



November 2003

LMS485E

Low Power RS-485 / RS-422 Differential Bus Transceiver

General Description

The LMS485E is a low power differential bus/line transceiver designed for high speed bidirectional data communication on multipoint bus transmission lines. It is designed for balanced transmission lines. It meets ANSI Standards TIA/EIA RS422-B, TIA/EIA RS485-A and ITU recommendation and V.11 and X.27. The driver outputs and receiver inputs have $\pm 15\text{kV}$ ESD protection. The LMS485E combines a TRI-STATE™ differential line driver and differential input receiver, both of which operate from a single 5.0V power supply. The driver and receiver have an active high and active low, respectively, that can be externally connected to function as a direction control. The driver outputs and receiver inputs are internally connected to form a differential input/output (I/O) bus port that is designed to offer minimum loading to bus whenever the driver is disabled or when $V_{CC} = 0\text{V}$. These ports feature wide positive and negative common mode voltage ranges, making the device suitable for multipoint applications in noisy environments. The LMS485E is available in 8-Pin SOIC and 8-pin DIP packages. It is a drop-in replacement to Maxim's MAX485E.

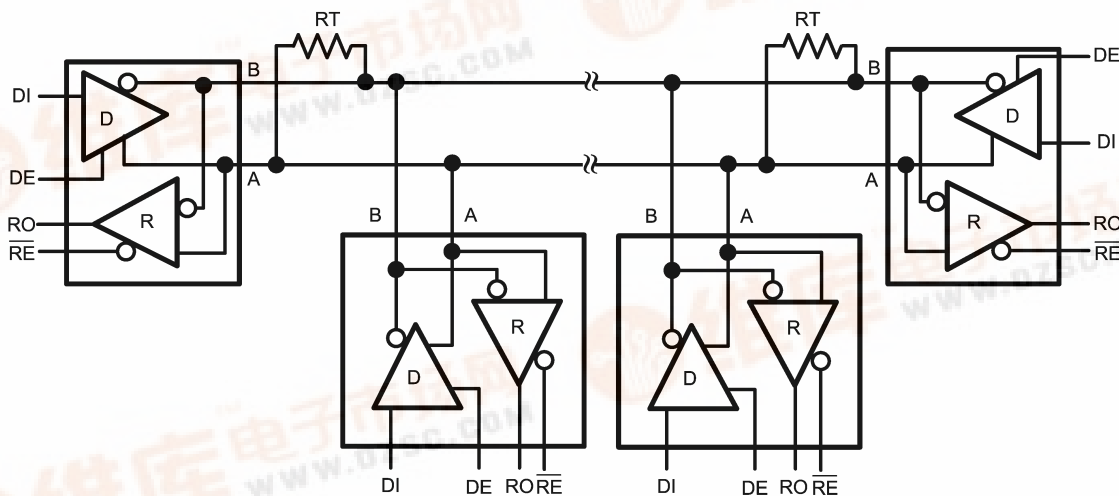
Features

- Meet ANSI standard RS-485 and RS-422
- Data rate 2.5 Mbps
- Single supply voltage operation, 5V
- Wide input and output voltage range
- Thermal shutdown protection
- Short circuit protection
- Low quiescent current 800 μA (max)
- Allows up to 32 transceivers on the bus
- Open circuit fail-safe for receiver
- Extended operating temperature range -40°C to 85°C
- Drop-in replacement to MAX485E
- Available in 8-pin SOIC and 8-pin DIP packages

Applications

- Low power RS-485 systems
- Network hubs, bridges, and routers
- Point of sales equipment (ATM, barcode scanners,...)
- Local area networks (LAN)
- Integrated service digital network (ISDN)
- Industrial programmable logic controllers
- High speed parallel and serial applications
- Multipoint applications with noisy environment

Typical Application



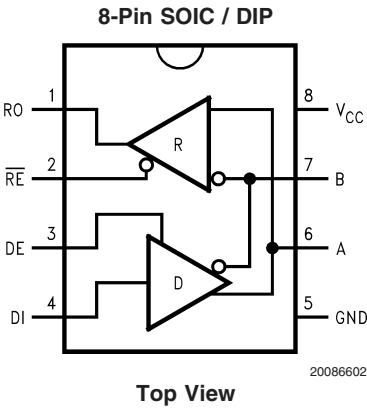
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A typical multipoint application is shown in the above figure. Terminating resistor, R_T are typically required but only located at the two ends of the cable. Pull-up and pull-down resistors maybe required at the end of the bus to provide fail-safe biasing. The biasing resistors provide a bias to the cable when all drivers are in TRI-STATE, See National Application Note, AN-847 for further information.

