

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

General Description

The LMS1487E 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 LMS1487E 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 LMS1487E is available in 8-Pin SOIC and 8-pin DIP packages. It is a drop-in replacement to Maxim's MAX1487E.

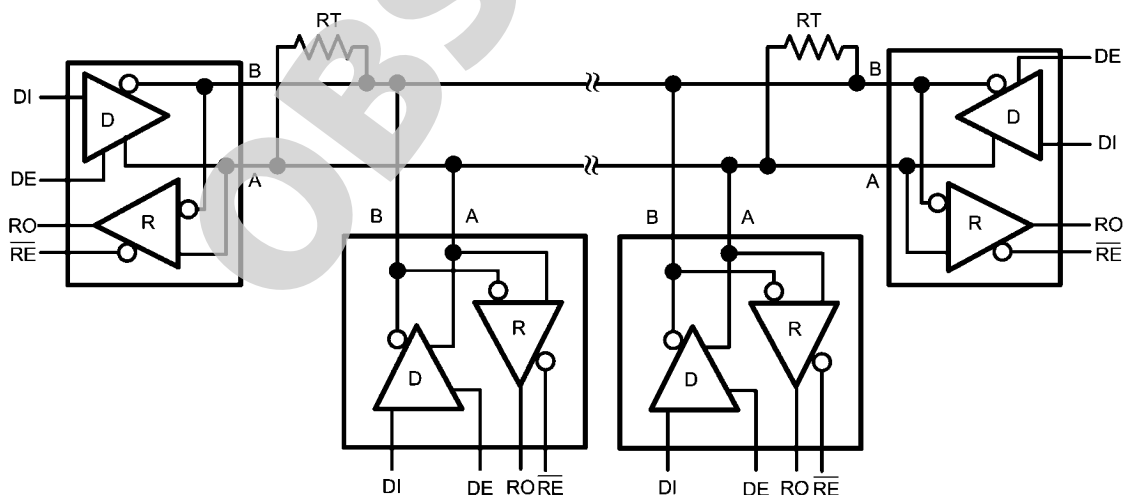
Features

- 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 660 μA (max)
- Allows up to 128 transceivers on the bus
- Open circuit fail-safe for receiver
- Extended operating temperature range -40°C to 85°C
- Drop-in replacement to MAX1487E
- 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

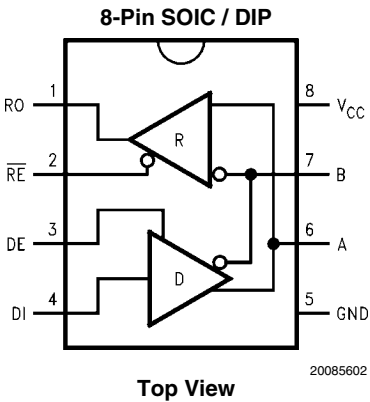
Typical Application



20085601

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 may be 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.

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 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	LMS1487ECM	LMS1487ECM	95 Units/Rail	M08A
	LMS1487ECMX		2.5k Units Tape and Reel	
	LMS1487EIM	LMS1487EIM	95 Units/Rail	
	LMS1487EIMX		2.5k Units Tape and Reel	
8-Pin DIP	LMS1487ECNA	LMS1487ECNA	40 Units/Rail	N08E
	LMS1487EINA	LMS1487EINA	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

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
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	$0.4V \leq V_O \leq +2.4V$			±1	μA

Symbol	Parameter	Conditions	Min	Typ	Max	Units
R_{IN}	Input Resistance	$-7V \leq V_{CM} \leq +12V$	48			k Ω
Power Supply Current						
I_{CC}	Supply Current	$DE = V_{CC}, \overline{RE} = GND \text{ or } V_{CC}$		400	660	μA
		$DE = 0V, \overline{RE} = GND \text{ or } V_{CC}$		360	560	
I_{OSD1}	Driver Short-circuit Output Current	$V_O = \text{high}, -7V \leq V_{CM} \leq +12V$			250	mA
I_{OSD2}	Driver Short-circuit Output Current	$V_O = \text{low}, -7V \leq V_{CM} \leq +12V$			250	mA
I_{OSR}	Receiver Short-circuit Output Current	$0V \leq V_O \leq V_{CC}$			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, $\overline{RE}$ pins.

