19-3274; Rev 0; 5/04

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

General Description

The MAX3051 interfaces between the CAN protocol controller and the physical wires of the bus lines in a controller area network (CAN). The MAX3051 provides differential transmit capability to the bus and differential receive capability to the CAN controller. The MAX3051 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 MAX3051 is available in 8-pin SO and SOT23 packages and operates over the -40°C to +85°C extended temperature range.

Applications

Printers JetLink

Industrial Control and Networks

Telecom Backplane

Consumer Applications

Typical Operating Circuit at end of data sheet.

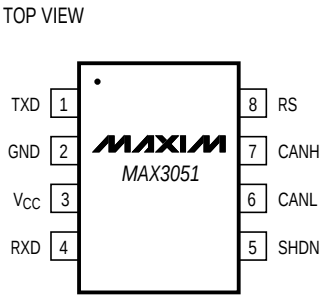
Features

- ♦ **Low +3.3V Single-Supply Operation**
- ♦ **Wide -7V to +12V Common-Mode Range**
- ♦ **Small SOT23 Package**
- ♦ **Four Operating Modes**
  High-Speed Operation Up to 1Mbps
  Slope-Control Mode to Reduce EMI (Up to 500kbps)
  Standby Mode
  Low-Current Shutdown Mode
- ♦ **Thermal Shutdown**
- ♦ **Current Limiting**

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

Pin Configuration



SO/SOT23

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

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

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°C)
8-Pin SO (derate 5.9mW/°C above +70°C).....470mW
8-Pin SOT23 (derate 9.7mW/°C above +70°C).....774mW

Operating Temperature Range .....-40°C to +85°C
Maximum Junction Temperature .....+150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature Range (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.

ELECTRICAL CHARACTERISTICS

(V_{CC} = +3.3V ±5%, R_L = 60Ω, 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°C.) (Note 1)

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

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +3.3V ±5%, R_L = 60Ω, 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°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CANH Short-Circuit Current	I_{CANHSC}	-7V ≤ V_{CANH} ≤ 0V	-200			mA
		Minimum foldback current			-35	
CANL Short-Circuit Current	I_{CANLSC}	V_{CC} ≤ V_{CANL} ≤ 12V			200	mA
RXD OUTPUT LEVELS						
RXD High Output-Voltage Level	V_{OH}	I = -1mA	0.8 x V_{CC}		V_{CC}	V
RXD Low Output-Voltage Level	V_{OL}	I = 4mA			0.4	V
DC BUS RECEIVER (V_{TXD} = V_{CC}; CANH and CANL externally driven; -7V ≤ V_{CANH}, V_{CANL} ≤ +12V, unless otherwise specified)						
Differential Input Voltage (Recessive)	V_{DIFF}	-7V ≤ V_{CM} ≤ +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	kΩ
Differential Input Resistance	R_{DIFF}		40		100	kΩ
MODE SELECTION (RS)						
Input Voltage for High Speed	V_{SLP}				0.3 x V_{CC}	V
Input Voltage for Standby	V_{STBY}		0.75 x V_{CC}			V
Slope-Control Mode Voltage	V_{SLOPE}	R_{RS} = 25kΩ to 200kΩ	0.4 x V_{CC}		0.6 x V_{CC}	V
High-Speed Mode Current	I_{HS}	V_{RS} = 0			-500	µA
SHUTDOWN (SHDN)						
SHDN Input Voltage High	V_{SHDNH}		2			V
SHDN Input Voltage Low	V_{SHDNL}				0.8	V
SHDN Pulldown Resistor	R_{INSHDN}		50		100	kΩ

