

# DS25MB100

## 2.5 Gbps 2:1/1:2 CML Mux/Buffer with Transmit De-Emphasis and Receive Equalization

### General Description

The DS25MB100 is a signal conditioning 2:1 multiplexer and 1:2 fan-out buffer designed for use in backplane redundancy or cable driving applications. Signal conditioning features include input equalization and programmable output de-emphasis that enable data communication in FR4 backplane up to 2.5 Gbps. Each input stage has a fixed equalizer to reduce ISI distortion from board traces. All output drivers have four selectable levels of de-emphasis to compensate for transmission losses from long FR4 backplane or cable attenuation reducing deterministic jitter. The de-emphasis levels can be independently controlled for the line-side and switch-side drivers. The internal loopback paths from switch-side input to switch-side output enable at-speed system testing. All receiver inputs and driver outputs are internally terminated with 100Ω differential terminating resistors.

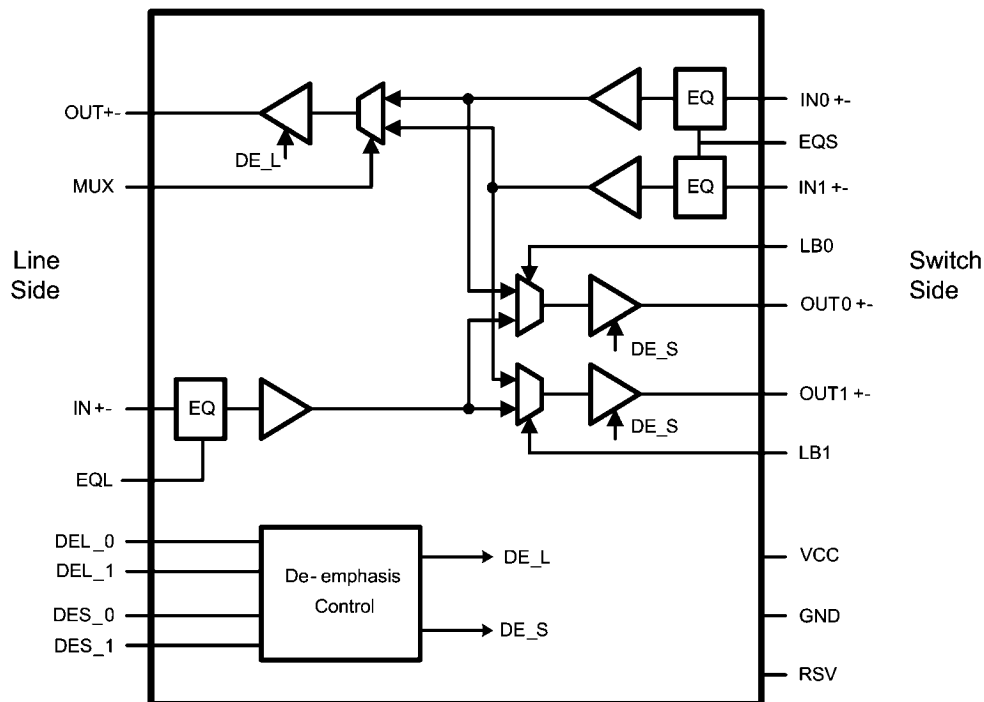
### Features

- 2:1 multiplexer and 1:2 buffer
- 0.25–2.5 Gbps fully differential data paths
- Fixed input equalization
- Programmable output de-emphasis
- Independent de-emphasis controls
- Programmable loopback modes
- On-chip terminations
- HBM ESD rating 5.5 kV on all pins
- +3.3V supply
- Low power, 0.45 W typical
- Lead-less LLP-36 package
- –40°C to +85°C operating temperature range

### Applications

- Backplane or cable driver
- Redundancy and signal conditioning applications
- CPRI/OBSAI

