ISL32613E, ISL32614E

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

FN7906
Rev 3.00
Jun 12, 2018

The 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 use 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, refer to the ISL32610E datasheet.

Related Literature

For a full list of related documents, visit our website

- ISL32613E and ISL32614E product pages

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
- 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

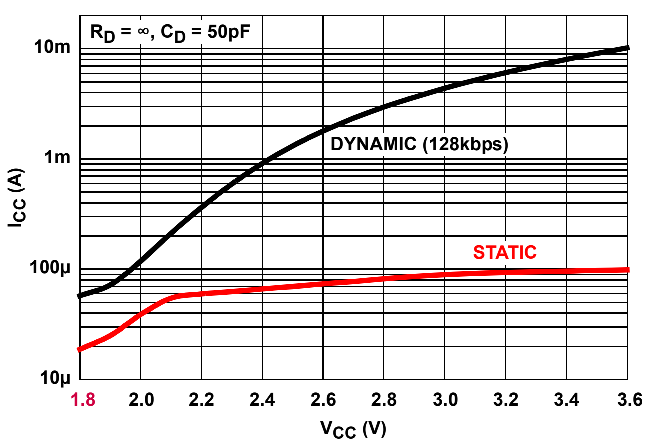


FIGURE 1. ISL32613E WITH V_{CC} = 1.8V REDUCES OPERATING I_{CC} BY A FACTOR OF 177 COMPARED WITH I_{CC} AT V_{CC} = 3.6V

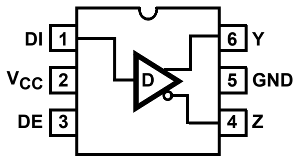
Truth Table

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

Pin Configuration

6 LD SOT-23
TOP VIEW



Pin Descriptions

PIN #	PIN NAME	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_{CC}	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_{CC} 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_{CC} = 1.8V

PART NUMBER	FUNCTION	DATA RATE (kbps)	SLEW-RATE LIMITED?	HOT PLUG?	TX ENABLED? (Note 9)	MAXIMUM QUIESCENT I_{CC} (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 2, 3)	PART MARKING (Note 4)	TEMP RANGE (°C)	TAPE AND REEL (UNITS) (Note 1)	PACKAGE (RoHS Compliant)	PKG. DWG. #
ISL32613EFHZ-T	613F	-40 to +125	3k	6 Ld SOT-23	P6.064
ISL32613EFHZ-T7A	613F	-40 to +125	250	6 Ld SOT-23	P6.064
ISL32614EFHZ-T	614F	-40 to +125	3k	6 Ld SOT-23	P6.064
ISL32614EFHZ-T7A	614F	-40 to +125	250	6 Ld SOT-23	P6.064

NOTES:

1. Refer to TB347 for details about reel specifications.
2. These 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). 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 ISL32613E and ISL32614E product information pages. For more information about MSL, refer to TB363.
4. SOT-23 “PART MARKING” is branded on the bottom side.

