

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

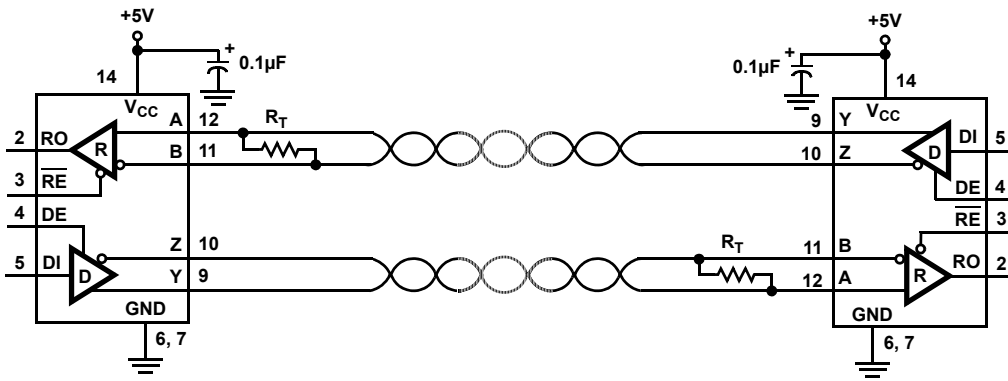


Figure 1. Typical Operating Circuit

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

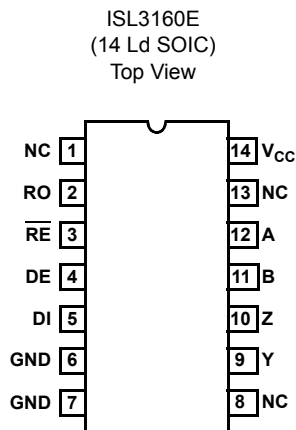
Notes:

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 _{CC} (V)	V _{OD} (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_{CC} through a 1k Ω 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_{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 (Note 4)	High-Z (Note 4)

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 (Note 4)

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 "ESD Performance" on page 7		

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)	θ_{JA} (°C/W)	θ_{JC} (°C/W)
14 Ld SOIC Package (Notes 5, 6)	80	41

Notes:

5. θ_{JA} is measured in free air with the component mounted on a high-effective thermal conductivity test board. See [TB379](#).
6. For θ_{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 TB493		