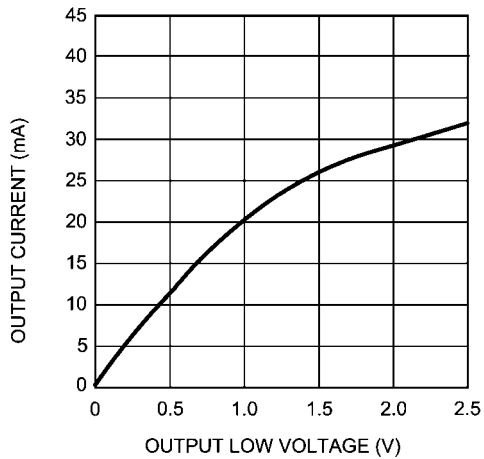
Note 6: Differential input/output bus voltage is measured at the non-inverting terminal A with respect to the inverting terminal B.

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

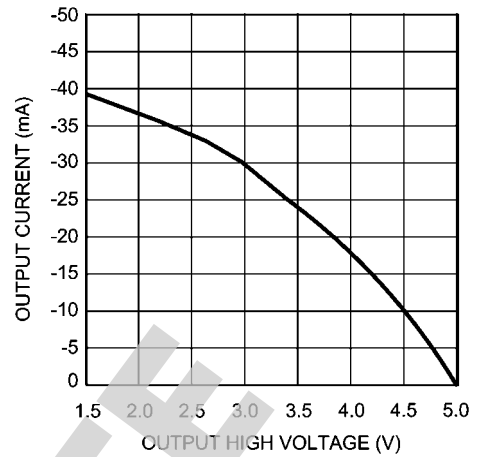
Typical Performance Characteristics

Output Current vs. Receiver Output Low Voltage



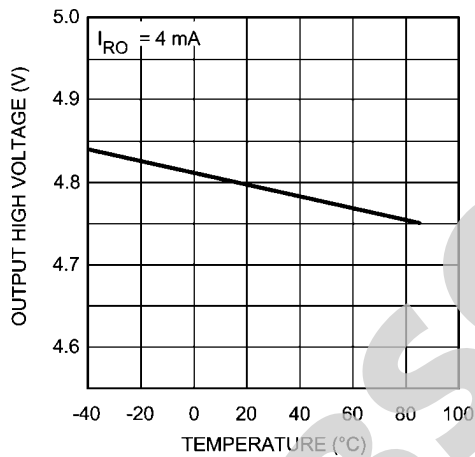
20085613

Output Current vs. Receiver Output High Voltage



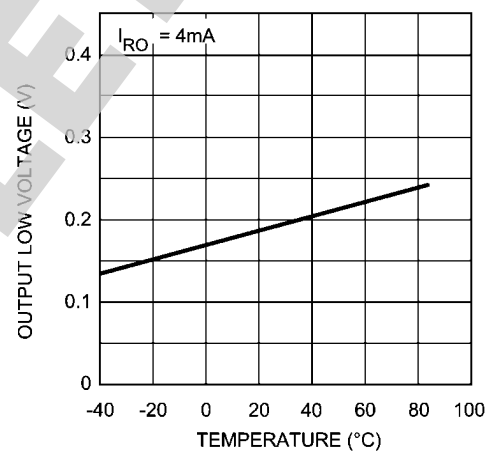
20085614

Receiver Output High Voltage vs. Temperature



