

## 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.

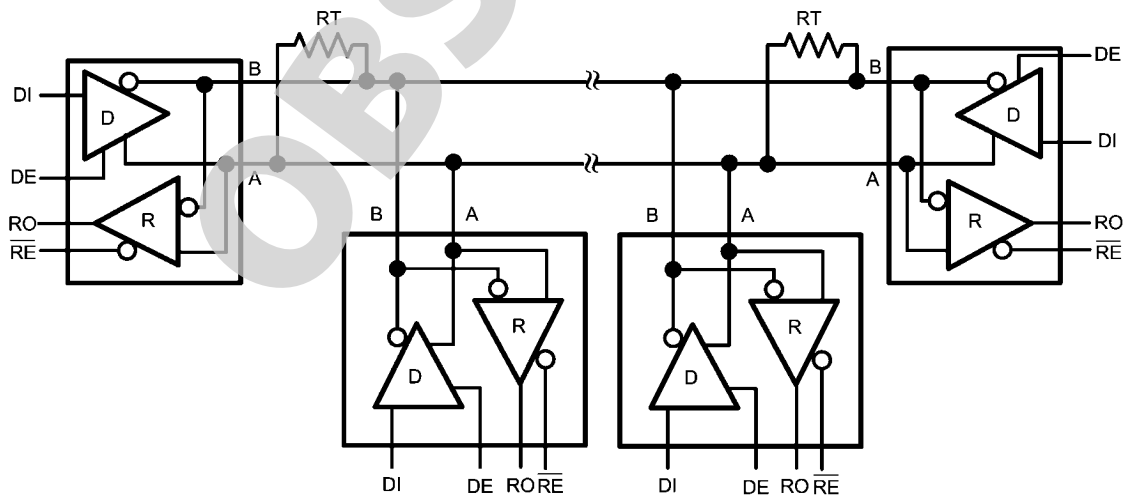
### Features

- 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 $\mu\text{A}$  (max)
- Allows up to 128 transceivers on the bus
- Open circuit fail-safe for receiver
- Extended operating temperature range  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$
- 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

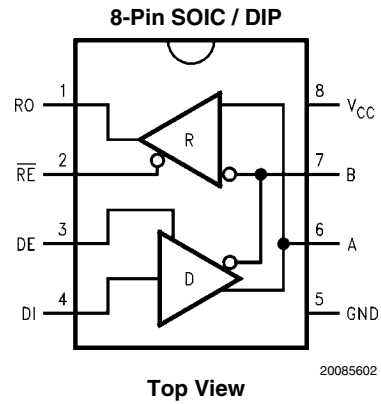
### Typical Application



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A typical multipoint application is shown in the above figure. Terminating resistor, RT 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.

## Connection Diagram



## Truth Table

DRIVER SECTION				
$\overline{RE}^*$	DE	DI	A	B
X	H	H	H	L
X	H	L	L	H
X	L	X	Z	Z
RECEIVER SECTION				
$\overline{RE}^*$	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, $\theta_{JA}$	
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	Units
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**

