

## Absolute Maximum Ratings

|                                                            |                 |
|------------------------------------------------------------|-----------------|
| $V_{CC}$ to GND .....                                      | -0.3V to +6V    |
| TXD, RS, SHDN to GND.....                                  | -0.3V to +6V    |
| RXD to GND.....                                            | -0.3V to +6V    |
| CANH, CANL to GND.....                                     | -7.5V to +12.5V |
| Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ ) |                 |
| 8-Pin SO (derate 5.9mW/°C above +70°C).....                | 470mW           |
| 8-Pin SOT23 (derate 5.1mW/°C above +70°C) .....            | 408.2mW         |

|                                        |                 |
|----------------------------------------|-----------------|
| Operating Temperature Range.....       | -40°C to +85°C  |
| Maximum 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.

## Electrical Characteristics

( $V_{CC} = +3.3\text{V} \pm 5\%$ ,  $R_L = 60\Omega$ ,  $C_L = 100\text{pF}$ ,  $T_A = T_{\text{MIN}}$  to  $T_{\text{MAX}}$ , unless otherwise noted. Typical values are at  $V_{CC} = +3.3\text{V}$  and  $T_A = +25^\circ\text{C}$ .) (Note 1)

| PARAMETER                     | SYMBOL                                | CONDITIONS                                                                   | MIN  | TYP                    | MAX  | UNITS            |
|-------------------------------|---------------------------------------|------------------------------------------------------------------------------|------|------------------------|------|------------------|
| Supply Voltage                | $V_{CC}$                              |                                                                              | 3.14 |                        | 3.47 | V                |
| Supply Current                | $I_S$                                 | Dominant                                                                     |      | 35                     | 70   | mA               |
|                               |                                       | Recessive                                                                    |      | 2                      | 5    |                  |
|                               |                                       | Standby                                                                      |      | 8                      | 15   | $\mu\text{A}$    |
| Shutdown Current              | $I_{\text{SHDN}}$                     | $V_{\text{SHDN}} = V_{CC}$ , TXD = $V_{CC}$ or unconnected                   |      |                        | 1    | $\mu\text{A}$    |
| Thermal-Shutdown Threshold    | $V_{\text{TSH}}$                      |                                                                              |      | +160                   |      | $^\circ\text{C}$ |
| Thermal-Shutdown Hysteresis   |                                       |                                                                              |      | 25                     |      | $^\circ\text{C}$ |
| <b>TXD INPUT LEVELS</b>       |                                       |                                                                              |      |                        |      |                  |
| High-Level Input Voltage      | $V_{\text{IH}}$                       |                                                                              | 2    | $V_{CC} + 0.3\text{V}$ |      | V                |
| Low-Level Input Voltage       | $V_{\text{IL}}$                       |                                                                              |      | 0.8                    |      | V                |
| Input Capacitance             | $C_{\text{IN}}$                       |                                                                              |      | 5                      |      | pF               |
| Pullup Resistor               | $R_{\text{INTXD}}$                    |                                                                              | 50   |                        | 100  | k $\Omega$       |
| <b>CANH, CANL TRANSMITTER</b> |                                       |                                                                              |      |                        |      |                  |
| Recessive Bus Voltage         | $V_{\text{CANH}}, V_{\text{CANL}}$    | $V_{\text{TXD}} = V_{CC}$ , no load                                          | 2    | 2.3                    | 3    | V                |
|                               |                                       | $V_{\text{TXD}} = V_{CC}$ , no load, $V_{\text{RS}} = V_{CC}$ (standby mode) | -100 |                        | +100 | mV               |
| Off-State Output Leakage      |                                       | $-2\text{V} < V_{\text{CANH}}, V_{\text{CANL}} < +7\text{V}$ , SHDN = HIGH   | -250 |                        | +250 | $\mu\text{A}$    |
| Input Leakage Current         |                                       | $V_{CC} = 0\text{V}$ , $V_{\text{CANH}} = V_{\text{CANL}} = 5\text{V}$       | -250 |                        | +250 | $\mu\text{A}$    |
| CANH Output Voltage           | $V_{\text{CANH}}$                     | $V_{\text{TXD}} = 0\text{V}$                                                 | 2.45 |                        |      | V                |
| CANL Output Voltage           | $V_{\text{CANL}}$                     | $V_{\text{TXD}} = 0\text{V}$                                                 |      |                        | 1.25 | V                |
| Differential Output           | $(V_{\text{CANH}} - V_{\text{CANL}})$ | $V_{\text{TXD}} = 0\text{V}$                                                 | 1.5  |                        | 3.0  | V                |
|                               |                                       | $V_{\text{TXD}} = 0\text{V}$ , $R_L = 45\Omega$                              | 1.2  |                        | 3.0  |                  |
|                               |                                       | $V_{\text{TXD}} = V_{CC}$ , no load                                          | -500 |                        | +50  | mV               |
|                               |                                       | $V_{\text{TXD}} = V_{CC}$ , $R_L = 60\Omega$                                 | -120 |                        | +12  |                  |

