

DS90C031

DS90C031 LVDS Quad CMOS Differential Line Driver



Literature Number: SNLS095A

DS90C031

LVDS Quad CMOS Differential Line Driver

General Description

The DS90C031 is a quad CMOS differential line driver 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 DS90C031 accepts TTL/CMOS input levels and translates them to low voltage (350 mV) differential output signals. In addition the driver supports a TRI-STATE® function that may be used to disable the output stage, disabling the load current, and thus dropping the device to an ultra low idle power state of 11 mW typical.

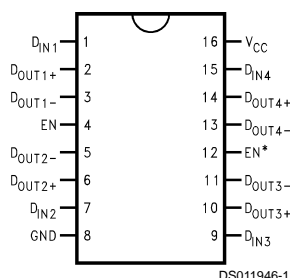
The DS90C031 and companion line receiver (DS90C032) provide a new alternative to high power pseudo-ECL devices for high speed point-to-point interface applications.

Features

- >155.5 Mbps (77.7 MHz) switching rates
- ± 350 mV differential signaling
- Ultra low power dissipation
- 400 ps maximum differential skew (5V, 25°C)
- 3.5 ns maximum propagation delay
- Industrial operating temperature range
- Military operating temperature range option
- Available in surface mount packaging (SOIC) and (LCC)
- Pin compatible with DS26C31, MB571 (PECL) and 41LG (PECL)
- Compatible with IEEE 1596.3 SCI LVDS standard
- Conforms to ANSI/TIA/EIA-644 LVDS standard
- Available to Standard Microcircuit Drawing (SMD) 5962-95833

Connection Diagrams

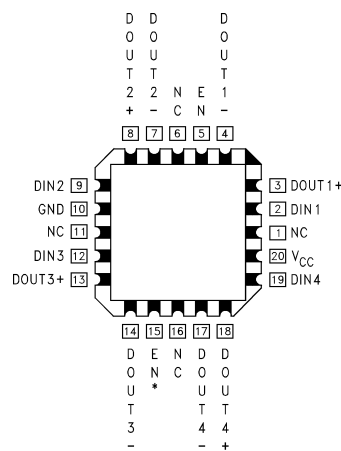
Dual-In-Line



DS011946-1

Order Number DS90C031TM
See NS Package Number M16A

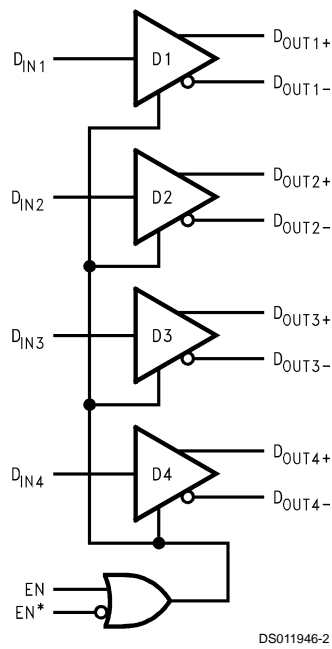
LCC Package



DS011946-33

Order Number DS90C031E-QML
See NS Package Number E20A
For Complete Military Specifications,
refer to appropriate SMD or MDS.

Functional Diagram



DRIVER

Enables		Input	Outputs	
EN	EN*	D _{IN}	D _{OUT+}	D _{OUT-}
L	H	X	Z	Z
All other combinations of ENABLE inputs		L	L	H
		H	H	L

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 (D_{IN})	-0.3V to ($V_{CC} + 0.3V$)
Enable Input Voltage (EN, EN*)	-0.3V to ($V_{CC} + 0.3V$)
Output Voltage (D_{OUT+} , D_{OUT-})	-0.3V to ($V_{CC} + 0.3V$)
Short Circuit Duration (D_{OUT+} , D_{OUT-})	Continuous
Maximum Package Power Dissipation @ +25°C	
M Package	1068 mW
E Package	1900 mW
Derate M Package	8.5 mW/°C above +25°C
Derate E Package	12.8 mW/°C above +25°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature Range Soldering (4 sec.)	+260°C

Maximum Junction Temperature (DS90C031T)	+150°C
Maximum Junction Temperature (DS90C031E)	+175°C
ESD Rating (Note 7)	
(HBM, 1.5 kΩ, 100 pF)	≥ 3,500V
(EIAJ, 0 Ω, 200 pF)	≥ 250V

Recommended Operating Conditions

	Min	Typ	Max	Units
Supply Voltage (V_{CC})	+4.5	+5.0	+5.5	V
Operating Free Air Temperature (T_A)				
DS90C031T	-40	+25	+85	°C
DS90C031E	-55	+25	+125	°C

Electrical Characteristics

Over supply voltage and operating temperature ranges, unless otherwise specified. (Notes 2, 3)

