

## DS90LV019

### 3.3V or 5V LVDS Driver/Receiver

#### General Description

The DS90LV019 is a Driver/Receiver designed specifically for the high speed low power point-to-point interconnect applications. The device operates from a single 3.3V or 5.0V power supply and includes one differential line driver and one receiver. The DS90LV019 features an independent driver and receiver with TTL/CMOS compatibility ( $D_{IN}$  and  $R_{OUT}$ ). The logic interface provides maximum flexibility as 4 separate lines are provided ( $D_{IN}$ ,  $DE$ ,  $\overline{RE}$ , and  $R_{OUT}$ ). The device also features a flow-through pin out which allows easy PCB routing for short stubs between its pins and the connector. The driver has 3.5 mA output loop current.

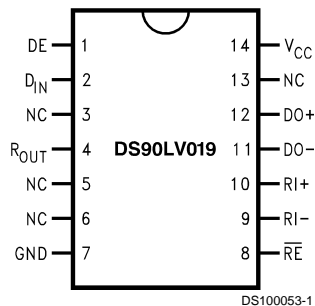
The driver translates between TTL levels (single-ended) to Low Voltage Differential Signaling levels. This allows for high speed operation, while consuming minimal power with reduced EMI. In addition, the differential signaling provides common-mode noise rejection.

The receiver threshold is  $\pm 100$  mV over a  $\pm 1V$  common-mode range and translates the low swing differential levels to standard (TTL/CMOS) levels.

#### Features

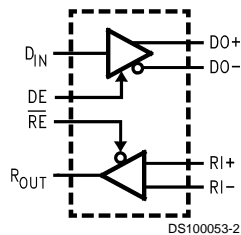
- LVDS Signaling
- 3.3V or 5.0V operation
- Low power CMOS design
- Balanced Output Impedance
- Glitch free power up/down (Driver disabled)
- High Signaling Rate Capacity (above 100 Mbps)
- Ultra Low Power Dissipation
- $\pm 1V$  Common-Mode Range
- $\pm 100$  mV Receiver Sensitivity
- Product offered in SOIC and TSSOP packages
- Flow-Through Pin Out
- Industrial Temperature Range Operation

#### Connection Diagram



Order Number DS90LV019TM or DS90LV019TMTC  
See NS Package Number M14A or MTC14

#### Block Diagram



**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 $V_{CC}$	6.0V
Enable Input Voltage (DE, $\overline{RE}$ )	-0.3V to ( $V_{CC} + 0.3V$ )
Driver Input Voltage ( $D_{IN}$ )	-0.3V to ( $V_{CC} + 0.3V$ )
Receiver Output Voltage ( $R_{OUT}$ )	-0.3V to ( $V_{CC} + 0.3V$ )
Driver Output Voltage ( $DO_{\pm}$ )	-0.3V to +3.9V
Receiver Input Voltage ( $RI_{\pm}$ )	-0.3V to ( $V_{CC} + 0.3V$ )
Driver Short Circuit Current	Continuous
ESD (Note 4)	
(HBM, 1.5 k $\Omega$ , 100 pF)	> 2.0 kV
(EIAJ, 0 $\Omega$ , 200 pF)	> 200 V
Maximum Package Power Dissipation at 25°C	
SOIC	960 mW

Derate SOIC Package	7.7mW/°C
TSSOP	790 mW
Derate TSSOP Package	6.3mW/°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 4 sec.)	260°C

**Recommended Operating Conditions**

	Min	Max	Units
Supply Voltage ( $V_{CC}$ ) or	3.0	3.6	V
Supply Voltage ( $V_{CC}$ )	4.5	5.5	V
Receiver Input Voltage	0.0	2.4	V
Operating Free Air Temperature $T_A$	-40	+85	°C

**DC Electrical Characteristics**

$T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$  unless otherwise noted,  $V_{CC} = 3.3 \pm 0.3V$ . (Notes 2, 3)

