

# DS3695/DS3695T/DS3696/DS3697 Multipoint RS485/RS422 Transceivers/Repeaters

#### **General Description**

The DS3695, DS3696, and DS3697 are high speed differential TRI-STATE® bus/line transceivers/repeaters designed to meet the requirements of EIA standard RS485 with extended common mode range (+12V to −7V), for multipoint data transmission.

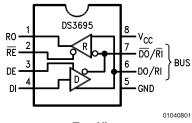
The driver and receiver outputs feature TRI-STATE capability. The driver outputs remain in TRI-STATE over the entire common mode range of +12V to –7V. Bus faults that cause excessive power dissipation within the device trigger a thermal shutdown circuit, which forces the driver outputs into the high impedance state. The DS3696 provides an output pin TS (thermal shutdown) which reports the occurrence of the thermal shutdown of the device. This is an "open collector" pin with an internal  $10~\mathrm{k}\Omega$  pull-up resistor. This allows the line fault outputs of several devices to be wire OR-ed.

Both AC and DC specifications are guaranteed over the  $0^{\circ}$ C to  $70^{\circ}$ C temperature and 4.75V to 5.25V supply voltage range.

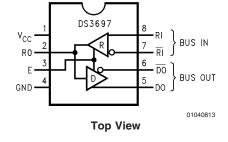
#### **Features**

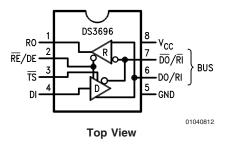
- Meets EIA standard RS485 for multipoint bus transmission and is compatible with RS-422
- 15 ns driver propagation delays with 2 ns skew (typical)
- Single +5V supply
- -7V to +12V bus common mode range permits ±7V ground difference between devices on the bus
- Thermal shutdown protection
- High impedance to bus with driver in TRI-STATE or with power off, over the entire common mode range allows the unused devices on the bus to be powered down
- Combined impedance of a driver output and receiver input is less than one RS485 unit load, allowing up to 32 transceivers on the bus
- 70 mV typical receiver hysteresis

### **Connection and Logic Diagrams**



Top View





Order Number DS3695N, DS3695TN, DS3696N, or DS3697NSee NS Package Number N08E

Note 1: TS pin was LF (Line Fault) in previous datasheets and reports the occurrence of a thermal shutdown of the device.

TRI-STATE® is a registered trademark of National Semiconductor Corporation.

# **Absolute Maximum Ratings** (Note 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage,  $V_{CC}$  7V Control Input Voltages 7V Driver Input Voltage 7V Driver Output Voltages +15V/-10V

Receiver Input Voltages

(DS3695, DS3696) +15V/-10V

Receiver Common Mode Voltage

(DS3697) ±25V Receiver Output Voltage 5.5V

Continuous Power Dissipation @ 25°C

N Package 1.07W (Note

Storage Temperature Range -65°C to +150°C

Lead Temperature (Soldering, 4

260°C

# Recommended Operating Conditions

	Min	Max	Units
Supply Voltage, V <sub>CC</sub>	4.75	5.25	V
Bus Voltage	-7	+12	V
Operating Free Air Temp. $(T_A)$			
Commercial	0	+70	°C
Industrial	-40	+85	°C

### **Electrical Characteristics** (Notes 3, 4)

 $0^{\circ}\text{C} \leq \text{T}_{\text{A}} \leq +70^{\circ}\text{C},~4.75\text{V} \leq \text{V}_{\text{CC}} \leq 5.25\text{V}$  unless otherwise specified

