

**$\pm 15\text{kV}$  ESD Protected,  $+125^\circ\text{C}$ , 40Mbps,  
5V, PROFIBUS<sup>®</sup>, Full Fail-safe,  
RS-485/RS-422 Transceivers**

Intersil's ISL3159E is a  $\pm 15\text{kV}$  IEC61000 ESD Protected, 5V powered, single transceiver that meets both the RS-485 and RS-422 standards for balanced communication. It also features the larger output voltage and higher data rate - up to 40Mbps - required by high speed PROFIBUS applications, and is offered in Industrial and Extended Industrial ( $-40^\circ\text{C}$  to  $+125^\circ\text{C}$ ) temperature ranges. The low bus currents ( $+220\mu\text{A}/-150\mu\text{A}$ ) present a "1/5 unit load" to the RS-485 bus, thus allowing 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  $\pm 10\%$  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  $120\Omega$  terminations in "star" or other non-standard bus topologies, at the exceptional 40Mbps data rate.

SCSI applications benefit from the ISL3159's low receiver and transmitter part-to-part skews, which make it perfect for high speed parallel applications where large numbers of bits must be simultaneously captured. 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  $>30\text{mA}$  @  $V_{OL} = 1\text{V}$ ) 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.

**Features**

- IEC61000 ESD Protection on RS-485 I/O Pins . . .  $\pm 15\text{kV}$   
- Class 3 HBM ESD Level on all Other Pins . . . . .  $>9\text{kV}$
- Large Differential  $V_{OUT}$  . . . . . 2.8V into  $54\Omega$   
Better Noise Immunity, or drive up to 6 Terminations
- High Data Rates . . . . . up to 40Mbps
- Specified for  $+125^\circ\text{C}$  Operation
- 11/13ns (Max) Tx/Rx Propagation Delays; 1.5ns (Max) 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. . . . .  $1\mu\text{A}$
- $-7\text{V}$  to  $+12\text{V}$  Common Mode Input Voltage Range
- Three-State Rx and Tx Outputs
- Operates from a Single  $+5\text{V}$  Supply (10% Tolerance)
- Current Limiting and Thermal Shutdown for driver Overload Protection
- Pb-Free Plus Anneal Available (RoHS Compliant)

**Applications**

- PROFIBUS<sup>®</sup> DP and FMS Networks
- 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

**Ordering Information**

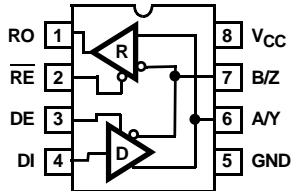
PART NUMBER (Notes 1, 2)	PART MARKING	TEMP. RANGE (°C)	PACKAGE (Pb-Free)	PKG. DWG. #
ISL3159EIBZ	3159 EIBZ	-40 to +85	8 Ld SOIC	M8.15
ISL3159EIUZ	3159Z	-40 to +85	8 Ld MSOP	M8.118
ISL3159EIRZ	159Z	-40 to +85	10 Ld DFN	L10.3x3C
ISL3159EFBZ	3159 EFBZ	-40 to +125	8 Ld SOIC	M8.15
ISL3159EFUZ	159FZ	-40 to +125	8 Ld MSOP	M8.118
ISL3159EFRZ	59FZ	-40 to +125	10 Ld DFN	L10.3x3C

NOTES:

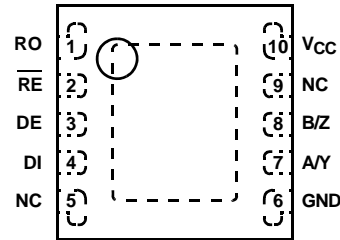
1. Add "-T" suffix for tape and reel. Please refer to TB347 for details on reel specifications.
2. Intersil Pb-free plus anneal products employ special Pb-free material sets; molding compounds/die attach materials and 100% matte tin plate termination finish, which are RoHS compliant and compatible with both SnPb and Pb-free soldering operations. Intersil 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.

**Pinouts**

ISL3159E  
(8 LD SOIC, MSOP)  
TOP VIEW



ISL3159E  
(10 LD DFN)  
TOP VIEW



**Truth Table**

TRANSMITTING				
INPUTS			OUTPUTS	
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 *	High-Z *

NOTE: \*Shutdown Mode

**Truth Table**

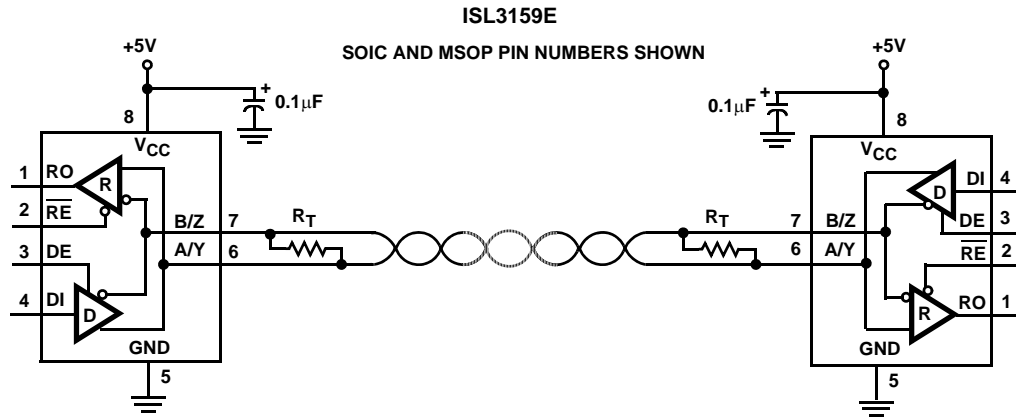
RECEIVING			
INPUTS			OUTPUT
RE	DE	A-B	RO
0	0	$\geq -0.05V$	1
0	0	$\leq -0.2V$	0
0	0	Inputs Open/Shorted	1
1	1	X	High-Z
1	0	X	High-Z *

NOTE: \*Shutdown Mode

**Pin Descriptions**

PIN	FUNCTION
RO	Receiver output: If $A-B \geq -50\text{mV}$ , RO is high; If $A-B \leq -200\text{mV}$ , RO is low; RO = High if A and B are unconnected (floating) or shorted, or connected to a terminated bus that is undriven.
$\overline{\text{RE}}$	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.
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 $1\text{k}\Omega$ or greater resistor.
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.
GND	Ground connection. This is also the potential of the DFN thermal pad.
A/Y	$\pm 15\text{kV}$ IEC61000 ESD Protected RS-485/422 level, noninverting receiver input and noninverting driver output. Pin is an input (A) if $\text{DE} = 0$ ; pin is an output (Y) if $\text{DE} = 1$ .
B/Z	$\pm 15\text{kV}$ IEC61000 ESD Protected RS-485/422 level, inverting receiver input and inverting driver output. Pin is an input (B) if $\text{DE} = 0$ ; pin is an output (Z) if $\text{DE} = 1$ .
$V_{\text{CC}}$	System power supply input (4.5V to 5.5V).
NC	No Connection.