**Electrical Characteristics (continued)**

( $V_{CC} = +3.3V \pm 5\%$ ,  $R_L = 60\Omega$ ,  $C_L = 100pF$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = +3.3V$  and  $T_A = +25^\circ C$ .) (Note 1)

| PARAMETER                                                                                                                                                                            | SYMBOL           | CONDITIONS                           | MIN                  | TYP                 | MAX      | UNITS      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|--------------------------------------|----------------------|---------------------|----------|------------|
| CANH Short-Circuit Current                                                                                                                                                           | $I_{CANHSC}$     | $-7V \leq V_{CANH} \leq 0V$          | -200                 |                     |          | mA         |
|                                                                                                                                                                                      |                  | Minimum foldback current             |                      |                     | -35      |            |
| CANL Short-Circuit Current                                                                                                                                                           | $I_{CANLSC}$     | $V_{CC} \leq V_{CANL} \leq 12V$      |                      |                     | 200      | mA         |
| <b>RXD OUTPUT LEVELS</b>                                                                                                                                                             |                  |                                      |                      |                     |          |            |
| RXD High Output-Voltage Level                                                                                                                                                        | $V_{OH}$         | $I = -1mA$                           | $0.8 \times V_{CC}$  |                     | $V_{CC}$ | V          |
| RXD Low Output-Voltage Level                                                                                                                                                         | $V_{OL}$         | $I = 4mA$                            |                      |                     | 0.4      | V          |
| <b>DC BUS RECEIVER (<math>V_{TXD} = V_{CC}</math>; CANH and CANL externally driven; <math>-7V \leq V_{CANH}</math>, <math>V_{CANL} \leq +12V</math>, unless otherwise specified)</b> |                  |                                      |                      |                     |          |            |
| Differential Input Voltage (Recessive)                                                                                                                                               | $V_{DIFF}$       | $-7V \leq V_{CM} \leq +12V$          | 0.5                  |                     |          | V          |
|                                                                                                                                                                                      |                  | $V_{RS} = V_{CC}$ (standby mode)     | 0.5                  |                     |          |            |
| Differential Input Voltage (Dominant)                                                                                                                                                | $V_{DIFF}$       | Dominant                             |                      |                     | 0.9      | V          |
|                                                                                                                                                                                      |                  | $V_{RS} = V_{CC}$ (standby mode)     |                      |                     | 1.1      |            |
| Differential Input Hysteresis                                                                                                                                                        | $V_{DIFF(HYST)}$ |                                      |                      | 20                  |          | mV         |
| CANH and CANL Input Resistance                                                                                                                                                       | $R_I$            |                                      | 20                   |                     | 50       | k $\Omega$ |
| Differential Input Resistance                                                                                                                                                        | $R_{DIFF}$       |                                      | 40                   |                     | 100      | k $\Omega$ |
| <b>MODE SELECTION (RS)</b>                                                                                                                                                           |                  |                                      |                      |                     |          |            |
| Input Voltage for High Speed                                                                                                                                                         | $V_{SLP}$        |                                      |                      | $0.3 \times V_{CC}$ |          | V          |
| Input Voltage for Standby                                                                                                                                                            | $V_{STBY}$       |                                      | $0.75 \times V_{CC}$ |                     |          | V          |
| Slope-Control Mode Voltage                                                                                                                                                           | $V_{SLOPE}$      | $R_{RS} = 25k\Omega$ to $200k\Omega$ | $0.4 \times V_{CC}$  | $0.6 \times V_{CC}$ |          | V          |
| High-Speed Mode Current                                                                                                                                                              | $I_{HS}$         | $V_{RS} = 0V$                        |                      |                     | -500     | $\mu A$    |
| <b>SHUTDOWN (SHDN)</b>                                                                                                                                                               |                  |                                      |                      |                     |          |            |
| SHDN Input Voltage High                                                                                                                                                              | $V_{SHDNH}$      |                                      | 2                    |                     |          | V          |
| SHDN Input Voltage Low                                                                                                                                                               | $V_{SHDNL}$      |                                      |                      |                     | 0.8      | V          |
| SHDN Pulldown Resistor                                                                                                                                                               | $R_{INSHDN}$     |                                      | 50                   |                     | 100      | k $\Omega$ |

## Timing Characteristics

( $V_{CC} = +3.3V \pm 5\%$ ,  $R_L = 60\Omega$ ,  $C_L = 100pF$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = +3.3V$  and  $T_A = +25^\circ C$ .)

