maxim integrated™

MAX250/MAX251

+5V Powered Isolated RS-232 Drivers/Receivers

General Description

The MAX250 and MAX251 chip set form the heart of a complete, electrically isolated, RS-232 dual transmitter/receiver. By combining many functions on two chips, the cost and complexity required for an isolated digital interface is greatly reduced. Four low cost optocouplers, four capacitors, a diode and a small pot-core type transformer are all that are required to complete a 19.2k baud transceiver. Faster data rates are possible by using high speed optocouplers. In addition to the driving and receiving circuitry for the optocouplers, the chip set includes a push-pull transformer driver to supply power to the interface's isolated side.

Other convenient features include single +5V operation, a low power shutdown mode, and output enable control for three-state operation. The MAX250 and MAX251 are supplied in 14 lead DIP, 14 lead small outline and 20 leadless chip carrier packages.

The MAX252 has all the required components for RS-232 communication in a single package.

Applications

High Noise Data Communications
Industrial Communications
Data Links To Analog Circuits
Bridge Ground Differentials

Features

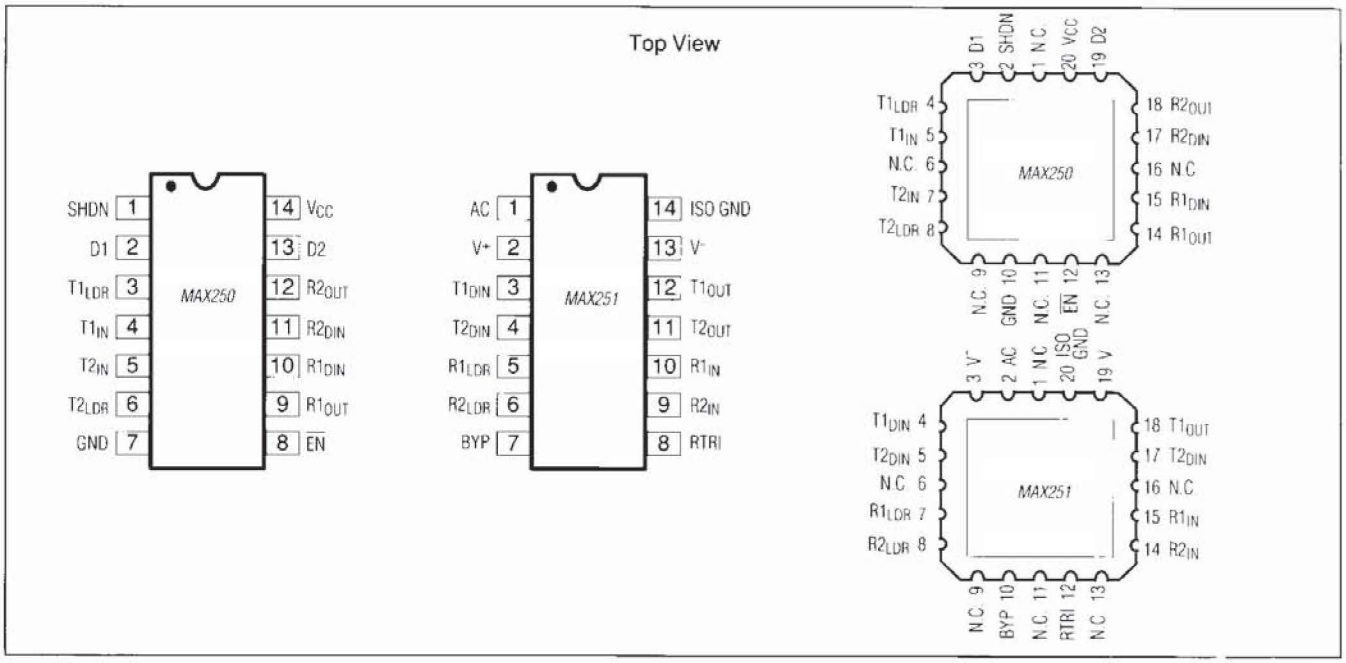
- ♦ Isolated Data Interface
- ♦ Single +5V Supply
- ♦ Uses Low Cost Optocouplers
- ♦ 5µW Low Power Shutdown
- ♦ 2 Transmitters and 2 Receivers

Ordering Information

PART	TEMP. RANGE	PACKAGE*
MAX250CPD	0°C to +70°C	14 Lead Plastic DIP
MAX250CSD	0°C to +70°C	14 Lead SO
MAX250C/D	0°C to +70°C	Dice
MAX250EPD	-40°C to +85°C	14 Lead Plastic DIP
MAX250ESD	-40°C to +85°C	14 Lead SO
MAX250EJD	-40°C to +85°C	14 Lead CERDIP
MAX250MJD	-55°C to +125°C	14 Lead CERDIP
MAX250MLP	-55°C to +125°C	20 Lead LCC
MAX251CPD	0°C to +70°C	14 Lead Plastic DIP
MAX251CSD	0°C to +70°C	14 Lead SO
MAX251C/D	0°C to +70°C	Dice
MAX251EPD	-40°C to +85°C	14 Lead Plastic DIP
MAX251ESD	-40°C to +85°C	14 Lead SO
MAX251EJD	-40°C to +85°C	14 Lead CERDIP
MAX251MJD	-55°C to +125°C	14 Lead CERDIP
MAX251MLP	-55°C to +125°C	20 Lead LCC

** Maxim reserves the right to ship Ceramic packages in lieu of CERDIP packages.*

Pin Configurations



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

19-1275; Rev 1; 7/89

ABSOLUTE MAXIMUM RATINGS: MAX250

Supply Voltage, V_{CC} 6V
Input Voltages ..... -0.3V to (V_{CC} +0.3V)
Output Drive Current, D1, D2 ..... 240mA
Output Drive Voltage, D1, D2 ..... V_{CC} + 6V
Opto Driver pins $T1_{LDR}$, $T2_{LDR}$, $R1_{OUT}$ and $R2_{OUT}$ may be shorted one at a time indefinitely to V_{CC} or GND