Symbol	Parame	ter		Conditions	Min	Тур	Max	Units
V <sub>OD1</sub>	Differential Driver Outpu	ıt	I <sub>O</sub> = 0				5	V
	Voltage (Unloaded)							
V <sub>OD2</sub>	Differential Driver Outpu	ıt	(Figure 1) $R = 50Ω$ ; (RS-422) (N		2			V
				6)				
	Voltage (with Load)			$R = 27\Omega$ ; (RS-485)	1.5			V
$\Delta V_{OD}$	Change in Magnitude of	Driver						
	Differential Output Volta	ge for					0.2	V
	Complementary Output	States						
V <sub>oc</sub>	Driver Common Mode C	Output Voltage	(Figure 1)	$R = 27\Omega$			3.0	V
$\Delta  V_{OC} $	Change in Magnitude of	Driver						
	Common Mode Output	Voltage					0.2	V
	for Complementary Out	out States						
V <sub>IH</sub>	Input High Voltage		1		2			V
V <sub>IL</sub>	Input Low Voltage	DI	, DE,				0.8	V
V <sub>CL</sub>	Input Clamp Voltage	RE, E	, RE /DE	I <sub>IN</sub> = -18 mA			-1.5	V
I <sub>IL</sub>	Input Low Current			$V_{IL} = 0.4V$			-200	μΑ
I <sub>IH</sub>	Input High Current			V <sub>IH</sub> = 2.4V			20	μΑ
I <sub>IN</sub>	Input Current	DO/RI, DO /RI	V <sub>CC</sub> = 0V or 5.25V	V <sub>IN</sub> = 12V			+1.0	mA
		RI, RĪ	RE /DE or DE =	$V_{IN} = -7V$			-0.8	mA
I <sub>OZD</sub>	TRI-STATE Current	DO, DO	V <sub>CC</sub> = 0V or 5.25	V, E = 0V			±100	μΑ
	DS3697 & DS3698		$-7V < V_O < +12$	V				
V <sub>TH</sub>	Differential Input Thresh	old	$-7V \le V_{CM} \le +12$	V	-0.2		+0.2	V
	Voltage for Receiver							
$\Delta V_{TH}$	Receiver Input Hysteres	sis	V <sub>CM</sub> = 0V			70		mV
V <sub>OH</sub>	Receiver Output High V	oltage	$I_{OH} = -400 \ \mu A$		2.4			V
V <sub>OL</sub>	Output Low Voltage	RO	I <sub>OL</sub> = 16 mA (Not	e 6)			0.5	V
		TS	I <sub>OL</sub> = 8 mA				0.45	V
I <sub>OZR</sub>	OFF-State (High Imped	ance)	V <sub>CC</sub> = Max				±20	μΑ
	Output Current at Recei	ver	$0.4V \le V_O \le 2.4V$					
R <sub>IN</sub>	Receiver Input Resistan	ce	$-7V \le V_{CM} \le +12$		12			kΩ

### Electrical Characteristics (Notes 3, 4) (Continued)

 $0^{\circ}\text{C} \leq \text{T}_{\text{A}} \leq +70^{\circ}\text{C},~4.75\text{V} < \text{V}_{\text{CC}} < 5.25\text{V}$  unless otherwise specified

Symbol	Parameter	Conditions			Тур	Max	Units
I <sub>cc</sub>	Supply Current	No Load Driver Outputs Enabled			42	60	mA
		(Note 6)	Driver Outputs Disabled		27	40	mA
I <sub>OSD</sub>	Driver Short-Circuit Output Current	$V_O = -7V$ (Note 6)				-250	mA
		V <sub>O</sub> = +12V (Note 6)				+250	mA
I <sub>OSR</sub>	Receiver Short-Circuit Output Current	$V_O = 0V$				-85	mA

**Note 2:** "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 3: 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 4:** All typicals are given for  $V_{CC} = 5V$  and  $T_A = 25^{\circ}C$ .

Note 5: Derate linearly at 11.1 mW/°C to 570 mW at 70°C.

Note 6: All limits for which Note 5 is applied must be derated by 10% for DS3695T and DS3696T. Other parameters remain the same for this extended temperature range device ( $-40^{\circ}\text{C} \le T_A \le +85^{\circ}\text{C}$ ).

