

## MAX14940

# 2.75kV<sub>RMS</sub> Isolated 20Mbps Half-Duplex PROFIBUS/RS-485 Transceiver with $\pm 35$ kV ESD Protection and Integrated Transformer Driver

### General Description

The MAX14940 isolated RS-485/PROFIBUS-DP transceiver provides 2750V<sub>RMS</sub> (60s) of galvanic isolation between the cable-side (RS-485 driver/receiver-side) and the UART-side of the device. Isolation improves communication by breaking ground loops and reduced noise when there are large differences in ground potential between ports. This device allows for robust communication up to 20Mbps.

The MAX14940 includes an integrated 450kHz transformer driver for power transfer to the cable-side of the transceiver using an external transformer. An integrated LDO provides a simple and space-efficient way of designing an isolated DC/DC supply.

The MAX14940 includes one half-duplex driver/receiver channel that is fully compliant with both RS-485 and PROFIBUS-DP standards. The receiver is 1/4-unit load, allowing up to 128 transceivers on a common bus.

Integrated true fail-safe circuitry ensures a logic-high on the receiver output when inputs are shorted or open. Undervoltage lockout disables the driver when cable-side or UART-side power supplies are below functional levels.

The driver outputs/receiver inputs are protected from  $\pm 35$ kV electrostatic discharge (ESD) to GNDB on the cable-side, as specified by the Human Body Model (HBM).

The MAX14940 is available in a wide body 16-pin SOIC package and operates over the -40°C to +105°C temperature range.

### Applications

- Industrial Automation Equipment
- Programmable Logic Controllers
- HVAC
- Power Meters

### Safety Regulatory Approvals Pending

- UL According to UL1577
- cUL According to CSA Bulletin 5A

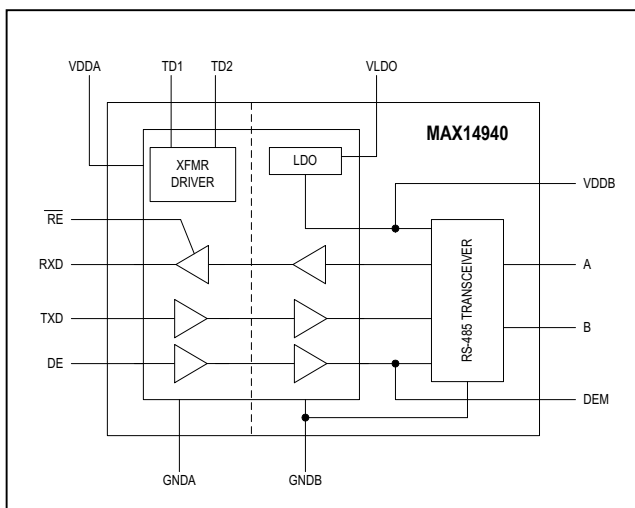
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### Benefits and Features

- High Integration Simplifies Designs
  - Integrated LDO for Cable-Side Power Can Also Power External Loads Up to 10mA
  - Integrated Transformer Driver for Power Transfer to Cable-Side Has Up to 80% Efficiency at 150mA Load
- High-Performance Transceiver Enables Flexible Designs
  - Compliant with RS-485 EIA/TIA-485 and EIA 61158-2 Type 3 PROFIBUS-DP Standards
  - 20Mbps (max) Data Rate
  - Up to 128 Devices on the Bus
- Integrated Protection for Robust Communication
  - $\pm 35$ kV ESD (HBM) on Driver Outputs/Receiver Inputs
  - 2.75kV<sub>RMS</sub> Withstand Isolation Voltage for 60 Seconds ( $V_{ISO}$ )
  - 630V<sub>PEAK</sub> Maximum Repetitive Peak Isolation Voltage ( $V_{IORM}$ )
  - 445V<sub>RMS</sub> Maximum Working Isolation Voltage ( $V_{IOWM}$ )
  - > 30 Years Lifetime at Rated Working Voltage
  - Withstands  $\pm 10$ kV Surge per IEC 61000-4-5
  - Thermal Shutdown

Ordering Information appears at end of data sheet.

### Functional Diagram



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## Absolute Maximum Ratings

V <sub>DDA</sub> to GNDA .....	-0.3V to +6V	V <sub>DDB</sub> to GNDB) .....	Continuous
V <sub>DDB</sub> to GNDB .....	-0.3V to +6V	Continuous Power Dissipation (T <sub>A</sub> = +70°C)	
V <sub>LDO</sub> to GNDB .....	-0.3V to +16V	16-pin WIDE SOIC	
TD1, TD2 to GNDA .....	-0.3V to +12V	(derate 14.1mW/°C above +70°C) .....	1126.8mW
TXD, DE, $\overline{\text{RE}}$ to GNDA .....	-0.3V to +6V	Operating Temperature Range .....	-40°C to +105°C
RXD to GNDA .....	-0.3V to (V <sub>DDA</sub> + 0.3V)	Junction Temperature .....	+150°C
DEM to GNDB .....	-0.3V to +6V	Storage Temperature Range .....	-65°C to +150°C
A, B to GNDB .....	-8V to +13V	Lead Temperature (soldering, 10s) .....	+300°C
TD1, TD2 Continuous Current .....	$\pm 1.4$ A	Soldering Temperature (reflow) .....	+260°C
Short-Circuit Duration (RXD to GNDA, A, B, DEM),			

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## Package Thermal Characteristics (Note 1)

Junction-to-Case Thermal Resistance ( $\theta_{JC}$ ) .....	71°C/W	Junction-to-Ambient Thermal Resistance ( $\theta_{JA}$ ) .....	23°C/W
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**Note 1:** Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to [www.maximintegrated.com/thermal-tutorial](http://www.maximintegrated.com/thermal-tutorial).

## DC Electrical Characteristics

(V<sub>DDA</sub> - V<sub>GNDA</sub> = 3.0V to 5.5V, V<sub>DDB</sub> - V<sub>GNDB</sub> = 4.5V to 5.5V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at V<sub>DDA</sub> - V<sub>GNDA</sub> = 3.3V, V<sub>DDB</sub> - V<sub>GNDB</sub> = 5V, V<sub>GNDA</sub> = V<sub>GNDB</sub>, and T<sub>A</sub> = +25°C.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
POWER						
Supply Voltage	V <sub>DDA</sub>		3.0		5.5	V
	V <sub>DDB</sub>		4.5		5.5	
Supply Current	I <sub>DDA</sub>	V <sub>DDA</sub> = 5V, DE = high, $\overline{\text{RE}}$ = TXD = low, RXD unconnected, no load, TD1/TD2 unconnected		4.7	7.7	mA
	I <sub>DDB</sub>	DE = high, $\overline{\text{RE}}$ = TXD = low, RXD unconnected, no load, V <sub>DDB</sub> = 5V		7.7	12.5	
Undervoltage Lockout Threshold	V <sub>UVLOA</sub>	$\overline{\text{RE}}$ , RXD, DE, TXD, V <sub>DDA</sub> rising	1.50	1.58	1.65	V
		TD1/TD2 driver, V <sub>DDA</sub> rising	2.55	2.7	2.85	
	V <sub>UVLOB</sub>	V <sub>DDB</sub> rising	2.55	2.7	2.85	
Undervoltage Lockout Threshold Hysteresis	V <sub>UVHYSTA</sub>	$\overline{\text{RE}}$ , RXD, DE, TXD		50		mV
		TD1/TD2 driver		200		
	V <sub>UVHYSTB</sub>			200		
TRANSFORMER DRIVER						
Output Resistance	R <sub>O</sub>	TD1/TD2 = low, I <sub>OUT</sub> = 300mA		0.6	1.5	Ω
TD1, TD2 Current Limit	I <sub>LIM</sub>	4.5V ≤ V <sub>DDA</sub> ≤ 5.5V	540	785	1300	mA
		3.0V ≤ V <sub>DDA</sub> ≤ 3.6V	485	730	1170	
Switching Frequency	f <sub>SW</sub>		350	450	550	kHz
Duty Cycle	D			50		%
Crossover Dead Time	t <sub>DEAD</sub>			50		ns

