

# DS91D180/DS91C180 100 MHz M-LVDS Line Driver/Receiver Pair

## General Description

The DS91D180 and DS91C180 are 100 MHz M-LVDS (Multipoint Low Voltage Differential Signaling) line driver/receiver pairs designed for applications that utilize multipoint networks (e.g. clock distribution in ATCA and uTCA based systems). M-LVDS is a new bus interface standard (TIA/EIA-899) optimized for multidrop networks. Controlled edge rates, tight input receiver thresholds and increased drive strength are one of the key enhancements that make M-LVDS devices an ideal choice for distributing signals via multipoint networks.

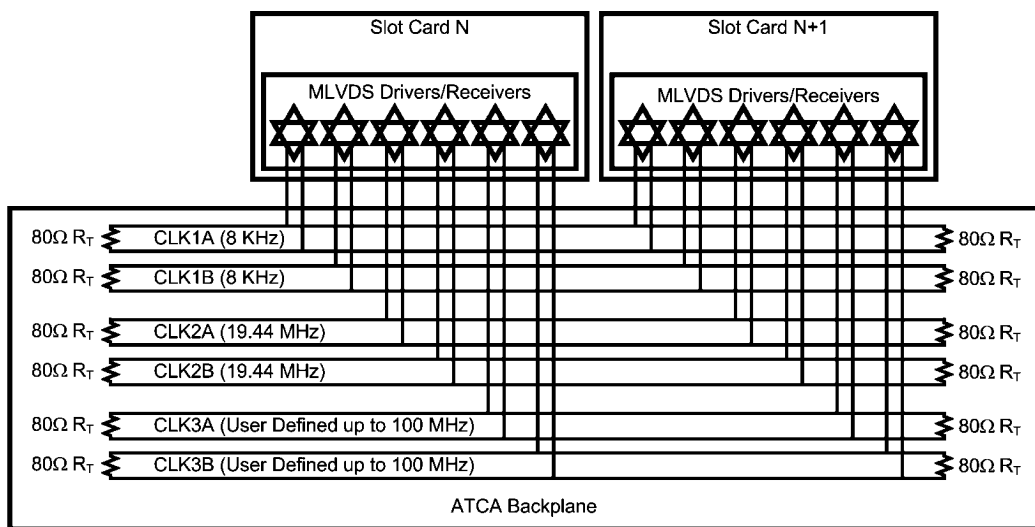
The DS91D180/DS91C180 driver input accepts LVTTTL/LVCMOS signals and converts them to differential M-LVDS signal levels. The DS91D180/DS91C180 receiver accepts low voltage differential signals (LVDS, B-LVDS, M-LVDS, LV-PECL and CML) and converts them to 3V LVCMOS signals. The DS91D180 device has a M-LVDS type 1 receiver input with

no offset. The DS91C180 device has a type 2 receiver input which enable failsafe functionality.

## Features

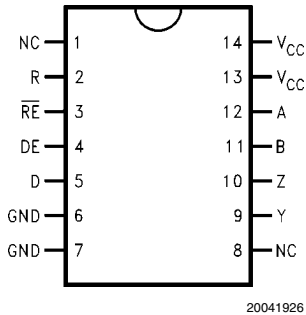
- DC to 100+ MHz / 200+ Mbps low power, low EMI operation
- Optimal for ATCA, uTCA clock distribution networks
- Meets or exceeds TIA/EIA-899 M-LVDS Standard
- Wide Input Common Mode Voltage for Increased Noise Immunity
- DS91D180 has type 1 receiver input
- DS91C180 has type 2 receiver input for fail-safe functionality
- Industrial temperature range
- Space saving SOIC-14 package (JEDEC MS-012)

## Typical Application in an ATCA Clock Distribution Network



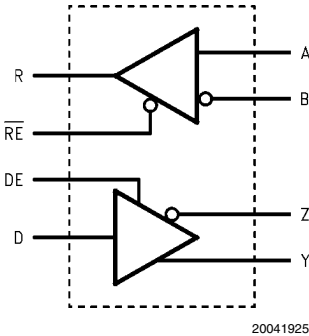
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Connection Diagram



Top View  
Order Number DS91D180TMA, DS91C180TMA  
See NS Package Number M14A

Logic Diagram



Ordering Information

Order Number	Receiver Input	Function	Package Type
DS91D180TMA	type 1	Data (0V threshold receiver)	SOIC/M14A
DS91C180TMA	type 2	Control (offset fail-safe receiver)	SOIC/M14A

M-LVDS Receiver Types

The EIA/TIA-899 M-LVDS standard specifies two different types of receiver input stages. A type 1 receiver has a conventional threshold that is centered at the midpoint of the input amplitude,  $V_{ID}/2$ . A type 2 receiver has a built in offset that is 100mV greater than  $V_{ID}/2$ . The type 2 receiver offset acts as a failsafe circuit where open or short circuits at the input will always result in the output stage being driven to a low logic state.