Typical Operating Circuits

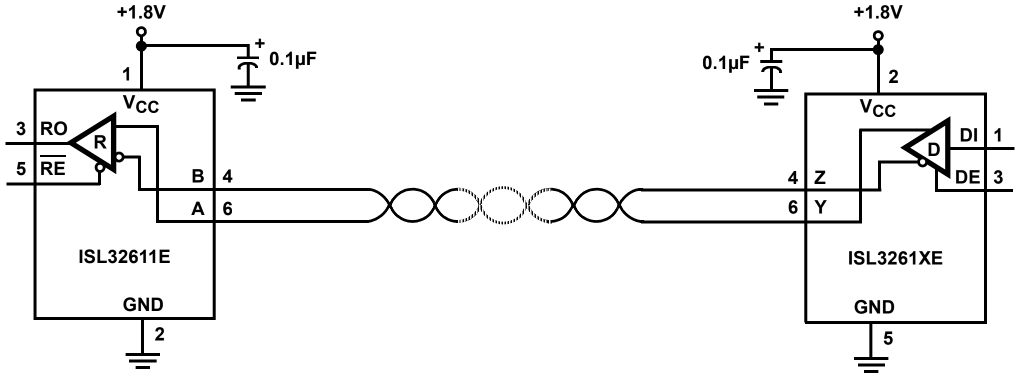


FIGURE 2. NETWORK WITH ENABLES

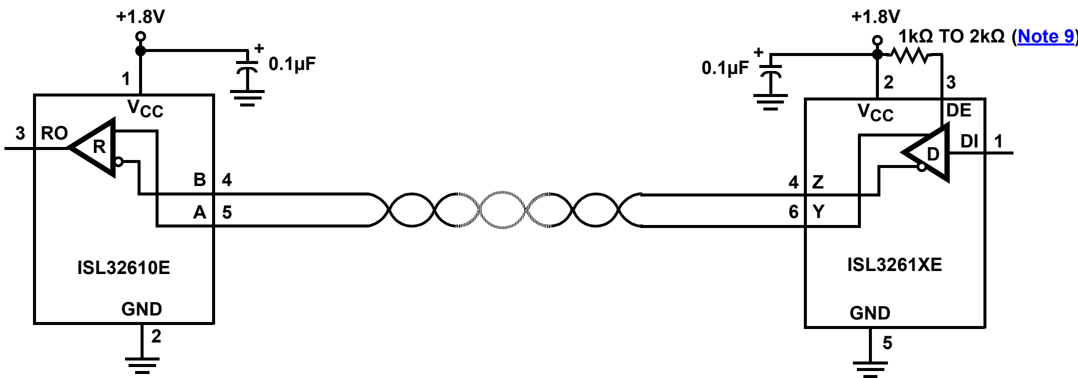


FIGURE 3. NETWORK WITHOUT ENABLES

Absolute Maximum Ratings

V_{CC} to GND . . . . -0.3V to 7V
Input Voltages
DI, DE . . . . -0.3V to 7V
Output Voltages
Y, Z (V_{CC} = 0V or ≥ 2.7V) . . . . -8V to +13V
Y, Z (V_{CC} = 1.8V, Output Enabled) . . . . -8V to +3V
Y, Z (V_{CC} = 1.8V, Output Disabled) . . . . -8V to +8V
Short Circuit Duration
Y, Z . . . . Indefinite
ESD Rating . . . . see "ESD PERFORMANCE"
Latch-up (per JESD78, Level 2, Class A) . . . . +125°C

Thermal Information

Thermal Resistance (Typical)	θ_{JA} (°C/W)	θ_{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 TB493

Recommended Operating Conditions

Supply Voltage Range . . . . 1.8V to 3.3V
Common Mode Range; V_{CC} = 1.8V . . . . ±2V
V_{CC} ≥ 2.7V . . . . -7V to +12V
Temperature Range (F Suffix) . . . . -40°C to +125°C
Differential Load (R_D); V_{CC} = 1.8V . . . . ≥10kΩ
V_{CC} ≥ 2.7V . . . . ≥60Ω

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

NOTES:

5. θ_{JA} is measured with the component mounted on a high-effective thermal conductivity test board in free air. See TB379 for details.
6. For θ_{JC}, the "case temp" location is taken at the package top center.

Electrical Specifications

V_{CC} = 1.8V; typical values are at T_A = +25°C; unless otherwise specified. **Boldface limits apply across the operating temperature range.** (Note 7)

PARAMETER	SYMBOL	TEST CONDITIONS		TEMP (°C)	MIN (Note 10)	TYP	MAX (Note 10)	UNIT
DC CHARACTERISTICS								
Driver Differential V_{OUT}	V_{OD}	R_L = 100Ω (Figure 4)	V_{CC} = 1.8V	Full	**0.8**	0.92	-	V
			V_{CC} ≥ 3.15V	Full	**2**	-	-	V
		R_L = 54Ω (Figure 4), V_{CC} ≥ 3V		Full	**1.5**	-	-	V
		No Load		Full	**1.1**	1.45	**V_{CC}**	V
Change in Magnitude of Driver Differential V_{OUT} for Complementary Output States	ΔV_{OD}	R_L = 100Ω (Figure 4)		Full	-	0.01	**0.2**	V
Driver Common Mode V_{OUT}	V_{OC}	R_L = 100Ω (Figure 4)		Full	-	1.1	**1.4**	V
Change in Magnitude of Driver Common Mode V_{OUT} for Complementary Output States	ΔV_{OC}	R_L = 100Ω (Figure 4)		Full	-	0.01	**0.2**	V
Logic Input High Voltage (DI, DE)	V_{IH}	V_{CC} = 1.8V		Full	**1.26**	-	-	V
		2.7V ≤ V_{CC} ≤ 3.6V		Full	**2.2**	-	-	V
Logic Input Low Voltage (DI, DE)	V_{IL}	V_{CC} = 1.8V		Full	-	-	**0.4**	V
		2.7V ≤ V_{CC} ≤ 3.6V		Full	-	-	**0.8**	V
Logic Input Current	I_{IN}	DI = DE = 0V or V_{CC} (Note 9)		Full	**-2**	-	**2**	µA
Output Leakage Current (Y, Z, Note 9)	I_{OZ}	DE = 0V, V_{CC} = 0V or 1.8V, or 3.6V	V_O = 7V at V_{CC} = 1.8V	Full	-	0.1	**30**	µA
			V_O = 12V at V_{CC} = 3.6V	Full	-	0.1	**40**	µA
			V_O = -7V	Full	**-40**	-8	-	µA
Driver Short-Circuit Current, V_O = High or Low (Note 8)	I_{OS}	V_{CC} = 1.8V, DE = V_{CC}, -2V ≤ V_O ≤ 2V		Full	-	-	**±250**	mA
		V_{CC} ≥ 2.7V, DE = V_{CC}, -7V ≤ V_O ≤ 12V		Full	-	±150	-	mA
SUPPLY CURRENT								
No-load Supply Current	I_{CC}	DE = V_{CC} = 1.8V, DI = 0V or V_{CC}		Full	-	20	**80**	µA
		DE = V_{CC}, 2.7V ≤ V_{CC} ≤ 3.6V, DI = 0V or V_{CC}		Full	-	100	**150**	µA

