



±15kV ESD-Protected, 10Mbps, 3V/5V, Quad RS-422/RS-485 Receivers

MAX3095/MAX3096

General Description

The MAX3095/MAX3096 are rugged, low-power, quad, RS-422/RS-485 receivers with electrostatic discharge (ESD) protection for use in harsh environments. All receiver inputs are protected to $\pm 15\text{kV}$ using IEC 1000-4-2 Air-Gap Discharge, $\pm 8\text{kV}$ using IEC 1000-4-2 Contact Discharge, and $\pm 15\text{kV}$ using the Human Body Model. The MAX3095 operates from a +5V supply, while the MAX3096 operates from a +3.3V supply. Receiver propagation delays are guaranteed to within $\pm 8\text{ns}$ of a pre-determined value, thereby ensuring device-to-device matching across production lots.

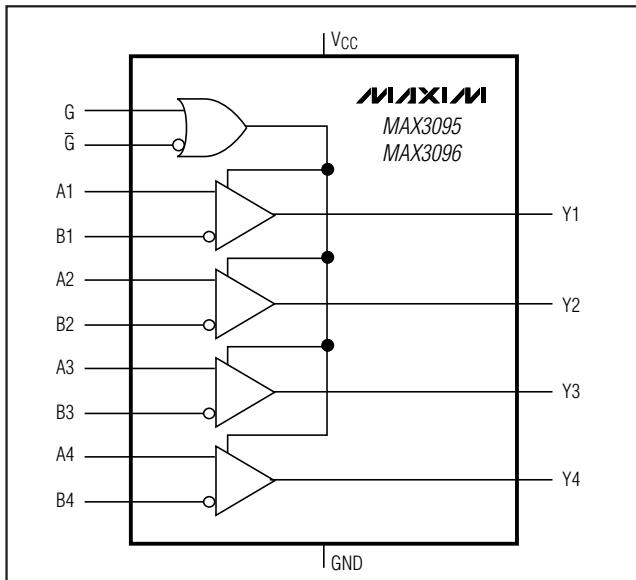
Complementary enable inputs can be used to place the devices in a 1nA low-power shutdown mode in which the receiver outputs are high impedance. When active, these receivers have a fail-safe feature that guarantees a logic-high output if the input is open circuit. They also feature a quarter-unit-load input impedance that allows 128 receivers on a bus.

The MAX3095/MAX3096 are pin-compatible, low-power upgrades to the industry-standard '26LS32. They are available in a space-saving QSOP package.

Applications

Telecommunications Equipment
Rugged RS-422/RS-485/RS-423 Bus Receiver
Receivers for ESD-Sensitive Applications
Level Translators

Functional Diagram



Features

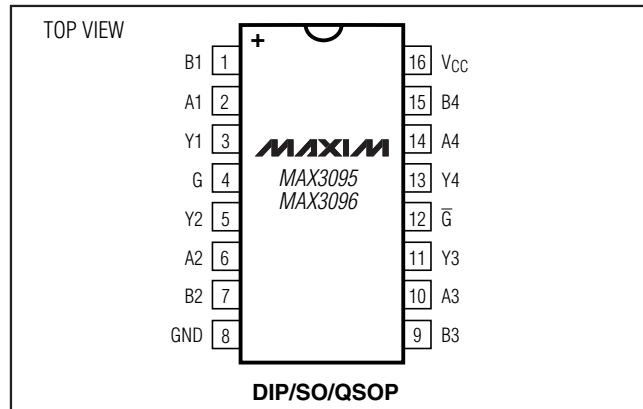
- ◆ **ESD Protection:**
 - ±15kV—IEC 1000-4-2, Air-Gap Discharge
 - ±8kV—IEC 1000-4-2, Contact Discharge
 - ±15kV—Human Body Model
- ◆ **Guaranteed Propagation-Delay Tolerance Between All ICs:**
 - ±8ns (MAX3095)
 - ±10ns (MAX3096)
- ◆ **Single +3V Operation (MAX3096)**
Single +5V Operation (MAX3095)
- ◆ **16-Pin QSOP (8-pin SO footprint)**
- ◆ **10Mbps Data Rate**
- ◆ **Allow up to 128 Receivers on the Bus**
- ◆ **1nA Low-Power Shutdown Mode**
- ◆ **2.4mA Operating Supply Current**
- ◆ **Pin-Compatible Upgrades to '26LS32**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX3095CPE+	0°C to +70°C	16 Plastic DIP
MAX3095CSE+	0°C to +70°C	16 Narrow SO
MAX3095CEE+	0°C to +70°C	16 QSOP
MAX3095EPE+	-40°C to +85°C	16 Plastic DIP
MAX3095ESE+	-40°C to +85°C	16 Narrow SO
MAX3095EEE+	-40°C to +85°C	16 QSOP
MAX3096CPE+	0°C to +70°C	16 Plastic DIP
MAX3096CSE+	0°C to +70°C	16 Narrow SO
MAX3096CEE+	0°C to +70°C	16 QSOP
MAX3096EPE+	-40°C to +85°C	16 Plastic DIP
MAX3096ESE+	-40°C to +85°C	16 Narrow SO
MAX3096EEE+	-40°C to +85°C	16 QSOP