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

TIMING CHARACTERISTICS

(V_{CC} = +3.3V ±5%, R_L = 60Ω, 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°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Delay TXD to Bus Active (Figure 1)	t_{ONTXD}	V_{RS} = 0V (≤1Mbps)			50	ns
		R_{RS} = 25kΩ (≤500kbps)		183		
		R_{RS} = 100kΩ (≤125kbps)		770		
Delay TXD to Bus Inactive (Figure 1)	t_{OFFTXD}	V_{RS} = 0V (≤1Mbps)			70	ns
		R_{RS} = 25kΩ (≤500kbps)		226		
		R_{RS} = 100kΩ (≤125kbps)		834		
Delay Bus to Receiver Active (Figure 1)	t_{ONRXD}	V_{RS} = 0V (≤1Mbps)			80	ns
		R_{RS} = 25kΩ (≤500kbps)		200		
		R_{RS} = 100kΩ (≤125kbps)		730		
Delay Bus to Receiver Inactive (Figure 1)	t_{OFFRXD}	V_{RS} = 0V (≤1Mbps)			100	ns
		R_{RS} = 25kΩ (≤500kbps)		245		
		R_{RS} = 100kΩ (≤125kbps)		800		
Differential-Output Slew Rate	SR	V_{RS} = 0V (≤1Mbps)		96		V/µs
		R_{RS} = 25kΩ (≤500kbps)		12.5		
		R_{RS} = 100kΩ (≤125kbps)		2.9		
		R_{RS} = 200kΩ (≤62.5kbps)		1.6		
Bus Dominant to RXD Active	t_{DRXDL}	V_{RS} > 0.8 x V_{CC}, standby, Figure 2			1	µs
Standby to Receiver Active	t_{SBRXDL}	BUS dominant, Figure 2			4	µs
SHDN to Bus Inactive	$t_{OFFSHDN}$	TXD = GND, Figure 3 (Note 2)			1	µs
SHDN to Receiver Active	t_{ONSHDN}	BUS dominant, Figure 3 (Note 3)			4	µs
SHDN to Standby	t_{SHDNSB}	Figure 4	20			µs