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_{OUT}	V_{OD}	No Load	Full	-	-	V_{CC}		
		$R_L = 100\Omega$ (RS-422) (Figure 2)	Full	2.6	3.4	-	V	
		$R_L = 54\Omega$ (RS-485) (Figure 2)	Full	2.1	2.8	V_{CC}	V	
		$R_L = 60\Omega$, $-7V \leq V_{CM} \leq 12V$ (Figure 3, Note 15)	Full	1.9	2.7	-	V	
Change in Magnitude of Driver Differential V_{OUT} for Complementary Output States	ΔV_{OD}	$R_L = 54\Omega$ or 100Ω (Figure 2)	Full	-	0.01	0.2	V	
Driver Common-Mode V_{OUT}	V_{OC}	$R_L = 54\Omega$ or 100Ω (Figure 2, Note 15)	Full	-	2	2.5	V	
Change in Magnitude of Driver Common-Mode V_{OUT} for Complementary Output States	ΔV_{OC}	$R_L = 54\Omega$ or 100Ω (Figure 2)	Full	-	0.02	0.2	V	
Logic Input High Voltage	V_{IH}	DI, DE, \overline{RE}	Full	2	-	-	V	
Logic Input Low Voltage	V_{IL}	DI, DE, \overline{RE}	Full	-	-	0.8	V	
Logic Input Current	I_{IN1}	DI = DE = $\overline{RE} = 0V$ or V_{CC}	Full	-2	-	2	μA	
Input Current (A/Y, B/Z)	I_{IN2}	DE = 0V, $V_{CC} = 0V$ or 5.5V	$V_{IN} = 12V$	Full	-	-	220	μA
			$V_{IN} = -7V$	Full	-160	-	-	μA
Driver Short-Circuit Current, $V_O =$ High or Low	I_{OSD1}	DE = V_{CC} , $-7V \leq V_Y$ or $V_Z \leq 12V$	Full	-	-	± 250	mA	
Differential Capacitance	C_D	A/Y to B/Z	+25	-	9	-	pF	
Receiver Differential Threshold Voltage	V_{TH}	$-7V \leq V_{CM} \leq 12V$	Full	-200	-	-50	mV	
Receiver Input Hysteresis	ΔV_{TH}	$V_{CM} = 0V$	+25	-	28	-	mV	
Receiver Output High Voltage	V_{OH}	$I_O = -8mA$, $V_{ID} = -50mV$	Full	$V_{CC} - 0.5$	-	-	V	
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	μA	
Receiver Input Resistance	R_{IN}	$-7V \leq V_{CM} \leq 12V$	Full	54	80	-	k Ω	
Receiver Short-Circuit Current	I_{OSR}	$0V \leq V_O \leq V_{CC}$	Full	± 20	-	± 110	mA	
Supply Current								
No-Load Supply Current (Note 8)	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}	-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_{MAX}	$V_{OD} \geq \pm 1.5V$, $R_D = 54\Omega$, $C_L = 100pF$ (Figure 8)	Full	40	60	-	Mbps
Driver Differential Output Delay	t_{DD}	$R_D = 54\Omega$, $C_D = 50pF$ (Figure 2)	Full	-	11	16	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 14)	Full	-	-	4	ns
Driver Differential Rise or Fall Time	t_R, t_F	$R_D = 54\Omega$, $C_D = 50pF$ (Figure 2)	Full	-	4	8	ns
Driver Enable to Output High	t_{ZH}	$R_L = 110\Omega$, $C_L = 50pF$, SW = GND (Figure 6, Note 9)	Full	-	18	25	ns
Driver Enable to Output Low	t_{ZL}	$R_L = 110\Omega$, $C_L = 50pF$, SW = V_{CC} (Figure 6, Note 9)	Full	-	16	25	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 6)	Full	-	15	25	ns
Driver Disable from Output Low	t_{LZ}	$R_L = 110\Omega$, $C_L = 50pF$, SW = V_{CC} (Figure 6)	Full	-	18	25	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 11)	Full	60	-	600	ns
Driver Enable from Shutdown to Output High	$t_{ZH(SHDN)}$	$R_L = 110\Omega$, $C_L = 50pF$, SW = GND (Figure 6, Notes 11, 12)	Full	-	-	1000	ns
Driver Enable from Shutdown to Output Low	$t_{ZL(SHDN)}$	$R_L = 110\Omega$, $C_L = 50pF$, SW = V_{CC} (Figure 6, Notes 11, 12)	Full	-	-	1000	ns
Receiver Switching Characteristics							
Maximum Data Rate	f_{MAX}	$V_{ID} = \pm 1.5V$	Full	40	60	-	Mbps
Receiver Input to Output Delay	t_{PLH}, t_{PHL}	(Figure 8)	Full	-	10	16.5	ns
Receiver Skew $t_{PLH} - t_{PHL}$	t_{SKD}	(Figure 8)	Full	-	0	1.5	ns
Prop Delay Part-to-Part Skew	t_{SKP-P}	(Figure 8, Note 14)	Full	-	-	4	ns
Receiver Enable to Output High	t_{ZH}	$R_L = 1k\Omega$, $C_L = 15pF$, SW = GND (Figure 12, Note 10)	Full	-	10	15	ns
Receiver Enable to Output Low	t_{ZL}	$R_L = 1k\Omega$, $C_L = 15pF$, SW = V_{CC} (Figure 12, Note 10)	Full	-	11	15	ns
Receiver Disable from Output High	t_{HZ}	$R_L = 1k\Omega$, $C_L = 15pF$, 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	15	ns
Time to Shutdown	t_{SHDN}	(Note 11)	Full	60	-	600	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	-	-	1000	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	-	-	1000	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