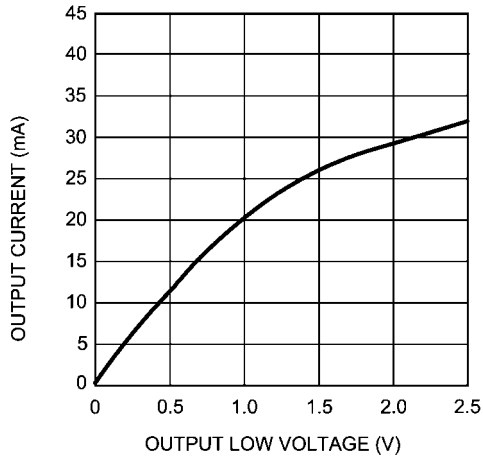
Over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>Driver Section</b>						
$ 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	
$\Delta V_{OD}$	Change in Magnitude of Driver Differential Output Voltage for Complementary Output States	$R = 27\Omega$ or $50\Omega$ (Figure 1), (Note 7)			0.2	V
$V_{OC}$	Common Mode Output Voltage	$R = 27\Omega$ or $50\Omega$ (Figure 1)			3.0	V
$\Delta V_{OC}$	Change in Magnitude of Driver Common-Mode Output Voltage for Complementary Output States	$R = 27\Omega$ or $50\Omega$ (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
<b>Receiver Section</b>						
$I_{IN2}$	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
$\Delta V_{TH}$	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 $\Omega$
<b>Power Supply Current</b>						
$I_{CC}$	Supply Current	$DE = V_{CC}, \overline{RE} = GND \text{ or } V_{CC}$		400	660	$\mu A$
		$DE = 0V, \overline{RE} = GND \text{ or } V_{CC}$		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
<b>Switching Characteristics</b>						
<b>Driver</b>						
$T_{PLH},$ $T_{PHL}$	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
<b>Receiver</b>						
$T_{PLH},$ $T_{PHL}$	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
<p><b>Note 1:</b> 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.</p> <p><b>Note 2:</b> All voltage values, except differential I/O bus voltage, are with respect to the network ground terminal.</p> <p><b>Note 3:</b> The maximum power dissipation is a function of <math>T_{J(MAX)}, \theta_{JA},</math> and <math>T_A.</math> The maximum allowable power dissipation at any ambient temperature, <math>T_A,</math> is <math>P_D = (T_{J(MAX)} - T_A)/\theta_{JA}.</math> All numbers apply for packages soldered directly into a PC board.</p> <p><b>Note 4:</b> ESD rating based upon human body model, 100 pF discharged through 1.5 k<math>\Omega.</math></p> <p><b>Note 5:</b> Voltage limits apply to DI, DE, <math>\overline{RE}</math> pins.</p> <p><b>Note 6:</b> Differential input/output bus voltage is measured at the non-inverting terminal A with respect to the inverting terminal B.</p> <p><b>Note 7:</b> <math> \Delta V_{OD} </math> and <math> \Delta V_{OC} </math> are changes in magnitude of <math>V_{OD}</math> and <math>V_{OC},</math> respectively when the input changes from high to low levels.</p> <p><b>Note 8:</b> Peak current</p>						

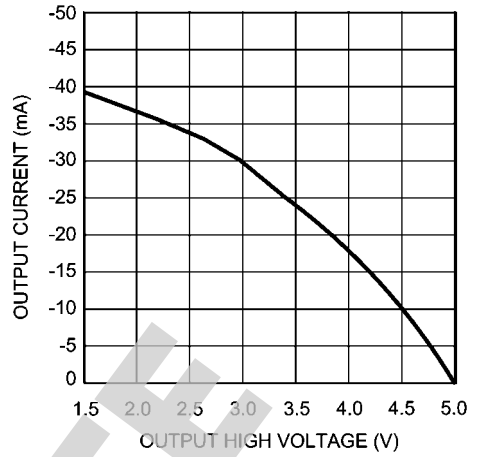
# Typical Performance Characteristics

Output Current vs. Receiver Output Low Voltage



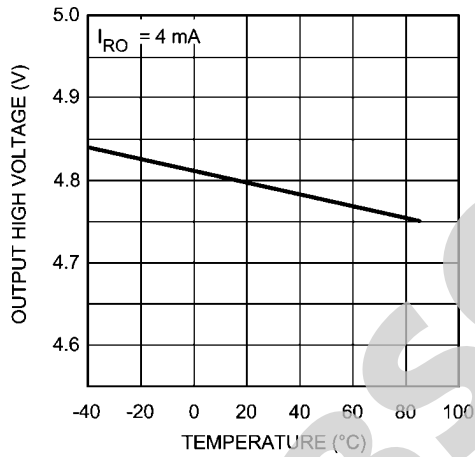
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Output Current vs. Receiver Output High Voltage