Symbol	Parameter	Conditions	Pin	Min	Typ	Max	Units
V_{OD1}	Differential Output Voltage	$R_L = 100\Omega$ (Figure 1)	D_{OUT-} , D_{OUT+}	250	345	450	mV
ΔV_{OD1}	Change in Magnitude of V_{OD1} for Complementary Output States				4	35	mV
V_{OS}	Offset Voltage			1.125	1.25	1.375	V
ΔV_{OS}	Change in Magnitude of V_{OS} for Complementary Output States				5	25	mV
V_{OH}	Output Voltage High	$R_L = 100\Omega$			1.41	1.60	V
V_{OL}	Output Voltage Low			0.90	1.07		V
V_{IH}	Input Voltage High		D_{IN} , EN, EN*	2.0		V_{CC}	V
V_{IL}	Input Voltage Low			GND		0.8	V
I_I	Input Current	$V_{IN} = V_{CC}$, GND, 2.5V or 0.4V		-10	±1	+10	μA
V_{CL}	Input Clamp Voltage	$I_{CL} = -18$ mA		-1.5	-0.8		V
I_{OS}	Output Short Circuit Current	$V_{OUT} = 0V$ (Note 8)	D_{OUT-} , D_{OUT+}		-3.5	-5.0	mA
I_{OZ}	Output TRI-STATE Current	EN = 0.8V and EN* = 2.0V, $V_{OUT} = 0V$ or V_{CC}		-10	±1	+10	μA
I_{CC}	No Load Supply Current Drivers Enabled	$D_{IN} = V_{CC}$ or GND	V_{CC}		1.7	3.0	mA
		$D_{IN} = 2.5V$ or 0.4V			4.0	6.5	mA
I_{CCL}	Loaded Supply Current Drivers Enabled	$R_L = 100\Omega$ All Channels			15.4	21.0	mA
		$V_{IN} = V_{CC}$ or GND (all inputs)			15.4	25.0	mA
I_{CCZ}	No Load Supply Current Drivers Disabled	$D_{IN} = V_{CC}$ or GND			2.2	4.0	mA
		EN = GND, EN* = V_{CC}			2.2	10.0	mA

Switching Characteristics

$V_{CC} = +5.0V$, $T_A = +25^\circ C$ DS90C031T. (Notes 3, 4, 6, 9)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{PHLD}	Differential Propagation Delay High to Low	$R_L = 100\Omega$, $C_L = 5$ pF (Figure 2 and Figure 3)	1.0	2.0	3.0	ns
t_{PLHD}	Differential Propagation Delay Low to High		1.0	2.1	3.0	ns
t_{SKD}	Differential Skew $ t_{PHLD} - t_{PLHD} $		0	80	400	ps
t_{SK1}	Channel-to-Channel Skew (Note 4)		0	300	600	ps

Switching Characteristics (Continued)

$V_{CC} = +5.0V$, $T_A = +25^{\circ}C$ DS90C031T. (Notes 3, 4, 6, 9)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{TLH}	Rise Time	$R_L = 100\Omega$, $C_L = 5\text{ pF}$ (Figure 4 and Figure 5)		0.35	1.5	ns
t_{THL}	Fall Time			0.35	1.5	ns
t_{PHZ}	Disable Time High to Z			2.5	10	ns
t_{PLZ}	Disable Time Low to Z			2.5	10	ns
t_{PZH}	Enable Time Z to High			2.5	10	ns
t_{PZL}	Enable Time Z to Low			2.5	10	ns

Switching Characteristics

$V_{CC} = +5.0V \pm 10\%$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$ DS90C031T. (Notes 3, 4, 5, 6, 9)

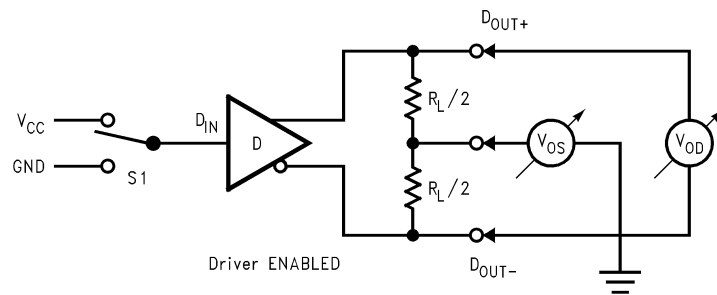
Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{PHLD}	Differential Propagation Delay High to Low	$R_L = 100\Omega$, $C_L = 5\text{ pF}$ (Figure 2 and Figure 3)	0.5	2.0	3.5	ns
t_{PLHD}	Differential Propagation Delay Low to High		0.5	2.1	3.5	ns
t_{SKD}	Differential Skew $ t_{PHLD} - t_{PLHD} $		0	80	900	ps
t_{SK1}	Channel-to-Channel Skew (Note 4)		0	0.3	1.0	ns
t_{SK2}	Chip to Chip Skew (Note 5)				3.0	ns
t_{TLH}	Rise Time			0.35	2.0	ns
t_{THL}	Fall Time	$R_L = 100\Omega$, $C_L = 5\text{ pF}$ (Figure 4 and Figure 5)		0.35	2.0	ns
t_{PHZ}	Disable Time High to Z			2.5	15	ns
t_{PLZ}	Disable Time Low to Z			2.5	15	ns
t_{PZH}	Enable Time Z to High			2.5	15	ns
t_{PZL}	Enable Time Z to Low			2.5	15	ns

Switching Characteristics

$V_{CC} = +5.0V \pm 10\%$, $T_A = -55^{\circ}C$ to $+125^{\circ}C$ DS90C031E. (Notes 3, 4, 5, 6, 9, 10)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{PHLD}	Differential Propagation Delay High to Low	$R_L = 100\Omega$, $C_L = 20\text{ pF}$ (Figure 3) C_L Connected between each Output and GND	0.5	2.0	5.0	ns
t_{PLHD}	Differential Propagation Delay Low to High		0.5	2.1	5.0	ns
t_{SKD}	Differential Skew $ t_{PHLD} - t_{PLHD} $		0	0.08	3.0	ns
t_{SK1}	Channel-to-Channel Skew (Note 4)		0	0.3	3.0	ns
t_{SK2}	Chip to Chip Skew (Note 5)	$R_L = 100\Omega$, $C_L = 5\text{ pF}$ (Figure 4 and Figure 5)			4.5	ns
t_{PHZ}	Disable Time High to Z			2.5	20	ns
t_{PLZ}	Disable Time Low to Z			2.5	20	ns
t_{PZH}	Enable Time Z to High			2.5	20	ns
t_{PZL}	Enable Time Z to Low			2.5	20	ns