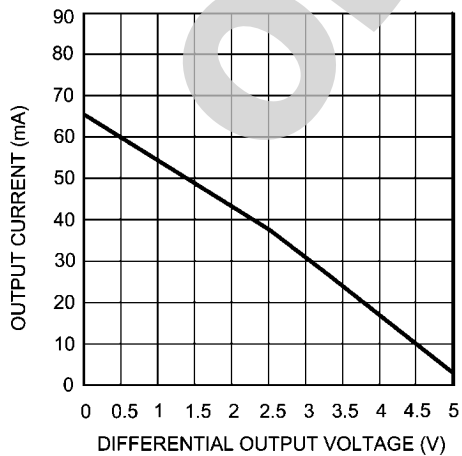
20085615

Receiver Output Low-Voltage vs. Temperature



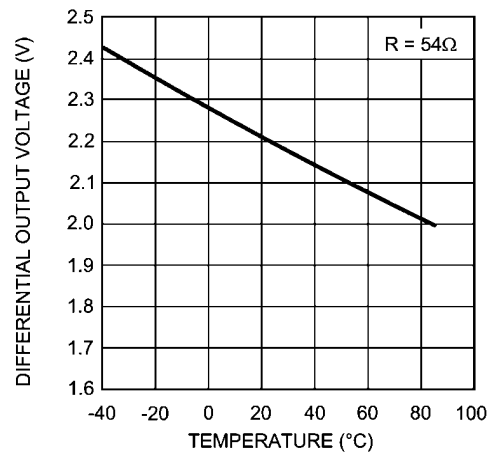
20085616

Driver Output Current vs. Differential Output Voltage



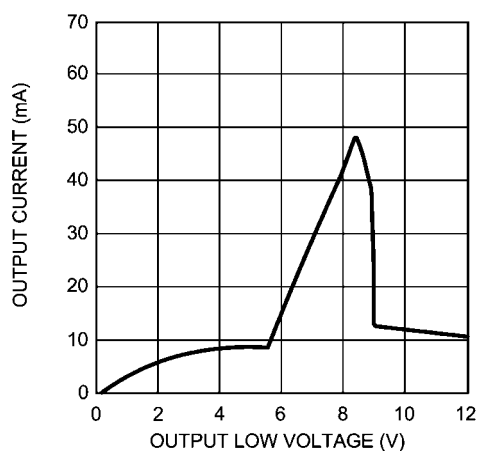
20085617

Driver Differential Output Voltage vs. Temperature



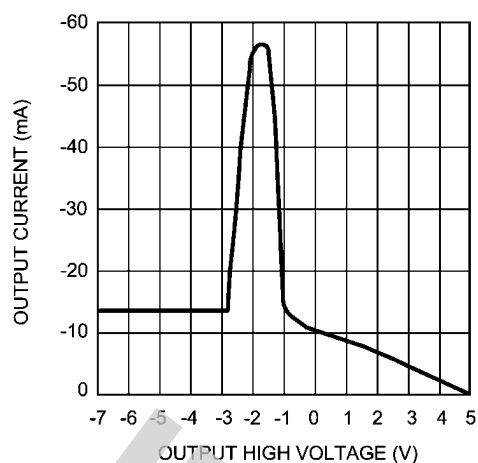
20085618

Output Current vs. Driver Output Low Voltage



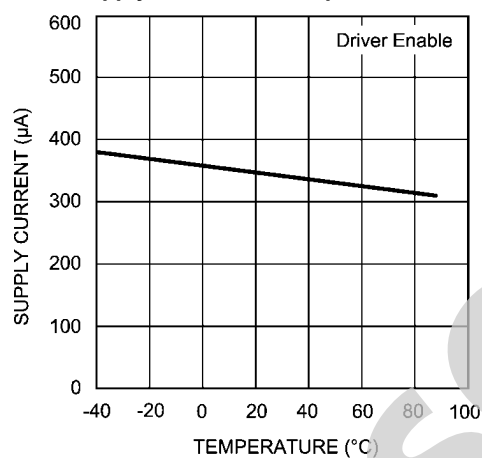
20085619

Output Current vs. Driver Output High Voltage



20085620

Supply Current vs. Temperature



20085621