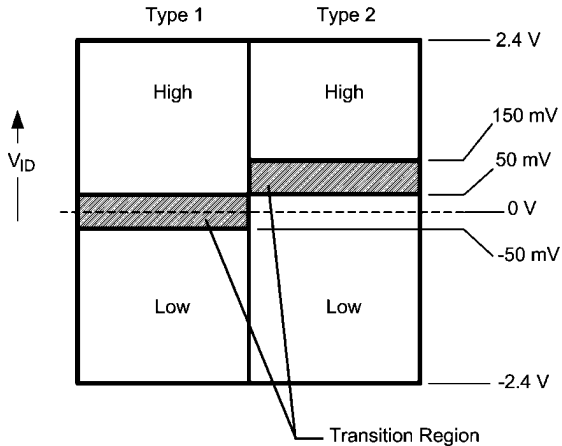


FIGURE 1. M-LVDS Receiver Input Thresholds

## 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 +4V
Control Input Voltages	-0.3V to ( $V_{CC} + 0.3V$ )
Driver Input Voltage	-0.3V to ( $V_{CC} + 0.3V$ )
Driver Output Voltages	-1.8V to +4.1V
Receiver Input Voltages	-1.8V to +4.1V
Receiver Output Voltage	-0.3V to ( $V_{CC} + 0.3V$ )
Maximum Package Power Dissipation at +25°C	
SOIC Package	1.1 W
Derate SOIC Package	8.8 mW/°C above +25°C
Thermal Resistance	
$\theta_{JA}$	113.7 °C/W
$\theta_{JC}$	36.9 °C/W
Maximum Junction Temperature	150°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 4 seconds)	260°C

ESD Ratings:

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

$\geq 5$  kV

(EIAJ 0 $\Omega$ , 200pF)

$\geq 250$  V

(CDM 0 $\Omega$ , 0pF)

$\geq 1000$  V

## Recommended Operating Conditions

	Min	Typ	Max	Units
Supply Voltage, $V_{CC}$	3.0	3.3	3.6	V
Voltage at Any Bus Terminal (Separate or Common-Mode)	-1.4		+3.8	V
Differential Input Voltage $V_{ID}$			2.4	V
High Level Input Voltage $V_{IH}$	2.0		$V_{CC}$	V
Low Level Input Voltage $V_{IL}$	0		0.8	V
Operating Free Air Temperature $T_A$	-40	+25	+85	°C

## Electrical Characteristics

Over recommended operating supply and temperature ranges unless otherwise specified. (Notes 2, 3, 4, 8)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>M-LVDS Driver</b>						
$ V_{YZ} $	Differential output voltage magnitude	$R_L = 50\Omega$ , $C_L = 5pF$	480		650	mV
$\Delta V_{YZ}$	Change in differential output voltage magnitude between logic states	Figure 2 and Figure 4	-50	0	+50	mV
$V_{OS(SS)}$	Steady-state common-mode output voltage	$R_L = 50\Omega$ , $C_L = 5pF$	0.3	1.8	2.1	V
$ \Delta V_{OS(SS)} $	Change in steady-state common-mode output voltage between logic states	Figure 2 and Figure 3	0		+50	mV
$V_{OS(PP)}$	Peak-to-peak common-mode output voltage	( $V_{OS(pp)}$ @ 500KHz clock)		143		mV
$V_{Y(OC)}$	Maximum steady-state open-circuit output voltage	Figure 5	0		2.4	V
$V_{Z(OC)}$	Maximum steady-state open-circuit output voltage		0		2.4	V
$V_{P(H)}$	Voltage overshoot, low-to-high level output	$R_L = 50\Omega$ , $C_L = 5pF$ ,			1.2 $V_{SS}$	V
$V_{P(L)}$	Voltage overshoot, high-to-low level output	$C_D = 0.5pF$ Figure 7 and Figure 8 (Note 9)	-0.2 $V_S$			V
$I_{IH}$	High-level input current (LVTTTL inputs)	$V_{IH} = 2.0V$	-15		15	$\mu A$
$I_{IL}$	Low-level input current (LVTTTL inputs)	$V_{IL} = 0.8V$	-15		15	$\mu A$
$V_{IKL}$	Input Clamp Voltage (LVTTTL inputs)	$I_{IN} = -18$ mA	-1.5			V
$I_{OS}$	Differential short-circuit output current	Figure 6	-43		43	mA
<b>M-LVDS Receiver</b>						
$V_{IT+}$	Positive-going differential input voltage threshold	See Function Tables	Type 1		20	50 mV
			Type 2		94	150 mV
$V_{IT-}$	Negative-going differential input voltage threshold	See Function Tables	Type 1	-50	20	mV
			Type 2	50	94	mV
$V_{OH}$	High-level output voltage	$I_{OH} = -8$ mA	2.4	2.7		V
$V_{OL}$	Low-level output voltage	$I_{OL} = 8$ mA		0.28	0.4	V
$I_{OZ}$	TRI-STATE output current	$V_O = 0V$ or 3.6V	-10		10	$\mu A$
$I_{OSR}$	Short circuit Receiver output current (LVTTTL Output)	$V_O = 0V$	-90	-48		mA

