



March 1999

# DS90C032B

## LVDS Quad CMOS Differential Line Receiver

### General Description

The DS90C032B is a quad CMOS differential line receiver designed for applications requiring ultra low power dissipation and high data rates. The device is designed to support data rates in excess of 155.5 Mbps (77.7 MHz) utilizing Low Voltage Differential Signaling (LVDS) technology.

The DS90C032B accepts low voltage (350 mV) differential input signals and translates them to CMOS (TTL compatible) output levels. The receiver supports a TRI-STATE® function that may be used to multiplex outputs. The receiver also supports OPEN and terminated (100Ω) input Fail-safe. Receiver output will be HIGH for both Fail-safe conditions.

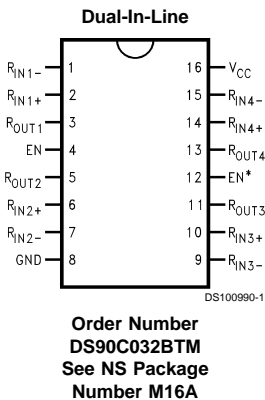
The DS90C032B provides power-off high impedance LVDS inputs. This feature assures minimal loading effect on the LVDS bus lines when  $V_{CC}$  is not present.

The DS90C032B and companion line driver (DS90C031B) provide a new alternative to high power pseudo-ECL devices for high speed point-to-point interface applications.

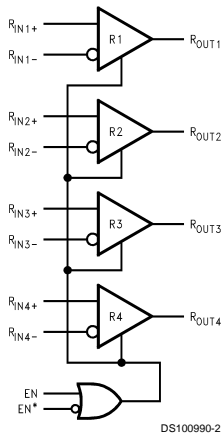
### Features

- >155.5 Mbps (77.7 MHz) switching rates
- Accepts small swing (350 mV) differential signal levels
- High Impedance LVDS inputs with power down
- Ultra low power dissipation
- 600 ps maximum differential skew (5V, 25°C)
- 6.0 ns maximum propagation delay
- Industrial operating temperature range
- Available in surface mount packaging (SOIC)
- Pin compatible with DS26C32A, MB570 (PECL) and 41LF (PECL)
- Supports OPEN and terminated input fail-safe
- Conforms to ANSI/TIA/EIA-644 LVDS standard

### Connection Diagram



### Functional Diagram



### Receiver Truth Table

ENABLES		INPUTS	OUTPUT
EN	EN*	$R_{IN+} - R_{IN-}$	$R_{OUT}$
L	H	X	Z
All other combinations of ENABLE inputs		$V_{ID} \geq 0.1V$	H
		$V_{ID} \leq -0.1V$	L
		Fail-safe OPEN or Terminated	H

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DS90C032B LVDS Quad CMOS Differential Line Receiver

## 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 ( $V_{CC}$ )	–0.3V to +6V
Input Voltage ( $R_{IN+}$ , $R_{IN-}$ )	–0.3V to +5.8V
Enable Input Voltage ( $EN$ , $EN^*$ )	–0.3V to ( $V_{CC} + 0.3V$ )
Output Voltage ( $R_{OUT}$ )	–0.3V to ( $V_{CC} + 0.3V$ )
Maximum Package Power Dissipation @ +25°C	
M Package	1025 mW
Derate M Package	8.2 mW/°C above +25°C
Storage Temperature Range	–65°C to +150°C
Lead Temperature Range	
Soldering (4 sec.)	+260°C
Maximum Junction Temperature	+150°C

## ESD Rating (Note 7)

(HBM, 1.5 k $\Omega$ , 100 pF)

≥ 2kV

(EIAJ, 0  $\Omega$ , 200 pF)

≥ 250V

## Recommended Operating Conditions

	Min	Typ	Max	Units
Supply Voltage ( $V_{CC}$ )	+4.5	+5.0	+5.5	V
Receiver Input Voltage	GND		2.4	V
Operating Free Air Temperature ( $T_A$ )				°C
DS90C032BT	–40	+25	+85	

## Electrical Characteristics

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified. (Notes 2, 3)