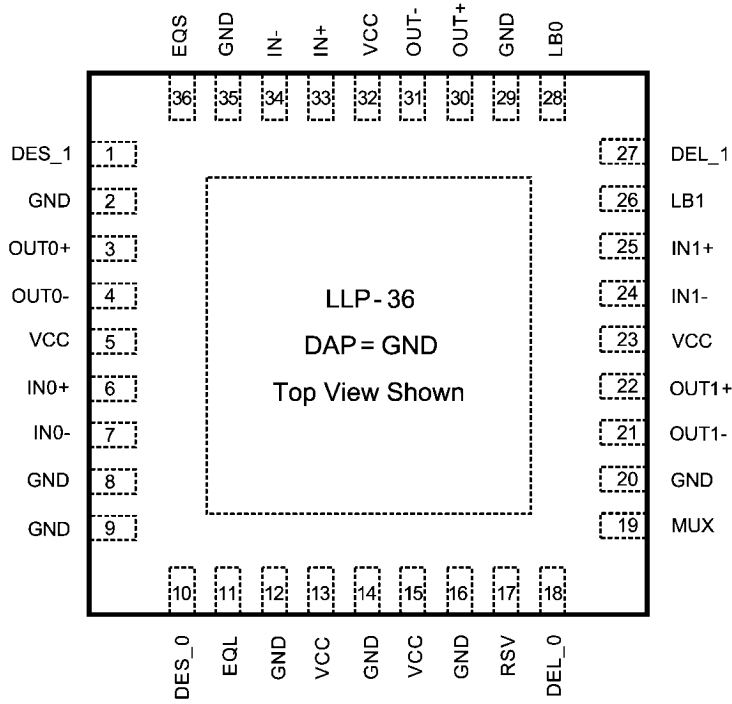
### Functional Block Diagram



20208901



# Connection Diagram



www.DataSheet4U.com

Order Number DS25MB100TSQ  
See NS Package Number SQA36A

20208903

## Pin Descriptions

Pin Name	Pin Number	I/O	Description
<b>LINE SIDE HIGH SPEED DIFFERENTIAL IO's</b>			
IN+	33	I	Inverting and non-inverting differential inputs at the line side. IN+ and IN- have an internal 50Ω connected to an internal reference voltage.
IN-	34		
OUT+	30	O	Inverting and non-inverting differential outputs at the line side. OUT+ and OUT- have an internal 50Ω connected to V <sub>CC</sub> .
OUT-	31		
<b>SWITCH SIDE HIGH SPEED DIFFERENTIAL IO's</b>			
OUT0+	3	O	Inverting and non-inverting differential outputs of mux0 at the switch side. OUT0+ and OUT0- have an internal 50Ω connected to V <sub>CC</sub> .
OUT0-	4		
OUT1+	22	O	Inverting and non-inverting differential outputs of mux1 at the switch side. OUT1+ and OUT1- have an internal 50Ω connected to V <sub>CC</sub> .
OUT1-	21		
IN0+	6	I	Inverting and non-inverting differential inputs to the mux at the switch side. IN0+ and IN0- have an internal 50Ω connected to an internal reference voltage.
IN0-	7		
IN1+	25	I	Inverting and non-inverting differential inputs to the mux at the switch side. IN1+ and IN1- have an internal 50Ω connected to an internal reference voltage.
IN1-	24		
<b>CONTROL (3.3V LVCMOS)</b>			
MUX	19	I	A logic low at MUX_S0 selects mux_0 to switch B. MUX_S0 is internally pulled high. Default state for mux_0 is switch A.
EQL	11	I	A logic low enables the EQ. EQL is internally pulled high. Default is with EQ disabled.
EQS	36	I	A logic low enables the EQ. EQS is internally pulled high. Default is with EQ disabled.
DEL_0	18	I	DEL_0 and DEL_1 select the output de-emphasis of the line side drivers (OUT±). DEL_0 and DEL_1 are internally pulled high.
DEL_1	27		
DES_0	10	I	DES_0 and DES_1 select the output de-emphasis of the switch side drivers (OUT0±, OUT1±). DES_0 and DES_1 are internally pulled high.
DES_1	1		
LB0	28		A logic low at LB0 enables the internal loopback path from IN0± to OUT0±. LB0 is internally pulled high.
LB1	26	I	A logic low at LB1 enables the internal loopback path from IN1± to OUT1±. LB1 is internally pulled high.
RSV	17	I	Reserve pin to support factory testing. This pin can be left open, or tied to GND, or tied to GND through an external pull-down resistor.
<b>POWER</b>			
V <sub>CC</sub>	5, 13, 15, 23, 32	P	V <sub>CC</sub> = 3.3V ± 5%. The maximum current consumption under worst voltage, temperature, and process variation conditions does not exceed 170mA. Each V <sub>CC</sub> pin should be connected to the V <sub>CC</sub> plane through a low inductance path, typically with a via located as close as possible to the landing pad of the V <sub>CC</sub> pin. It is recommended to have a 0.01 μF or 0.1 μF, X7R, size-0402 bypass capacitor from each V <sub>CC</sub> pin to ground plane.
GND	2, 8, 9, 12, 14, 16, 20, 29, 35	P	Ground reference. Each ground pin should be connected to the ground plane through a low inductance path, typically with a via located as close as possible to the landing pad of the GND pin.
GND	DAP	P	DAP is the metal contact at the bottom side, located at the center of the LLP package. It should be connected to the GND plane with at least 16 via to lower the ground impedance and improve the thermal performance of the package.

**Note:** I=Input, O=Output, P=Power

## Functional Description

The DS25MB100 is a signal conditioning 2:1 multiplexer and a 1:2 buffer designed to support port redundancy up to 2.5 Gbps. Each input stage has a fixed equalizer that provides equalization to compensate about 5 dB of transmission loss from a short backplane trace (about 10 inches backplane). The output driver has de-emphasis (driver-side equalization) to compensate the transmission loss of the backplane that it is driving. The driver conditions the output signal such that the lower frequency and higher frequency pulses reach approximately the same amplitude at the end of the backplane, and minimize the deterministic jitter caused by the amplitude disparity. The DS25MB100 provides four steps of user-selectable de-emphasis ranging from 0, -3, -6 and -9 dB to handle different lengths of backplane. *Figure 1* shows a driver de-emphasis waveform. The de-emphasis duration is 188ps nominal, corresponds to 0.47 bit-width at 2.5 Gbps. The de-emphasis levels of switch-side and line-side can be individually programmed.

The high speed inputs are self-biased to about 1.3V and are designed for AC coupling. The inputs are compatible to most

AC coupling differential signals such as LVDS, LVPECL and CML.