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>M-LVDS Bus (Input and Output) Pins</b>						
$I_A, I_Y$	Receiver input or driver high-impedance output current	$V_{A,Y} = 3.8V, V_{B,Z} = 1.2V, DE = GND$			32	$\mu A$
		$V_{A,Y} = 0V \text{ or } 2.4V, V_{B,Z} = 1.2V, DE = GND$	-20		+20	$\mu A$
		$V_{A,Y} = -1.4V, V_{B,Z} = 1.2V, DE = GND$	-32			$\mu A$
$I_B, I_Z$	Receiver input or driver high-impedance output current	$V_{B,Z} = 3.8V, V_{A,Y} = 1.2V, DE = GND$			32	$\mu A$
		$V_{B,Z} = 0V \text{ or } 2.4V, V_{A,Y} = 1.2V, DE = GND$	-20		+20	$\mu A$
		$V_{B,Z} = -1.4V, V_{A,Y} = 1.2V, DE = GND$	-32			$\mu A$
$I_{AB}, I_{YZ}$	Receiver input or driver high-impedance output differential current ( $I_A - I_B$ or $I_Y - I_Z$ )	$V_{A,Y} = V_{B,Z}, -1.4V \leq V \leq 3.8V, DE = GND$	-4		+4	$\mu A$
$I_{A(OFF)}, I_{Y(OFF)}$	Receiver input or driver high-impedance output power-off current	$V_{A,Y} = 3.8V, V_{B,Z} = 1.2V, DE = V_{CC} = 1.5V$			32	$\mu A$
		$V_{A,Y} = 0V \text{ or } 2.4V, V_{B,Z} = 1.2V, DE = V_{CC} = 1.5V$	-20		+20	$\mu A$
		$V_{A,Y} = -1.4V, V_{B,Z} = 1.2V, DE = V_{CC} = 1.5V$	-32			$\mu A$
$I_{B(OFF)}, I_{Z(OFF)}$	Receiver input or driver high-impedance output power-off current	$V_{B,Z} = 3.8V, V_{A,Y} = 1.2V, DE = V_{CC} = 1.5V$			32	$\mu A$
		$V_{B,Z} = 0V \text{ or } 2.4V, V_{A,Y} = 1.2V, DE = V_{CC} = 1.5V$	-20		+20	$\mu A$
		$V_{B,Z} = -1.4V, V_{A,Y} = 1.2V, DE = V_{CC} = 1.5V$	-32			$\mu A$
$I_{AB(OFF)}, I_{YZ(OFF)}$	Receiver input or driver high-impedance output power-off differential current ( $I_{A(OFF)} - I_{B(OFF)}$ or $I_{Y(OFF)} - I_{Z(OFF)}$ )	$V_{A,Y} = V_{B,Z}, -1.4V \leq V \leq 3.8V, V_{CC} = 1.5V, DE = 1.5V$	-4		+4	$\mu A$
$C_A, C_B$	Receiver input capacitance	$V_{CC} = OPEN$		5.1		pF
$C_Y, C_Z$	Driver output capacitance			8.5		pF
$C_{AB}$	Receiver input differential capacitance			2.5		pF
$C_{YZ}$	Driver output differential capacitance			5.5		pF
$C_{A/B}, C_{Y/Z}$	Receiver input or driver output capacitance balance ( $C_A/C_B$ or $C_Y/C_Z$ )			1.0		
<b>SUPPLY CURRENT (<math>V_{CC}</math>)</b>						
$I_{CCD}$	Driver Supply Current	$R_L = 50\Omega, DE = V_{CC}, \overline{RE} = V_{CC}$		17	29.5	mA
$I_{CCZ}$	TRI-STATE Supply Current	$DE = GND, \overline{RE} = V_{CC}$		7	9.0	mA
$I_{CCR}$	Receiver Supply Current	$DE = GND, \overline{RE} = GND$		14	18.5	mA
$I_{CCB}$	Supply Current, Driver and Receiver Enabled	$DE = V_{CC}, \overline{RE} = GND$		20	29.5	mA