| PARAMETER                                    | SYMBOL        | CONDITIONS                                       | MIN | TYP      | MAX | UNITS      |
|----------------------------------------------|---------------|--------------------------------------------------|-----|----------|-----|------------|
| Delay TXD to Bus Active<br>(Figure 1)        | $t_{ONTXD}$   | $V_{RS} = 0V (\leq 1Mbps)$                       |     |          | 50  | ns         |
|                                              |               | $R_{RS} = 25k\Omega (\leq 500kbps)$              |     | 183      |     |            |
|                                              |               | $R_{RS} = 100k\Omega (\leq 125kbps)$             |     | 770      |     |            |
| Delay TXD to Bus Inactive<br>(Figure 1)      | $t_{OFFTXD}$  | $V_{RS} = 0V (\leq 1Mbps)$                       |     |          | 70  | ns         |
|                                              |               | $R_{RS} = 25k\Omega (\leq 500kbps)$              |     | 226      |     |            |
|                                              |               | $R_{RS} = 100k\Omega (\leq 125kbps)$             |     | 834      |     |            |
| Delay Bus to Receiver Active<br>(Figure 1)   | $t_{ONRXD}$   | $V_{RS} = 0V (\leq 1Mbps)$                       |     |          | 80  | ns         |
|                                              |               | $R_{RS} = 25k\Omega (\leq 500kbps)$              |     | 200      |     |            |
|                                              |               | $R_{RS} = 100k\Omega (\leq 125kbps)$             |     | 730      |     |            |
| Delay Bus to Receiver Inactive<br>(Figure 1) | $t_{OFFRXD}$  | $V_{RS} = 0V (\leq 1Mbps)$                       |     |          | 100 | ns         |
|                                              |               | $R_{RS} = 25k\Omega (\leq 500kbps)$              |     | 245      |     |            |
|                                              |               | $R_{RS} = 100k\Omega (\leq 125kbps)$             |     | 800      |     |            |
| Differential-Output Slew Rate                | SR            | $V_{RS} = 0V (\leq 1Mbps)$                       |     | 96       |     | V/ $\mu s$ |
|                                              |               | $R_{RS} = 25k\Omega (\leq 500kbps)$              |     | 12.5     |     |            |
|                                              |               | $R_{RS} = 100k\Omega (\leq 125kbps)$             |     | 2.9      |     |            |
|                                              |               | $R_{RS} = 200k\Omega (\leq 62.5kbps)$            |     | 1.6      |     |            |
| Bus Dominant to RXD Active                   | $t_{DRXDL}$   | $V_{RS} > 0.8 \times V_{CC}$ , standby, Figure 2 |     |          | 1   | $\mu s$    |
| Standby to Receiver Active                   | $t_{SBRXDL}$  | BUS dominant, Figure 2                           |     |          | 4   | $\mu s$    |
| SHDN to Bus Inactive                         | $t_{OFFSHDN}$ | TXD = GND, Figure 3 (Note 2)                     |     |          | 1   | $\mu s$    |
| SHDN to Receiver Active                      | $t_{ONSHDN}$  | BUS dominant, Figure 3 (Note 3)                  |     |          | 4   | $\mu s$    |
| SHDN to Standby                              | $t_{SHDNSB}$  | Figure 4                                         | 20  |          |     | $\mu s$    |
| ESD Protection                               |               | Human Body Model                                 |     | $\pm 12$ |     | kV         |