**TABLE 1. Logic Table For Multiplex Controls**

MUX_S0	Mux Function
0	MUX select switch input, IN1±.
1 (default)	MUX select switch input, IN0±.

**TABLE 2. Logic Table For Loopback Controls**

LB0	Loopback Function
0	Enable loopback from IN0± to OUT0±.
1 (default)	Normal mode. Loopback disabled.
LB1	Loopback Function
0	Enable loopback from IN1± to OUT1±.
1 (default)	Normal mode. Loopback disabled.

**TABLE 3. Line-Side De-Emphasis Controls**

DEL_[1:0]	De-Emphasis Level in mV <sub>PP</sub> (VODB)	De-Emphasis Level in mV <sub>PP</sub> (VODPE)	De-Emphasis in dB (VODPE/VODB)	Typical FR4 Board Trace
0 0	1300	1300	0	10 inches
0 1	1300	920	-3	20 inches
1 0	1300	650	-6	30 inches
1 1 (default)	1300	461	-9	40 inches

**TABLE 4. Switch-Side De-Emphasis Controls**

DES_[1:0]	De-Emphasis Level in mV <sub>PP</sub> (VODB)	De-Emphasis Level in mV <sub>PP</sub> (VODPE)	De-Emphasis in dB (VODPE/VODB)	Typical FR4 Board Trace
0 0	1300	1300	0	10 inches
0 1	1300	920	-3	20 inches
1 0	1300	650	-6	30 inches
1 1 (default)	1300	461	-9	40 inches

**TABLE 5. EQ Controls For Line And Switch Sides**

EQL/EQS	Loopback Function
0	Enable equalization.
1 (default)	Normal mode. Equalization disabled.

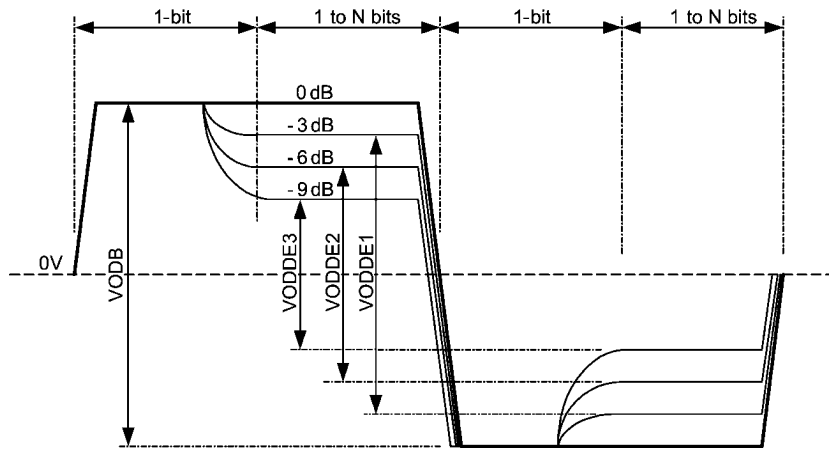


FIGURE 1. Driver De-Emphasis Differential Waveform (Showing All 4 De-Emphasis Steps)

www.DataSheet4U.com

**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
CMOS/TTL Input Voltage	-0.3V to ( $V_{CC}+0.3V$ )
CML Input/Output Voltage	-0.3V to ( $V_{CC}+0.3V$ )
Junction Temperature	+150°C
Storage Temperature	-65°C to +150°C
Lead Temperature	
Soldering, 4 seconds	+260°C
Thermal Resistance, $\theta_{JA}$ (Note 8)	26.2°C/W
Thermal Resistance, $\theta_{JC-top}$	3.3°C/W

Thermal Resistance, $\Phi_{JB}$	11.1°C/W
ESD Rating (Note 10)	
HBM, 1.5 k $\Omega$ , 100 pF	6 kV
CDM	1.25 kV
MM	350V

**Recommended Operating Ratings**

	Min	Typ	Max	Units
Supply Voltage ( $V_{CC-GND}$ )	3.13	3.3	3.465	V
	5			
Supply Noise Amplitude 10 Hz to 2 GHz			100	mV <sub>PP</sub>
Ambient Temperature	-40		85	°C
Case Temperature			100	°C