Symbol	Parameter	Conditions	Pin	Min	Typ	Max	Units
$V_{TH}$	Differential Input High Threshold	$V_{CM} = +1.2V$	$R_{IN+}$			+100	mV
$V_{TL}$	Differential Input Low Threshold		$R_{IN-}$	–100			mV
$I_{IN}$	Input Current	$V_{IN} = +2.4V$ $V_{IN} = 0V$		–10 –10	±1 ±1	+10 +10	µA
$V_{OH}$	Output High Voltage	$I_{OH} = -0.4 mA$ , $V_{ID} = +200 mV$ $I_{OH} = -0.4 mA$ , Input terminated	$R_{OUT}$	3.8 3.8	4.9 4.9		V
$V_{OL}$	Output Low Voltage	$I_{OL} = 2 mA$ , $V_{ID} = -200 mV$			0.07	0.3	V
$I_{OS}$	Output Short Circuit Current	Enabled, $V_{OUT} = 0V$ (Note 8)		–15	–60	–100	mA
$I_{OZ}$	Output TRI-STATE Current	Disabled, $V_{OUT} = 0V$ or $V_{CC}$		–10	±1	+10	µA
$V_{IH}$	Input High Voltage		EN, EN*	2.0			V
$V_{IL}$	Input Low Voltage					0.8	V
$I_I$	Input Current			–10	±1	+10	µA
$V_{CL}$	Input Clamp Voltage	$I_{CL} = -18 mA$		–1.5	–0.8		V
$I_{CC}$	No Load Supply Current Receivers Enabled	EN, EN* = $V_{CC}$ or GND, Inputs Open EN, EN* = 2.4 or 0.5, Inputs Open	$V_{CC}$		3.5 3.7	10 11	mA
$I_{CCZ}$	No Load Supply Current Receivers Disabled	EN = GND, EN* = $V_{CC}$ , Inputs Open			3.5	10	mA

## Switching Characteristics

$V_{CC} = +5.0V$ ,  $T_A = +25^{\circ}C$  (Notes 3, 4, 9)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{PHLD}$	Differential Propagation Delay High to Low	$C_L = 5\text{ pF}$ $V_{ID} = 200\text{ mV}$ (Figure 1 and Figure 2)	1.5	3.40	5.0	ns
$t_{PLHD}$	Differential Propagation Delay Low to High		1.5	3.48	5.0	ns
$t_{SKD}$	Differential Skew $ t_{PHLD} - t_{PLHD} $		0	80	600	ps
$t_{SK1}$	Channel-to-Channel Skew (Note 5)		0	0.6	1.0	ns
$t_{TLH}$	Rise Time			0.5	2.0	ns
$t_{THL}$	Fall Time			0.5	2.0	ns
$t_{PHZ}$	Disable Time High to Z	$R_L = 2\text{ k}\Omega$ $C_L = 10\text{ pF}$ (Figure 3 and Figure 4)		10	15	ns
$t_{PLZ}$	Disable Time Low to Z			10	15	ns
$t_{PZH}$	Enable Time Z to High			4	10	ns
$t_{PZL}$	Enable Time Z to Low			4	10	ns

## Switching Characteristics

$V_{CC} = +5.0V \pm 10\%$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$  (Notes 3, 4, 9)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{PHLD}$	Differential Propagation Delay High to Low	$C_L = 5\text{ pF}$ $V_{ID} = 200\text{ mV}$ (Figure 1 and Figure 2)	1.0	3.40	6.0	ns
$t_{PLHD}$	Differential Propagation Delay Low to High		1.0	3.48	6.0	ns
$t_{SKD}$	Differential Skew $ t_{PHLD} - t_{PLHD} $		0	0.08	1.2	ns
$t_{SK1}$	Channel-to-Channel Skew (Note 5)		0	0.6	1.5	ns
$t_{SK2}$	Chip to Chip Skew (Note 6)				5.0	ns
$t_{TLH}$	Rise Time			0.5	2.5	ns
$t_{THL}$	Fall Time	$R_L = 2\text{ k}\Omega$ $C_L = 10\text{ pF}$ (Figure 3 and Figure 4)		0.5	2.5	ns
$t_{PHZ}$	Disable Time High to Z			10	20	ns
$t_{PLZ}$	Disable Time Low to Z			10	20	ns
$t_{PZH}$	Enable Time Z to High			4	15	ns
$t_{PZL}$	Enable Time Z to Low			4	15	ns

**Note 1:** "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the devices should be operated at these limits. The table of "Electrical Characteristics" specifies conditions of device operation.