### DC Electrical Characteristics (continued)

(V<sub>DDA</sub> - V<sub>GNDA</sub> = 3.0V to 5.5V, V<sub>DDB</sub> - V<sub>GNDB</sub> = 4.5V to 5.5V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at V<sub>DDA</sub> - V<sub>GNDA</sub> = 3.3V, V<sub>DDB</sub> - V<sub>GNDB</sub> = 5V, V<sub>GNDA</sub> = V<sub>GNDB</sub>, and T<sub>A</sub> = +25°C.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>LDO</b>						
LDO Supply Voltage	V <sub>LDO</sub>	Relative to GNDB, LDO is on (Note 4)	4.68		14	V
LDO Supply Current	I <sub>LDO</sub>	DE = high, TXD = low, no load on RXD, V <sub>LDO</sub> = 5.5V		7.8	12.9	mA
LDO Output Voltage	V <sub>DDB</sub>		4.5	5	5.5	V
Maximum Output Current		Available for external circuits	10			mA
LDO Current Limit				300		mA
Load Regulation		V <sub>LDO</sub> = 5.68V, I <sub>LOAD</sub> = 20mA to 40mA		0.19	1.7	mV/mA
Line Regulation		V <sub>LDO</sub> = 5.68V to 14V, I <sub>LOAD</sub> = 20mA		0.12	1.8	mV/V
Dropout Voltage		V <sub>LDO</sub> = 4.68V, I <sub>DDB</sub> = 120mA		100	180	mV
Load Capacitance		Nominal value (Note 5)	1		10	μF
<b>LOGIC INTERFACE (TXD, RXD, DE, <math>\overline{\text{RE}}</math>, DEM)</b>						
Input High Voltage	V <sub>IH</sub>	$\overline{\text{RE}}$ , TXD, DE to GNDA	0.7 x V <sub>DDA</sub>			V
Input Low Voltage	V <sub>IL</sub>	$\overline{\text{RE}}$ , TXD, DE to GNDA			0.8	V
Input Hysteresis	V <sub>HYS</sub>	$\overline{\text{RE}}$ , TXD, DE to GNDA		220		mV
Input Capacitance	C <sub>IN</sub>	$\overline{\text{RE}}$ , TXD, DE, f = 1MHz		2		pF
Input Pullup Current	I <sub>PU</sub>	TXD	-10	-4.5	-1.5	μA
Input Pulldown Current	I <sub>PD</sub>	DE, $\overline{\text{RE}}$	1.5	4.5	10	μA
Output Voltage High	V <sub>OH</sub>	RXD to GNDA, I <sub>OUT</sub> = -4mA	V <sub>DDA</sub> - 0.4			V
		DEM to GNDB, I <sub>OUT</sub> = -4mA	V <sub>DDB</sub> - 0.4			
Output Voltage Low	V <sub>OL</sub>	RXD to GNDA, I <sub>OUT</sub> = 4mA			0.40	V
		DEM to GNDB, I <sub>OUT</sub> = 4mA			0.40	
Short Circuit Output Pullup Current	I <sub>SH_PU</sub>	0V ≤ V <sub>RXD</sub> ≤ V <sub>DDA</sub> , V <sub>A</sub> - V <sub>B</sub> > -50mV, $\overline{\text{RE}}$ = low	-42			mA
		0V ≤ V <sub>DEM</sub> ≤ V <sub>DDB</sub> , DE = high	-42			
Short Circuit Output Pulldown Current	I <sub>SH_PD</sub>	0V ≤ V <sub>RXD</sub> ≤ V <sub>DDA</sub> , V <sub>A</sub> - V <sub>B</sub> < -200mV, $\overline{\text{RE}}$ = low			+40	mA
		0V ≤ V <sub>DEM</sub> ≤ V <sub>DDB</sub> , DE = low			+40	
Three-State Output Current	I <sub>OZ</sub>	0V ≤ V <sub>RXD</sub> ≤ V <sub>DDA</sub> , $\overline{\text{RE}}$ = high	-1		+1	μA

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## DC Electrical Characteristics (continued)

(V<sub>DDA</sub> - V<sub>GNDA</sub> = 3.0V to 5.5V, V<sub>DDB</sub> - V<sub>GNDB</sub> = 4.5V to 5.5V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at V<sub>DDA</sub> - V<sub>GNDA</sub> = 3.3V, V<sub>DDB</sub> - V<sub>GNDB</sub> = 5V, V<sub>GNDA</sub> = V<sub>GNDB</sub>, and T<sub>A</sub> = +25°C.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DRIVER							
Differential Driver Output	V <sub>OD</sub>	R <sub>L</sub> = 54Ω, TXD = high or low, Figure 1a		2.1		V	
		R <sub>L</sub> = 100Ω, TXD = high or low, Figure 1a		2.9			
		-7V ≤ V <sub>CM</sub> ≤ +12V, Figure 1b		1.5                      5			
Differential Driver Peak-to-Peak Output	V <sub>ODPP</sub>	Figure 2 (Note 5)		4.0                      6.8		V	
Change in Magnitude of Differential Driver Output Voltage	ΔV <sub>OD</sub>	R <sub>L</sub> = 54Ω, Figure 1b (Note 6)		-0.2                      +0.2		V	
Driver Common-Mode Output Voltage	V <sub>OC</sub>	R <sub>L</sub> = 54Ω, Figure 1b		1.8                      3		V	
Change in Magnitude of Common-Mode Voltage	ΔV <sub>OC</sub>	R <sub>L</sub> = 54Ω, Figure 1b (Note 6)		-0.2                      +0.2		V	
Driver Short-Circuit Output Current	I <sub>OSD</sub>	GNDB ≤ V <sub>OUT</sub> ≤ +12V, output low (Note 7)		+250		mA	
		-7V ≤ V <sub>OUT</sub> ≤ V <sub>DDB</sub> , output high (Note 7)		-250			
Driver Short-Circuit Foldback Output Current	I <sub>OSDF</sub>	(V <sub>DDB</sub> - 1V) ≤ V <sub>OUT</sub> ≤ +12V, output low (Note 7, 8)		+15		mA	
		-7V ≤ V <sub>OUT</sub> ≤ +1V, output high (Note 7, 8)		-15			
RECEIVER							
Input Current (A and B)	I <sub>A</sub> , I <sub>B</sub>	DE = GNDA, V <sub>DDB</sub> = V <sub>GNDB</sub> or 5.5V	V <sub>IN</sub> = +12V	+250		μA	
			V <sub>IN</sub> = -7V	-200			
Receiver Differential Threshold Voltage	V <sub>TH</sub>	-7V ≤ V <sub>CM</sub> ≤ +12V		-200	-125	-50	mV
Receiver Input Hysteresis	ΔV <sub>TH</sub>	V <sub>CM</sub> = 0V		15		mV	
Receiver Input Resistance	R <sub>IN</sub>	-7V ≤ V <sub>CM</sub> ≤ +12V, DE = low		48		kΩ	
Differential Input Capacitance	C <sub>A,B</sub>	Measured between A and B, DE = RE = GNDA at 6MHz		8		pF	
PROTECTION							
Thermal-Shutdown Threshold	T <sub>SHDN</sub>	Temperature rising		+160		°C	
Thermal-Shutdown Hysteresis	T <sub>HYST</sub>			15		°C	
ESD Protection (A and B Pins to GNDB)		Human Body Model		±35		kV	
		IEC 61000-4-2 Air-Gap Discharge		±12			
		IEC 61000-4-2- Contact Discharge		±10			
ESD Protection (All Other Pins)		Human Body Model		±4		kV	

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## Switching Electrical Characteristics

(V<sub>DDA</sub> - V<sub>GNDA</sub> = 3.0V to 5.5V, V<sub>DDB</sub> - V<sub>GNDB</sub> = 4.5V to 5.5V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at V<sub>DDA</sub> - V<sub>GNDA</sub> = 3.3V, V<sub>DDB</sub> - V<sub>GNDB</sub> = 5V, V<sub>GNDA</sub> = V<sub>GNDB</sub>, and T<sub>A</sub> = +25°C.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>DYNAMIC</b>						
Common-Mode Transient Immunity	CMTI	(Note 9)		35		kV/μs
Glitch Rejection		TXD, DE, RXD	10	17	29	ns
<b>DRIVER</b>						
Driver Propagation Delay	t <sub>DPLH</sub> , t <sub>DPHL</sub>	R <sub>L</sub> = 54Ω, C <sub>L</sub> = 50pF, Figure 3 and Figure 4			68	ns
Differential Driver Output Skew  t <sub>DPLH</sub> - t <sub>DPHL</sub>	t <sub>DSKEW</sub>	R <sub>L</sub> = 54Ω, C <sub>L</sub> = 50pF, Figure 3 and Figure 4 (Note 8)			6	ns
Driver Differential Output Rise or Fall Time	t <sub>LH</sub> , t <sub>HL</sub>	R <sub>L</sub> = 54Ω, C <sub>L</sub> = 50pF, Figure 3 and Figure 4			15	ns
Maximum Data Rate	DR <sub>MAX</sub>		20			Mbps
Driver Enable to Output High	t <sub>DZH</sub>	R <sub>L</sub> = 500Ω, C <sub>L</sub> = 50pF, Figure 5			88	ns
Driver Enable to Output Low	t <sub>DZL</sub>	R <sub>L</sub> = 500Ω, C <sub>L</sub> = 50pF, Figure 6			88	ns
Driver Disable Time From Low	t <sub>DLZ</sub>	R <sub>L</sub> = 500Ω, C <sub>L</sub> = 50pF, Figure 6			80	ns
Driver Disable Time From High	t <sub>DHZ</sub>	R <sub>L</sub> = 500Ω, C <sub>L</sub> = 50pF, Figure 5			80	ns
<b>RECEIVER</b>						
Receiver Propagation Delay	t <sub>RPLH</sub> , t <sub>RPHL</sub>	C <sub>L</sub> = 15pF, Figures 7 and 8 (Note 10)			68	ns
Receiver Output Skew	t <sub>RSKEW</sub>	C <sub>L</sub> = 15pF, Figures 7 and 8 (Note 8, 10)			6	ns
Maximum Data Rate	DR <sub>MAX</sub>		20			Mbps
Receiver Enable to Output High	t <sub>RZH</sub>	R <sub>L</sub> = 1kΩ, C <sub>L</sub> = 15pF, S2 closed, Figure 9			20	ns
Receiver Enable to Output Low	t <sub>RZL</sub>	R <sub>L</sub> = 1kΩ, C <sub>L</sub> = 15pF, S1 closed, Figure 9			30	ns
Receiver Disable Time From Low	t <sub>RLZ</sub>	R <sub>L</sub> = 1kΩ, C <sub>L</sub> = 15pF, S1 closed, Figure 9			20	ns
Receiver Disable Time From High	t <sub>RHZ</sub>	R <sub>L</sub> = 1kΩ, C <sub>L</sub> = 15pF, S2 closed, Figure 9			20	ns

**Note 2:** All devices are 100% production tested at T<sub>A</sub> = +25°C. Specifications over temperature are guaranteed by design.