**Electrical Characteristics**

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ (Note 2)	Max	Units
<b>LVC MOS DC SPECIFICATIONS</b>						
$V_{IH}$	High Level Input Voltage		2.0		$V_{CC}+0.3$	V
$V_{IL}$	Low Level Input Voltage		-0.3		0.8	V
$I_{IH}$	High Level Input Current	$V_{IN} = V_{CC}$	-10		10	$\mu$ A
$I_{IL}$	Low Level Input Current	$V_{IN} = GND$	75	94	124	$\mu$ A
$R_{PU}$	Pull-High Resistance			35		k $\Omega$
<b>RECEIVER SPECIFICATIONS</b>						
$V_{ID}$	Differential Input Voltage Range (Note 9)	AC Coupled Differential Signal Below 1.25 Gbps Above 1.25 Gbps This parameter is not tested at production	100 100		1750 1560	mV <sub>P-P</sub> mV <sub>P-P</sub>
$V_{ICM}$	Common Mode Voltage at Receiver Inputs	Measured at receiver inputs reference to ground		1.3		V
$R_{ITD}$	Input Differential Termination (Note 3)	On-chip differential termination between IN+ or IN-	84	100	116	$\Omega$
$R_{ITSE}$	Input Termination (single-end)	On-chip termination IN+ or IN- to GND for frequency > 100 MHz		50		$\Omega$
<b>DRIVER SPECIFICATIONS</b>						
$V_{ODB}$	Output Differential Voltage Swing without De-Emphasis (Note 4)	$R_L = 100\Omega \pm 1\%$ DES_1=DES_0=0 DEL_1=DEL_0=0 Driver De-emphasis disabled Running K28.7 pattern at 2.5 Gbps See Figure 5 for test circuit.	1100	1300	1500	mV <sub>P-P</sub>
$V_{DE}$	Output De-Emphasis Voltage Ratio $20 \cdot \log(V_{DODPE}/V_{ODB})$	$R_L = 100\Omega \pm 1\%$ Running K28.7 pattern at 2.5 Gbps DEX_[1:0]=00 DEX_[1:0]=01 PREX_[1:0]=10 DEX_[1:0]=11 x=S for switch side de-emphasis control x=L for line side de-emphasis control See Figure 1 on waveform. See Figure 5 for test circuit.		0 -3 -6 -9		dB dB dB dB

Symbol	Parameter	Conditions	Min	Typ (Note 2)	Max	Units
T <sub>DE</sub>	De-Emphasis Width	Tested at -9 dB de-emphasis level, DEX[1:0]=11 x=S for switch side de-emphasis control x=L for line side de-emphasis control See <i>Figure 4</i> on measurement condition.	125	188	250	ps
R <sub>OTSE</sub>	Output Termination (Note 3)	On-chip termination from OUT+ or OUT- to V <sub>CC</sub>	42	50	58	Ω
R <sub>OTD</sub>	Output Differential Termination	On-chip differential termination between OUT+ and OUT-		100		Ω
ΔR <sub>OTSE</sub>	Mis-Match in Output Termination Resistors	Mis-match in output terminations at OUT+ and OUT-			5	%
V <sub>OCM</sub>	Output Common Mode Voltage			2.7		V
<b>POWER DISSIPATION</b>						
P <sub>D</sub>	Power Dissipation	V <sub>DD</sub> = 3.3V @ 25°C All outputs terminated by 100Ω ±1%. DEL_[1:0]=0, DES_[1:0]=0 Running PRBS 27-1 pattern at 2.5 Gbps		0.45		W
<b>AC CHARACTERISTICS</b>						
t <sub>R</sub>	Differential Low to High Transition Time	Measured with a clock-like pattern at 2.5 Gbps, between 20% and 80% of the differential output voltage. de-emphasis disabled Transition time is measured with fixture as shown in <i>Figure 5</i> , adjusted to reflect the transition time at the output pins		100		ps
t <sub>F</sub>	Differential High to Low Transition Time			100		ps
t <sub>PLH</sub>	Differential Low to High Propagation Delay	Measured at 50% differential voltage from input to output			1	ns
t <sub>PHL</sub>	Differential High to Low Propagation Delay				1	ns
t <sub>SKP</sub>	Pulse Skew	t <sub>PHL</sub> - t <sub>PLH</sub>			20	ps
t <sub>SKO</sub>	Output Skew (Note 7)	Difference in propagation delay between two outputs in the same device			100	ps
t <sub>SKPP</sub>	Part-to-Part Skew	Difference in propagation delay between the same output from devices operating under identical conditions			100	ps
t <sub>SM</sub>	Mux Switch Time	Measured from V <sub>IH</sub> or V <sub>IL</sub> of the mux-control or loopback control to 50% of the valid differential output		1.8	6	ns
RJ	Device Random Jitter (Note 5)	See <i>Figure 5</i> for test circuit. Alternating-1-0 pattern EQ and de-emphasis disabled. At 0.25 Gbps At 1.25 Gbps At 2.5 Gbps			2 2 2	psrms psrms psrms
DJ	Device Deterministic Jitter (Note 6)	See <i>Figure 5</i> for test circuit. EQ and de-emphasis disabled Between 0.25 and 2.5 Gbps with PRBS7 pattern for DS25MB100 @ -40°C to 85°C			35	Psp
DR	Data Rate (Note 9)	Tested with alternating-1-0 pattern	0.25		2.5	Gbps
<p><b>Note 1:</b> "Absolute Maximum Ratings" are the ratings 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.</p> <p><b>Note 2:</b> Typical parameters measured at V<sub>CC</sub> = 3.3V, T<sub>A</sub> = 25°C, and represent most likely parametric norms at the time of product characterization. The typical specifications are not guaranteed.</p> <p><b>Note 3:</b> IN+ and IN- are generic names refer to one of the many pairs of complimentary inputs of the DS25MB100. OUT+ and OUT- are generic names refer to one of the many pairs of the complimentary outputs of the DS25MB100. Differential input voltage V<sub>ID</sub> is defined as  IN+ - IN- . Differential output voltage V<sub>OD</sub> is defined as  OUT+ - OUT- .</p>						



**Note 4:** K28.7 pattern is a 10-bit repeating pattern of K28.7 code group {001111 1000}

K28.5 pattern is a 20-bit repeating pattern of +K28.5 and -K28.5 code groups {110000 0101 001111 1010}

**Note 5:** Device output random jitter is a measurement of the random jitter contribution from the device. It is derived by the equation  $\sqrt{RJ_{OUT}^2 - RJ_{IN}^2}$ , where  $RJ_{OUT}$  is the total random jitter measured at the output of the device in psrms,  $RJ_{IN}$  is the random jitter of the pattern generator driving the device.

