

## ISL3160E

±10kV ESD Protected, +125°C, 40Mbps, 5V, Full-Duplex, Full Fail-Safe  
RS-485/RS-422 Transceiver

FN8980  
Rev.0.00  
Mar 21, 2018

The [ISL3160E](#) is a ±10kV IEC61000 ESD protected, 5V powered, full-duplex transceiver that meets both the RS-485 and RS-422 standards for balanced communication. It also features a large differential output voltage and high data rate (up to 40Mbps) and is offered in the standard industrial (-40°C to +85°C) and extended industrial (-40°C to +125°C) temperature ranges. The low bus currents (+220μA/-150μA) present a 1/5 unit load to the RS-485 bus. This allows up to 160 transceivers on the network without violating the RS-485 specification's load limit and without using repeaters.

This transceiver requires a 5V ±10% tolerance supply, and delivers at least a 2.1V differential output voltage over this supply range. This translates into better noise immunity (data integrity), longer reach, or the ability to drive up to six 120Ω terminations in “star” or other nonstandard bus topologies at the exceptional 40Mbps data rate.

SCSI applications benefit from the ISL3160E's low receiver and transmitter part-to-part skews. The ISL3160E is perfect for high speed parallel applications requiring simultaneous capture of large numbers of bits. The low bit-to-bit skew eases the timing constraints on the data latching signal.

Receiver (Rx) inputs feature a “full fail-safe” design, which ensures a logic high Rx output if Rx inputs are floating, shorted, or terminated but undriven. Rx outputs feature high drive levels (typically >30mA at  $V_{OL} = 1V$ ) to ease the design of optically isolated interfaces.

Hot plug circuitry ensures that the Tx and Rx outputs remain in a high impedance state while the power supply stabilizes.

Driver (Tx) outputs are short-circuit protected, even for voltages exceeding the power supply voltage. Additionally, on-chip thermal shutdown circuitry disables the Tx outputs to prevent damage if power dissipation becomes excessive.

### Related Literature

For a full list of related documents, visit our website

- [ISL3160E](#) product page

### Features

- High ESD protection on RS-485 I/O pins: ±10kV
- Class 3 HBM ESD level on all other pins: >3kV
- Large differential  $V_{OUT}$  2.8V into 54Ω better noise immunity, or drive up to 6 terminations
- High data rates: up to 40Mbps
- Specified for +125°C operation (FBZ), +85°C (IBZ)
- 11/13ns (maximum) Tx/Rx propagation delays; 1.5ns (maximum) skew
- 1/5 unit load allows up to 160 devices on the bus
- Full fail-safe (open, shorted, terminated/undriven) receiver
- High Rx  $I_{OL}$  to drive opto-couplers for isolated applications
- Hot plug - Tx and Rx outputs remain three-state during power-up
- Low quiescent supply current: 4mA
- Low current shutdown mode: 1μA
- -7V to +12V common-mode input voltage range
- Three-state Rx and Tx outputs
- Operates from a single +5V supply (10% tolerance)
- Current limiting and thermal shutdown for driver overload protection
- Pb-free (RoHS compliant)

### Applications

- Industrial robotics
- SCSI “fast 40” drivers and receivers
- Motor controller/position encoder systems
- Factory automation
- Field bus networks
- Security networks
- Building environmental control systems
- Industrial/process control networks

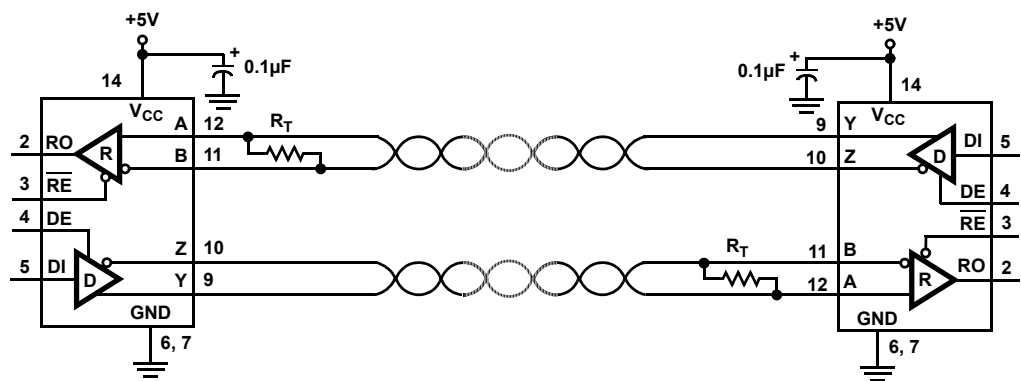


Figure 1. Typical Operating Circuit

## 1. Overview

### 1.1 Ordering Information

Part Number (Notes 2, 3)	Part Marking	Temp. Range (°C)	Tape and Reel (Units)	Package (RoHS Compliant)	Pkg. Dwg. #
ISL3160EIBZ	ISL3160 EIBZ	-40 to +85	-	14 Ld SOIC	M14.15
ISL3160EIBZ-T (Note 1)	ISL3160 EIBZ	-40 to +85	2.5k	14 Ld SOIC	M14.15
ISL3160EFBZ	ISL3160 EFBZ	-40 to +125	-	14 Ld SOIC	M14.15
ISL3160EFBZ-T (Note 1)	ISL3160 EFBZ	-40 to +125	2.5k	14 Ld SOIC	M14.15

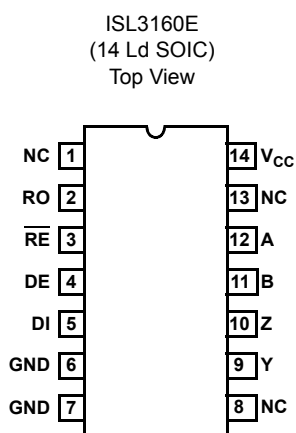
Notes:

1. Refer to [TB347](#) for details about reel specifications.
2. Pb-free plus anneal products employ special Pb-free material sets; molding compounds/die attach materials and 100% matte tin plate termination finish, which are RoHS compliant and compatible with both SnPb and Pb-free soldering operations. Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J STD-020.
3. For Moisture Sensitivity Level (MSL), refer to the [ISL3160E](#) product information page. For more information about MSL, refer to [TB363](#).

Table 1. Key Differences Between High-Speed Interface Family of Parts

Part Number	Full/Half Duplex	V <sub>CC</sub> (V)	V <sub>OD</sub> (V)	Data Rate (Mbps)
ISL3160E	Full	5	2.1	40
ISL3159E	Half	5	2.1	40
ISL3259E	Half	5	2.1	100
ISL3179E	Half	3.3	1.5	40
ISL3180E	Full	3.3	1.5	40

### 1.2 Pin Configurations



### 1.3 Pin Descriptions

Pin Number	Pin	Function
2	RO	Receiver output. If $A - B \geq -50\text{mV}$ , RO is high. If $A - B \leq -200\text{mV}$ , RO is low. If A and B are unconnected (floating) or shorted, or connected to a terminated bus that is undriven, RO is high.
3	$\overline{\text{RE}}$	Receiver output enable. RO is enabled when $\overline{\text{RE}}$ is low. RO is high impedance when $\overline{\text{RE}}$ is high. If the Rx enable function isn't required, connect $\overline{\text{RE}}$ directly to GND.
4	DE	Driver output enable. The driver outputs, Y and Z, are enabled by bringing DE high. They are high impedance when DE is low. If the Tx enable function isn't required, connect DE to $V_{\text{CC}}$ through a 1k $\Omega$ or greater resistor.
5	DI	Driver input. A low on DI forces output Y low and output Z high. Similarly, a high on DI forces output Y high and output Z low.
6, 7	GND	Ground connection.
9	Y	$\pm 10\text{kV}$ IEC61000 ESD protected RS-485/422 level, non-inverting driver output.
10	Z	$\pm 10\text{kV}$ IEC61000 ESD protected RS-485/422 level, inverting driver output.
11	B	$\pm 10\text{kV}$ IEC61000 ESD protected RS-485/422 level, inverting receiver input.
12	A	$\pm 10\text{kV}$ IEC61000 ESD protected RS-485/422 level, non-inverting receiver input.
14	$V_{\text{CC}}$	System power supply input (4.5V to 5.5V).
1, 8, 13	NC	No internal connection.