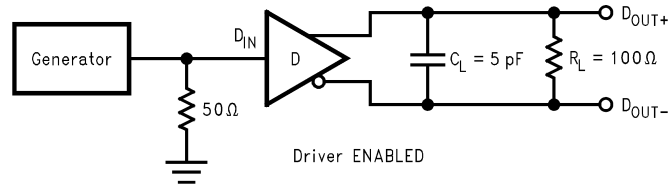
Parameter Measurement Information



DS011946-3

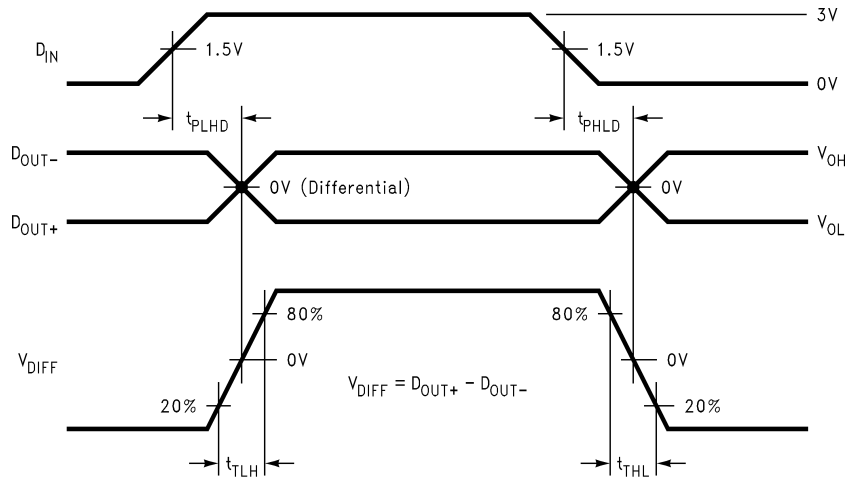
FIGURE 1. Driver V_{OD} and V_{OS} Test Circuit

Parameter Measurement Information (Continued)



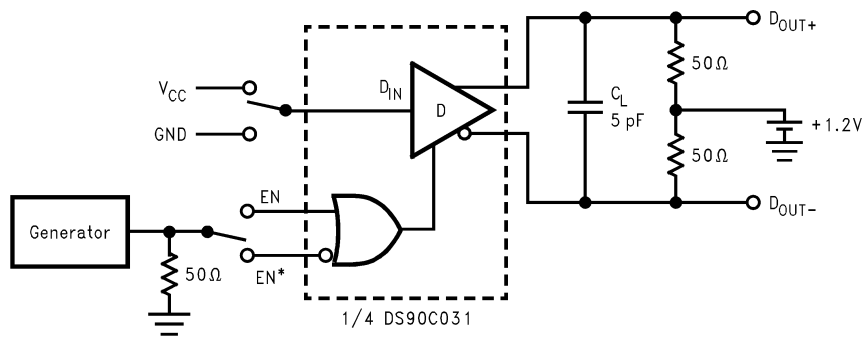
DS011946-4

FIGURE 2. Driver Propagation Delay and Transition Time Test Circuit



DS011946-5

FIGURE 3. Driver Propagation Delay and Transition Time Waveforms



DS011946-6

FIGURE 4. Driver TRI-STATE Delay Test Circuit

Parameter Measurement Information (Continued)