LMS485E Low Power RS-485 / RS-422 Differential Bus Transceiver



Connection Diagram



Truth Table

DRIVER SECTION				
RE*	DE	DI	A	B
X	H	H	H	L
X	H	L	L	H
X	L	X	Z	Z
RECEIVER SECTION				
RE*	DE	A-B		RO
L	L	$\geq +0.2V$		H
L	L	$\leq -0.2V$		L
H	X	X		Z
L	L	OPEN *		H

Note: * = Non Terminated, Open Input only
X = Irrelevant
Z = TRI-STATE
H = High level
L = Low level

Pin Descriptions

Pin #	I/O	Name	Function
1	O	RO	Receiver Output: If $A > B$ by 200 mV, RO will be high; If $A < B$ by 200 mV, RO will be low. RO will be high also if the inputs (A and B) are open (non-terminated).
2	I	$\overline{RE}^*$	Receiver Output Enable: RO is enabled when $\overline{RE}^*$ is low; RO is in TRI-STATE when $\overline{RE}^*$ is high
3	I	DE	Driver Output Enable: The driver outputs (A and B) are enabled when DE is high; they are in TRI-STATE TRI-STATE® when DE is low. Pins A and B also function as the receiver input pins (see below)
4	I	DI	Driver Input: A low on DI forces A low and B high while a high on DI forces A high and B low when the driver is enabled
5	NA	GND	Ground
6	I/O	A	Non-inverting Driver Output and Receiver Input pin. Driver output levels conform to RS-485 signaling levels
7	I/O	B	Inverting Driver Output and Receiver Input pin. Driver Output levels conform to RS-485 signaling levels
8	NA	V_{CC}	Power Supply: $4.75V \leq V_{CC} \leq 5.25V$

Ordering Information

Package	Part Number	Package Marking	Transport Media	NSC Drawing
8-Pin SOIC	LMS485ECM	LMS485ECM	95 Units/Rail	M08A
	LMS485ECMX		2.5k Units Tape and Reel	
	LMS485EIM	LMS485EIM	95 Units/Rail	
	LMS485EIMX		2.5k Units Tape and Reel	
8-Pin DIP	LMS485ECNA	LMS485ECNA	40 Units/Rail	N08E
	LMS485EINA	LMS485EINA	40 Units/Rail	

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage, V_{CC} (Note 2)	6V
Input Voltage, V_{IN} (DI, DE, or $\overline{RE}$)	-0.3V to $V_{CC} + 0.3V$
Voltage Range at Bus Terminals (AB)	-7V to 12V
Receiver Output	-0.3V to $V_{CC} + 0.3V$
Package Thermal Impedance, θ_{JA}	
SOIC	125° C/W
DIP	92° C/W
Junction Temperature (Note 3)	150°C
Operating Free-Air Temperature Range, T_A	
Commercial	0°C to 70°C
Industrial	-40°C to 85°C
Storage Temperature Range	-65°C to 150°C
Soldering Information	
Infrared or Convection (20 sec.)	235°C
Lead Temperature Range	+260°C

ESD Rating (Human Body Model)(Note 4)

Bus Pins	15kV
Other Pins	2kV

ESD Rating (Machine Model)

All Pins	200V
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Operating Ratings

	Min	Nom	Max	
Supply Voltage, V_{CC}	4.75	5.0	5.25	V
Voltage at any Bus Terminal (Separately or Common Mode)	-7		12	V
High-Level Input Voltage, V_{IH} (Note 5)	2			V
Low-Level Input Voltage, V_{IL} (Note 5)			0.8	V
Differential Input Voltage, V_{ID} (Note 6)			±12	V