### 1.4 Truth Tables

Driver				
Inputs			Outputs	
$\overline{\text{RE}}$	DE	DI	B/Z	A/Y
X	1	1	0	1
X	1	0	1	0
0	0	X	High-Z	High-Z
1	0	X	High-Z ( <a href="#">Note 4</a> )	High-Z ( <a href="#">Note 4</a> )

Receiver			
Inputs			Output
$\overline{\text{RE}}$	DE	A-B	RO
0	X	$V_{\text{AB}} \geq -0.05\text{V}$	1
0	X	$-0.05\text{V} > V_{\text{AB}} > -0.2\text{V}$	Undetermined
0	X	$V_{\text{AB}} \leq -0.2\text{V}$	0
0	X	Inputs Open/Shorted	1
1	1	X	High-Z
1	0	X	High-Z ( <a href="#">Note 4</a> )

Note:

4. Shutdown mode

## 2. Specifications

### 2.1 Absolute Maximum Ratings

Parameter	Minimum	Maximum	Unit
$V_{CC}$ to GND		+7	V
Input Voltages DI, DE, $\overline{RE}$	-0.3	+7	V
Input/Output Voltages A, B, Y, Z	-9	+13	V
Input/Output Voltages RO	-0.3	( $V_{CC} + 0.3$ )	V
Short-Circuit Duration Y, Z	Continuous		
ESD Rating	Refer to <a href="#">"ESD Performance" on page 7</a>		

CAUTION: Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions may adversely impact product reliability and result in failures not covered by warranty.

### 2.2 Thermal Information

Thermal Resistance (Typical)	$\theta_{JA}$ (°C/W)	$\theta_{JC}$ (°C/W)
14 Ld SOIC Package ( <a href="#">Notes 5, 6</a> )	80	41

Notes:

5.  $\theta_{JA}$  is measured in free air with the component mounted on a high-effective thermal conductivity test board. See [TB379](#).
6. For  $\theta_{JC}$ , the "case temp" location is taken at the package top center.

Parameter	Minimum	Maximum	Unit
Maximum Junction Temperature (Plastic Package)		+150	°C
Maximum Storage Temperature Range	-65	+150	°C
Pb-Free Reflow Profile	Refer to <a href="#">TB493</a>		

### 2.3 Recommended Operating Conditions

Parameter	Minimum	Maximum	Unit
Temperature Range ISL3160EFBZ	-40	+125	°C
Temperature Range ISL3160EIBZ	-40	+85	°C

## 2.4 Electrical Specifications

Test Conditions:  $V_{CC} = 4.5V$  to  $5.5V$ ; unless otherwise specified. Typical values are at  $V_{CC} = 5V$ ,  $T_A = +25^{\circ}C$ , **Boldface limits apply across the operating temperature range** (Note 7).

Parameter	Symbol	Test Conditions	Temp (°C)	Min (Note 16)	Typ	Max (Note 16)	Unit	
DC Characteristics								
Driver Differential V <sub>OUT</sub>	V <sub>OD</sub>	No Load	Full	-	-	V <sub>CC</sub>		
		R <sub>L</sub> = 100Ω (RS-422) (Figure 2)	Full	2.6	3.4	-	V	
		R <sub>L</sub> = 54Ω (RS-485) (Figure 2)	Full	2.1	2.8	V <sub>CC</sub>	V	
		R <sub>L</sub> = 60Ω, -7V ≤ V <sub>CM</sub> ≤ 12V (Figure 3, Note 15)	Full	1.9	2.7	-	V	
Change in Magnitude of Driver Differential V <sub>OUT</sub> for Complementary Output States	ΔV <sub>OD</sub>	R <sub>L</sub> = 54Ω or 100Ω (Figure 2)	Full	-	0.01	0.2	V	
Driver Common-Mode V <sub>OUT</sub>	V <sub>OC</sub>	R <sub>L</sub> = 54Ω or 100Ω (Figure 2, Note 15)	Full	-	2	2.5	V	
Change in Magnitude of Driver Common-Mode V <sub>OUT</sub> for Complementary Output States	ΔV <sub>OC</sub>	R <sub>L</sub> = 54Ω or 100Ω (Figure 2)	Full	-	0.02	0.2	V	
Logic Input High Voltage	V <sub>IH</sub>	DI, DE, $\overline{RE}$	Full	2	-	-	V	
Logic Input Low Voltage	V <sub>IL</sub>	DI, DE, $\overline{RE}$	Full	-	-	0.8	V	
Logic Input Current	I <sub>IN1</sub>	DI = DE = $\overline{RE}$ = 0V or V <sub>CC</sub>	Full	-2	-	2	μA	
Input Current (A/Y, B/Z)	I <sub>IN2</sub>	DE = 0V, V <sub>CC</sub> = 0V or 5.5V	V <sub>IN</sub> = 12V	Full	-	-	220	μA
			V <sub>IN</sub> = -7V	Full	-160	-	-	μA
Driver Short-Circuit Current, V <sub>O</sub> = High or Low	I <sub>OSD1</sub>	DE = V <sub>CC</sub> , -7V ≤ V <sub>Y</sub> or V <sub>Z</sub> ≤ 12V	Full	-	-	±250	mA	
Differential Capacitance	C <sub>D</sub>	A/Y to B/Z	+25	-	9	-	pF	
Receiver Differential Threshold Voltage	V <sub>TH</sub>	-7V ≤ V <sub>CM</sub> ≤ 12V	Full	-200	-	-50	mV	
Receiver Input Hysteresis	ΔV <sub>TH</sub>	V <sub>CM</sub> = 0V	+25	-	28	-	mV	
Receiver Output High Voltage	V <sub>OH</sub>	I <sub>O</sub> = -8mA, V <sub>ID</sub> = -50mV	Full	V <sub>CC</sub> - 0.5	-	-	V	
Receiver Output Low Voltage	V <sub>OL</sub>	I <sub>O</sub> = +10mA, V <sub>ID</sub> = -200mV	Full	-	-	0.4	V	
Receiver Output Low Current	I <sub>OL</sub>	V <sub>OL</sub> = 1V, V <sub>ID</sub> = -200mV	Full	25	40	-	mA	
Three-State (High Impedance) Receiver Output Current	I <sub>OZR</sub>	0.4V ≤ V <sub>O</sub> ≤ 2.4V	Full	-1	0.015	1	μA	
Receiver Input Resistance	R <sub>IN</sub>	-7V ≤ V <sub>CM</sub> ≤ 12V	Full	54	80	-	kΩ	
Receiver Short-Circuit Current	I <sub>OSR</sub>	0V ≤ V <sub>O</sub> ≤ V <sub>CC</sub>	Full	±20	-	±110	mA	
Supply Current								
No-Load Supply Current (Note 8)	I <sub>CC</sub>	DI = DE = 0V or V <sub>CC</sub>	Full	-	2.6	4	mA	
Shutdown Supply Current	I <sub>SHDN</sub>	DE = 0V, $\overline{RE}$ = V <sub>CC</sub> , DI = 0V or V <sub>CC</sub>	-40°C to +85°C	Full	-	0.05	1	μA
			-40°C to +125°C	Full		1.4	2	μA