**Typical Operating Circuit**



**Absolute Maximum Ratings**

V <sub>CC</sub> to GND	7V
Input Voltages	
DI, DE, RE	-0.3V to 7V
Input/Output Voltages	
A/Y, B/Z	-9V to +13V
RO	-0.3V to (V <sub>CC</sub> +0.3V)
Short Circuit Duration	
Y, Z	Continuous
ESD Rating	See Specification Table

**Thermal Information**

Thermal Resistance (Typical)	θ <sub>JA</sub> (°C/W)
8 Ld SOIC Package (Note 3)	105
8 Ld MSOP Package (Note 3)	140
10 Ld DFN Package (Note 4)	75
Maximum Junction Temperature (Plastic Package)	+150°C
Maximum Storage Temperature Range	-65°C to +150°C
Pb-free reflow profile	see link below
<a href="http://www.intersil.com/pbfree/Pb-FreeReflow.asp">http://www.intersil.com/pbfree/Pb-FreeReflow.asp</a>	

**Operating Conditions**

Temperature Range	
ISL3159EF	-40°C to +125°C
ISL3159EI	-40°C to +85°C

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.

NOTE:

3. θ<sub>JA</sub> is measured with the component mounted on a high effective thermal conductivity test board in free air. See Tech Brief TB379 for details.
4. θ<sub>JA</sub> is measured in free air with the component mounted on a high effective thermal conductivity test board with "direct attach" features. See Tech Brief TB379.

**Electrical Specifications** Test Conditions: V<sub>CC</sub> = 4.5V to 5.5V; Unless Otherwise Specified. Typicals are at V<sub>CC</sub> = 5V, T<sub>A</sub> = +25°C, (Note 5)

PARAMETER	SYMBOL	TEST CONDITIONS	TEMP (°C)	MIN (NOTE 15)	TYP	MAX (NOTE 15)	UNITS	
<b>DC CHARACTERISTICS</b>								
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 1A)	Full	2.6	3.4	-	V	
		R <sub>L</sub> = 54Ω (RS-485) (Figure 1A)	I Suffix	Full	2.1	2.8	V <sub>CC</sub>	V
			F Suffix, (Note 14)	Full	2.1	2.8	V <sub>CC</sub>	V
		R <sub>L</sub> = 60Ω, -7V ≤ V <sub>CM</sub> ≤ 12V (Figure 1B), (Note 14)	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 1A)	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 1A), (Note 14)	Full	-	2	3	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 1A)	Full	-	0.01	0.2	V	
Logic Input High Voltage	V <sub>IH</sub>	DI, DE, RE	Full	2	-	-	V	
Logic Input Low Voltage	V <sub>IL</sub>	DI, DE, RE	Full	-	-	0.8	V	
Logic Input Current	I <sub>IN1</sub>	DI = DE = 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 (Note 7)	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	

# ISL3159E

**Electrical Specifications** Test Conditions:  $V_{CC} = 4.5V$  to  $5.5V$ ; Unless Otherwise Specified. Typical values are at  $V_{CC} = 5V$ ,  $T_A = +25^\circ C$ , (Note 5) (Continued)

PARAMETER	SYMBOL	TEST CONDITIONS	TEMP (°C)	MIN (NOTE 15)	TYP	MAX (NOTE 15)	UNITS
Receiver Output Low Voltage	$V_{OL}$	$I_O = +10mA$ , $V_{ID} = -200mV$	Full	-	-	0.4	V
Receiver Output Low Current	$I_{OL}$	$V_{OL} = 1V$ , $V_{ID} = -200mV$	Full	25	40	-	mA
Three-State (high impedance) Receiver Output Current	$I_{OZR}$	$0.4V \leq V_O \leq 2.4V$	Full	-1	0.015	1	$\mu A$
Receiver Input Resistance	$R_{IN}$	$-7V \leq V_{CM} \leq 12V$	Full	54	80	-	k $\Omega$
Receiver Short-Circuit Current	$I_{OSR}$	$0V \leq V_O \leq V_{CC}$	Full	$\pm 20$	-	$\pm 110$	mA
<b>SUPPLY CURRENT</b>							
No-Load Supply Current (Note 6)	$I_{CC}$	$DI = DE = 0V$ or $V_{CC}$	Full	-	2.6	4	mA
Shutdown Supply Current	$I_{SHDN}$	$DE = 0V$ , $\overline{RE} = V_{CC}$ , $DI = 0V$ or $V_{CC}$	Full	-	0.05	1	$\mu A$
<b>ESD PERFORMANCE</b>							
RS-485 Pins (A/Y, B/Z)		IEC61000-4-2, Air-Gap Discharge Method	25	-	$\pm 15$	-	kV
		IEC61000-4-2, Contact Discharge Method	25	-	$\pm 8$	-	kV
		Human Body Model, From Bus Pins to GND	25	-	$\pm 16.5$	-	kV
All Pins		HBM, per MIL-STD-883 Method 3015	25	-	$> \pm 9$	-	kV
		Machine Model	25	-	$> \pm 400$	-	V
<b>DRIVER SWITCHING CHARACTERISTICS</b>							
Maximum Data Rate	$f_{MAX}$	$V_{OD} \geq \pm 1.5V$ , $R_D = 54\Omega$ , $C_L = 100pF$ (Figure 4)	Full	40	-	-	Mbps
Driver Differential Output Delay	$t_{DD}$	$R_D = 54\Omega$ , $C_D = 50pF$ (Figure 2)	Full	-	8	12	ns
Driver Differential Output Skew	$t_{SKEW}$	$R_D = 54\Omega$ , $C_D = 50pF$ (Figure 2)	Full	-	0.5	1.5	ns
Prop Delay Part-to-Part Skew	$t_{SKP-P}$	$R_D = 54\Omega$ , $C_D = 50pF$ (Figure 2), (Note 13)	Full	-	-	4	ns
Driver Differential Rise or Fall Time	$t_R$ , $t_F$	$R_D = 54\Omega$ , $C_D = 50pF$ (Figure 2)	Full	2	5	8	ns
Driver Enable to Output High	$t_{ZH}$	$R_L = 110\Omega$ , $C_L = 50pF$ , $SW = GND$ (Figure 3), (Note 8)	Full	-	13	20	ns
Driver Enable to Output Low	$t_{ZL}$	$R_L = 110\Omega$ , $C_L = 50pF$ , $SW = V_{CC}$ (Figure 3), (Note 8)	Full	-	11	20	ns
Driver Enable Time Skew	$t_{ENSKEW}$	$ t_{ZH} (Y \text{ or } Z) - t_{ZL} (Z \text{ or } Y) $	Full	-	2.5	-	ns
Driver Disable from Output High	$t_{HZ}$	$R_L = 110\Omega$ , $C_L = 50pF$ , $SW = GND$ (Figure 3),	Full	-	14	20	ns
Driver Disable from Output Low	$t_{LZ}$	$R_L = 110\Omega$ , $C_L = 50pF$ , $SW = V_{CC}$ (Figure 3),	Full	-	12	20	ns
Driver Disable Time Skew	$t_{DISSKEW}$	$ t_{HZ} (Y \text{ or } Z) - t_{LZ} (Z \text{ or } Y) $	Full	-	3	-	ns
Time to Shutdown	$t_{SHDN}$	(Note 10)	Full	60	-	600	ns
Driver Enable from Shutdown to Output High	$t_{ZH(SHDN)}$	$R_L = 110\Omega$ , $C_L = 50pF$ , $SW = GND$ (Figure 3), (Notes 10, 11)	Full	-	-	1000	ns
Driver Enable from Shutdown to Output Low	$t_{ZL(SHDN)}$	$R_L = 110\Omega$ , $C_L = 50pF$ , $SW = V_{CC}$ (Figure 3), (Notes 10, 11)	Full	-	-	1000	ns
<b>RECEIVER SWITCHING CHARACTERISTICS</b>							
Maximum Data Rate	$f_{MAX}$	$V_{ID} = \pm 1.5V$	Full	40	-	-	Mbps
Receiver Input to Output Delay	$t_{PLH}$ , $t_{PHL}$	(Figure 5)	Full	-	9	13	ns
Receiver Skew $ t_{PLH} - t_{PHL} $	$t_{SKD}$	(Figure 5)	Full	-	0	1.5	ns
Prop Delay Part-to-Part Skew	$t_{SKP-P}$	(Figure 5), (Note 13)	Full	-	-	4	ns
Receiver Enable to Output High	$t_{ZH}$	$R_L = 1k\Omega$ , $C_L = 15pF$ , $SW = GND$ (Figure 6), (Note 9)	Full	-	-	12	ns