Power Dissipation
- Plastic DIP (derate 7mW/°C above 70°C) 375mW
- CERDIP (derate 9.5mW/°C above 70°C) 675mW
- Small Outline (derate 7mW/°C above 70°C) 375mW
- LCC (derate 7mW/°C above 70°C) 375mW

Lead Temperature (Soldering, 10 seconds) ..... +300°C
Storage Temperature ..... -65°C to +160°C

Stresses above 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 above those indicated in the operational section of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS: MAX250

(V_{CC} = 5V ±10%, T_A = Full Temperature Range unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{CC}	Over Temp.	4.5		5.5	V
Operating Supply Current	I_{CC}	D1, D2 Open		0.1	0.5	mA
Shutdown Supply Current	I_{CS}	Shutdown T_A = -40°C to +85°C T_A = -55°C to +125°C		1	10 100	µA
Input Currents	$I_{\overline{EN}}$, I_{SHDN}	Input = GND to V_{CC}		0.001	1	µA
POWER DRIVER D1, D2						
Switch Frequency	$f_{D1, D2}$	V_{CC} = 5V, T_A = 25°C	100	200	275	kHz
ON Resistance Power Driver	$r_{DS(ON)}$	At 25 mA		25	50	Ω
Leakage Current					10	µA
Zener Clamp Voltage	V_{CL}	w. r. t. V_{CC}	6	8	10	V
DRIVER SECTION						
Pull-up Current Input source	I_P	V_{CC} = 5V, V_{IN} = 0V, T_A = 25°C	2	3	6	µA
Current Output Source	I_S	V_{OUT} = 1.4V, T_A = 25°C	-5	-8	-15	mA
TTL/CMOS Output Voltage Low	V_{OL}	I_{OUT} = 3.2mA			0.4	V
TTL/CMOS Output Voltage High	V_{OH}	I_{OUT} = -1.0mA	2.4			V
Input Logic Threshold High	V_{IH}	T_{IN}, R_{DIN}, $\overline{EN}$, Shutdown		1.8	2.4	V
Input Logic Threshold Low	V_{IL}	T_{IN}, R_{DIN}, $\overline{EN}$, Shutdown	0.8	1.3		V
Input Hysteresis	V_{IHYS}			0.5		V
Leakage Current Input and Output	I_I	($\overline{EN}$ or Shutdown) = V_{CC}			10	µA
Input Capacitance	C_{IN}			5		pF

ABSOLUTE MAXIMUM RATINGS: MAX251

Positive Input Voltage, AC terminal 15V
Positive Input Voltage, V^+ terminal 14V
Negative Input Voltage, V^- terminal ..... -14V
RS-232 Input Voltage ..... -30V to 30V
RS-232 Applied Output Voltage ..... -15V to 15V
Tristate Input Voltage, V_{RTRI} ..... -0.3V to (V^+ + 0.3V)
RS-232 Transmitters may be indefinitely shorted to GND
Opto Driver pins $R1_{LDR}$, $R2_{LDR}$ may be shorted one at a time indefinitely to GND

Diode Forward Current (AC to V^+) 250mA
Reverse Diode Voltage ..... -28V
Power Dissipation
Plastic DIP (derate 7mW/°C above 70°C) 375mW
CERDIP (derate 9.5mW/°C above 70°C) 675mW
Small Outline (derate 7mW/°C above 70°C) 375mW
LCC (derate 7mW/°C above 70°C) 375mW
Lead Temperature (Soldering, 10 seconds) ..... +300°C
Storage Temperature ..... -65°C to +160°C

Stresses above 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 above those indicated in the operational section of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS: MAX251

(Test Circuit 1, See Figure 3, T_A = Full Temperature Range unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Positive Supply Current	I^+	$R_L = \infty$		0.7	2.5	mA
Negative Supply Current	I^-	$R_L = \infty$		0.45	1.0	mA
RS-232 CHARACTERISTICS						
RS-232 Output Voltage Swing	T_{VS}	All Transmitter Outputs loaded with 3kΩ to Ground	±5	±7.2		V
RS-232 Output Leakage Current	T_{OL}	$V^+ = V^- = 0V$ $T_{OUT} = ±15V$	-10		+10	µA
RS-232 Input Threshold High	V_{IH}			1.8	3.0	V
RS-232 Input Threshold Low	V_{IL}		0.6	1.2		V
RS-232 Input Hysteresis	V_{IHYS}			0.6		V
RS-232 Input Resistance		$T_A = 25°C$	3		7	kΩ
3-State Enable	t_{EN}			3.5		µs
3-State Disable	t_{DS}			1.0		µs
Transmitter Slew Rate		$R_L = 3kΩ$, $C_L = 2500pF$	3			V/µs
OPTOINTERFACE CHARACTERISTICS						
Input Pull-up Current	I_P	$T_A = 25°C$	2.5	4	6	µA
Input Pull-up Voltage Clamp	V_{PCL}	w. r. t. ISO GND		3		V
Input Threshold Voltage High	V_{IH}			1.5	2	V
Input Threshold Voltage Low	V_{IL}		0.8	1.2		V
Input Hysteresis Voltage	V_{IHYS}			0.3		V

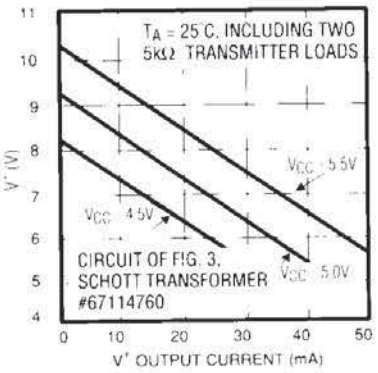
ELECTRICAL CHARACTERISTICS: MAX251 (continued)

(Test Circuit 1, See Figure 3, T_A = Full Temperature Range unless otherwise noted.)