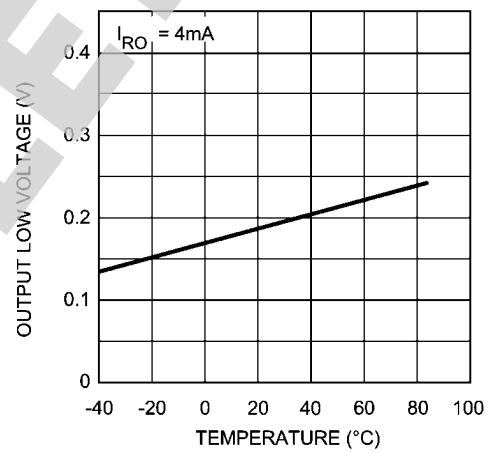
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Receiver Output High Voltage vs. Temperature



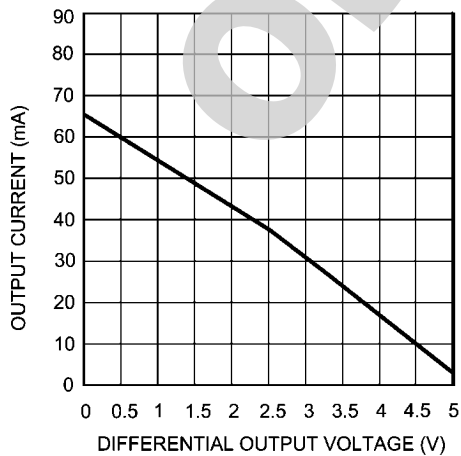
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Receiver Output Low-Voltage vs. Temperature



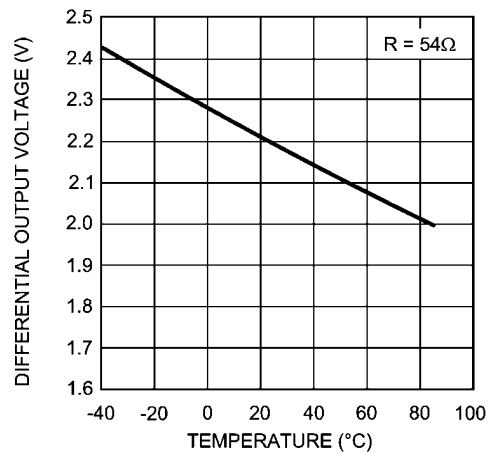
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Driver Output Current vs. Differential Output Voltage



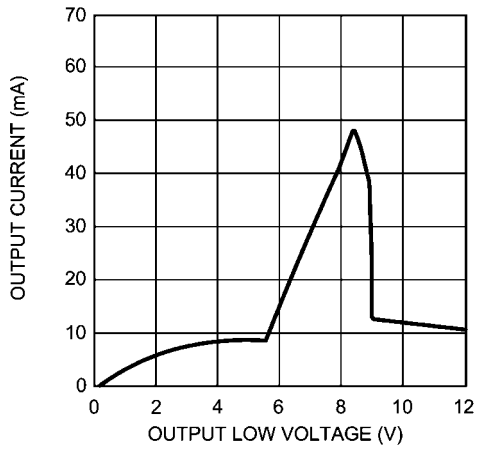
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Driver Differential Output Voltage vs. Temperature



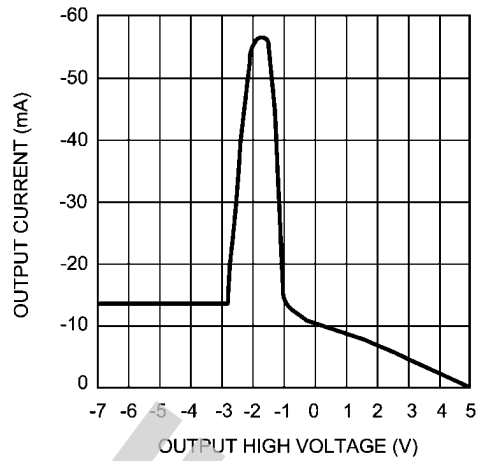
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Output Current vs. Driver Output Low Voltage