Test Conditions:  $V_{CC} = 4.5V$  to  $5.5V$ ; unless otherwise specified. Typical values are at  $V_{CC} = 5V$ ,  $T_A = +25^\circ C$ , **Boldface limits apply across the operating temperature range (Note 7).** (Continued)

Parameter	Symbol	Test Conditions	Temp (°C)	Min (Note 16)	Typ	Max (Note 16)	Unit
ESD Performance							
RS-485 Pins (A, B, Y, Z)		IEC61000-4-2, Air-Gap Discharge Method	+25	-	±4	-	kV
		IEC61000-4-2, Contact Discharge Method	+25	-	±5	-	kV
		Human Body Model, From Bus Pins to GND	+25	-	±10	-	kV
All Pins		HBM, per MIL-STD-883 Method 3015	+25	-	> ±3	-	kV
		Machine Model	+25	-	> ±150	-	V
Driver Switching Characteristics							
Maximum Data Rate	f <sub>MAX</sub>	V <sub>OD</sub> ≥ ±1.5V, R <sub>D</sub> = 54Ω, C <sub>L</sub> = 100pF (Figure 8)	Full	40	60	-	Mbps
Driver Differential Output Delay	t <sub>DD</sub>	R <sub>D</sub> = 54Ω, C <sub>D</sub> = 50pF (Figure 2)	Full	-	11	16	ns
Driver Differential Output Skew	t <sub>SKEW</sub>	R <sub>D</sub> = 54Ω, C <sub>D</sub> = 50pF (Figure 2)	Full	-	0.5	1.5	ns
Prop Delay Part-to-Part Skew	t <sub>SKP-P</sub>	R <sub>D</sub> = 54Ω, C <sub>D</sub> = 50pF (Figure 2, Note 14)	Full	-	-	4	ns
Driver Differential Rise or Fall Time	t <sub>R</sub> , t <sub>F</sub>	R <sub>D</sub> = 54Ω, C <sub>D</sub> = 50pF (Figure 2)	Full	-	4	8	ns
Driver Enable to Output High	t <sub>ZH</sub>	R <sub>L</sub> = 110Ω, C <sub>L</sub> = 50pF, SW = GND (Figure 6, Note 9)	Full	-	18	25	ns
Driver Enable to Output Low	t <sub>ZL</sub>	R <sub>L</sub> = 110Ω, C <sub>L</sub> = 50pF, SW = V <sub>CC</sub> (Figure 6, Note 9)	Full	-	16	25	ns
Driver Enable Time Skew	t <sub>ENSKW</sub>	t <sub>ZH</sub> (Y or Z) - t <sub>ZL</sub> (Z or Y)	Full	-	2.5	-	ns
Driver Disable from Output High	t <sub>HZ</sub>	R <sub>L</sub> = 110Ω, C <sub>L</sub> = 50pF, SW = GND (Figure 6)	Full	-	15	25	ns
Driver Disable from Output Low	t <sub>LZ</sub>	R <sub>L</sub> = 110Ω, C <sub>L</sub> = 50pF, SW = V <sub>CC</sub> (Figure 6)	Full	-	18	25	ns
Driver Disable Time Skew	t <sub>DISSKEW</sub>	t <sub>HZ</sub> (Y or Z) - t <sub>LZ</sub> (Z or Y)	Full	-	3	-	ns
Time to Shutdown	t <sub>SHDN</sub>	(Note 11)	Full	60	-	600	ns
Driver Enable from Shutdown to Output High	t <sub>ZH(SHDN)</sub>	R <sub>L</sub> = 110Ω, C <sub>L</sub> = 50pF, SW = GND (Figure 6, Notes 11, 12)	Full	-	-	1000	ns
Driver Enable from Shutdown to Output Low	t <sub>ZL(SHDN)</sub>	R <sub>L</sub> = 110Ω, C <sub>L</sub> = 50pF, SW = V <sub>CC</sub> (Figure 6, Notes 11, 12)	Full	-	-	1000	ns
Receiver Switching Characteristics							
Maximum Data Rate	f <sub>MAX</sub>	V <sub>ID</sub> = ±1.5V	Full	40	60	-	Mbps
Receiver Input to Output Delay	t <sub>PLH</sub> , t <sub>PHL</sub>	(Figure 8)	Full	-	10	16.5	ns
Receiver Skew   t <sub>PLH</sub> - t <sub>PHL</sub>	t <sub>SKD</sub>	(Figure 8)	Full	-	0	1.5	ns
Prop Delay Part-to-Part Skew	t <sub>SKP-P</sub>	(Figure 8, Note 14)	Full	-	-	4	ns
Receiver Enable to Output High	t <sub>ZH</sub>	R <sub>L</sub> = 1kΩ, C <sub>L</sub> = 15pF, SW = GND (Figure 12, Note 10)	Full	-	10	15	ns
Receiver Enable to Output Low	t <sub>ZL</sub>	R <sub>L</sub> = 1kΩ, C <sub>L</sub> = 15pF, SW = V <sub>CC</sub> (Figure 12, Note 10)	Full	-	11	15	ns
Receiver Disable from Output High	t <sub>HZ</sub>	R <sub>L</sub> = 1kΩ, C <sub>L</sub> = 15pF, SW = GND (Figure 12)	Full	-	10	15	ns

Test Conditions:  $V_{CC} = 4.5V$  to  $5.5V$ ; unless otherwise specified. Typical values are at  $V_{CC} = 5V$ ,  $T_A = +25^{\circ}C$ , **Boldface limits apply across the operating temperature range (Note 7).** (Continued)

Parameter	Symbol	Test Conditions	Temp (°C)	Min (Note 16)	Typ	Max (Note 16)	Unit
Receiver Disable from Output Low	$t_{LZ}$	$R_L = 1k\Omega$ , $C_L = 15pF$ , $SW = V_{CC}$ (Figure 12)	Full	-	10	<b>15</b>	ns
Time to Shutdown	$t_{SHDN}$	(Note 11)	Full	<b>60</b>	-	<b>600</b>	ns
Receiver Enable from Shutdown to Output High	$t_{ZH}(SHDN)$	$R_L = 1k\Omega$ , $C_L = 15pF$ , $SW = GND$ (Figure 12, Notes 11, 13)	Full	-	-	<b>1000</b>	ns
Receiver Enable from Shutdown to Output Low	$t_{ZL}(SHDN)$	$R_L = 1k\Omega$ , $C_L = 15pF$ , $SW = V_{CC}$ (Figure 12, Notes 11, 13)	Full	-	-	<b>1000</b>	ns

Notes:

7. All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.
8. Supply current specification is valid for loaded drivers when  $DE = 0V$ .
9. Because of the shutdown feature, keep  $\overline{RE} = 0$  to prevent the device from entering SHDN.
10. Because of the shutdown feature, the  $\overline{RE}$  signal high time must be short enough (typically  $<100ns$ ) to prevent the device from entering shutdown.
11. These ICs are put into shutdown by bringing  $\overline{RE}$  high and  $DE$  low. If the inputs are in this state for less than  $60ns$ , the parts will not enter shutdown. If the inputs are in this state for at least  $700ns$ , the parts will enter shutdown. See "[Low Power Shutdown Mode](#)" on page 17.
12. Keep  $\overline{RE} = V_{CC}$ , and set the  $DE$  signal low time  $>700ns$  to ensure that the device enters shutdown.
13. Set the  $\overline{RE}$  signal high time  $>700ns$  to ensure that the device enters shutdown.
14. This is the part-to-part skew between any two units tested with identical test conditions (temperature,  $V_{CC}$ , etc.).
15.  $V_{CC} = 5V \pm 5\%$ .
16. Parts are 100% tested at  $+25^{\circ}C$ . Over-temperature limits established by characterization and are not production tested.