**Switching Characteristics** (Notes 4, 7)  $0^{\circ}C \le T_{A} \le +70^{\circ}C$ ,  $4.75V < V_{CC} < 5.25V$  unless otherwise specified

## **Receiver Switching Characteristics**

(Figures 2, 3, 4)

Symbol Conditions		Min	Тур	Max	Units
t <sub>PLH</sub>	C <sub>L</sub> = 15 pF	15	25	37	ns
t <sub>PHL</sub>	S1 and S2	15	25	37	ns
It <sub>PLH</sub> -t <sub>PHL</sub> I	Closed	0			ns
t <sub>PLZ</sub>	C <sub>L</sub> = 15 pF, S2 Open	5	12	16	ns
t <sub>PHZ</sub>	C <sub>L</sub> = 15 pF, S1 Open	5	12	16	ns
t <sub>PZL</sub>	C <sub>L</sub> = 15 pF, S2 Open	7	15	20	ns
t <sub>PZH</sub>	C <sub>L</sub> = 15 pF, S1 Open	7	15	20	ns

## **Driver Switching Characteristics**

Symbol Conditions		Min	Тур	Max	Units			
SINGLE ENDED CHARACTERISTICS (Figures 5, 6, 7)								
t <sub>PLH</sub>	$R_L DIFF = 60\Omega$	9	15	22	ns			
t <sub>PHL</sub>	$C_{L1} = C_{L2} = 100 \text{ pF}$	9	15	22	ns			
t <sub>SKEW</sub> lt <sub>PLH</sub> -t <sub>PHL</sub> l			2	8	ns			
t <sub>PLZ</sub>	C <sub>L</sub> = 15 pF, S2 Open	7	15	30	ns			
t <sub>PHZ</sub>	C <sub>L</sub> = 15 pF, S1 Open	7	15	30	ns			
t <sub>PZL</sub>	C <sub>L</sub> = 100 pF, S2 Open	30	35	50	ns			
t <sub>PZH</sub>	C <sub>L</sub> = 100 pF, S1 Open	30	35	50	ns			
DIFFERENTIAL CHAR	ACTERISTICS (Figures 5, 8)	•						
t <sub>r</sub> , t <sub>f</sub>	$R_L DIFF = 60\Omega$	6	10	18	ns			
	$C_{L1} = C_{L2} = 100 \text{ pF}$							

Note 7: Switching Characteristics apply for DS3695, DS3695T, DS3696, DS3697 only.

# **AC Test Circuits and Switching Waveforms**

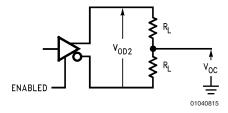


FIGURE 1. Driver  $V_{\text{OD}}$  and  $V_{\text{OC}}$ 

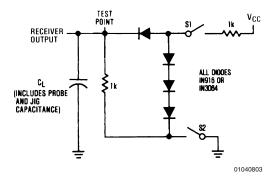
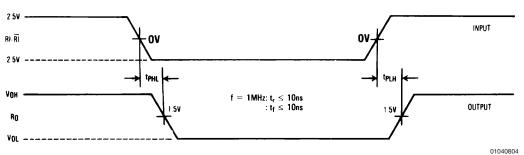


FIGURE 2. Receiver Propagation Delay Test Circuit



 $\textbf{Note:} \ \ \text{Differential input voltage may be realized by grounding } \ \overline{\text{RI}} \ \text{and pulsing RI between } +2.5 \text{V} \ \text{and } -2.5 \text{V}.$ 

FIGURE 3. Receiver Input-to-Output Propagation Delay Timing

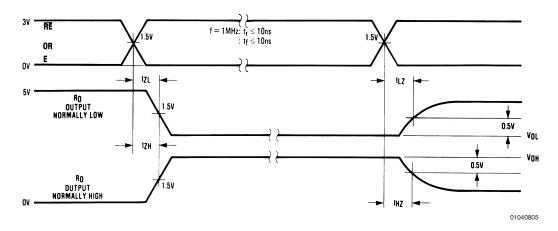
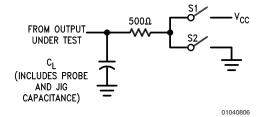


FIGURE 4. Receiver Enable/Disable Propagation Delay Timing

## AC Test Circuits and Switching Waveforms (Continued)



Note: Unless otherwise specified the switches are closed.

