MAX14891E

Quad Fault-Protected RS-485/RS-422 Receiver with Fault Detection

General Description

The MAX14891E quad fault-protected RS-485/RS-422 receiver is ideal for applications requiring high data rates and reduced noise in rugged environments. Each receiver features a wide common-mode input range of -20V to +20V and is guaranteed to receive data at speeds up to 35Mbps.

All receiver inputs are fault-protected against voltage shorts in the ±40V range. Per-channel fault detection provides warning of irregular conditions, such as short circuits and open connections.

The MAX14891E is available in a 20-pin TQFN-EP (4mm x 4mm) and operates over the -40°C to +125°C temperature range.

Applications

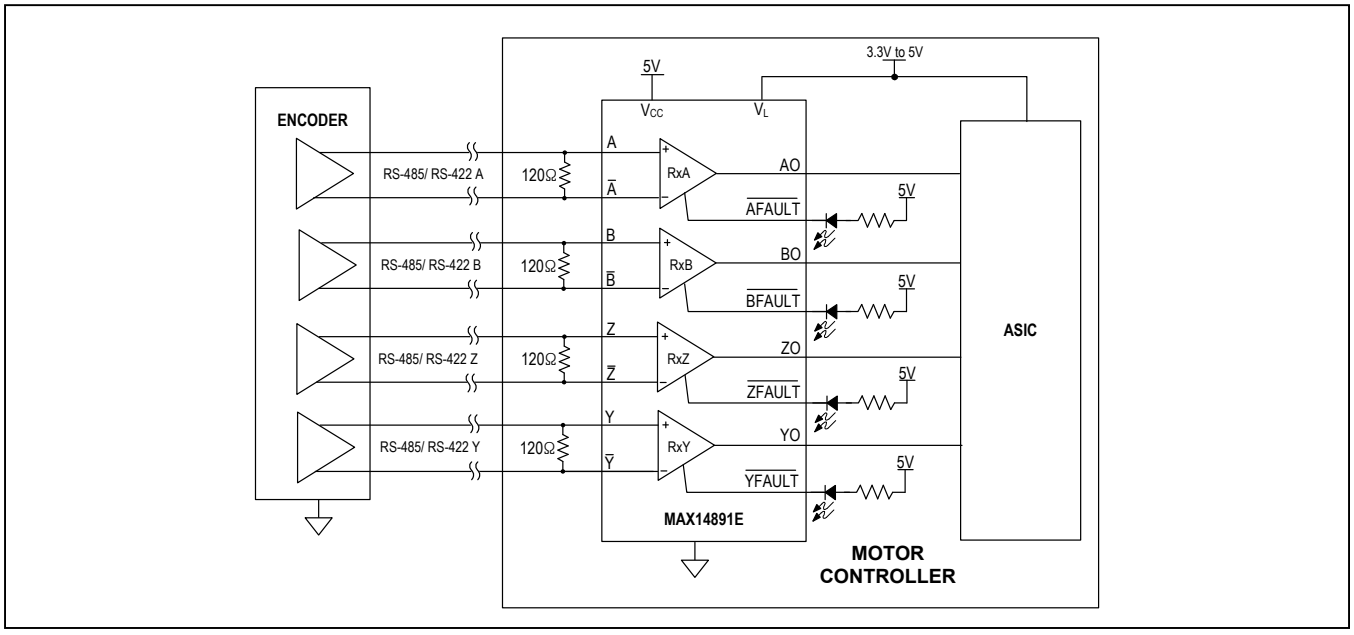
- Encoder Interfaces
- Motor Controllers
- Servo Control Commutation

Benefits and Features

- High Flexibility Simplifies Design
  - Switching Rates up to 35Mbps
  - 1.62V to 5.5V Logic Interface
- Integrated Fault Detection Reduces Downtime
  - Open-Wire and Short-Circuit Detection
  - Overvoltage and Undervoltage Fault Detection
- Integrated Protection Ensures Robust Communication
  - ±40V Fault Protection Range
  - ±20V Common Mode Range
  - ±25kV HBM ESD
  - ±7kV Air-Gap IEC 61000-4-2 ESD
  - ±10kV Contact IEC 61000-4-2 ESD
  - -40°C to +125°C Operating Temperature Range

Ordering Information **appears at end of data sheet.**

Typical Operating Circuit



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Absolute Maximum Ratings

(All voltages referenced to GND)