### 3. Test Circuits and Waveforms

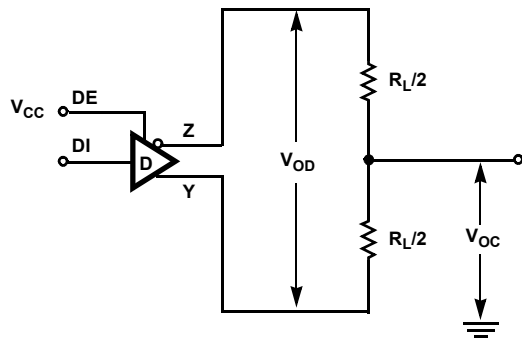


Figure 2. DC Driver Test Circuits  $V_{OD}$  and  $V_{OC}$

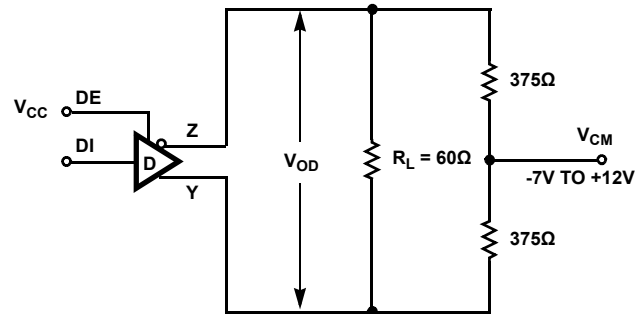


Figure 3. DC Driver Test Circuits  $V_{OD}$  with Common-Mode Load

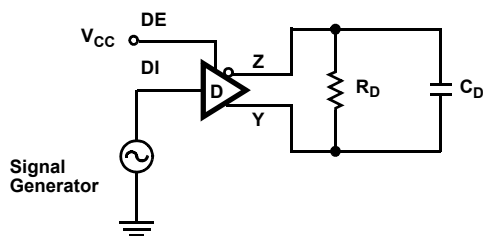


Figure 4. Driver Propagation Delay and Differential Transition Times Test Circuit

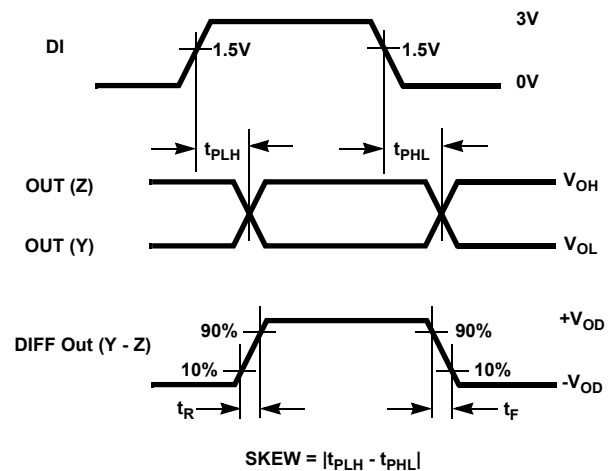
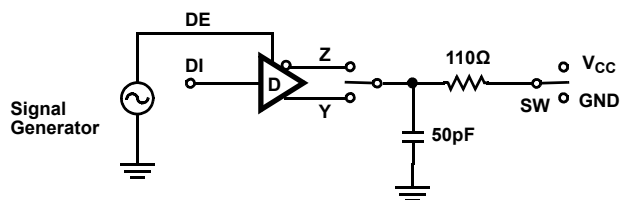


Figure 5. Driver Propagation Delay and Differential Transition Times Measurement Points



Parameter	Output	RE	DI	SW
$t_{HZ}$	Y/Z	X	1/0	GND
$t_{LZ}$	Y/Z	X	0/1	$V_{CC}$
$t_{ZH}$	Y/Z	0 (Note 9)	1/0	GND
$t_{ZL}$	Y/Z	0 (Note 9)	0/1	$V_{CC}$
$t_{HZ(SHDN)}$	Y/Z	1 (Note 12)	1/0	GND
$t_{LZ(SHDN)}$	Y/Z	1 (Note 12)	0/1	$V_{CC}$

Figure 6. Driver Enable and Disable Times Test Circuit

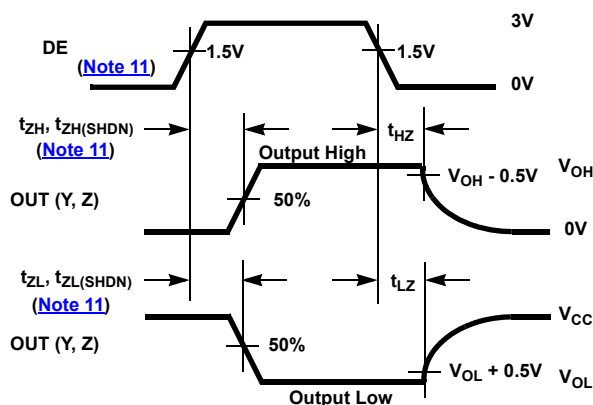


Figure 7. Driver Enable and Disable Times Measurement Points

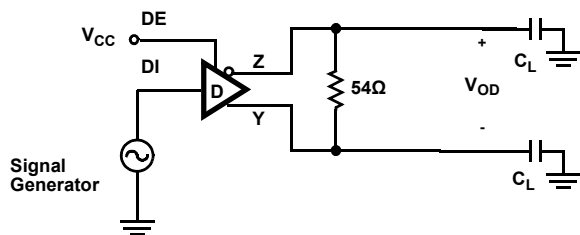


Figure 8. Driver Data Rate Test Circuit

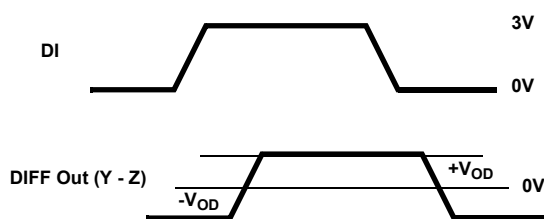


Figure 9. Driver Data Rate Measurement Points

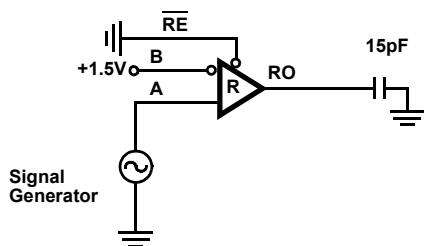


Figure 10. Receiver Propagation Delay Test Circuit

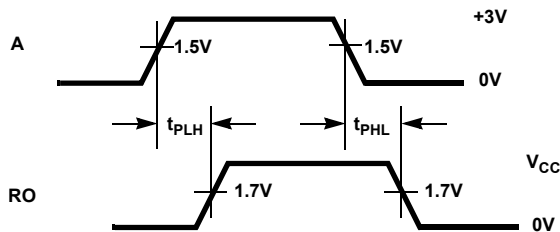
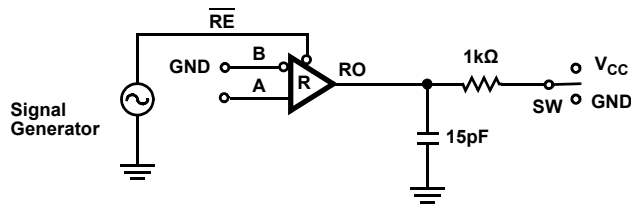