**Note 6:** Device output deterministic jitter is a measurement of the deterministic jitter contribution from the device. It is derived by the equation  $DJ_{OUT} - DJ_{IN}$ , where  $DJ_{OUT}$  is the total peak-to-peak deterministic jitter measured at the output of the device in pspp,  $DJ_{IN}$  is the peak-to-peak deterministic jitter of the pattern generator driving the device.

**Note 7:**  $t_{SKO}$  is the magnitude difference in the propagation delays among data paths between switch A and switch B of the same port and similar data paths between port 0 and port 1. An example is the output skew among data paths from SIA\_0± to LO\_0±, SIB\_0± to LO\_0±, SIA\_1± to LO\_1± and SIB\_1± to LO\_1±. Another example is the output skew among data paths from LI\_0± to SOA\_0±, LI\_0± to SOB\_0±, LI\_1± to SOA\_1± and LI\_1± to SOB\_1±.  $t_{SKO}$  also refers to the delay skew of the loopback paths of the same port and between similar data paths between port 0 and port 1. An example is the output skew among data paths SIA\_0± to SOA\_0±, SIB\_0± to SOB\_0±, SIA\_1± to SOA\_1± and SIB\_1± to SOB\_1±.

**Note 8:** Thermal resistances are based on having 16 thermal relief vias on the DAP pad under the 0 airflow condition.

**Note 9:** This parameter is guaranteed by design and/or characterization. It is not tested in production.

**Note 10:** ESD tests conform to the following standards:

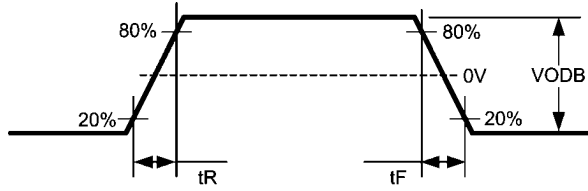
Human Body Model applicable standard: MIL-STD-883, Method 3015.7

Machine Model applicable standard: JESD22-A115-A (ESD MM standard of JEDEC)

Field-induced Charge Device Model: Applicable standard JESD22-C101-C (ESD FICDM standard of JEDEC)

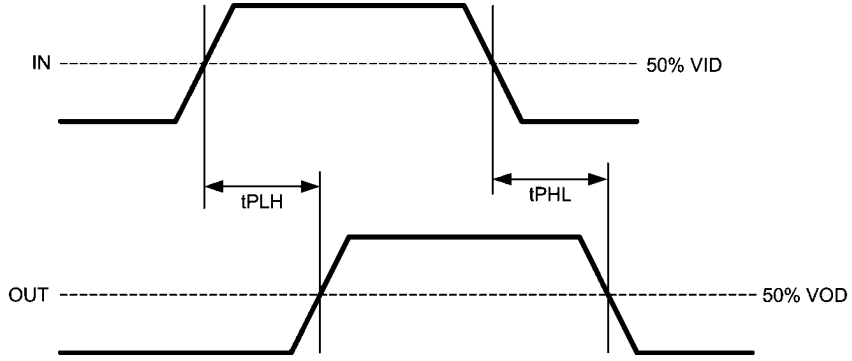
[www.DataSheet4U.com](http://www.DataSheet4U.com)