V_{CC} .....-0.3V to +6V
V_L .....-0.3V to (V_{CC} + 0.3V)
AO, BO, ZO, YO.....-0.3V to (V_L + 0.3V)
$\overline{AFAULT}$, $\overline{BFAULT}$, $\overline{ZFAULT}$, $\overline{YFAULT}$, ...-0.3V to +6V
A, $\overline{A}$, B, $\overline{B}$, Z, $\overline{Z}$, Y, $\overline{Y}$ .....-40V to +40V
Short-Circuit Duration (_O, $\overline{_FAULT}$ to GND) .....Continuous

Continuous Power Dissipation (T_A = +70°C)
TQFN (derate 25.6mW/°C above +70°C).....2051mW
Operating Temperature Range..... -40°C to +125°C
Junction Temperature.....+150°C
Storage Temperature Range..... -65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C
Soldering Temperature (reflow).....+260°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.

Package Thermal Characteristics (Note 1)

Junction-to-Ambient Thermal Resistance (θ_{JA}).....39°C/W

Junction-to-Case Thermal Resistance (θ_{JC}).....6°C/W

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**.

Electrical Characteristics

(V_{CC} = 5V±10%, V_L = 1.62V to V_{CC}, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at V_{CC} = 5V, V_L = 3.3V, T_A = +25°C.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
POWER SUPPLY							
Supply Voltage	V_{CC}			4.5		5.5	V
Supply Current	I_{CC}	Outputs not switching, no load			9	14	mA
Logic Supply Voltage	V_L			1.62		5.5	V
RS-485/RS-422 RECEIVERS (RxA, RxB, RxZ, RxY)							
Differential Threshold Voltage	V_{TH}	-20V ≤ V_{CM} ≤ +20V		-200		+200	mV
Differential Input Hysteresis	ΔV_{TH}	-20V ≤ V_{CM} ≤ +20V			230		mV
Single-Ended Input Current	I_{IN}	V_{CC} = 0V or 5V	V_{IN} = -10V	-270	-170		µA
			V_{IN} = +10V		+100	+160	
Low Differential Voltage Fault Threshold	V_{TH_DFP}	-20V ≤ V_{CM} ≤ +20V, positive		+270		+460	mV
	V_{TH_DFN}	-20V ≤ V_{CM} ≤ +20V, negative		-460		-270	

Electrical Characteristics (continued)

(V_{CC} = 5V±10%, V_L = 1.62V to V_{CC}, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at V_{CC} = 5V, V_L = 3.3V, T_A = +25°C.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Single-Ended Input Fault Threshold	V_{TH_SELP}	Positive	+15		+18	V
	V_{TH_SELN}	Negative	-18		-15	
LOGIC INTERFACE (AO, $\overline{\text{AFAULT}}$, BO, $\overline{\text{BFAULT}}$, ZO, $\overline{\text{ZFAULT}}$, YO, $\overline{\text{YFAULT}}$)						
Output High Voltage	V_{OH}	AO, BO, ZO, YO, I_{OUT} = -3mA	V_L - 0.4V			V
Output Low Voltage	V_{OL}	AO, BO, ZO, YO, $\overline{\text{AFAULT}}$, $\overline{\text{BFAULT}}$, $\overline{\text{ZFAULT}}$, $\overline{\text{YFAULT}}$, I_{OUT} = +3mA			0.4	V
PROTECTION						
Thermal-Shutdown Threshold	T_{SHDN}	Temperature rising		+160		°C
Thermal-Shutdown Hysteresis	T_{HYST}			10		°C
Fault-Protected Input Voltage Range (A, $\overline{\text{A}}$, B, $\overline{\text{B}}$, Z, $\overline{\text{Z}}$, Y, $\overline{\text{Y}}$)	V_{IN_F}		-40		+40	V
ESD Protection (A, $\overline{\text{A}}$, B, $\overline{\text{B}}$, Z, $\overline{\text{Z}}$, DIY, $\overline{\text{Y}}$)		IEC 61000-4-2 air-gap discharge to GND		±7		kV
		IEC 61000-4-2 contact discharge to GND		±10		
		Human Body Model		±25		
ESD Protection (All Other Pins)		Human Body Model		±2		kV