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

**Note 2:** No other devices on the BUS.

**Note 3:** BUS externally driven.

Timing Diagrams

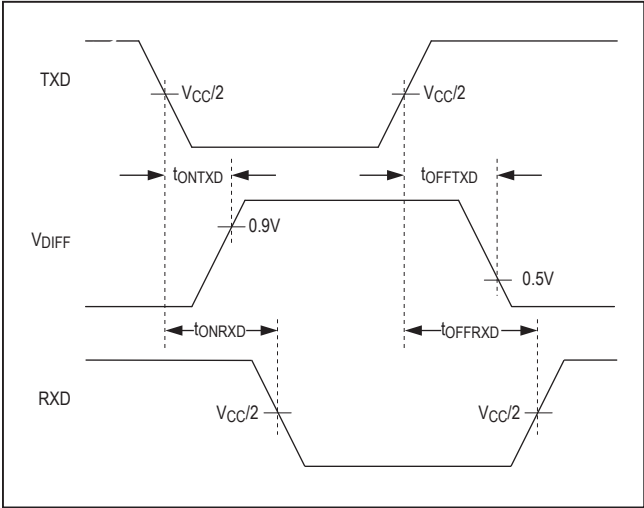


Figure 1. Timing Diagram

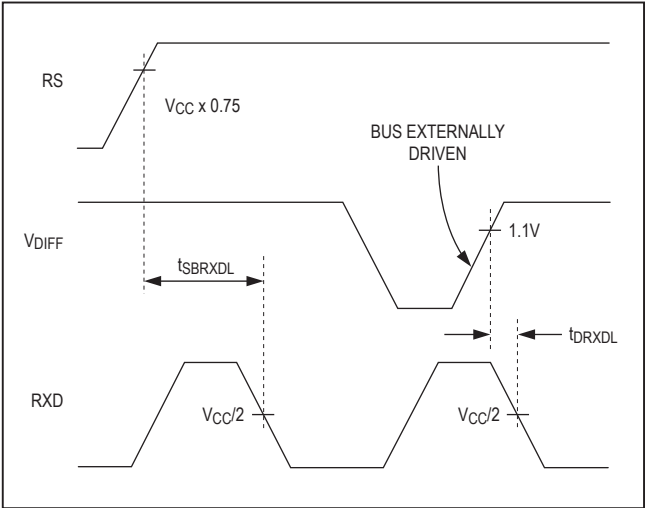


Figure 2. Timing Diagram for Standby Signal

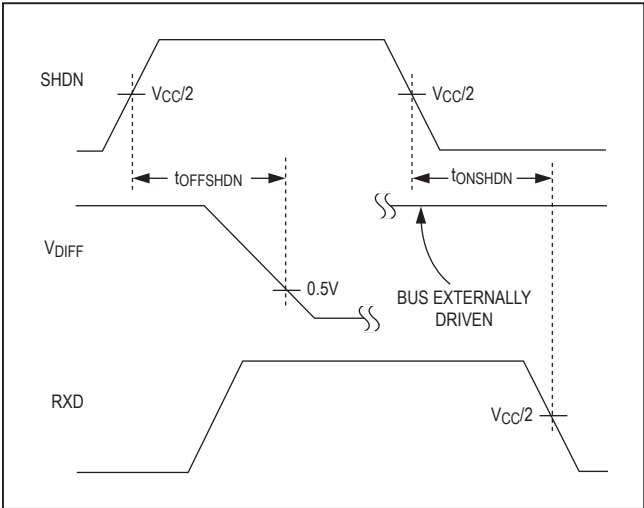


Figure 3. Timing Diagram for Shutdown Signal

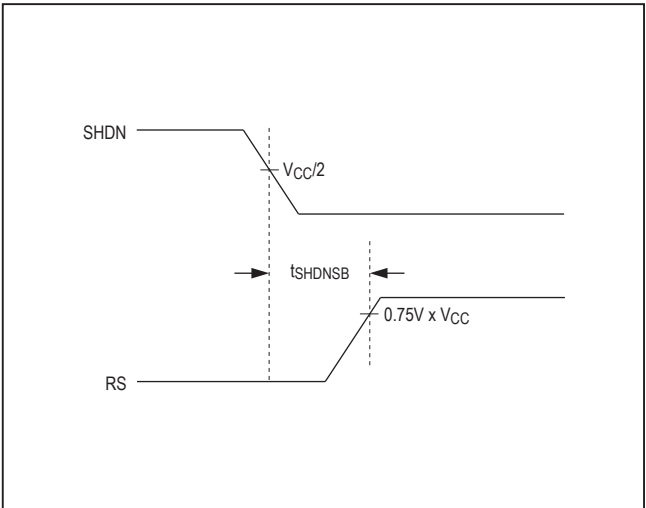
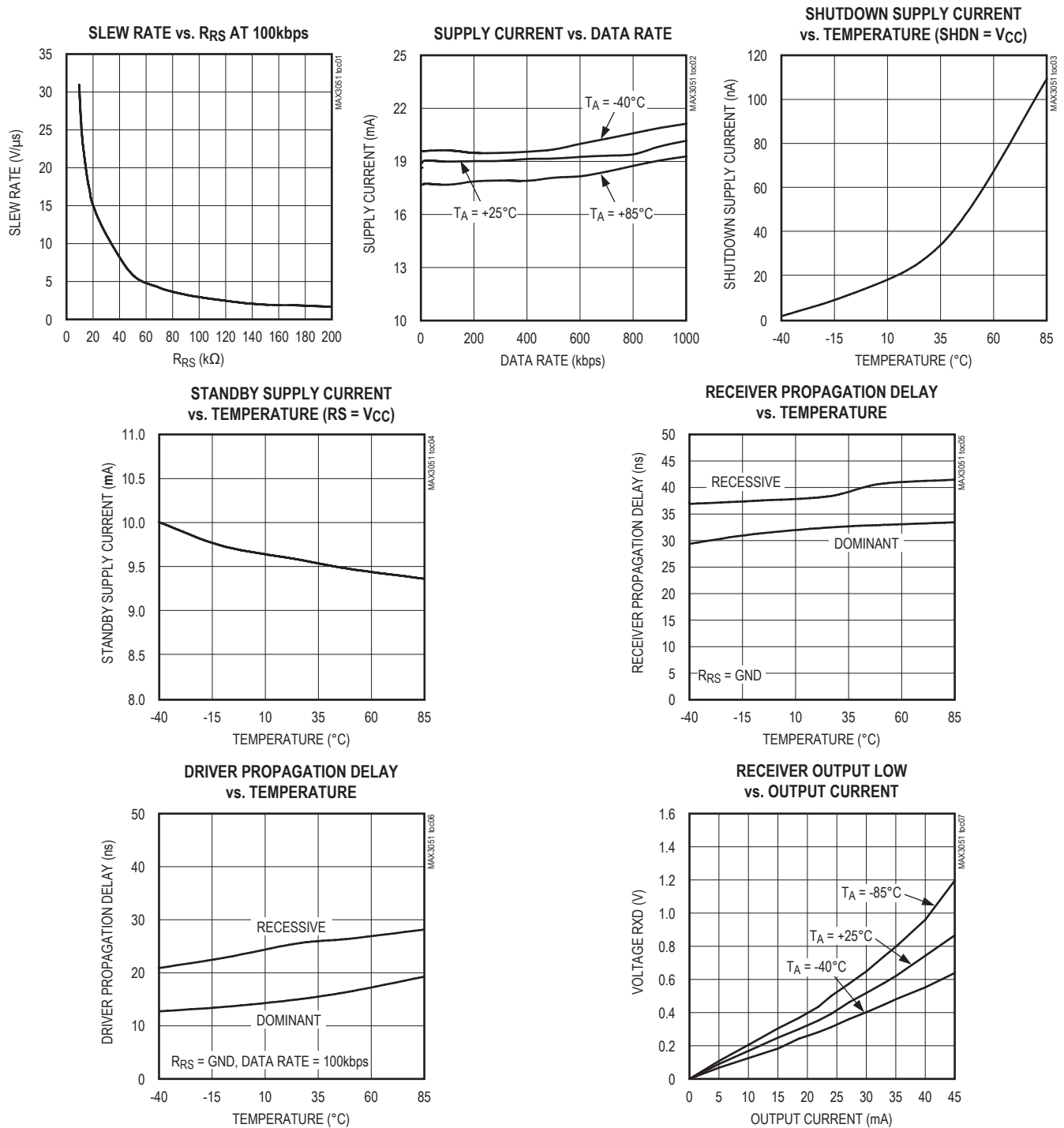