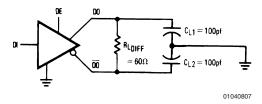
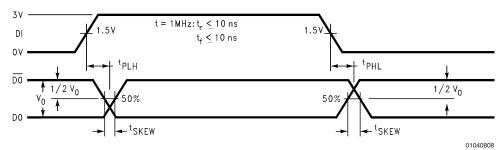


FIGURE 5. Driver Propagation Delay and Transition Time Test Circuits



 $\textbf{Note:}\ t_{PLH}\ \text{and}\ t_{PHL}\ \text{are measured to the respective 50\% points.}\ t_{SKEW}\ \text{is the difference between propagation delays of the complementary outputs.}$ 

FIGURE 6. Driver Input-to-Output Propagation Delay Timing (Single-Ended)

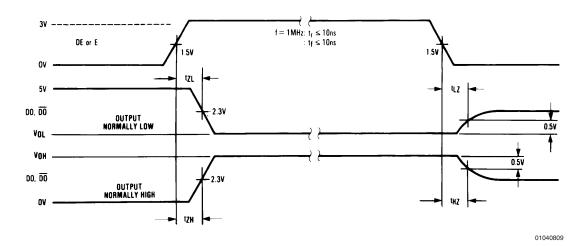


FIGURE 7. Driver Enable/Disable Propagation Delay Timing

# AC Test Circuits and Switching Waveforms (Continued)

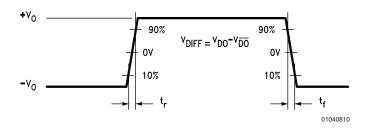


FIGURE 8. Driver Differential Transition Timing

### **Function Tables**

#### DS3695/DS3696 Transmitting

	Inputs		Thermal		Out	puts
RE	DE	DI	Shutdown	DO DO		TS *
						(DS3696 Only)
Х	1	1	OFF	0	1	Н
X	1	0	OFF	1	0	Н
X	0	Х	OFF	Z	Z	Н
X	1	Х	ON	Z	Z	L

#### DS3695/DS3696 Receiving

	Inputs		Outputs		
RE	RE DE RI-RI			TS *	
				(DS3696 Only)	
0	0	≥ +0.2V	1	Н	
0	0	≤ -0.2V	0	Н	
1	0	X	Z	Н	

#### DS3697

	Inputs	Thermal	Outputs		
E	RI-RI	Shutdown	DO	DO	RO
					(DS3697 Only)
1	≥ +0.2V	OFF	0	1	1
1	≤ -0.2V	OFF	1	0	0
0	Х	OFF	Z	Z	Z
1	≥ +0.2V	ON	Z	Z	1
1	≤ -0.2V	ON	Z	Z	0

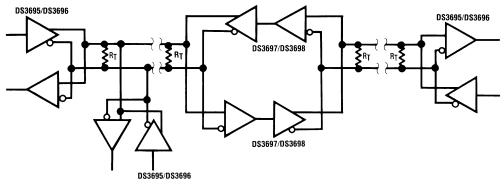
X — Don't care condition

X—Born care contained.

Z—High impedance state

\*TS is an "open collector" output with an on-chip 10 kΩ pull-up resistor that reports the occurrence of a thermal shutdown of the device.

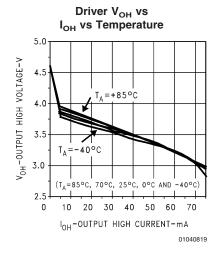
# **Typical Application**

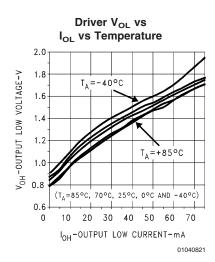


Note: Repeater control logic not shown, see AN-702.