Symbol	Parameter	Conditions	Pin	Min	Typ	Max	Units
<b>DIFFERENTIAL DRIVER CHARACTERISTICS</b>							
$V_{OD}$	Output Differential Voltage	$R_L = 100\Omega$ (Figure 1)	DO+, DO-	250	350	450	mV
$\Delta V_{OD}$	$V_{OD}$ Magnitude Change				6	60	mV
$V_{OS}$	Offset Voltage			1	1.25	1.7	V
$\Delta V_{OS}$	Offset Magnitude Change				5	60	mV
$I_{OZD}$	TRI-STATE® Leakage	$V_{OUT} = V_{CC}$ or GND, DE = 0V		-10	$\pm 1$	+10	$\mu A$
$I_{OXD}$	Power-Off Leakage	$V_{OUT} = 3.6V$ or GND, $V_{CC} = 0V$		-10	$\pm 1$	+10	$\mu A$
$I_{OSD}$	Output Short Circuit Current	$V_{OUT} = 0V$ , DE = $V_{CC}$		-10	-6	-4	mA
<b>DIFFERENTIAL RECEIVER CHARACTERISTICS</b>							
$V_{OH}$	Voltage Output High	VID = +100 mV	$R_{OUT}$	2.9	3.3		V
		Inputs Open					
$V_{OL}$	Voltage Output Low	$I_{OL} = 2.0$ mA, VID = -100 mV			0.1	0.4	V
$I_{OS}$	Output Short Circuit Current	$V_{OUT} = 0V$		-75	-34	-20	mA
$V_{TH}$	Input Threshold High		RI+, RI-			+100	mV
$V_{TH}$	Input Threshold Low			-100			mV
$I_{IN}$	Input Current	$V_{IN} = +2.4V$ or 0V, $V_{CC} = 3.6V$ or 0V		-10	$\pm 1$	+10	$\mu A$
<b>DEVICE CHARACTERISTICS</b>							
$V_{IH}$	Minimum Input High Voltage		$D_{IN}$ , DE, $\overline{RE}$	2.0		$V_{CC}$	V
$V_{IL}$	Maximum Input Low Voltage			GND		0.8	V
$I_{IH}$	Input High Current	$V_{IN} = V_{CC}$ or 2.4V			$\pm 1$	$\pm 10$	$\mu A$
$I_{IL}$	Input Low Current	$V_{IN} = GND$ or 0.4V			$\pm 1$	$\pm 10$	$\mu A$
$V_{CL}$	Input Diode Clamp Voltage	$I_{CLAMP} = -18$ mA		-1.5	-0.7		V
$I_{CCD}$	Power Supply Current	DE = $\overline{RE} = V_{CC}$	$V_{CC}$		9	12.5	mA
$I_{CCR}$		DE = $\overline{RE} = 0V$			4.5	7.0	mA
$I_{CCZ}$		DE = 0V, $\overline{RE} = V_{CC}$			3.7	7.0	mA
$I_{CC}$		DE = $V_{CC}$ , $\overline{RE} = 0V$			15	20	mA
$C_{D\text{ output}}$	Capacitance		DO+, DO-		5		pF
$C_{R\text{ input}}$	Capacitance		RI+, RI-		5		pF

## DC Electrical Characteristics

$T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$  unless otherwise noted,  $V_{CC} = 5.0 \pm 0.5\text{V}$ . (Notes 2, 3)

Symbol	Parameter	Conditions	Pin	Min	Typ	Max	Units	
<b>DIFFERENTIAL DRIVER CHARACTERISTICS</b>								
$V_{OD}$	Output Differential Voltage	$R_L = 100\Omega$ (Figure 1)	DO+, DO-	250	360	450	mV	
$\Delta V_{OD}$	$V_{OD}$ Magnitude Change				6	60	mV	
$V_{OS}$	Offset Voltage			1	1.25	1.8	V	
$\Delta V_{OS}$	Offset Magnitude Change				5	60	mV	
$I_{OZD}$	TRI-STATE Leakage			$V_{OUT} = V_{CC}$ or GND, DE = 0V	-10	$\pm 1$	+10	$\mu\text{A}$
$I_{OXD}$	Power-Off Leakage			$V_{OUT} = 5.5\text{V}$ or GND, $V_{CC} = 0\text{V}$	-10	$\pm 1$	+10	$\mu\text{A}$
$I_{OSD}$	Output Short Circuit Current	$V_{OUT} = 0\text{V}$ , DE = $V_{CC}$	-10	-6	-4	mA		
<b>DIFFERENTIAL RECEIVER CHARACTERISTICS</b>								
$V_{OH}$	Voltage High	VID = +100 mV	$I_{OH} = -400 \mu\text{A}$	$R_{OUT}$	4.3	5.0		V
		Inputs Open			4.3	5.0		V
$V_{OL}$	Voltage Output Low	$I_{OL} = 2.0 \text{ mA}$ , VID = -100 mV			0.1	0.4	V	
$I_{OS}$	Output Short Circuit Current	$V_{OUT} = 0\text{V}$			-150	-75	-40	mA
$V_{TH}$	Input Threshold High			RI+, RI-			+100	mV
$V_{TH}$	Input Threshold Low							-100
$I_{IN}$	Input Current	$V_{IN} = +2.4\text{V}$ or 0V, $V_{CC} = 5.5\text{V}$ or 0V			-15	$\pm 1$	+15	$\mu\text{A}$
<b>DEVICE CHARACTERISTICS</b>								
$V_{IH}$	Minimum Input High Voltage			$D_{IN},$ DE, $\overline{RE}$	2.0		$V_{CC}$	V
$V_{IL}$	Maximum Input Low Voltage				GND		0.8	V
$I_{IH}$	Input High Current	$V_{IN} = V_{CC}$ or 2.4 V				$\pm 1$	$\pm 10$	$\mu\text{A}$
$I_{IL}$	Input Low Current	$V_{IN} = \text{GND}$ or 0.4V				$\pm 1$	$\pm 10$	$\mu\text{A}$
$V_{CL}$	Input Diode Clamp Voltage	$I_{CLAMP} = -18 \text{ mA}$			-1.5	-0.8		V
$I_{CCD}$	Power Supply Current	DE = $\overline{RE} = V_{CC}$		$V_{CC}$		12	19	mA
$I_{CCR}$		DE = $\overline{RE} = 0\text{V}$				5.8	8	mA
$I_{CCZ}$		DE = 0V, $\overline{RE} = V_{CC}$				4.5	8.5	mA
$I_{CC}$		DE = $V_{CC}$ , $\overline{RE} = 0\text{V}$				18	48	mA
$C_{D \text{ output}}$	Capacitance			DO+, DO-		5		pF
$C_{R \text{ input}}$	Capacitance			RI+, RI-		5		pF