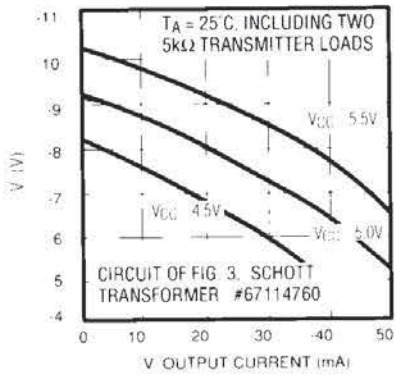
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Source Current	I_{PH}	V_{OUT} = 1.4V, T_A = 25°C	-12	-7	-5	mA
Output Voltage Low	V_{OL}	I_{OUT} = 3.2mA			0.4	V
Output Leakage Current, $R1_{LDR}$, $R2_{LDR}$	I_L	(RTR! or Shutdown) = +5V			10	µA
3-STATE CONTROL						
Pulldown Current	I_{TPD}	V = GND	10	4	1	µA
Threshold Voltage	V_T		0.6	1.4	2	V

Typical Operating Characteristics

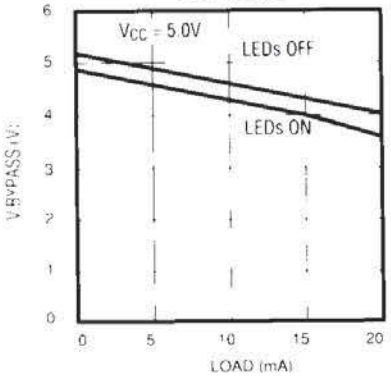
MAX251 V+ SUPPLY VOLTAGE vs. LOAD CURRENT



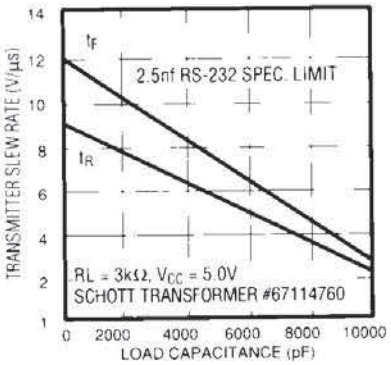
MAX251 V- SUPPLY VOLTAGE vs. LOAD CURRENT



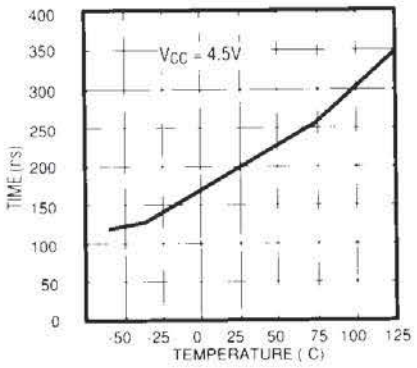
MAX251 V BYPASS vs. LOAD



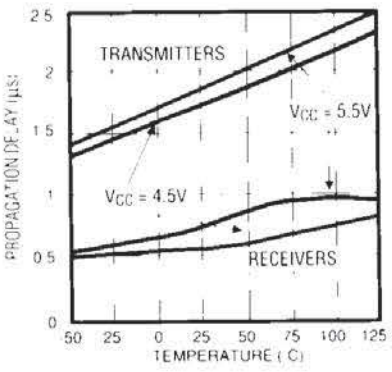
MAX251 TRANSMITTER SLEW RATE vs. LOAD CAPACITANCE



MAX250 PROPAGATION DELAY vs. TEMPERATURE

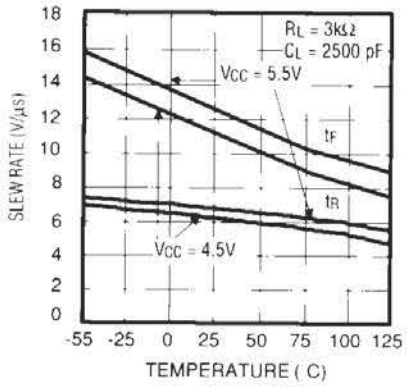


MAX251 PROPAGATION DELAY vs. TEMPERATURE

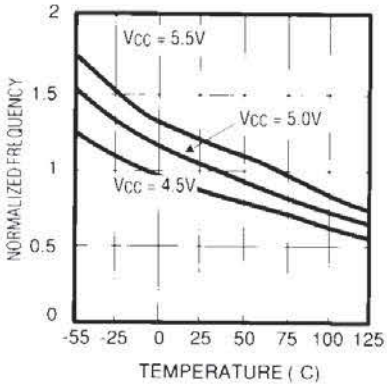


Typical Operating Characteristics (continued)

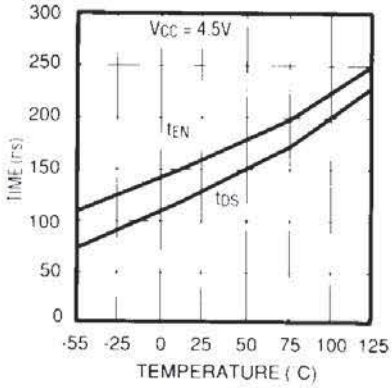
MAX251 TRANSMITTER SLEW RATE vs. TEMPERATURE



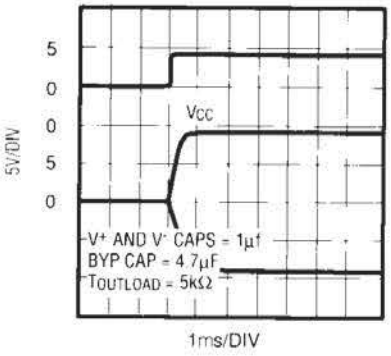
MAX250 D1, D2 SWITCH FREQUENCY vs. TEMPERATURE