Parameter Measuring Information

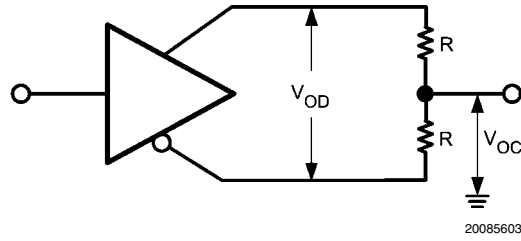


FIGURE 1. Test Circuit for V_{OD} and V_{OC}

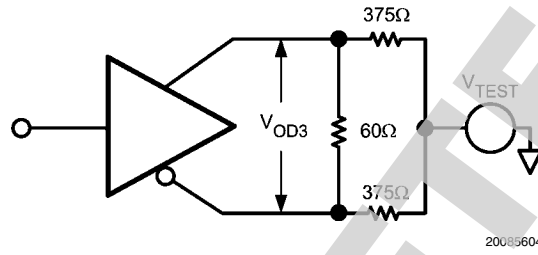


FIGURE 2. Test Circuit for V_{OD3}

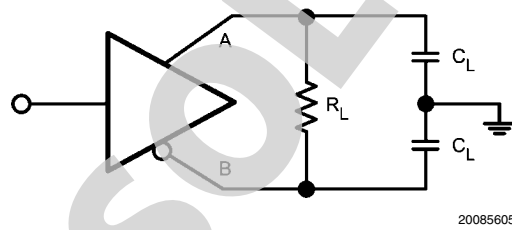


FIGURE 3. Test Circuit for Driver Propagation Delay

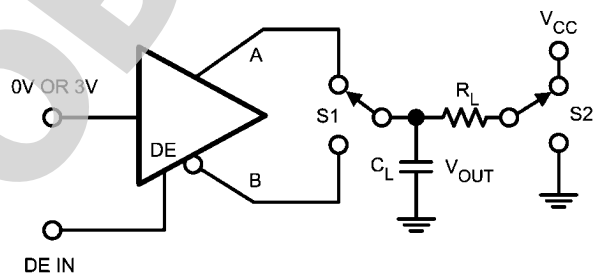


FIGURE 4. Test Circuit for Driver Enable / Disable

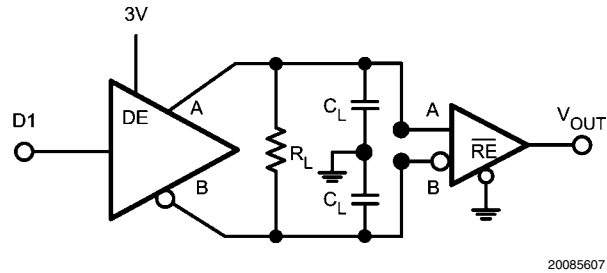


FIGURE 5. Test Circuit for Receiver Propagation Delay

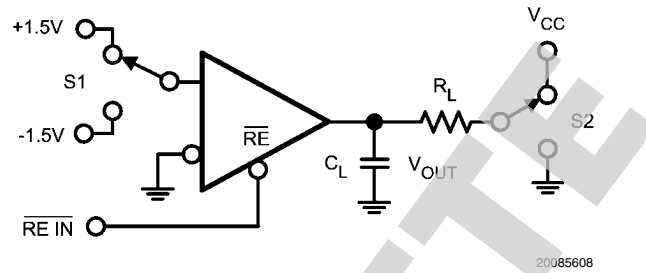
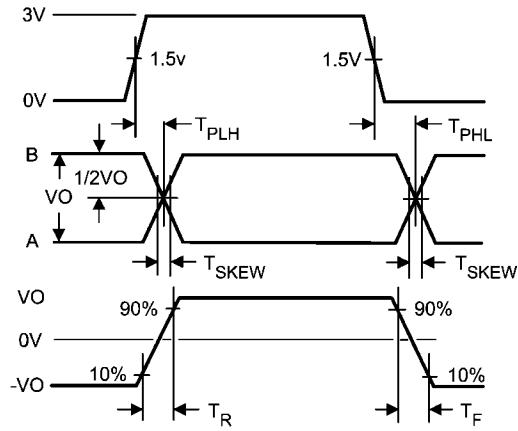