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

**Note 2:** All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.

**Note 3:** All typicals are given for  $V_{CC} = +3.3\text{V}$  or  $+5.0\text{V}$  and  $T_A = +25^\circ\text{C}$ , unless otherwise stated.

**Note 4:** ESD Rating:

HBM (1.5 k $\Omega$ , 100 pF) > 2.0 kV

EIAJ (0 $\Omega$ , 200 pF) > 200V.

**Note 5:**  $C_L$  includes probe and fixture capacitance.

**Note 6:** Generator waveforms for all tests unless otherwise specified;  $f = 1 \text{ MHz}$ ,  $Z_O = 50\Omega$ ,  $t_r = t_f \leq 6.0 \text{ ns}$  (0%–100%).

## AC Electrical Characteristics

$T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $V_{CC} = 3.3\text{V} \pm 0.3\text{V}$ . (Note 6)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>DRIVER TIMING REQUIREMENTS</b>						
$t_{PHLD}$	Differential Propagation Delay High to Low	$R_L = 100\Omega,$ $C_L = 10 \text{ pF}$ (Figure 2 and Figure 3)	2.0	4.0	6.5	ns
$t_{PLHD}$	Differential Propagation Delay Low to High		1.0	5.6	7.0	ns
$t_{SKD}$	Differential Skew $ t_{PHLD} - t_{PLHD} $			0.4	1.0	ns
$t_{TLH}$	Transition Time Low to High		0.2	0.7	3.0	ns
$t_{THL}$	Transition Time High to Low		0.2	0.8	3.0	ns

## AC Electrical Characteristics (Continued)

$T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{CC} = 3.3\text{V} \pm 0.3\text{V}$ . (Note 6)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>DRIVER TIMING REQUIREMENTS</b>						
$t_{PHZ}$	Disable Time High to Z	$R_L = 100\Omega$ , $C_L = 10\text{ pF}$ (Figure 4 and Figure 5)	1.5	4.0	8.0	ns
$t_{PLZ}$	Disable Time Low to Z		2.5	5.3	9.0	ns
$t_{PZH}$	Enable Time Z to High		4.0	6.0	8.0	ns
$t_{PZL}$	Enable Time Z to Low		3.5	6.0	8.0	ns
<b>RECEIVER TIMING REQUIREMENTS</b>						
$t_{PHLD}$	Differential Propagation Delay High to Low	$C_L = 10\text{ pF}$ , $VID = 200\text{ mV}$ (Figure 6 and Figure 7)	3.0	5.8	7.0	ns
$t_{PLHD}$	Differential Propagation Delay Low to High		3.0	5.6	9.0	ns
$t_{SKD}$	Differential Skew $ t_{PHLD} - t_{PLHD} $			0.55	1.5	ns
$t_r$	Rise Time		0.15	2.0	3.0	ns
$t_f$	Fall Time		0.15	0.9	3.0	ns
$t_{PHZ}$	Disable Time High to Z	$R_L = 500\Omega$ , $C_L = 10\text{ pF}$ (Figure 8 and Figure 9)	3.0	4.0	6.0	ns
$t_{PLZ}$	Disable Time Low to Z		3.0	4.5	6.0	ns
$t_{PZH}$	Enable Time Z to High		3.0	6.0	8.0	ns
$t_{PZL}$	Enable Time Z to Low		3.0	6.0	8.0	ns