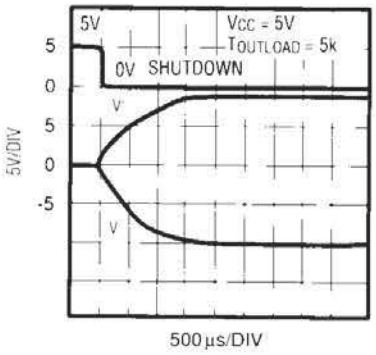
MAX250 ENABLE, DISABLE TIME vs. TEMPERATURE



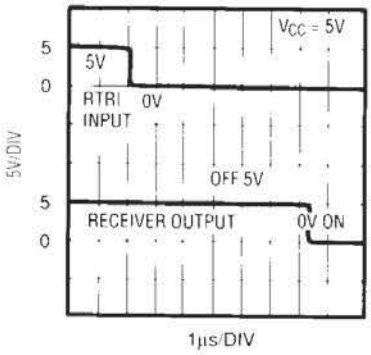
POWER UP DELAY FROM MAX250 V_{CC} TO MAX251 TRANSMITTER OUTPUTS



TIME FROM SHUTDOWN TO POWER UP



RTRI DELAY TIME TO RECEIVER OUTPUT ACTIVE



Pin Description

MAX250 LCC PIN#	MAX250 DIP & SO PIN#	SYMBOL	DESCRIPTION
1	-	N.C.	
2	1	SHDN	Shutdown: When+5V, turns off the oscillator, disconnects driver input pull-up resistors and opens D1, D2. For normal operation, ground shutdown.
3	2	D1	Open Drain of Transformer Driver MOSFET
4	3	$T1_{LDR}$	Transmitter #1 LED Driver
5	4	$T1_{IN}$	TTL/CMOS Transmitter #1 Input
6	-	N.C.	
7	5	$T2_{IN}$	TTL/CMOS Transmitter #2 Input
8	6	$T2_{LDR}$	Transmitter #2 LED Driver
9	-	N.C.	
10	7	GND	Ground
11	-	N.C.	
12	8	$\overline{EN}$	Output Enable: When +5V, Pins $T1_{LDR}$, $T2_{LDR}$, $R1_{OUT}$ and $R2_{OUT}$ go Hi impedance
13	-	N.C.	
14	9	$R1_{OUT}$	TTL/CMOS Receiver #1 Output
15	10	$R1_{DIN}$	Receiver #1 Detector Input
16	-	N.C.	
17	11	$R2_{DIN}$	Receiver #2 Detector Input
18	12	$R2_{OUT}$	TTL/CMOS Receiver #2 Output
19	13	D2	Open Drain of Transformer Driver MOSFET
20	14	V_{CC}	+5V Positive Supply Voltage

MAX251 LCC PIN#	MAX251 DIP & SO PIN#	SYMBOL	DESCRIPTION
1	-	N.C.	
2	1	AC	Anode of Input Power Supply Diode
3	2	V^+	Positive Supply Output Terminal
4	3	$T1_{DIN}$	Transmitter #1 Detector Input
5	4	$T2_{DIN}$	Transmitter #2 Detector Input
6	-	N.C.	
7	5	$R1_{LDR}$	Receiver #1 LED Driver
8	6	$R2_{LDR}$	Receiver #2 LED Driver
9	-	N.C.	
10	7	BYP	Internal V_{CC} Bypass Point
11	-	N.C.	
12	8	RTRI	Receiver Output 3-State: When +5V, Receiver Outputs go Hi impedance
13	-	N.C.	
14	9	$R2_{IN}$	RS-232 Receiver #2 Input
15	10	$R1_{IN}$	RS-232 Receiver #1 Input
16	-	N.C.	
17	11	$T2_{OUT}$	RS-232 Transmitter #2 Output
18	12	$T1_{OUT}$	RS-232 Transmitter #1 Output
19	13	V^-	Negative Supply Output Voltage
20	14	ISO GND	Isolated Ground