## Switching Characteristics

Over recommended operating supply and temperature ranges unless otherwise specified. (Notes 3, 8)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>DRIVER AC SPECIFICATION</b>						
$t_{PLH}$	Differential Propagation Delay Low to High	$R_L = 50\Omega$ , $C_L = 5\text{ pF}$ , $C_D = 0.5\text{ pF}$ <i>Figure 7 and Figure 8</i>	1.0	3.4	5.5	ns
$t_{PHL}$	Differential Propagation Delay High to Low		1.0	3.1	5.5	ns
$t_{SKD1} (t_{sk(p)})$	Pulse Skew $ t_{PLHD} - t_{PHLD} $ (Notes 5, 9)			300	420	ps
$t_{SKD3}$	Part-to-Part Skew (Notes 6, 9)				1.9	ns
$t_{TLH} (t_r)$	Rise Time (Note 9)		1.0	1.8	3.0	ns
$t_{THL} (t_f)$	Fall Time (Note 9)		1.0	1.8	3.0	ns
$t_{PZH}$	Enable Time (Z to Active High)	$R_L = 50\Omega$ , $C_L = 5\text{ pF}$ , $C_D = 0.5\text{ pF}$ <i>Figure 9 and Figure 10</i>			8	ns
$t_{PZL}$	Enable Time (Z to Active Low)				8	ns
$t_{PLZ}$	Disable Time (Active Low to Z)				8	ns
$t_{PHZ}$	Disable Time (Active High to Z)				8	ns
$t_{JIT}$	Random Jitter, RJ (Note 9)	100MHz clock pattern (Note 7)		2.5	5.5	psrms
$f_{MAX}$	Maximum Data Rate		200			Mbps
<b>RECEIVER AC SPECIFICATION</b>						
$t_{PLH}$	Propagation Delay Low to High	$C_L = 15\text{ pF}$ <i>Figures 11, 12 and Figure 13</i>	2.0	4.7	7.5	ns
$t_{PHL}$	Propagation Delay High to Low		2.0	5.3	7.5	ns
$t_{SKD1} (t_{sk(p)})$	Pulse Skew $ t_{PLHD} - t_{PHLD} $ (Notes 5, 9)			0.6	1.9	ns
$t_{SKD3}$	Part-to-Part Skew (Notes 6, 9)				1.5	ns
$t_{TLH} (t_r)$	Rise Time (Note 9)		0.5	1.2	3.0	ns
$t_{THL} (t_f)$	Fall Time (Note 9)		0.5	1.2	3.0	ns
$t_{PZH}$	Enable Time (Z to Active High)	$R_L = 500\Omega$ , $C_L = 15\text{ pF}$ <i>Figure 14 and Figure 15</i>			10	ns
$t_{PZL}$	Enable Time (Z to Active Low)				10	ns
$t_{PLZ}$	Disable Time (Active Low to Z)				10	ns
$t_{PHZ}$	Disable Time (Active High to Z)				10	ns
$f_{MAX}$	Maximum Data Rate		200			Mbps

**Note 1:** "Absolute Maximum Ratings" are those 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 tables of "Electrical Characteristics" provide 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  $V_{CC} = 3.3\text{V}$  and  $T_A = 25^\circ\text{C}$ .

**Note 4:** The algebraic convention, in which the least positive (most negative) limit is designated as minimum, is used in this datasheet.

**Note 5:**  $t_{SKD1}$ ,  $|t_{PLHD} - t_{PHLD}|$ , is the magnitude difference in differential propagation delay time between the positive going edge and the negative going edge of the same channel.

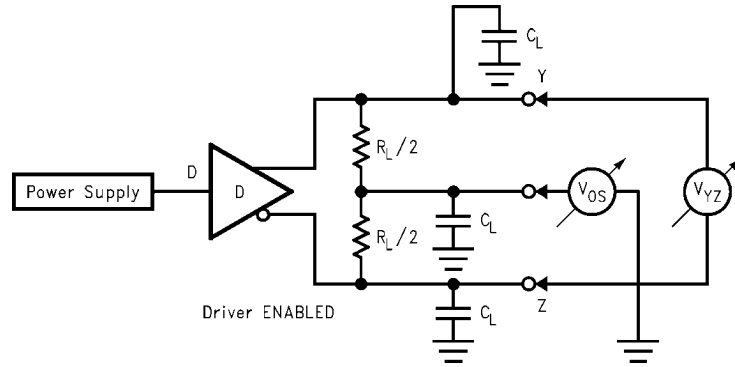
**Note 6:**  $t_{SKD3}$ , Part-to-Part Skew, is defined as the difference between the minimum and maximum specified differential propagation delays. This specification applies to devices at the same  $V_{CC}$  and within  $5^\circ\text{C}$  of each other within the operating temperature range.