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

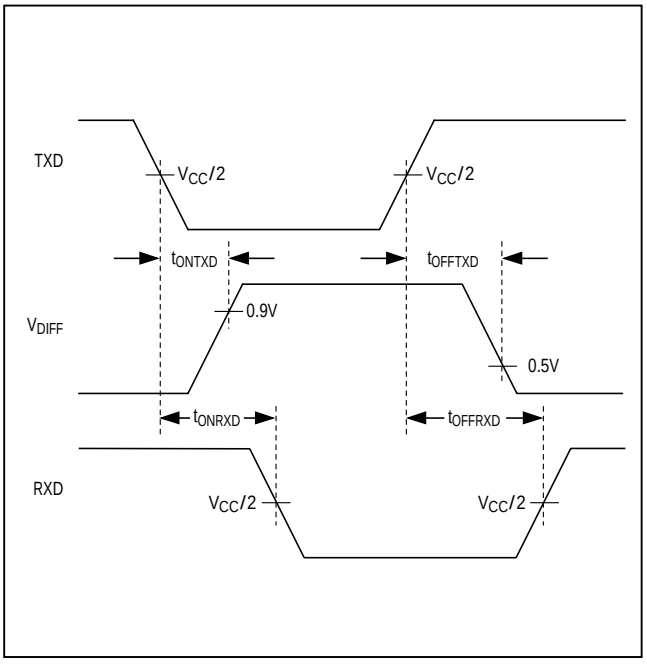


Figure 1. Timing Diagram

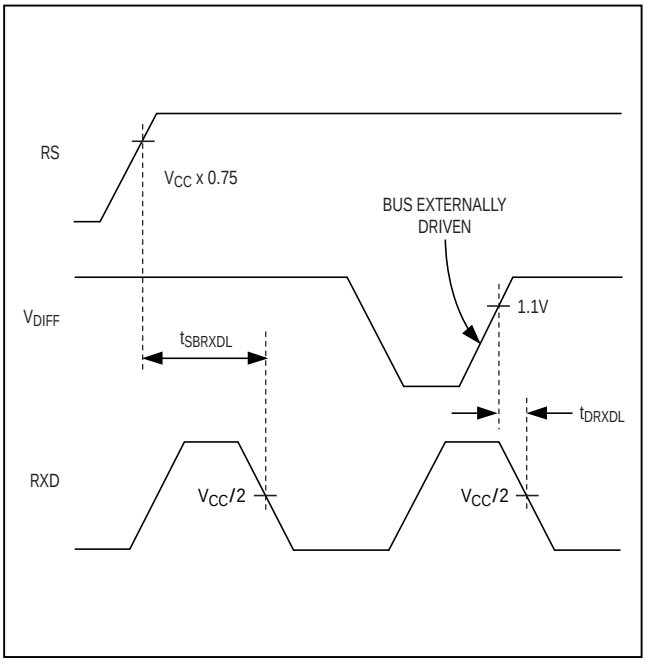


Figure 2. Timing Diagram for Standby Signal

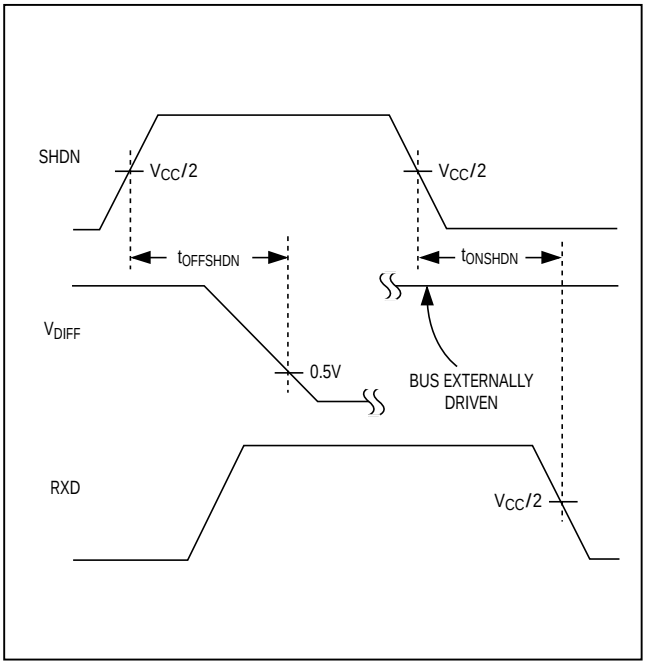


Figure 3. Timing Diagram for Shutdown Signal

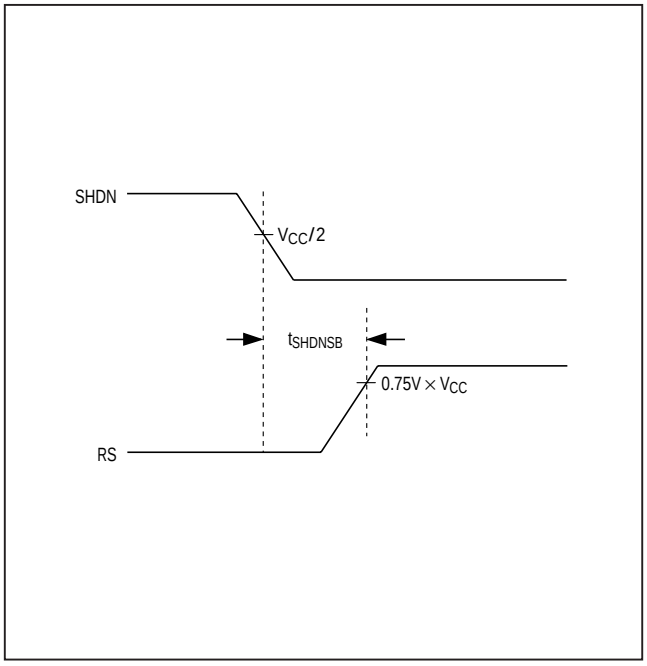


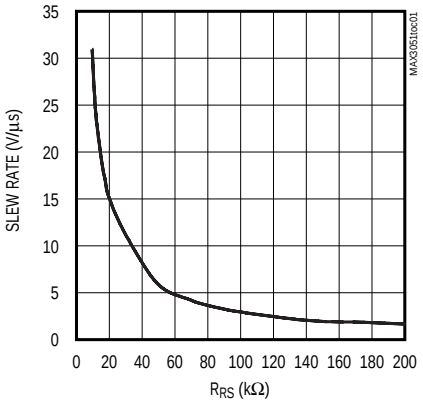
Figure 4. Timing Diagram for Shutdown-to-Standby Signal

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

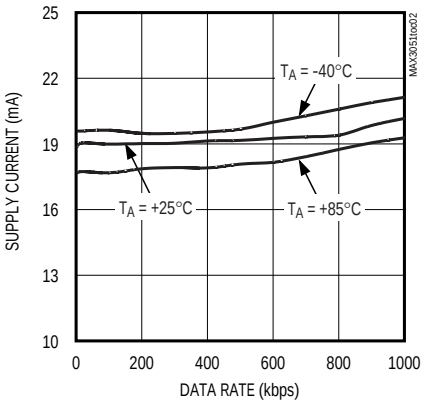
Typical Operating Characteristics

(V_{CC} = +3.3V, R_L = 60Ω, C_L = 100pF, T_A = +25°C, unless otherwise specified.)