# Timing Diagrams



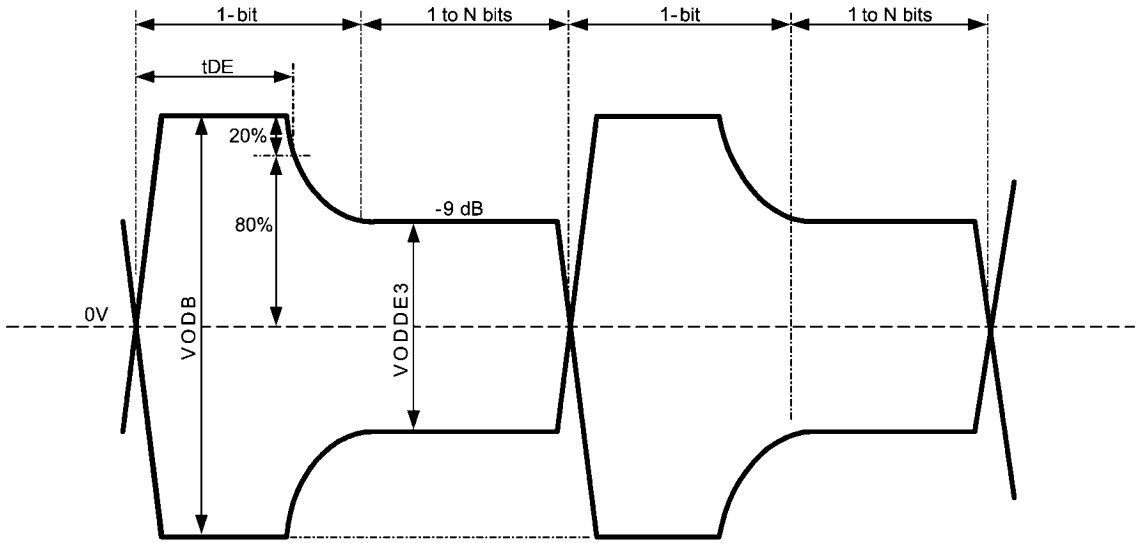
20208905

FIGURE 2. Driver Output Transition Time



20208906

FIGURE 3. Propagation Delay from Input to Output



20208907

FIGURE 4. Test Condition for Output Pre-Emphasis Duration