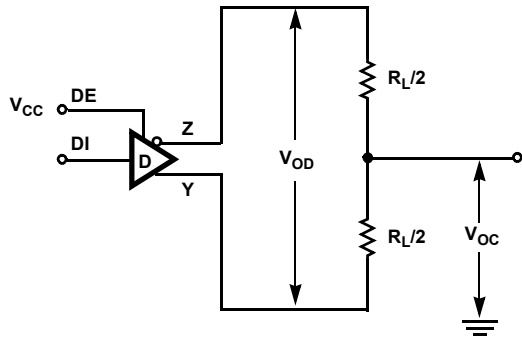


Figure 2. DC Driver Test Circuits V_{OD} and V_{OC}

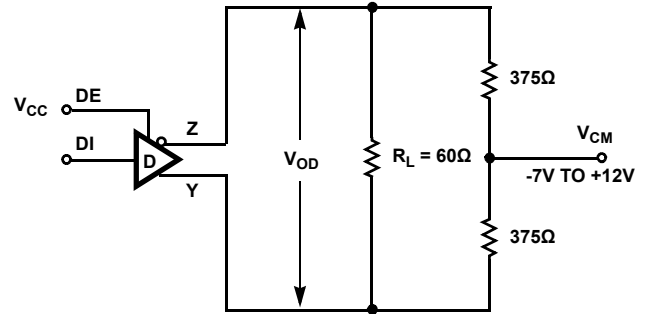


Figure 3. DC Driver Test Circuits V_{OD} with Common-Mode Load

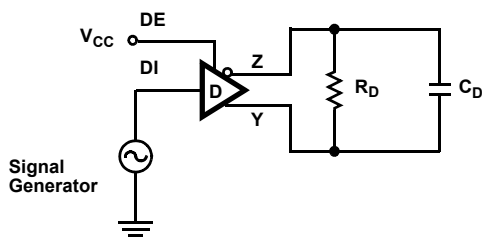


Figure 4. Driver Propagation Delay and Differential Transition Times Test Circuit

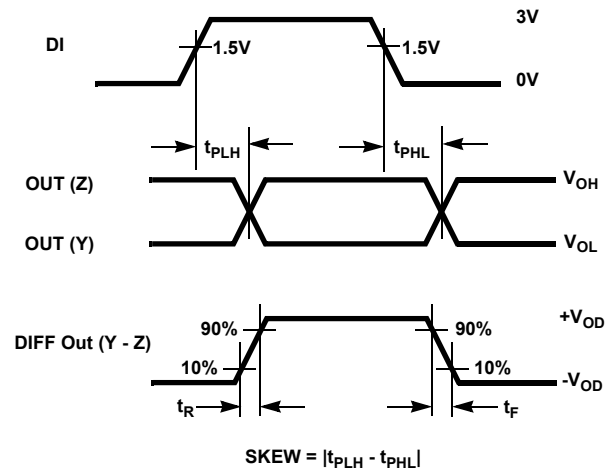
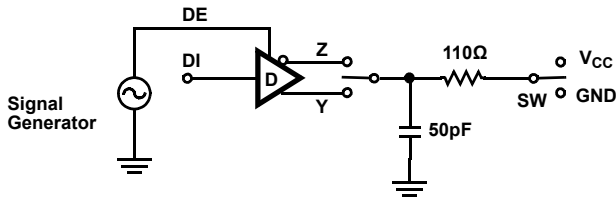


Figure 5. Driver Propagation Delay and Differential Transition Times Measurement Points



