

# ±16.5kV ESD Protected, +125 °C, 1.8V to 3.6V, Low Power, SOT-23, RS-485/RS-422 Transmitters

## ISL32613E, ISL32614E

The Intersil ISL32613E and ISL32614E are ±16.5kV HBM ESD Protected (7kV IEC61000 contact), 1.8V powered, single transmitters for differential communication. These drivers have very low bus currents (±40µA), so they present less than a “1/8 unit load” to the bus. This allows more than 256 transmitters on the network, without violating the RS-485 specification’s 32 unit load maximum and without using repeaters.

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

Both ICs utilize slew rate limited drivers, which reduce EMI and minimize reflections from improperly terminated transmission lines or unterminated stubs in multidrop and multipoint applications. The ISL32613E is more slew rate limited for data rates up to 128kbps, while the less limited ISL32614E is useful for data rates up to 256kbps.

For companion low power single RS-485 receivers, please see the ISL32610E data sheet.

## Features

- Wide Supply Voltage Range . . . . . 1.8V to 3.6V
- Low Quiescent Supply Current . . . . . 80µA (Max)
  - Very Low Shutdown Supply Current . . . . . 2µA (Max)
- High ESD Protection on RS-485 Outputs . . . . ±16.5kV HBM
  - Class 3 ESD Level on All Other Pins . . . . . >8kV HBM
- Specified for +125 °C Operation
- Hot Plug - Tx Outputs Remain Three-state During Power-up
- Low Tx Leakage Allows >256 Devices on the Bus
- Slew Rate Limited for Data Rates Up to 256kbps
- Current Limiting and Thermal Shutdown for Driver Overload Protection
- 5V Tolerant Logic Inputs
- Pb-Free (RoHS Compliant)

## Applications

- Industrial/Process Control Networks
- Space-constrained Systems
- Factory Automation
- Building Environmental Control/Lighting Systems

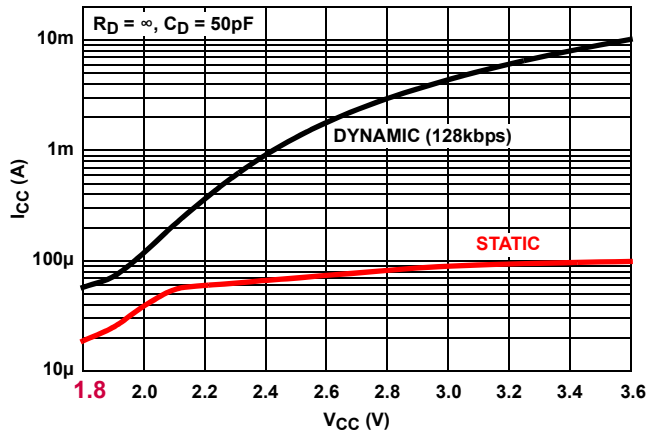


FIGURE 1. V<sub>CC</sub> 1.8V TO 3.6V

ISL32613E with V<sub>CC</sub> = 1.8V Reduces Operating I<sub>CC</sub> by a Factor of 177 Compared with I<sub>CC</sub> at V<sub>CC</sub> = 3.6V

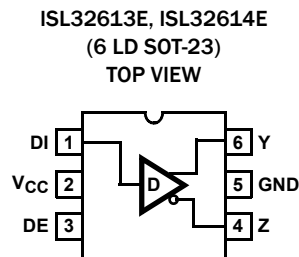
## Truth Table

TRANSMITTING			
INPUTS		OUTPUTS	
DE (Note 9)	DI	Z	Y
1	1	0	1
1	0	1	0
0	X	High-Z *	High-Z *

NOTE: \*Shutdown Mode

# ISL32613E, ISL32614E

## Pin Configuration



## Pin Descriptions

SOT-23	SYMBOL	FUNCTION
1	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.
2	V <sub>CC</sub>	System power supply input (1.8V to 3.6V).
3	DE	Driver output enable. The driver outputs, Y and Z, are enabled by bringing DE high, and are high impedance when DE is low. If the driver enable function is not needed, connect DE to V <sub>CC</sub> through a 1kΩ to 2kΩ resistor.
4	Z	±16.5kV HBM, ±7kV IEC61000 (contact method) ESD Protected inverting differential transmitter output.
5	GND	Ground connection.
6	Y	±16.5kV HBM, ±7kV IEC61000 (contact method) ESD Protected noninverting differential transmitter output.

TABLE 1. SUMMARY OF FEATURES AT V<sub>CC</sub> = 1.8V

PART NUMBER	FUNCTION	DATA RATE (kbps)	SLEW-RATE LIMITED?	HOT PLUG?	TX ENABLE? (Note 9)	MAXIMUM QUIESCENT I <sub>CC</sub> (μA)	LOW POWER SHUTDOWN?	PIN COUNT
ISL32613E	1 Tx	128	Yes	Yes	Yes	80	Yes	6 Ld SOT
ISL32614E	1 Tx	256	Yes	Yes	Yes	80	Yes	6 Ld SOT