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

Pin Configuration



For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

$\pm 15kV$ ESD-Protected, 10Mbps, 3V/5V, Quad RS-422/RS-485 Receivers

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V _{CC})	7V
Control Input Voltage (G, \overline{G})	-0.3V to (V _{CC} + 0.3V)
Receiver Input Voltage (A ₊ , B ₋)	$\pm 25V$
Receiver Output Voltage (Y ₊)	-0.3V to (V _{CC} + 0.3V)
Continuous Power Dissipation (T _A = +70°C)	
16-Pin Plastic DIP (derate 10.5mW/°C above +70°C)	.762mW
16-Pin SO (derate 8.7mW/°C above +70°C)	696mW
16-Pin QSOP (derate 8.3mW/°C above +70°C)	667mW

Operating Temperature Ranges	
MAX309_C	0°C to +70°C
MAX309_E	-40°C to +85°C
Storage Temperature Range	-65°C to +160°C
Lead Temperature (soldering, 10s)	+300°C

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.

DC ELECTRICAL CHARACTERISTICS—MAX3095

(V_{CC} = 5V $\pm 5\%$, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Receiver Differential Input Threshold	V _{TH}	-7V \leq V _{CM} \leq 12V	-200	200		mV
Receiver Input Hysteresis		V _{CM} = 0V		45		mV
Receiver Input Current (A ₊ , B ₋)	I _{IN}	V _{CC} = 0V or 5.25V	V _{IN} = 12V	250		μA
			V _{IN} = -7V	-200		
Enable Input Current (G, \overline{G})				± 1		μA
Enable Input High Voltage (G, \overline{G})	V _{IH}		2.0			V
Enable Input Low Voltage (G, \overline{G})	V _{IL}			0.8		V
Receiver Output High Voltage	V _{OH}	I _{OUT} = -4mA, V _{ID} = 200mV, G = V _{CC} or \overline{G} = GND, Figure 1	V _{CC} - 1.5			V
Receiver Output Low Voltage	V _{OL}	I _{OUT} = 4mA, V _{ID} = -200mV, G = V _{CC} or \overline{G} = GND, Figure 1		0.4		V
Three-State Current at Receiver Output	I _{OZR}	0 \leq V _{OUT} \leq V _{CC} , G = GND and \overline{G} = V _{CC}		± 1		μA
Output Short-Circuit Current	I _{OSR}	0 \leq V _{OUT} \leq V _{CC} , G = V _{CC} or \overline{G} = GND	± 7	± 75		mA
Receiver Input Resistance	R _{IN}	-7V \leq V _{CM} \leq 12V	48			kΩ
Supply Current	I _{CC}	No load, G = V _{CC} or \overline{G} = GND		2.4	3.5	mA
		G = GND and \overline{G} = V _{CC}		0.001	10	μA
ESD Protection (Note 2)		Human Body Model		± 15		kV
		IEC 1000-4-2 (Air-Gap Discharge)		± 15		
		IEC 1000-4-2 (Contact Discharge)		± 8		

$\pm 15kV$ ESD-Protected, 10Mbps, 3V/5V, Quad RS-422/RS-485 Receivers

SWITCHING CHARACTERISTICS—MAX3095

($V_{CC} = 5V \pm 5\%$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

PARAMETER	SYMBOL	CONDITIONS			MIN	TYP	MAX	UNITS	
Input-to-Output Propagation Delay	t_{PLH}, t_{PHL}	$V_{CC} = 5V \pm 5\%$, $T_A = T_{MIN}$ to T_{MAX}			65	98		ns	
		$IV_{IDL} = 3V$, Figure 2	$T_A = +85^\circ C$	$T_A = +85^\circ C$	78	86	94		
				$T_A = +25^\circ C$	71	79	87		
			$T_A = -40^\circ C$	$T_A = -40^\circ C$	65	73	81		
		$V_{CC} = 4.75V$	$T_A = +85^\circ C$	$T_A = +85^\circ C$	82	90	98		
				$T_A = +25^\circ C$	74	82	90		
			$T_A = -40^\circ C$	$T_A = -40^\circ C$	68	76	84		
Device-to-Device Propagation-Delay Matching		$IV_{IDL} = 3V$, Figure 2, matched conditions				16		ns	
Propagation-Delay Skew ($t_{PLH} - t_{PHL}$)	t_{SK}					-4	± 10	ns	
Output Enable Time to Low Level	t_{ZL}	Figure 3			600	800		ns	
Output Enable Time to High Level	t_{ZH}	Figure 3			600	800		ns	
Output Disable Time from Low Level	t_{LZ}	Figure 3			60	100		ns	
Output Disable Time from High Level	t_{HZ}	Figure 3			60	100		ns	
Maximum Data Rate	f_{MAX}				10			Mbps	