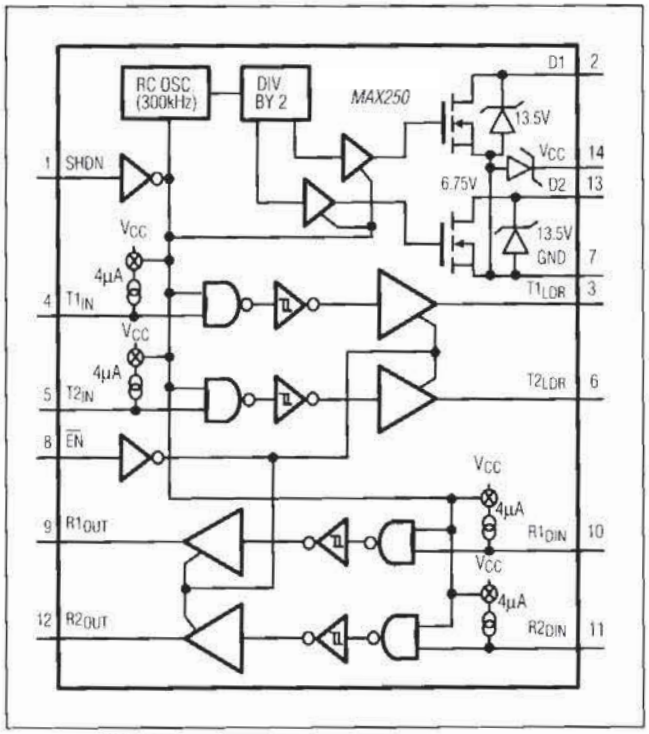


Figure 1. MAX250 Block Diagram

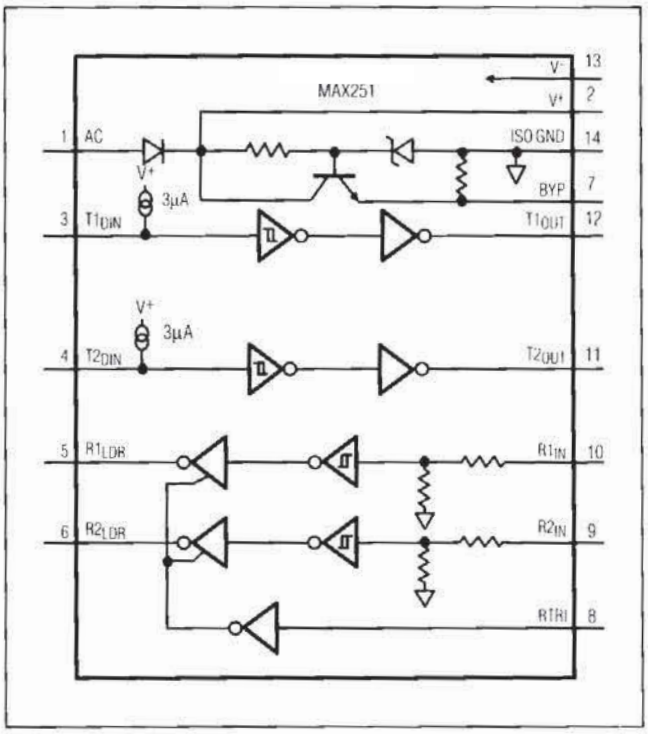


Figure 2. MAX251 Block Diagram

Typical Applications

Figure 3 shows the typical connection for a complete 19.2k baud isolated RS-232 circuit. Figure 3 also shows how 4N26 optocouplers can be replaced by 6N136 devices to achieve 90k baud rates.

A recommended printed circuit board layout is shown in Figure 4. This may be modified for individual designs but two important factors should be considered. 1.) To maximize isolation, the "isolation line" through the center of Figure 4 should not be breached. Connections and components from one side should not be located near those of the other side. 2.) Since the optocoupler outputs are relatively high impedance nodes, they should be located as close as possible to the MAX250 and MAX251. This minimizes stray capacitance and maximizes data rate.

When the MAX250's shutdown input (SHDN) is taken high, power is removed from the MAX251, and the RS-232 transmitter outputs ($T1_{OUT}$, $T2_{OUT}$) go to high impedance states. Timing plots in the Typical Operating Characteristics section show the turn-on and enable delays for various control functions.

The circuit in Figure 4 has been laid out so that it can be used for either a one or two sided PC board. The lines that are thick from one IC pad to the next IC pad are on the bottom side. Lines that are broken by a thin line can either go on the top side of the board or on the bottom side with jumpers where the thin lines appear. At no time should any lines cross the middle of the board at the isolation barrier.

The MAX250 and MAX251 have a logic inversion in the optocoupler when using the standard configuration. For applications where no inversion is required, or more LED drive current is needed, Figure 5 shows the output structure of the LDR output. The LDR output can typically source 7mA and sink 25mA. Because of the higher sinking capability, a current limiting resistor is required.

Detailed Description

The MAX250 and MAX251, together with four optocouplers and a transformer, form an isolated dual RS-232 transmitter and receiver (See Figure 3). The MAX250 connects to the non-isolated or "logic" side of the interface, translating logic signals to and from the optocouplers, while the MAX251 resides on the isolated or "cable" side, translating data between the optocouplers and RS-232 line drivers and receivers. In addition to the optocoupler drivers and receivers, the MAX250 also contains isolation transformer drive circuitry which supplies power to the isolated side of the interface, and the MAX251.