**Note 3:** All currents into the device are positive. All currents out of the device are negative. All voltages are referenced to their respective ground (GNDA or GNDB), unless otherwise noted.

**Note 4:** V<sub>LDO</sub> max indicates voltage capability of the circuit. Power dissipation requirements may limit V<sub>LDO</sub> max to a lower value.

**Note 5:** V<sub>ODPP</sub> is the difference in V<sub>OD</sub> when TXD is high and when TXD is low.

**Note 6:** ΔV<sub>OD</sub> and ΔV<sub>OC</sub> are the changes in V<sub>OD</sub> and V<sub>OC</sub>, respectively, when the TXD input changes state.

**Note 7:** The short circuit output current applies to the peak current just prior to foldback current limiting. The short circuit foldback output current applies during current limiting to allow a recovery from bus contention. See TOC 6 and TOC 7.

**Note 8:** Not production tested. Guaranteed by design.

**Note 9:** CMTI is the maximum sustainable common-mode voltage slew rate while maintaining the correct output states. CMTI applies to both rising and falling common-mode voltage edges. Tested with the transient generator connected between GNDA and GNDB. ΔV<sub>CM</sub> = 1kV.

**Note 10:** Capacitive load includes test probe and fixture capacitance.

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## Insulation Characteristics

PARAMETER	SYMBOL	CONDITIONS	VALUE	UNITS
Partial Discharge Test Voltage	V <sub>PR</sub>	Method B1 = V <sub>IORM</sub> × 1.875 (t = 1s, partial discharge < 5pC)	1182	V <sub>P</sub>
Maximum Repetitive Peak Withstand Voltage	V <sub>IORM</sub>	(Note 11)	630	V <sub>P</sub>
Maximum Working Isolation Voltage	V <sub>IOWM</sub>	(Note 11)	445	V <sub>RMS</sub>
Maximum Transient Isolation Voltage	V <sub>IOTM</sub>	t = 1s	4600	V <sub>P</sub>
Maximum Withstand Isolation Voltage	V <sub>ISO</sub>	t = 60s, f = 60Hz (Notes 11, 12)	2750	V <sub>RMS</sub>
Maximum Surge Isolation Voltage	V <sub>ISOM</sub>	Basic Insulation	10	kV
Insulation Resistance	R <sub>S</sub>		10 <sup>12</sup>	Ω
Barrier Capacitance Input to Output	CIO		2	pF
Minimum Creepage Distance	CPG	Wide SOIC	8	mm
Minimum Clearance Distance	CLR	Wide SOIC	8	mm
Internal Clearance		Distance through insulation	0.015	mm
Comparative Tracking Resistance Index	CTI	Material Group II (IEC 60112)	575	
Climatic Category			40/125/21	
Pollution Degree (DIN VDE 0110, Table 1)			2	

**Note 11:** V<sub>IORM</sub>, V<sub>IOWM</sub>, and V<sub>ISO</sub> are defined by the IEC 60747-5-5 standard.

**Note 12:** Product is qualified V<sub>ISO</sub> for 60 seconds. 100% production tested at 120% of V<sub>ISO</sub> for 1s.

## Safety Regulatory Approvals

<b>UL</b>
The MAX14940 is certified under UL1577. For more details, see File E351759.
Rate up to 2750V <sub>RMS</sub> isolation voltage for basic insulation.
<b>cUL</b>
The MAX14940 is certified under UL1577. For more details, see File E351759. Rate up to 2750V <sub>RMS</sub> isolation voltage for basic insulation.

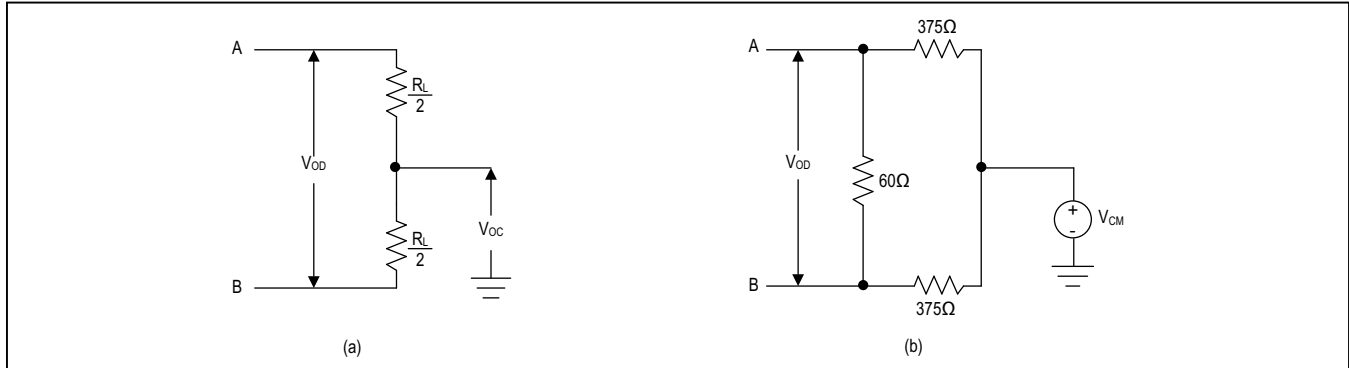


Figure 1. Driver DC Test Load

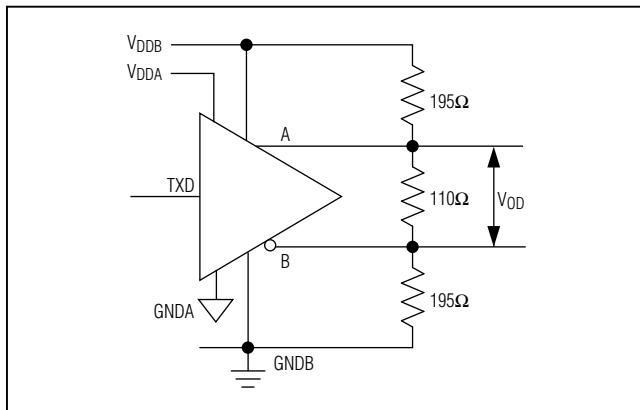
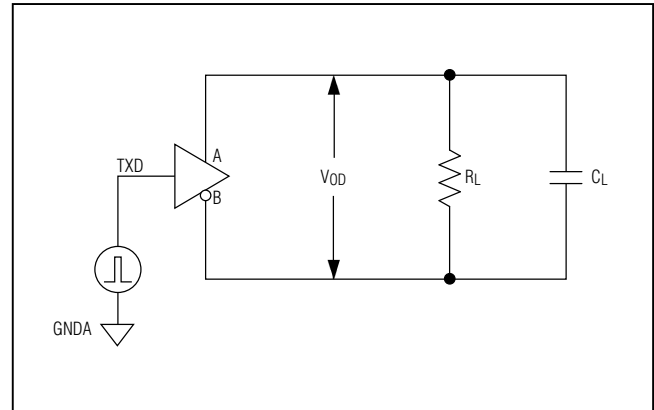
Figure 2.  $V_{ODPP}$  Swing Under Profibus Equivalent Load Test