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

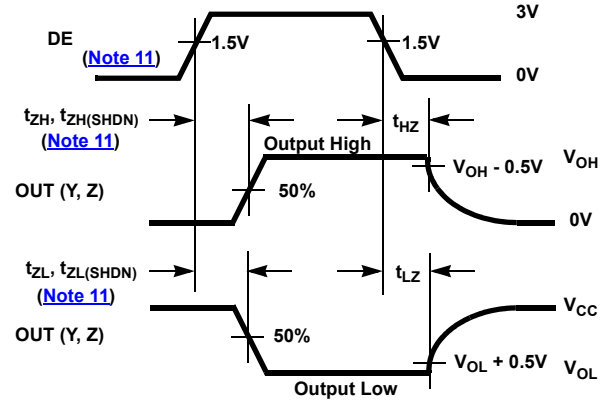


Figure 7. Driver Enable and Disable Times Measurement Points

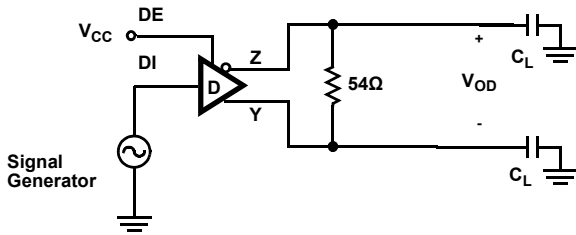


Figure 8. Driver Data Rate Test Circuit

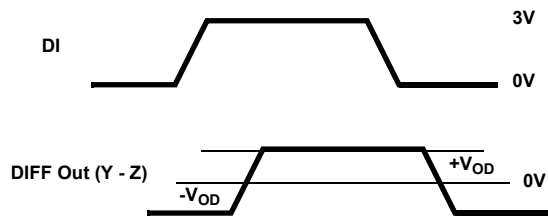


Figure 9. Driver Data Rate Measurement Points

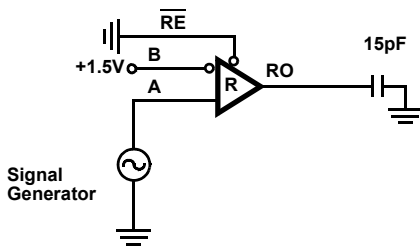


Figure 10. Receiver Propagation Delay Test Circuit

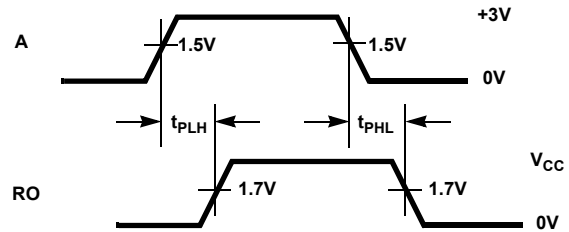
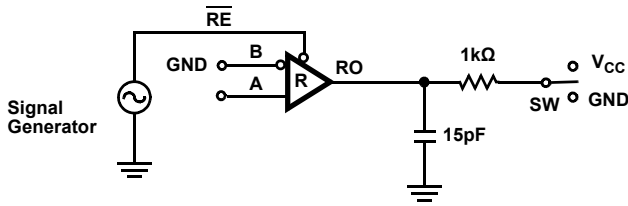