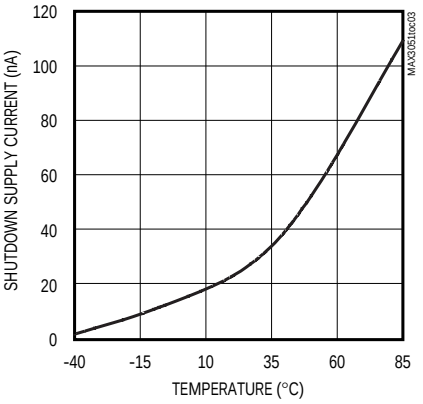
SLEW RATE vs. R_{RS} AT 100kbps



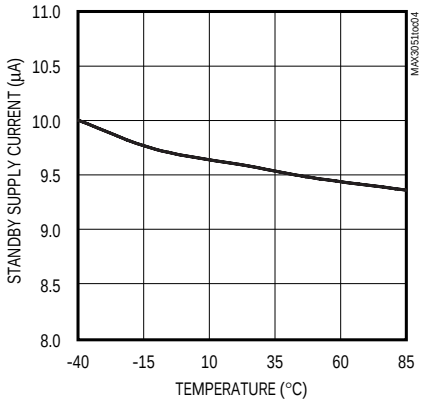
SUPPLY CURRENT vs. DATA RATE



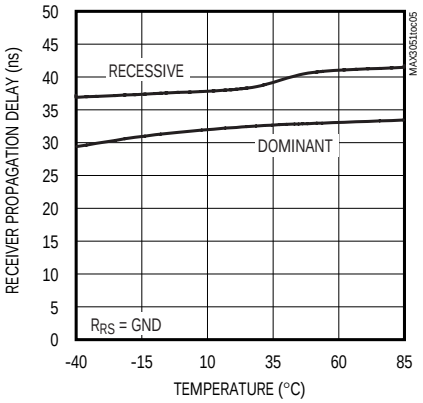
SHUTDOWN SUPPLY CURRENT vs. TEMPERATURE (SHDN = V_{CC})



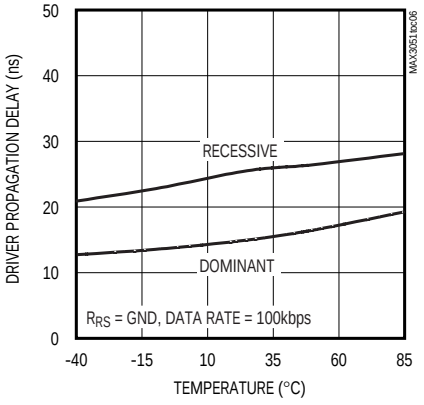
STANDBY SUPPLY CURRENT vs. TEMPERATURE (RS = V_{CC})



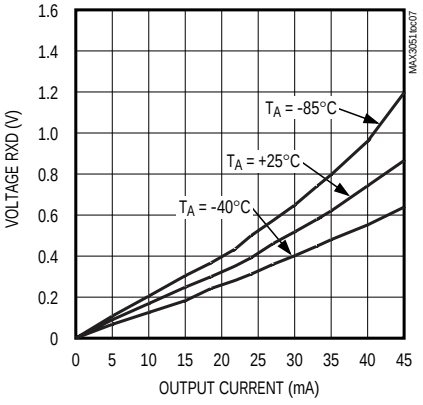
RECEIVER PROPAGATION DELAY vs. TEMPERATURE



DRIVER PROPAGATION DELAY vs. TEMPERATURE



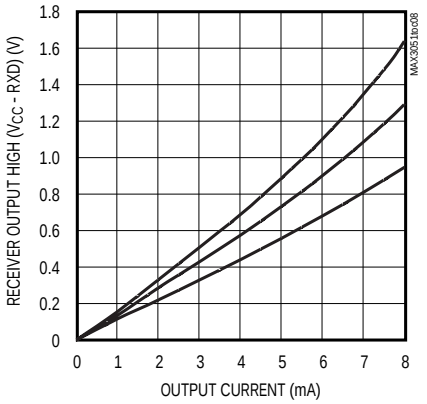
RECEIVER OUTPUT LOW vs. OUTPUT CURRENT



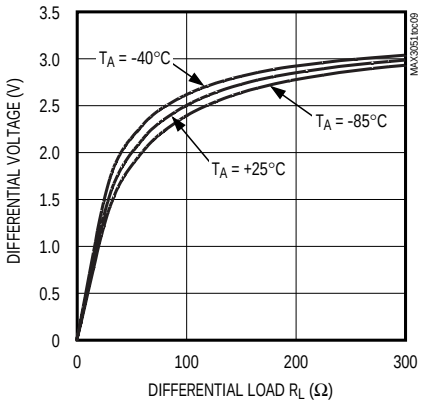
Typical Operating Characteristics (continued)

(V_{CC} = +3.3V, R_L = 60Ω, C_L = 100pF, T_A = +25°C, unless otherwise specified.)