Switching Characteristics

(V_{CC} = 5V±10%, V_L = 1.62V to V_{CC}, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at V_{CC} = 5V, V_L = 3.3V, T_A = +25°C.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
RECEIVER (RxA, RxB, RxZ, RxY) (Note 4)						
Maximum Data Rate	DR_{MAX}		35			Mbps
Receiver Propagation Delay	t_{DPLH}	C_L = 15pF, V_{ID} = ±3V, Figure 1, Figure 2			25	ns
	t_{DPHL}				25	ns
Receiver Propagation Delay Skew $\lvert t_{DPLH} - t_{DPHL} \rvert$	t_{HLSKEW}	C_L = 15pF, V_{ID} = ±3V, Figure 1, Figure 2	0		5	ns
Receiver Channel-to-Channel Skew	t_{CSKEW}	C_L = 15pF, V_{ID} = ±3V, Figure 1, Figure 2	0		8	ns
FAULT DETECTION ($\overline{AFAULT}$, $\overline{BFAULT}$, $\overline{ZFAULT}$) (Note 4)						
Differential Fault Propagation Delay to $\overline{_FAULT}$ Output Active	t_{DFLH}	R_{FAULT} = 5kΩ, C_{FAULT} = 15pF, Figure 1, Figure 3			18	µs
					6	
Differential Slew Rate to Avoid Fault Alarm Output		R_{FAULT} = 5kΩ, C_{FAULT} = 15pF, Figure 1, Figure 3	1			V/µs
Single-Ended Propagation Delay to $\overline{_FAULT}$ Output Active	t_{SEFLH}	R_{FAULT} = 5kΩ, C_{FAULT} = 15pF		970		µs
	t_{SEFHL}			970		

Note 2: All devices 100% production tested at T_A = 25°C. Specifications over temperature are guaranteed by design.

Note 3: Currents into the device are positive; all currents out of the device are negative. All voltages are referenced to ground, unless otherwise noted.

Note 4: Capacitive load includes test prove and fixture capacitance.