Figure 11. Receiver Propagation Delay Measurement Points



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

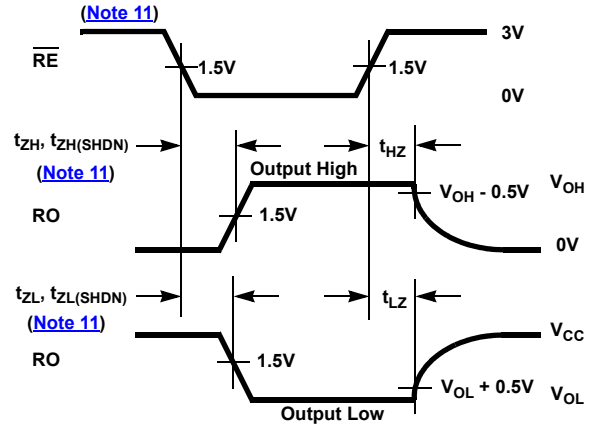


Figure 13. Receiver Enable and Disable Times Measurement Points

4. Typical Performance Curves

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

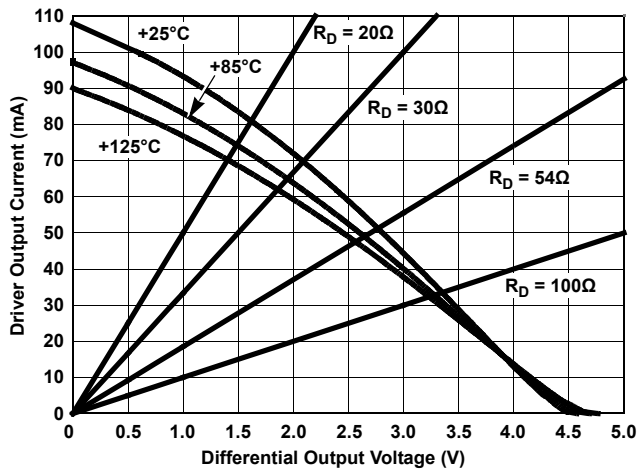


Figure 14. Driver Output Current vs Differential Output Voltage

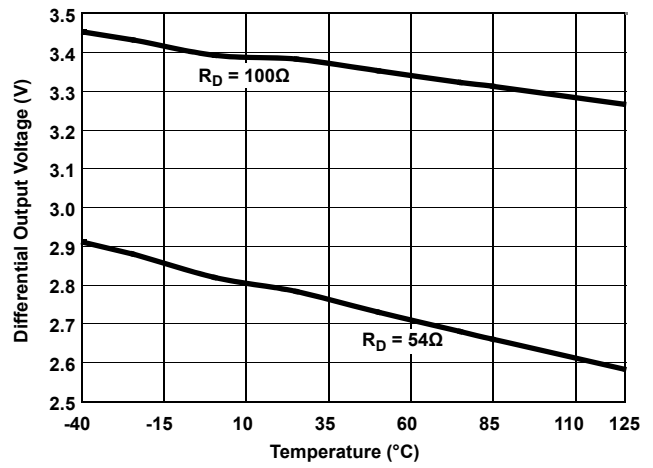


Figure 15. Driver Differential Output Voltage vs Temperature

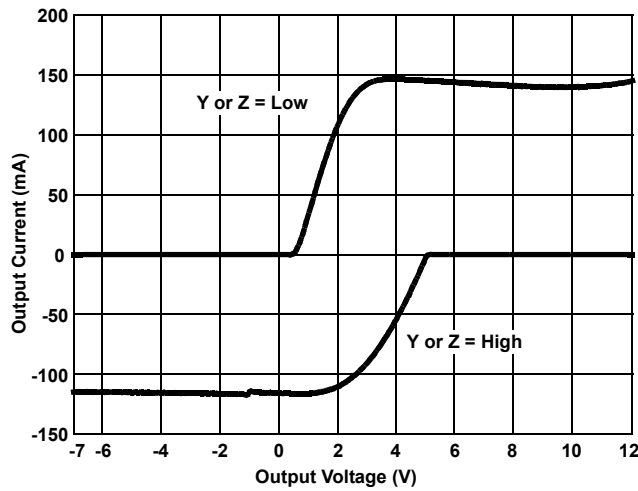


Figure 16. Driver Output Current vs Short-Circuit Voltage

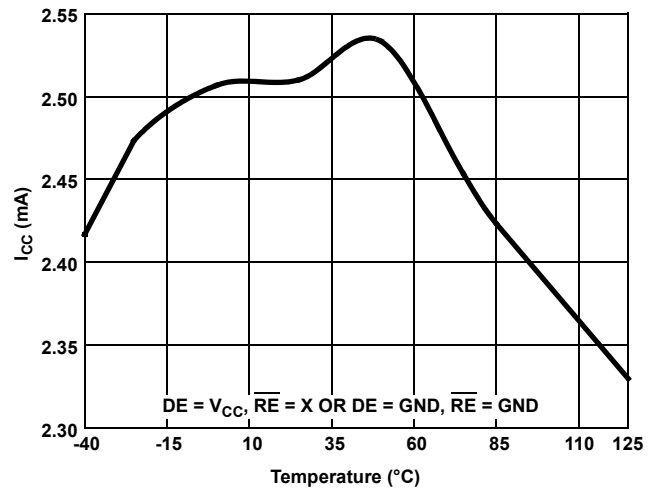