Figure 3. Driver Timing Test Circuit

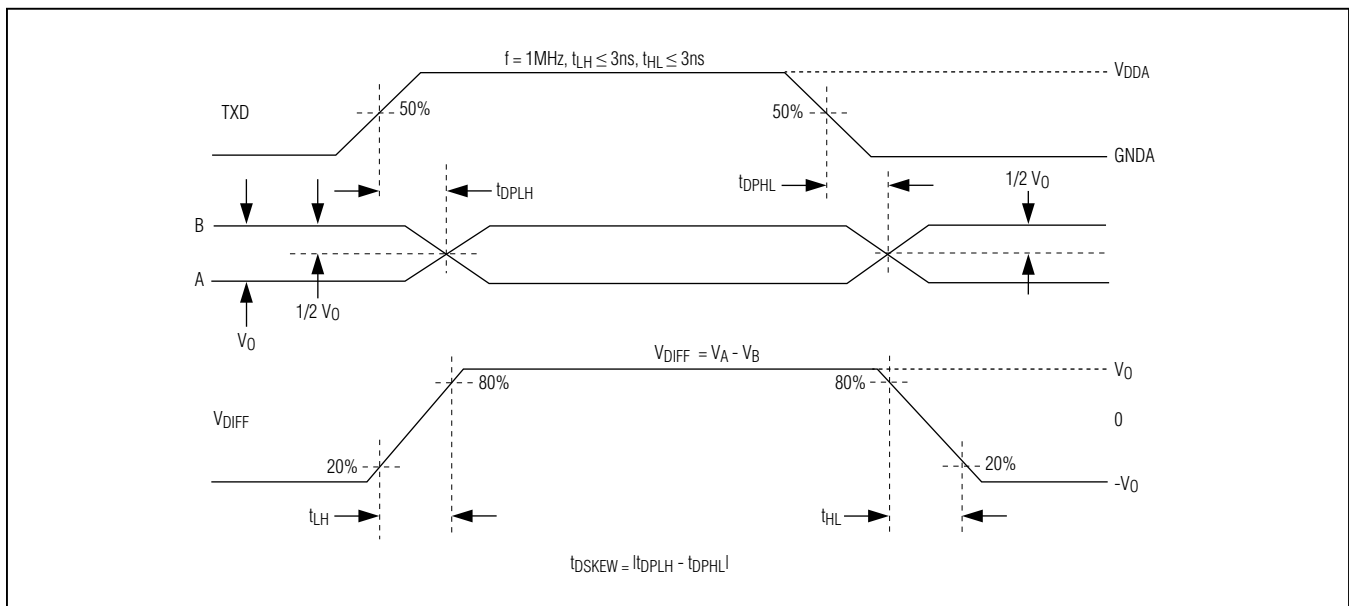


Figure 4. Driver Propagation Delays

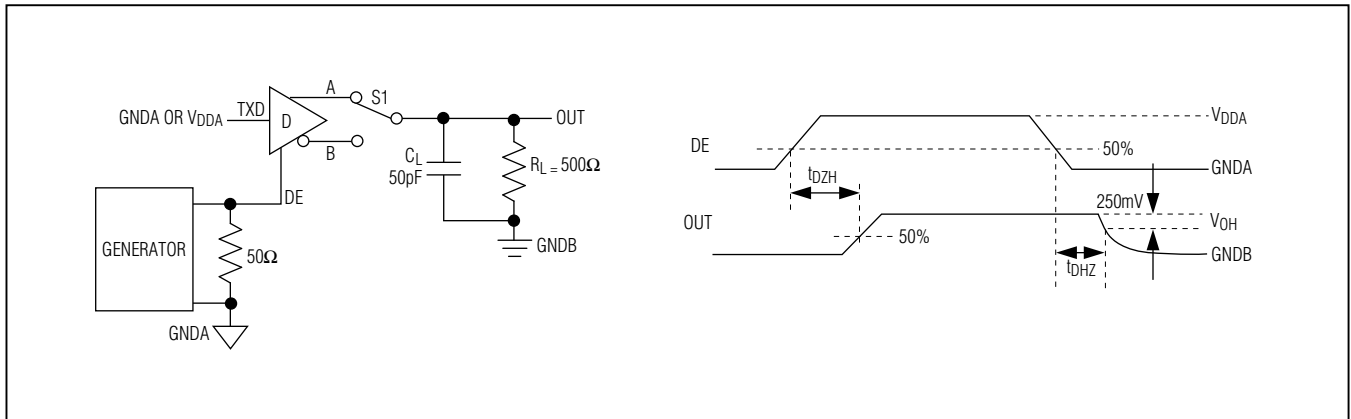


Figure 5. Driver Enable and Disable Times ( $t_{DZH}$ ,  $t_{DZL}$ )

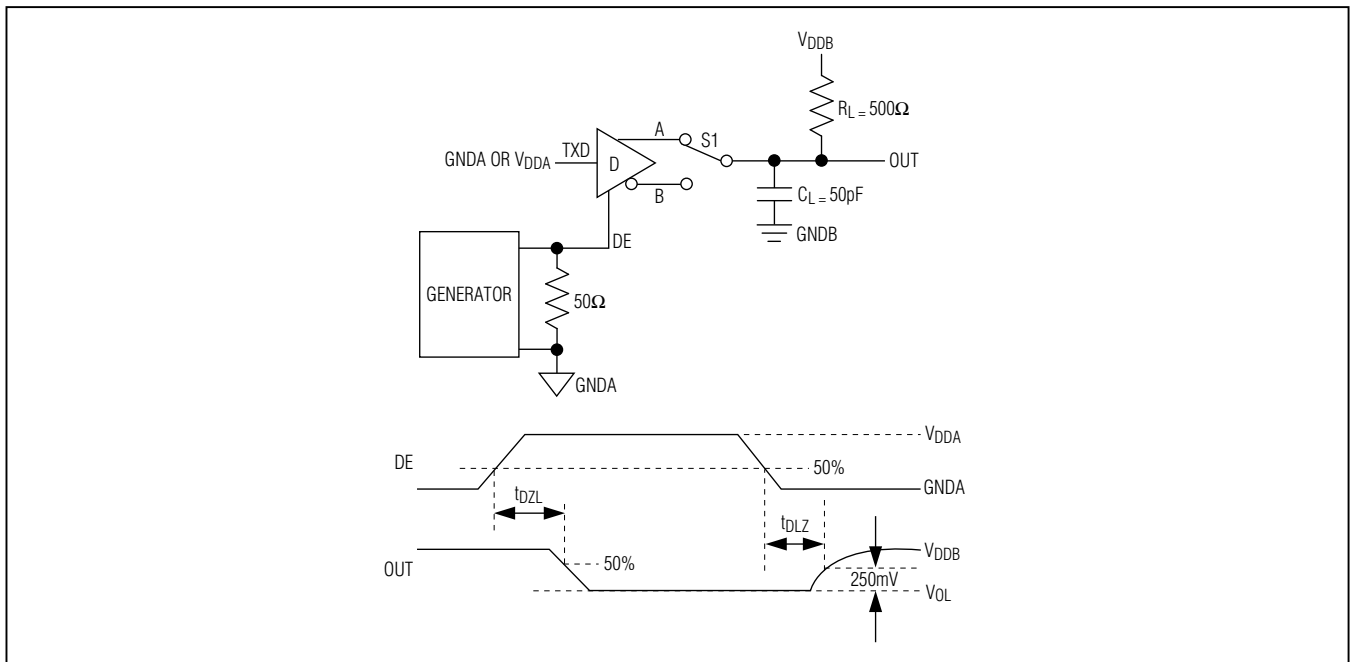


Figure 6. Driver Enable and Disable Times ( $t_{DZL}$ ,  $t_{DLZ}$ )

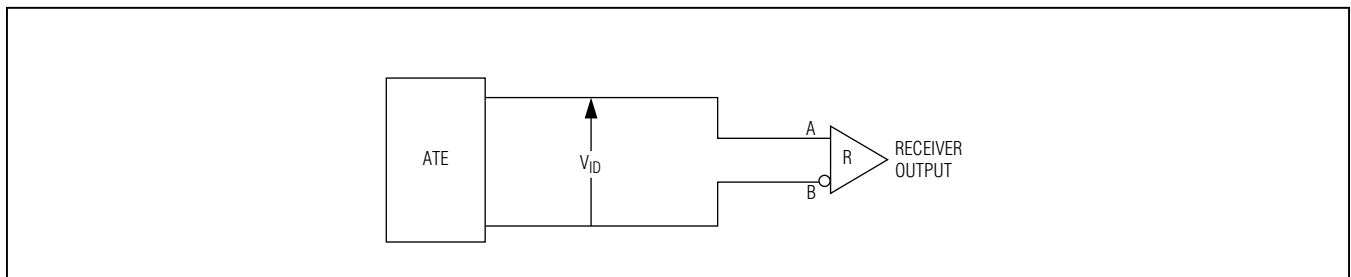
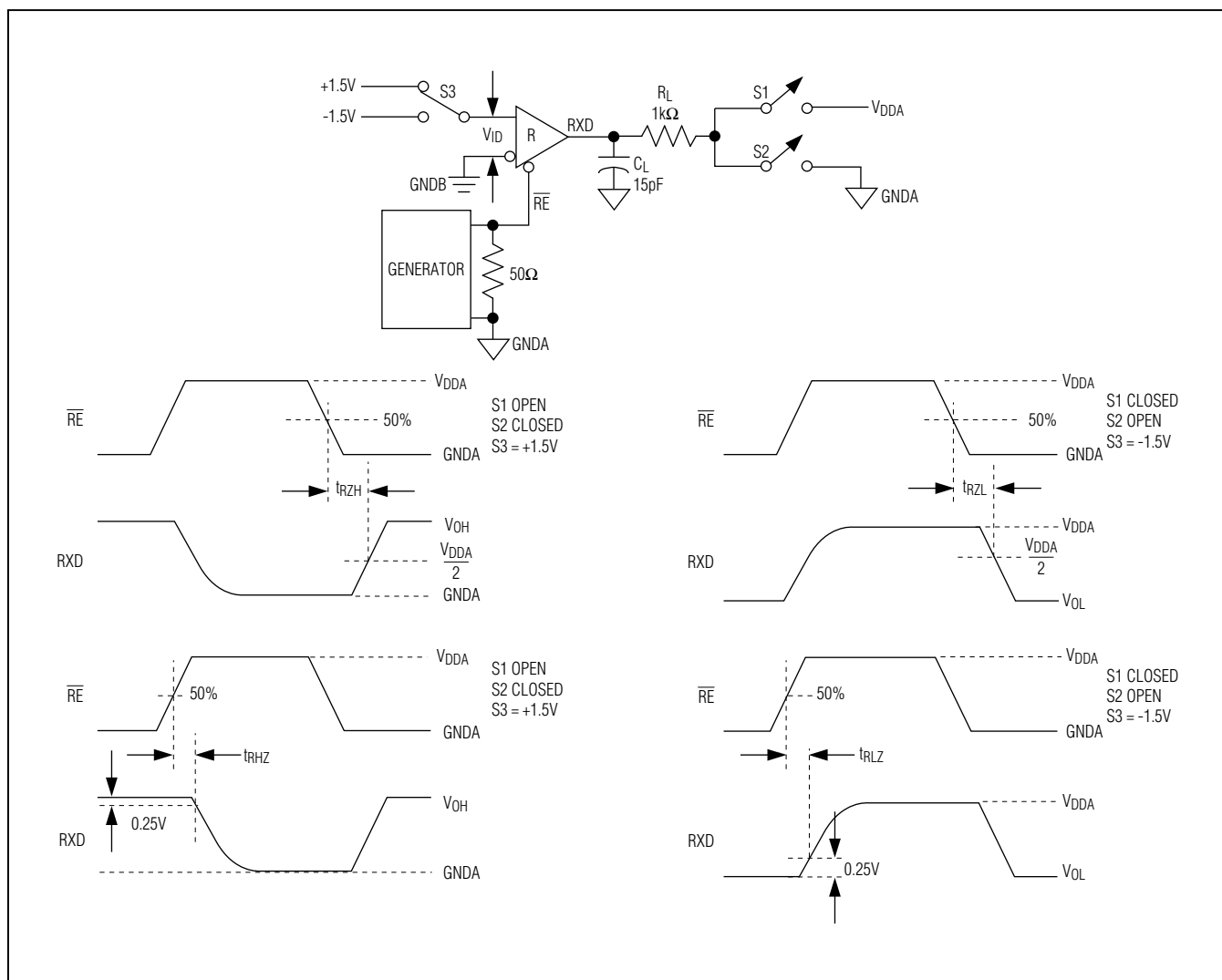
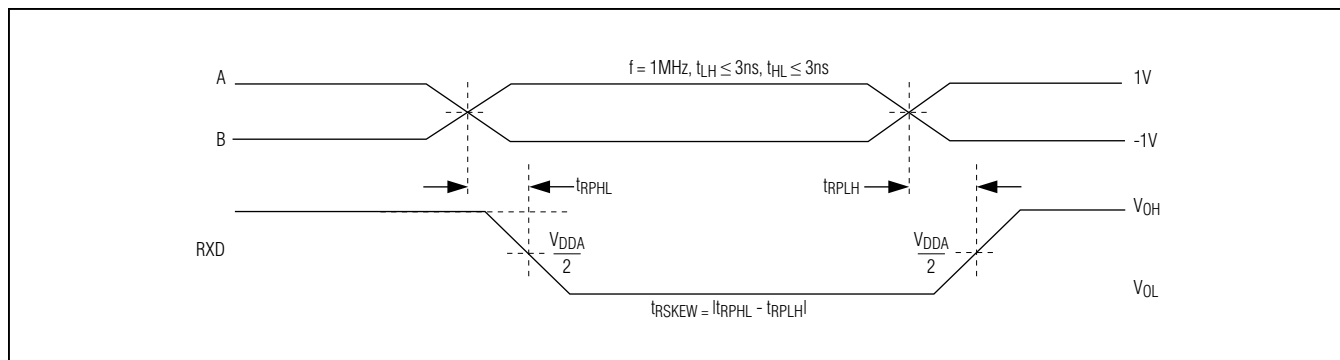