**Electrical Specifications** Test Conditions:  $V_{CC} = 4.5V$  to  $5.5V$ ; Unless Otherwise Specified. Typicals are at  $V_{CC} = 5V$ ,  $T_A = +25^\circ C$ , (Note 5) (Continued)

PARAMETER	SYMBOL	TEST CONDITIONS	TEMP (°C)	MIN (NOTE 15)	TYP	MAX (NOTE 15)	UNITS
Receiver Enable to Output Low	$t_{ZL}$	$R_L = 1k\Omega$ , $C_L = 15pF$ , $SW = V_{CC}$ (Figure 6), (Note 9)	Full	-	-	12	ns
Receiver Disable from Output High	$t_{HZ}$	$R_L = 1k\Omega$ , $C_L = 15pF$ , $SW = GND$ (Figure 6)	Full	-	-	12	ns
Receiver Disable from Output Low	$t_{LZ}$	$R_L = 1k\Omega$ , $C_L = 15pF$ , $SW = V_{CC}$ (Figure 6)	Full	-	-	12	ns
Time to Shutdown	$t_{SHDN}$	(Note 10)	Full	60	-	600	ns
Receiver Enable from Shutdown to Output High	$t_{ZH(SHDN)}$	$R_L = 1k\Omega$ , $C_L = 15pF$ , $SW = GND$ (Figure 6), (Notes 10, 12)	Full	-	-	1000	ns
Receiver Enable from Shutdown to Output Low	$t_{ZL(SHDN)}$	$R_L = 1k\Omega$ , $C_L = 15pF$ , $SW = V_{CC}$ (Figure 6), (Notes 10, 12)	Full	-	-	1000	ns

NOTES:

- 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.
- Supply current specification is valid for loaded drivers when  $DE = 0V$ .
- Applies to peak current. See "Typical Performance Curves" for more information.
- Because of the shutdown feature, keep  $\overline{RE} = 0$  to prevent the device from entering SHDN.
- Because of the shutdown feature, the  $\overline{RE}$  signal high time must be short enough (typically  $<100ns$ ) to prevent the device from entering SHDN.
- These IC's 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 are guaranteed not to enter shutdown. If the inputs are in this state for at least  $700ns$ , the parts are guaranteed to have entered shutdown. See "Low-Power Shutdown Mode" section.
- Keep  $\overline{RE} = V_{CC}$ , and set the  $DE$  signal low time  $>700ns$  to ensure that the device enters SHDN.
- Set the  $\overline{RE}$  signal high time  $>700ns$  to ensure that the device enters SHDN.
- This is the part-to-part skew between any two units tested with identical test conditions (Temperature,  $V_{CC}$ , etc.).
- $V_{CC} = 5V \pm 5\%$
- Parts are 100% tested at  $+25^\circ C$ . Over temperature limits established by characterization and are not production tested.

**Test Circuits and Waveforms**

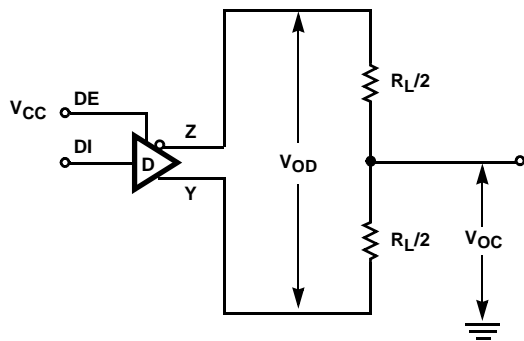


FIGURE 1A.  $V_{OD}$  AND  $V_{OC}$

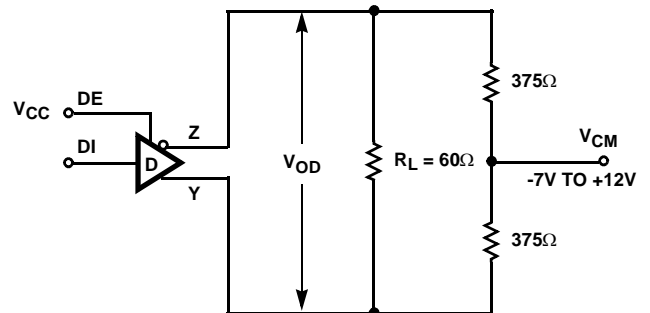


FIGURE 1B.  $V_{OD}$  WITH COMMON MODE LOAD

FIGURE 1. DC DRIVER TEST CIRCUITS

Test Circuits and Waveforms (Continued)

