ADC Driver Evaluation Boards

National Semiconductor
Application Note 1812
Jason Seitz and Maithil Pachchigar
March 6, 2008

General Description

The ADC driver evaluation boards are designed to aid in the characterization of National Semiconductor's high-speed operational amplifier portfolio. Utilize these evaluation boards as guides for high frequency layout and as tools to aid in the design of ADC driver applications.

ADC Driver Configuration	Package	Device
Single to Single	6-Pin SOT23	LMH6611MK or LMH6618MK
Single to Differential	8-Pin SOIC	LMH6612MA or LMH6619MA
Differential to Differential	8-Pin SOIC	LMH6612MA or LMH6619MA

Although specifically designed for high speed op amps, these evaluation boards can be used for op amps in these packages with the same pinout.

Basic Operation

Single to Single ADC Driver

This architecture has a single-ended input source connected to the input of the op amp and the single-ended output of the op amp can then be fed off board to the single-ended input of an ADC. Figure 1 shows the board schematic of the single to single ADC driver in a 2nd order multiple-feedback inverting configuration. The inverting configuration is preferred over the non-inverting configuration, as it offers more linear output response. The ADC driver's cutoff frequency is found from the equation:

$$f_0 = \frac{1}{2\pi} * \sqrt{\frac{1}{R_2 * R_3 * C_2 * C_3}}$$

The op amp's gain is set by the equation:

$$\text{GAIN} = -\frac{R_2}{R_1}$$

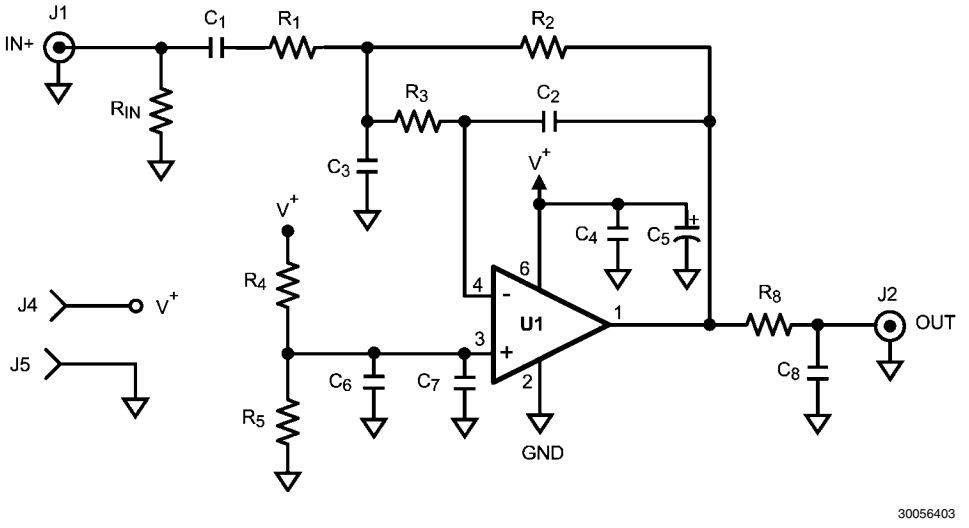


FIGURE 1. Single to Single ADC Driver Board Schematic

© 2008 National Semiconductor Corporation

A sample Bill of Material (BOM) for a single to single ADC driver board is given in the table below. The ADC driver will have a cutoff frequency of 500 kHz and a gain of -1.

Designator	Description	Comment
C_1	0805 Capacitor	1 µF
C_2	0805 Capacitor	150 pF
C_3	0805 Capacitor	1 nF
C_4	0603 Capacitor	0.1 µF
C_5	Tantalum Capacitor	6.8 µF
C_6	0805 Capacitor	5.6 µF
C_7	0805 Capacitor	0.1 µF
C_8	0805 Capacitor	220 pF
J1	SMA Connector	IN+
J2	SMA Connector	OUT
J4, J5	Test Point	Test Point
R_1, R_2	0805 Capacitor	549
R_3	0805 Capacitor	1.24k
R_4, R_5	0805 Capacitor	14.3k
R_8	0805 Capacitor	22
R_{IN}	0805 Capacitor	50
U1	6-Pin SOT23	LMH6611/LMH6618