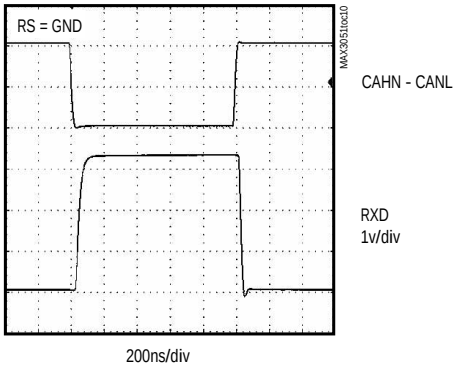
RECEIVER OUTPUT HIGH vs. OUTPUT CURRENT



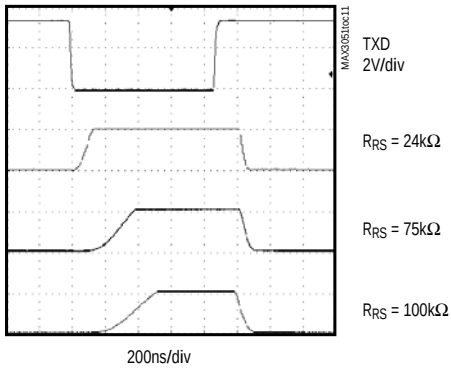
DIFFERENTIAL VOLTAGE vs. DIFFERENTIAL LOAD



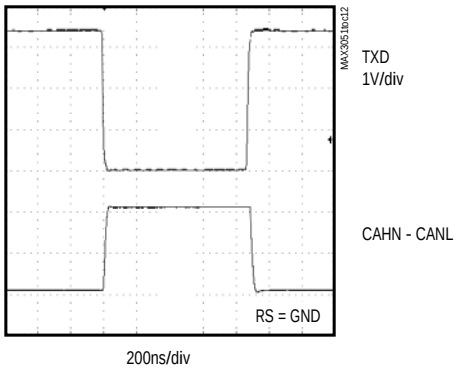
RECEIVER PROPAGATION DELAY



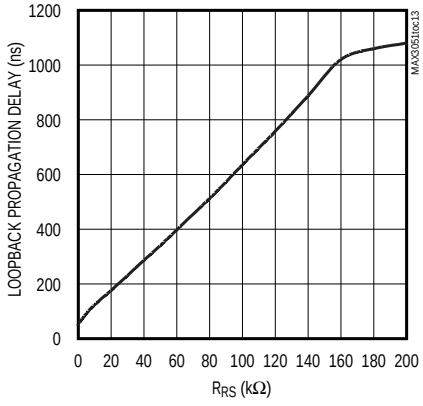
DRIVER PROPAGATION DELAY



DRIVER PROPAGATION DELAY



LOOPBACK PROPAGATION DELAY vs. R_{RS}



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

Detailed Description

PIN	NAME	FUNCTION
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_{CC}	Supply Voltage. Bypass V_{CC} 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 *Mode Selection* section).