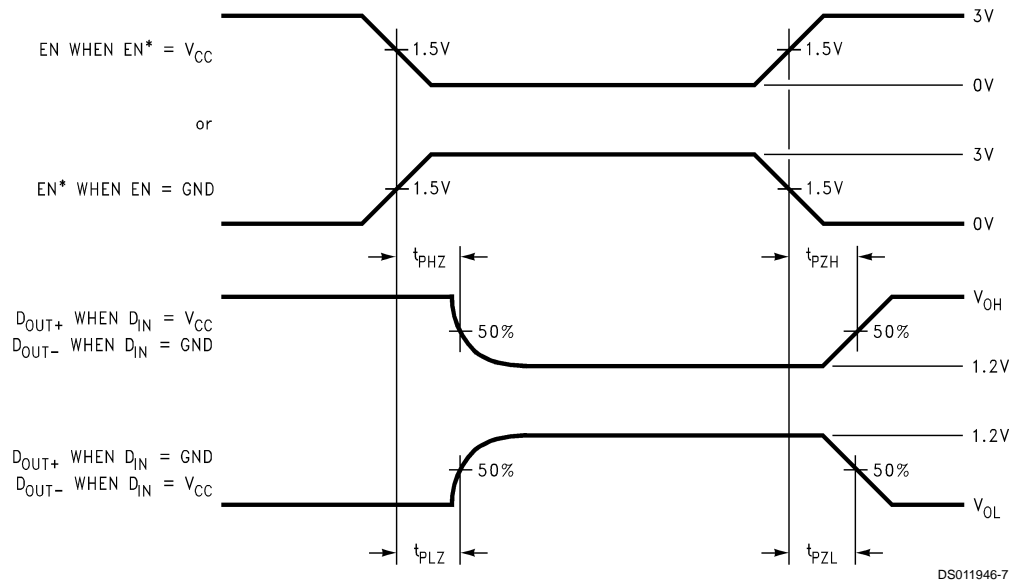


FIGURE 5. Driver TRI-STATE Delay Waveform

Typical Application

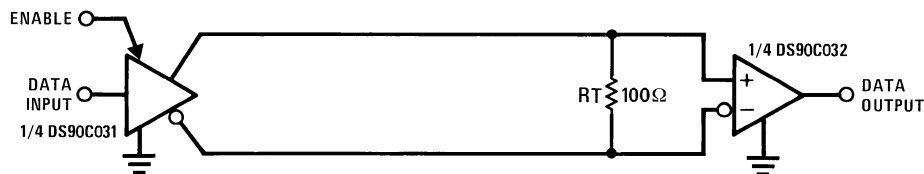


FIGURE 6. Point-to-Point Application

Applications Information

LVDS drivers and receivers are intended to be primarily used in an uncomplicated point-to-point configuration as is shown in Figure 6. 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 DS90C031 differential line driver is a balanced current source design. A current mode driver, generally speaking has a high output impedance and supplies a constant current for a range of loads (a voltage mode driver on the other hand supplies a constant voltage for a range of loads). Current is switched through the load in one direction to produce a logic state and in the other direction to produce the other logic state. The typical output current is mere 3.4 mA, a minimum of 2.5 mA, and a maximum of 4.5 mA. The current mode **requires** (as discussed above) that a resistive termi-

nation be employed to terminate the signal and to complete the loop as shown in Figure 6. AC or unterminated configurations are not allowed. The 3.4 mA loop current will develop a differential voltage of 340 mV across the 100Ω termination resistor which the receiver detects with a 240 mV minimum differential noise margin neglecting resistive line losses (driven signal minus receiver threshold (340 mV – 100 mV = 240 mV)). The signal is centered around +1.2V (Driver Offset, V_{OS}) with respect to ground as shown in Figure 7. Note that the steady-state voltage (V_{SS}) peak-to-peak swing is twice the differential voltage (V_{OD}) and is typically 680 mV.

The current mode driver provides substantial benefits over voltage mode drivers, such as an RS-422 driver. Its quiescent current remains relatively flat versus switching frequency. Whereas the RS-422 voltage mode driver increases exponentially in most case between 20 MHz–50 MHz. This is due to the overlap current that flows between the rails of the device when the internal gates switch. Whereas the current mode driver switches a fixed current between its output without any substantial overlap current. This is similar to some ECL and PECL devices, but without the heavy static I_{CC} requirements of the ECL/PECL designs. LVDS requires 80% less current than similar PECL devices. AC specifications for the driver are a tenfold improvement over other existing RS-422 drivers.

The TRI-STATE function allows the driver outputs to be disabled, thus obtaining an even lower power state when the transmission of data is not required.

Applications Information (Continued)

The footprint of the DS90C031 is the same as the industry standard 26LS31 Quad Differential (RS-422) Driver.

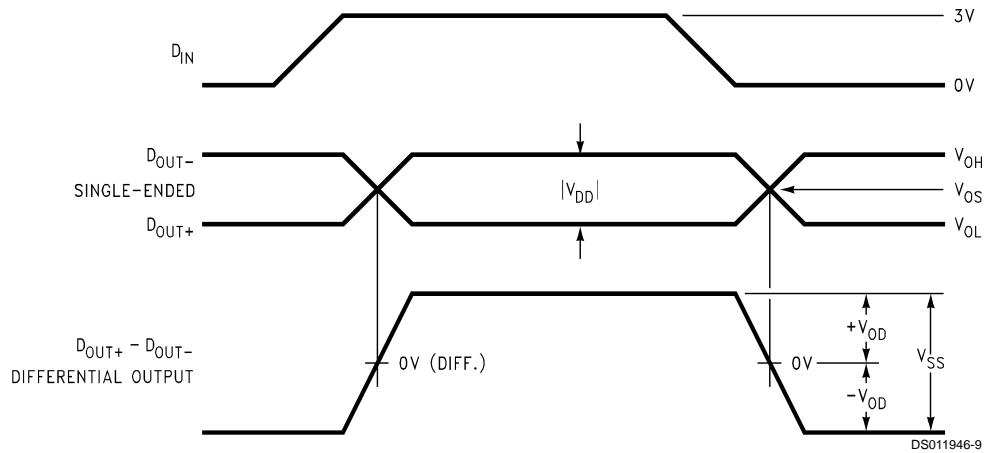


FIGURE 7. Driver Output Levels

Pin Descriptions

Pin No. (SOIC)	Name	Description
1, 7, 9, 15	D _{IN}	Driver input pin, TTL/CMOS compatible
2, 6, 10, 14	D _{OUT+}	Non-inverting driver output pin, LVDS levels
3, 5, 11, 13	D _{OUT-}	Inverting driver output pin, LVDS levels
4	EN	Active high enable pin, OR-ed with EN*
12	EN*	Active low enable pin, OR-ed with EN

Pin No. (SOIC)	Name	Description
16	V _{CC}	Power supply pin, +5V ± 10%
8	GND	Ground pin

Ordering Information

Operating Temperature	Package Type/ Number	Order Number
-40°C to +85°C	SOP/M16A	DS90C031TM
-55°C to +125°C	LCC/E20A	DS90C031E-QML
DS90C031E-QML	(NSID)	
5962-95833	(SMD)	

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 except: V_{OD1} and ΔV_{OD1}.

Note 3: All typicals are given for: V_{CC} = +5.0V, T_A = +25°C.

Note 4: Channel-to-Channel Skew is defined as the difference between the propagation delay of the channel and the other channels in the same chip with an event on the inputs.

Note 5: Chip to Chip Skew is defined as the difference between the minimum and maximum specified differential propagation delays.

Note 6: Generator waveform for all tests unless otherwise specified: f = 1 MHz, Z_O = 50Ω, t_r ≤ 6 ns, and t_f ≤ 6 ns.