Figure 4. Timing Diagram for Shutdown-to-Standby Signal

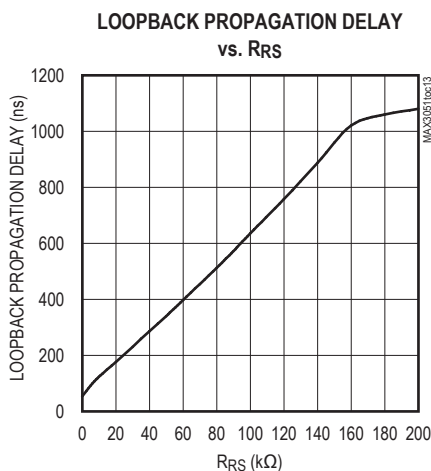
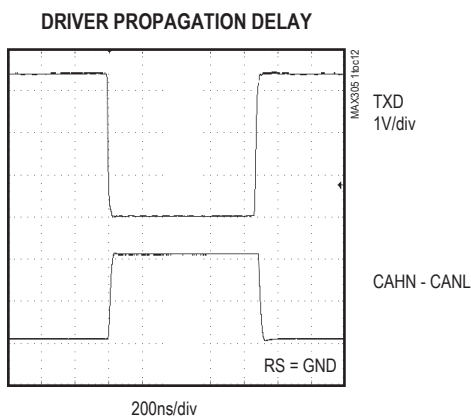
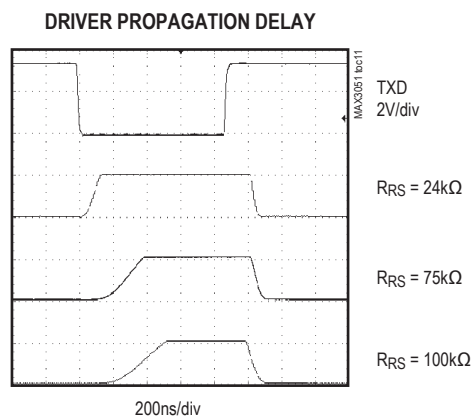
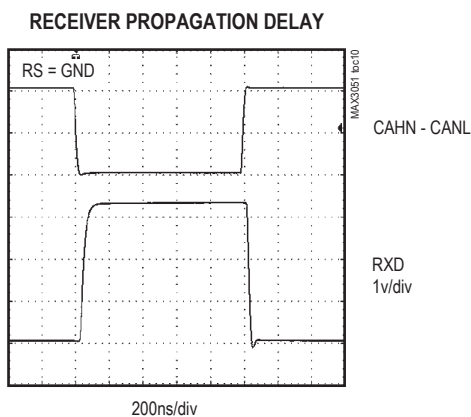
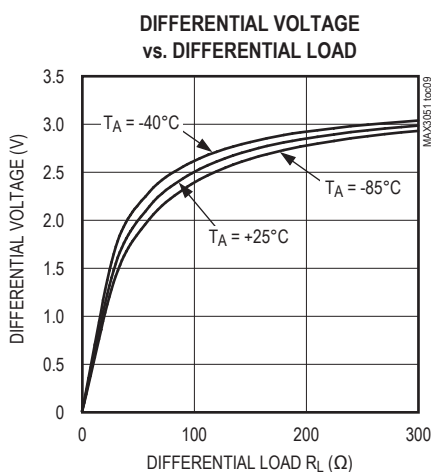
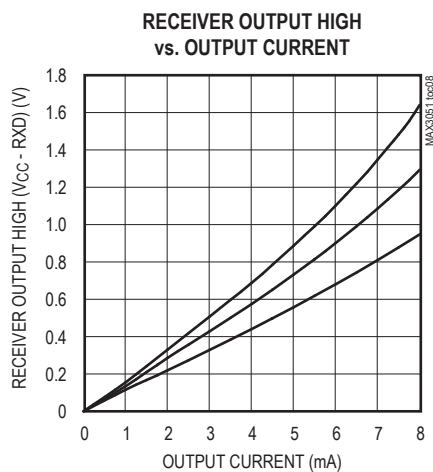
## Typical Operating Characteristics

( $V_{CC} = +3.3V$ ,  $R_L = 60\Omega$ ,  $C_L = 100pF$ ,  $T_A = +25^\circ C$ , unless otherwise specified.)



Typical Operating Characteristics (continued)

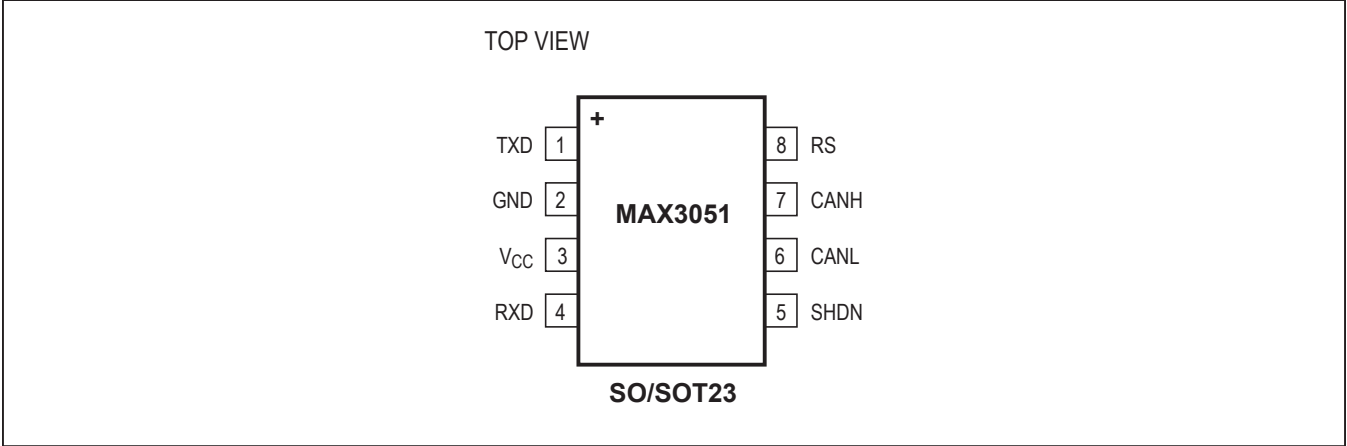
( $V_{CC} = +3.3V$ ,  $R_L = 60\Omega$ ,  $C_L = 100pF$ ,  $T_A = +25^\circ C$ , unless otherwise specified.)