## AC Electrical Characteristics

$T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{CC} = 5.0\text{V} \pm 0.5\text{V}$ . (Note 6)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>DRIVER TIMING REQUIREMENTS</b>						
$t_{PHLD}$	Differential Propagation Delay High to Low	$R_L = 100\Omega$ , $C_L = 10\text{ pF}$ (Figure 2 and Figure 3)	2.0	3.3	6.0	ns
$t_{PLHD}$	Differential Propagation Delay Low to High		1.0	3.3	5.0	ns
$t_{SKD}$	Differential Skew $ t_{PHLD} - t_{PLHD} $			0.6	1.0	ns
$t_{TLH}$	Transition Time Low to High		0.15	0.9	3.0	ns
$t_{THL}$	Transition Time High to Low		0.15	1.2	3.0	ns
$t_{PHZ}$	Disable Time High to Z	$R_L = 100\Omega$ , $C_L = 10\text{ pF}$ (Figure 4 and Figure 5)	1.5	3.5	7.0	ns
$t_{PLZ}$	Disable Time Low to Z		3.0	5.2	9.0	ns
$t_{PZH}$	Enable Time Z to High		2.0	4.5	7.0	ns
$t_{PZL}$	Enable Time Z to Low		2.0	4.5	7.0	ns
<b>RECEIVER TIMING REQUIREMENTS</b>						
$t_{PHLD}$	Differential Propagation Delay High to Low	$C_L = 10\text{ pF}$ , $VID = 200\text{ mV}$ (Figure 6 and Figure 7)	3.0	6.0	8.0	ns
$t_{PLHD}$	Differential Propagation Delay Low to High		3.0	5.6	8.0	ns
$t_{SKD}$	Differential Skew $ t_{PHLD} - t_{PLHD} $			0.7	1.6	ns
$t_r$	Rise Time		0.15	0.8	3.0	ns
$t_f$	Fall Time		0.15	0.8	3.0	ns
$t_{PHZ}$	Disable Time High to Z	$R_L = 500\Omega$ , $C_L = 10\text{ pF}$ (Figure 8 and Figure 9)	3.0	3.5	4.5	ns
$t_{PLZ}$	Disable Time Low to Z		3.5	3.6	7.0	ns
$t_{PZH}$	Enable Time Z to High		3.0	5.0	7.0	ns
$t_{PZL}$	Enable Time Z to Low		3.0	5.0	7.0	ns