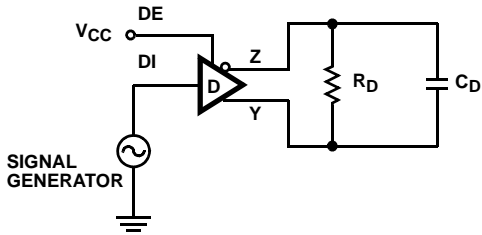


FIGURE 2A. TEST CIRCUIT

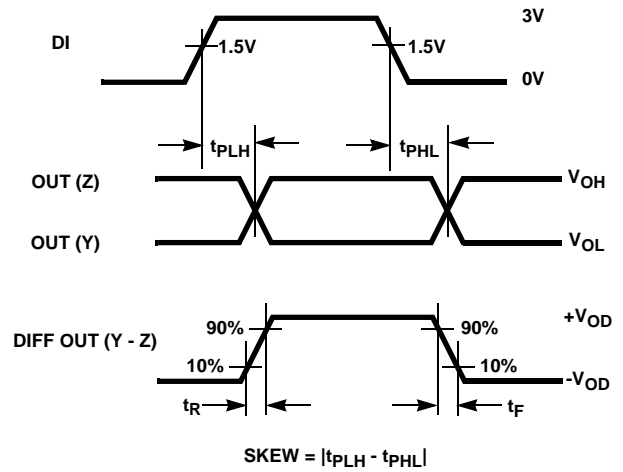


FIGURE 2B. MEASUREMENT POINTS

FIGURE 2. DRIVER PROPAGATION DELAY AND DIFFERENTIAL TRANSITION TIMES

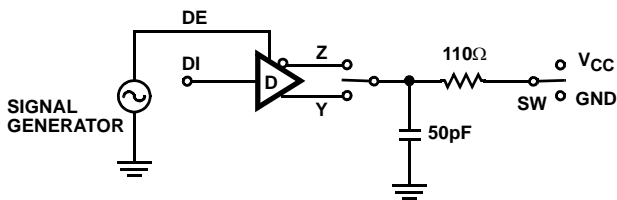


FIGURE 3A. TEST CIRCUIT

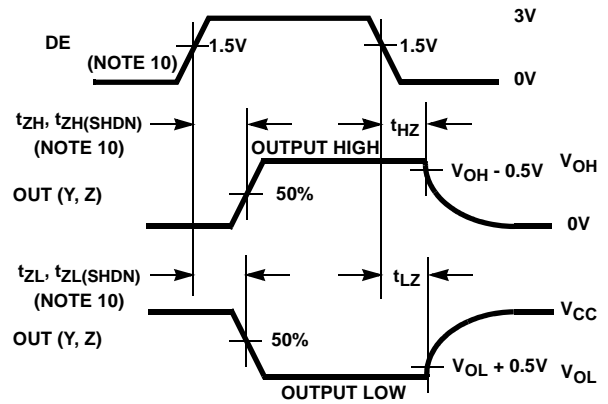


FIGURE 3B. MEASUREMENT POINTS

FIGURE 3. DRIVER ENABLE AND DISABLE TIMES

PARAMETER	OUTPUT	$\overline{RE}$	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 8)	1/0	GND
$t_{ZL}$	Y/Z	0 (Note 8)	0/1	$V_{CC}$
$t_{HZ(SHDN)}$	Y/Z	1 (Note 11)	1/0	GND
$t_{LZ(SHDN)}$	Y/Z	1 (Note 11)	0/1	$V_{CC}$

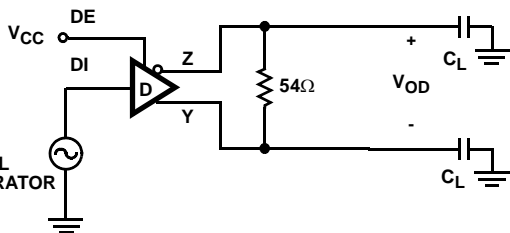


FIGURE 4A. TEST CIRCUIT

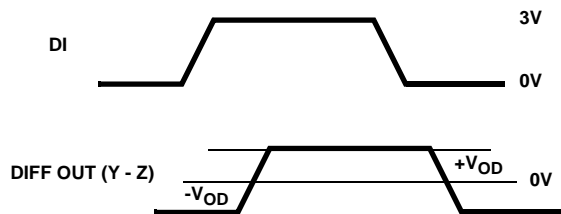


FIGURE 4B. MEASUREMENT POINTS

Test Circuits and Waveforms (Continued)

FIGURE 4. DRIVER DATA RATE

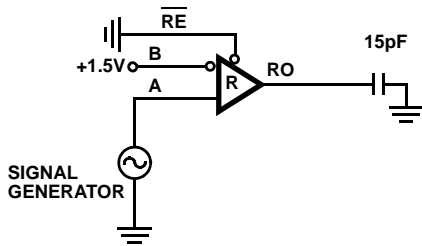


FIGURE 5A. TEST CIRCUIT

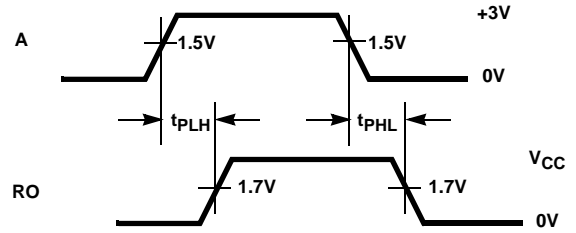


FIGURE 5B. MEASUREMENT POINTS

FIGURE 5. RECEIVER PROPAGATION DELAY

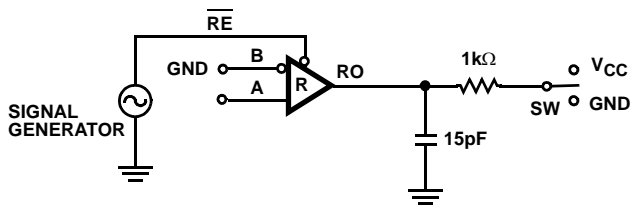


FIGURE 6A. TEST CIRCUIT

PARAMETER	DE	A	SW
$t_{HZ}$	0	+1.5V	GND
$t_{LZ}$	0	-1.5V	$V_{CC}$
$t_{ZH}$ (Note 9)	0	+1.5V	GND
$t_{ZL}$ (Note 9)	0	-1.5V	$V_{CC}$
$t_{HZ}(SHDN)$ (Note 12)	0	+1.5V	GND
$t_{LZ}(SHDN)$ (Note 12)	0	-1.5V	$V_{CC}$

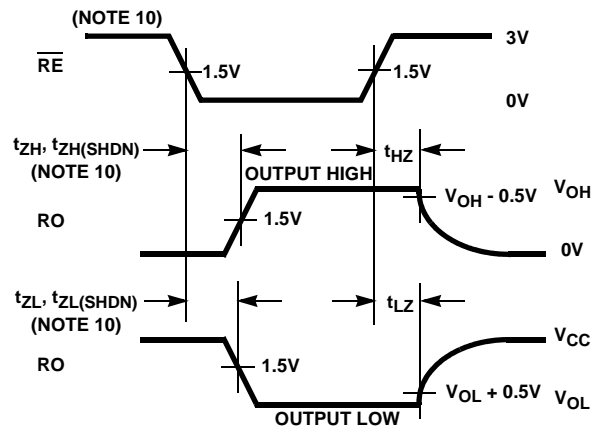


FIGURE 6B. MEASUREMENT POINTS

FIGURE 6. RECEIVER ENABLE AND DISABLE TIMES



## 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 (assuming one unit load devices) receivers on each bus. 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 spec 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 runs as long as 4000' (~1200m), so the wide CMR is necessary to handle ground potential differences, as well as voltages induced in the cable by external fields.

### Receiver (Rx) Features

This transceiver utilizes a differential input receiver for maximum noise immunity and common mode rejection. Input sensitivity is  $\pm 200\text{mV}$ , as required by the RS422 and RS-485 specifications. Receiver inputs function with common mode voltages as great as 7V outside the power supplies (i.e., +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 spec of  $4\text{k}\Omega$ , and is five times the RS-485 "Unit Load" (UL) requirement of  $12\text{k}\Omega$  minimum. Thus, the ISL3159E 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 guarantees 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 via the active low  $\overline{RE}$  input.

### 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/PROFIBUS), 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.