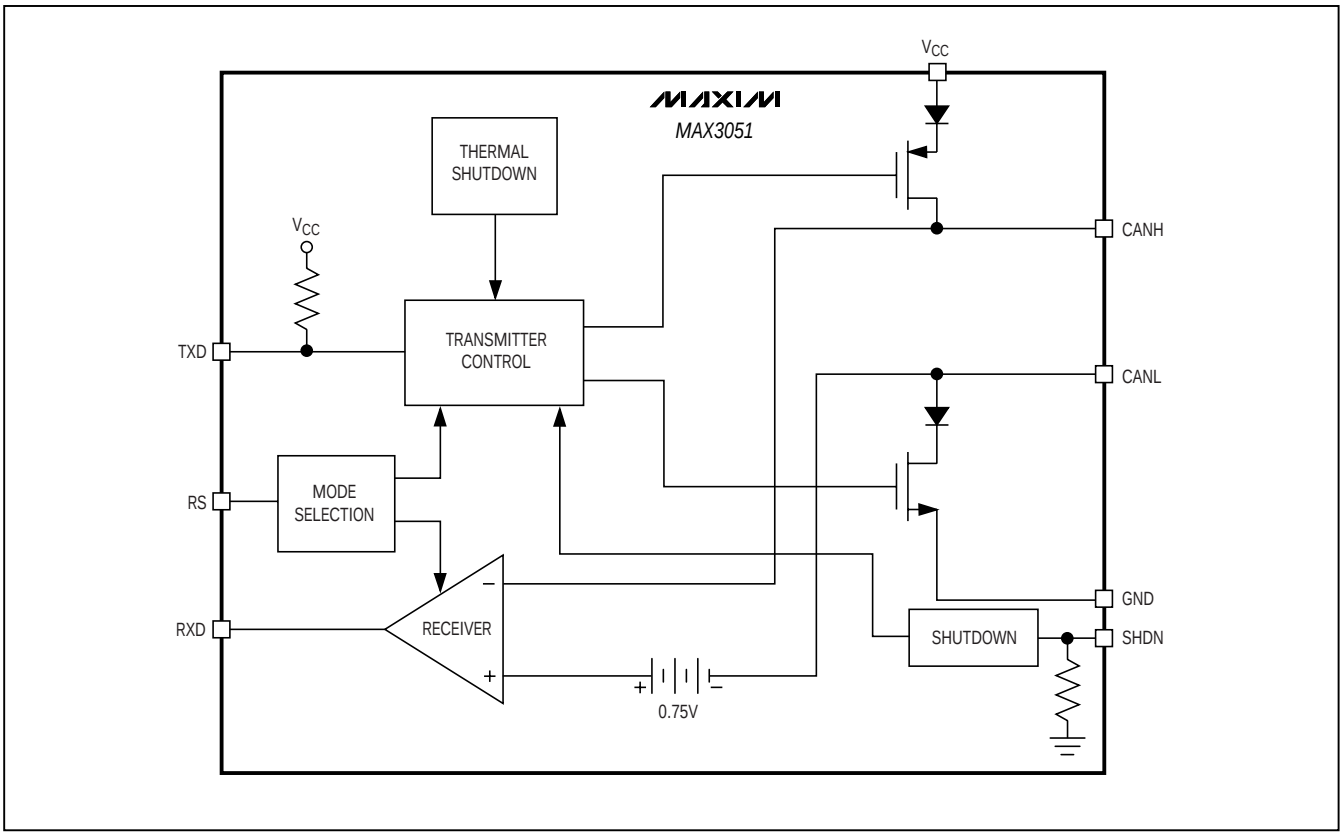


Figure 5. MAX3051 Functional Diagram

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 R_{RS} 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:

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

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 x V_{CC}	Low	High	Low	Dominant	Low
High or float	V_{RS} < 0.75 x V_{CC}	Low	5kΩ to 25kΩ to V_{CC} / 2	5kΩ to 25kΩ to V_{CC} / 2	Recessive	High
X	V_{RS} > 0.75 x V_{CC}	Low	5kΩ to 25kΩ to GND	5kΩ to 25kΩ to GND	Recessive	High
X	X	High	Floating	Floating	Floating	High

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

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_{SBRXDL}), the BUS should be in dominant state (see Figure 2).

Shutdown

Drive SHDN high to enter shutdown mode. Connect SHDN to ground or leave floating 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_{CC} 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	MODE	RESULTING CURRENT AT RS
$V_{RS} < 0.3 \times V_{CC}$	High Speed	$\lvert I_{RS}\rvert < 500\mu A$
$0.4 \times V_{CC} < V_{RS} < 0.6 \times V_{CC}$	Slope Control	$10\mu A < \lvert I_{RS}\rvert < 200\mu A$
$V_{RS} > 0.75 \times V_{CC}$	Standby	$\lvert I_{RS}\rvert < 10\mu A$