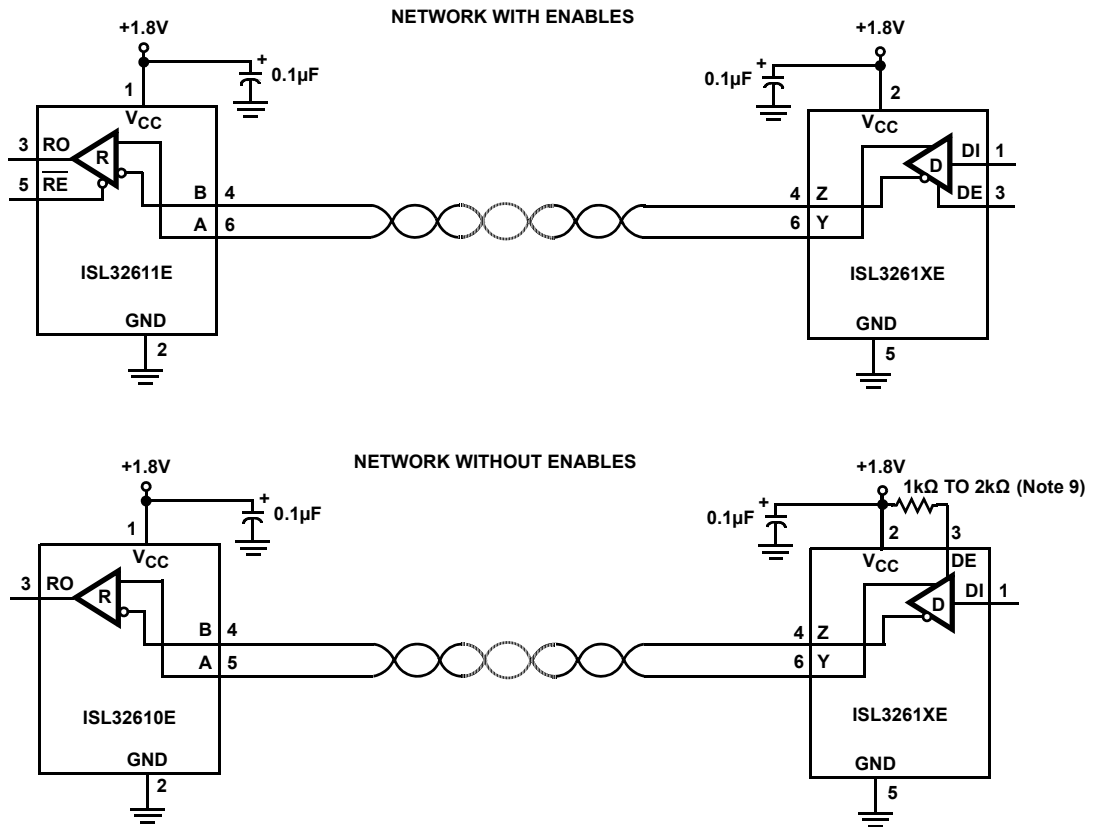
## Ordering Information

PART NUMBER (Notes 1, 2)	PART MARKING (Note 4)	TEMP. RANGE (°C)	PACKAGE (Tape and Reel) (Pb-Free)	PKG. DWG. #
ISL32613EFHZ-T	613F	-40 to +125	6 Ld SOT-23	P6.064
ISL32614EFHZ-T	614F	-40 to +125	6 Ld SOT-23	P6.064

### NOTES:

1. These Intersil Pb-free plastic packaged products employ special Pb-free material sets, molding compounds/die attach materials, and 100% matte tin plate plus anneal (e3 termination finish, which is 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.
2. Please refer to [TB347](#) for details on reel specifications.
3. For Moisture Sensitivity Level (MSL), please see device information page for [ISL32613E](#), [ISL32614E](#). For more information on MSL please see techbrief [TB363](#).
4. SOT-23 "PART MARKING" is branded on the bottom side.

## Typical Operating Circuits



# ISL32613E, ISL32614E

## Absolute Maximum Ratings

V <sub>CC</sub> to GND	-0.3V to 7V
Input Voltages	
DI, DE	-0.3V to 7V
Output Voltages	
Y, Z (V <sub>CC</sub> = 0V or ≥ 2.7V)	-8V to +13V
Y, Z (V <sub>CC</sub> = 1.8V)	-8V to +3V
Short Circuit Duration	
Y, Z	Indefinite
ESD Rating	see "Electrical Specifications"
Latch-up (per JESD78, Level 2, Class A)	+125°C

## Thermal Information

Thermal Resistance (Typical)	$\theta_{JA}$ (°C/W)	$\theta_{JC}$ (°C/W)
6 Ld SOT-23 Package (Notes 5, 6)	177	95
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>	

## Recommended Operating Conditions

Supply Voltage Range	1.8V to 3.3V
Common Mode Range; V <sub>CC</sub> = 1.8V	±2V
V <sub>CC</sub> ≥ 2.7V	-7V to +12V
Temperature Range	-40°C to +125°C
R <sub>D</sub> ; V <sub>CC</sub> = 1.8V	≥10kΩ
V <sub>CC</sub> ≥ 2.7V	≥60Ω

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.