Figure 17. Supply Current vs Temperature

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

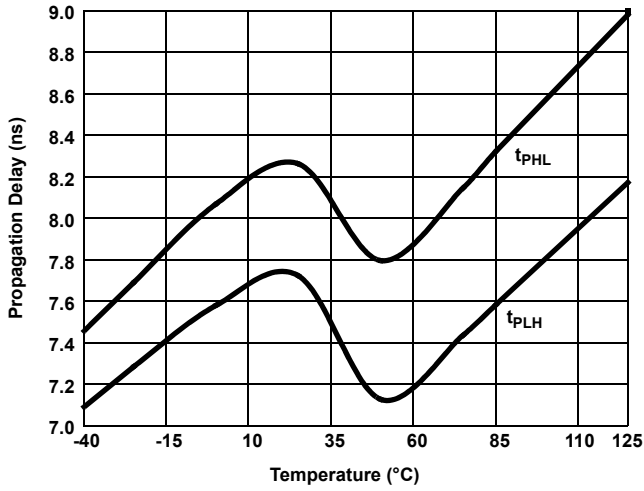


Figure 18. Driver Differential Propagation Delay vs Temperature

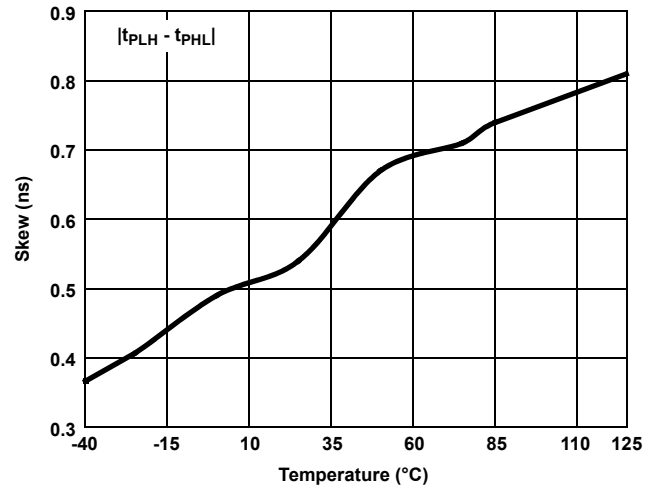


Figure 19. Driver Differential Skew vs Temperature

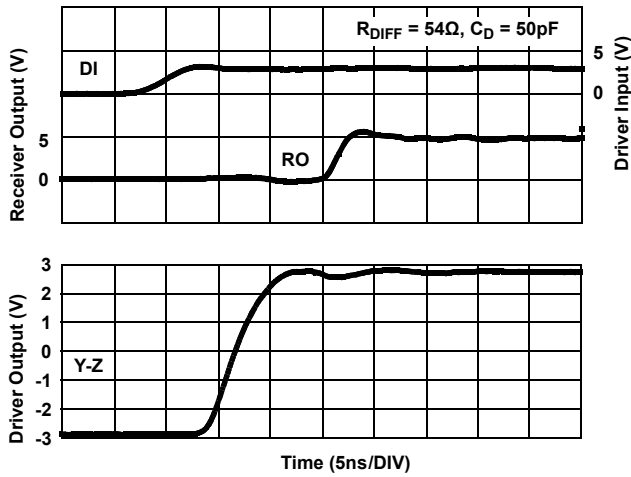


Figure 20. Driver and Receiver Waveforms

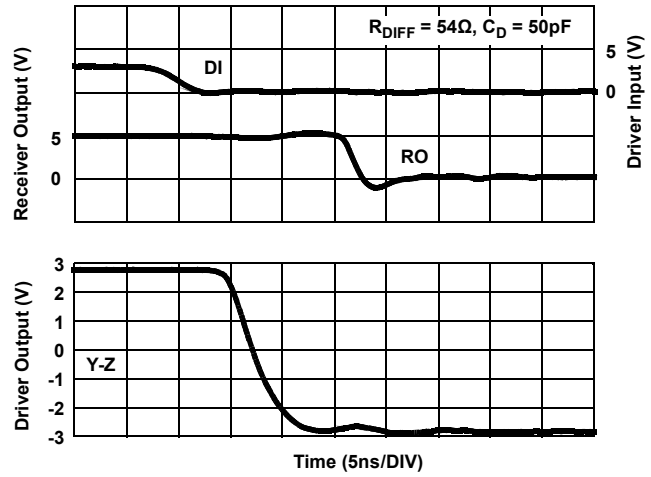


Figure 21. Driver and Receiver Waveforms

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

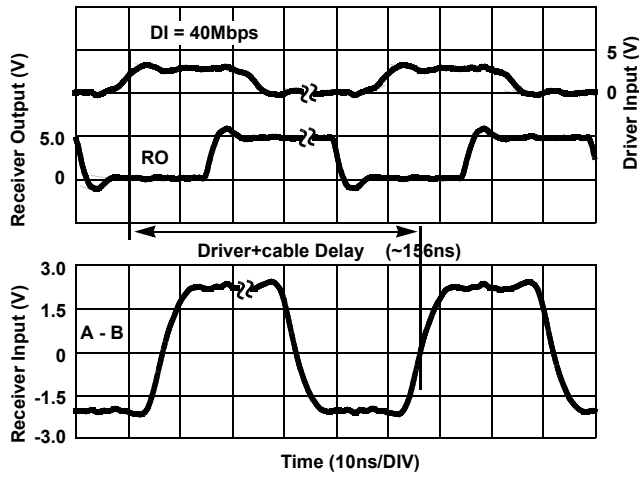


Figure 22. Driver and Receiver Waveforms Driving 100ft (31m) of Cat 5 Cable (Double Terminated with 120Ω)