# Test Circuits and Timing Waveforms

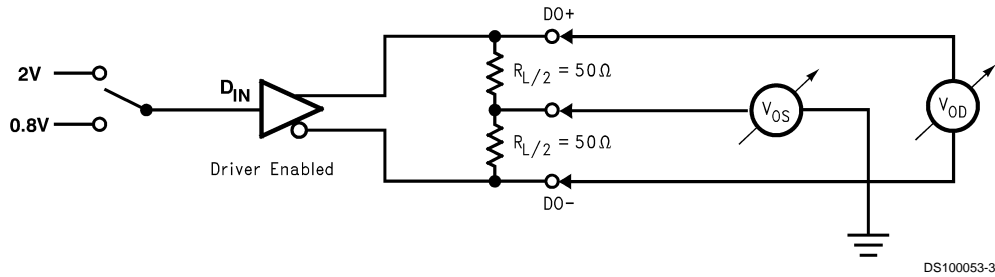


FIGURE 1. Differential Driver DC Test Circuit

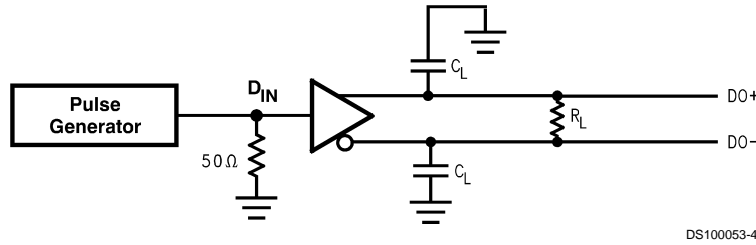


FIGURE 2. Differential Driver Propagation Delay and Transition Test Circuit

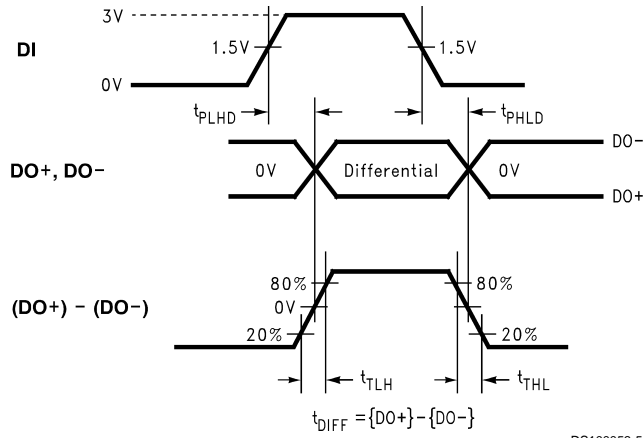


FIGURE 3. Differential Driver Propagation and Transition Time Waveforms

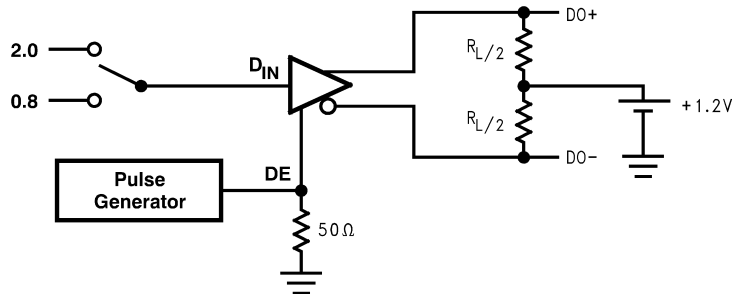


FIGURE 4. Driver TRI-STATE Delay Test Circuit

Test Circuits and Timing Waveforms (Continued)

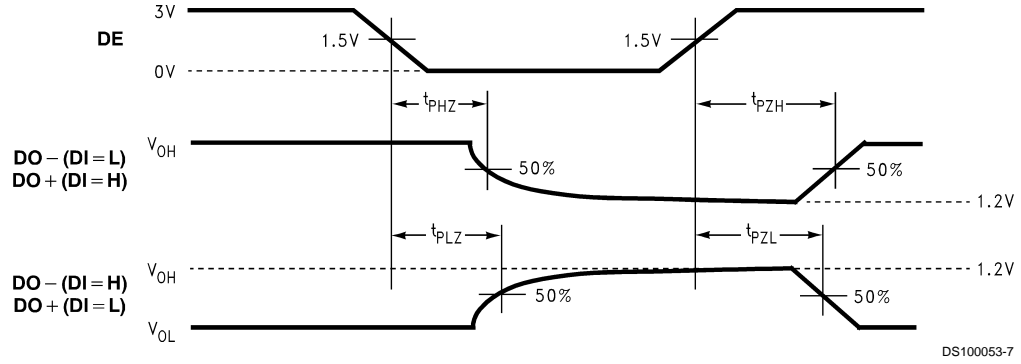
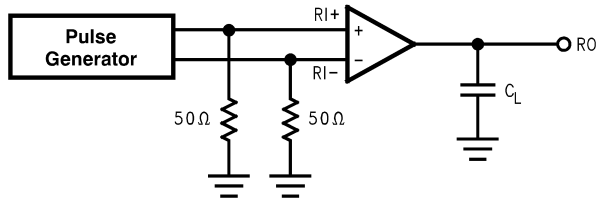
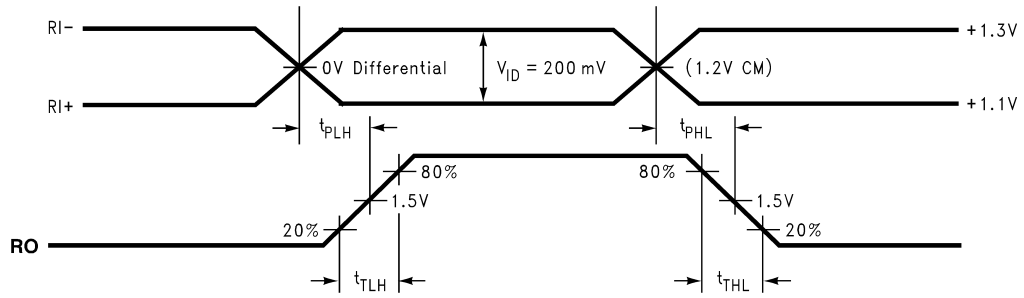