Figure 7. Receiver Propagation Delay Test Circuit

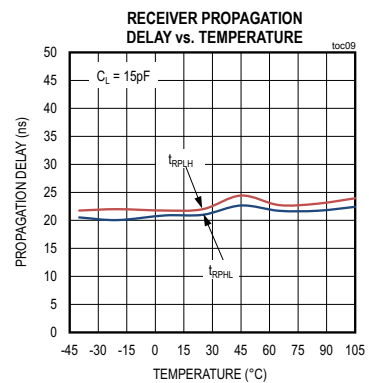
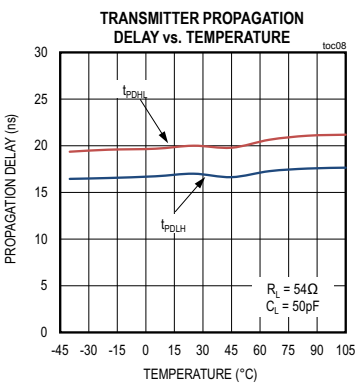
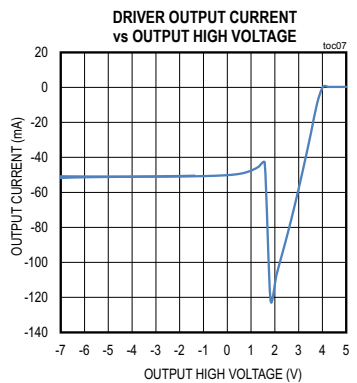
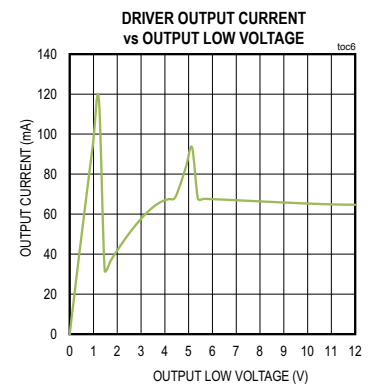
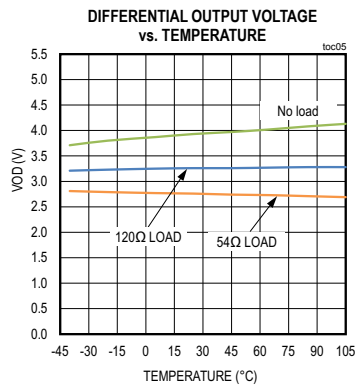
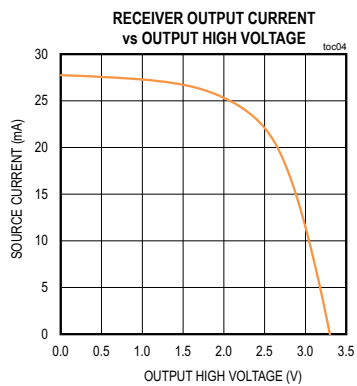
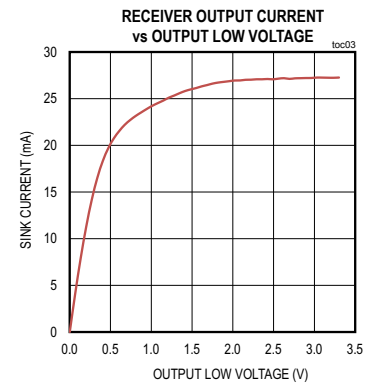
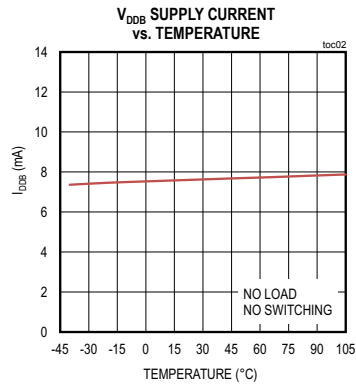
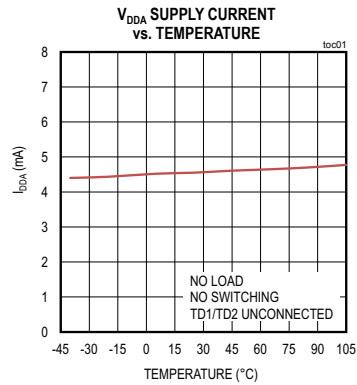


2.75kV<sub>RMS</sub> Isolated 20Mbps Half-Duplex  
PROFIBUS/RS-485 Transceiver with ±35kV ESD  
Protection and Integrated Transformer Driver



## Typical Operating Characteristics

( $V_{DDA} - G_{NDA} = 3.3V$ ,  $V_{DDB} - G_{NDB} = 5V$ ,  $V_{GND A} = V_{GND B}$ , and  $T_A = +25^\circ C$ , unless otherwise noted.)

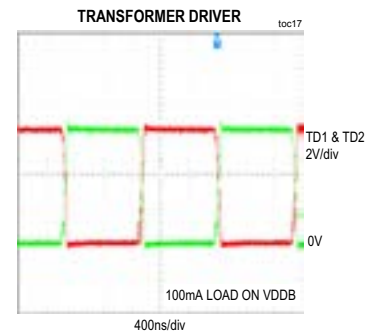
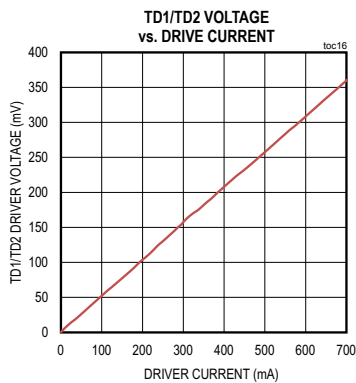
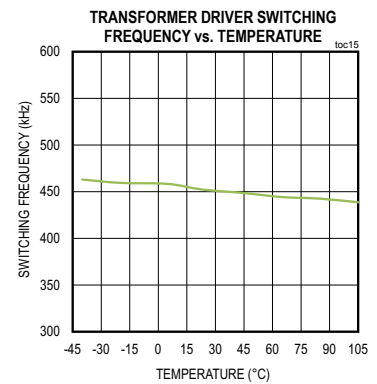
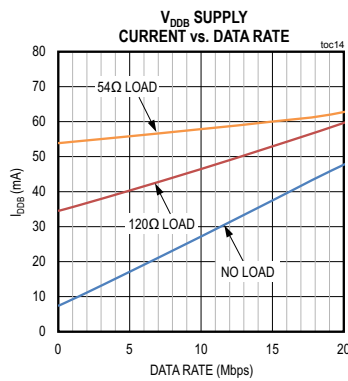
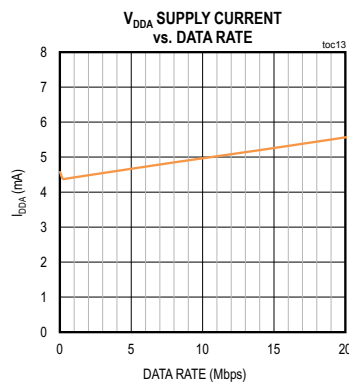
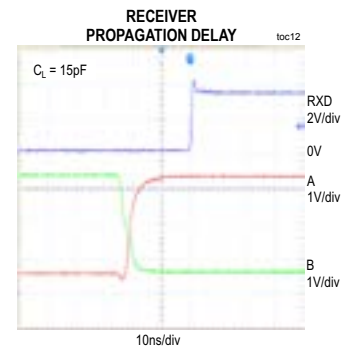
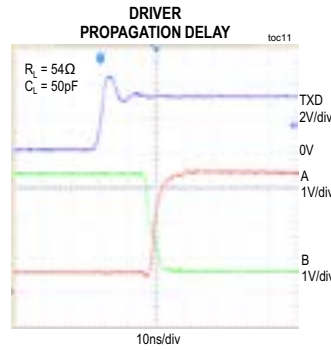
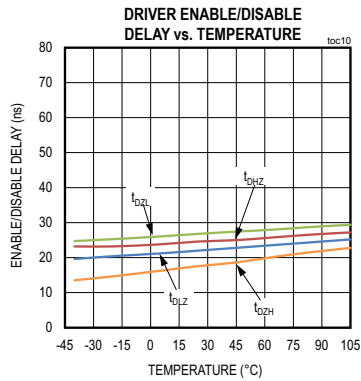