Electrical Characteristics

Over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Driver Section						
$ V_{OD1} $	Differential Output Voltage	$R = \infty$ (Figure 1)			5.25	V
$ V_{OD2} $	Differential Output Voltage	$R = 50\Omega$ (Figure 1) , RS-422	2.0			V
		$R = 27\Omega$ (Figure 1) , RS-485	1.5		5.0	
ΔV_{OD}	Change in Magnitude of Driver Differential Output Voltage for Complementary Output States	$R = 27\Omega$ or 50Ω (Figure 1) , (Note 7)			0.2	V
V_{OC}	Common Mode Output Voltage	$R = 27\Omega$ or 50Ω (Figure 1)			3.0	V
ΔV_{OC}	Change in Magnitude of Driver Common-Mode Output Voltage for Complementary Output States	$R = 27\Omega$ or 50Ω (Figure 1), (Note 7)			0.2	V
V_{IH}	CMOS Input Logic Threshold High	DE, DI, $\overline{RE}$	2.0			V
V_{IL}	CMOS Input Logic Threshold Low	DE, DI, $\overline{RE}$			0.8	V
I_{IN1}	Logic Input Current	DE, DI, $\overline{RE}$			±2	µA
Receiver Section						
I_{IN2}	Input Current (A, B)	DE = 0V, $V_{CC} = 0V$ or 5.25V			0.25	mA
		$V_{IN} = 12V$				
		$V_{IN} = -7V$			-0.2	
V_{TH}	Differential Input Threshold Voltage	$-7V \leq V_{CM} \leq +12V$	-0.2		+0.2	V
ΔV_{TH}	Input Hysteresis ($V_{TH+} - V_{TH-}$)	$V_{CM} = 0$		95		mV
V_{OH}	CMOS High-level Output Voltage	$I_{OH} = 4\text{ mA}$, $V_{ID} = -200\text{ mV}$	3.5			V

Electrical Characteristics (Continued)

Over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{OL}	CMOS Low-level Output Voltage	$I_{OL} = -4 \text{ mA}$, $V_{ID} = 200 \text{ mV}$			0.4	V
I_{OZR}	Tristate Output Leakage Current	$0.4\text{V} \leq V_O \leq +2.4\text{V}$			± 1	μA
R_{IN}	Input Resistance	$-7\text{V} \leq V_{CM} \leq +12\text{V}$	12			$\text{k}\Omega$
Power Supply Current						
I_{CC}	Supply Current	$DE = V_{CC}$, $\overline{RE} = \text{GND}$ or V_{CC}		400	800	μA
		$DE = 0\text{V}$, $\overline{RE} = \text{GND}$ or V_{CC}		360	560	
I_{OSD1}	Driver Short-circuit Output Current	$V_O = \text{high}$, $-7\text{V} \leq V_{CM} \leq +12\text{V}$			250	mA
I_{OSD2}	Driver Short-circuit Output Current	$V_O = \text{low}$, $-7\text{V} \leq V_{CM} \leq +12\text{V}$			250	mA
I_{OSR}	Receiver Short-circuit Output Current	$0\text{V} \leq V_O \leq V_{CC}$			95	mA
Switching Characteristics						
Driver						
T_{PLH} , T_{PHL}	Propagation Delay Input to Output	$R_L = 54\Omega$, $C_L = 100 \text{ pF}$	10	40	80	ns
T_{SKEW}	Driver Output Skew	$R_L = 54\Omega$, $C_L = 100 \text{ pF}$		5	10	ns
T_R , T_F	Driver Rise and Fall Time	$R_L = 54\Omega$, $C_L = 100 \text{ pF}$	3	10	40	ns
T_{ZH} , T_{ZL}	Driver Enable to Output Valid Time	$C_L = 100 \text{ pF}$		25	70	ns
T_{HZ} , T_{LZ}	Driver Output Disable Time	$C_L = 15 \text{ pF}$		35	70	ns
Receiver						
T_{PLH} , T_{PHL}	Propagation Delay Input to Output	$R_L = 54\Omega$, $C_L = 100 \text{ pF}$	20	90	200	ns
T_{SKEW}	Receiver Output Skew	$R_L = 54\Omega$, $C_L = 100 \text{ pF}$		5		ns
T_{ZH} , T_{ZL}	Receiver Enable Time	$C_L = 15 \text{ pF}$		20	50	ns
T_{HZ} , T_{LZ}	Receiver Disable Time	$C_L = 15 \text{ pF}$		20	50	ns
F_{MAX}	Maximum Data Rate		2.5			Mbps

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.