Note 7: ESD Ratings:

HBM (1.5 kΩ, 100 pF) ≥ 3,500V

EIAJ (0Ω, 200 pF) ≥ 250V

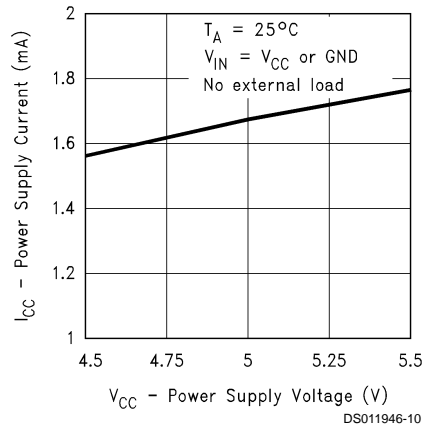
Note 8: Output short circuit current (I_{OS}) is specified as magnitude only, minus sign indicates direction only.

Note 9: C_L includes probe and jig capacitance.

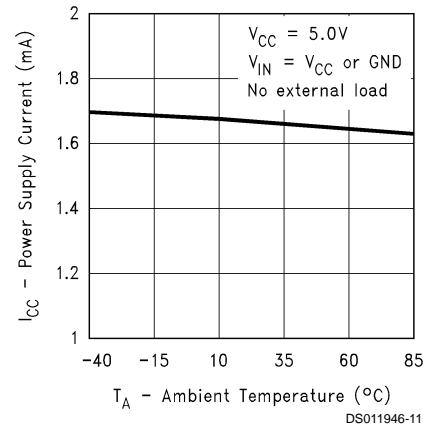
Note 10: Guaranteed by characterization data (DS90C031E).

Typical Performance Characteristics

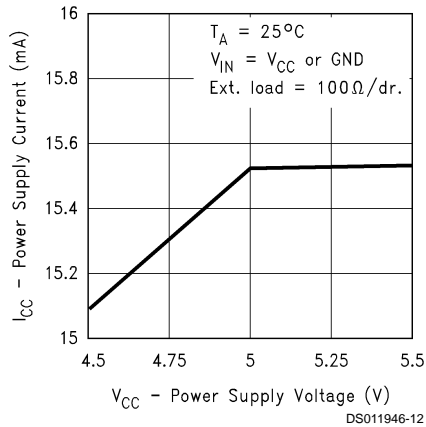
**Power Supply Current
vs Power Supply Voltage**



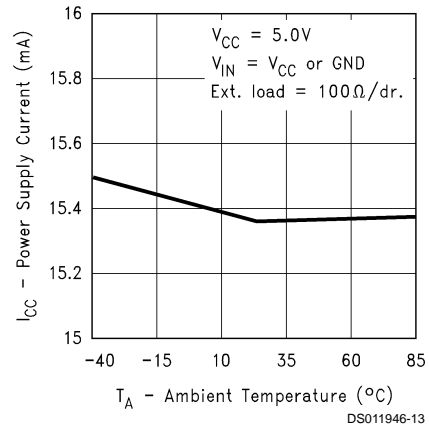
**Power Supply Current
vs Temperature**



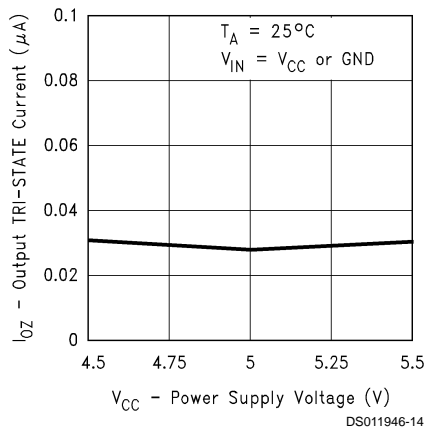
**Power Supply Current
vs Power Supply Voltage**



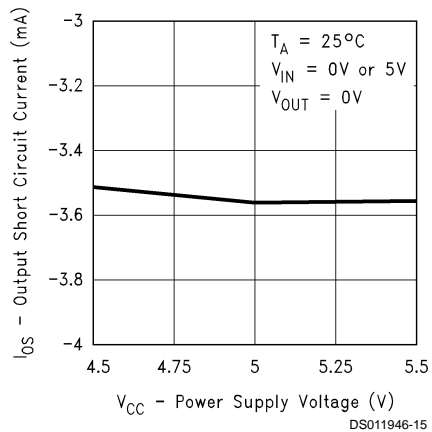
**Power Supply Current
vs Temperature**



**Output TRI-STATE Current
vs Power Supply Voltage**

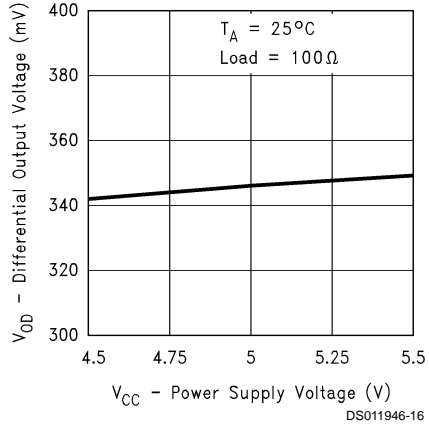


**Output Short Circuit Current
vs Power Supply Voltage**

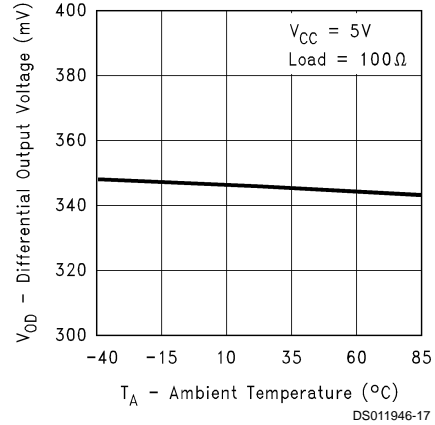


Typical Performance Characteristics (Continued)