### NOTES:

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

## Electrical Specifications

V<sub>CC</sub> = 1.8V; typicals are at T<sub>A</sub> = +25°C; unless otherwise specified. **Boldface limits apply over the operating temperature range, -40°C to +125°C. (Note 7)**

PARAMETER	SYMBOL	TEST CONDITIONS	TEMP (°C)	MIN (Note 10)	TYP	MAX (Note 10)	UNITS	
<b>DC CHARACTERISTICS</b>								
Driver Differential V <sub>OUT</sub>	V <sub>OD</sub>	R <sub>L</sub> = 100Ω (Figure 2)	V <sub>CC</sub> = 1.8V	Full	<b>0.8</b>	0.92	-	V
			V <sub>CC</sub> ≥ 3.15V	Full	<b>2</b>	-	-	V
		R <sub>L</sub> = 54Ω (Figure 2), V <sub>CC</sub> ≥ 3V		Full	<b>1.5</b>	-	-	V
		No Load		Full	<b>1.1</b>	1.45	V <sub>CC</sub>	V
Change in Magnitude of Driver Differential V <sub>OUT</sub> for Complementary Output States	ΔV <sub>OD</sub>	R <sub>L</sub> = 100Ω (Figure 2)	Full	-	0.01	<b>0.2</b>	V	
Driver Common-Mode V <sub>OUT</sub>	V <sub>OC</sub>	R <sub>L</sub> = 100Ω (Figure 2)	Full	-	1.1	<b>1.4</b>	V	
Change in Magnitude of Driver Common-Mode V <sub>OUT</sub> for Complementary Output States	ΔV <sub>OC</sub>	R <sub>L</sub> = 100Ω (Figure 2)	Full	-	0.01	<b>0.2</b>	V	
Logic Input High Voltage (DI, DE)	V <sub>IH</sub>	V <sub>CC</sub> = 1.8V	Full	<b>1.26</b>	-	-	V	
		2.7V ≤ V <sub>CC</sub> ≤ 3.6V	Full	<b>2.2</b>	-	-	V	
Logic Input Low Voltage (DI, DE)	V <sub>IL</sub>	V <sub>CC</sub> = 1.8V	Full	-	-	<b>0.4</b>	V	
		2.7V ≤ V <sub>CC</sub> ≤ 3.6V	Full	-	-	<b>0.8</b>	V	
Logic Input Current	I <sub>IN</sub>	DI = DE = 0V or V <sub>CC</sub> (Note 9)	Full	<b>-2</b>	-	<b>2</b>	μA	
Output Leakage Current (Y, Z, Note 9)	I <sub>OZ</sub>	DE = 0V, V <sub>CC</sub> = 0V or 1.8V, or 3.6V	V <sub>O</sub> = 7V at V <sub>CC</sub> = 1.8V	Full	-	0.1	<b>30</b>	μA
			V <sub>O</sub> = 12V at V <sub>CC</sub> = 3.6V	Full	-	0.1	<b>40</b>	μA
			V <sub>O</sub> = -7V	Full	<b>-40</b>	-8	-	μA
Driver Short-Circuit Current, V <sub>O</sub> = High or Low (Note 8)	I <sub>OS</sub>	V <sub>CC</sub> = 1.8V, DE = V <sub>CC</sub> , -2V ≤ V <sub>O</sub> ≤ 2V	Full	-	-	<b>±250</b>	mA	
		V <sub>CC</sub> ≥ 2.7V, DE = V <sub>CC</sub> , -7V ≤ V <sub>O</sub> ≤ 12V	Full	-	±150	-	mA	

# ISL32613E, ISL32614E

**Electrical Specifications**  $V_{CC} = 1.8V$ ; typicals are at  $T_A = +25^\circ C$ ; unless otherwise specified. **Boldface limits apply over the operating temperature range,  $-40^\circ C$  to  $+125^\circ C$ .** (Note 7) (Continued)