Electrical Specifications

V_{CC} = 1.8V; typical values are at T_A = +25°C; unless otherwise specified. **Boldface limits apply across the operating temperature range.** (Note 7) **(Continued)**

PARAMETER	SYMBOL	TEST CONDITIONS		TEMP (°C)	MIN (Note 10)	TYP	MAX (Note 10)	UNIT
Shutdown Supply Current	I_{SHDN}	1.8V ≤ V_{CC} ≤ 3.6V, DE = 0V, DI = 0V or V_{CC}		Full	-	0.01	**2**	µA
ESD PERFORMANCE								
RS-485 Pins (Y, Z)		Human Body Model, from bus pins to GND		25	-	±16.5	-	kV
		IEC61000 Contact, from bus pins to GND		25	-	±7	-	kV
All Pins		HBM, per MIL-STD-883 Method 3015		25	-	±8	-	kV
		Machine Model		25	-	±400	-	V
DRIVER SWITCHING CHARACTERISTICS (ISL32613E, 128kbps Version)								
Maximum Data Rate	f_{MAX}		V_{CC} = 1.8V	Full	**128**	-	-	kbps
			3V ≤ V_{CC} ≤ 3.6V	Full	**256**	-	-	kbps
Driver Differential Output Delay	t_{DD}	C_D = 50pF (Figure 5)	V_{CC} = 1.8V	Full	-	1700	**2600**	ns
			3V ≤ V_{CC} ≤ 3.6V	Full	-	1100	**1500**	ns
Driver Differential Output Skew	t_{DSK}	C_D = 50pF (Figure 5)	V_{CC} = 1.8V	Full	-	30	**200**	ns
			3V ≤ V_{CC} ≤ 3.6V	Full	-	2	**30**	ns
Driver Differential Rise or Fall Time	t_R, t_F	C_D = 50pF (Figure 5)	V_{CC} = 1.8V	Full	-	1600	**2600**	ns
			3V ≤ V_{CC} ≤ 3.6V	Full	**400**	960	**1500**	ns
Driver Enable to Output High	t_{ZH}	R_L = 500Ω, C_L = 50pF, SW = GND (Figure 6)		Full	-	460	**800**	ns
Driver Enable to Output Low	t_{ZL}	R_L = 500Ω, C_L = 50pF, SW = V_{CC} (Figure 6)		Full	-	460	**800**	ns
Driver Disable from Output High	t_{HZ}	R_L = 500Ω, C_L = 50pF, SW = GND (Figure 6)		Full	-	60	**250**	ns
Driver Disable from Output Low	t_{LZ}	R_L = 500Ω, C_L = 50pF, SW = V_{CC} (Figure 6)		Full	-	60	**250**	ns
DRIVER SWITCHING CHARACTERISTICS (ISL32614E, 256kbps Version)								
Maximum Data Rate	f_{MAX}	R_D = ∞, C_D = 50pF	V_{CC} = 1.8V	Full	**256**	-	-	kbps
			3V ≤ V_{CC} ≤ 3.6V	Full	**500**	-	-	kbps
Driver Differential Output Delay	t_{DD}	R_D = ∞, C_D = 50pF (Figure 5)	V_{CC} = 1.8V	Full	-	700	**2000**	ns
			3V ≤ V_{CC} ≤ 3.6V	Full	-	350	**500**	ns
Driver Differential Output Skew	t_{DSK}	R_D = ∞, C_D = 50pF (Figure 5)	V_{CC} = 1.8V	Full	-	30	**200**	ns
			3V ≤ V_{CC} ≤ 3.6V	Full	-	2	**30**	ns
Driver Differential Rise or Fall Time	t_R, t_F	R_D = ∞, C_D = 50pF (Figure 5)	V_{CC} = 1.8V	Full	-	1700	**2600**	ns
			3V ≤ V_{CC} ≤ 3.6V	Full	**200**	350	**800**	ns
Driver Enable to Output High	t_{ZH}	R_L = 500Ω, C_L = 50pF, SW = GND (Figure 6)		Full	-	460	**800**	ns
Driver Enable to Output Low	t_{ZL}	R_L = 500Ω, C_L = 50pF, SW = V_{CC} (Figure 6)		Full	-	460	**800**	ns
Driver Disable from Output High	t_{HZ}	R_L = 500Ω, C_L = 50pF, SW = GND (Figure 6)		Full	-	60	**250**	ns
Driver Disable from Output Low	t_{LZ}	R_L = 500Ω, C_L = 50pF, SW = V_{CC} (Figure 6)		Full	-	60	**250**	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 1kΩ to 2kΩ resistor.
10. Compliance to datasheet limits is assured by one or more methods: production test, characterization, and/or design.