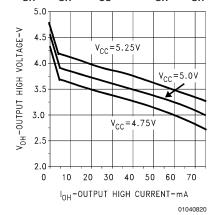
01040811

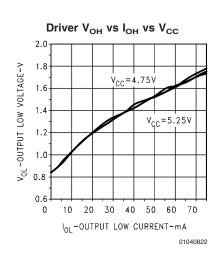
# **Typical Performance Characteristics**



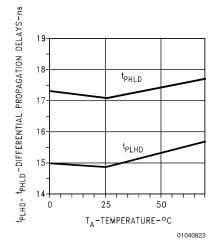


### Driver V<sub>OH</sub> vs I<sub>OH</sub> vs V<sub>CC</sub>Driver V<sub>OH</sub> vs I<sub>OH</sub> vs V<sub>CC</sub>

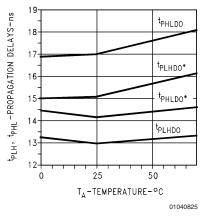




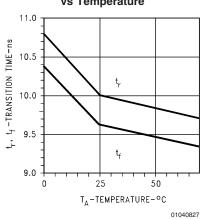
# Driver Differential Propagation Delay vs Temperature



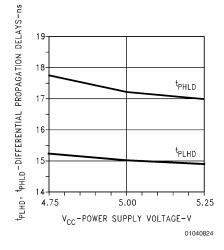
#### Driver Single-Ended Propagation Delay vs Temperature



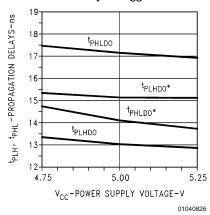
# Driver Transition Time vs Temperature



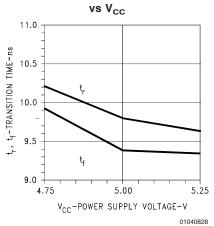
#### 



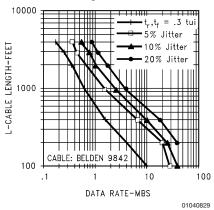
#### 



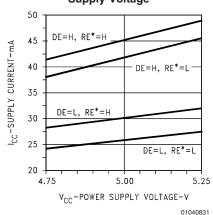
# Driver Transition Time



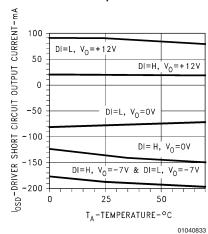
#### Cable Length vs Data Rate



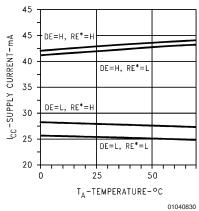
# Supply Current vs Power Supply Voltage



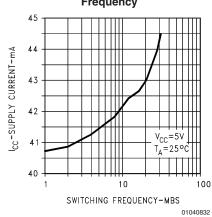
#### Driver Short Circuit Current vs Temperature



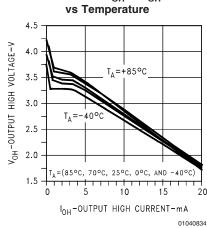
#### Supply Current vs Temperature

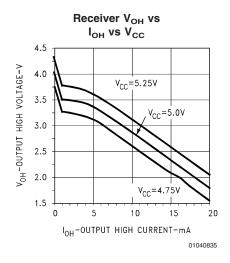


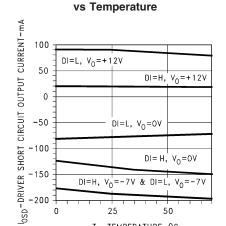
# Driver I<sub>CC</sub> vs Switching Frequency