PARAMETER	SYMBOL	TEST CONDITIONS	TEMP ( $^\circ C$ )	MIN (Note 10)	TYP	MAX (Note 10)	UNITS	
<b>SUPPLY CURRENT</b>								
No-Load Supply Current	$I_{CC}$	$DE = V_{CC} = 1.8V, DI = 0V$ or $V_{CC}$	Full	-	20	<b>80</b>	$\mu A$	
		$DE = V_{CC}, 2.7V \leq V_{CC} \leq 3.6V, DI = 0V$ or $V_{CC}$	Full	-	100	<b>150</b>	$\mu A$	
Shutdown Supply Current	$I_{SHDN}$	$1.8V \leq V_{CC} \leq 3.6V, DE = 0V, DI = 0V$ or $V_{CC}$	Full	-	0.01	<b>2</b>	$\mu A$	
<b>ESD PERFORMANCE</b>								
RS-485 Pins (Y, Z)		Human Body Model, from bus pins to GND	25	-	$\pm 16.5$	-	kV	
		IEC61000 Contact, from bus pins to GND	25	-	$\pm 7$	-	kV	
All Pins		HBM, per MIL-STD-883 Method 3015	25	-	$\pm 8$	-	kV	
		Machine Model	25	-	$\pm 400$	-	V	
<b>DRIVER SWITCHING CHARACTERISTICS (ISL32613E, 128kbps Version)</b>								
Maximum Data Rate	$f_{MAX}$		$V_{CC} = 1.8V$	Full	<b>128</b>	-	-	kbps
			$3V \leq V_{CC} \leq 3.6V$	Full	<b>256</b>	-	-	kbps
Driver Differential Output Delay	$t_{DD}$	$C_D = 50pF$ (Figure 3)	$V_{CC} = 1.8V$	Full	-	1700	<b>2600</b>	ns
			$3V \leq V_{CC} \leq 3.6V$	Full	-	1100	<b>1500</b>	ns
Driver Differential Output Skew	$t_{DSK}$	$C_D = 50pF$ (Figure 3)	$V_{CC} = 1.8V$	Full	-	30	<b>200</b>	ns
			$3V \leq V_{CC} \leq 3.6V$	Full	-	2	<b>30</b>	ns
Driver Differential Rise or Fall Time	$t_R, t_F$	$C_D = 50pF$ (Figure 3)	$V_{CC} = 1.8V$	Full	-	1600	<b>2600</b>	ns
			$3V \leq V_{CC} \leq 3.6V$	Full	<b>400</b>	960	<b>1500</b>	ns
Driver Enable to Output High	$t_{ZH}$	$R_L = 500\Omega, C_L = 50pF, SW = GND$ (Figure 4)	Full	-	460	<b>800</b>	ns	
Driver Enable to Output Low	$t_{ZL}$	$R_L = 500\Omega, C_L = 50pF, SW = V_{CC}$ (Figure 4)	Full	-	460	<b>800</b>	ns	
Driver Disable from Output High	$t_{HZ}$	$R_L = 500\Omega, C_L = 50pF, SW = GND$ (Figure 4)	Full	-	60	<b>250</b>	ns	
Driver Disable from Output Low	$t_{LZ}$	$R_L = 500\Omega, C_L = 50pF, SW = V_{CC}$ (Figure 4)	Full	-	60	<b>250</b>	ns	
<b>DRIVER SWITCHING CHARACTERISTICS (ISL32614E, 256kbps Version)</b>								
Maximum Data Rate	$f_{MAX}$	$R_D = \infty, C_D = 50pF$	$V_{CC} = 1.8V$	Full	<b>256</b>	-	-	kbps
			$3V \leq V_{CC} \leq 3.6V$	Full	<b>500</b>	-	-	kbps
Driver Differential Output Delay	$t_{DD}$	$R_D = \infty, C_D = 50pF$ (Figure 3)	$V_{CC} = 1.8V$	Full	-	700	<b>2000</b>	ns
			$3V \leq V_{CC} \leq 3.6V$	Full	-	350	<b>500</b>	ns
Driver Differential Output Skew	$t_{DSK}$	$R_D = \infty, C_D = 50pF$ (Figure 3)	$V_{CC} = 1.8V$	Full	-	30	<b>200</b>	ns
			$3V \leq V_{CC} \leq 3.6V$	Full	-	2	<b>30</b>	ns
Driver Differential Rise or Fall Time	$t_R, t_F$	$R_D = \infty, C_D = 50pF$ (Figure 3)	$V_{CC} = 1.8V$	Full	-	1700	<b>2600</b>	ns
			$3V \leq V_{CC} \leq 3.6V$	Full	<b>200</b>	350	<b>800</b>	ns
Driver Enable to Output High	$t_{ZH}$	$R_L = 500\Omega, C_L = 50pF, SW = GND$ (Figure 4)	Full	-	460	<b>800</b>	ns	
Driver Enable to Output Low	$t_{ZL}$	$R_L = 500\Omega, C_L = 50pF, SW = V_{CC}$ (Figure 4)	Full	-	460	<b>800</b>	ns	
Driver Disable from Output High	$t_{HZ}$	$R_L = 500\Omega, C_L = 50pF, SW = GND$ (Figure 4)	Full	-	60	<b>250</b>	ns	
Driver Disable from Output Low	$t_{LZ}$	$R_L = 500\Omega, C_L = 50pF, SW = V_{CC}$ (Figure 4)	Full	-	60	<b>250</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. Applies to peak current. See "Typical Performance Curves" on page 8 for more information.
9. If the Driver Enable function is not needed, connect DE to  $V_{CC}$  through a 1k $\Omega$  to 2k $\Omega$  resistor.
10. Compliance to data sheet limits is assured by one or more methods: production test, characterization and/or design.

## Test Circuits and Waveforms

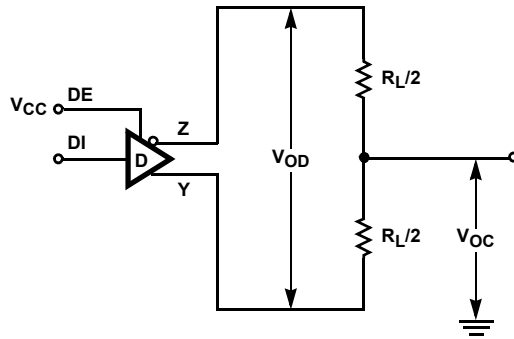


FIGURE 2. DC DRIVER TEST CIRCUITS

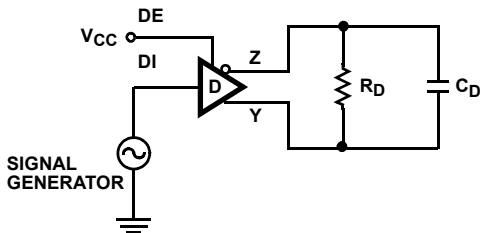
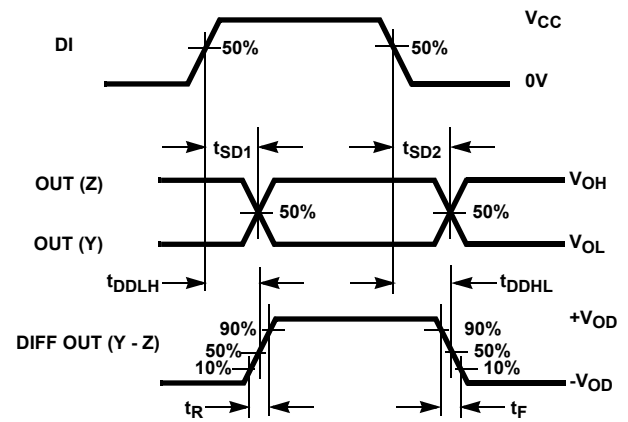