Figure 11. Receiver Propagation Delay Measurement Points



Parameter	DE	A	SW
$t_{HZ}$	0	+1.5V	GND
$t_{LZ}$	0	-1.5V	$V_{CC}$
$t_{ZH}$ (Note 10)	0	+1.5V	GND
$t_{ZL}$ (Note 10)	0	-1.5V	$V_{CC}$
$t_{HZ(SHDN)}$ (Note 13)	0	+1.5V	GND
$t_{LZ(SHDN)}$ (Note 13)	0	-1.5V	$V_{CC}$

Figure 12. Receiver Enable and Disable Times Test Circuit

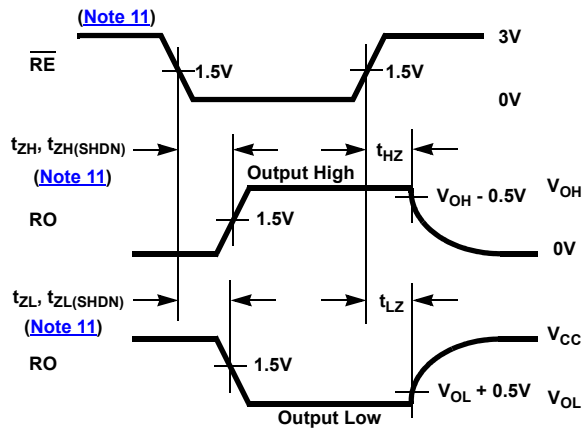


Figure 13. Receiver Enable and Disable Times Measurement Points

## 4. Typical Performance Curves

$V_{CC} = 5V$ ,  $T_A = +25^\circ C$ ; unless otherwise specified

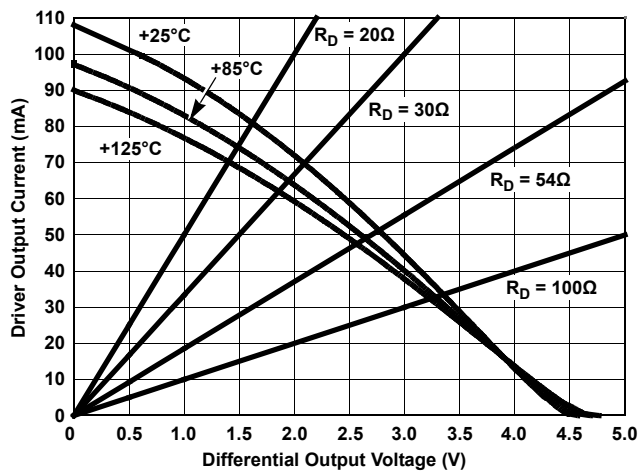


Figure 14. Driver Output Current vs Differential Output Voltage

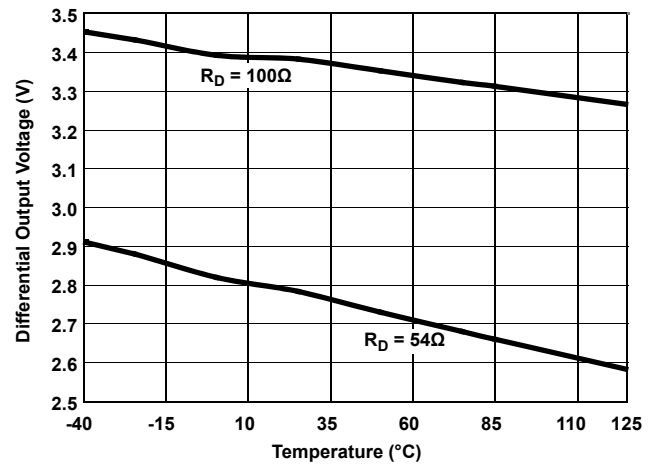


Figure 15. Driver Differential Output Voltage vs Temperature

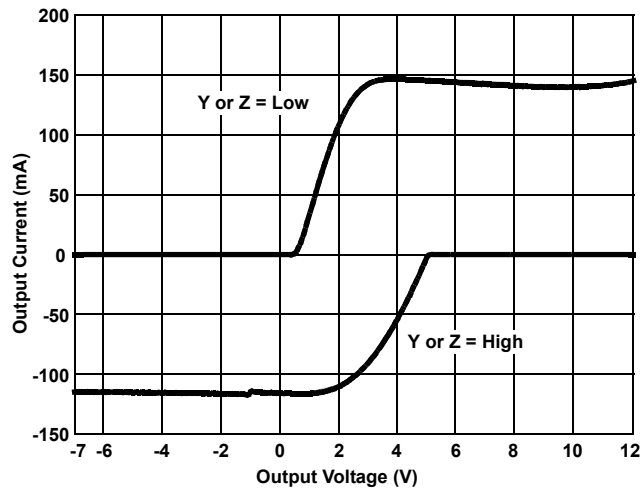


Figure 16. Driver Output Current vs Short-Circuit Voltage

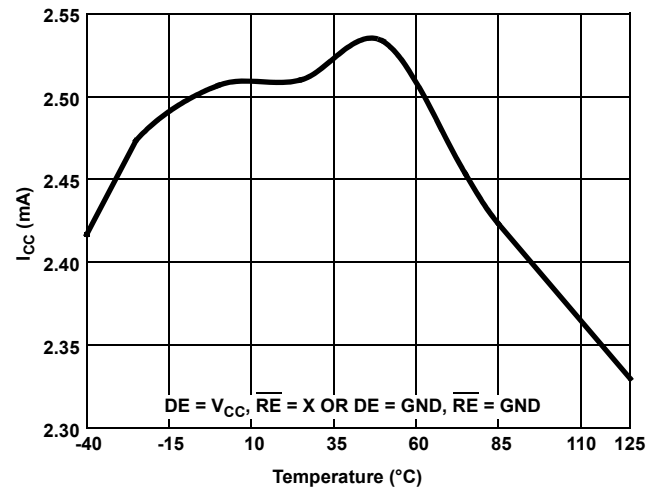


Figure 17. Supply Current vs Temperature

$V_{CC} = 5V$ ,  $T_A = +25^\circ C$ ; unless otherwise specified (Continued)