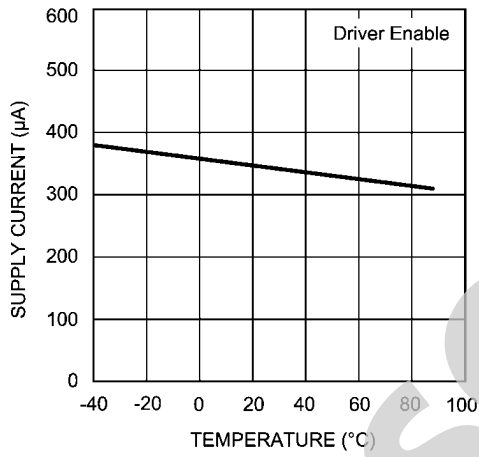
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Output Current vs. Driver Output High Voltage



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Supply Current vs. Temperature



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## Parameter Measuring Information

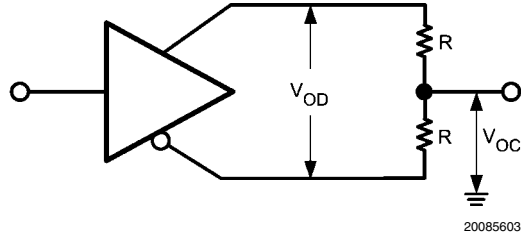


FIGURE 1. Test Circuit for  $V_{OD}$  and  $V_{OC}$

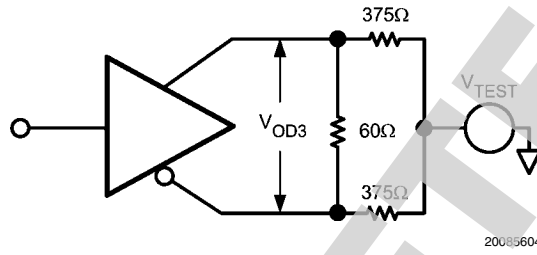


FIGURE 2. Test Circuit for  $V_{OD3}$

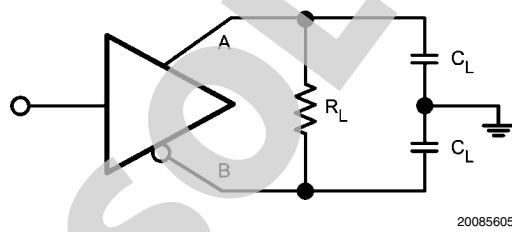


FIGURE 3. Test Circuit for Driver Propagation Delay

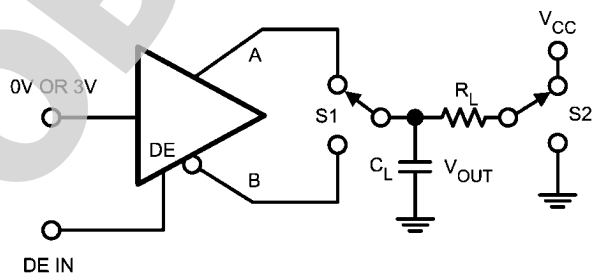


FIGURE 4. Test Circuit for Driver Enable / Disable



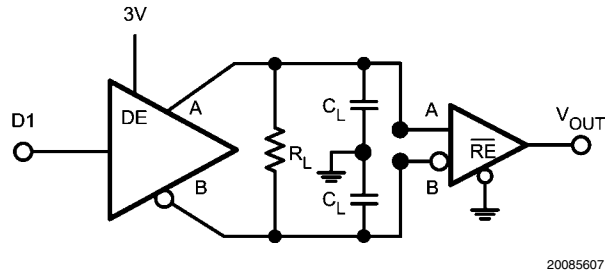


FIGURE 5. Test Circuit for Receiver Propagation Delay