**Note 7:** Stimulus and fixture jitter has been subtracted.

**Note 8:**  $C_L$  includes fixture capacitance and  $C_D$  includes probe capacitance.

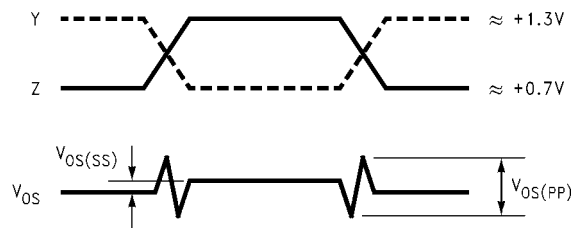
**Note 9:** Not production tested. Guaranteed by a statistical analysis on a sample basis at the time of characterization.

## Test Circuits and Waveforms



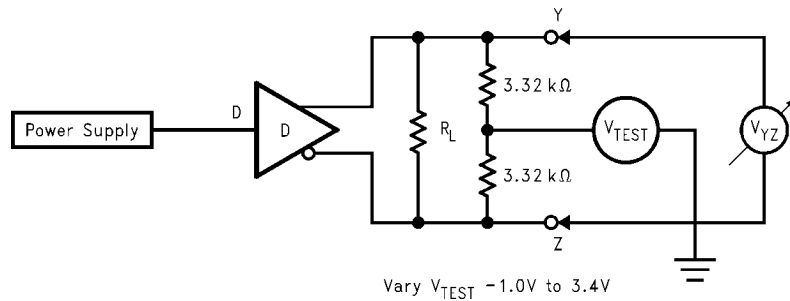
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FIGURE 2. Differential Driver Test Circuit



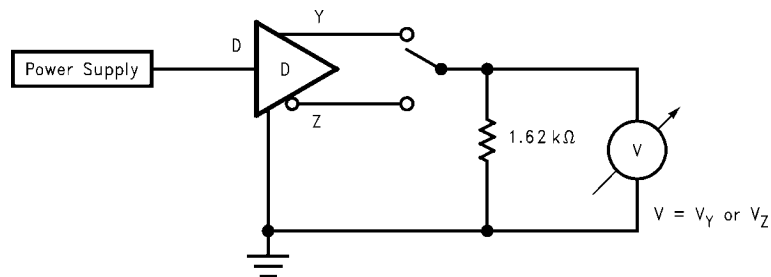
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FIGURE 3. Differential Driver Waveforms



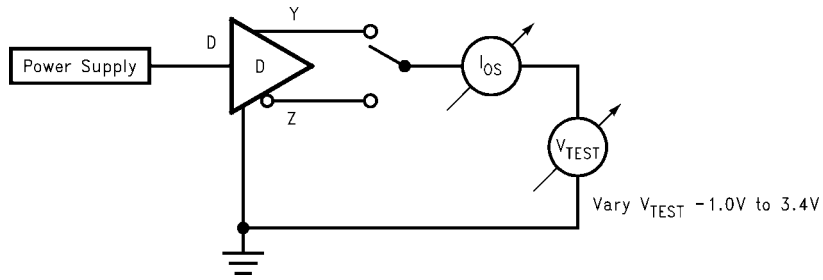
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FIGURE 4. Differential Driver Full Load Test Circuit



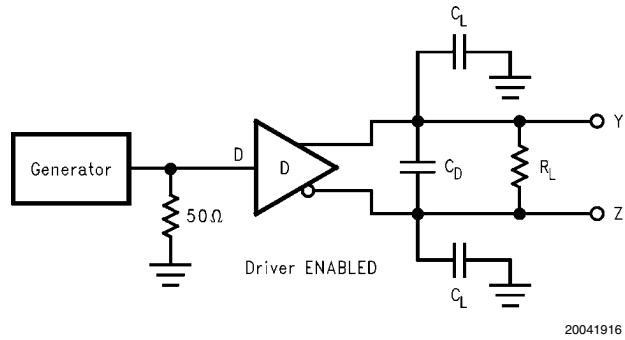
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FIGURE 5. Differential Driver DC Open Test Circuit



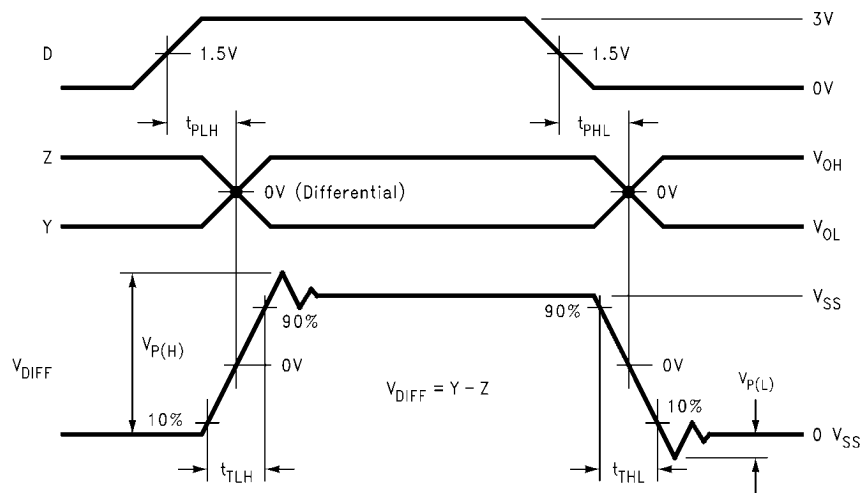
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FIGURE 6. Differential Driver Short-Circuit Test Circuit