Note 2: All voltage values, except differential I/O bus voltage, are with respect to the network ground terminal.

Note 3: The maximum power dissipation is a function of $T_{J(MAX)}$, θ_{JA} , and T_A . The maximum allowable power dissipation at any ambient temperature, T_A , is $P_D = (T_{J(MAX)} - T_A)/\theta_{JA}$. All numbers apply for packages soldered directly into a PC board.

Note 4: ESD rating based upon human body model, 100 pF discharged through 1.5 k Ω .

Note 5: Voltage limits apply to DI, DE, RE pins.

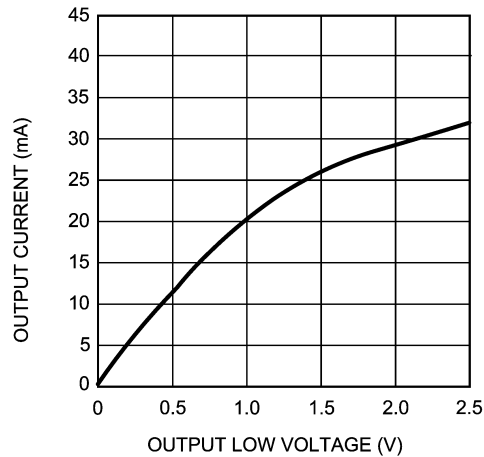
Note 6: Differential input/output bus voltage is measured at the non-inverting terminal A with respect to the inverting terminal B.

Note 7: $|\Delta V_{OD}|$ and $|\Delta V_{OC}|$ are changes in magnitude of V_{OD} and V_{OC} , respectively when the input changes from high to low levels.

Note 8: Peak current

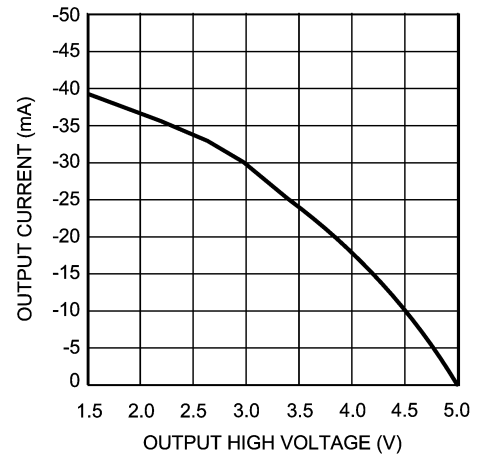
Typical Performance Characteristics

Output Current vs. Receiver Output Low Voltage



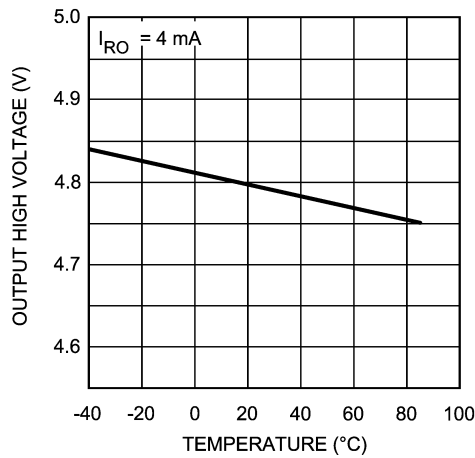
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Output Current vs. Receiver Output High Voltage



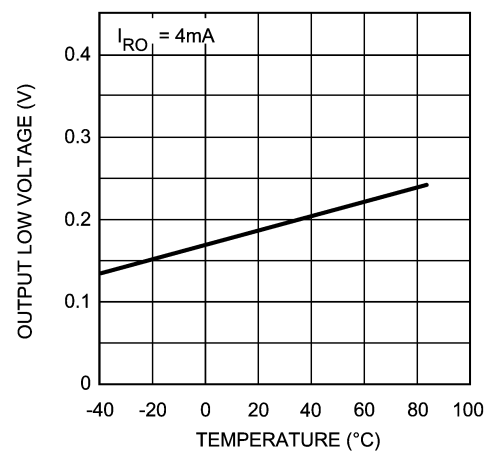
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Receiver Output High Voltage vs. Temperature