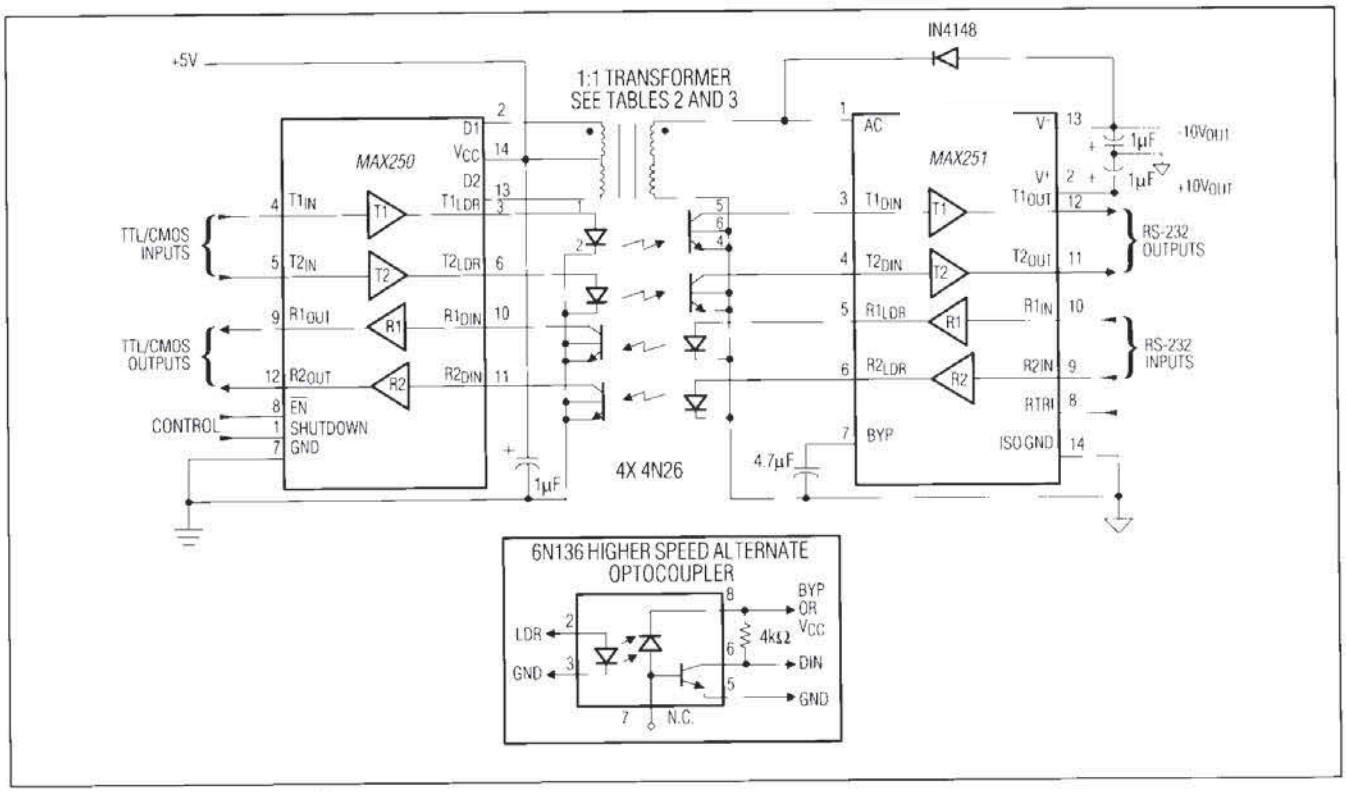


Figure 3. Isolated RS-232 Interface

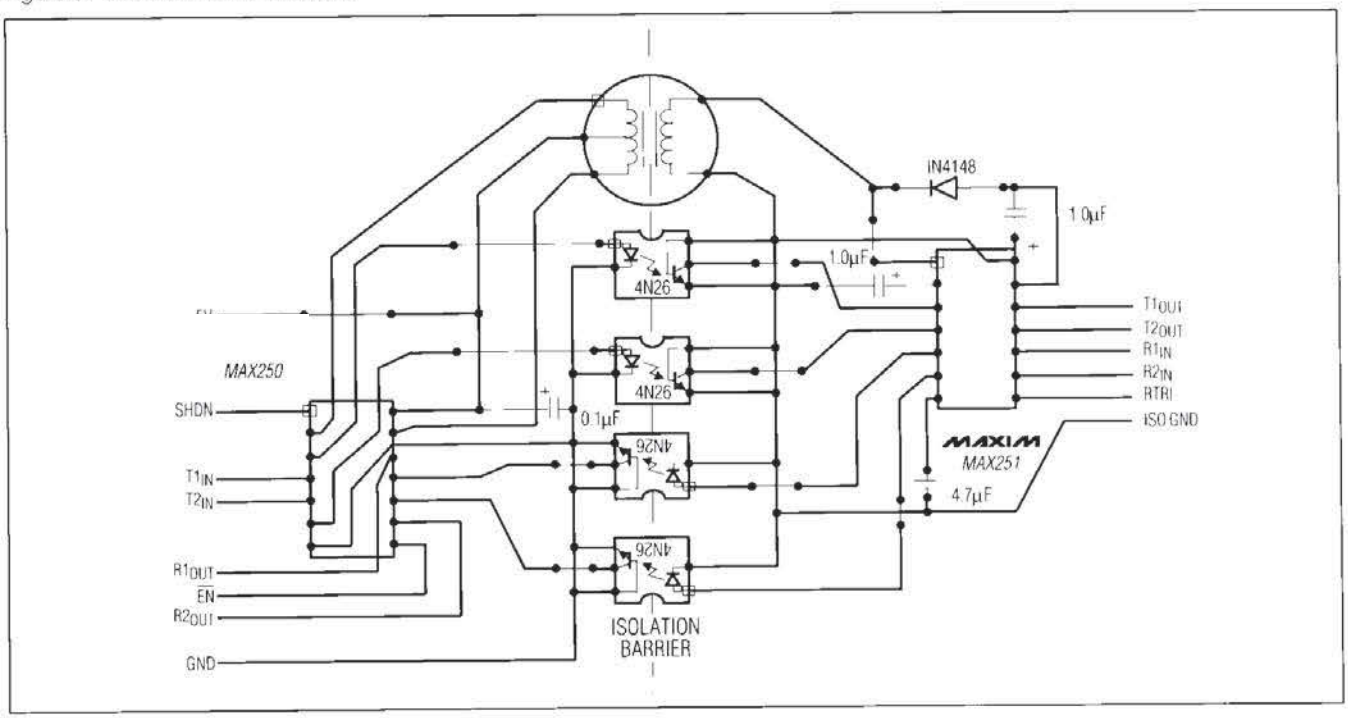


Figure 4. Recommended PC Board Layout for Dual Channel, Optoisolated, Self-Powered RS-232

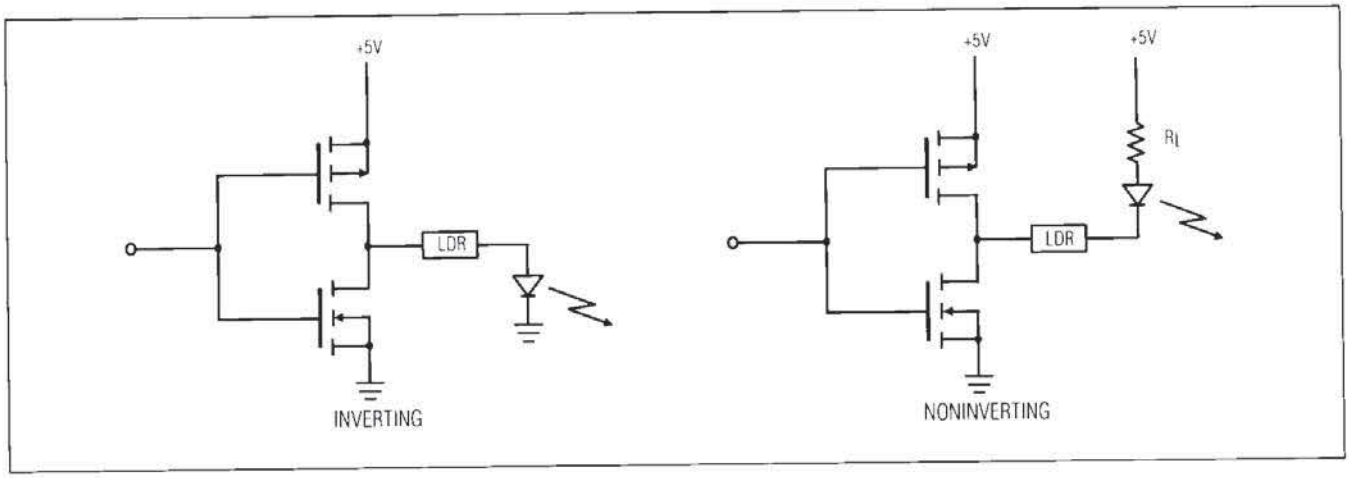


Figure 5. LDR Output Structure

MAX250

The MAX250 contains four identical noninverting drivers whose outputs may be used either as optocoupler LED drivers or as TTL/CMOS logic outputs. Each driver input ($T1_{IN}$, $T2_{IN}$, $R1_{DIN}$, $R2_{DIN}$) has a "weak" 4µA internal pull-up current source, and 0.5V of hysteresis to improve noise rejection. The input logic thresholds conform to standard TTL/CMOS specifications.