**Note 2:** Current into device pins is defined as positive. Current out of device pins is defined as negative. All voltages are referenced to ground unless otherwise specified.

**Note 3:** All typicals are given for:  $V_{CC} = +5.0V$ ,  $T_A = +25^{\circ}C$ .

**Note 4:** Generator waveform for all tests unless otherwise specified:  $f = 1\text{ MHz}$ ,  $Z_O = 50\Omega$ ,  $t_r$  and  $t_f$  (0%–100%)  $\leq 1\text{ ns}$  for  $R_{IN}$  and  $t_r$  and  $t_f \leq 6\text{ ns}$  for EN or EN\*.

**Note 5:** Channel-to-Channel Skew is defined as the difference between the propagation delay of one channel and that of the others on the same chip with an event on the inputs.

**Note 6:** Chip to Chip Skew is defined as the difference between the minimum and maximum specified differential propagation delays.

**Note 7:** ESD Rating:

HBM (1.5 kV, 100 pF)  $\geq 2\text{ kV}$

IEAJ (0V, 200 pF)  $\geq 250\text{ V}$

**Note 8:** Output short circuit current ( $I_{OS}$ ) is specified as magnitude only, minus sign indicates direction only. Only one output should be shorted at a time, do not exceed maximum junction temperature specification.

**Note 9:**  $C_L$  includes probe and jig capacitance.

## Parameter Measurement Information

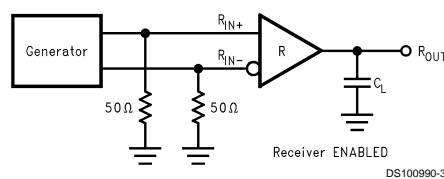


FIGURE 1. Receiver Propagation Delay and Transition Time Test Circuit

## Parameter Measurement Information (Continued)

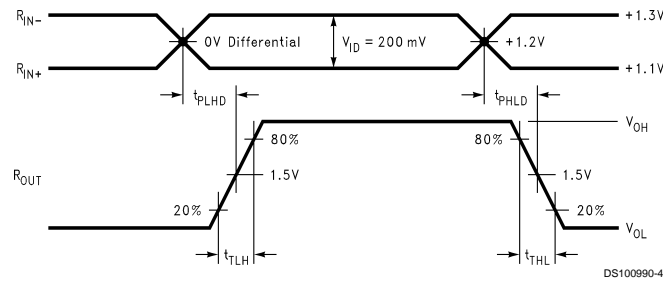
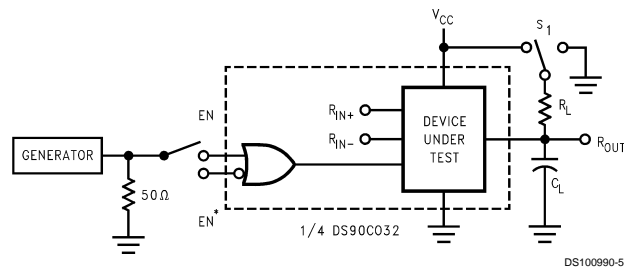


FIGURE 2. Receiver Propagation Delay and Transition Time Waveforms



$C_L$  includes load and test jig capacitance.  
 $S_1 = V_{CC}$  for  $t_{PZL}$  and  $t_{PLZ}$  measurements.  
 $S_1 = GND$  for  $t_{PHZ}$  and  $t_{PHZ}$  measurements.