Test Circuits and Waveforms

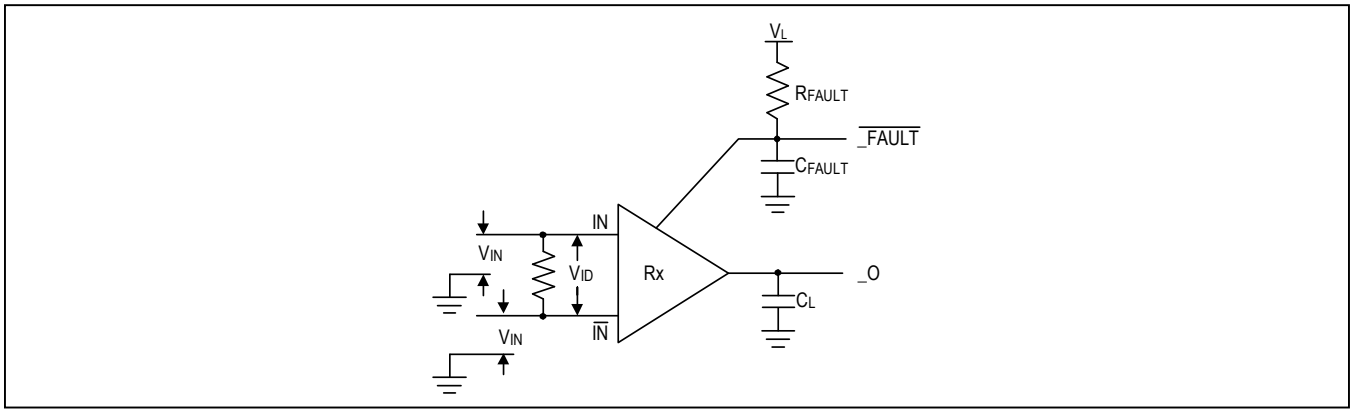


Figure 1. Receiver Test Circuit

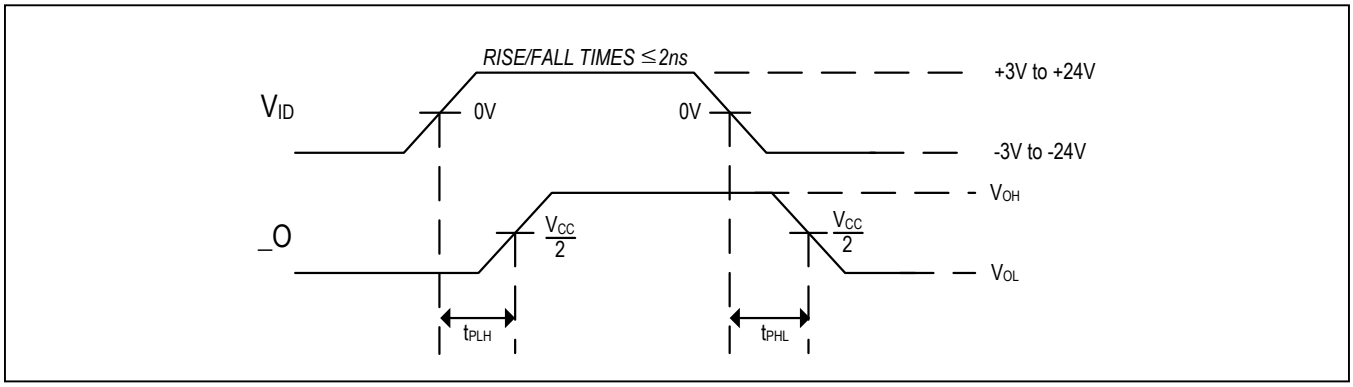


Figure 2. Receiver Propagation Delay

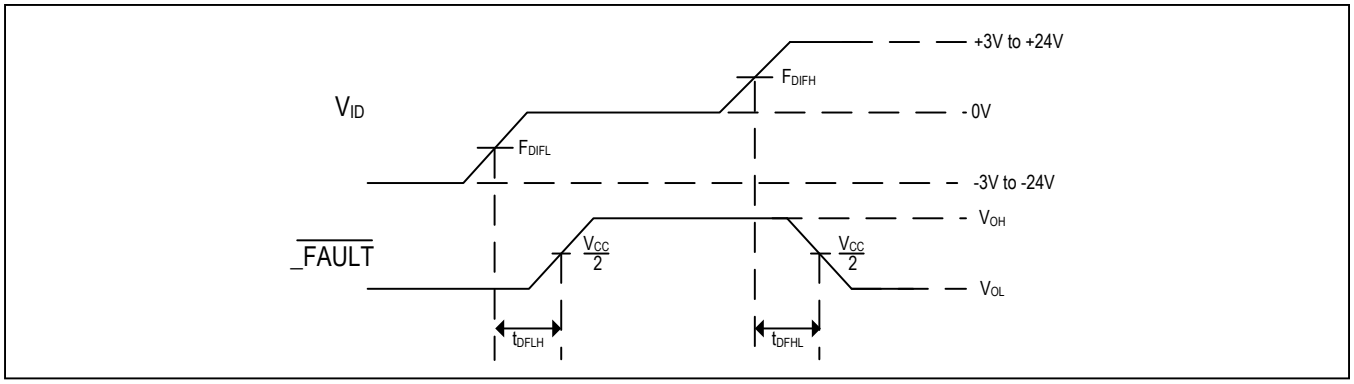
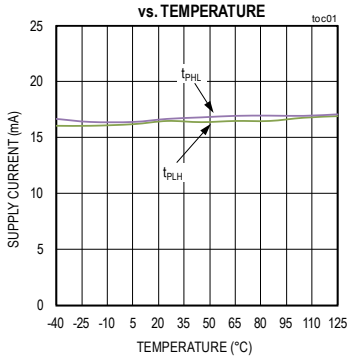