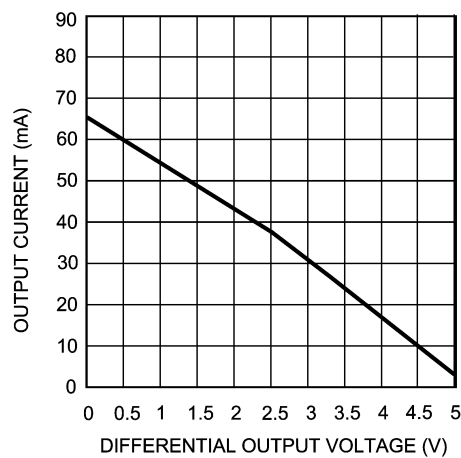
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Receiver Output Low-Voltage vs. Temperature



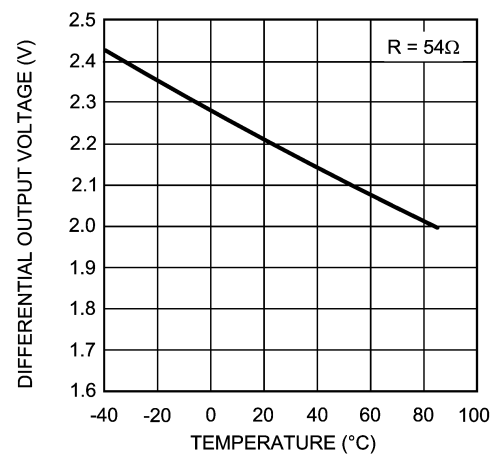
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Driver Output Current vs. Differential Output Voltage



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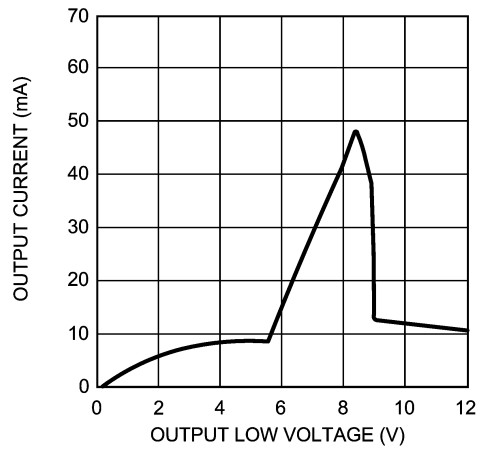
Driver Differential Output Voltage vs. Temperature



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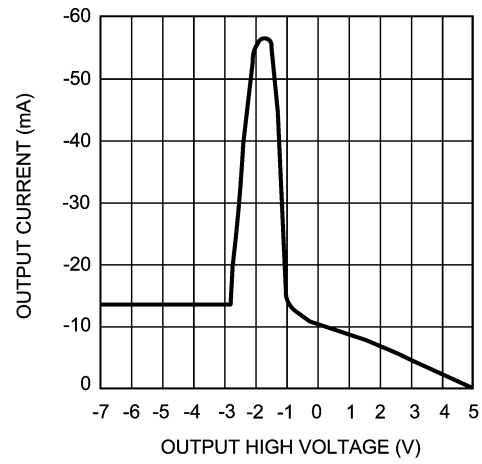
Typical Performance Characteristics (Continued)

Output Current vs. Driver Output Low Voltage



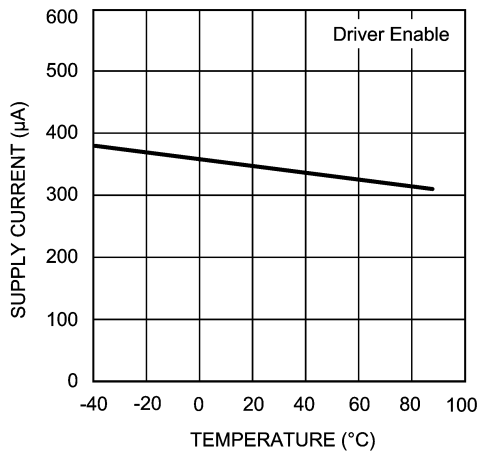
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Output Current vs. Driver Output High Voltage



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Supply Current vs. Temperature



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Parameter Measuring Information