MAX3051

+3.3V, 1Mbps, Low-Supply-Current  
CAN Transceiver

Pin Configuration



Pin Description

| PIN | NAME            | DESCRIPTION                                                                                                                                                                                                                |
|-----|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | TXD             | Transmit Data Input. TXD is a CMOS/TTL-compatible input from a CAN controller. TXD has an internal 75kΩ pullup resistor.                                                                                                   |
| 2   | GND             | Ground                                                                                                                                                                                                                     |
| 3   | V <sub>CC</sub> | Supply Voltage. Bypass V <sub>CC</sub> to GND with a 0.1μF capacitor.                                                                                                                                                      |
| 4   | RXD             | Receive Data Output. RXD is a CMOS/TTL-compatible output.                                                                                                                                                                  |
| 5   | SHDN            | Shutdown Input, CMOS/TTL-Compatible. Drive SHDN high to put the MAX3051 in shutdown. SHDN has an internal 75kΩ pulldown resistor to GND.                                                                                   |
| 6   | CANL            | CAN Bus Line Low                                                                                                                                                                                                           |
| 7   | CANH            | CAN Bus Line High                                                                                                                                                                                                          |
| 8   | RS              | Mode-Select Input. Drive RS low or connect to GND for high-speed operation. Connect a resistor between RS and GND to control output slope. Drive RS high to put into standby mode (see the <i>Mode Selection</i> section). |

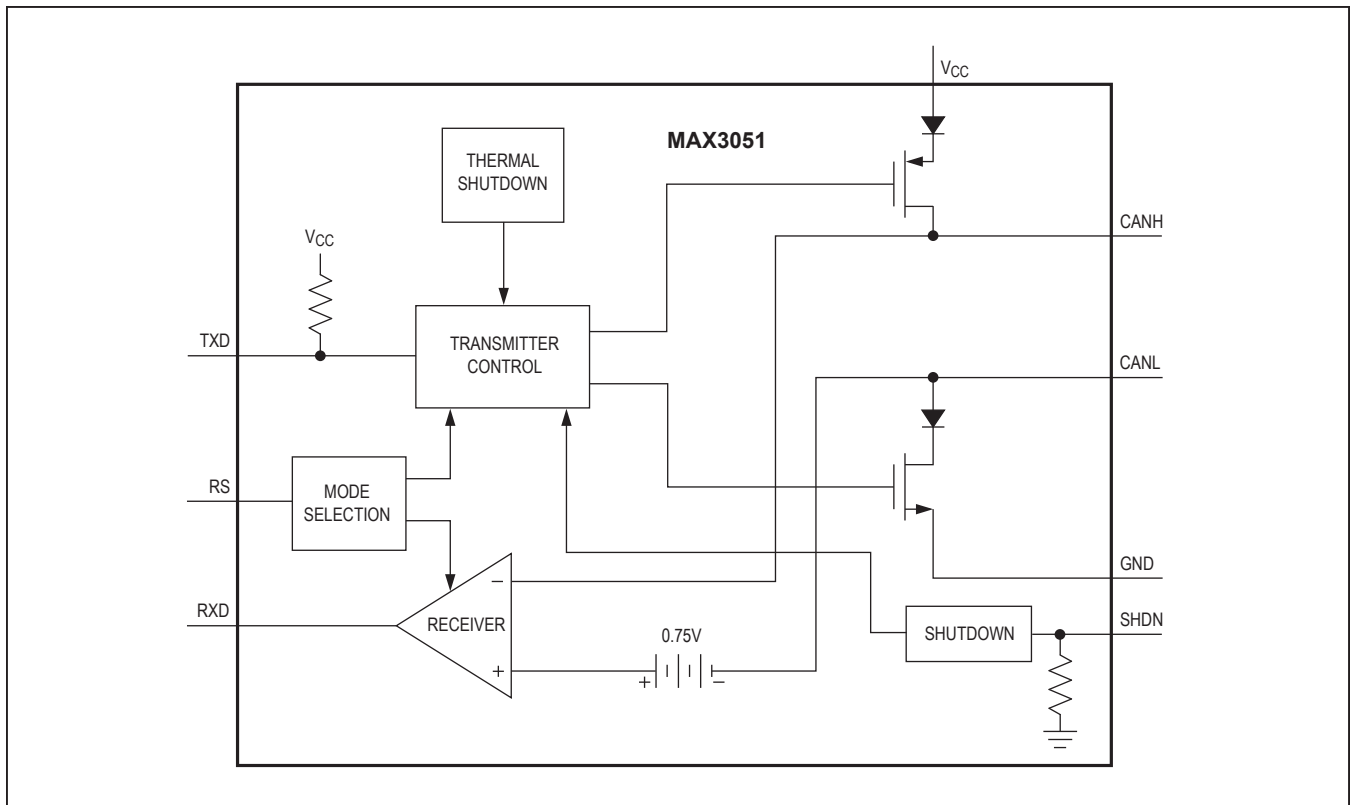


Figure 5. MAX3051 Functional Diagram



## Detailed Description

The MAX3051 interfaces between the CAN protocol controller and the physical wires of the bus lines in a CAN. It provides differential transmit capability to the bus and differential receive capability to the CAN controller. It is primarily intended for +3.3V single-supply applications that do not require the stringent fault protection specified by the automotive industry (ISO 11898).