In normal operation, the MAX250 driver outputs ($T1_{LDR}$, $T2_{LDR}$, $R1_{OUT}$, $R2_{OUT}$) source 7mA via internal current sources and do not require limiting resistors when driving grounded optocoupler LEDs or CMOS/TTL logic inputs. The outputs can also sink up to 25mA when the current is limited by external resistors.

D1 and D2 are open-drain N-Channel MOSFETs which drive an external isolation transformer in push-pull fashion at 150kHz with a 50% duty cycle. A 1:1 transformer turns ratio provides a 10V peak-to-peak output at the secondary. Specifications and suitable manufacturer's part numbers for this transformer are listed in Tables 2 and 3. No transformer snubbers are required because D1 and D2 are protected against switching transients by internal 13.5V zener clamp diodes as shown in Figure 1.

The MAX250 functions also include an output enable control (EN) and a SHUTDOWN pin (SHDN). EN puts all driver outputs into a high impedance state when driven high. SHDN, when pulled high, disables the following MAX250 functions:

1.) Disables D1 and D2;

2.) Turns off the oscillator;

3.) Shuts off 4µA pull-up currents at driver inputs;

4.) Resets driver outputs to a low state;

5.) Lowers power consumption to 5µW.

MAX251

The MAX251 connects to the "cable" side of the RS-232 interface and includes two line drivers and receivers along with circuitry to translate these levels to optocoupler signals. The RS-232 inputs ($R1_{IN}$, $R2_{IN}$) and outputs ($T1_{OUT}$, $T2_{OUT}$) completely conform to all EIA RS-232C and CCITT V.28 specifications. The receiver outputs ($R1_{LDR}$, $R2_{LDR}$) source 7mA and can drive optocoupler inputs without external current limiting resistors. The MAX251 transmitter inputs ($T1_{DIN}$, $T2_{DIN}$) contain 4µA internal pull-ups which allow direct connection to optocoupler output transistors, again without external resistors.

When the MAX251's RTRI input is pulled high, the receiver outputs ($R1_{LDR}$, $R2_{LDR}$) are disabled and go to a high impedance state. In normal operation, this pin is left open or grounded.

Optocoupler Limitations

In Figure 3, the 4N26 optocouplers are connected in "diode mode" to optimize cost and data rate. While Current Transfer Ratio (CTR) is generally unspecified for this configuration, optocouplers from several manufacturers have been successfully tested in this circuit. The MAX250/MAX251 require a minimum optocoupler current transfer ratio of 0.12%, but may exhibit data rate limitations from the combined effect of higher MAX250/MAX251 drive and high optocoupler CTR.

The 6N136 optocouplers, shown in the inset in Figure 3 and listed in Table 1, operate in phototransistor mode, with limiting values of CTR specified by the manufacturers.

If further information is required, please contact Maxim Applications.

Component Selection

Optoisolators

Optoisolator manufacturers are listed in Table 1 for easy selection. The MAX250/251 combination can be used with a 4N26 to obtain a 19.2k baud rate when used in the diode-to-diode mode (base tied to the emitter). When the MAX250/251 is used with the 6N136, a 90k baud rate can be achieved when a 4kΩ pull-up resistor to 5V is used on pin 6 of the 6N136.

Table 1. Manufacturers of Optoisolators

PART NO.	MFGS	SUGGESTED R_L	V_{IOS} (V_{PK})	TYP. PROP t_{pHL}	t_{pLH}
4N25	MOT,PHL,QT,SM,TRW*	NONE[2]	2500V	14µs	6.3µs
4N26	MOT,PHL,QT,SM,TRW	NONE[2]	1500V	14µs	4.3µs
6N136	HP,QT,TRW	4K	2500V	1.8µs	1.5µs

* MOT= Motorola Inc. (303) 337-3434
PHL= Phillips (401) 232-0500
QT = Quality Technologies (General Instrument) (415) 493-0400
SM = Siemens Components (408) 257-7910
TRW= TRW Electronic Components Group (214) 323-2200

Note 1: This list does not constitute an endorsement by Maxim Integrated Products and is not intended to be a comprehensive list of all manufacturers of these components.
Note 2: When used with a MAX250/251.

Transformers

Table 2 is a list of transformer characteristics that should be used to customize your own transformer. Table 3 is a list of transformers that are compatible with the MAX250/251 chip set. The list includes both transformers that are small and more expensive and transformers that are larger and less expensive.

Table 2. Transformer Characteristics

Pri. Inductance	1mH to 2.5mH
Pri. Leakage Inductance	30µH
Turns Ratio	1:1 Pri. center tapped
ET	50V-µs
Switching Frequency	150kHz
Interwinding Capacitance	< 100pF
DC Resistance	< 2Ω
Ipk	300mA
Dielectric Strength	> 1500 VAC/1sec.