Test Circuits and Waveforms

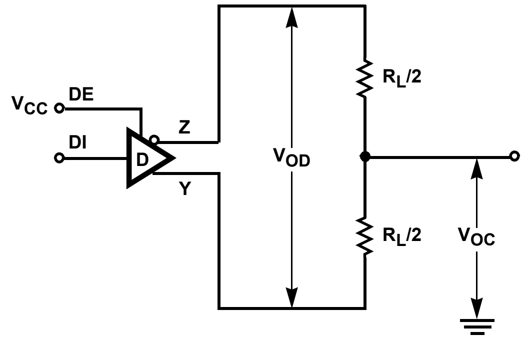


FIGURE 4. DC DRIVER TEST CIRCUITS

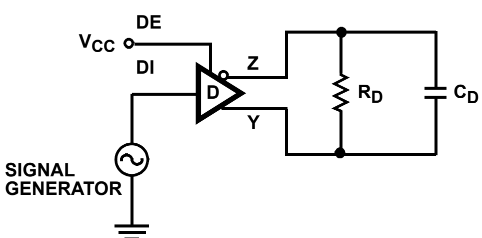
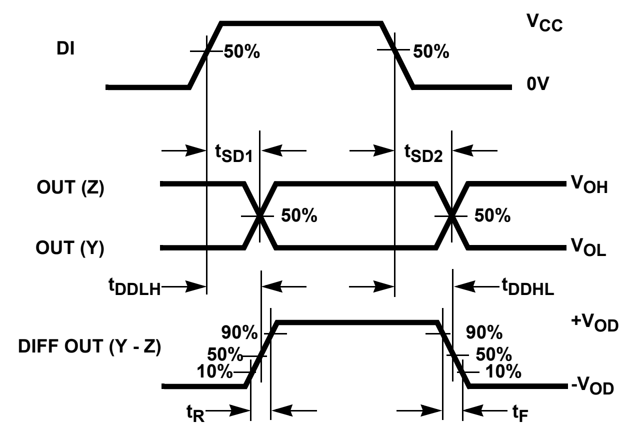