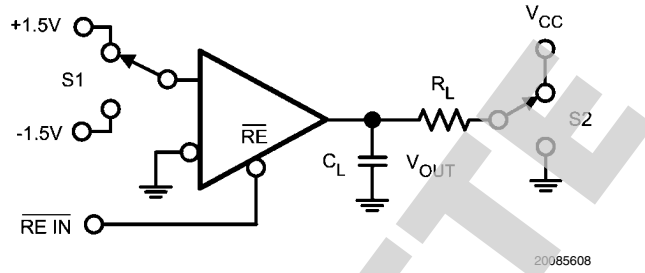
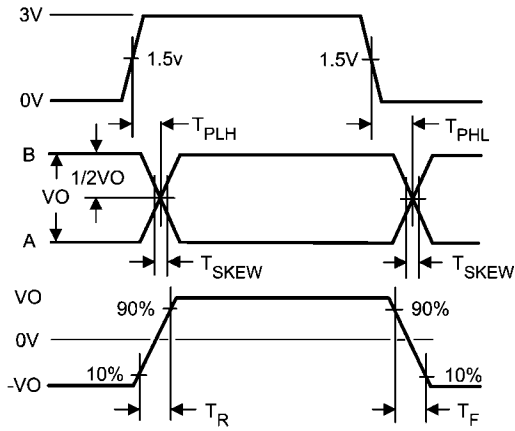


FIGURE 6. Test Circuit for Receiver Enable / Disable

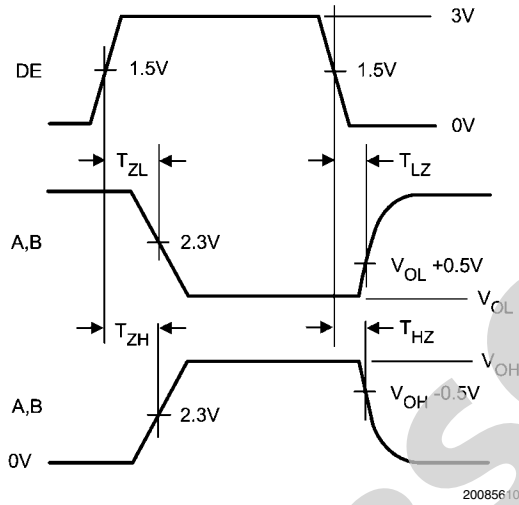
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## Switching Characteristics



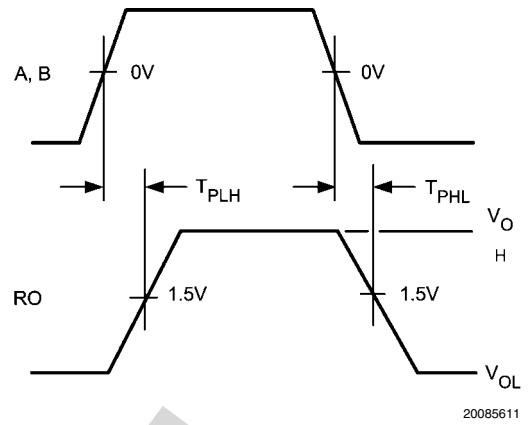
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FIGURE 7. Driver Propagation Delay, Rise / Fall Time



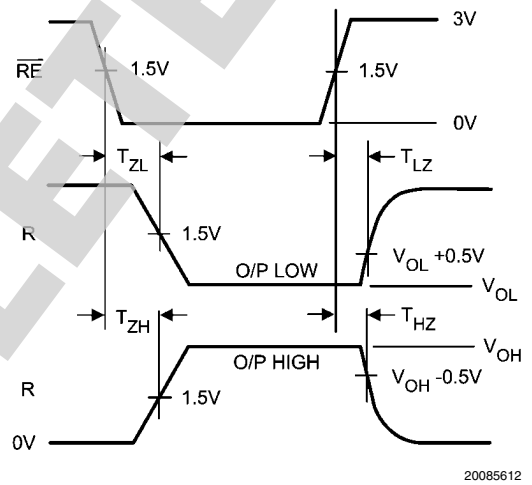
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FIGURE 8. Driver Enable / Disable Time



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FIGURE 9. Receiver Propagation Delay



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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.