# MAX14940

## 2.75kV<sub>RMS</sub> Isolated 20Mbps Half-Duplex PROFIBUS/RS-485 Transceiver with $\pm 35$ kV ESD Protection and Integrated Transformer Driver

### Typical Operating Characteristics (continued)

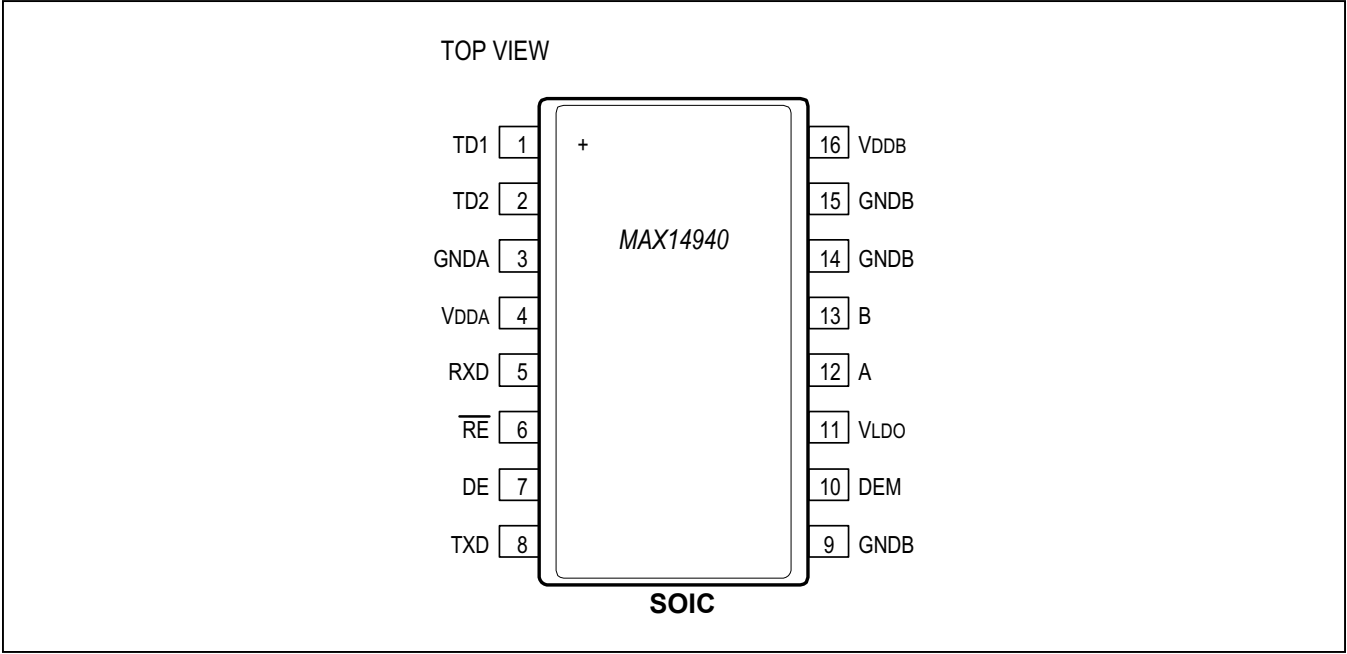
( $V_{DDA} - G_{NDA} = 3.3V$ ,  $V_{DDB} - G_{NDB} = 5V$ ,  $V_{G_{NDA}} = V_{G_{NDB}}$ , and  $T_A = +25^\circ C$ , unless otherwise noted.)



MAX14940

2.75kV<sub>RMS</sub> Isolated 20Mbps Half-Duplex  
PROFIBUS/RS-485 Transceiver with ±35kV ESD  
Protection and Integrated Transformer Driver

Pin Configuration



Pin Description

PIN	NAME	REFERENCE	FUNCTION
1	TD1	GNDA	Transformer Driver Output 1
2	TD2	GNDA	Transformer Driver Output 2
3	GNDA	—	UART/Logic-Side Ground. GNDA is the ground reference for digital signals and the transformer driver.
4	VDDA	GNDA	Logic-Side Power Input. Bypass VDDA to GNDA with both 0.1μF and 1μF capacitors as close to the device as possible.
5	RXD	GNDA	Receiver Data Output. Drive $\overline{RE}$ low to enable RXD. With $\overline{RE}$ low, RXD is high when $(V_A - V_B) > -50\text{mV}$ and is low when $(V_A - V_B) < -200\text{mV}$ . RXD is high when VDDB is less than VUVLOB. RXD is high impedance when $\overline{RE}$ is high.
6	$\overline{RE}$	GNDA	Receiver Output Enable. Drive $\overline{RE}$ low or connect to GNDA to enable RXD. Drive $\overline{RE}$ high to disable RXD. RXD is high impedance when $\overline{RE}$ is high. $\overline{RE}$ has an internal 4.5μA pull-down to GNDA.

MAX14940

2.75kV<sub>RMS</sub> Isolated 20Mbps Half-Duplex  
PROFIBUS/RS-485 Transceiver with  $\pm 35$ kV ESD  
Protection and Integrated Transformer Driver

## Pin Description (continued)

PIN	NAME	REFERENCE	FUNCTION
7	DE	GNDA	Driver Output Enable. Drive DE high to enable bus driver outputs A and B. Drive DE low or connect to GNDA to disable A and B. A and B are high impedance when DE is low. DE has an internal 4.5 $\mu$ A pulldown to GNDA.
8	TXD	GNDA	Driver Input. With DE high, a low on TXD forces the noninverting output (A) low and the inverting output (B) high. Similarly, a high on TXD forces the noninverting output high and the inverting output low. TXD has an internal 4.5 $\mu$ A pullup to V <sub>DDA</sub> .
9, 14, 15	GNDB	—	Cable-Side Ground. GNDB is the ground reference for the internal LDO, the DEM output, and the RS-485/PROFIBUS bus signals.
10	DEM	GNDB	Driver Enable Monitor Output. DEM is high when the transmitter is enabled. See the <a href="#">Function Tables</a> for more information.
11	V <sub>LDO</sub>	GNDB	LDO Power Input. Connect a minimum voltage of 4.68V to V <sub>LDO</sub> to power the cable-side of the transceiver. Bypass V <sub>LDO</sub> to GNDB with both 0.1 $\mu$ F and 1 $\mu$ F capacitors as close as possible to the device. To disable the internal LDO, leave V <sub>LDO</sub> unconnected or connect to GNDB.
12	A	GNDB	Noninverting Receiver Input and Noninverting Driver Output
13	B	GNDB	Inverting Receiver Input and Inverting Driver Output
16	V <sub>DDB</sub>	GNDB	Cable-Side Power Input/Isolated LDO Power Output. Bypass V <sub>DDB</sub> to GNDB with both 0.1 $\mu$ F and 1 $\mu$ F capacitors as close to the device as possible. V <sub>DDB</sub> is the output of the internal LDO when power is applied to V <sub>LDO</sub> . When the internal LDO is not used (V <sub>LDO</sub> is unconnected or connected to GNDB), V <sub>DDB</sub> is the positive supply input for the cable-side of the IC.

## Function Tables

TRANSMITTING						
INPUTS				OUTPUTS		
V <sub>DDA</sub>	V <sub>ddb</sub>	DE	TXD	A	B	DEM
$\geq V_{UVLOA}$	$\geq V_{UVLOB}$	1	1	1	0	1
$\geq V_{UVLOA}$	$\geq V_{UVLOB}$	1	0	0	1	1
$\geq V_{UVLOA}$	$\geq V_{UVLOB}$	0	X	High-Z	High-Z	0
$< V_{UVLOA}$	$\geq V_{UVLOB}$	X	X	High-Z	High-Z	0
$\geq V_{UVLOA}$	$< V_{UVLOB}$	X	X	High-Z	High-Z	0
$< V_{UVLOA}$	$< V_{UVLOB}$	X	X	High-Z	High-Z	0

**Note:** Drive DE low to disable the transmitter outputs. Drive DE high to enable the transmitter outputs. DE has an internal pulldown to GNDA.