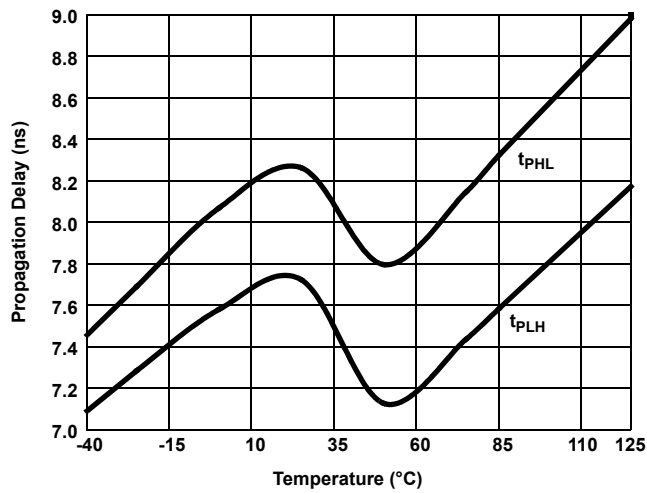


Figure 18. Driver Differential Propagation Delay vs Temperature

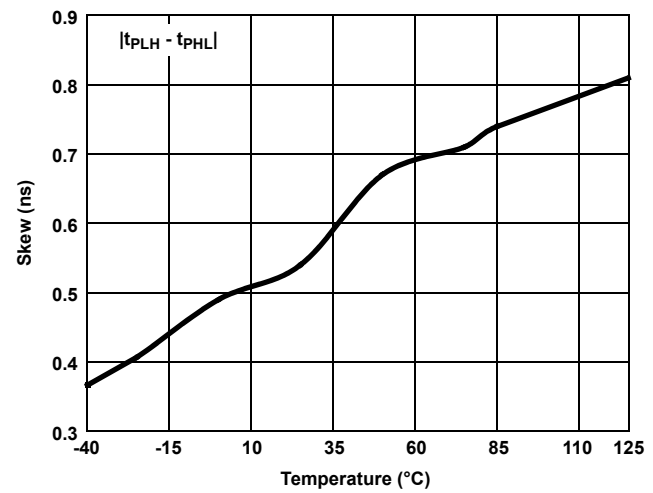


Figure 19. Driver Differential Skew vs Temperature

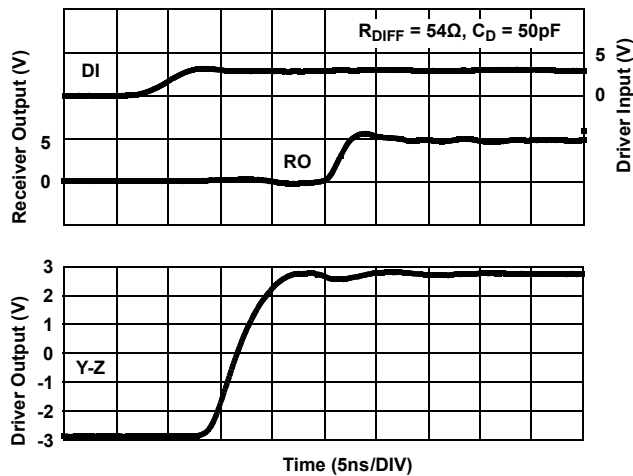


Figure 20. Driver and Receiver Waveforms

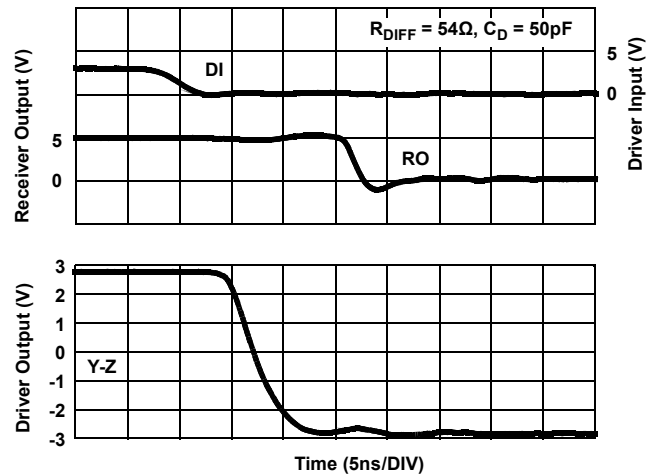


Figure 21. Driver and Receiver Waveforms

$V_{CC} = 5V$ ,  $T_A = +25^\circ C$ ; unless otherwise specified (Continued)

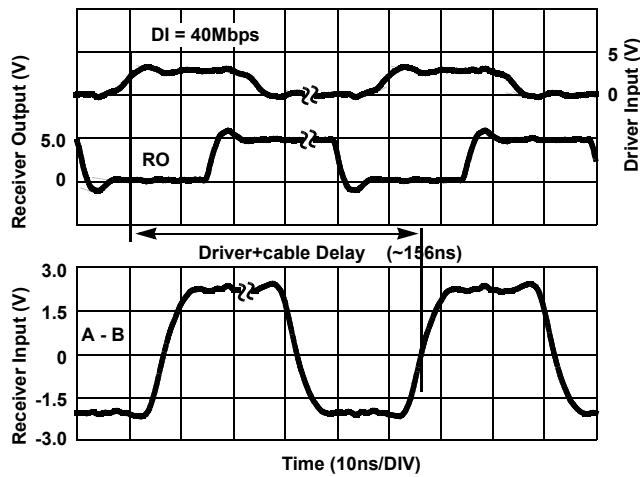


Figure 22. Driver and Receiver Waveforms Driving 100ft (31m) of Cat 5 Cable (Double Terminated with 120 $\Omega$ )

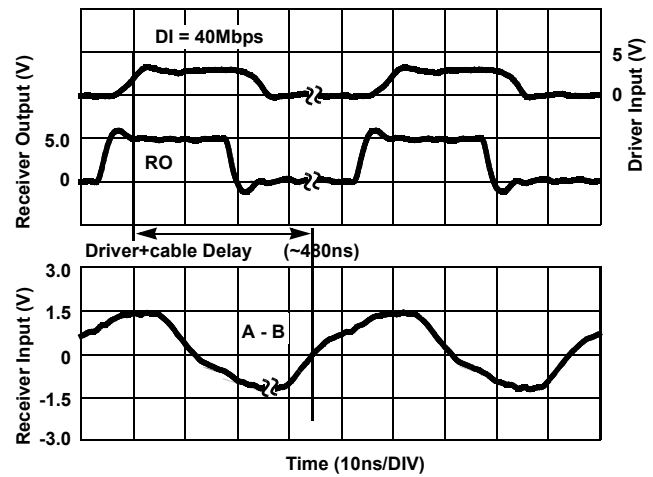


Figure 23. Driver and Receiver Waveforms Driving 350ft (107m) of Cat 5 Cable (Double Terminated with 120 $\Omega$ )

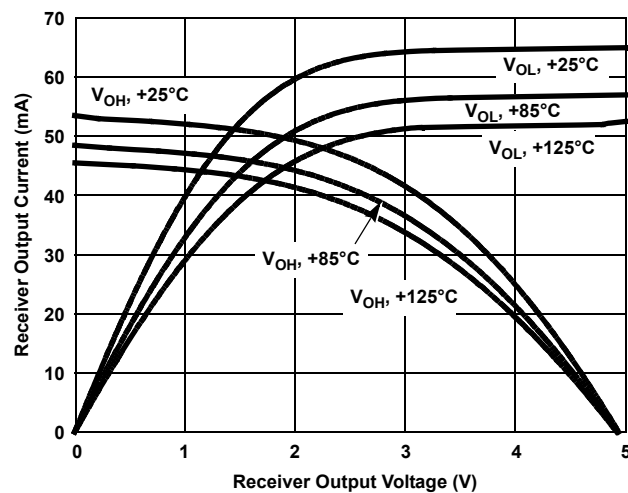


Figure 24. Receiver Output Current vs Receiver Output Voltage

## 5. Application Information

RS-485 and RS-422 are differential (balanced) data transmission standards for use in long haul or noisy environments. RS-422 is a subset of RS-485, so RS-485 transceivers are also RS-422 compliant. RS-422 is a point-to-multipoint (multidrop) standard, which allows only one driver and up to 10 receivers on each bus, assuming one unit load devices. RS-485 is a true multipoint standard, which allows up to 32 one unit load devices (any mix of drivers and receivers) on each bus. To allow for multipoint operation, the RS-485 specification requires that drivers must handle bus contention without sustaining any damage.