Figure 3. Fault Detection Timing

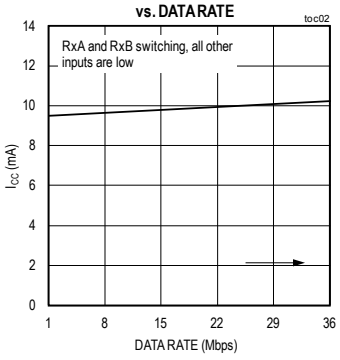
Typical Operating Characteristics

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

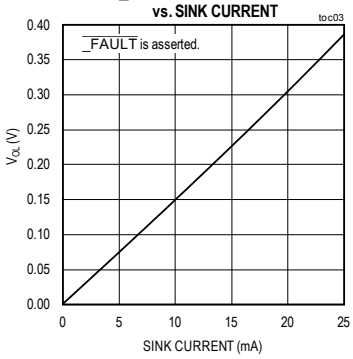
PROPAGATION DELAY
vs. TEMPERATURE



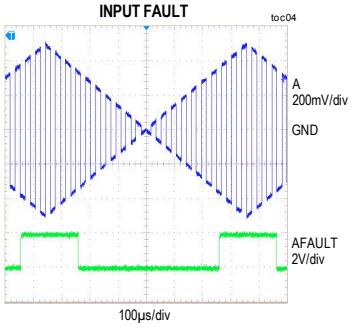
SUPPLY CURRENT
vs. DATA RATE



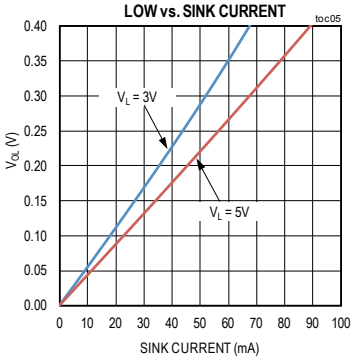
_FAULT OUTPUT VOLTAGE
vs. SINK CURRENT



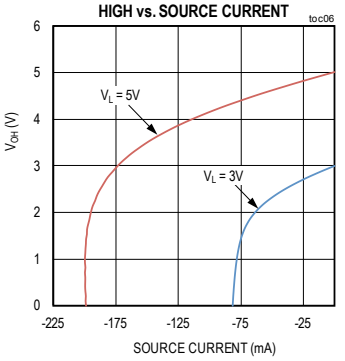
LOW DIFFERENTIAL
INPUT FAULT



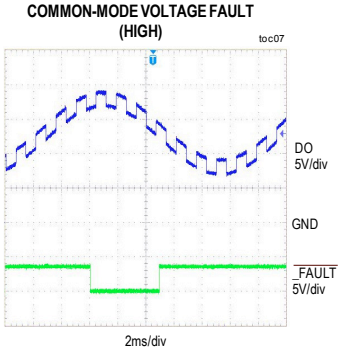
RECEIVER OUTPUT VOLTAGE
LOW vs. SINK CURRENT



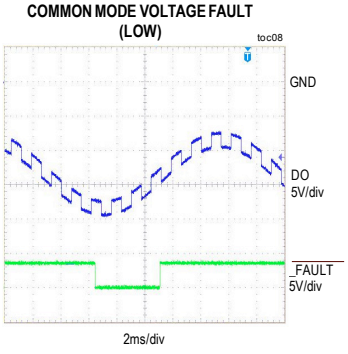
RECEIVER OUTPUT VOLTAGE
HIGH vs. SOURCE CURRENT



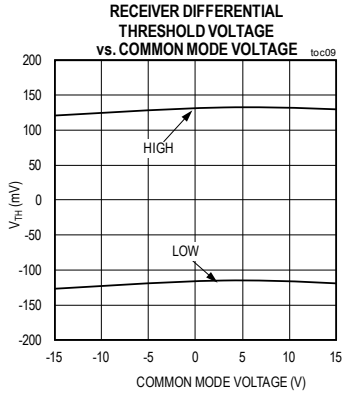
COMMON-MODE VOLTAGE FAULT
(HIGH)



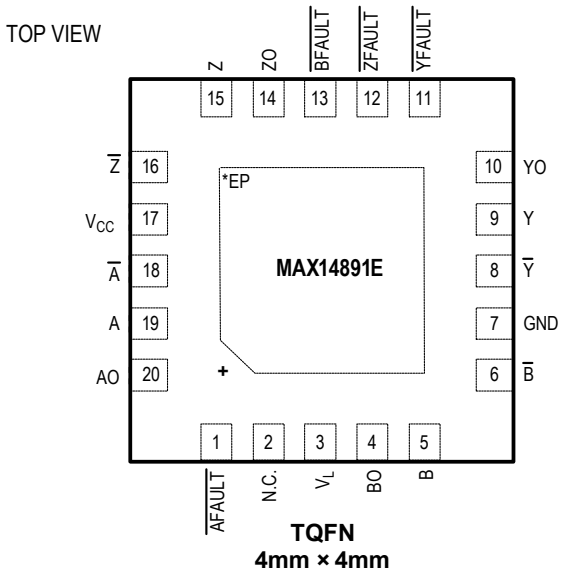
COMMON MODE VOLTAGE FAULT
(LOW)