FIGURE 5. Driver TRI-STATE Delay Waveforms



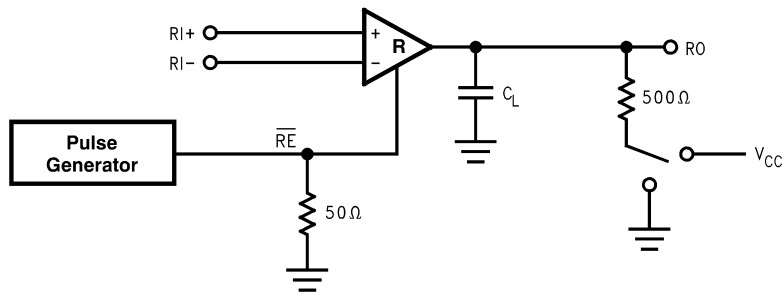
DS100053-8

FIGURE 6. Receiver Propagation Delay and Transition Time Test Circuit



DS100053-9

FIGURE 7. Receiver Propagation Delay and Transition Time Waveforms



DS100053-10

FIGURE 8. Receiver TRI-STATE Delay Test Circuit

## Test Circuits and Timing Waveforms (Continued)

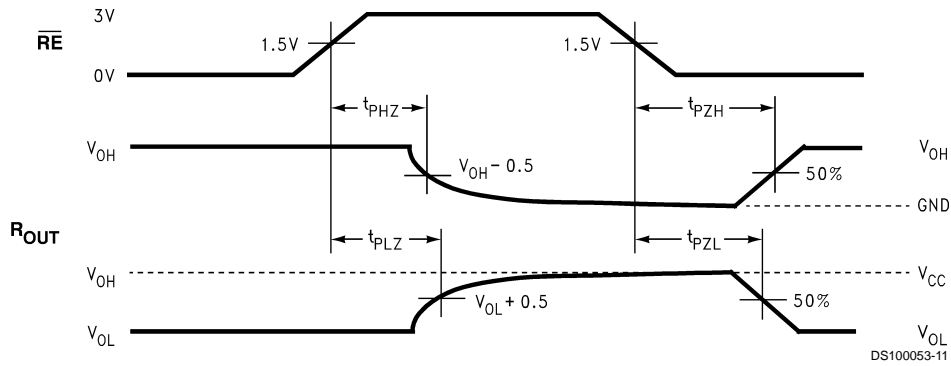
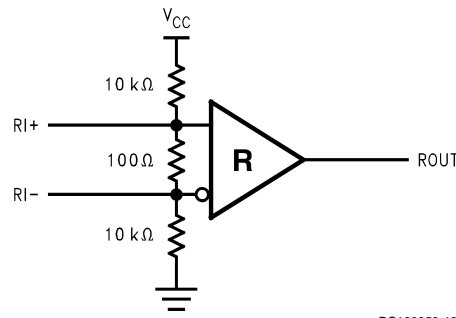


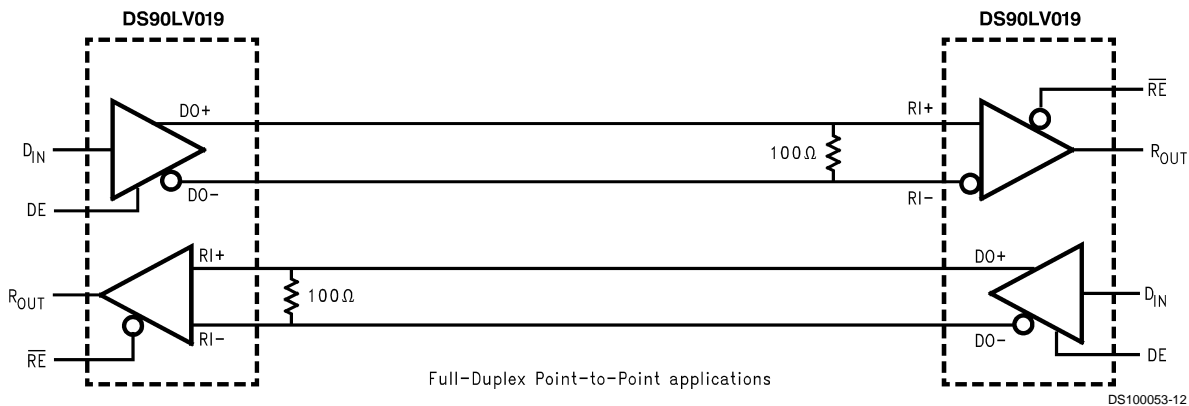
FIGURE 9. Receiver TRI-STATE Delay Waveforms



DS100053-13

FIGURE 10. Terminated Input Fail-Safe Circuit

## Typical Application Diagram



DS100053-12

## Applications Information

The DS90LV019 has two control pins, which allows the device to operate as a driver, a receiver or both driver and a receiver at the same time. There are a few common practices which should be implied when designing PCB for LVDS signaling. Recommended practices are:

- Use at least 4 PCB board layer (LVDS signals, ground, power and TTL signals).
- Keep drivers and receivers as close to the (LVDS port side) connector as possible.
- Bypass each LVDS device and also use distributed bulk capacitance. Surface mount capacitors placed close to power and ground pins work best. Two or three multi-layer ceramic (MLC) surface mount capacitors 0.1  $\mu$ F,

and 0.01  $\mu$ F in parallel should be used between each  $V_{CC}$  and ground. The capacitors should be as close as possible to the  $V_{CC}$  pin.