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

For parallel applications, bit-to-bit skews between any two ISL3159E transmitter and receiver pairs are guaranteed to be no worse than 8ns (4ns max for any two Tx, 4ns max for any two Rx).

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

The ISL3159E 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  $\pm 2.1\text{V}$   $V_{OD}$  guarantees 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 for utilizing the ISL3159E in "star" and other multi-terminated, "non-standard" network topologies. Figure 8, 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. The figure 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 ISL3159E typically delivers RS-485 voltage levels with 2x to 3x the number of terminations.

### ESD Protection

All pins on the ISL3159E include class 3 ( $>9\text{kV}$ ) 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  $\pm 16.5\text{kV}$  HBM and  $\pm 15\text{kV}$  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 might 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 -7V to +12V. This built-in ESD protection eliminates the need for board level protection structures (e.g., transient suppression diodes), and the associated, undesirable capacitive load they present.

### IEC61000-4-2 Testing

The IEC61000 test method applies to finished equipment, rather than to an individual IC. Therefore, the pins most likely to suffer an ESD event are those that are exposed to the outside world (the RS-485 pins in this case), and the IC is tested in its typical application configuration (power applied) rather than testing each pin-to-pin combination. The IEC61000 standard's lower current limiting resistor coupled with the larger charge storage capacitor yields a test that is much more severe than the HBM test. The extra ESD protection built into this device's RS-485 pins allows the

design of equipment meeting level 4 criteria without the need for additional board level protection on the RS-485 port.

#### AIR-GAP DISCHARGE TEST METHOD

For this test method, a charged probe tip moves toward the IC pin until the voltage arcs to it. The current waveform delivered to the IC pin depends on approach speed, humidity, temperature, etc., so it is more difficult to obtain repeatable results. The ISL3159E RS-485 pins withstand  $\pm 15\text{kV}$  air-gap discharges.

#### CONTACT DISCHARGE TEST METHOD

During the contact discharge test, the probe contacts the tested pin before the probe tip is energized, thereby eliminating the variables associated with the air-gap discharge. The result is a more repeatable and predictable test, but equipment limits prevent testing devices at voltages higher than  $\pm 9\text{kV}$ . The RS-485 pins of the ISL3159E survive  $\pm 8\text{kV}$  contact discharges.

#### Hot Plug Function

When a piece of equipment powers up, there is a period of time where 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 ISL3159E incorporates a "Hot Plug" function. Circuitry monitoring  $V_{CC}$  ensures that, during power up and power down, the Tx and Rx outputs remain disabled, regardless of the state of DE and RE, if  $V_{CC}$  is less than  $\sim 3.2\text{V}$ . This gives the processor/ASIC a chance to stabilize and drive the RS-485 control lines to the proper states.

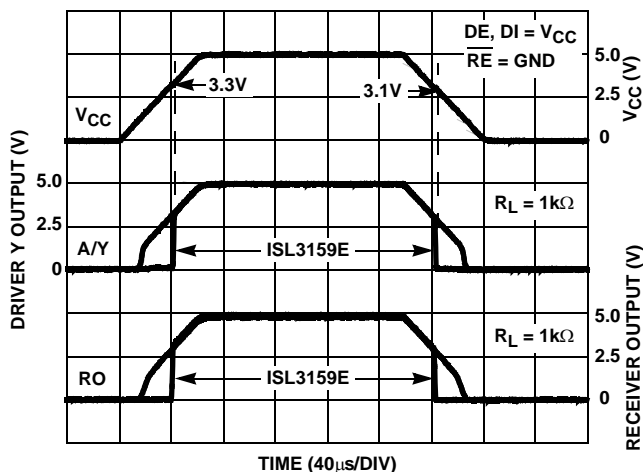


FIGURE 7. HOT PLUG PERFORMANCE (ISL3159E) vs ISL83088E WITHOUT HOT PLUG CIRCUITRY

#### 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 PROFIBUS specifications, networks operating at data rates in excess of 3Mbps should be limited to cable lengths of 100m (328 ft) or less, and the PROFIBUS specification recommends that the more expensive "Type A" (22AWG) cable be used. The ISL3159E'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 (328 ft). Figure 17 details the ISL3159E 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 16. Performance should be even better if the "Type A" cable is utilized.

The ISL3159E may also be used at slower data rates over longer cables, but there are some limitations. 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 1000' (305m) CAT 5 cable) yields excellent performance over 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  $120\Omega$  for "CAT5", and  $220\Omega$  for "Type A") at the end farthest from the driver. In multi-receiver applications, stubs connecting receivers to the main cable should be kept as short as possible. Multipoint (multi-driver) 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.

#### 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 via 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 degrees. If the contention persists, the thermal shutdown/reenable cycle repeats until the fault is cleared. Receivers stay operational during thermal shutdown.

**Low Power Shutdown Mode**

This BiCMOS transceiver uses a fraction of the power required by their bipolar counterparts, but it also 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 guarantees that the transceiver will not enter shutdown.

Note that receiver and driver enable times increase when the transceiver enables from shutdown. Refer to Notes 8, 9, 10, 11 and 12, at the end of the Electrical Specification table on page 6, for more information.