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FIGURE 7. Driver Propagation Delay and Transition Time Test Circuit



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FIGURE 8. Driver Propagation Delays and Transition Time Waveforms



**FIGURE 9. Driver TRI-STATE Delay Test Circuit**



**FIGURE 10. Driver TRI-STATE Delay Waveforms**



**FIGURE 11. Receiver Propagation Delay and Transition Time Test Circuit**

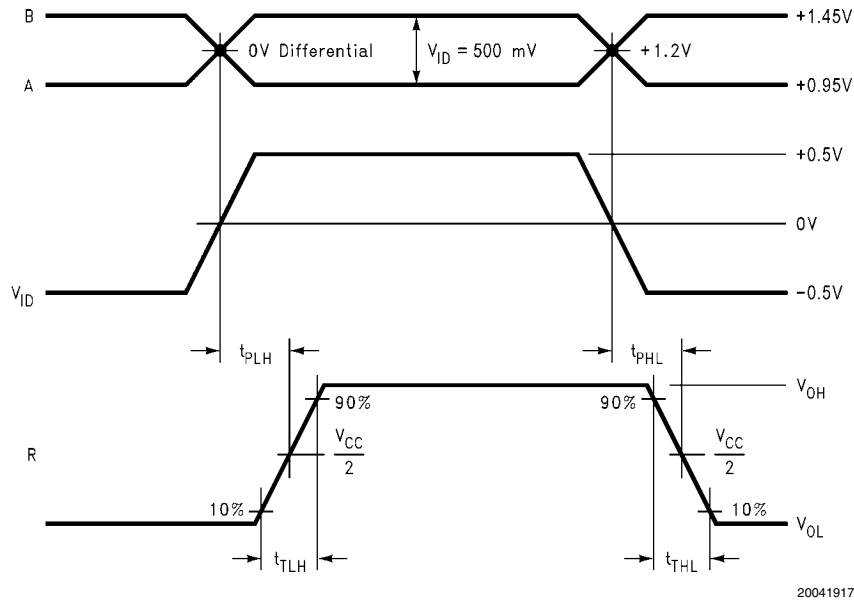


FIGURE 12. Type 1 Receiver Propagation Delay and Transition Time Waveforms

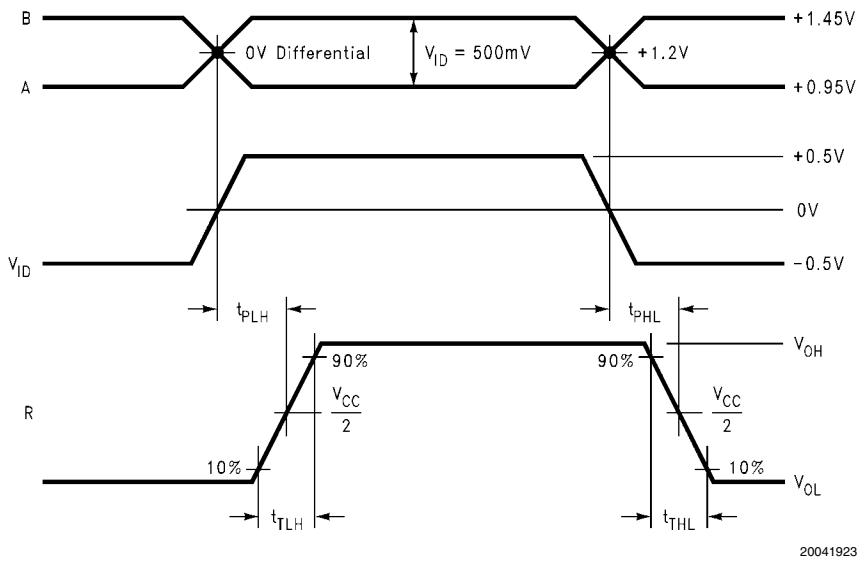


FIGURE 13. Type 2 Receiver Propagation Delay and Transition Time Waveforms

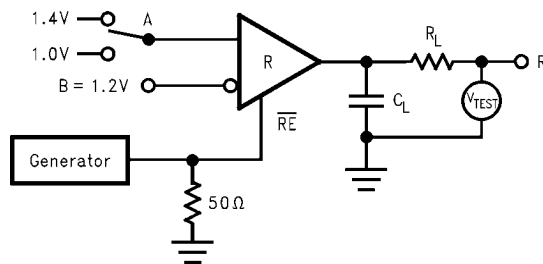


FIGURE 14. Receiver TRI-STATE Delay Test Circuit

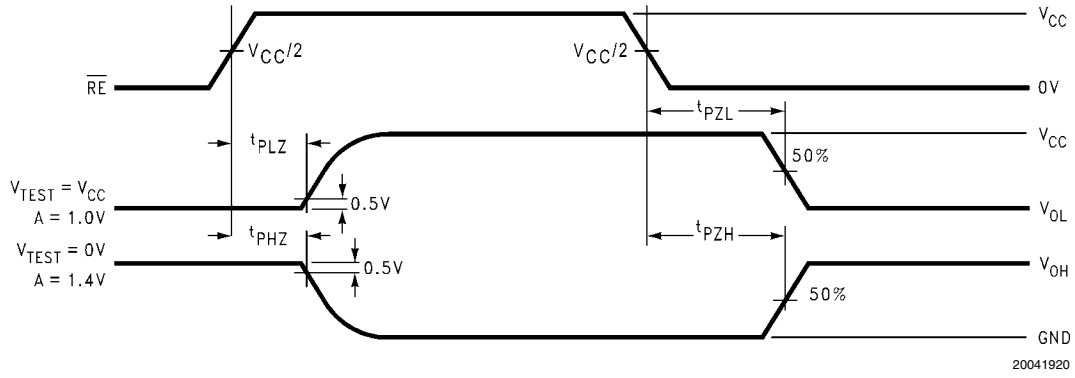


FIGURE 15. Receiver TRI-STATE Delay Waveforms

## Function Tables

DS91D180/DS91C180 Transmitting

Inputs		Outputs	
DE	D	Z	Y