- Use controlled impedance traces which match the differential impedance of your transmission medium (i.e., Cable) and termination resistor.
- Use the termination resistor which best matches the differential impedance of your transmission line.
- Isolate TTL signals from LVDS signals.

### MEDIA (CABLE AND CONNECTOR) SELECTION:

- Use controlled impedance media. The cables and connectors should have a matched differential impedance of about 100 $\Omega$ .

## Applications Information (Continued)

- Balanced cables (e.g., twisted pair) are usually better than unbalanced cables (ribbon cable, simple coax) for noise reduction and signal quality.
- For cable distances  $< 0.5\text{m}$ , most cables can be made to work effectively. For distances  $0.5\text{m} \leq d \leq 10\text{m}$ , CAT 3 (category 3) twisted pair cable works well and is readily available and relatively inexpensive. For distances  $> 10\text{m}$ , and high data rates CAT 5 twisted pair is recommended.
- There are three Fail-Safe scenarios, open input pins, shorted inputs pins and terminated input pins. The first case is guaranteed for DS90LV019. A HIGH state on  $R_{OUT}$  pin can be achieved by using two external resistors (one to  $V_{CC}$  and one to GND) per *Figure 10* (Terminated Input Fail-Safe Circuit).  $R_1$  and  $R_2$  should be  $R_T$  to limit the loading to the LVDS driver.  $R_T$  is selected to match the impedance of the cable.

TABLE 1. Functional Table

MODE SELECTED	DE	$\overline{RE}$
DRIVER MODE	H	H
RECEIVER MODE	L	L
TRI-STATE MODE	L	H
FULL DUPLEX MODE	H	L

TABLE 2. Transmitter Mode

INPUTS		OUTPUTS	
DE	DI	DO+	DO-
H	L	L	H
H	H	H	L
H	$2 > \& > 0.8$	X	X
L	X	Z	Z

X = High or Low logic state  
 Z = High impedance state  
 L = Low state  
 H = High state

TABLE 3. Receiver Mode

INPUTS		OUTPUT
$\overline{RE}$	(RI+) – (RI-)	
L	L ( $< -100\text{mV}$ )	L
L	H ( $> +100\text{mV}$ )	H
L	$100\text{mV} > \& > -100\text{mV}$	X
H	X	Z

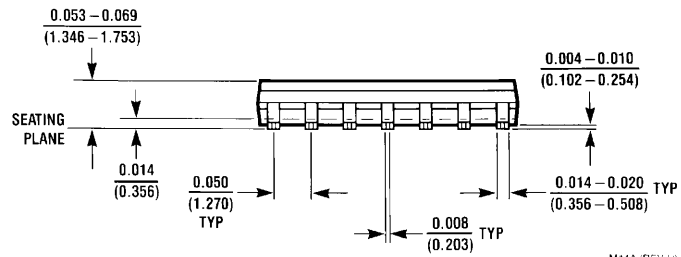
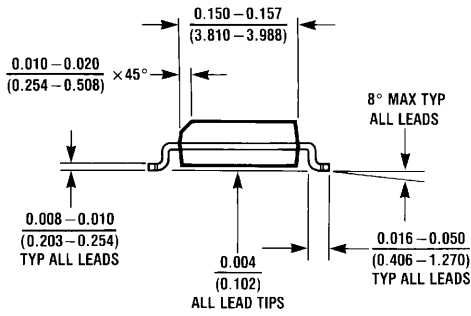
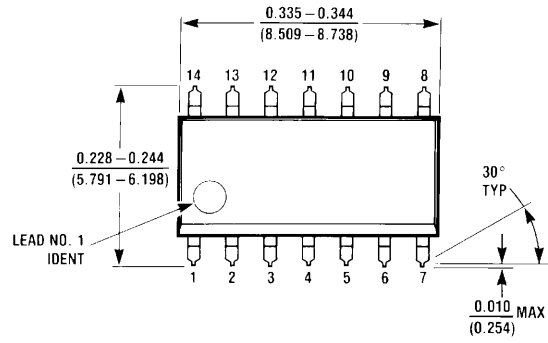
X = High or Low logic state  
 Z = High impedance state  
 L = Low state  
 H = High state