**Typical Performance Curves**  $V_{CC} = 5V, T_A = +25^\circ C$ ; Unless Otherwise Specified

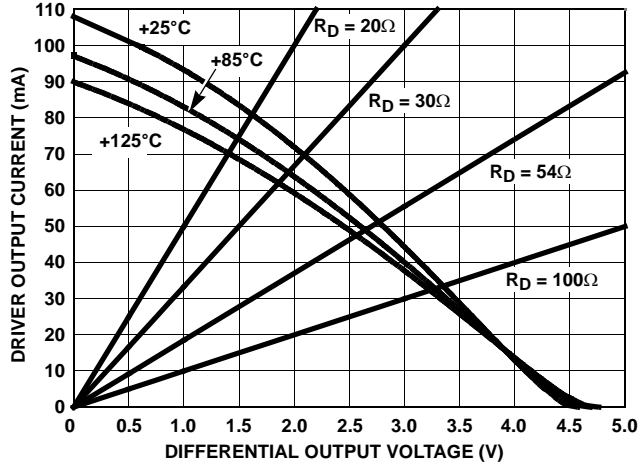


FIGURE 8. DRIVER OUTPUT CURRENT vs DIFFERENTIAL OUTPUT VOLTAGE

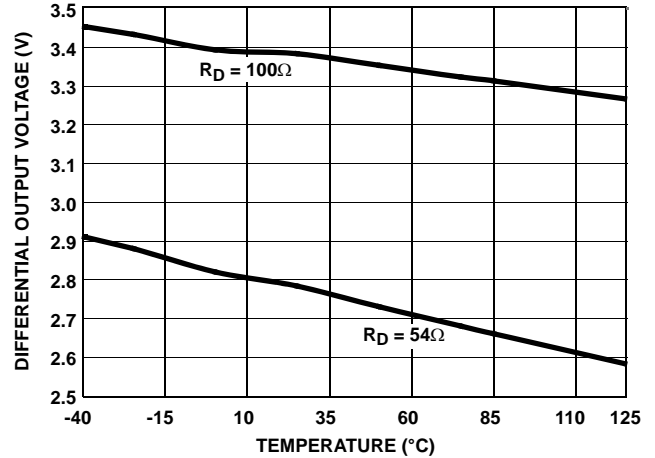


FIGURE 9. DRIVER DIFFERENTIAL OUTPUT VOLTAGE vs TEMPERATURE

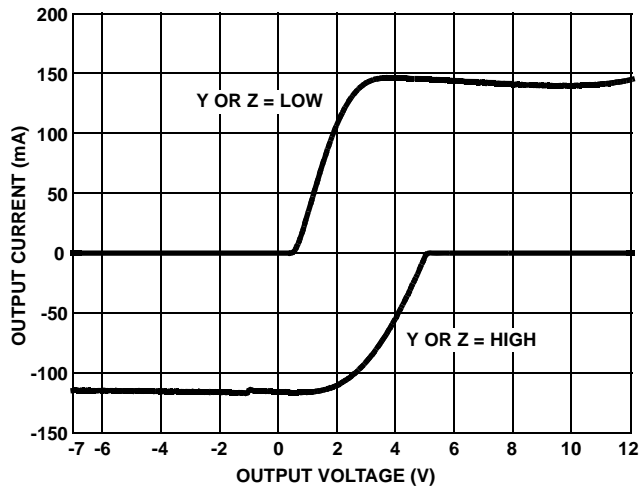


FIGURE 10. DRIVER OUTPUT CURRENT vs SHORT CIRCUIT VOLTAGE

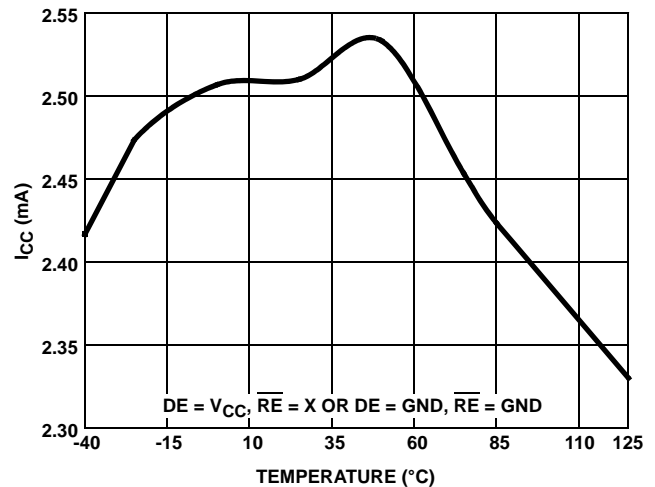


FIGURE 11. SUPPLY CURRENT vs TEMPERATURE

**Typical Performance Curves**  $V_{CC} = 5V, T_A = +25^\circ C$ ; Unless Otherwise Specified (Continued)

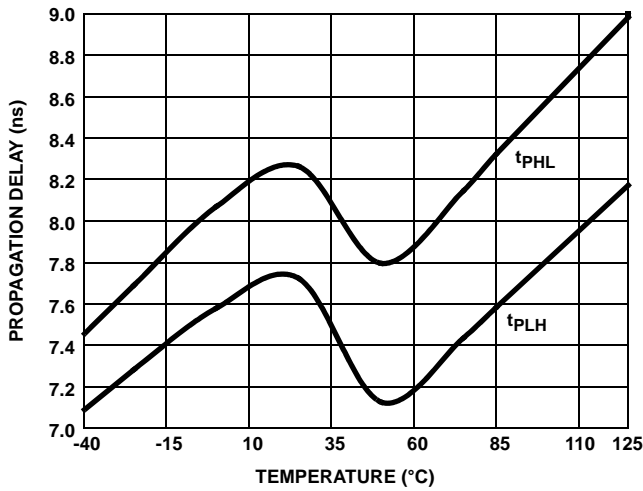


FIGURE 12. DRIVER DIFFERENTIAL PROPAGATION DELAY vs TEMPERATURE

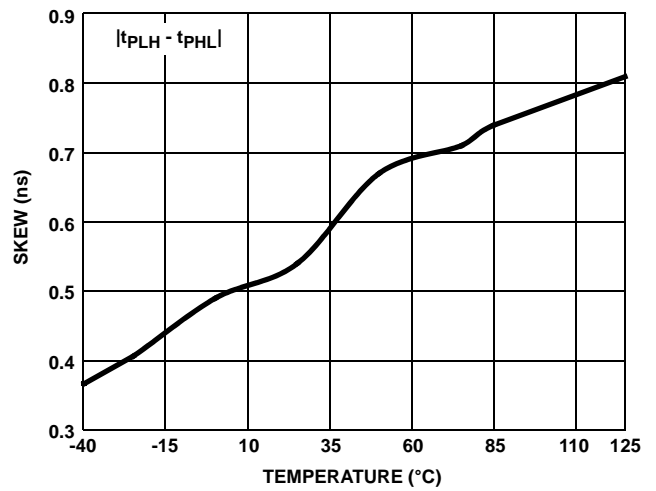


FIGURE 13. DRIVER DIFFERENTIAL SKEW vs TEMPERATURE

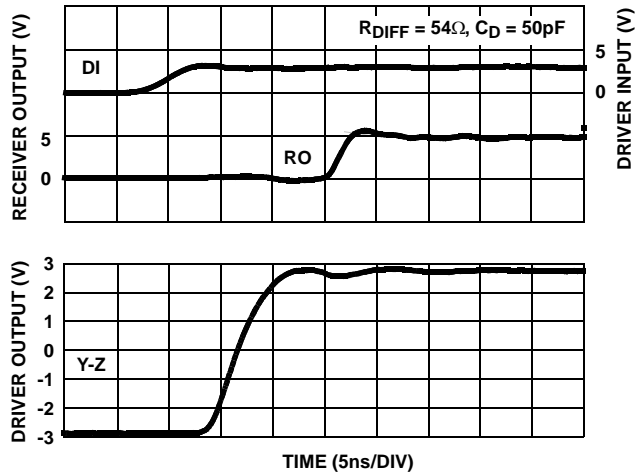