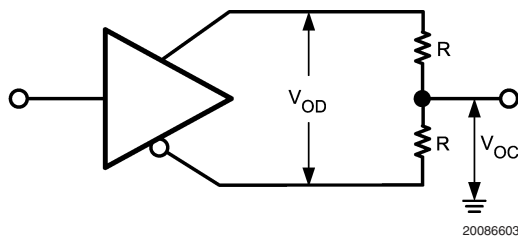


FIGURE 1. Test Circuit for V_{OD} and V_{OC}

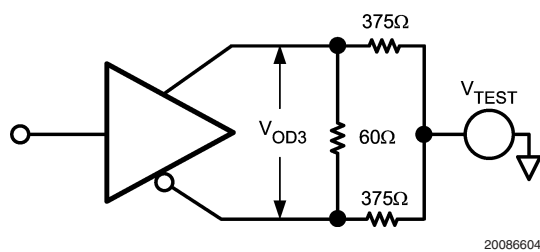


FIGURE 2. Test Circuit for V_{OD3}

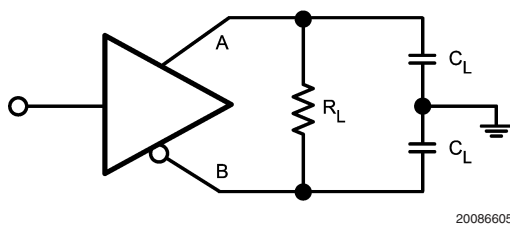


FIGURE 3. Test Circuit for Driver Propagation Delay

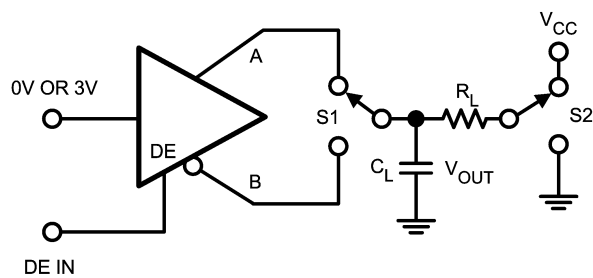


FIGURE 4. Test Circuit for Driver Enable / Disable

Parameter Measuring Information (Continued)