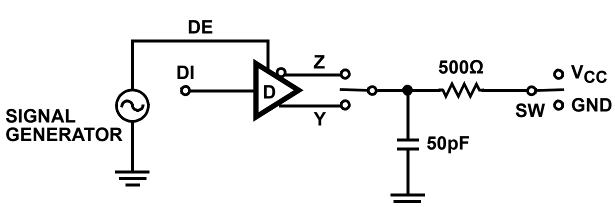
FIGURE 5A. TEST CIRCUIT



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

FIGURE 5B. MEASUREMENT POINTS

FIGURE 5. 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 6A. TEST CIRCUIT

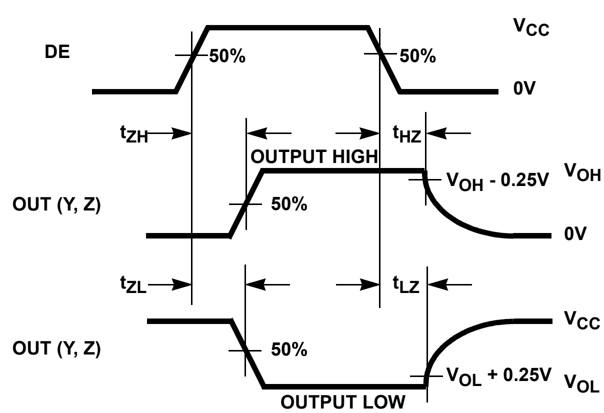


FIGURE 6B. MEASUREMENT POINTS

FIGURE 6. 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. The 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 with the active high DE input. If the Tx enable function is not needed, tie DE to V_{CC} through a 1kΩ to 2kΩ 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 9 and 10 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 56µA (a factor of 177).

5.5V Tolerant Logic Pins

The logic input pins (DI and 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 ±16.5kV HBM and ±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 (for example, 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 ±2V (-7V to +12V for $V_{CC} \geq 2.7V$) common mode voltage range.

The device also includes a thermal shutdown feature that disables the drivers whenever the die temperature becomes excessive in the event of a major short-circuit condition. This eliminates power dissipation, allowing the die to cool. The drivers automatically reenable after the die temperature drops by about +20°C. If the condition persists, the thermal shutdown/reenable 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°C; unless otherwise specified.