Another important advantage of RS-485 is the extended Common-Mode Range (CMR), which specifies that the driver outputs and receiver inputs withstand signals that range from +12V to -7V. RS-422 and RS-485 are intended for cable lengths as long as 4000ft (~1200m), so the wide CMR is necessary to handle ground potential differences, as well as voltages induced in the cable by external fields.

### 5.1 Receiver (Rx) Features

This transceiver uses a differential input receiver for maximum noise immunity and common-mode rejection. Input sensitivity is  $\pm 200\text{mV}$ , as required by the RS-422 and RS-485 specifications. Receiver inputs function with common-mode voltages as great as 7V outside the power supplies (that is, +12V and -7V), making them ideal for long networks, or industrial environments, where induced voltages are a realistic concern.

The receiver input resistance of  $50\text{k}\Omega$  surpasses the RS-422 specification of  $4\text{k}\Omega$ , and is five times the RS-485 “Unit Load” (UL) requirement of  $12\text{k}\Omega$  minimum. Thus, the ISL3160E is known as a “one-fifth UL” transceiver, and there can be up to 160 devices on the RS-485 bus while still complying with the RS-485 loading specification.

The receiver is a “full fail-safe” version that assures a high level receiver output if the receiver inputs are unconnected (floating), shorted together, or connected to a terminated bus with all the transmitters disabled (terminated/undriven).

Rx outputs deliver large low state currents (typically  $>30\text{mA}$ ) at  $V_{OL} = 1\text{V}$  (to ease the design of optically coupled isolated networks).

Receivers easily meet the 40Mbps data rate supported by the driver, and the receiver output is tri-statable using the active low  $\overline{\text{RE}}$  input.

### 5.2 Driver (Tx) Features

The RS-485/RS-422 driver is a differential output device that delivers at least 2.1V across a  $54\Omega$  load (RS-485), and at least 2.6V across a  $100\Omega$  load (RS-422) even with  $V_{CC} = 4.5\text{V}$ . The drivers feature low propagation delay skew to maximize bit width and to minimize EMI.

Driver outputs are not slew rate limited, so faster output transition times allow data rates of at least 40Mbps. Driver outputs are tri-statable using the active high DE input.

For parallel applications, bit-to-bit skews between any two ISL3160E transmitter and receiver pairs are assured to be no worse than 8ns (4ns max for any two Tx, 4ns max for any two Rx).

#### 5.2.1 High $V_{OD}$ Improves Noise Immunity and Flexibility

The ISL3160E driver design delivers larger differential output voltages ( $V_{OD}$ ) than the RS-485 standard requires, or than most RS-485 transmitters can deliver. The minimum  $\pm 2.1\text{V}$   $V_{OD}$  assures at least  $\pm 600\text{mV}$  more noise immunity than networks built using standard 1.5V  $V_{OD}$  transmitters.

Another advantage of the large  $V_{OD}$  is the ability to drive more than two bus terminations, which allows use of the ISL3160E in “star” and other multiterminated, nonstandard network topologies. [Figure 14 on page 12](#) details the transmitter’s  $V_{OD}$  vs  $I_{OUT}$  characteristic, and includes load lines for four ( $30\Omega$ ) and six ( $20\Omega$ )  $120\Omega$  terminations. [Figure 14](#) shows that the driver typically delivers 1.9/1.5V into 4/6 terminations, even at  $+85^\circ\text{C}$ . The RS-485 standard requires a minimum 1.5V  $V_{OD}$  into two terminations, but the ISL3160E typically delivers RS-485 voltage levels with 2 to 3 times the number of terminations.

### 5.3 ESD Protection

All pins on the ISL3160E include Class 3 (>3kV) Human Body Model (HBM) ESD protection structures, but the RS-485 pins (driver outputs and receiver inputs) incorporate advanced structures allowing them to survive ESD events in excess of  $\pm 10\text{kV}$  HBM and  $\pm 5\text{kV}$  IEC61000-4-2. The RS-485 pins are particularly vulnerable to ESD strikes because they typically connect to an exposed port on the exterior of the finished product. Simply touching the port pins, or connecting a cable, can cause an ESD event that can destroy unprotected ICs. These new ESD structures protect the device whether or not it is powered up and without degrading the RS-485 common-mode range of  $-7\text{V}$  to  $+12\text{V}$ . This built-in ESD protection eliminates the need for board level protection structures (for example, transient suppression diodes) and the associated undesirable capacitive load they present.

### 5.4 Hot Plug Function

When a piece of equipment powers up, a period of time occurs in which the processor or ASIC driving the RS-485 control lines (DE, RE) is unable to ensure that the RS-485 Tx and Rx outputs are kept disabled. If the equipment is connected to the bus, a driver activating prematurely during power-up may crash the bus. To avoid this scenario, the ISL3160E incorporates a “hot plug” function. Circuitry monitoring  $V_{CC}$  ensures that the Tx and Rx outputs remain disabled during power-up and power-down, regardless of the state of DE and RE, if  $V_{CC}$  is less than  $\sim 3.2\text{V}$ . This gives the processor or ASIC a chance to stabilize and drive the RS-485 control lines to the proper states.

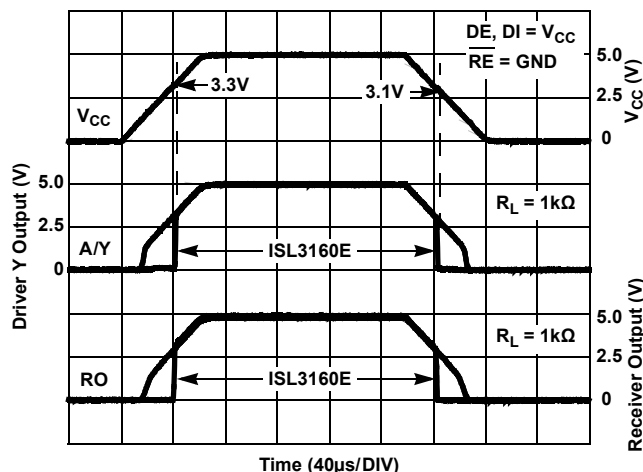


Figure 25. Hot Plug Performance (ISL3160E) vs ISL83086E without Hot Plug Circuitry

### 5.5 Data Rate, Cables, and Terminations

Twisted pair is the cable of choice for RS-485, RS-422, and PROFIBUS networks. Twisted pair cables tend to pick up noise and other electromagnetically induced voltages as common-mode signals, which are effectively rejected by the differential receivers in these ICs.