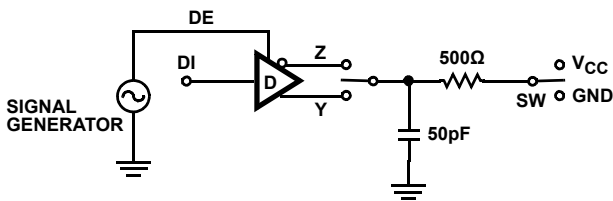
FIGURE 3A. TEST CIRCUIT



$$t_{SSK} = |t_{SD1(Y)} - t_{SD2(Y)}| \text{ OR } |t_{SD1(Z)} - t_{SD2(Z)}| \quad t_{DSK} = |t_{DDLH} - t_{DDHL}|$$

FIGURE 3B. MEASUREMENT POINTS

FIGURE 3. DRIVER PROPAGATION DELAY AND DIFFERENTIAL TRANSITION TIMES



PARAMETER	OUTPUT	DI	SW
$t_{HZ}$	Y/Z	1/0	GND
$t_{LZ}$	Y/Z	0/1	$V_{CC}$
$t_{ZH}$	Y/Z	1/0	GND
$t_{ZL}$	Y/Z	0/1	$V_{CC}$

FIGURE 4A. TEST CIRCUIT

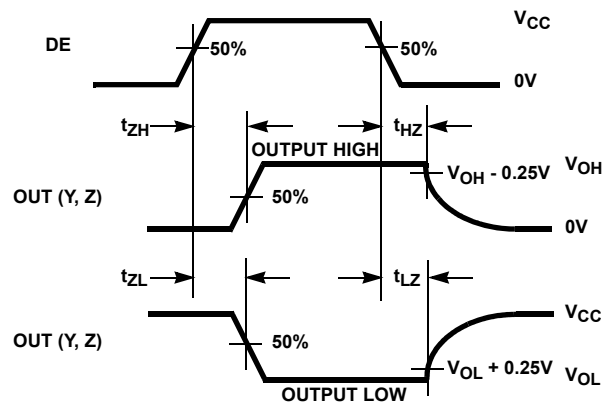


FIGURE 4B. MEASUREMENT POINTS

FIGURE 4. DRIVER ENABLE AND DISABLE TIMES

## Application Information

### Driver Features

These transmitters are differential output devices that operate with  $V_{CC}$  as low as 1.8V, and up to 3.6V. Devices are RS-485 compliant with  $V_{CC} \geq 3V$ , but significant power savings are obtained by operating at  $V_{CC} = 1.8V$ .

The transmitter outputs are tri-statable via the active high DE input. If the Tx enable function is not needed, tie DE to  $V_{CC}$  through a 1k $\Omega$  to 2k $\Omega$  resistor. Outputs are slew rate limited to minimize EMI, and to reduce reflections in unterminated or improperly terminated networks.

### 1.8V Operation

The ISL32613E and ISL32614E operate with  $V_{CC}$  as low as 1.8V. When coupled with the ISL32610E or ISL32611E 1.8V receivers, they provide a differential communication link optimized for very low power, and for slow data rates. Figures 7 and 8 illustrate the static and dynamic power savings from using these transmitters at low supply voltages. With  $V_{CC} = 1.8V$  rather than 3.3V, using the ISL32613E at 128kbps reduces the operating supply current from 9.9mA to 56 $\mu$ A (a factor of 177)!

### 5.5V Tolerant Logic Pins

Logic input pins (DI, DE) contain no ESD or parasitic diodes to  $V_{CC}$ , so they withstand input voltages exceeding 5.5V, regardless of the  $V_{CC}$  voltage.

### Hot Plug Function

When a piece of equipment powers up, there is a period of time during which the processor or ASIC driving the RS-485 control line (DE) is unable to ensure that the RS-485 Tx 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, these transmitters incorporate a "Hot Plug" function. During power-up, circuitry monitoring  $V_{CC}$  ensures that the Tx outputs remain disabled for a period of time, regardless of the state of DE. This gives the processor/ASIC a chance to stabilize and drive the control lines to the proper states.

### ESD Protection

All pins on these devices include class 3 (8kV) Human Body Model (HBM) ESD protection structures, but the driver outputs incorporate advanced structures that allow them to survive ESD events in excess of  $\pm 16.5kV$  HBM and  $\pm 7kV$  to the IEC61000 contact test method. The RS-485 pins are particularly vulnerable to ESD damage 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 it is powered up or not, and without degrading the common mode range. 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.

### Driver Overload Protection

The driver output stages incorporate short-circuit, current-limiting circuitry, which ensures that the output current never exceeds the RS-485 specification over a  $\pm 2V$  (-7V to +12V for  $V_{CC} \geq 2.7V$ ) common mode voltage range.