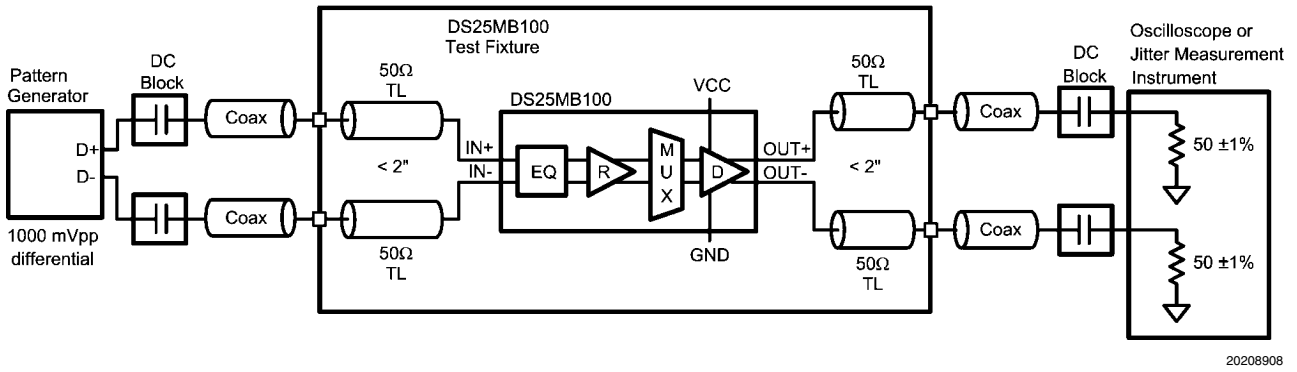


FIGURE 5. AC Test Circuit

www.DataSheet4U.com

# Application Information

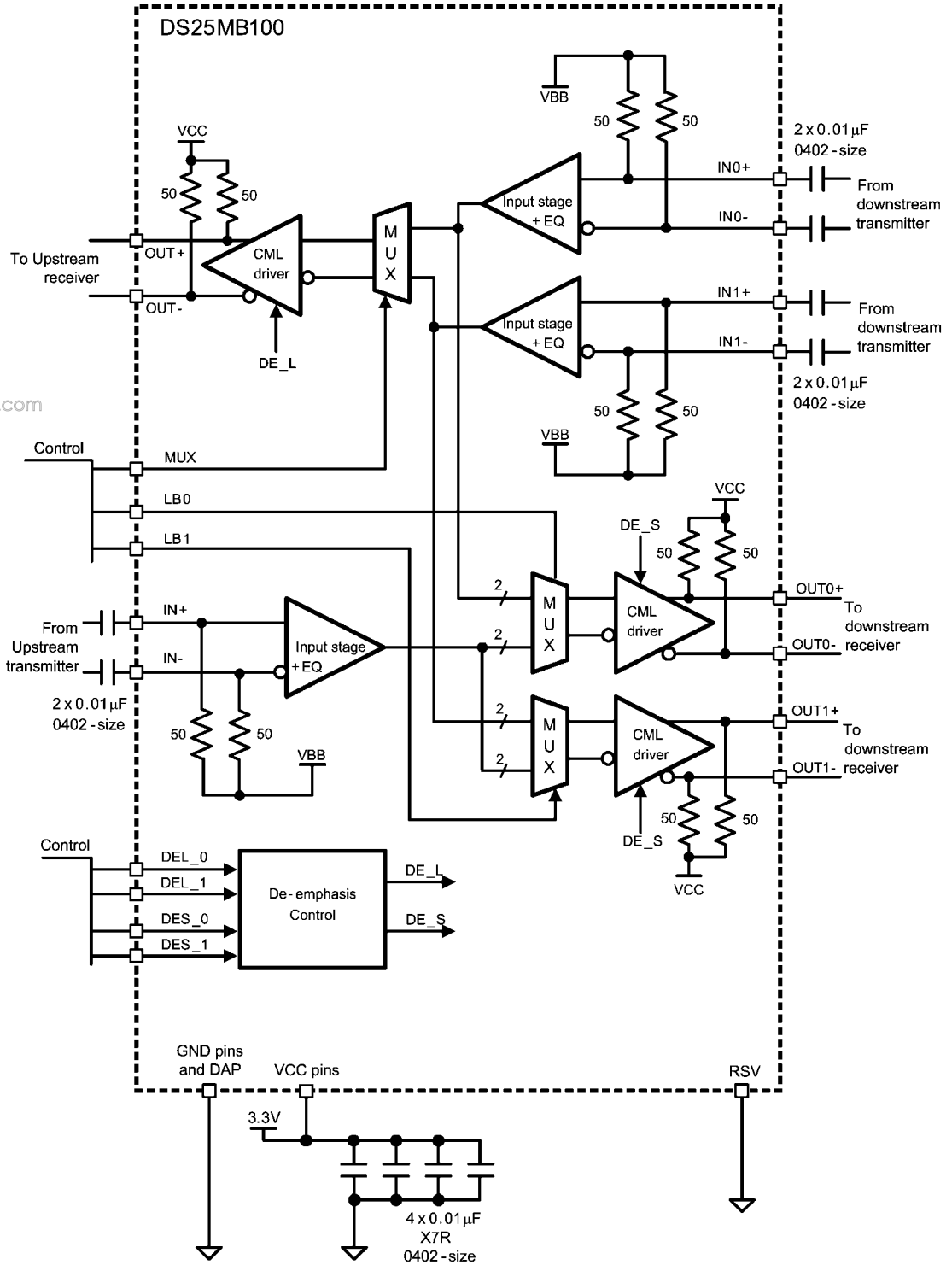
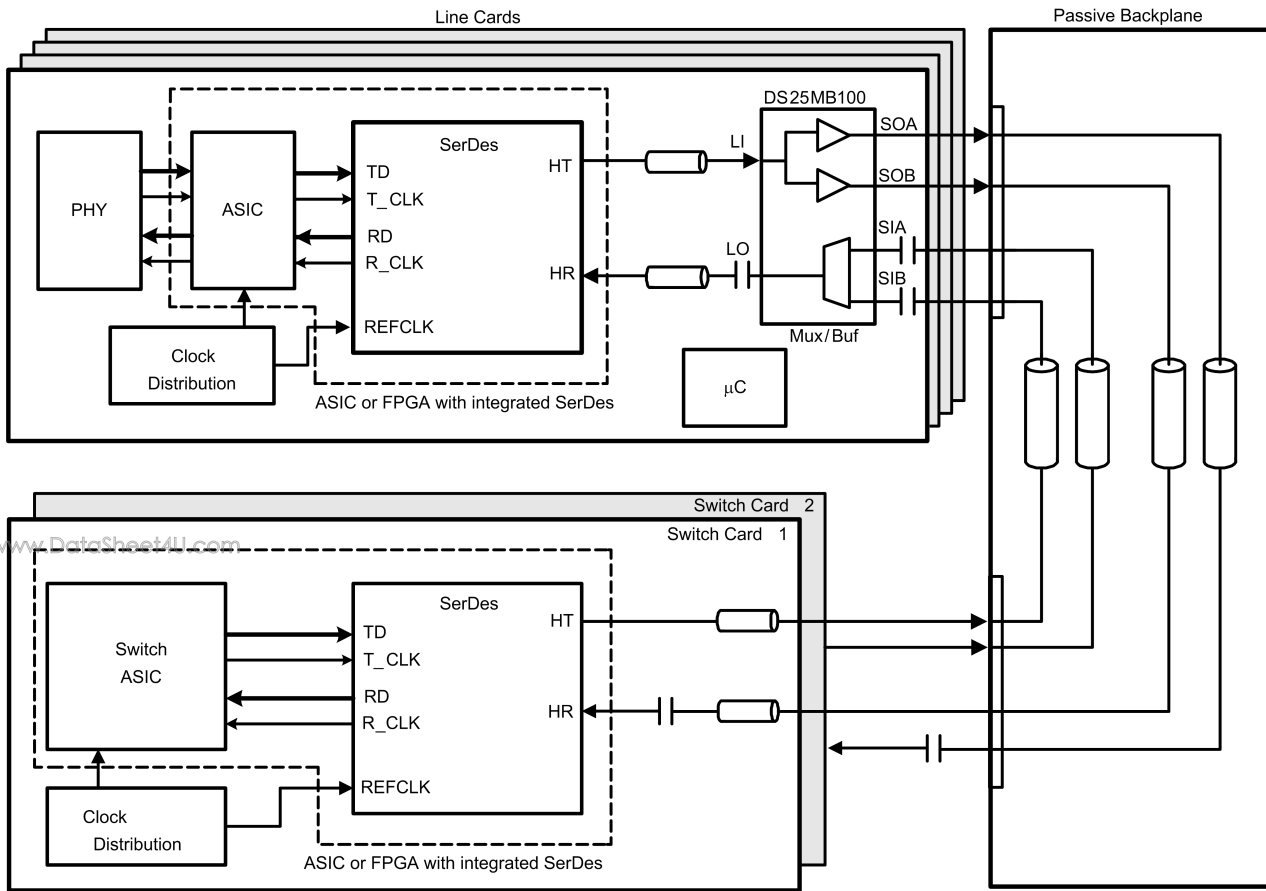