DC ELECTRICAL CHARACTERISTICS—MAX3096

($V_{CC} = 3.135V$ to $3.6V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $V_{CC} = 3.3V$, $T_A = +25^\circ C$.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Receiver Differential Input Threshold	V_{TH}	$-7V \leq V_{CM} \leq 12V$		-200		200	mV
Receiver Input Hysteresis		$V_{CM} = 0V$			45		mV
Receiver Input Current (A_-, B_-)	I_{IN}	$V_{CC} = 0V$ or $3.6V$	$V_{IN} = 12V$		250		μA
			$V_{IN} = -7V$		-200		
Enable Input Current (G , \overline{G})						± 1	μA
Enable Input High Voltage (G , \overline{G})	V_{IH}				2.0		V
Enable Input Low Voltage (G , \overline{G})	V_{IL}					0.8	V
Receiver Output High Voltage	V_{OH}	$I_{OUT} = -1.5mA$, $V_{ID} = 200mV$, $G = V_{CC}$ or $\overline{G} = GND$, Figure 1		$V_{CC} - 0.4$			V
Receiver Output Low Voltage	V_{OL}	$I_{OUT} = 2.5mA$, $V_{ID} = -200mV$, $G = V_{CC}$ or $\overline{G} = GND$, Figure 1		0.4			V
Three-State Current at Receiver Output	I_{OZR}	$0 \leq V_{OUT} \leq V_{CC}$, $G = GND$ and $\overline{G} = V_{CC}$		± 1		μA	
Output Short-Circuit Current	I_{OSR}	$0 \leq V_{OUT} \leq V_{CC}$, $G = V_{CC}$ or $\overline{G} = GND$		± 4	± 60	mA	
Receiver Input Resistance	R_{IN}	$-7V \leq V_{CM} \leq 12V$		48			$k\Omega$

MAX3095/MAX3096

$\pm 15kV$ ESD-Protected, 10Mbps, 3V/5V, Quad RS-422/RS-485 Receivers

DC ELECTRICAL CHARACTERISTICS—MAX3096 (continued)

(V_{CC} = 3.135V to 3.6V, T_A = T_{MIN} to T_{MAX} , unless otherwise noted. Typical values are at V_{CC} = 3.3V, T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current	I_{CC}	No load, $G = V_{CC}$ or $\bar{G} = GND$		2.4	4.0	mA
		$G = GND$ and $\bar{G} = V_{CC}$		0.001	10	μA
ESD Protection (Note 2)		Human Body Model		± 15		kV
		IEC 1000-4-2 (Air-Gap Discharge)		± 15		
		IEC 1000-4-2 (Contact Discharge)		± 8		

SWITCHING CHARACTERISTICS—MAX3096

(V_{CC} = 3.135V to 3.6V, T_A = T_{MIN} to T_{MAX} , unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input-to-Output Propagation Delay	t_{PLH}, t_{PHL}	V_{CC} = 3.135V to 3.6V, T_A = T_{MIN} to T_{MAX}	69	127		ns
		$ V_{IDL} = 3V$, Figure 2	$T_A = +85^\circ C$	88	98	112
			$T_A = +25^\circ C$	78	88	102
			$T_A = -40^\circ C$	69	79	93
		$V_{CC} = 3.135V$	$T_A = +85^\circ C$	103	113	127
			$T_A = +25^\circ C$	91	101	115
			$T_A = -40^\circ C$	82	92	106
Device-to-Device Propagation-Delay Matching		$ V_{IDL} = 3V$, Figure 2, matched conditions			24	ns
Propagation-Delay Skew ($t_{PLH} - t_{PHL}$)	t_{SK}			-2	± 10	ns
Output Enable Time to Low Level	t_{ZL}	Figure 3		600	1000	ns
Output Enable Time to High Level	t_{ZH}	Figure 3		600	1000	ns
Output Disable Time from Low Level	t_{LZ}	Figure 3		80	180	ns
Output Disable Time from High Level	t_{HZ}	Figure 3		80	180	ns
Maximum Data Rate	f_{MAX}		10			Mbps

Note 1: All currents into the device are positive; all currents out of the device are negative. All voltages are referred to device ground, unless otherwise noted.