X = Don't care

RECEIVING				
INPUTS				OUTPUTS
V <sub>DDA</sub>	V <sub>ddb</sub>	$\overline{RE}$	(V <sub>A</sub> - V <sub>B</sub> )	RXD
$\geq V_{UVLOA}$	$\geq V_{UVLOB}$	0	$> -50\text{mV}$	1
$\geq V_{UVLOA}$	$\geq V_{UVLOB}$	0	$< -200\text{mV}$	0
$\geq V_{UVLOA}$	$\geq V_{UVLOB}$	0	Open/Short	1
$\geq V_{UVLOA}$	$\geq V_{UVLOB}$	1	X	High-Z
$< V_{UVLOA}$	$\geq V_{UVLOB}$	X	X	High-Z
$\geq V_{UVLOA}$	$< V_{UVLOB}$	0	X	1
$< V_{UVLOA}$	$< V_{UVLOB}$	X	X	High-Z

**Note:** Drive  $\overline{RE}$  high to disable the receiver output. Drive  $\overline{RE}$  low to enable to receiver output.  $\overline{RE}$  has an internal pulldown to GNDA.

X = Don't care

## Detailed Description

The MAX14940 isolated RS-485/PROFIBUS-DP transceiver provides 2750V<sub>RMS</sub> (60s) of galvanic isolation between the RS-485/PROFIBUS-DP cable-side of the transceiver and the UART-side. This device allows up to 20Mbps communication across an isolation barrier when a large potential exists between grounds on each side of the barrier.

### Isolation

Both data and power can be transmitted across the isolation barrier. Data isolation is achieved using integrated capacitive isolation that allows data transmission between the UART-side and the cable-side of the transceiver.

To achieve power isolation, the MAX14940 features an integrated transformer driver to drive an external center-tapped transformer, allowing the transfer of operating power from the UART-side across the isolation barrier to the cable-side. Connect the primary side of the external transformer to the device's transformer driver outputs, TD1 and TD2. Connect the primary center-tap to V<sub>DDA</sub>.

### Integrated LDO

The device includes an internal low-dropout regulator with a set 5V (typ) output that is used to power the cable-side of the IC. The output of the LDO is V<sub>DDB</sub>. The LDO has a 300mA (typ) current limit. If the LDO is unused, connect V<sub>LDO</sub> to G<sub>NDB</sub> and apply +5V directly to V<sub>DDB</sub>.

### True Fail Safe

The device guarantees a logic-high on the receiver output when the receiver inputs are shorted, open, or when connected to a terminated transmission line with all drivers disabled. The receiver threshold is fixed between -50mV and -200mV. If the differential receiver input voltage (V<sub>A</sub> – V<sub>B</sub>) is greater than or equal to -50mV, RXD is logic high. In the case of a terminated bus with all transmitters disabled, the receiver's differential input voltage is pulled to zero by the termination resistors. Due to the receiver thresholds of the device, this results in a logic-high at RXD.

### Driver Output Protection

Two mechanisms prevent excessive output current and power dissipation caused by faults or by bus contention. The first, a foldback mode current limit on the output stage, provides immediate protection against short circuits over the entire common-mode voltage range. The second, a thermal-shutdown circuit, forces the driver outputs into a high-impedance state if the die temperature exceeds +160°C (typ).

### Thermal Shutdown

The MAX14940 is protected from overtemperature damage by integrated thermal shutdown circuitry. When the junction temperature (T<sub>J</sub>) exceeds +160°C (typ), the driver outputs go high impedance. The device resumes normal operation when T<sub>J</sub> falls below +145°C (typ).

### Transformer Driver

#### Overcurrent Limiting

The device features overcurrent limiting to protect the integrated transformer driver from excessive currents when charging large capacitive loads or driving into short circuits. Current limiting is achieved in two stages: internal circuitry monitors the output current and detects when the peak current rises above 1.2A. When the 1.2A threshold is exceeded, internal circuitry reduces the output current to the 730mA current-limit. The device monitors the driver current on a cycle-by-cycle basis and limits the current until the short is removed.

The transformer driver on the device can dissipate large amounts of power during overcurrent limiting, causing the IC to enter thermal shutdown. When the junction temperature of the driver exceeds the thermal shutdown threshold, the TD1 and TD2 driver outputs are disabled. The driver resumes normal operation when the temperature falls below the thermal shutdown hysteresis.

### Transformer Selection

The integrated push-pull transformer driver allows the transmission of operating power from the UART-side, across the isolation barrier, to the isolated cable-side of the device. The 450kHz transformer driver operates with center-tapped primary transformers. Select a transformer with an ET product greater than or equal to the ET of the driver to ensure that the transformer does not enter saturation. E is the voltage applied to the transformer and T is the maximum time it is applied during any one cycle. Calculate the minimum ET product for the transformer primary as:

$$ET = V_{MAX} / (2 \times f_{MIN})$$

Where V<sub>MAX</sub> is the worst-case maximum supply voltage on V<sub>DDA</sub> and f<sub>MIN</sub> is the minimum frequency at that supply voltage. For example, using 5.5V and 350kHz, the required minimum ET product is 7.9Vμs. [Table 1](#) includes a list of recommended transformers.

## Applications Information

### 128 Transceivers on the Bus

The standard RS-485 receiver input impedance is one unit load, and a standard driver can drive up to 32 unit loads. The device transceiver has a 1/4-unit load receiver, which allows up to 128 transceivers connected in parallel on one communication line. Connect any combination of these devices, and/or other RS-485 devices, for a maximum of 32 unit loads to the line.

### Typical Application

The device transceiver is designed for bidirectional data communications on multipoint bus transmission lines. [Figure 10](#) and [Figure 11](#) show typical network applications circuits. To minimize reflections, the bus should be terminated at both ends in its characteristics impedance, and stub lengths off the main line should be kept as short as possible.

### Profibus Termination

The device is designed for driving PROFIBUS-DP terminated networks. The driver maintains 2.1V(min) when driving a worst-case loading condition of two standard 220Ω termination resistors with 390Ω pullups/pulldowns.

### Layout Considerations

It is recommended to design an isolation or keep out channel underneath the isolator that is free from ground and signal planes. Any galvanic or metallic connection between the cable-side and UART-side defeats the isolation.

Ensure that the decoupling capacitors between V<sub>DDA</sub> and GNDA and between V<sub>LDO</sub>, V<sub>DDB</sub>, and GNDB are located as close as possible to the IC to minimize inductance.

Route important signal lines close to the ground plane to minimize possible external influences. On the cable-side of the MAX14940, it is good practice to have the bus connectors and termination resistor as close as possible to the A and B pins.

### Extended ESD Protection

ESD protection structures are incorporated on all pins to protect against electrostatic discharge encountered during handling and assembly. The driver outputs and receiver inputs of the MAX14940 have extra protection against static electricity. The ESD structures withstand high ESD in normal operation and when powered down. After an ESD event, the devices keep working without latch-up or damage.

**Table 1. Recommended Transformers**

MANUFACTURER PART NUMBER	APPLICATION	CONFIGURATION	ISOLATION (V <sub>RMS</sub> )	DIMENSIONS (L x W x H) (mm)
HALO TGMS-1440V6LF	5V to 5V	1CT:1.33CT	2750	9.45 x 10.87 x 10.03
HALO TGMS-1464V6LF	3.3V to 5V	1CT:2.4CT	2750	9.45 x 10.87 x 10.03
WURTH 750315225	5V to 5V	1CT:1.1CT	2750	6.73 x 7.14 x 4.19
WURTH 750315226	5V to 5V	1CT:1.3CT	2750	6.73 x 7.14 x 4.19
WURTH 750315227	3.3V to 5V	1CT:1.7CT	2750	6.73 x 7.14 x 4.19
WURTH 750315228	3.3V to 5V	1CT:2CT	2750	6.73 x 7.14 x 4.19



## MAX14940

## 2.75kV<sub>RMS</sub> Isolated 20Mbps Half-Duplex PROFIBUS/RS-485 Transceiver with $\pm 35\text{kV}$ ESD Protection and Integrated Transformer Driver