FIGURE 6. Application Diagram

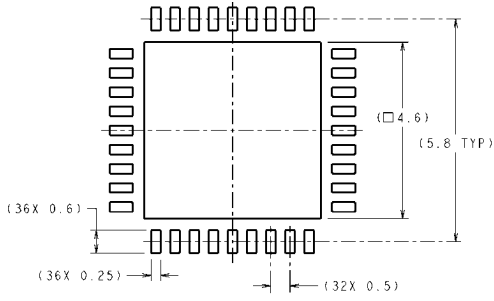
20208909



20208910

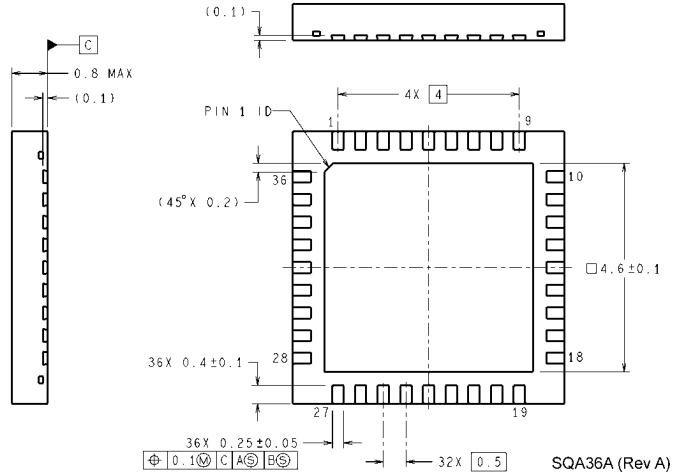
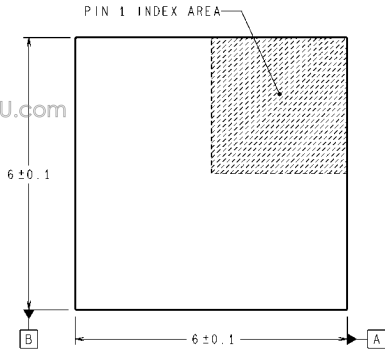
FIGURE 7. Chassis Based Network Switch System With Redundancy

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



**DIMENSIONS ARE IN MILLIMETERS**  
DIMENSIONS IN ( ) FOR REFERENCE ONLY

**RECOMMENDED LAND PATTERN**



**LLP-36 Package**  
**Order Number DS25MB100TSQ**  
**NS Package Number SQA36A**

SQA36A (Rev A)

www.DataSheet4U.com

# Notes

[www.DataSheet4U.com](http://www.DataSheet4U.com)

## Notes

For more National Semiconductor product information and proven design tools, visit the following Web sites at:

Products		Design Support	
Amplifiers	<a href="http://www.national.com/amplifiers">www.national.com/amplifiers</a>	WEBENCH	<a href="http://www.national.com/webench">www.national.com/webench</a>
Audio	<a href="http://www.national.com/audio">www.national.com/audio</a>	Analog University	<a href="http://www.national.com/AU">www.national.com/AU</a>
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>
Interface	<a href="http://www.national.com/interface">www.national.com/interface</a>	Quality and Reliability	<a href="http://www.national.com/quality">www.national.com/quality</a>
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>		

THE CONTENTS OF THIS DOCUMENT ARE PROVIDED IN CONNECTION WITH NATIONAL SEMICONDUCTOR CORPORATION ("NATIONAL") PRODUCTS. NATIONAL MAKES NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO THE ACCURACY OR COMPLETENESS OF THE CONTENTS OF THIS PUBLICATION AND RESERVES THE RIGHT TO MAKE CHANGES TO SPECIFICATIONS AND PRODUCT DESCRIPTIONS AT ANY TIME WITHOUT NOTICE. NO LICENSE, WHETHER EXPRESS, IMPLIED, ARISING BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT.

TESTING AND OTHER QUALITY CONTROLS ARE USED TO THE EXTENT NATIONAL DEEMS NECESSARY TO SUPPORT NATIONAL'S PRODUCT WARRANTY. EXCEPT WHERE MANDATED BY GOVERNMENT REQUIREMENTS, TESTING OF ALL PARAMETERS OF EACH PRODUCT IS NOT NECESSARILY PERFORMED. NATIONAL ASSUMES NO LIABILITY FOR APPLICATIONS ASSISTANCE OR BUYER PRODUCT DESIGN. BUYERS ARE RESPONSIBLE FOR THEIR PRODUCTS AND APPLICATIONS USING NATIONAL COMPONENTS. PRIOR TO USING OR DISTRIBUTING ANY PRODUCTS THAT INCLUDE NATIONAL COMPONENTS, BUYERS SHOULD PROVIDE ADEQUATE DESIGN, TESTING AND OPERATING SAFEGUARDS.

EXCEPT AS PROVIDED IN NATIONAL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, NATIONAL ASSUMES NO LIABILITY WHATSOEVER, AND NATIONAL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY RELATING TO THE SALE AND/OR USE OF NATIONAL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

### LIFE SUPPORT POLICY

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

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.

National Semiconductor and the National Semiconductor logo are registered trademarks of National Semiconductor Corporation. All other brand or product names may be trademarks or registered trademarks of their respective holders.

Copyright© 2007 National Semiconductor Corporation

For the most current product information visit us at [www.national.com](http://www.national.com)



**National Semiconductor Americas Customer Support Center**  
 Email: [new.feedback@nsc.com](mailto:new.feedback@nsc.com)  
 Tel: 1-800-272-9959

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

**National Semiconductor Asia Pacific Customer Support Center**  
 Email: [ap.support@nsc.com](mailto:ap.support@nsc.com)

**National Semiconductor Japan Customer Support Center**  
 Fax: 81-3-5639-7507  
 Email: [jpn.feedback@nsc.com](mailto:jpn.feedback@nsc.com)  
 Tel: 81-3-5639-7560