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 power dissipation, allowing the die to cool. The drivers automatically re-enable after the die temperature drops by about +20°C. If the condition persists, the thermal shutdown/re-enable cycle repeats until the fault is cleared.

### Low Power Shutdown Mode

This BiCMOS transmitter uses a fraction of the power required by its bipolar counterparts, but it also includes a shutdown feature that reduces the already low quiescent  $I_{CC}$  to a 10nA trickle. This device enters shutdown whenever the driver disables (DE = GND).

## Typical Performance Curves $V_{CC} = 1.8V, T_A = +25^\circ C$ ; Unless Otherwise Specified.

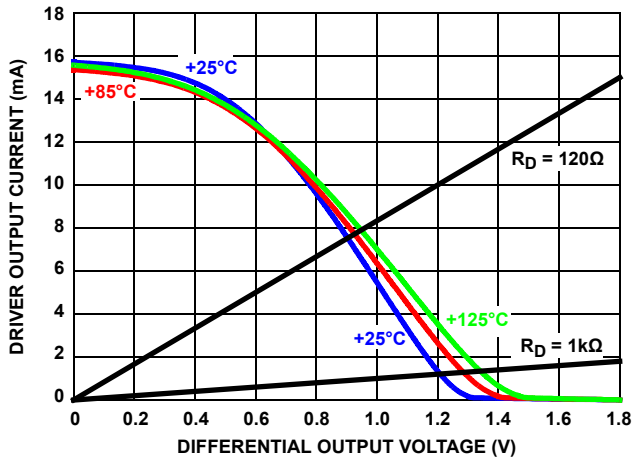


FIGURE 5. DRIVER OUTPUT CURRENT vs DIFFERENTIAL OUTPUT VOLTAGE

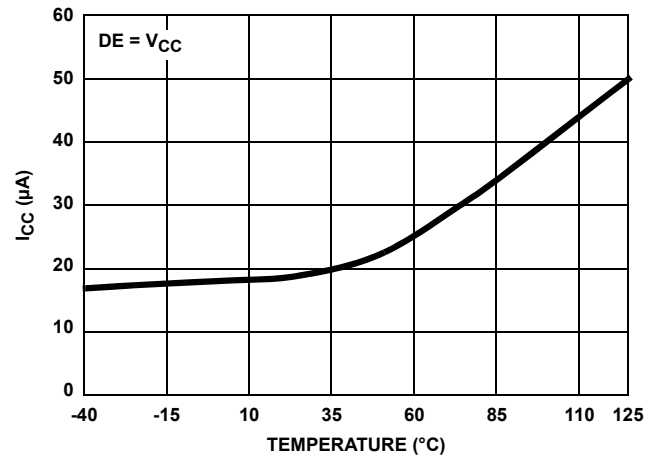


FIGURE 6. STATIC SUPPLY CURRENT vs TEMPERATURE

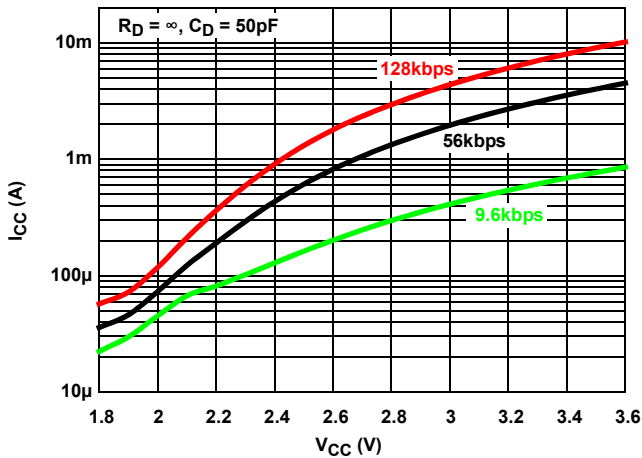


FIGURE 7. ISL32613E DYNAMIC SUPPLY CURRENT vs SUPPLY VOLTAGE AT DIFFERENT DATA RATES

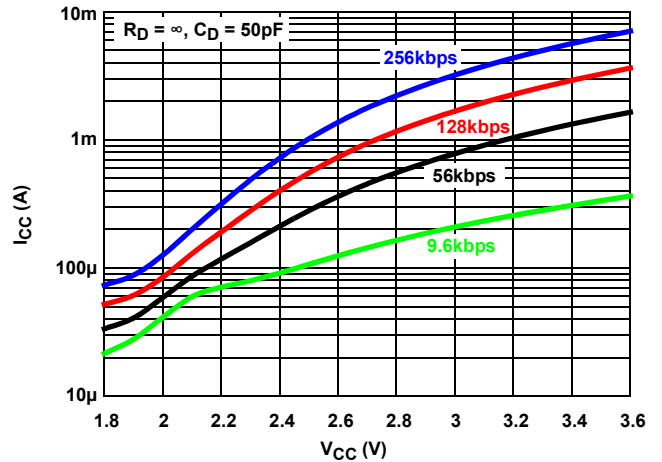