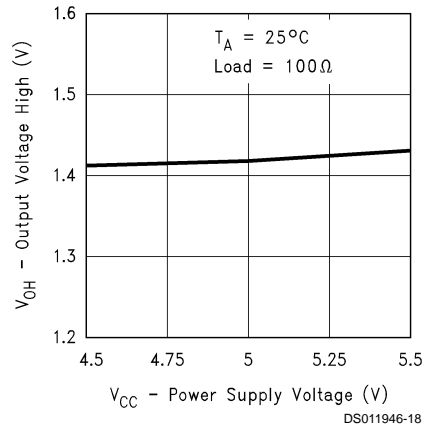
**Differential Output Voltage
vs Power Supply Voltage**



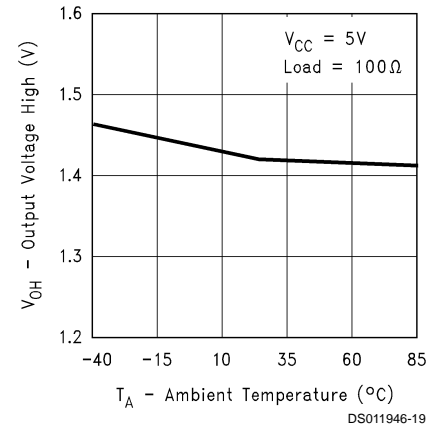
**Differential Output Voltage
vs Ambient Temperature**



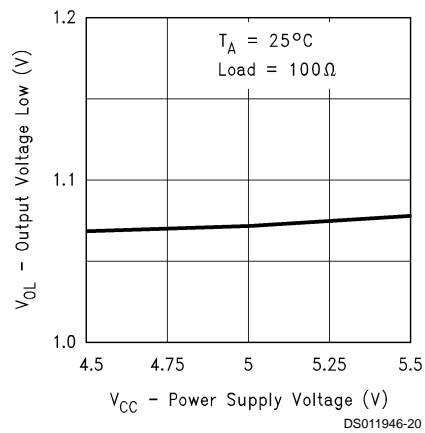
**Output Voltage High vs
Power Supply Voltage**



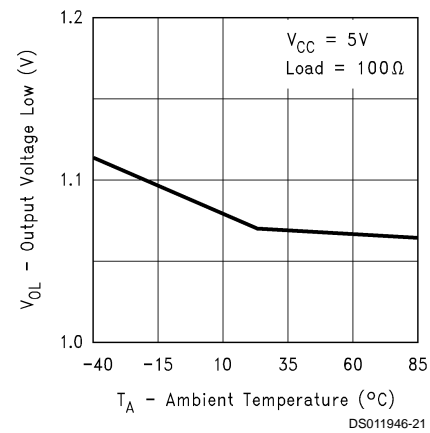
**Output Voltage High vs
Ambient Temperature**



**Output Voltage Low vs
Power Supply Voltage**

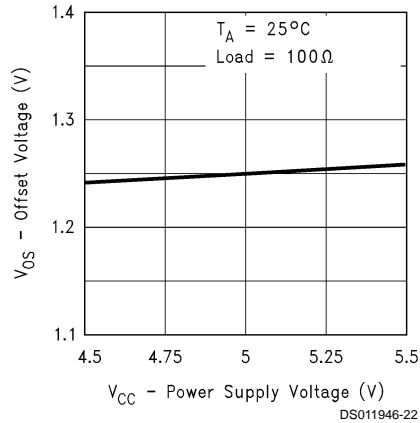


**Output Voltage Low vs
Ambient Temperature**

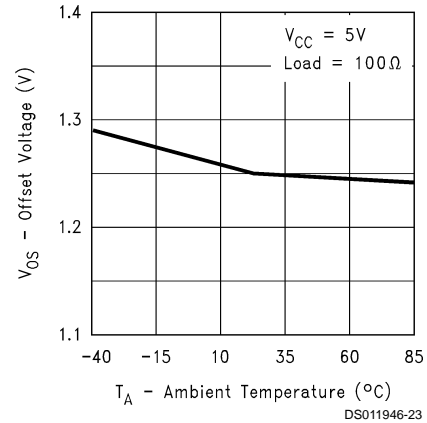


Typical Performance Characteristics (Continued)

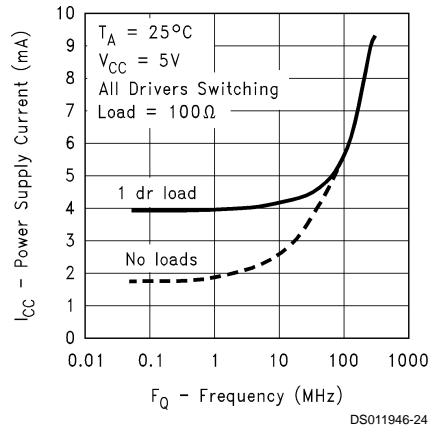
**Offset Voltage vs
Power Supply Voltage**



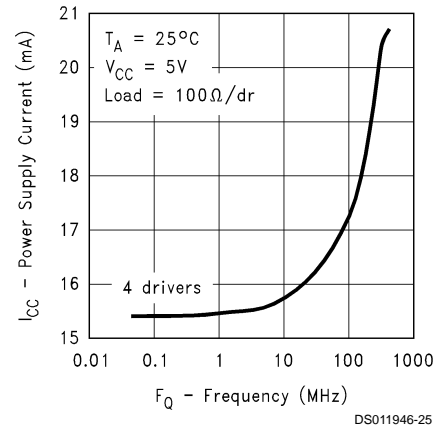
**Offset Voltage vs
Ambient Temperature**