FIGURE 14. DRIVER AND RECEIVER WAVEFORMS

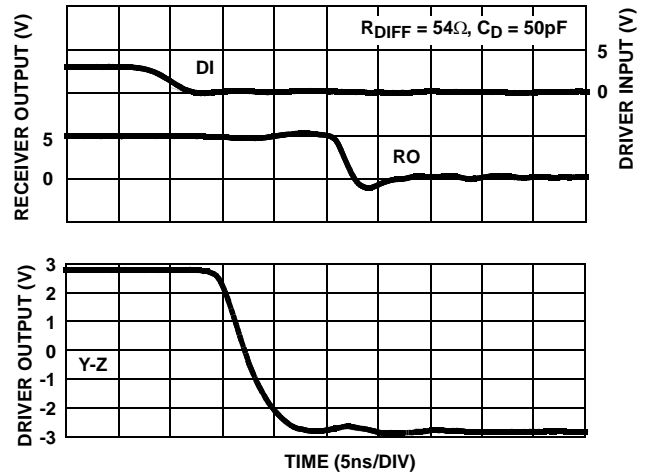


FIGURE 15. DRIVER AND RECEIVER WAVEFORMS

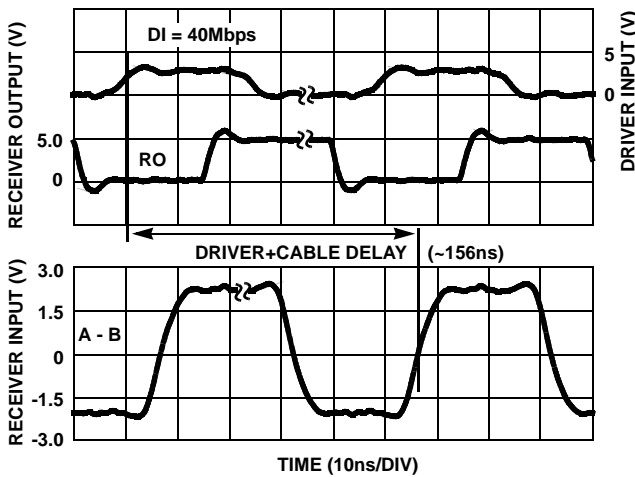


FIGURE 16. DRIVER AND RECEIVER WAVEFORMS DRIVING 100 FEET (31 METERS) OF CAT5 CABLE (DOUBLE TERMINATED WITH 120Ω)

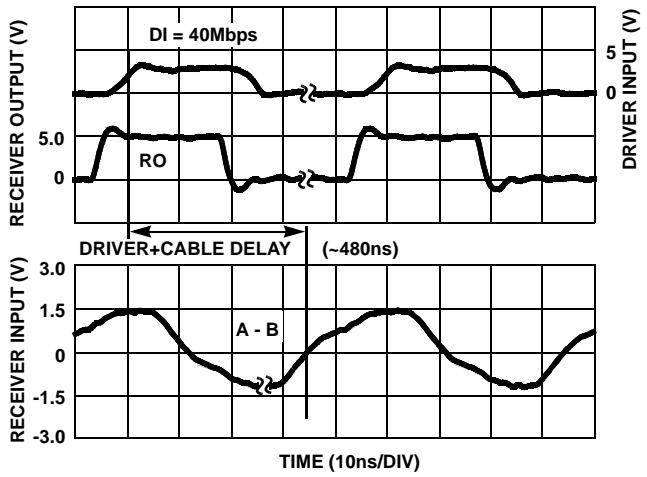


FIGURE 17. DRIVER AND RECEIVER WAVEFORMS DRIVING 350 FEET (107 METERS) OF CAT5 CABLE (DOUBLE TERMINATED WITH 120Ω)

**Typical Performance Curves**  $V_{CC} = 5V, T_A = +25^\circ C$ ; Unless Otherwise Specified (Continued)

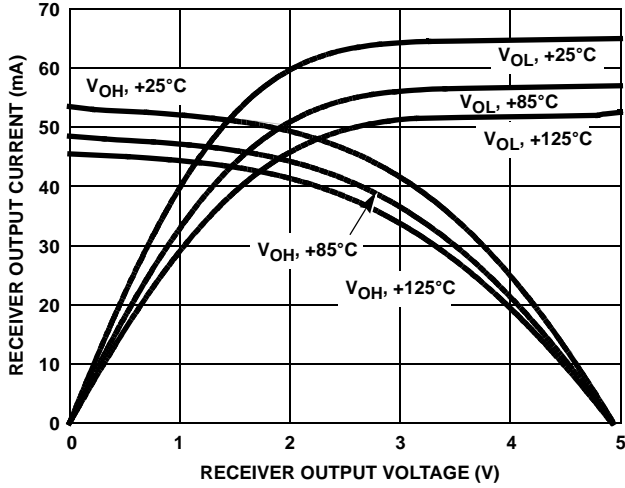


FIGURE 18. RECEIVER OUTPUT CURRENT vs RECEIVER OUTPUT VOLTAGE

**Die Characteristics**

SUBSTRATE AND DFN THERMAL PAD POTENTIAL (POWERED UP):

GND

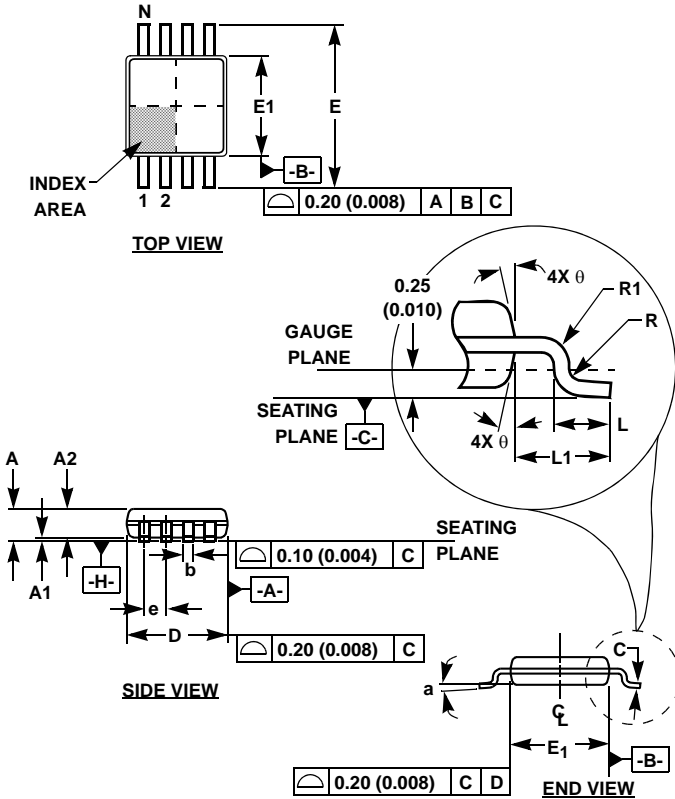
TRANSISTOR COUNT:

768

PROCESS:

Si Gate BiCMOS

Mini Small Outline Plastic Packages (MSOP)