RECEIVER DIFFERENTIAL
THRESHOLD VOLTAGE
vs. COMMON MODE VOLTAGE



Pin Configuration



** EXPOSED PAD. CONNECT TO GND*

Pin Description

PIN	NAME	FUNCTION
1	$\overline{\text{AFAULT}}$	Open-Drain Fault Output for Receiver A. $\overline{\text{AFAULT}}$ asserts low during a fault condition on Receiver A (RxA). See the *FAULT CONDITION* section for more information.
2	N.C.	No Connection. Not internally connected.
3	V_L	Logic Interface Supply Input. V_{CC} must always be greater than or equal to V_L.
4	BO	Receiver B Output
5	B	Non-Inverting Input for Receiver B
6	$\overline{\text{B}}$	Inverting Input for Receiver B
7	GND	Ground

Pin Description (continued)

PIN	NAME	FUNCTION
8	$\overline{Y}$	Inverting Input for Receiver Y
9	Y	Non-Inverting Input for Receiver Y
10	YO	Receiver Y Output
11	$\overline{YFAULT}$	Open-Drain Fault Output for Receiver Y. $\overline{YFAULT}$ asserts low during a fault condition on receiver Y. See the *FAULT CONDITION* section for more information.
12	$\overline{ZFAULT}$	Open-Drain Fault Output for Receiver Z. $\overline{ZFAULT}$ asserts low during a fault condition on receiver Z. See the *FAULT CONDITION* section for more information.
13	$\overline{BFAULT}$	Open-Drain Fault Output for Receiver B. $\overline{BFAULT}$ asserts low during a fault condition on receiver B. See the *FAULT CONDITION* section for more information.
14	ZO	Receiver Z Output
15	Z	Non-Inverting Input for Receiver Z
16	$\overline{Z}$	Inverting Input for Receiver Z
17	V_{CC}	Supply Input. Bypass V_{CC} to ground through a 0.1µF capacitor as close as possible to the device. V_{CC} must always be greater than or equal to V_L.
18	$\overline{A}$	Inverting Input for Receiver A
19	A	Non-Inverting Input for Receiver A
20	AO	Receiver A Output
–	EP	Exposed Pad. Connect EP to ground. Not intended as the primary ground connection.

Truth Tables

Receiver Fault Logic (RxA, RxB, RxZ, RxY)

DIFFERENTIAL INPUT VOLTAGE	SINGLE-ENDED INPUT VOLTAGE (A, $\overline{A}$, B, $\overline{B}$, Z, $\overline{Z}$, Y, $\overline{Y}$)	OUTPUT STATE (AO, BO, ZO, YO)	$\overline{_FAULT}$	FAULT CONDITION
V_{ID} > +0.45V	-20V ≤ V_{SE} ≤ +20V	H	H	No Fault
+0.27V < V_{ID} < +0.45V		H	Indeterminate	Indeterminate
-0.2V ≤ V_{ID} ≤ +0.2V		Indeterminate	L	Low Differential Input Voltage Fault
-0.45V ≤ V_{ID} ≤ -0.27V		L	Indeterminate	Indeterminate
V_{ID} ≤ -0.45V		L	H	No Fault
X	-40V < V_{SE} < -18.5V	VALID*	L	Single-Ended Voltage Fault
X	-18.5V < V_{SE} < -14.5V	VALID*	Indeterminate	Single-Ended Indeterminate Voltage
X	+14.5V < V_{SE} < +18.5V	VALID*	Indeterminate	Single-Ended Indeterminate Voltage
X	+18.5V < V_{SE} < +40V	VALID*	L	Single-Ended Voltage Fault

X = Don't care

**Receiver operates normally, although thresholds may deviate from limits in the Electrical Characteristics table.*

Detailed Description

The MAX14891E quad fault-protected RS-485/RS-422 receiver is ideal for applications requiring high data rates and reduced noise in rugged environments. Each receiver features a wide common-mode input range of -20V to +20V and is guaranteed to receive data at speeds up to 35Mbps

All receiver inputs are fault-protected against voltage shorts in the ±40V range. Per-channel fault-detection provides warning of irregular conditions such as short circuits and open connections.