FIGURE 3. Receiver TRI-STATE Delay Test Circuit

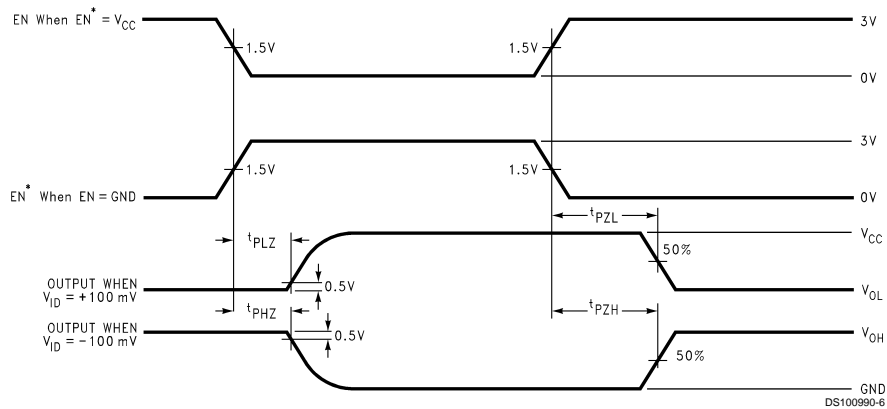
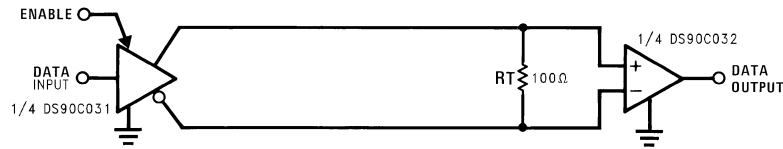


FIGURE 4. Receiver TRI-STATE Delay Waveforms

## Typical Application



DS100990-7

FIGURE 5. Point-to-Point Application

## Applications Information

LVDS drivers and receivers are intended to be primarily used in an uncomplicated point-to-point configuration as is shown in Figure 5. This configuration provides a clean signaling environment for the quick edge rates of the drivers. The receiver is connected to the driver through a balanced media which may be a standard twisted pair cable, a parallel pair cable, or simply PCB traces. Typically the characteristic impedance of the media is in the range of 100Ω. A termination resistor of 100Ω should be selected to match the media, and is located as close to the receiver input pins as possible. The termination resistor converts the current sourced by the driver into a voltage that is detected by the receiver. Other configurations are possible such as a multi-receiver configuration, but the effects of a mid-stream connector(s), cable stub(s), and other impedance discontinuities as well as ground shifting, noise margin limits, and total termination loading must be taken into account.

The DS90C032B differential line receiver is capable of detecting signals as low as 100 mV, over a ±1V common-mode range centered around +1.2V. This is related to the driver offset voltage which is typically +1.2V. The driven signal is centered around this voltage and may shift ±1V around this center point. The ±1V shifting may be the result of a ground potential difference between the driver's ground reference and the receiver's ground reference, the common-mode effects of coupled noise, or a combination of the two. Both receiver input pins should honor their specified operating input voltage range of 0V to +2.4V (measured from each pin to ground), exceeding these limits may turn on the ESD protection circuitry which will clamp the bus voltages.

### Receiver Fail-Safe:

The LVDS receiver is a high gain, high speed device that amplifies a small differential signal (20mV) to CMOS logic

levels. Due to the high gain and tight threshold of the receiver, care should be taken to prevent noise from appearing as a valid signal.

The receiver's internal fail-safe circuitry is designed to source/sink a small amount of current, providing fail-safe protection (a stable known state of HIGH output voltage) for floating or terminated receiver inputs.

1. **Open Input Pins.** The DS90C032B is a quad receiver device, and if an application requires only 1, 2 or 3 receivers, the unused channel(s) inputs should be left OPEN. Do not tie unused receiver inputs to ground or any other voltages. The input is biased by internal high value pull up and pull down resistors to set the output to a HIGH state. This internal circuitry will guarantee a HIGH, stable output state for open inputs.
2. **Terminated Input.** If the driver is disconnected (cable unplugged), or if the driver is in a TRI-STATE or power-off condition, the receiver output will again be in a HIGH state, even with the end of cable 100Ω termination resistor across the input pins. The unplugged cable can become a floating antenna which can pick up noise. If the cable picks up more than 10mV of differential noise, the receiver may see the noise as a valid signal and switch. To insure that any noise is seen as common-mode and not differential, a balanced interconnect should be used. Twisted pair cable will offer better balance than flat ribbon cable.

The footprint of the DS90C032B is the same as the industry standard 26LS32 Quad Differential (RS-422) Receiver.

For additional LVDS application information, please refer to National's LVDS Owner's Manual available through National's website [www.national.com/appinfo/lvds](http://www.national.com/appinfo/lvds).