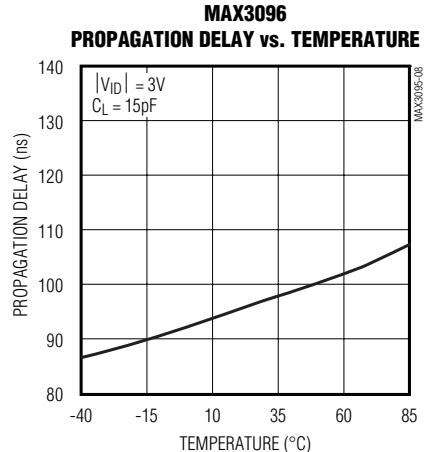
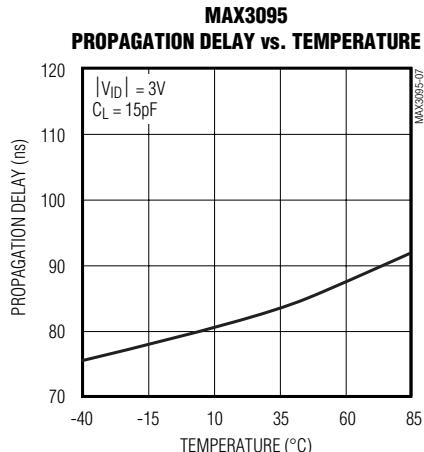
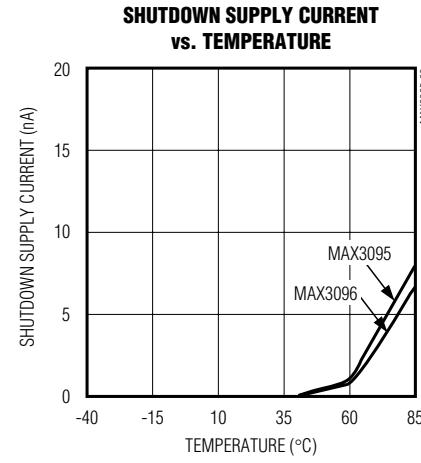
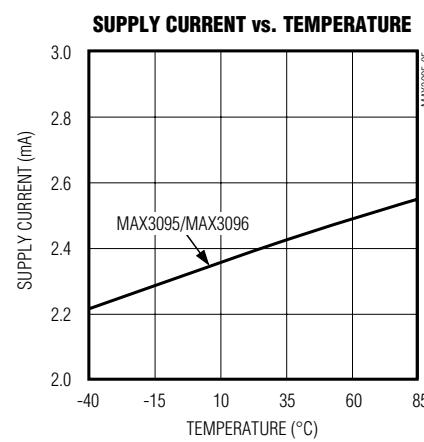
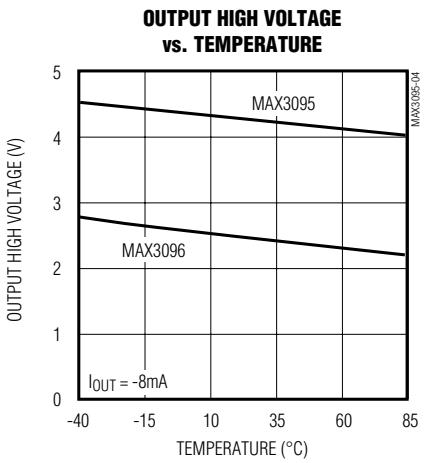
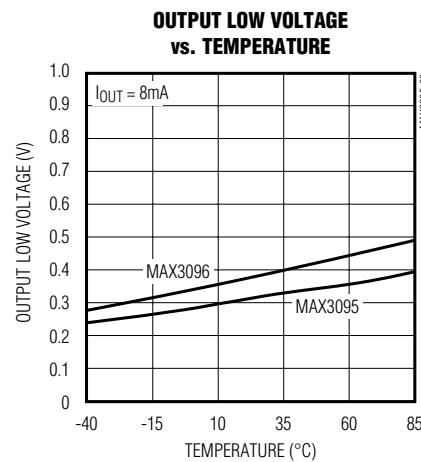
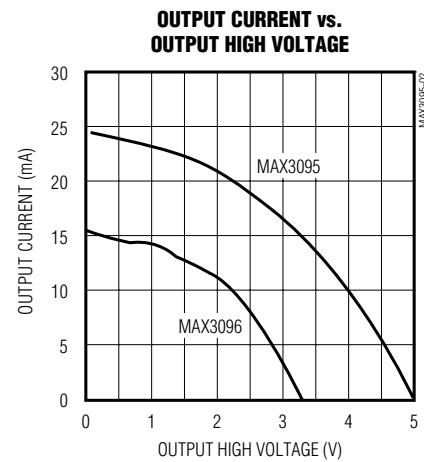
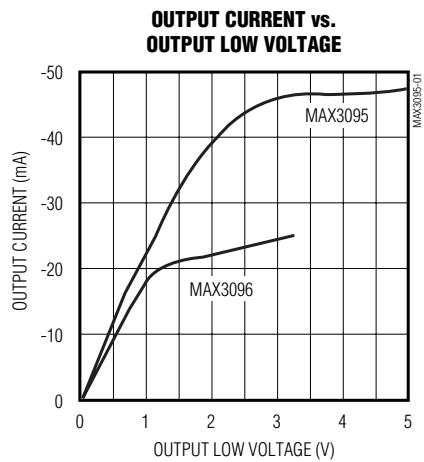
Note 2: Receiver inputs (A_—, B_—).