TABLE 4. Device Pin Description

Pin Name	Pin #	Input/Output	Description
$D_{IN}$	2	I	TTL Driver Input
$DO_{\pm}$	11, 12	O	LVDS Driver Outputs
$RI_{\pm}$	9, 10	I	LVDS Receiver Inputs
$R_{OUT}$	4	O	TTL Receiver Output
$\overline{RE}$	8	I	Receiver Enable TTL Input (Active Low)
DE	1	I	Driver Enable TTL Input (Active High)
GND	7	NA	Ground
$V_{CC}$	14	NA	Power Supply ( $3.3\text{V} \pm 0.3\text{V}$ or $5.0\text{V} \pm 0.5\text{V}$ )



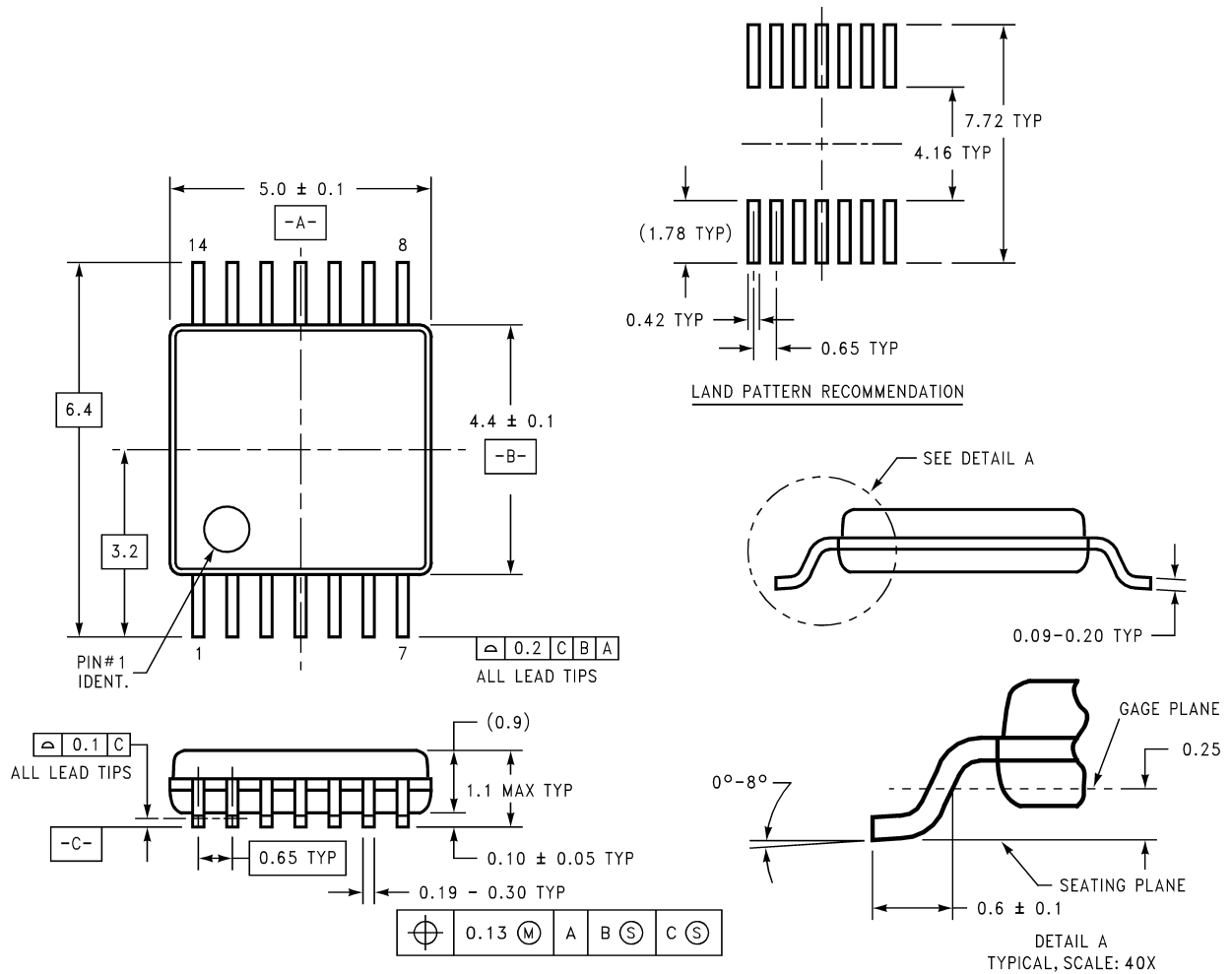
**Physical Dimensions** inches (millimeters) unless otherwise noted



M14A (REV H)

**Order Number DS90LV019TM**  
**NS Package Number M14A**

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



**Order Number DS90LV019TMT**  
**NS Package Number MTC14**

MTC14 (REV C)

**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.

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