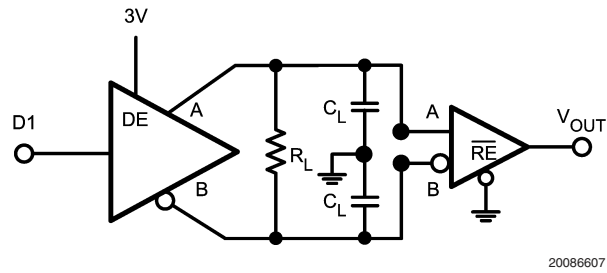


FIGURE 5. Test Circuit for Receiver Propagation Delay

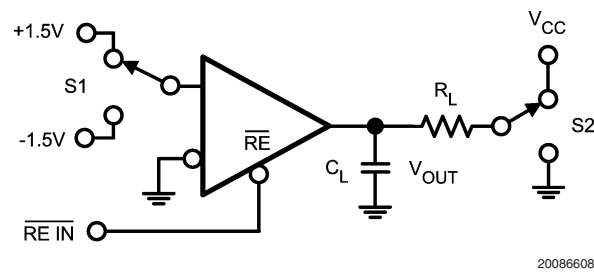


FIGURE 6. Test Circuit for Receiver Enable / Disable

Switching Characteristics

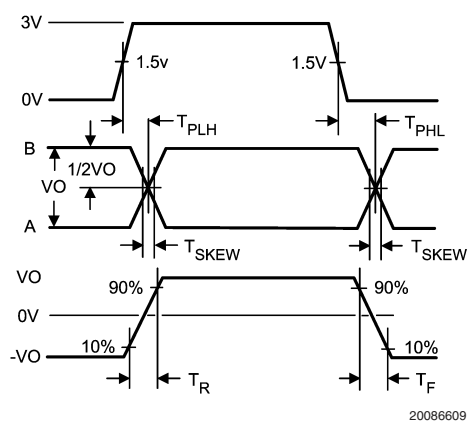


FIGURE 7. Driver Propagation Delay, Rise / Fall Time

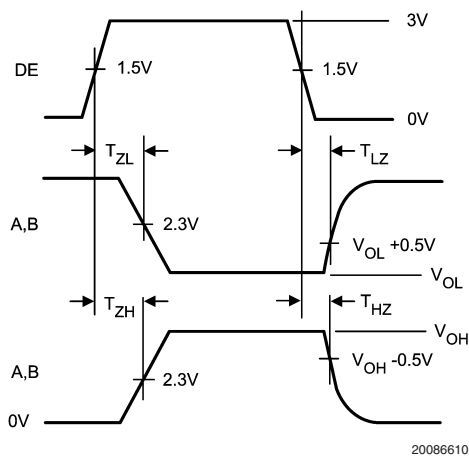


FIGURE 8. Driver Enable / Disable Time

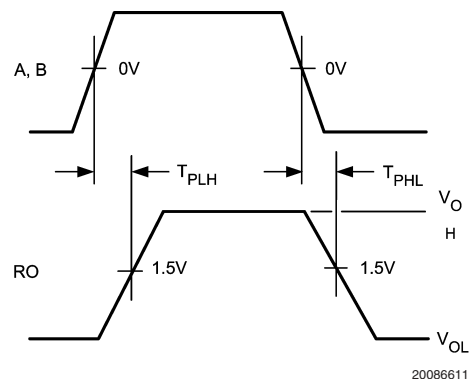


FIGURE 9. Receiver Propagation Delay

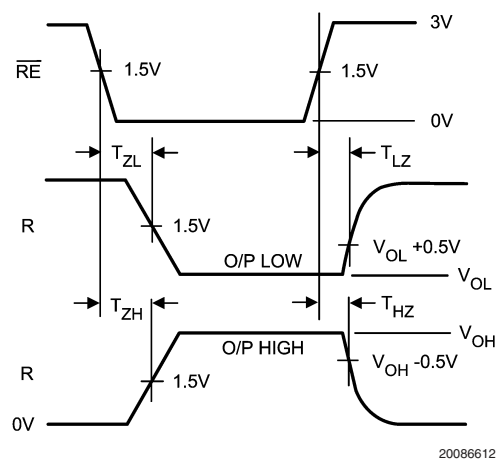


FIGURE 10. Receiver Enable / Disable Time

Application Information

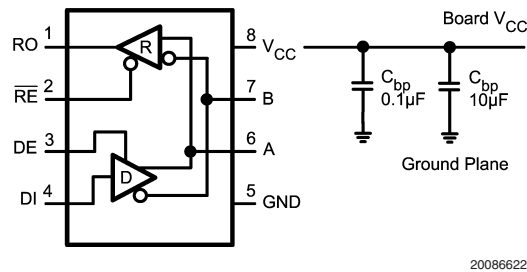
POWER LINE NOISE FILTERING

A factor to consider in designing power and ground is noise filtering. A noise filtering circuit is designed to prevent noise generated by the integrated circuit (IC) as well as noise entering the IC from other devices. A common filtering method is to place by-pass capacitors (C_{bp}) between the power and ground lines.

Placing a by-pass capacitor (C_{bp}) with the correct value at the proper location solves many power supply noise problems. Choosing the correct capacitor value is based upon the desired noise filtering range. Since capacitors are not

ideal, they may act more like inductors or resistors over a specific frequency range. Thus, many times two by-pass capacitors may be used to filter a wider bandwidth of noise. It is highly recommended to place a larger capacitor, such as $10\mu\text{F}$, between the power supply pin and ground to filter out low frequencies and a $0.1\mu\text{F}$ to filter out high frequencies.