$\pm 15kV$ ESD-Protected, 10Mbps, 3V/5V, Quad RS-422/RS-485 Receivers

Typical Operating Characteristics

($V_{CC} = 5V$ for MAX3095, $V_{CC} = 3.3V$ for MAX3096, $T_A = +25^\circ C$, unless otherwise noted.)

MAX3095/MAX3096

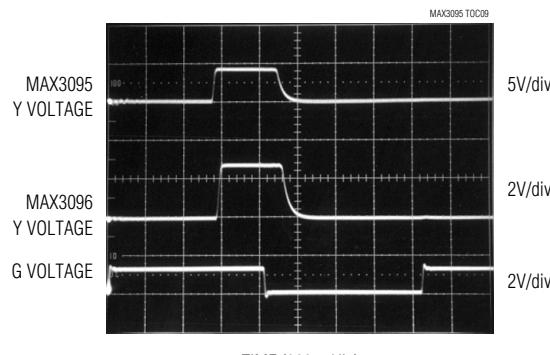


$\pm 15kV$ ESD-Protected, 10Mbps, 3V/5V, Quad RS-422/RS-485 Receivers

Typical Operating Characteristics (continued)

(V_{CC} = 5V for MAX3095, V_{CC} = 3.3V for MAX3096, T_A = +25°C, unless otherwise noted.)

SHUTDOWN TIMING



CIRCUIT OF FIGURE 3,
S1 OPEN, S2 CLOSED, S3 = 1V

Pin Description

PIN	NAME	FUNCTION
1	B1	Inverting Receiver Input
2	A1	Noninverting Receiver Input
3	Y1	Receiver Output. Enabled when G = high OR \overline{G} = low. Y1 is logic-high if V _{A1} > V _{B1} by 200mV, and low if V _{A1} < V _{B1} by 200mV. Y1 is logic-high if V _{A1} and V _{B1} remain unconnected. Otherwise, the state is undetermined. Y1 goes high impedance when the G = low and \overline{G} = high.
4	G	Active-High Receiver Output Enable. A logic-high on this input enables all receivers. When taken low and \overline{G} is high, all receivers are shut down, and the outputs go high impedance.
5	Y2	Receiver Output. Same functionality as Y1.
6	A2	Noninverting Receiver Input
7	B2	Inverting Receiver Input
8	GND	Ground
9	B3	Inverting Receiver Input
10	A3	Noninverting Receiver Input
11	Y3	Receiver Output. Same functionality as Y1.
12	\overline{G}	Active-Low Receiver Output Enable. A logic-low on this input enables all receivers. When \overline{G} = high and G = low, all receivers are shut down, and the outputs go high impedance.
13	Y4	Receiver Output. Same functionality as Y1.
14	A4	Noninverting Receiver Input
15	B4	Inverting Receiver Input
16	V _{CC}	Positive Supply