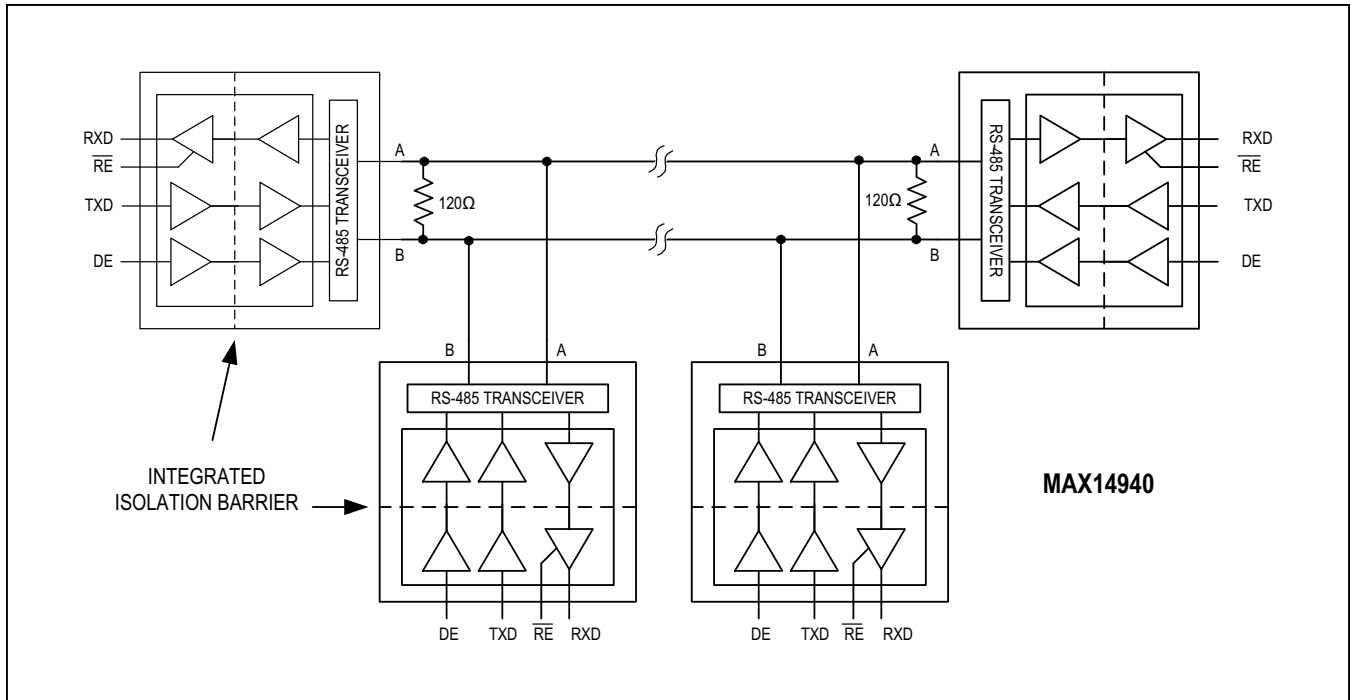


Figure 10. Typical Isolated Half-Duplex RS-485 Application

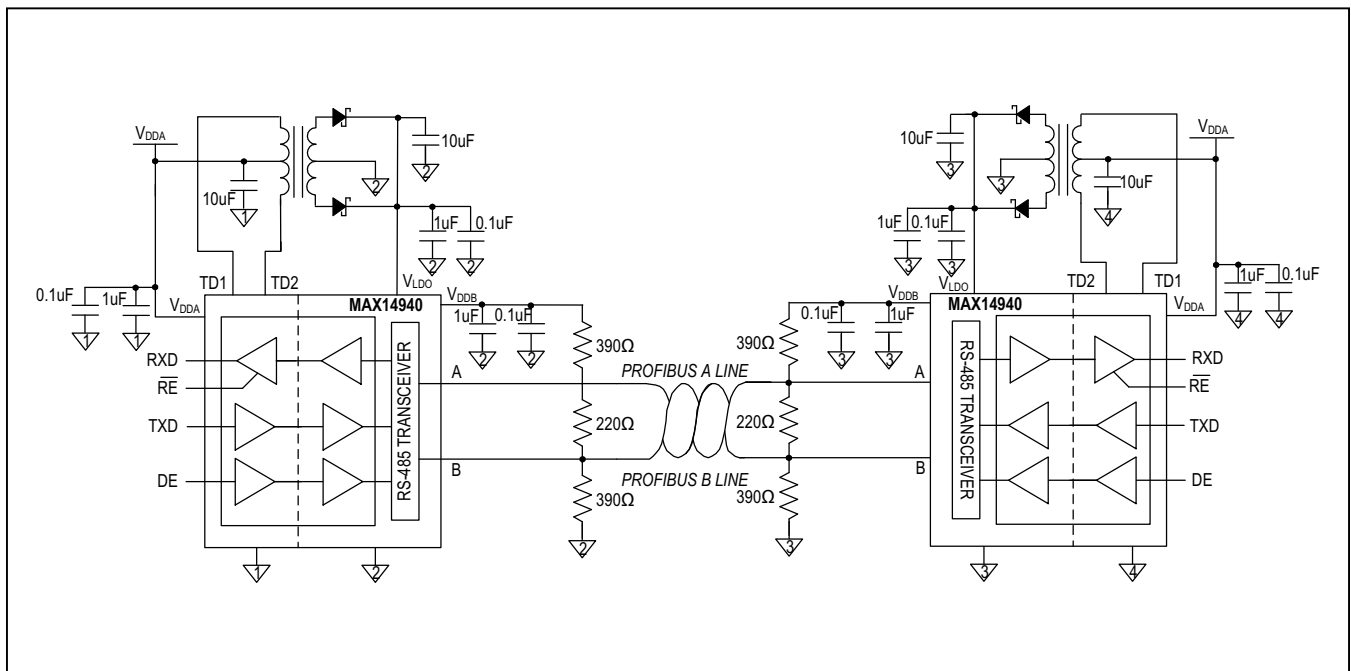


Figure 11. Typical Isolated Profibus Application with Integrated Transformer Driver

Bypass  $V_{DDA}$  to  $GNDA$  and bypass  $V_{DDB}$  and  $V_{LDO}$  to  $GNDB$  with  $0.1\mu\text{F}$  and  $1\mu\text{F}$  capacitors to ensure maximum ESD protection.

ESD protection can be tested in various ways. The transmitter outputs and receiver inputs of the MAX14940 are characterized for protection to the cable-side ground (GNDB) to the following limits:

- $\pm 35\text{kV}$  HBM
- $\pm 12\text{kV}$  using the Air-Gap Discharge method specified in IEC 61000-4-2
- $\pm 10\text{kV}$  using the Contact Discharge method specified in the IEC 61000-4-2

### ESD Test Conditions

ESD performance depends on a variety of conditions. Contact Maxim for a reliability report that documents test setup, test methodology, and test results.

### Human Body Model (HBM)

Figure 12 shows the HBM test model and Figure 13 shows the current waveform it generates when discharged in a low-impedance state. This model consists of a  $100\text{pF}$  capacitor charged to the ESD voltage of interest, which is then discharged in to the test device through a  $1.5\text{k}\Omega$  resistor.

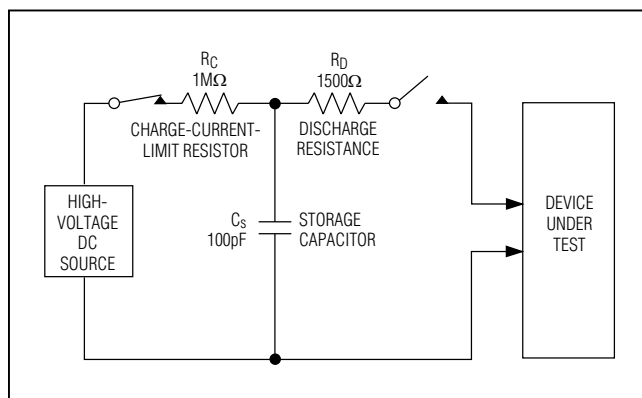


Figure 12. Human Body ESD Test Model

### IEC 61000-4-2

The IEC 61000-4-2 standard covers ESD testing and performance of finished equipment. However, it does not specifically refer to integrated circuits. The MAX14940 helps in designing equipment to meet IEC 61000-4-2 without the need for additional ESD protection components.

The major difference between tests done using the HBM and IEC 61000-4-2 is higher peak current in IEC 61000-4-2 because series resistance is lower in the IEC 61000-4-2 model. Hence, the ESD withstand voltage measured to IEC 61000-4-2 is generally lower than that measured using the HBM.

Figure 14 shows the IEC 61000-4-2 model and Figure 15 shows the current waveform for IEC 61000-4-2 ESD Contact Discharge Test.

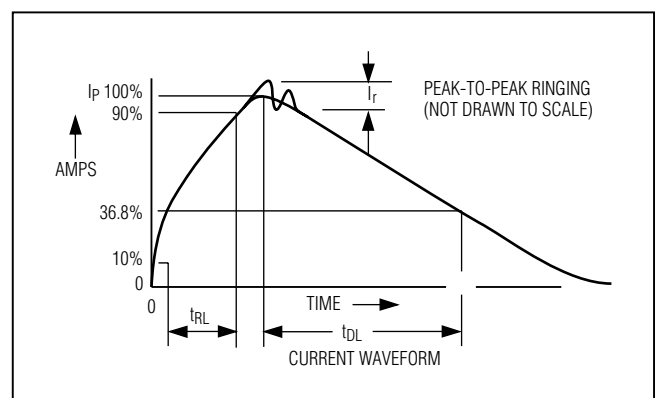
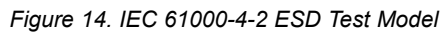


Figure 13. Human Body Current Waveform

2.75kV<sub>RMS</sub> Isolated 20Mbps Half-Duplex  
PROFIBUS/RS-485 Transceiver with ±35kV ESD  
Protection and Integrated Transformer Driver



The diagram illustrates a PoE system architecture. On the left, a microcontroller (uC) is connected to the MAX14940's RXD, TXD, and DE pins. The MAX14940 is powered by VDDA and VDDB, with a GND connection. It includes an XFMR DRIVER, an LDO, and an RS-485 TRANSCEIVER. The RS-485 TRANSCEIVER is connected to a network of twisted-pair cables (A, B, DEM, GNDB). The system is divided into two sections by an ISOLATION BARRIER.

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2.75kV<sub>RMS</sub> Isolated 20Mbps Half-Duplex  
PROFIBUS/RS-485 Transceiver with ±35kV ESD  
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### Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX14940GWE+	-40°C to +105°C	16 SOIC (W)
MAX14940GWE+T	-40°C to +105°C	16 SOIC (W)

+Denotes a lead(Pb)-free/RoHS-compliant package.

### Chip Information

PROCESS: BiCMOS

### Package Information

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://www.maximintegrated.com/packages). Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
16 SOIC	W16M+10	<a href="#">21-0042</a>	<a href="#">90-0107</a>

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## Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	10/15	Initial release	—
1	1/17	Updated pending safety approvals	1, 6
2	10/17	Corrected RXD voltage for RXD in <a href="#">Absolute Maximum Ratings</a>	2

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim Integrated's website at [www.maximintegrated.com](http://www.maximintegrated.com).

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