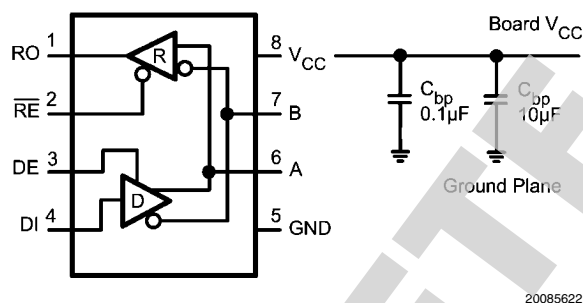
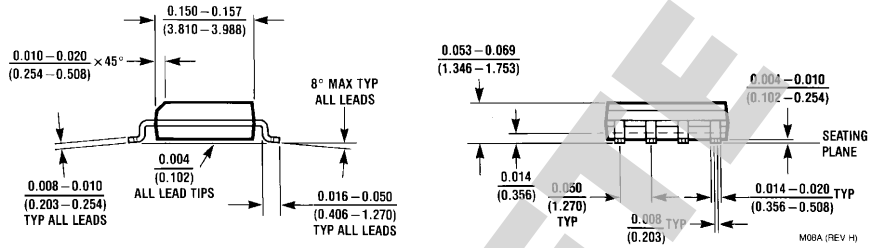
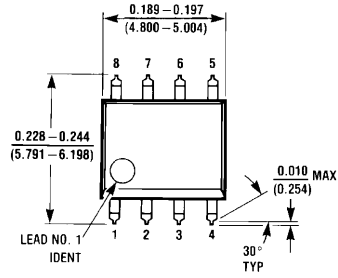
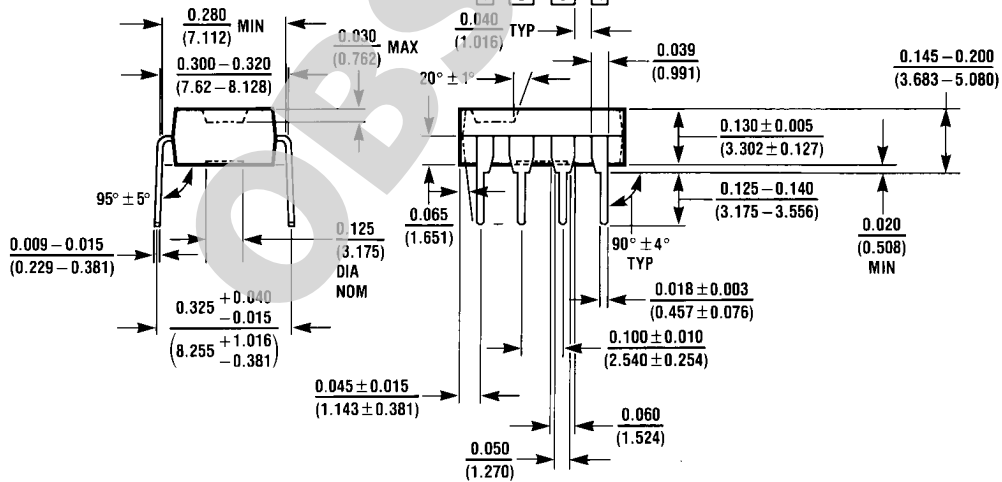
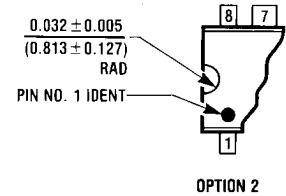
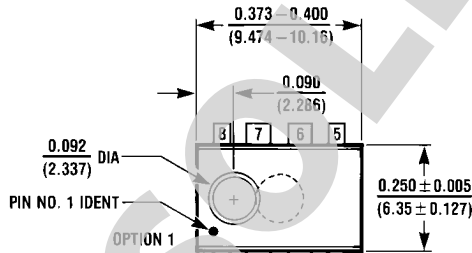


FIGURE 11. Placement of by-pass Capacitors,  $C_{bp}$

**Physical Dimensions** inches (millimeters) unless otherwise noted



**8-Pin SOIC**  
NS Package Number M08A



**8-Pin DIP**  
NS Package Number N08E

N08E (REV F)

# Notes

LMS1487E

**OBSOLETE**

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

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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.

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