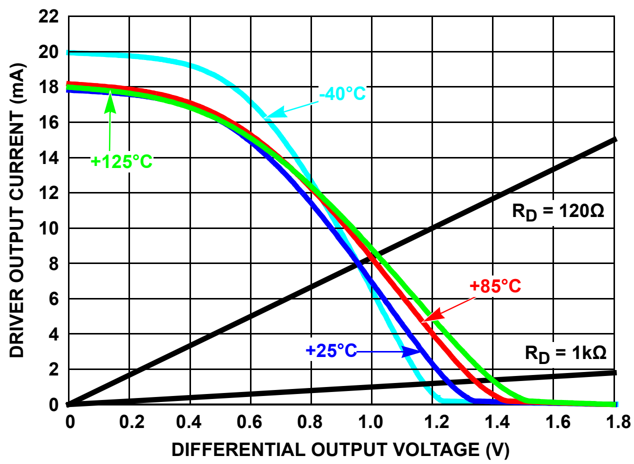


FIGURE 7. DRIVER OUTPUT CURRENT vs DIFFERENTIAL OUTPUT VOLTAGE

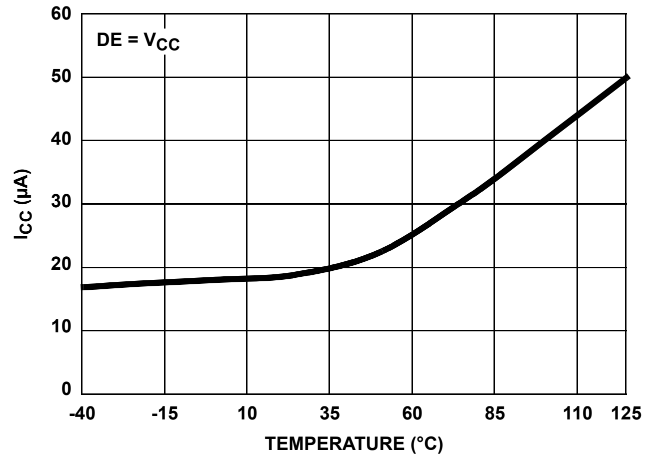


FIGURE 8. STATIC SUPPLY CURRENT vs TEMPERATURE

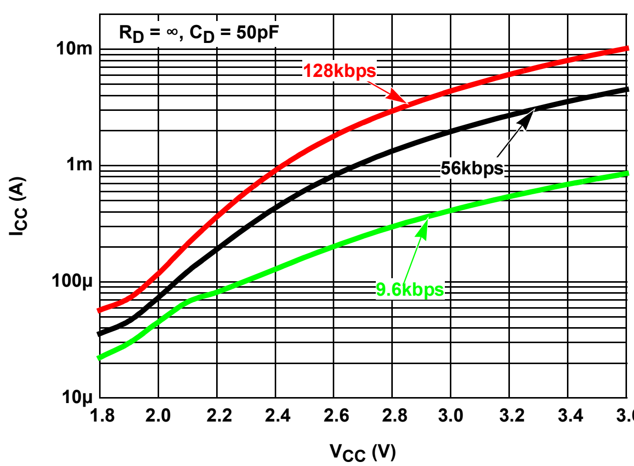


FIGURE 9. ISL32613E DYNAMIC SUPPLY CURRENT vs SUPPLY VOLTAGE AT DIFFERENT DATA RATES

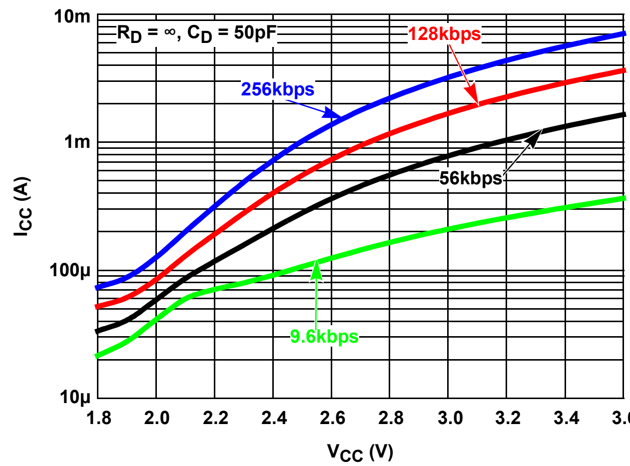


FIGURE 10. ISL32614E DYNAMIC SUPPLY CURRENT vs SUPPLY VOLTAGE AT DIFFERENT DATA RATES

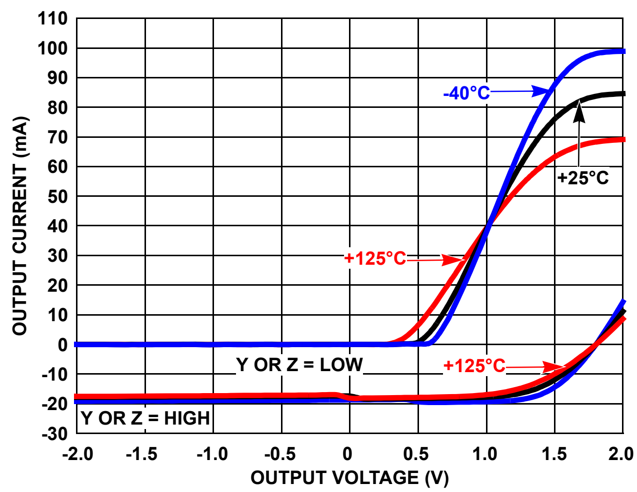


FIGURE 11. DRIVER OUTPUT CURRENT vs SHORT-CIRCUIT VOLTAGE

Typical Performance Curves
V_{CC} = 1.8V, T_A = +25°C; unless otherwise specified. **(Continued)**