## Pin Descriptions

Pin No.	Name	Description
2, 6, 10, 14	$R_{IN+}$	Non-inverting receiver input pin
1, 7, 9, 15	$R_{IN-}$	Inverting receiver input pin
3, 5, 11, 13	$R_{OUT}$	Receiver output pin
4	EN	Active high enable pin, OR-ed with EN*

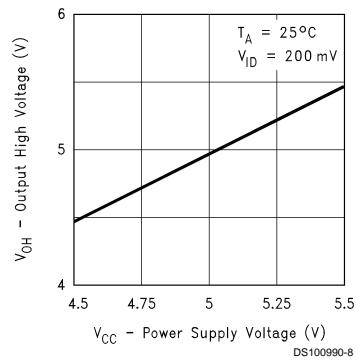
Pin No.	Name	Description
12	EN*	Active low enable pin, OR-ed with EN
16	$V_{CC}$	Power supply pin, +5V $\pm$ 10%
8	GND	Ground pin

## Ordering Information

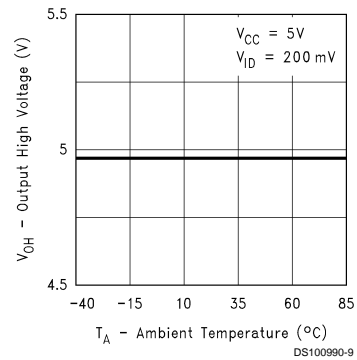
Operating Temperature	Package Type/ Number	Order Number
-40°C to +85°C	SOP/M16A	DS90C032BTM

## Typical Performance Characteristics

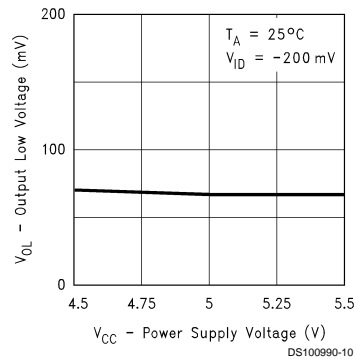
Output High Voltage vs Power Supply Voltage



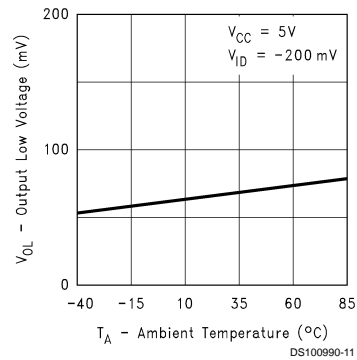
Output High Voltage vs Ambient Temperature



Output Low Voltage vs Power Supply Voltage

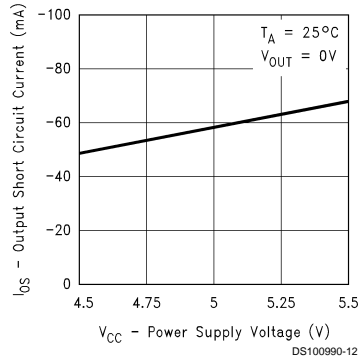


Output Low Voltage vs Ambient Temperature

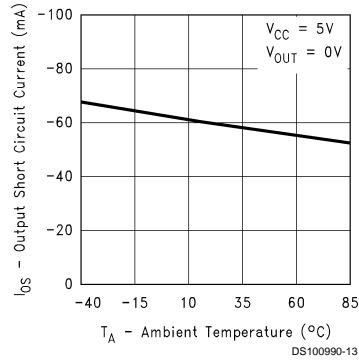


## Typical Performance Characteristics (Continued)

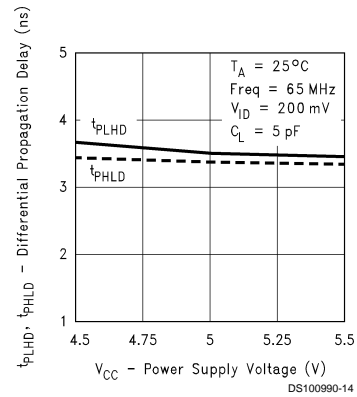
**Output Short Circuit Current vs Power Supply Voltage**