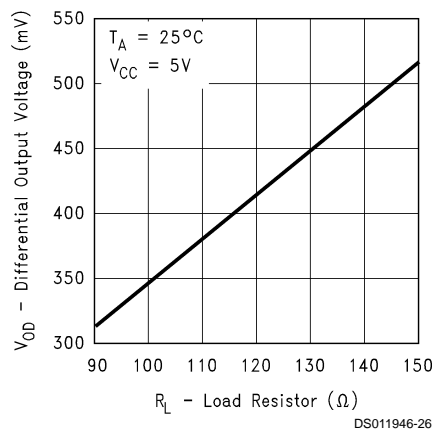
**Power Supply Current
vs Frequency**



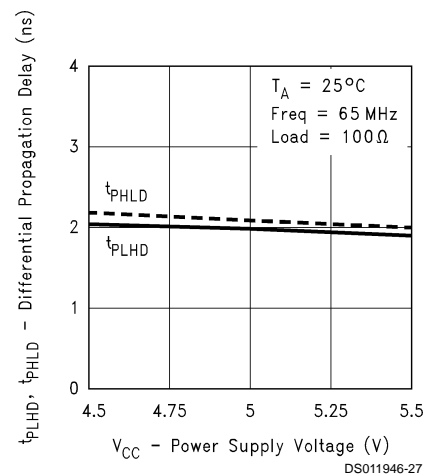
**Power Supply Current
vs Frequency**



**Differential Output Voltage
vs Load Resistor**

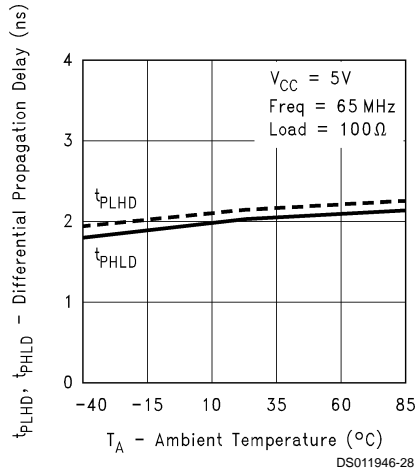


**Differential Propagation Delay
vs Power Supply Voltage**

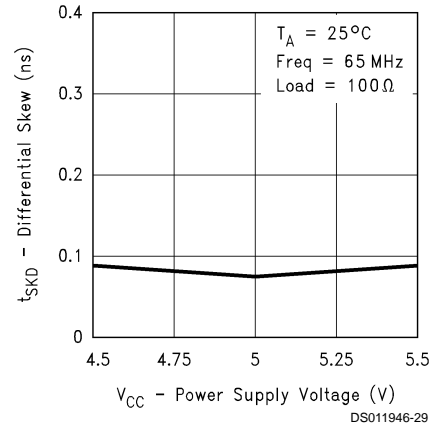


Typical Performance Characteristics (Continued)

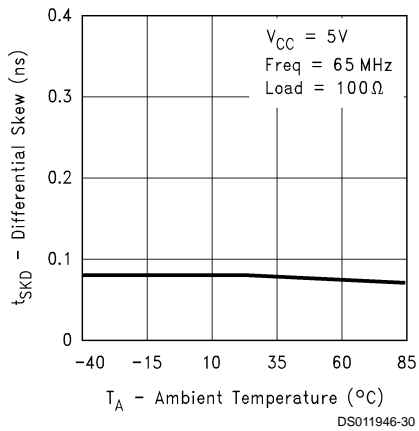
Differential Propagation Delay vs Ambient Temperature



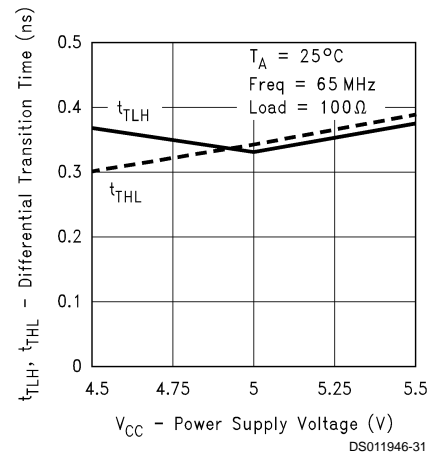
Differential Skew vs Power Supply Voltage



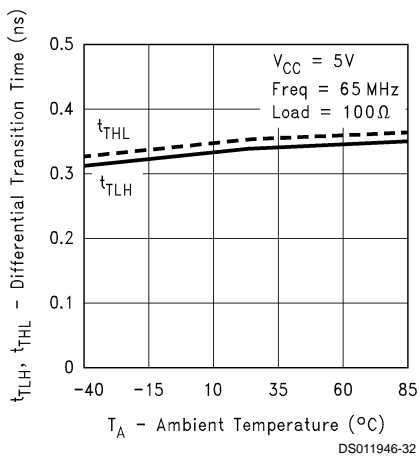
Differential Skew vs Ambient Temperature