FIGURE 8. ISL32614E DYNAMIC SUPPLY CURRENT vs SUPPLY VOLTAGE AT DIFFERENT DATA RATES

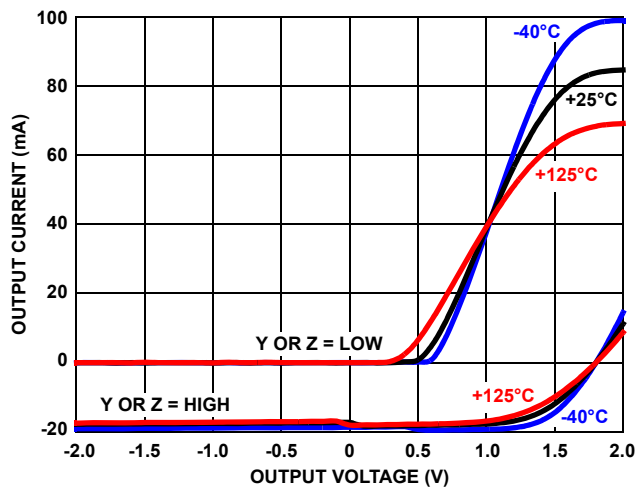


FIGURE 9. DRIVER OUTPUT CURRENT vs SHORT CIRCUIT VOLTAGE



# ISL32613E, ISL32614E

## Typical Performance Curves $V_{CC} = 1.8V, T_A = +25^\circ C$ ; Unless Otherwise Specified. (Continued)

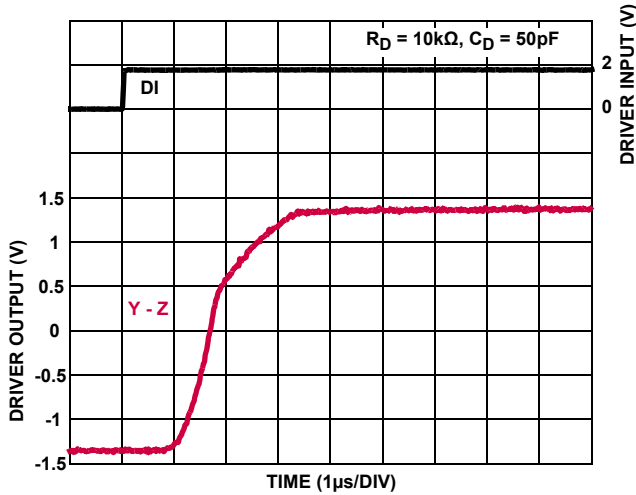


FIGURE 10. ISL32613E DRIVER WAVEFORMS, LOW TO HIGH

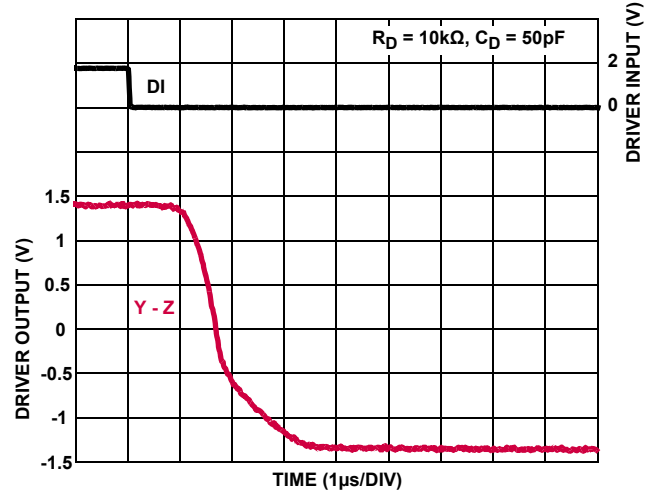


FIGURE 11. ISL32614E DRIVER WAVEFORMS, HIGH TO LOW

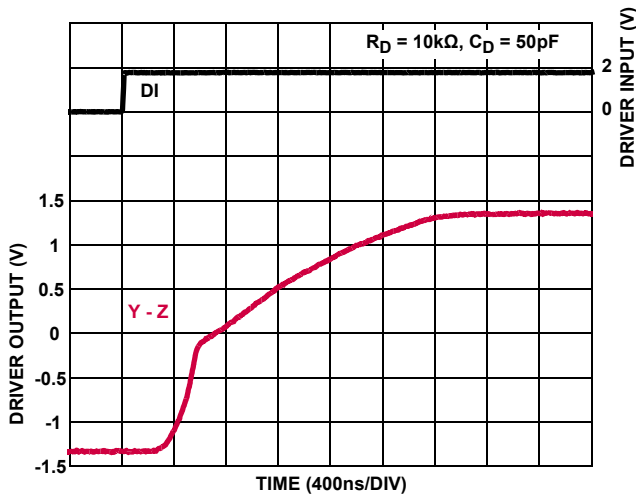


FIGURE 12. ISL32614E DRIVER WAVEFORMS, LOW TO HIGH

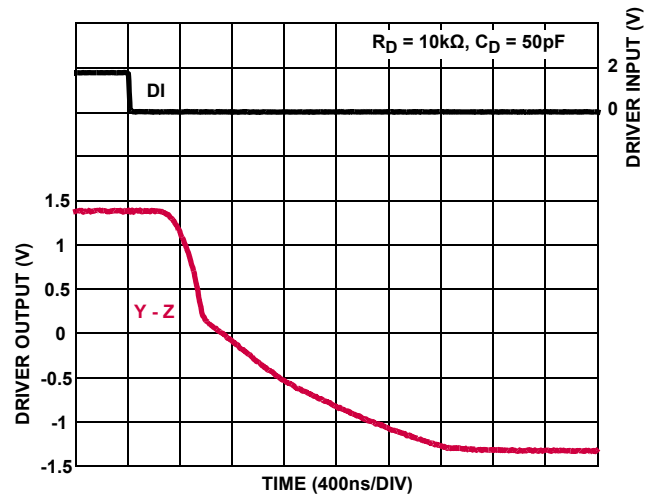


FIGURE 13. ISL32614E DRIVER WAVEFORMS, HIGH TO LOW

## Die Characteristics

### SUBSTRATE POTENTIAL (POWERED UP):

GND

### PROCESS:

Si Gate BiCMOS

# ISL32613E, ISL32614E

## Revision History

The revision history provided is for informational purposes only and is believed to be accurate, but not warranted. Please go to web to make sure you have the latest revision.