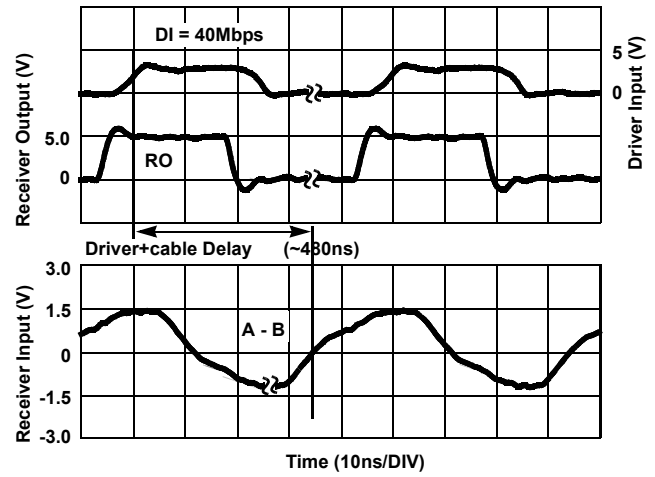


Figure 23. Driver and Receiver Waveforms Driving 350ft (107m) of Cat 5 Cable (Double Terminated with 120Ω)

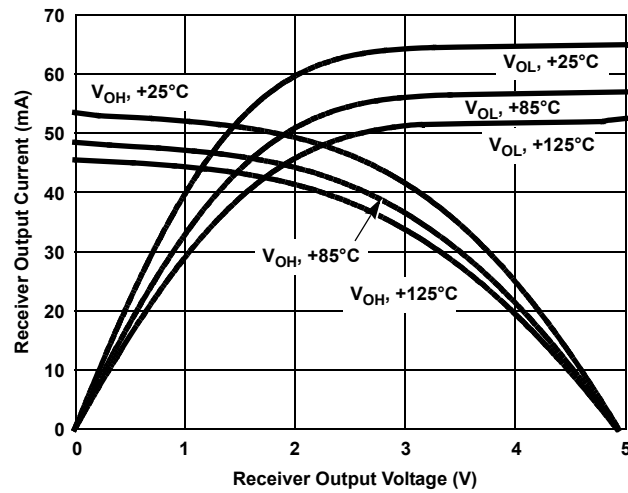


Figure 24. Receiver Output Current vs Receiver Output Voltage

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 54Ω load (RS-485), and at least 2.6V across a 100Ω 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 (30Ω) and six (20Ω) 120Ω 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 -7V 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.

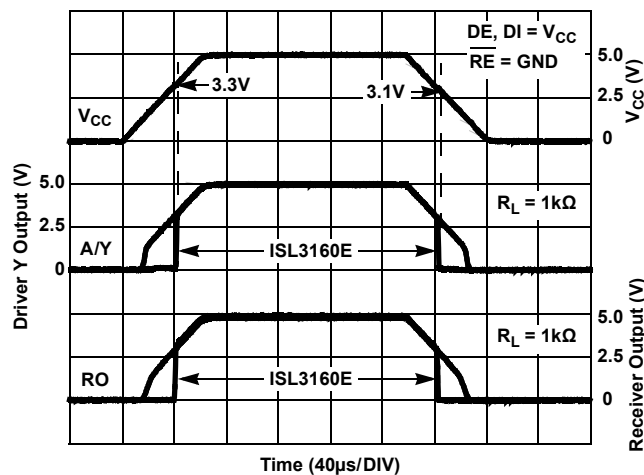


Figure 25. Hot Plug Performance (ISL3160E) vs ISL83086E without Hot Plug Circuitry

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 120Ω 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.