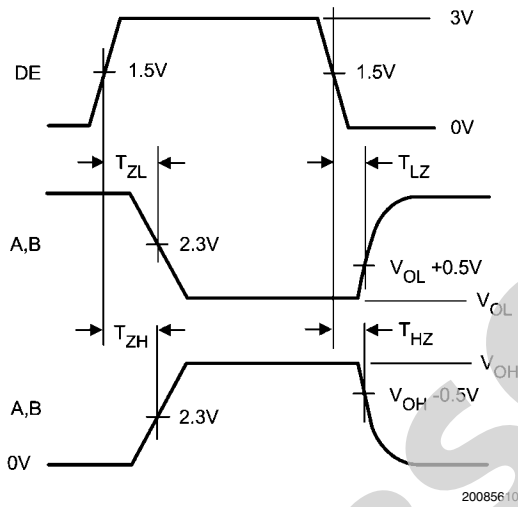
FIGURE 6. Test Circuit for Receiver Enable / Disable

Switching Characteristics



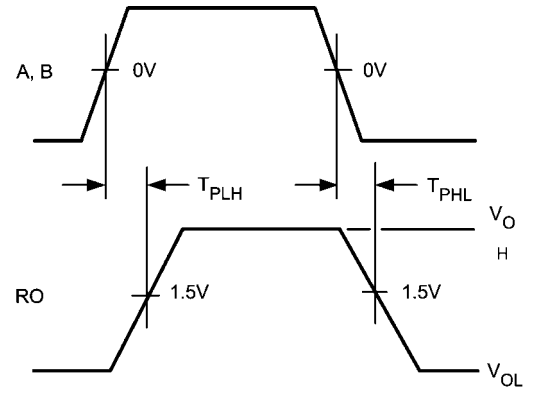
20085609

FIGURE 7. Driver Propagation Delay, Rise / Fall Time



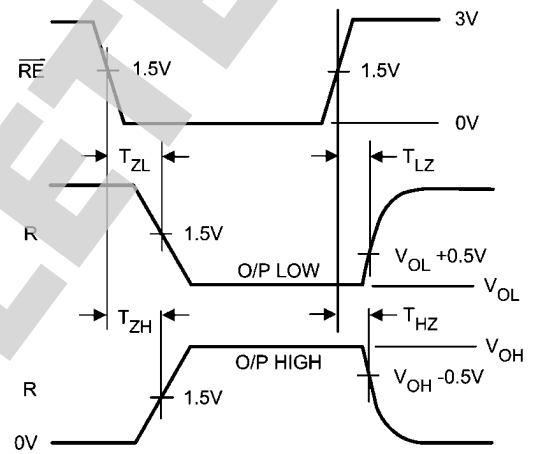
20085610

FIGURE 8. Driver Enable / Disable Time



20085611

FIGURE 9. Receiver Propagation Delay



20085612

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.