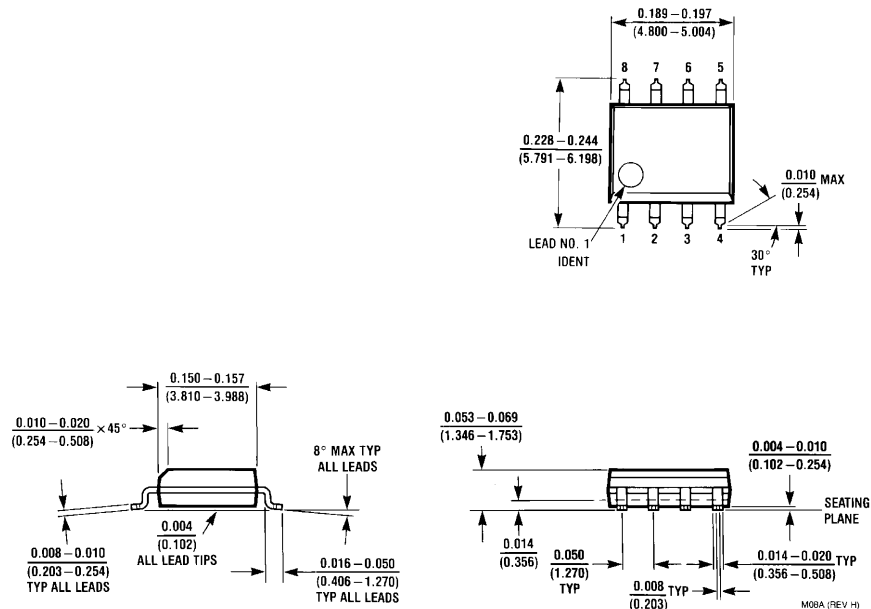
By-pass capacitors must be mounted as close as possible to the IC to be effective. Long leads produce higher impedance at higher frequencies due to stray inductance. Thus, this will reduce the by-pass capacitor's effectiveness. Surface mounted chip capacitors are the best solution because they have lower inductance.



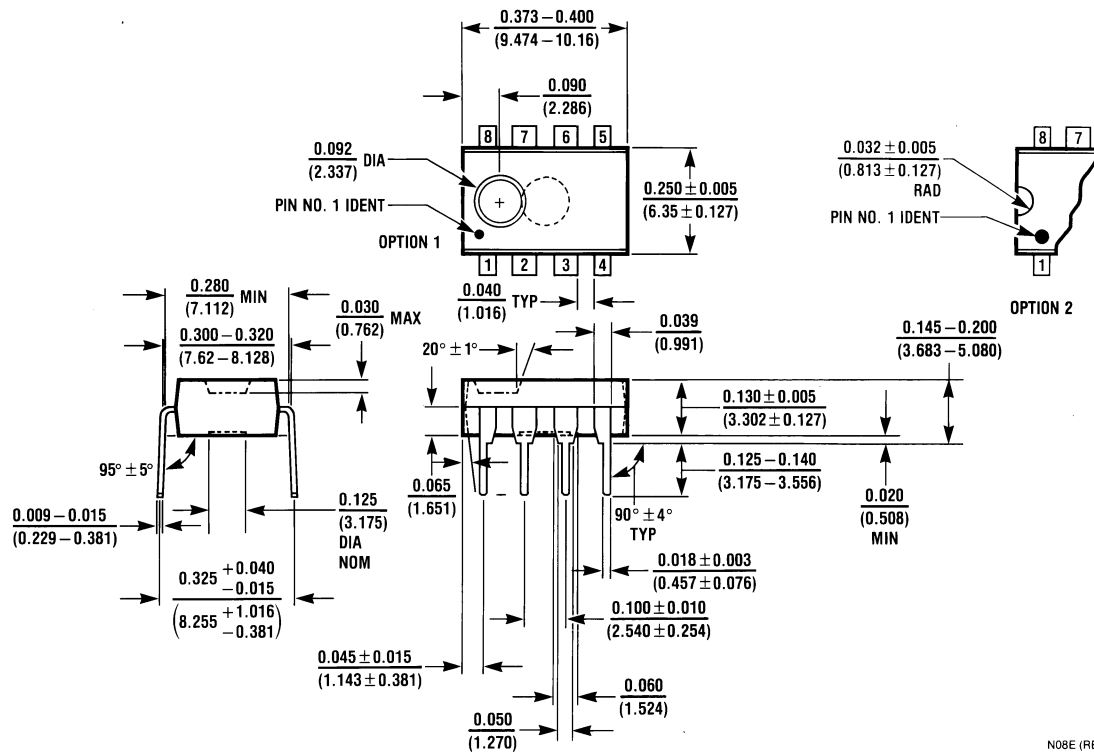
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FIGURE 11. Placement of by-pass Capacitors, C_{bp}

Physical Dimensions inches (millimeters) unless otherwise noted



8-Pin SOIC
NS Package Number M08A



8-Pin DIP
NS Package Number N08E

Notes

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