Numbers

IL612A-2E  
IL612A-3E  
IL612A-3ETR7  
IL612A-3ETR13



## Revision History

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**ISB-DS-001-IL600A-V**  
**May 2012**

**Changes**

- Separated and clarified Input Specifications.
- Added minimum/maximum coil resistance specifications.
- Merged and simplified “Operation” and “Applications” sections.

**ISB-DS-001-IL600A-U**

**Changes**

- Update terms and conditions.

**ISB-DS-001-IL600A-T**

**Changes**

- Additional changes to pin spacing specification on MSOP package drawing.

**ISB-DS-001-IL600A-S**

**Changes**

- Changed pin spacing specification on MSOP package drawing.

**ISB-DS-001-IL600A-R**

**Changes**

- Clarified failsafe operation input current (p. 4).

**ISB-DS-001-IL600A-Q**

**Changes**

- P. 2—Deleted MSOP IEC61010 approval.

**ISB-DS-001-IL600A-P**

**Changes**

- Added EMC details.

**ISB-DS-001-IL600A-O**

**Changes**

- Clarified I<sup>2</sup>C application diagram and expanded caption (p. 13).

**ISB-DS-001-IL600A-N**

**Changes**

- IEC 61010 approval for MSOP versions.

**ISB-DS-001-IL600A-M**

**Changes**

- Specify coil resistance as typical only.
- Revise section on calculating limiting resistors.

**ISB-DS-001-IL600A-L**

**Changes**

- Note on all package drawings that pin-spacing tolerances are non-accumulating; change MSOP pin-spacing dimensions and tolerance accordingly.

**ISB-DS-001-IL600A-K**

**Changes**

- Change lower limit of length on PDIP package drawing.
- Tightened pin-spacing tolerance on MSOP package drawing.

**ISB-DS-001-IL600A-J**

**Changes**

- Changed ordering information to reflect that devices are now fully RoHS compliant with no exemptions.

**ISB-DS-001-IL600A-I**

**Changes**

- Added differential drive specifications
- Eliminated soldering profile chart

**ISB-DS-001-IL600A-H**

**Changes**

- Changed RS-485 transceiver
- Revised I<sup>2</sup>C circuit component values

**ISB-DS-001-IL600A-G**

**Changes**

- Added enhanced failsafe specification

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