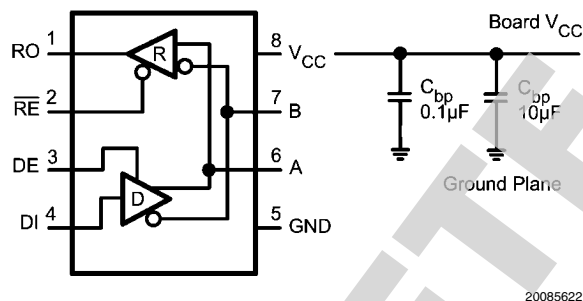
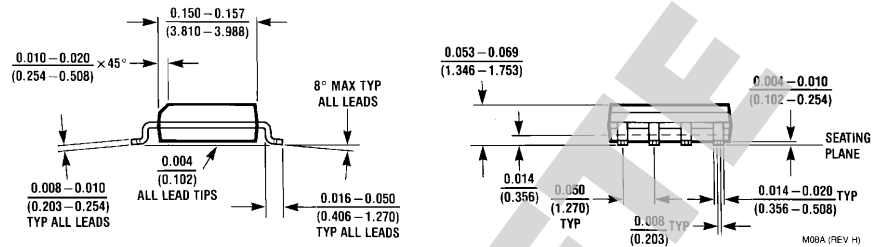
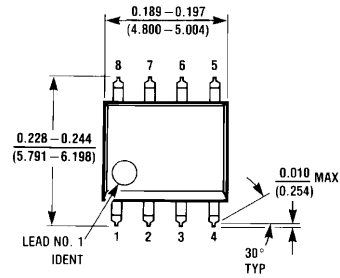
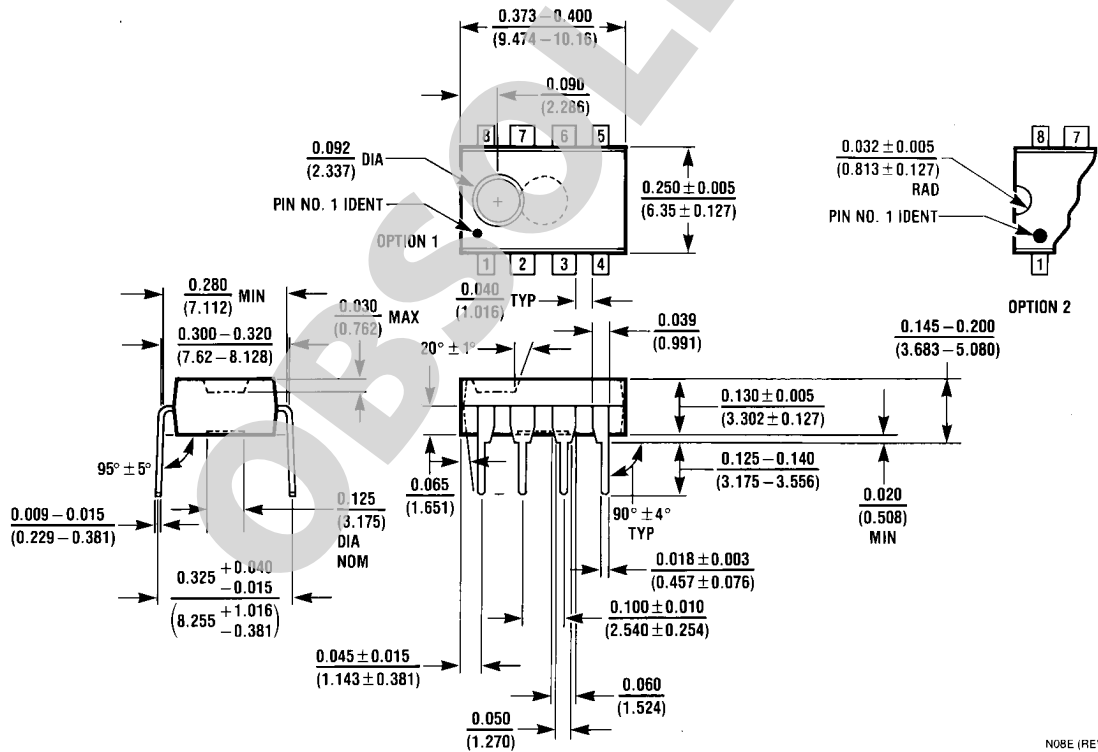


FIGURE 11. Placement of by-pass Capacitors, C_{bp}

Physical Dimensions inches (millimeters) unless otherwise noted



8-Pin SOIC
NS Package Number M08A



8-Pin DIP
NS Package Number N08E

Notes

OBSOLETE

Notes

For more National Semiconductor product information and proven design tools, visit the following Web sites at:
www.national.com