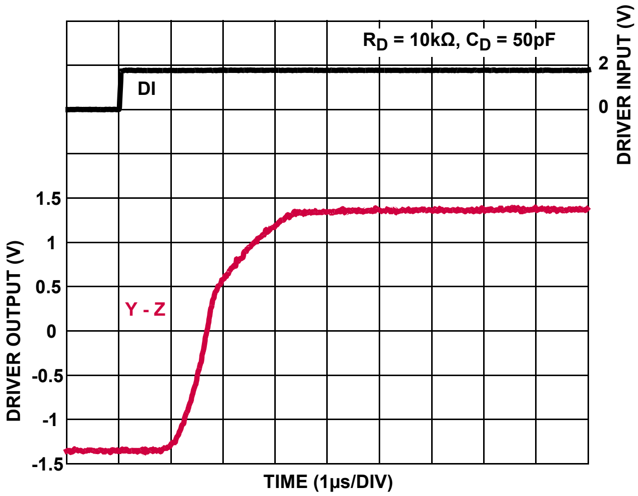


FIGURE 12. ISL32613E DRIVER WAVEFORMS, LOW-TO-HIGH

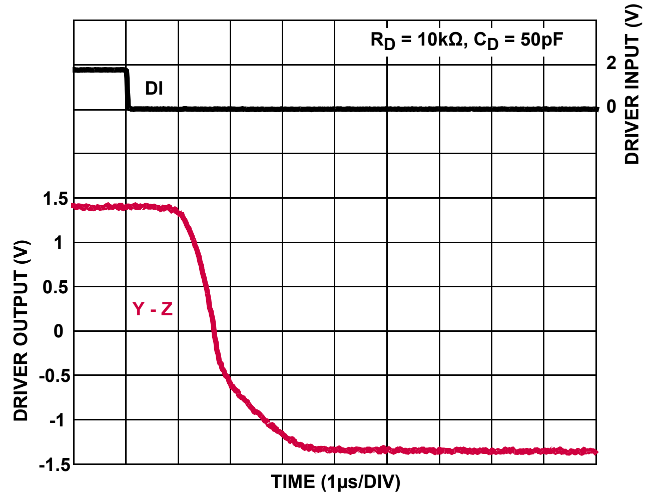


FIGURE 13. ISL32614E DRIVER WAVEFORMS, HIGH-TO-LOW

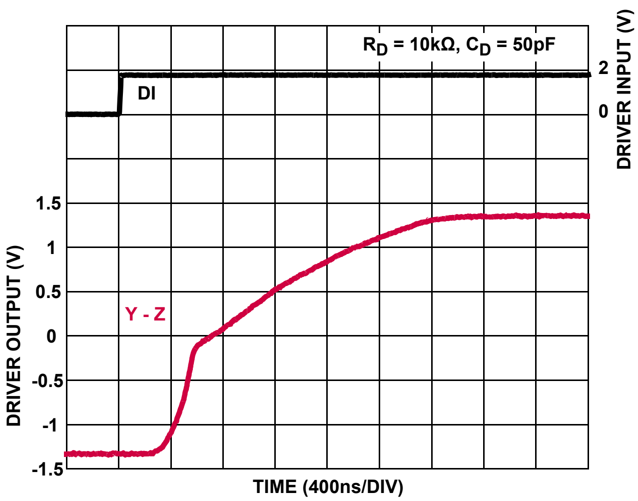


FIGURE 14. ISL32614E DRIVER WAVEFORMS, LOW-TO-HIGH

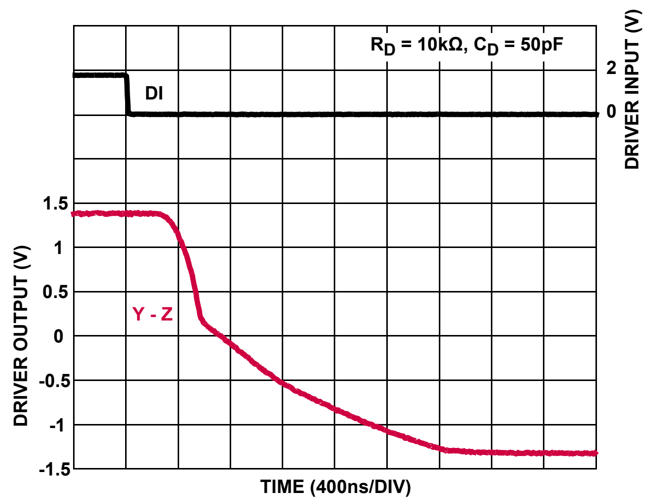


FIGURE 15. ISL32614E DRIVER WAVEFORMS, HIGH-TO-LOW

Die Characteristics

SUBSTRATE POTENTIAL (POWERED UP):

GND

PROCESS:

Si Gate BiCMOS

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
Jun 12, 2018	FN7906.3	Added Related Literature section on page 1. Updated Ordering information table by switching Notes 1 and 2 and adding the tape and reel units column. Removed military temperature range from Features on page 1. Removed 55°C curves from Figures 7 and 11 on page 8. Removed About Intersil section and added Renesas disclaimer.
Jul 27, 2015	FN7906.2	Ordering Information Table on page 2: Removed part numbers ISL32614EMHZ-T and ISL32614EMHZ-T7A. Recommended Operating Conditions table on page 4: Removed the line referencing “M Suffix”. Replaced “Product” section with “About Intersil” on page 10.
May 2, 2012	FN7906.1	Page 1, “Features” - changed “Specified for +125°C Operation” to “Specified for +125°C or Full Mil Temperature Operation”. Also changed Figure 1 title. Page 2, added new part “ISL32614EMHZ-T” to the “Ordering Information”. Page 4, changed “Y, Z (V_{CC} = 1.8V)” to “Y, Z (V_{CC} = 1.8V, Output Enabled)” and added “Y, Z (V_{CC} = 1.8V, Output Disabled)... -8V to +8V” under the “Absolute Maximum Rating”. Also added “(F Suffix)” and “(M Suffix)...-55°C to +125°C” under the “Recommended Operating Conditions”. Page 8, replaced Figure 7 and added -55°C curve to Figure 11 under the “Typical Performance Curves”.
Aug 30, 2011	FN7906.0	Initial Release