According to guidelines in the RS-422 and RS-485 specifications, networks operating at data rates in excess of 3Mbps should be limited to cable lengths of 100m (328ft) or less. The ISL3160E's large differential output swing, fast transition times, and high drive-current output stages allow operation even at 40Mbps over standard “CAT5” cables in excess of 100m (328ft). [Figure 23 on page 14](#) details the ISL3160E performance at this condition, with a  $120\Omega$  termination resistor at both the driver and the receiver ends. Note that the differential signal delivered to the receiver at the end of the cable (A-B) still exceeds 1V, so even longer cables could be driven if lower noise margins are acceptable. Of course, jitter or some other criteria may limit the network to shorter cable lengths than those discussed here. If more noise margin is desired, shorter cables produce a larger receiver input signal as illustrated in [Figure 22 on page 14](#). Performance should be even better if using the “Type A” cable.

The ISL3160E may also be used at slower data rates over longer cables, but some limitations apply. The Rx is optimized for high speed operation, so its output may glitch if the Rx input differential transition times are too slow.



Keeping the transition times below 500ns, (which equates to the Tx driving a 1000ft (305m) CAT 5 cable) yields excellent performance across the full operating temperature range.

To minimize reflections, proper termination is imperative when using this high data rate transceiver. In point-to-point, or point-to-multipoint (single driver on bus) networks, the main cable should be terminated in its characteristic impedance (typically 120Ω for “Cat 5” and 220Ω for “Type A”) at the end farthest from the driver. In multireceiver applications, stubs connecting receivers to the main cable should be kept as short as possible. Multipoint (multidriver) systems require that the main cable be terminated in its characteristic impedance at both ends. Stubs connecting a transceiver to the main cable should be kept as short as possible.

## 5.6 Built-In Driver Overload Protection

As stated previously, the RS-485 specification requires that drivers survive worst case bus contentions undamaged. These transmitters meet this requirement using driver output short-circuit current limits, and on-chip thermal shutdown circuitry.

The driver output stages incorporate short-circuit current limiting circuitry, which ensures that the output current never exceeds the RS-485 specification, even at the common-mode voltage range extremes. In the event of a major short-circuit condition, the device also includes a thermal shutdown feature that disables the drivers whenever the die temperature becomes excessive. This eliminates the power dissipation, allowing the die to cool. The drivers automatically reenables after the die temperature drops about 15°C. If the contention persists, the thermal shutdown/reenable cycle repeats until the fault is cleared. Receivers stay operational during thermal shutdown.

## 5.7 Low Power Shutdown Mode

This BiCMOS transceiver uses a fraction of the power required by its bipolar counterparts, and it includes a shutdown feature that reduces the already low quiescent  $I_{CC}$  to a 50nA trickle. It enters shutdown whenever the receiver and driver are simultaneously disabled ( $\overline{RE} = V_{CC}$  and  $DE = GND$ ) for a period of at least 600ns. Disabling both the driver and the receiver for less than 60ns assures that the transceiver will not enter shutdown.

Note that receiver and driver enable times increase when the transceiver enables from shutdown. Refer to [Notes 9, 10, 11, 12, and 13](#) on [page 8](#) for more information.

## 6. Revision History

Rev.	Date	Description
0.00	Mar 21, 2018	Initial release

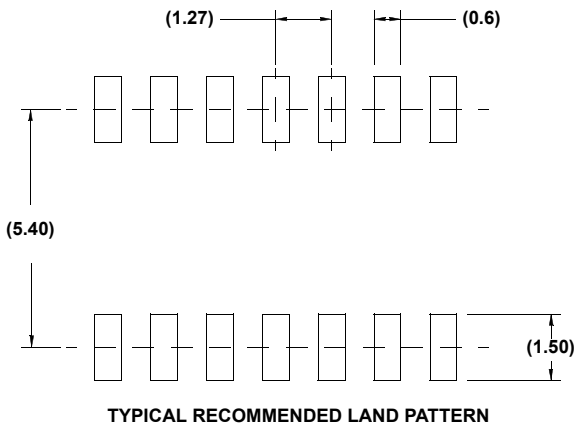
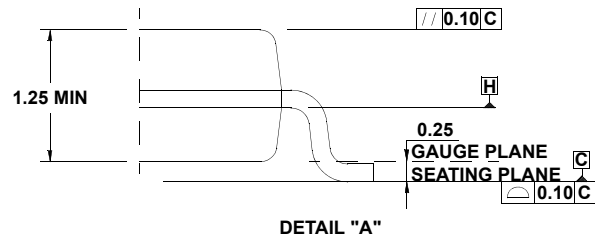
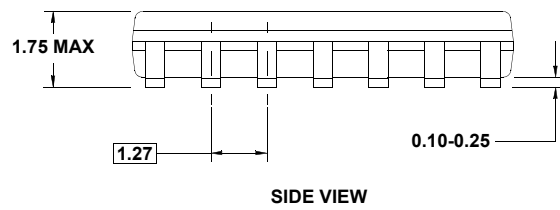
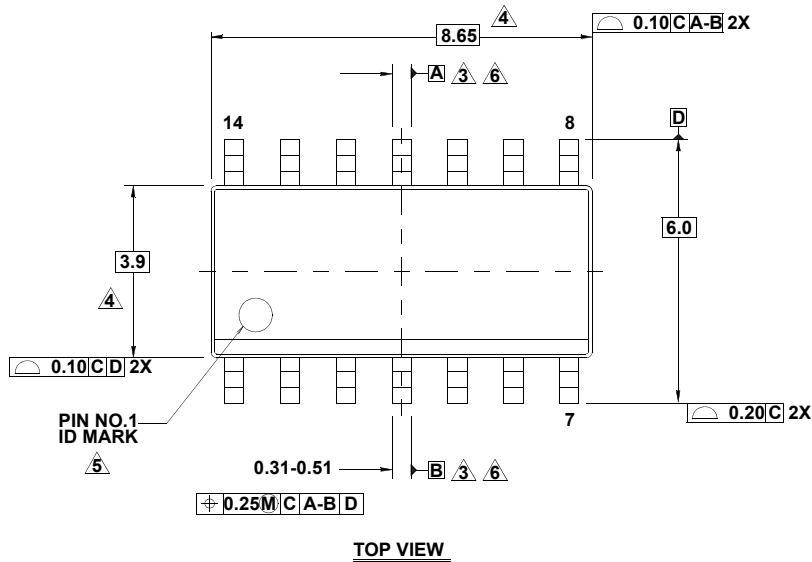
## 7. Package Outline Drawing

For the most recent package outline drawing, see [M14.15](#).

M14.15

14 LEAD NARROW BODY SMALL OUTLINE PLASTIC PACKAGE

Rev 1, 10/09



### NOTES:

1. Dimensions are in millimeters.  
Dimensions in ( ) for Reference Only.
2. Dimensioning and tolerancing conform to AMSEY14.5m-1994.
3. Datums A and B to be determined at Datum H.
4. Dimension does not include interlead flash or protrusions.  
Interlead flash or protrusions shall not exceed 0.25mm per side.
5. The pin #1 identifier may be either a mold or mark feature.
6. Does not include dambar protrusion. Allowable dambar protrusion shall be 0.10mm total in excess of lead width at maximum condition.
7. Reference to JEDEC MS-012-AB.

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