$\pm 15kV$ ESD-Protected, 10Mbps, 3V/5V, Quad RS-422/RS-485 Receivers

MAX3095/MAX3096

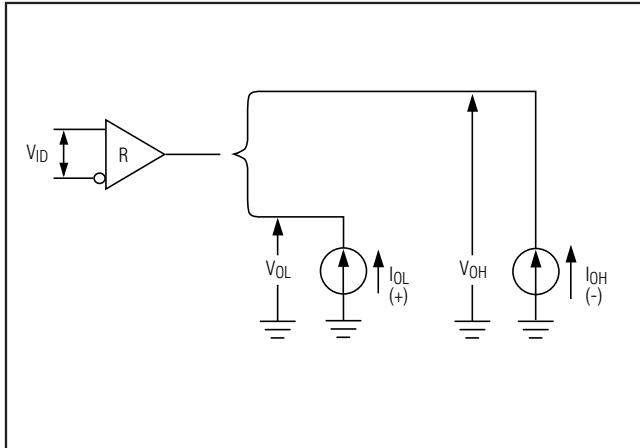


Figure 1. Receiver V_{OH} and V_{OL}

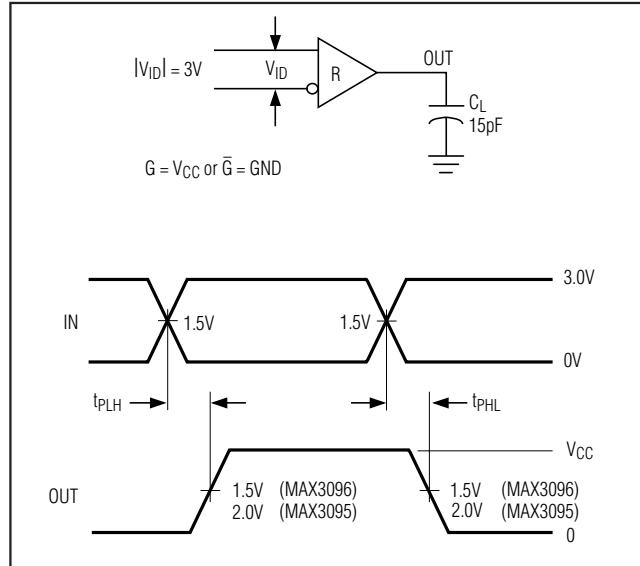


Figure 2. Receiver Propagation Delay

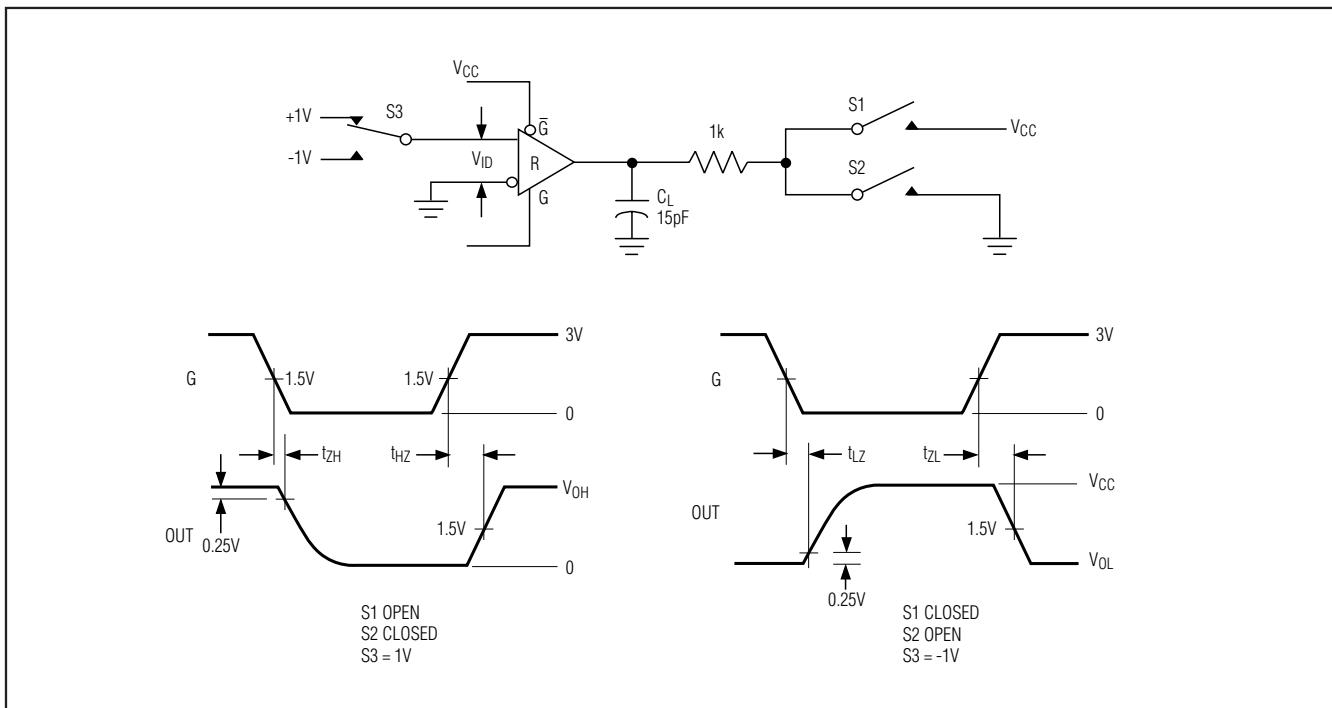


Figure 3. Receiver Enable and Disable Times

$\pm 15\text{kV}$ ESD-Protected, 10Mbps, 3V/5V, Quad RS-422/RS-485 Receivers

Detailed Description

$\pm 15\text{kV}$ ESD Protection

As with all Maxim devices, ESD-protection structures are incorporated on all pins to protect against electrostatic discharges (ESD) encountered during handling and assembly. The MAX3095/MAX3096 receiver inputs have extra protection against static electricity found in normal operation. Maxim's engineers developed state-of-the-art structures to protect these pins against $\pm 15\text{kV}$ ESD, without damage. After an ESD event, the MAX3095/MAX3096 continue working without latchup.

ESD protection can be tested in several ways. The receiver inputs are characterized for protection to the following:

- 1) $\pm 15\text{kV}$ using the Human Body Model
- 2) $\pm 8\text{kV}$ using the Contact-Discharge Method specified in IEC 1000-4-2 (formerly IEC 801-2)
- 3) $\pm 15\text{kV}$ using the Air-Gap Method specified in IEC 1000-4-2 (formerly IEC 801-2)

ESD Test Conditions

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

Human Body Model

Figure 4a shows the Human Body Model, and Figure 4b shows the current waveform it generates when discharged into a low impedance. This model consists of a 100pF capacitor charged to the ESD voltage of interest, which is then discharged into the device through a $1.5\text{k}\Omega$ resistor.