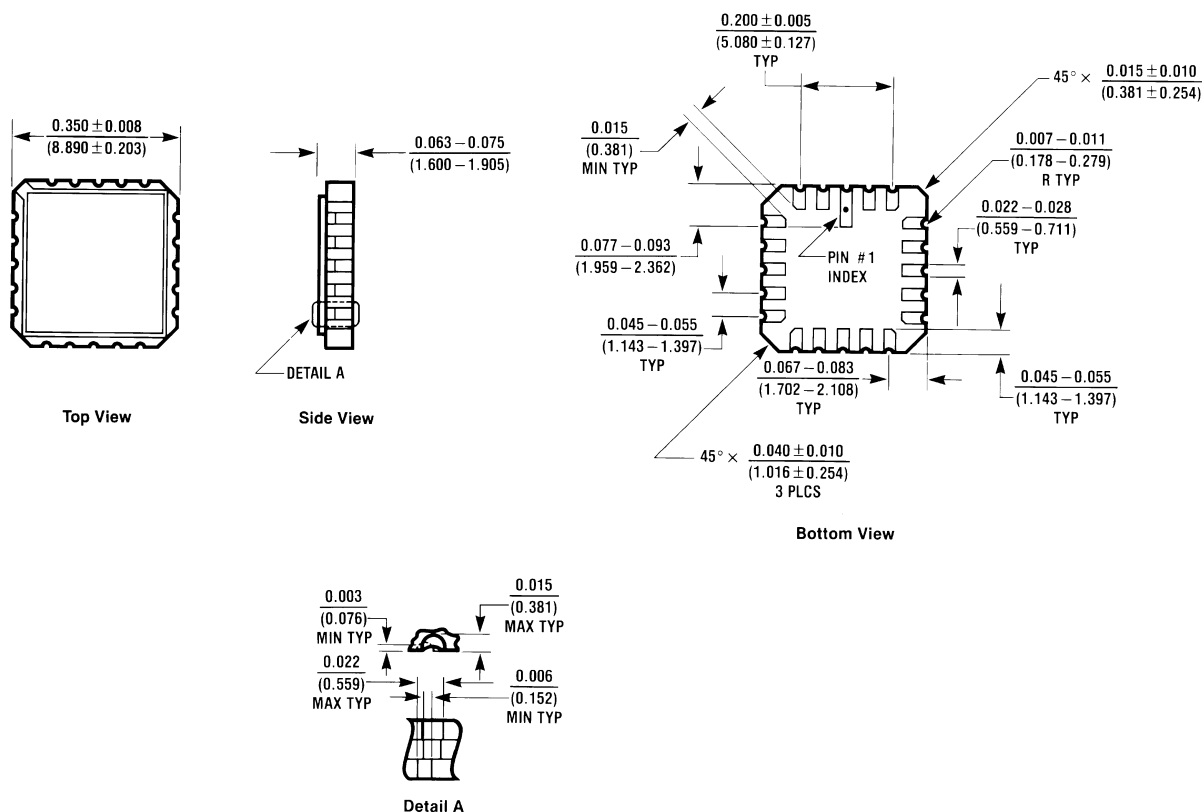
Differential Transition Time vs Power Supply Voltage



Differential Transition Time vs Ambient Temperature

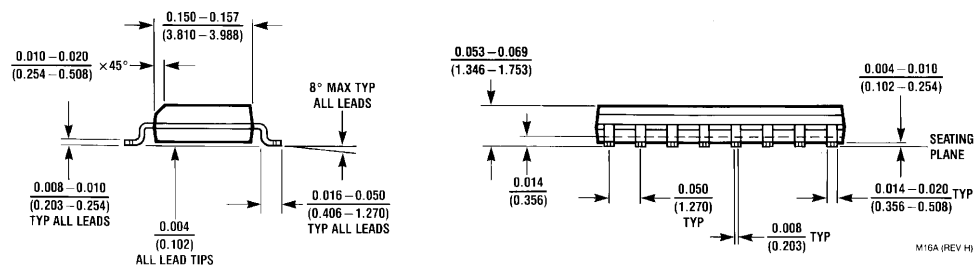
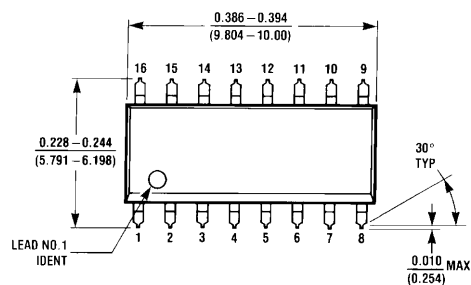


Physical Dimensions inches (millimeters) unless otherwise noted



E20A (REV D)

20-Lead Ceramic Leadless Chip Carrier, Type C
Order Number DS90C031E-QML
NS Package Number E20A



16-Lead (0.150" Wide) Molded Small Outline Package, JEDEC
Order Number DS90C031TM
NS Package Number M16A

Notes

LIFE SUPPORT POLICY

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

1. Life support devices or systems are devices or systems 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.
2. A critical component is any component of 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 Corporation
Americas
Tel: 1-800-272-9959
Fax: 1-800-737-7018
Email: support@nsc.com
www.national.com

National Semiconductor Europe
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor Asia Pacific Customer Response Group
Tel: 65-2544466
Fax: 65-2504466
Email: ap.support@nsc.com

National Semiconductor Japan Ltd.
Tel: 81-3-5639-7560
Fax: 81-3-5639-7507

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
DS90C031TM/NOPB	Active	Production	SOIC (D) 16	48 TUBE	Yes	SN	Level-1-260C-UNLIM	-40 to 85	DS90C031TM
DS90C031TM/NOPB.A	Active	Production	SOIC (D) 16	48 TUBE	Yes	SN	Level-1-260C-UNLIM	-40 to 85	DS90C031TM
DS90C031TMX/NOPB	Active	Production	SOIC (D) 16	2500 LARGE T&R	Yes	Call TI Sn	Level-1-260C-UNLIM	-40 to 85	DS90C031TM
DS90C031TMX/NOPB.A	Active	Production	SOIC (D) 16	2500 LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 85	DS90C031TM

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
DS90C031TMX/NOPB	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.3	8.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DS90C031TMX/NOPB	SOIC	D	16	2500	367.0	367.0	35.0

TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
DS90C031TM/NOPB	D	SOIC	16	48	495	8	4064	3.05
DS90C031TM/NOPB.A	D	SOIC	16	48	495	8	4064	3.05

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](#) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2025, Texas Instruments Incorporated

Last updated 10/2025