2.0V	2.0V	L	H
2.0V	0.8V	H	L
0.8V	X	Z	Z

X — Don't care condition  
Z — High impedance state

DS91D180 Receiving

Inputs		Output
$\overline{RE}$	A – B	R
0.8V	$\geq +0.05V$	H
0.8V	$\leq -0.05V$	L
0.8V	0V	X
2.0V	X	Z

X — Don't care condition  
Z — High impedance state

DS91C180 Receiving

Inputs		Output
$\overline{RE}$	A – B	R
0.8V	$\geq +0.15V$	H
0.8V	$\leq +0.05V$	L
0.8V	0V	L
2.0V	X	Z

X — Don't care condition  
Z — High impedance state

DS91D180 Receiver Input Threshold Test Voltages

Applied Voltages		Resulting Differential Input Voltage	Resulting Common-Mode Input Voltage	Receiver Output
$V_{IA}$	$V_{IB}$	$V_{ID}$	$V_{IC}$	R
2.400V	0.000V	2.400V	1.200V	H
0.000V	2.400V	-2.400V	1.200V	L
3.800V	3.750V	0.050V	3.775V	H
3.750V	3.800V	-0.050V	3.775V	L
-1.400V	-1.350V	-0.050V	-1.375V	H
-1.350V	-1.400V	0.050V	-1.375V	L

H — High Level  
L — Low Level  
Output state assumes that the receiver is enabled ( $\overline{RE} = L$ )