The MAX3051 features four different modes of operation: high-speed, slope-control, standby, and shutdown mode. High-speed mode allows data rates up to 1Mbps. The slope-control mode can be used to program the slew rate of the transmitter for data rates of up to 500kbps. This reduces the effects of EMI, thus allowing the use of unshielded twisted or parallel cable. In standby mode, the transmitter is shut off and the receiver is pulled high, placing the MAX3051 in low-current mode. In shutdown mode, the transmitter and receiver are switched off.

The MAX3051 input common-mode range is from -7V to +12V, exceeding the ISO 11898 specification of -2V to +7V. These features, and the programmable slew-rate limiting, make the part ideal for nonautomotive, harsh environments.

The transceivers operate from a single +3.3V supply and draw 35μA of supply current in dominant state and 2μA in recessive state. In standby mode, supply current is reduced to 8μA. In shutdown mode, supply current is less than 1μA.

CANH and CANL are output short-circuit current limited and are protected against excessive power dissipation by thermal-shutdown circuitry that places the driver outputs into a high-impedance state.

### Transmitter

The transmitter converts a single-ended input (TXD) from the CAN controller to differential outputs for the bus lines (CANH, CANL). The truth table for the transmitter and receiver is given in [Table 1](#).

### Receiver

The receiver reads differential inputs from the bus lines (CANH, CANL) and transfers this data as a single-ended output (RXD) to the CAN controller. It consists of a comparator that senses the difference  $V_{DIFF} = (CANH - CANL)$  with respect to an internal threshold of +0.75V. If this  $V_{DIFF}$  is greater than 0.75, a logic-low is present at RXD. If  $V_{DIFF}$  is less than 0.75V, a logic-high is present. The receiver always echoes the CAN BUS data.

The CANH and CANL common-mode range is -7V to +12V. RXD is logic-high when CANH and CANL are shorted or terminated and undriven.

## Mode Selection

### High-Speed Mode

Connect RS to ground to set the MAX3051 to high-speed mode. When operating in high-speed mode, the MAX3051 can achieve transmission rates of up to 1Mbps. In high-speed mode, use shielded twisted pair cable to avoid EMI problems.

### Slope-Control Mode

Connect a resistor from RS to ground to select slope-control mode ([Table 2](#)). In slope-control mode, CANH and CANL slew rates are controlled by the resistor connected to the RS pin. Maximum transmission speeds are controlled by RRS and range from 40kbps to 500kbps. Controlling the rise and fall slopes reduces EMI and allows the use of an unshielded twisted pair or a parallel pair of wires as bus lines. The equation for selecting the resistor value is given by:

$$RRS \text{ (k}\Omega\text{)} \approx 12000 / (\text{maximum speed in kbps})$$

See the Slew Rate vs. RRS graph in the [Typical Operating Characteristics](#).

### Standby Mode

If a logic-high is applied to RS, the MAX3051 enters a low-current standby mode. In this mode, the transmitter

**Table 1. Transmitter and Receiver Truth Table When Not Connected to the Bus**

| TXD           | RS                            | SHDN | CANH                      | CANL                      | BUS STATE   | RXD  |
|---------------|-------------------------------|------|---------------------------|---------------------------|-------------|------|
| Low           | $V_{RS} < 0.75 \times V_{CC}$ | Low  | High                      | Low                       | Dominant    | Low  |
| High or float | $V_{RS} < 0.75 \times V_{CC}$ | Low  | 5kΩ to 25kΩ to $V_{CC}/2$ | 5kΩ to 25kΩ to $V_{CC}/2$ | Recessive   | High |
| X             | $V_{RS} > 0.75 \times V_{CC}$ | Low  | 5kΩ to 25kΩ to GND        | 5kΩ to 25kΩ to GND        | Recessive   | High |
| X             | X                             | High | Unconnected               | Unconnected               | Unconnected | High |

is switched off and the receiver is switched to a low-current/low-speed state. If dominant bits are detected, RXD switches to low level. The microcontroller should react to this condition by switching the transceiver back to normal operation.

When the MAX3051 enters standby mode, RXD goes high for 4μs (max) regardless of the BUS state. However, after 4μs, RXD goes low only when the BUS is dominant, otherwise RXD remains high (when the BUS is recessive). For proper measurement of standby-to-receiver active time (t<sub>SBRXDL</sub>), the BUS should be in dominant state (see [Figure 2](#)).

Shutdown

Drive SHDN high to enter shutdown mode. Connect SHDN to ground or leave unconnected for normal operation.

Thermal Shutdown

If the junction temperature exceeds +160°C, the device is switched off. The hysteresis is approximately 25°C, disabling thermal shutdown once the temperature drops below 135°C. In thermal shutdown, CANH and CANL go recessive and all IC functions are disabled.