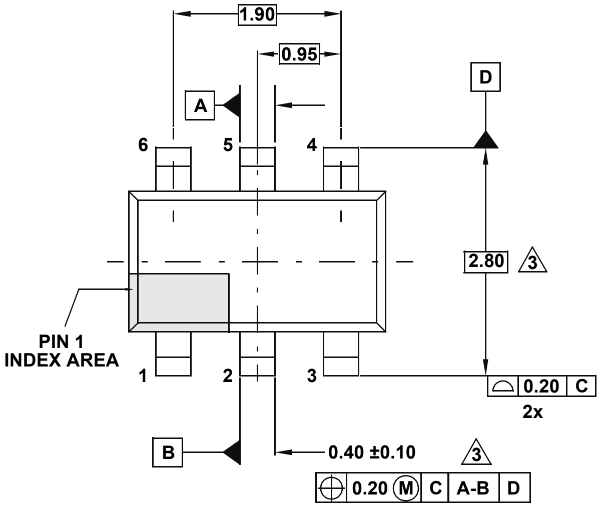
Package Outline Drawing

For the most recent package outline drawing, see P6.064.

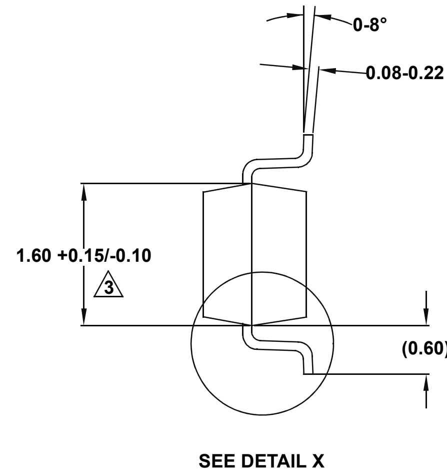
P6.064

6 LEAD SMALL OUTLINE TRANSISTOR PLASTIC PACKAGE

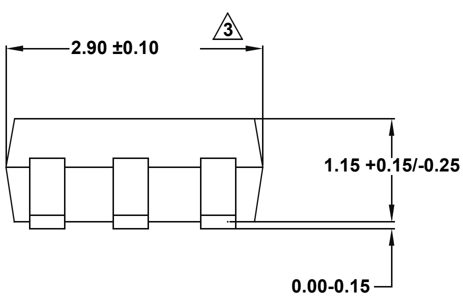
Rev 4, 2/10



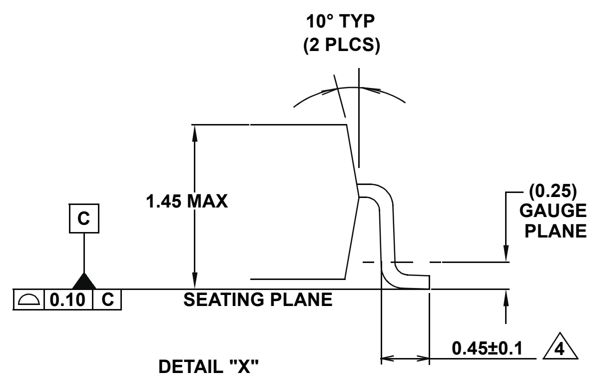
TOP VIEW



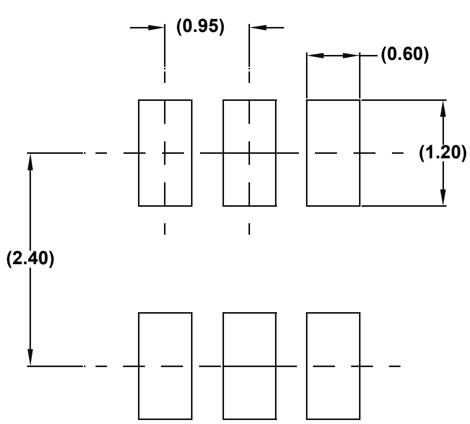
END VIEW



SIDE VIEW



DETAIL "X"



TYPICAL RECOMMENDED LAND PATTERN

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.

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SALES OFFICES

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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

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