DS91C180 Receiver Input Threshold Test Voltages

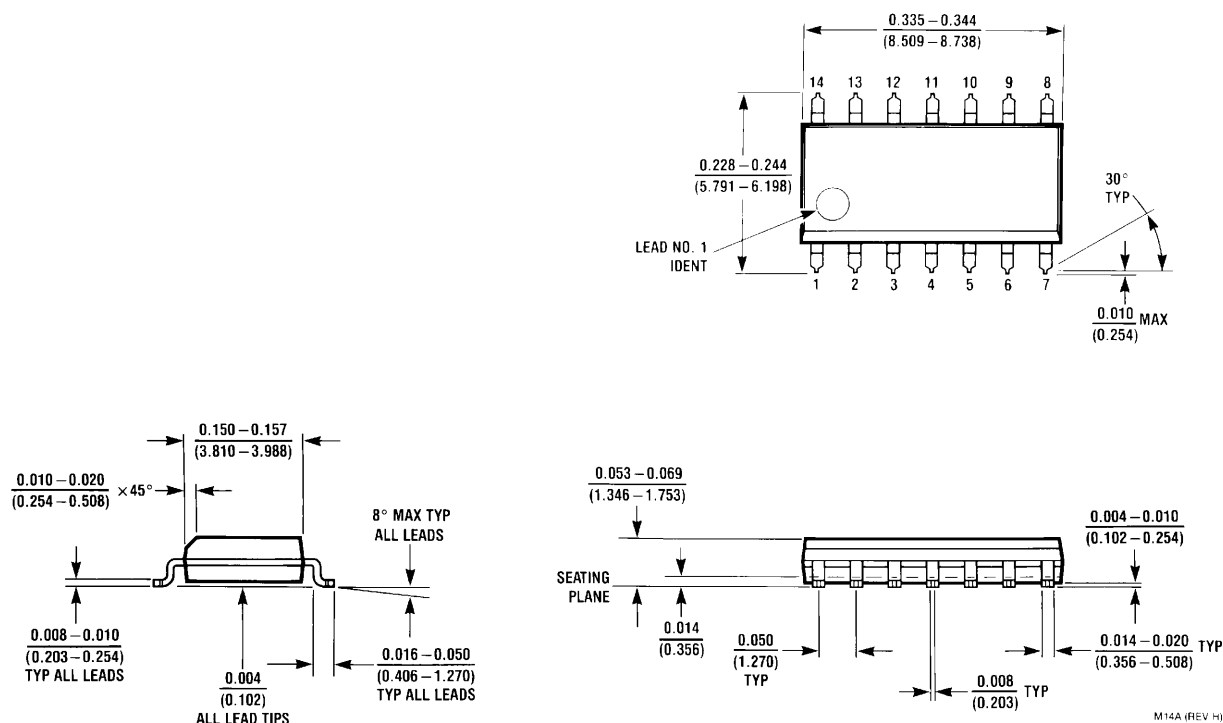
Applied Voltages		Resulting Differential Input Voltage	Resulting Common-Mode Input Voltage	Receiver Output
$V_{IA}$	$V_{IB}$	$V_{ID}$	$V_{IC}$	R
2.400V	0.000V	2.400V	1.200V	H
0.000V	2.400V	-2.400V	1.200V	L
3.800V	3.650V	0.150V	3.725V	H
3.800V	3.750V	0.050V	3.775V	L
-1.250V	-1.400V	0.150V	-1.325V	H
-1.350V	-1.400V	0.050V	-1.375V	L

H — High Level  
L — Low Level  
Output state assumes that the receiver is enabled ( $\overline{RE} = L$ )

## Pin Descriptions

Pin No.	Name	Description
1, 8	NC	No connect.
2	R	Receiver output pin
3	$\overline{RE}$	Receiver enable pin: When $\overline{RE}$ is high, the receiver is disabled. When $\overline{RE}$ is low or open, the receiver is enabled.
4	DE	Driver enable pin: When DE is low, the driver is disabled. When DE is high, the driver is enabled.
5	D	Driver input pin
6, 7	GND	Ground pin
9	Y	Non-inverting driver output pin
10	Z	Inverting driver output pin
11	B	Inverting receiver input pin
12	A	Non-inverting receiver input pin
13, 14	$V_{CC}$	Power supply pin, +3.3V $\pm$ 0.3V

# Physical Dimensions inches (millimeters) unless otherwise noted



Order Number DS91D180TMA, DS91C180TMA  
See NS package Number M14A

## Notes

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Clock Conditioners	<a href="http://www.national.com/timing">www.national.com/timing</a>	App Notes	<a href="http://www.national.com/appnotes">www.national.com/appnotes</a>
Data Converters	<a href="http://www.national.com/adc">www.national.com/adc</a>	Distributors	<a href="http://www.national.com/contacts">www.national.com/contacts</a>
Displays	<a href="http://www.national.com/displays">www.national.com/displays</a>	Green Compliance	<a href="http://www.national.com/quality/green">www.national.com/quality/green</a>
Ethernet	<a href="http://www.national.com/ethernet">www.national.com/ethernet</a>	Packaging	<a href="http://www.national.com/packaging">www.national.com/packaging</a>
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LVDS	<a href="http://www.national.com/lvds">www.national.com/lvds</a>	Reference Designs	<a href="http://www.national.com/refdesigns">www.national.com/refdesigns</a>
Power Management	<a href="http://www.national.com/power">www.national.com/power</a>	Feedback	<a href="http://www.national.com/feedback">www.national.com/feedback</a>
Switching Regulators	<a href="http://www.national.com/switchers">www.national.com/switchers</a>		
LDOs	<a href="http://www.national.com/ldo">www.national.com/ldo</a>		
LED Lighting	<a href="http://www.national.com/led">www.national.com/led</a>		
PowerWise	<a href="http://www.national.com/powerwise">www.national.com/powerwise</a>		
Serial Digital Interface (SDI)	<a href="http://www.national.com/sdi">www.national.com/sdi</a>		
Temperature Sensors	<a href="http://www.national.com/tempsensors">www.national.com/tempsensors</a>		
Wireless (PLL/VCO)	<a href="http://www.national.com/wireless">www.national.com/wireless</a>		

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