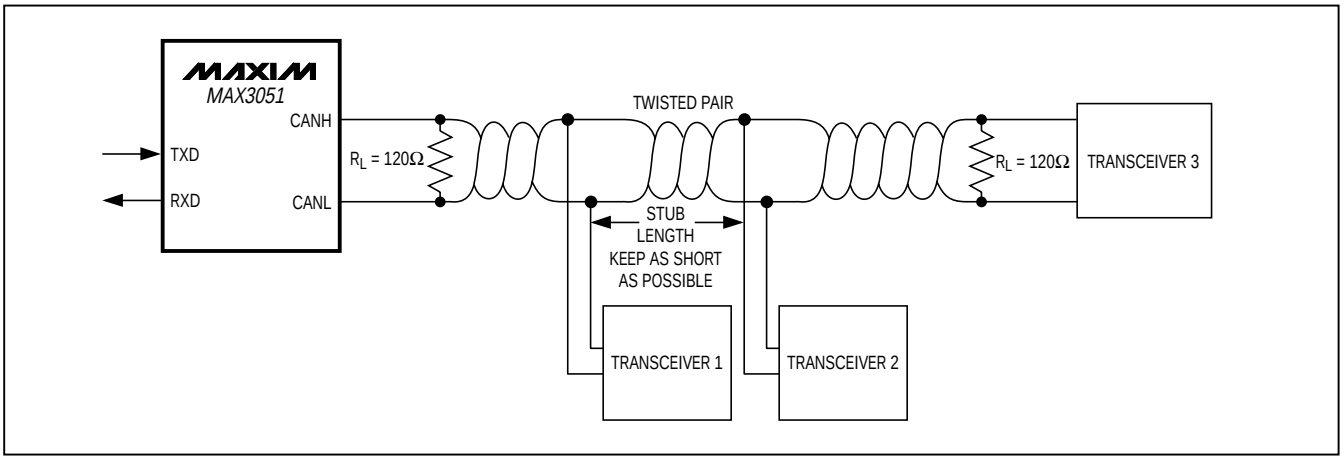
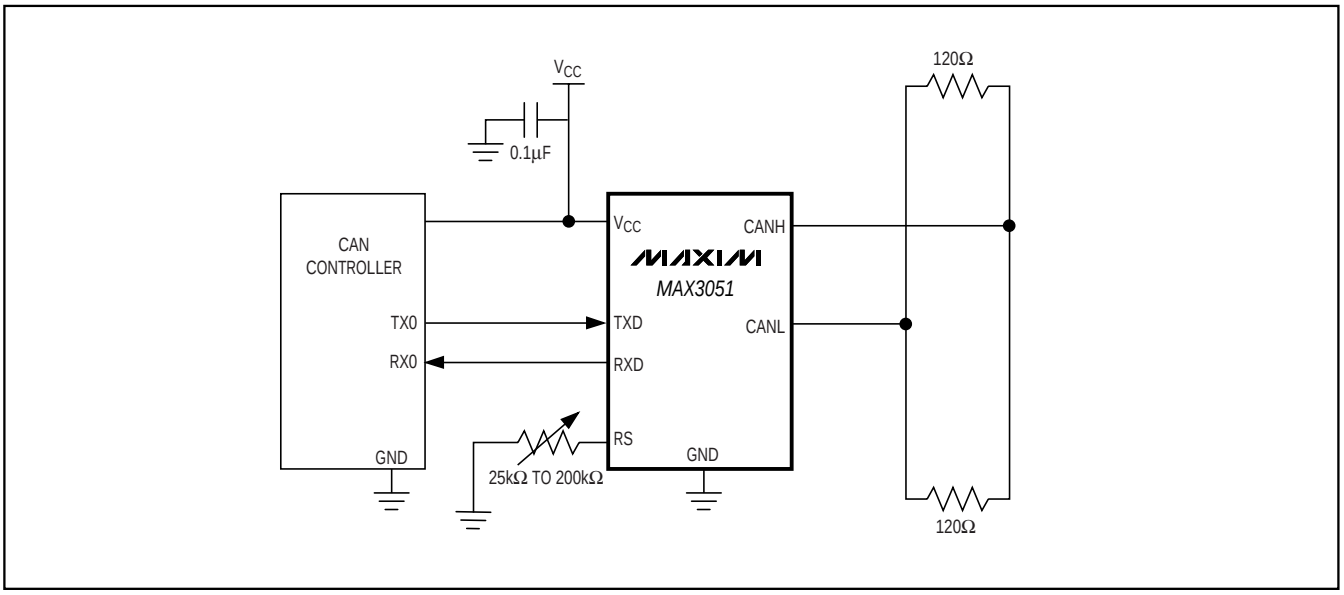


Figure 6. Multiple Receivers Connected to CAN Bus

Typical Operating Circuit



Chip Information

TRANSISTOR COUNT: 1024

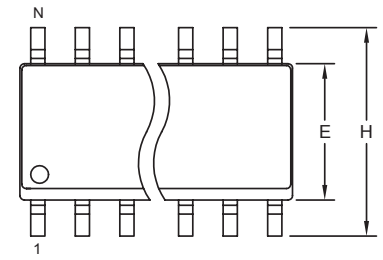
PROCESS: BiCMOS

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

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to **www.maxim-ic.com/packages**.)