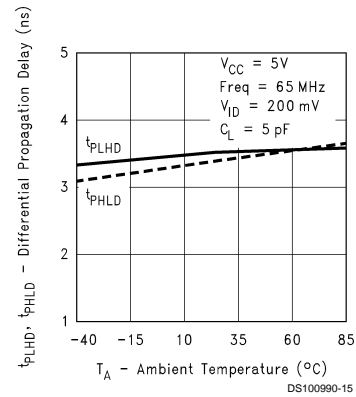
**Output Short Circuit Current vs Ambient Temperature**



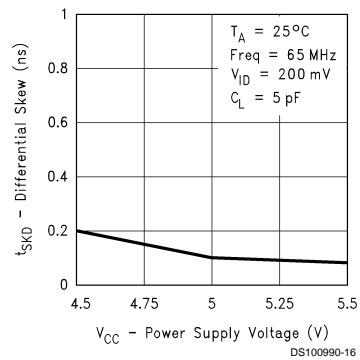
**Differential Propagation Delay vs Power Supply Voltage**



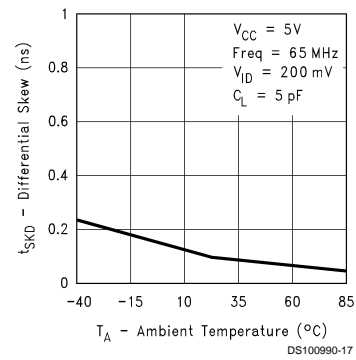
**Differential Propagation Delay vs Ambient Temperature**



**Differential Skew vs Power Supply Voltage**

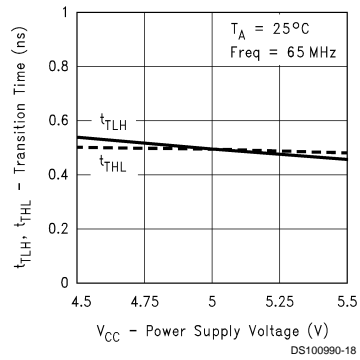


**Differential Skew vs Ambient Temperature**

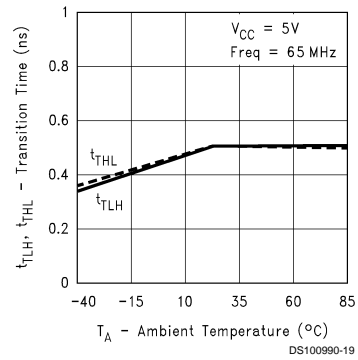


## Typical Performance Characteristics (Continued)

**Transition Time vs  
Power Supply Voltage**



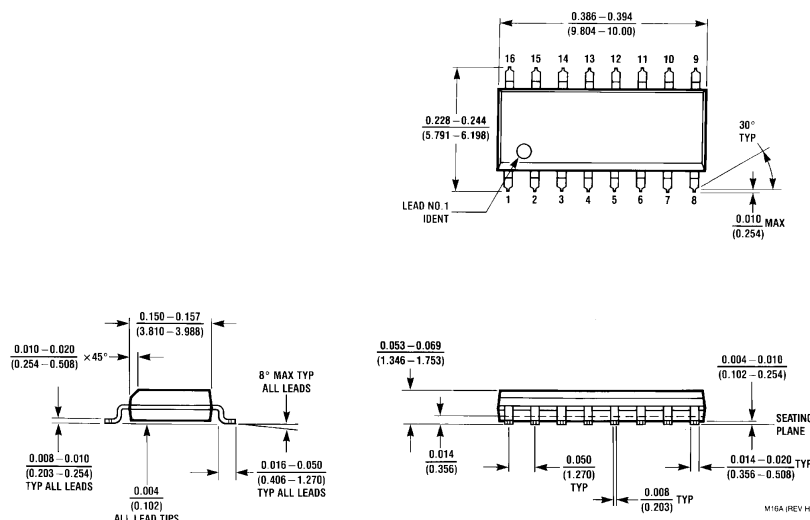
**Transition Time vs  
Ambient Temperature**





# Physical Dimensions

inches (millimeters) unless otherwise noted



**16-Lead (0.150" Wide) Molded Small Outline Package, JEDEC**  
**Order Number DS90C032BTM**  
**NS Package Number M16A**

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