Detecting Faults

Signal integrity is essential for reliable system operation. Degraded signals could cause problems ranging from simple errors to loss of data. The MAX14891E detects common RS-4845/RS-422 faults. These faults include low differential input signals, open-wire, short-circuits, and input voltages that are outside normal operating voltage ranges (below -18V and above +18V). See the *Truth Tables* for more information.

Detecting Small Differential Signals

Each receiver on the MAX14891E is capable of detecting small DC and AC signals. Small DC signals can occur due to open wires or shorts, both of which are explained in the *Detecting Short-Circuit and Open-Circuit Faults* sections. Small differential AC signals can result from either cable attenuation of long or inadequate cables, or due to poor wiring. The fault comparators are high speed and will detect low AC signal amplitudes up to 35Mbps

Detecting Short-Circuit and Open-Circuit Faults

The MAX14891E receivers detect short circuits on the inputs. When the A and $\overline{A}$ inputs are shorted together, the differential input voltage is 0V, generating a small-signal input voltage fault (Figure 4).

Open-circuit detection is similar to detecting a short-circuit condition and relies on the differential termination resistor across the receiver inputs. When an input is open, the termination resistor pulls the non-inverting and inverting inputs to the same voltage, generating a fault condition.

The $\overline{\text{FAULT}}$ output asserts when either a short-circuit or open-circuit condition is detected.

Thermal Shutdown

The MAX14891E enters thermal shutdown when the chip temperature rises to above 160°C (typ). Receiver outputs are undefined and the $\overline{\text{FAULT}}$ outputs are off when the device is in thermal shutdown.

Applications Information

Cable Termination

Transmission line termination is required for RS-485/RS-422 high-speed signals on long cables. 120Ω termination resistors are commonly used to match the characteristic impedance of the cable.

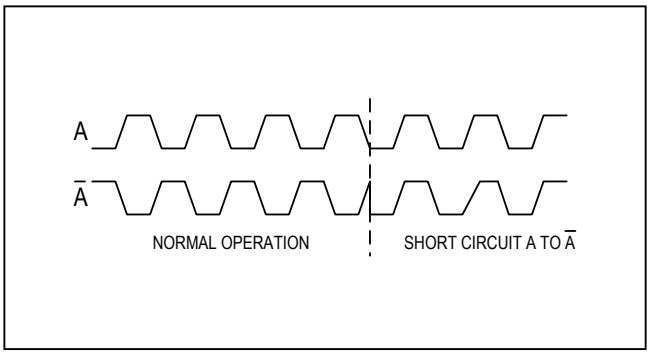
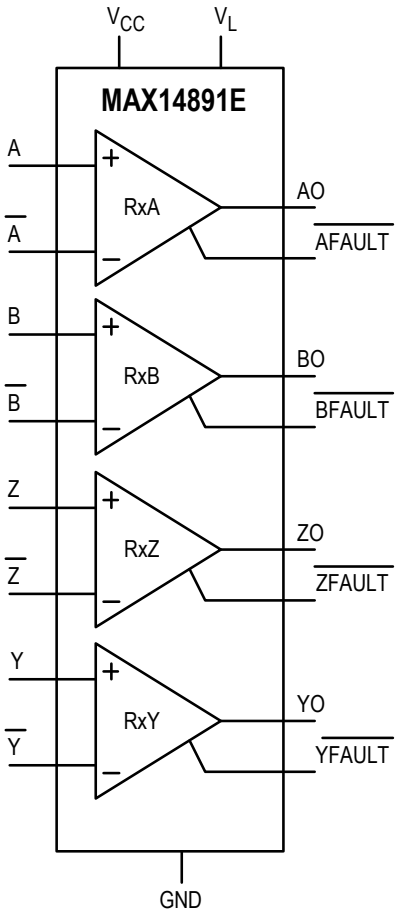


Figure 4. Short-Circuit Detection

Functional Diagram



Ordering Information

PART	TEMP RANGE	PIN PACKAGE
MAX14891EATP+	-40°C to +125°C	20 TQFN-EP
MAX14891EATP+T	-40°C to +125°C	20 TQFN-EP

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

T = Tape and reel.

**EP = Exposed pad.*

Chip Information

PROCESS: BiCMOS

Package Information

For the latest package outline information and land patterns (footprints), go to **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.
20 TQFN-EP	T2044-3C	21-0139	90-0037

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	12/14	Initial release	—
1	3/15	Added MAX14891EATP+ part number and tightened Electrical Characteristics limits.	1-4, 11

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.

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