IEC 1000-4-2

Since January 1996, all equipment manufactured and/or sold in the European community has been required to meet the stringent IEC 1000-4-2 specification. The IEC 1000-4-2 standard covers ESD testing and performance of finished equipment; it does not specifically refer to integrated circuits. The MAX3095/MAX3096 help you design equipment that meets Level 4 (the highest level) of IEC 1000-4-2, without additional ESD-protection components.

The main difference between tests done using the Human Body Model and IEC 1000-4-2 is higher peak current in IEC 1000-4-2. Because series resistance is lower in the IEC 1000-4-2 ESD test model (Figure 5a), the ESD-withstand voltage measured to this standard is generally lower than that measured using the Human Body Model. Figure 5b shows the current waveform for the $\pm 8\text{kV}$ IEC 1000-4-2 Level 4 ESD Contact-Discharge test. The Air-Gap test involves approaching the device with a charge probe. The Contact-Discharge method connects the probe to the device before the probe is energized.

Machine Model

The Machine Model for ESD testing uses a 200pF storage capacitor and zero-discharge resistance. It mimics the stress caused by handling during manufacturing and assembly. Of course, all pins (not just RS-485 inputs) require this protection during manufacturing. Therefore, the Machine Model is less relevant to the I/O ports than are the Human Body Model and IEC 1000-4-2.

Low-Power Shutdown Mode

Table 1 shows the functionality of the enable inputs. The MAX3095/MAX3096 enter shutdown when G is low and \bar{G} is high. In shutdown, all outputs go high impedance and the devices typically draw less than 1nA. The devices exit shutdown by taking G high or \bar{G} low. The typical shutdown exit time is 600ns.

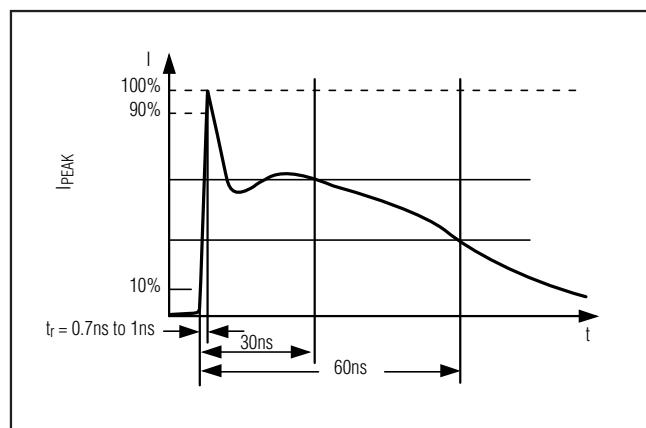
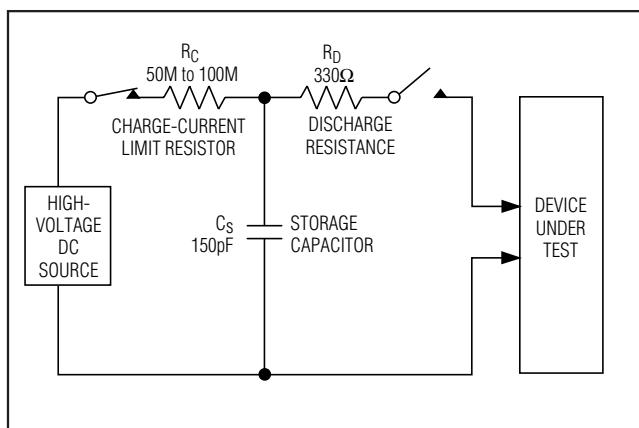
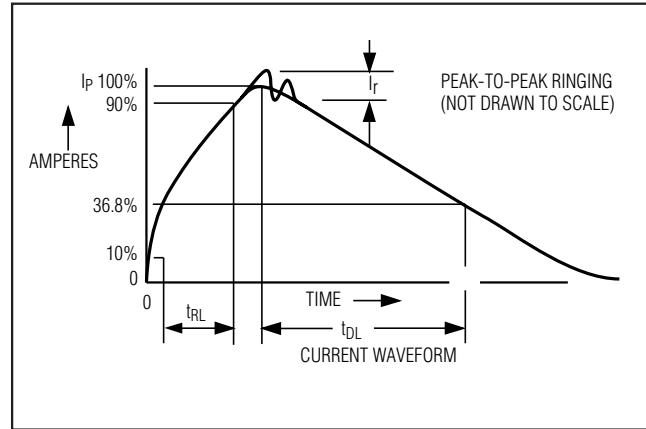
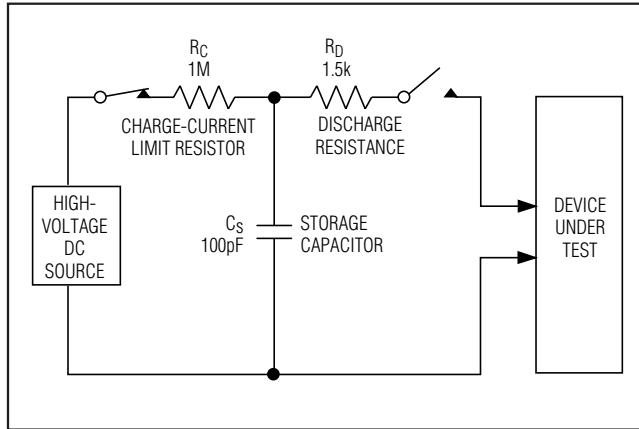
Table 1. Function Table