# Receiver V<sub>OH</sub> vs I<sub>OH</sub>





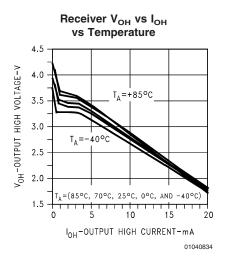


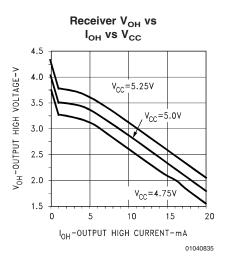
TA-TEMPERATURE-°C

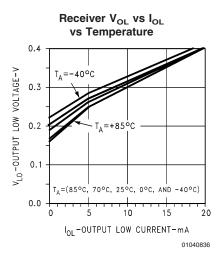
**Driver Short** 

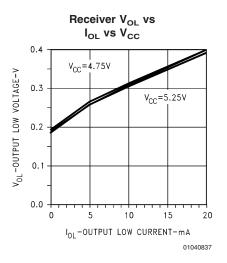
**Circuit Current** 

01040833

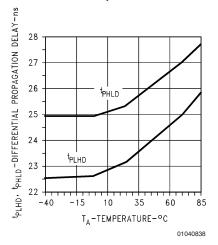




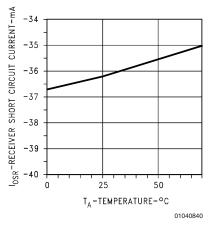




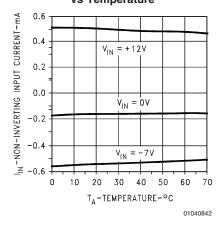
#### Receiver Differential Propagation Delay vs Temperature



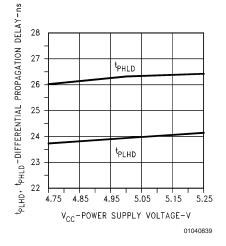
Receiver Short Circuit Current vs Temperature



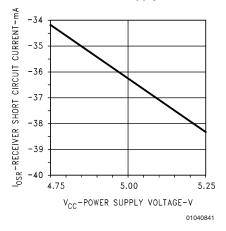
Receiver Non-Inverting Input Current vs Temperature



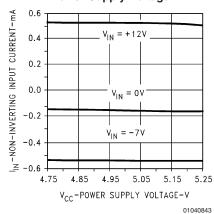
# Receiver Differential Propagation Delay vs V<sub>CC</sub>



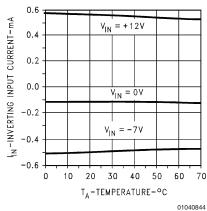
Receiver Short Circuit Current vs Power Supply



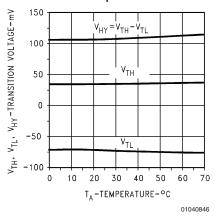
Receiver Non-Inverting Input Current vs Power Supply Voltage



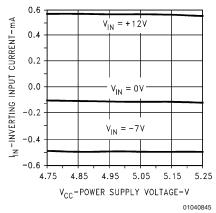




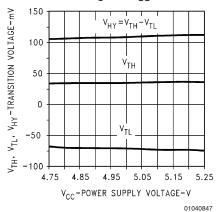
#### Hysteresis and Differential Transition Voltage vs Temperature



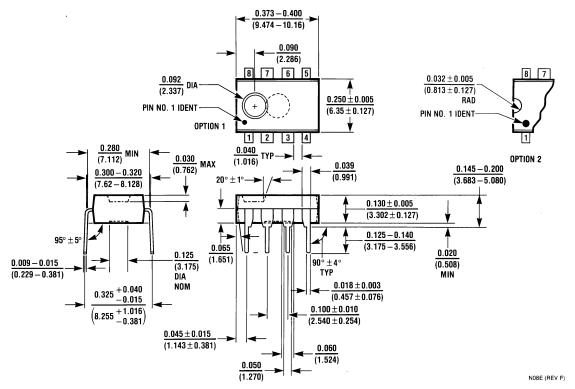
#### Receiver Inverting Input Current vs Power Supply Voltage



#### Hysteresis and Differential Transition Voltage vs V<sub>CC</sub>



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



8-Lead Molded Dual-In-Line Package (N) Order Number DS3695N, DS3696N, DS3697N, or DS3695TN **NS Package Number N08E** 

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.

For the most current product information visit us at www.national.com.

#### 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.

#### BANNED SUBSTANCE COMPLIANCE

National Semiconductor certifies that the products and packing materials meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.



National Semiconductor Americas Customer Support Center

Email: new.feedback@nsc.com

Tel: 1-800-272-9959

**Europe Customer Support Center** 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** 

**National Semiconductor** Asia Pacific Customer Support Center Email: ap.support@nsc.com **National Semiconductor** Japan Customer Support Center Fax: 81-3-5639-7507 Email: jpn.feedback@nsc.com Tel: 81-3-5639-7560