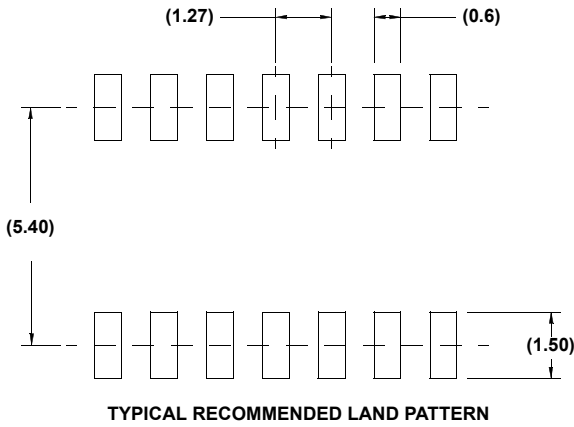
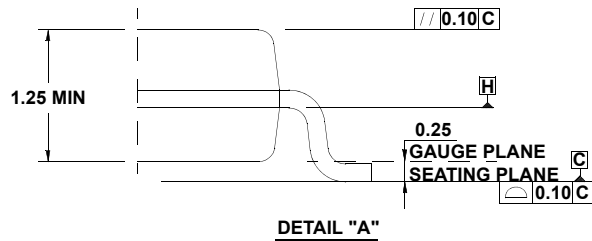
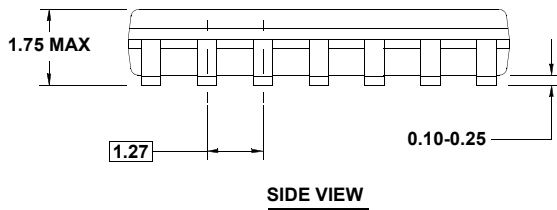
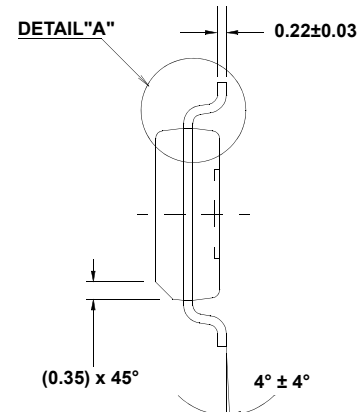
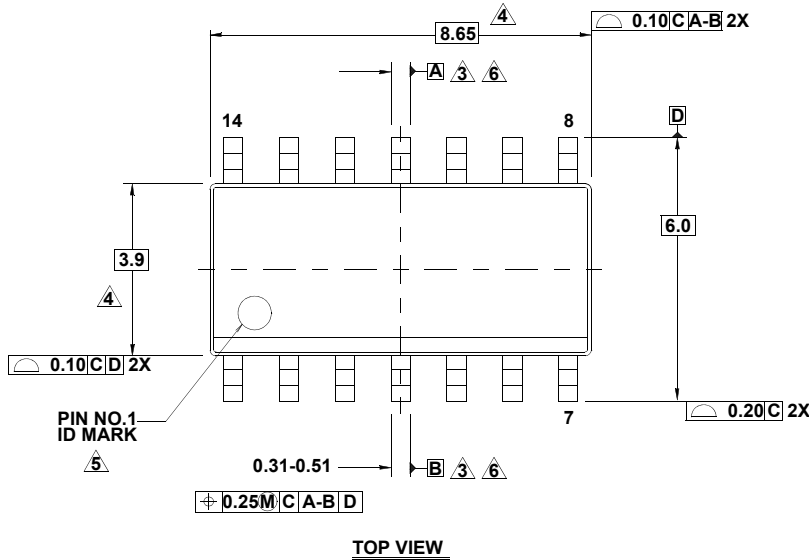
6. Revision History

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.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.
"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.
"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.
Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.
6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.
(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.
(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)



SALES OFFICES

Renesas Electronics Corporation

<http://www.renesas.com>

Refer to "<http://www.renesas.com/>" for the latest and detailed information.

Renesas Electronics America Inc.

1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.
Tel: +1-408-432-8888, Fax: +1-408-434-5351

Renesas Electronics Canada Limited

9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited

Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700, Fax: +44-1628-651-804

Renesas Electronics Europe GmbH

Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.

Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.

Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited

Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.

13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.

80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.

Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.

No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.

17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5338