G	\bar{G}	(A - B)	OUTPUT Y	DEVICE MODE
1	X	$\geq 200\text{mV}$	1	On
1	X	$\leq -200\text{mV}$	0	On
1	X	Open	1	On
X	0	$\geq 200\text{mV}$	1	On
X	0	$\leq -200\text{mV}$	0	On
X	0	Open	1	On
0	1	X	High-Z	Shutdown

X = don't care, High-Z = high impedance

$\pm 15kV$ ESD-Protected, 10Mbps, 3V/5V, Quad RS-422/RS-485 Receivers

MAX3095/MAX3096



$\pm 15kV$ ESD-Protected, 10Mbps, 3V/5V, Quad RS-422/RS-485 Receivers

Applications Information

Propagation-Delay Matching

The MAX3095/MAX3096 exhibit propagation delays that are closely matched from one device to another, even between devices from different production lots. This feature allows multiple data lines to receive data and clock signals with minimal skewing with respect to each other. The MAX3095 receiver propagation delays are trimmed to a predetermined value ± 8 ns, while the MAX3096 delays are trimmed to a predetermined value ± 10 ns.

128 Receivers on the Bus

The standard RS-485 input impedance is $12k\Omega$ (one-unit load). The standard RS-485 transmitter can drive 32 unit loads. The MAX3095/MAX3096 present a 1/4-unit-load input impedance ($48k\Omega$), which allows up to 128 receivers on a bus. Any combination of these RS-485 receivers with a total of 32 unit loads can be connected to the same bus.

Fail-Safe Implementation

The MAX3095/MAX3096 receiver inputs guarantee a logic high output when the inputs are open circuit (no termination resistor used). This occurs when the transmitter is removed from the bus or when all transmitter outputs are high impedance. However, when the line is terminated and the transmitters are disabled, the differential voltage between the A and B inputs falls below the $\pm 200mV$ RS-485 sensitivity threshold. Consequently, the outputs become undefined. To maintain a fail-safe receiver output while using a terminating resistor, input A must be biased at least 200mV above input B. The resistor-divider network shown in Figure 6 is recommended.

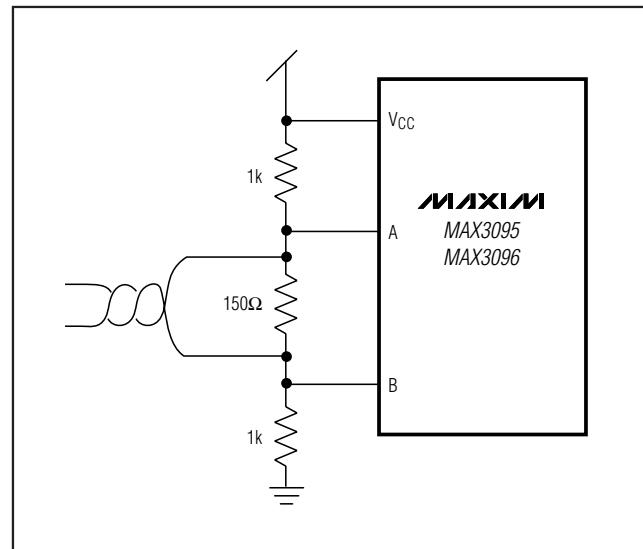


Figure 6. External Fail-Safe Implementation

Chip Information

PROCESS: BiCMOS

Package Information

For the latest package outline information and land patterns, go to www.maxim-ic.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	DOCUMENT NO.
16 QSOP	E16+5	21-0055
16 Narrow SO	S16+5	21-0041
16 PDIP	P16+1	21-0043

$\pm 15kV$ ESD-Protected, 10Mbps, 3V/5V, Quad RS-422/RS-485 Receivers

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
2	1/10	<ul style="list-style-type: none">Changed the lower specification in the V_{CC} range from 3.0V to 3.135V.Updated the MAX specifications for the “Input-to-Output Propagation Delay” in the <i>Switching Characteristics</i>—MAX3096 table.	3, 4
3	1/10	<ul style="list-style-type: none">Updated all the parts in the <i>Ordering Information</i> to be lead-free.Updated the Y1 description in the <i>Pin Description</i>.Changed the <i>Chip Information</i> section to “PROCESS: BiCMOS”.	1, 6, 10

MAX3095/MAX3096

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600 11