M8.118 (JEDEC MO-187AA)  
8 LEAD MINI SMALL OUTLINE PLASTIC PACKAGE

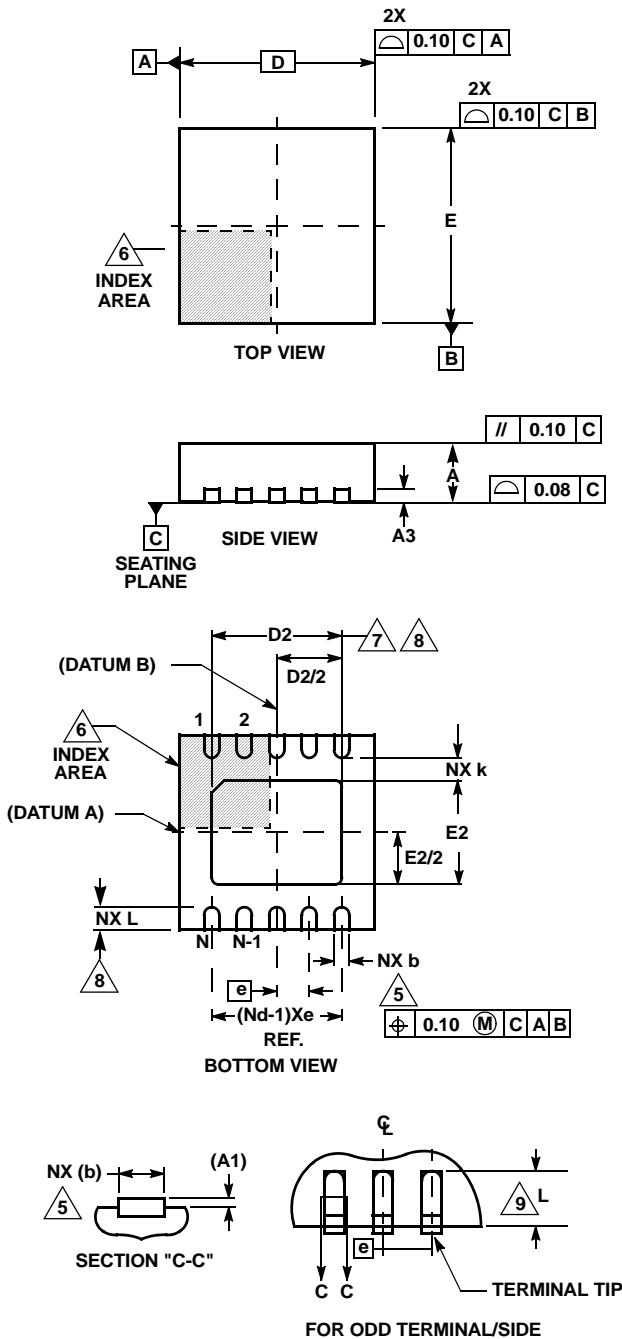
SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.037	0.043	0.94	1.10	-
A1	0.002	0.006	0.05	0.15	-
A2	0.030	0.037	0.75	0.95	-
b	0.010	0.014	0.25	0.36	9
c	0.004	0.008	0.09	0.20	-
D	0.116	0.120	2.95	3.05	3
E1	0.116	0.120	2.95	3.05	4
e	0.026 BSC		0.65 BSC		-
E	0.187	0.199	4.75	5.05	-
L	0.016	0.028	0.40	0.70	6
L1	0.037 REF		0.95 REF		-
N	8		8		7
R	0.003	-	0.07	-	-
R1	0.003	-	0.07	-	-
θ	5°	15°	5°	15°	-
α	0°	6°	0°	6°	-

Rev. 2 01/03

NOTES:

1. These package dimensions are within allowable dimensions of JEDEC MO-187BA.
2. Dimensioning and tolerancing per ANSI Y14.5M-1994.
3. Dimension "D" does not include mold flash, protrusions or gate burrs and are measured at Datum Plane. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension "E1" does not include interlead flash or protrusions and are measured at Datum Plane. [-H-] Interlead flash and protrusions shall not exceed 0.15mm (0.006 inch) per side.
5. Formed leads shall be planar with respect to one another within 0.10mm (0.004) at seating Plane.
6. "L" is the length of terminal for soldering to a substrate.
7. "N" is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. Dimension "b" does not include dambar protrusion. Allowable dambar protrusion shall be 0.08mm (0.003 inch) total in excess of "b" dimension at maximum material condition. Minimum space between protrusion and adjacent lead is 0.07mm (0.0027 inch).
10. Datums [-A-] and [-B-] to be determined at Datum plane [-H-].
11. Controlling dimension: MILLIMETER. Converted inch dimensions are for reference only.

Dual Flat No-Lead Plastic Package (DFN)



L10.3x3C

10 LEAD DUAL FLAT NO-LEAD PLASTIC PACKAGE

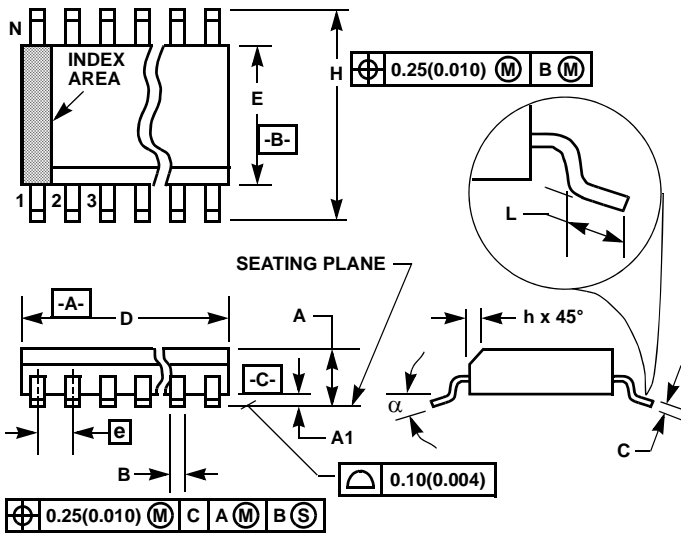
SYMBOL	MILLIMETERS			NOTES
	MIN	NOMINAL	MAX	
A	0.85	0.90	0.95	-
A1	-	-	0.05	-
A3	0.20 REF			-
b	0.20	0.25	0.30	5, 8
D	3.00 BSC			-
D2	2.33	2.38	2.43	7, 8
E	3.00 BSC			-
E2	1.59	1.64	1.69	7, 8
e	0.50 BSC			-
k	0.20	-	-	-
L	0.35	0.40	0.45	8
N	10			2
Nd	5			3

Rev. 1 4/06

NOTES:

1. Dimensioning and tolerancing conform to ASME Y14.5-1994.
2. N is the number of terminals.
3. Nd refers to the number of terminals on D.
4. All dimensions are in millimeters. Angles are in degrees.
5. Dimension b applies to the metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
6. The configuration of the pin #1 identifier is optional, but must be located within the zone indicated. The pin #1 identifier may be either a mold or mark feature.
7. Dimensions D2 and E2 are for the exposed pads which provide improved electrical and thermal performance.
8. Nominal dimensions are provided to assist with PCB Land Pattern Design efforts, see Intersil Technical Brief TB389.
9. COMPLIANT TO JEDEC MO-229-WEED-3 except for dimensions E2 & D2.

Small Outline Plastic Packages (SOIC)



M8.15 (JEDEC MS-012-AA ISSUE C)  
8 LEAD NARROW BODY SMALL OUTLINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0532	0.0688	1.35	1.75	-
A1	0.0040	0.0098	0.10	0.25	-
B	0.013	0.020	0.33	0.51	9
C	0.0075	0.0098	0.19	0.25	-
D	0.1890	0.1968	4.80	5.00	3
E	0.1497	0.1574	3.80	4.00	4
e	0.050 BSC		1.27 BSC		-
H	0.2284	0.2440	5.80	6.20	-
h	0.0099	0.0196	0.25	0.50	5
L	0.016	0.050	0.40	1.27	6
N	8		8		7
$\alpha$	0°	8°	0°	8°	-

NOTES:

1. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension "E" does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. "L" is the length of terminal for soldering to a substrate.
7. "N" is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. The lead width "B", as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch).
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

Rev. 1 6/05

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