Applications Information

Reduced EMI and Reflections

In slope-control mode, the CANH and CANL outputs are slew-rate limited, minimizing EMI and reducing reflections caused by improperly terminated cables.

In multidrop CAN applications, it is important to maintain a direct point-to-point wiring scheme. A single pair of wires should connect each element of the CAN bus, and the two ends of the bus should be terminated with 120Ω resistors ([Figure 6](#)). A star configuration should never be used.

Any deviation from the point-to-point wiring scheme creates a stub. The high-speed edge of the CAN data on a stub can create reflections back down the bus. These reflections can cause data errors by eroding the noise margin of the system.

Although stubs are unavoidable in a multidrop system, care should be taken to keep these stubs as small as possible, especially in high-speed mode. In slope-control mode, the requirements are not as rigorous, but stub length should still be minimized.

Power Supply and Bypassing

The MAX3051 requires no special layout considerations beyond common practices. Bypass V<sub>CC</sub> to GND with a 0.1μF ceramic capacitor mounted close to the IC with short lead lengths and wide trace widths.

Table 2. Mode Selection Truth Table

| CONDITION FORCED AT PIN RS                       | SHDN          | CANL                            |
|--------------------------------------------------|---------------|---------------------------------|
| $V_{RS} < 0.3 \times V_{CC}$                     | High Speed    | $ I_{RS}  < 500\mu A$           |
| $0.4 \times V_{CC} < V_{RS} < 0.6 \times V_{CC}$ | Slope Control | $10\mu A <  I_{RS}  < 200\mu A$ |
| $V_{RS} > 0.75 \times V_{CC}$                    | Standby       | $ I_{RS}  < 10\mu A$            |

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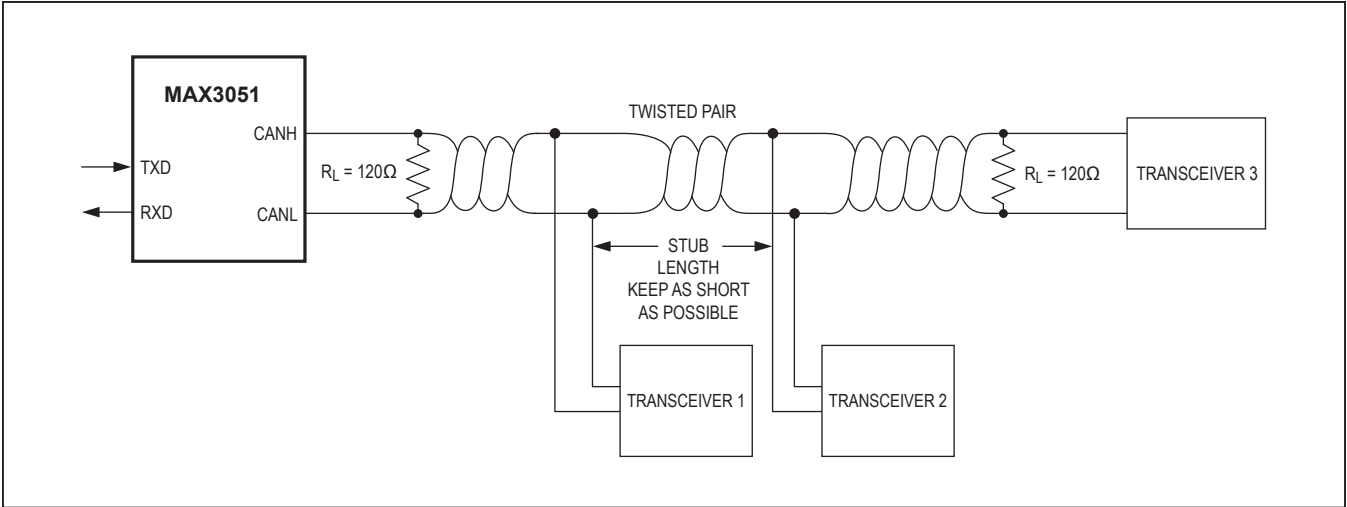


Figure 6. Multiple Receivers Connected to CAN Bus

Ordering Information

| PART         | TEMP RANGE     | PIN-PACKAGE | TOP MARK |
|--------------|----------------|-------------|----------|
| MAX3051ESA+  | -40°C to +85°C | 8 SO        | —        |
| MAX3051EKA+T | -40°C to +85°C | 8 SOT23-8   | AEKF     |

+Denotes a lead(Pb)-free/RoHS-compliant package.  
T = Tape and reel.

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.        |
|--------------|--------------|-------------------------|-------------------------|
| 8 SO         | S8+4         | <a href="#">21-0041</a> | <a href="#">90-0096</a> |
| 8 SOT23      | K8F+4        | <a href="#">21-0078</a> | <a href="#">90-0176</a> |

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## Revision History

| REVISION<br>NUMBER | REVISION<br>DATE | DESCRIPTION                                        | PAGES<br>CHANGED |
|--------------------|------------------|----------------------------------------------------|------------------|
| 2                  | 10/12            | Added lead-free part information to the data sheet | 1–13             |
| 3                  | 2/15             | Added the <i>Benefits and Features</i> section     | 1                |
| 4                  | 4/18             | Updated <i>Package Information</i> table           | 11               |
| 5                  | 9/18             | Updated <i>Electrical Characteristics</i> table    | 2                |

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