SOICN .EPS

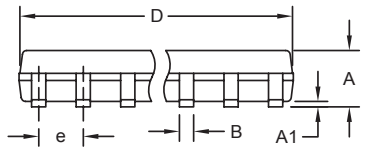


TOP VIEW

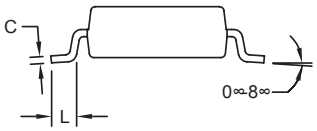
	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050 BSC		1.27 BSC	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
L	0.016	0.050	0.40	1.27

VARIATIONS:

	INCHES		MILLIMETERS			
DIM	MIN	MAX	MIN	MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	AA
D	0.337	0.344	8.55	8.75	14	AB
D	0.386	0.394	9.80	10.00	16	AC



FRONT VIEW



SIDE VIEW

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. LEADS TO BE COPLANAR WITHIN 0.10mm (.004").
4. CONTROLLING DIMENSION: MILLIMETERS.
5. MEETS JEDEC MS012.
6. N = NUMBER OF PINS.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

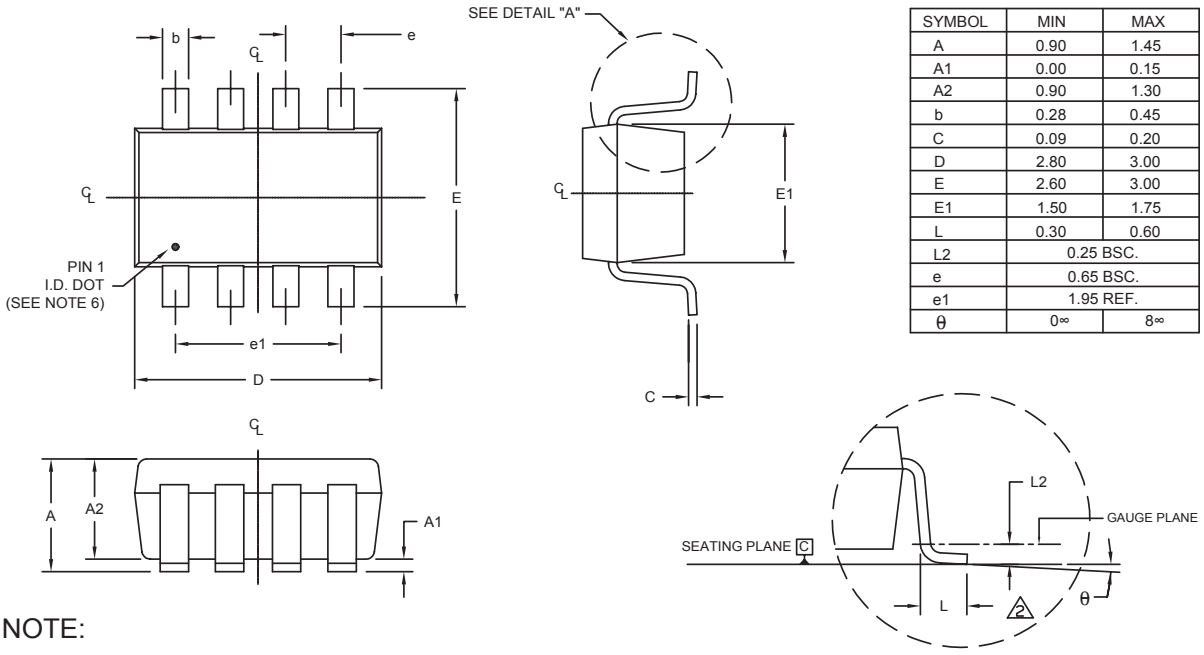
TITLE: PACKAGE OUTLINE, .150" SOIC

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0041	B	1/1

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to **www.maxim-ic.com/packages**.)

SOT23, 8L .EPS



SYMBOL	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.28	0.45
C	0.09	0.20
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.75
L	0.30	0.60
L2	0.25 BSC.	
e	0.65 BSC.	
e1	1.95 REF.	
θ	0∞	8∞

DETAIL "A"

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. FOOT LENGTH MEASURED FROM LEAD TIP TO UPPER RADIUS OF HEEL OF THE LEAD PARALLEL TO SEATING PLANE C.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
5. COPLANARITY 4 MILS. MAX.
6. PIN 1 I.D. DOT IS 0.3 MM ÿ MIN. LOCATED ABOVE PIN 1.
7. SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEAD TIP.
8. MEETS JEDEC MO178.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, SOT-23, 8L BODY

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0078	D	1/1

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