Products		Design Support	
Amplifiers	www.national.com/amplifiers	WEBENCH® Tools	www.national.com/webench
Audio	www.national.com/audio	App Notes	www.national.com/appnotes
Clock and Timing	www.national.com/timing	Reference Designs	www.national.com/refdesigns
Data Converters	www.national.com/adc	Samples	www.national.com/samples
Interface	www.national.com/interface	Eval Boards	www.national.com/evalboards
LVDS	www.national.com/lvds	Packaging	www.national.com/packaging
Power Management	www.national.com/power	Green Compliance	www.national.com/quality/green
Switching Regulators	www.national.com/switchers	Distributors	www.national.com/contacts
LDOs	www.national.com/ldo	Quality and Reliability	www.national.com/quality
LED Lighting	www.national.com/led	Feedback/Support	www.national.com/feedback
Voltage References	www.national.com/vref	Design Made Easy	www.national.com/easy
PowerWise® Solutions	www.national.com/powerwise	Applications & Markets	www.national.com/solutions
Serial Digital Interface (SDI)	www.national.com/sdi	Mil/Aero	www.national.com/milaero
Temperature Sensors	www.national.com/tempsensors	SolarMagic™	www.national.com/solarmagic
PLL/VCO	www.national.com/wireless	PowerWise® Design University	www.national.com/training

THE CONTENTS OF THIS DOCUMENT ARE PROVIDED IN CONNECTION WITH NATIONAL SEMICONDUCTOR CORPORATION ("NATIONAL") PRODUCTS. NATIONAL MAKES NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO THE ACCURACY OR COMPLETENESS OF THE CONTENTS OF THIS PUBLICATION AND RESERVES THE RIGHT TO MAKE CHANGES TO SPECIFICATIONS AND PRODUCT DESCRIPTIONS AT ANY TIME WITHOUT NOTICE. NO LICENSE, WHETHER EXPRESS, IMPLIED, ARISING BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT.

TESTING AND OTHER QUALITY CONTROLS ARE USED TO THE EXTENT NATIONAL DEEMS NECESSARY TO SUPPORT NATIONAL'S PRODUCT WARRANTY. EXCEPT WHERE MANDATED BY GOVERNMENT REQUIREMENTS, TESTING OF ALL PARAMETERS OF EACH PRODUCT IS NOT NECESSARILY PERFORMED. NATIONAL ASSUMES NO LIABILITY FOR APPLICATIONS ASSISTANCE OR BUYER PRODUCT DESIGN. BUYERS ARE RESPONSIBLE FOR THEIR PRODUCTS AND APPLICATIONS USING NATIONAL COMPONENTS. PRIOR TO USING OR DISTRIBUTING ANY PRODUCTS THAT INCLUDE NATIONAL COMPONENTS, BUYERS SHOULD PROVIDE ADEQUATE DESIGN, TESTING AND OPERATING SAFEGUARDS.

EXCEPT AS PROVIDED IN NATIONAL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, NATIONAL ASSUMES NO LIABILITY WHATSOEVER, AND NATIONAL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY RELATING TO THE SALE AND/OR USE OF NATIONAL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS PRIOR WRITTEN APPROVAL OF THE CHIEF EXECUTIVE OFFICER AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

Life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness.

National Semiconductor and the National Semiconductor logo are registered trademarks of National Semiconductor Corporation. All other brand or product names may be trademarks or registered trademarks of their respective holders.

Copyright© 2011 National Semiconductor Corporation

For the most current product information visit us at www.national.com


National Semiconductor
Americas Technical
Support Center
 Email: support@nsc.com
 Tel: 1-800-272-9959

National Semiconductor Europe
Technical Support Center
 Email: europe.support@nsc.com

National Semiconductor Asia
Pacific Technical Support Center
 Email: ap.support@nsc.com

National Semiconductor Japan
Technical Support Center
 Email: jpn.feedback@nsc.com