DATE	REVISION	CHANGE
August 30, 2011	FN7906.0	Initial Release

## Products

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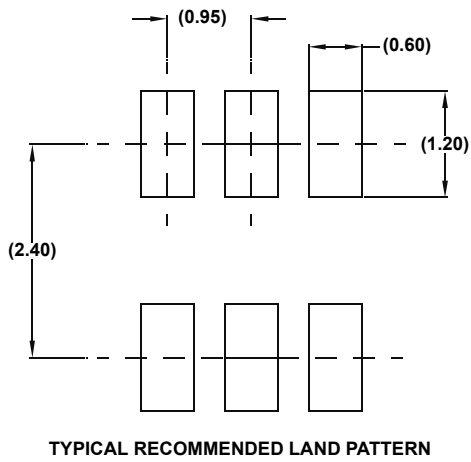
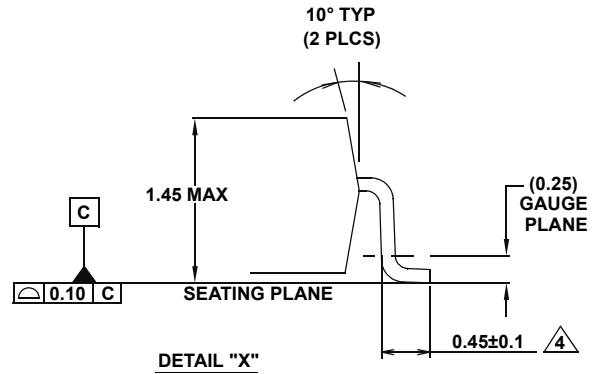
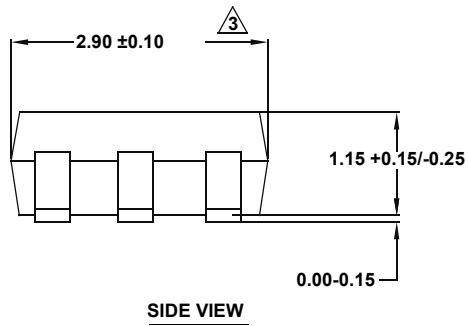
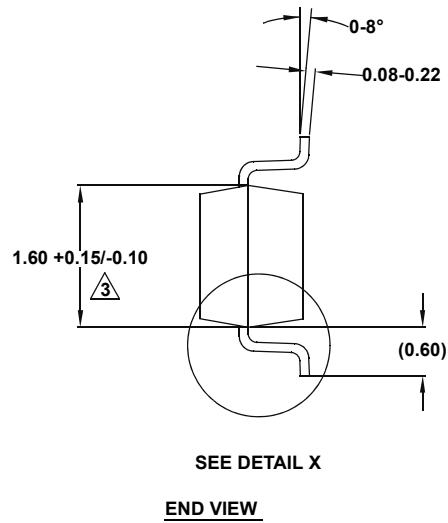
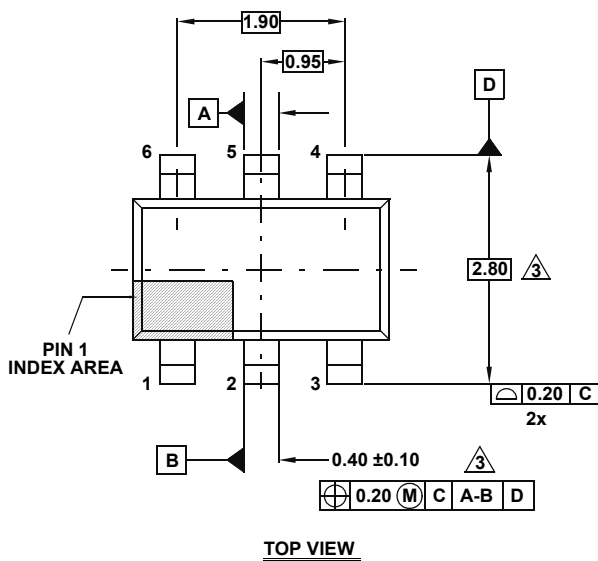
# ISL32613E, ISL32614E

## Package Outline Drawing

P6.064

6 LEAD SMALL OUTLINE TRANSISTOR PLASTIC PACKAGE

Rev 4, 2/10



**NOTES:**

1. Dimensions are in millimeters.  
Dimensions in ( ) for Reference Only.
2. Dimensioning and tolerancing conform to ASME Y14.5M-1994.
3. Dimension is exclusive of mold flash, protrusions or gate burrs.
4. Foot length is measured at reference to gauge plane.
5. Package conforms to JEDEC MO-178AB.