Single to Differential ADC Driver

The single to differential ADC driver board schematic in *Figure 2* utilizes a dual op amp to buffer a single-ended source to drive an ADC with differential inputs. One of the op amps, U1A, is configured as a unity gain buffer that drives the inverting (IN–) input of the op amp U1B and the non-inverting (IN+) input of the ADC. U1B inverts the input signal and drives the inverting input of the ADC. The ADC driver is configured for a gain of +2 to reduce the noise without sacrificing THD performance. The common mode voltage of 2.5V is supplied at the non-inverting inputs of both op amps U1A and U1B. This configuration produces differential ±2.5 V_{PP} output signals, when the single-ended input signal of 0 to VREF is AC coupled into the non-inverting terminal of the op amp and each non-inverting terminal of the op amp is biased at the mid-scale of 2.5V. The two output RC anti-aliasing filters are used between the outputs of both U1A and U1B and the inputs of the ADC to minimize the effect of undesired high frequency noise coming from the input source. Each RC filter's cutoff frequency is found from the equation:

$$f_0 = \frac{1}{2\pi RC}$$

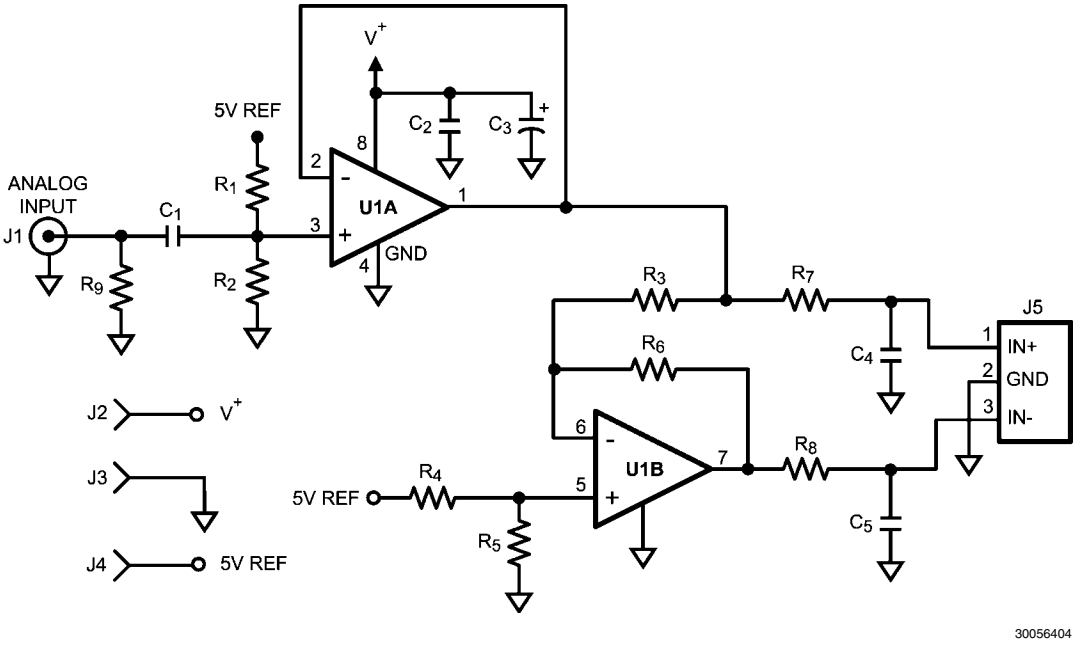


FIGURE 2. Single to Differential ADC Driver Board Schematic

A sample Bill of Material (BOM) for a single to differential ADC driver board is given in the table below.

Designator	Description	Comment
C_1	0805 Capacitor	10 µF
C_2	0805 Capacitor	0.1 µF
C_3	Tantalum Capacitor	6.8 µF
C_4, C_5	0805 Capacitor	220 pF
J1	SMA Connector	Analog Input
J2, J3, J4	Test Point	Test Point
J5	SIP3	Out
R_1, R_2, R_4, R_5	0805 Capacitor	2.5k
R_3, R_6	0805 Capacitor	560
R_7, R_8	0805 Capacitor	33
R_9	0805 Capacitor	50
U1	8-Pin SOIC	LMH6612/LMH6619

Differential to Differential ADC Driver

A dual op amp can be configured as a differential to differential ADC driver to buffer a differential source to a differential input ADC as shown in *Figure 3*. The differential to differential ADC driver can be formed using two single to single ADC drivers. Each output from these drivers goes to a separate input of the differential ADC. Each single to single ADC driver uses the same components and is in a multi-feedback inverting configuration.