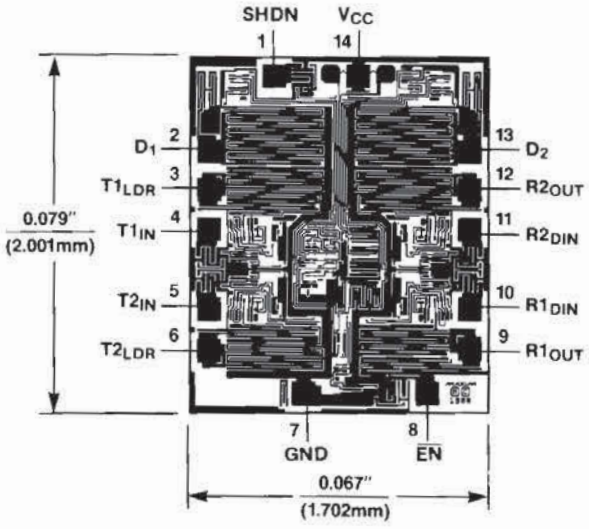
Table 3. Transformers Selection for Common Designs

MANUFACTURERS	LESS EXPENSIVE	SMALL
BH ELECTRONICS 604 Michigan Rd. Marshall, MN 56258 (507) 532-3211	Q6471-1	Q6471-2
MINI-MAGNETICS 1100 Fulton Place Fremont, CA 94539-7077 (415) 490-7500	MM2757	MM2758
SCHOTT Corporation 1000 Parkers Lake Rd. Minneapolis, MN 55391 (612) 475-1173	67114760	67117970

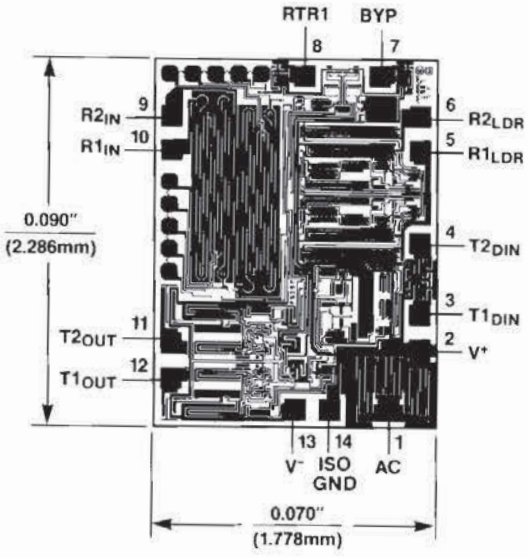
Note 1: This list does not constitute an endorsement by Maxim Integrated Products and is not intended to be a comprehensive list of all manufacturers of these components.

Chip Topographies

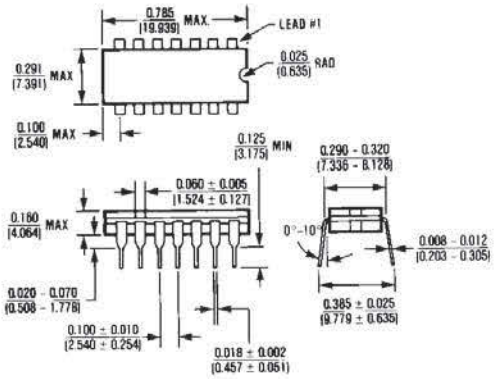
MAX250



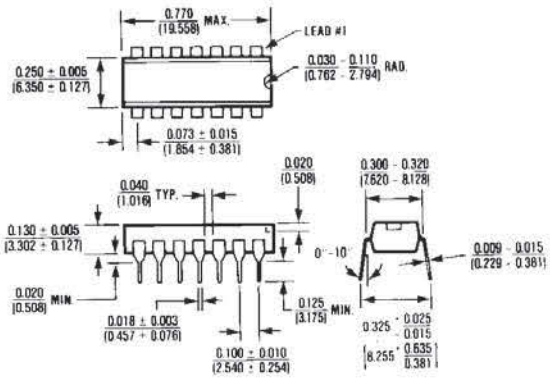
MAX251



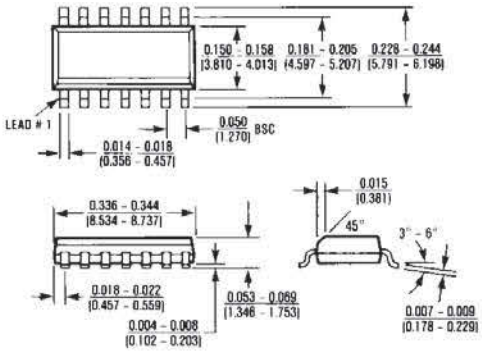
Package Information



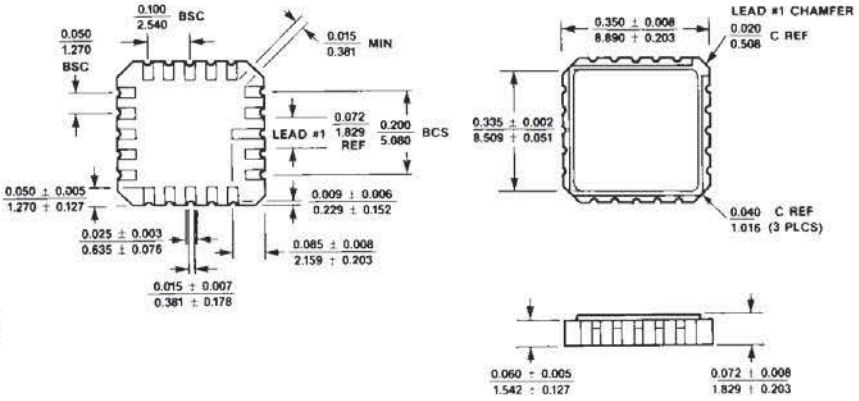
14 Lead CERDIP (JD)
θ_{JA} = 105°C/W
θ_{JC} = 50°C/W



14 Lead Plastic DIP (PD)
θ_{JA} = 140°C/W
θ_{JC} = 70°C/W



14 Lead Small Outline (SD)
θ_{JA} = 115°C/W
θ_{JC} = 60°C/W



20 Leadless Chip Carrier (LP)
θ_{JA} = 140°C/W
θ_{JC} = 45°C/W

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