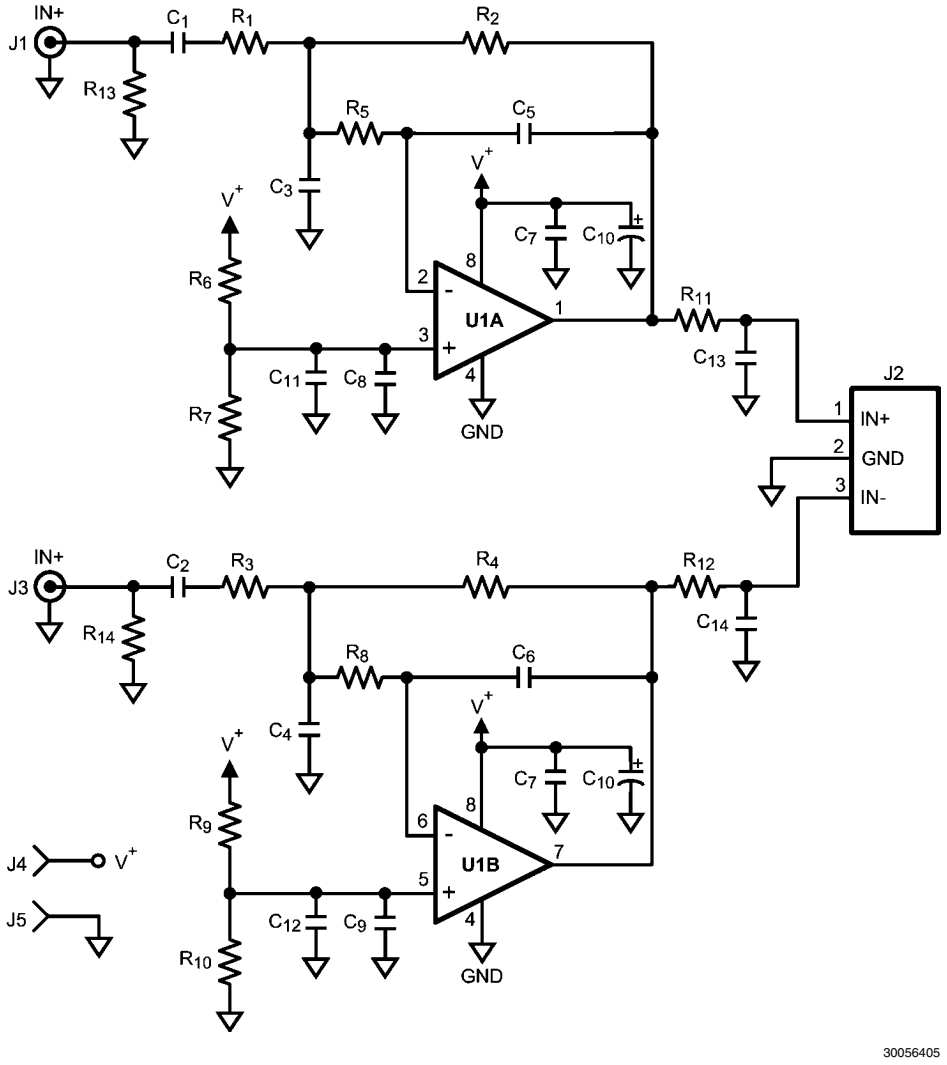


FIGURE 3. Differential to Differential ADC Driver Board Schematic

A sample Bill of Material (BOM) for a differential to differential ADC driver board is given in the table below. The ADC driver will have a cutoff frequency of 500 kHz and a gain of -1.

Designator	Description	Comment
C_1, C_2	0805 Capacitor	1 µF
C_3, C_4	0805 Capacitor	1 nF
C_5, C_6	0603 Capacitor	150 pF
C_7, C_8, C_9	0805 Capacitor	0.1 µF
C_{10}	Tantalum Capacitor	6.8 µF
C_{11}, C_{12}	0805 Capacitor	5.6 µF
C_{13}, C_{14}	0805 Capacitor	220 pF
J1, J3	SMA Connector	IN+
J2	SIP3	Out
J4, J5	Test Point	Test Point
R_1, R_2, R_3, R_4	0805 Capacitor	549
R_5, R_8	0805 Capacitor	1.24k
R_6, R_7, R_9, R_{10}	0805 Capacitor	14.3k
R_{11}, R_{12}	0805 Capacitor	22
R_{13}, R_{14}	0805 Capacitor	50
U1	8-Pin SOIC	LMH6612/LMH6619

Measurement Hints

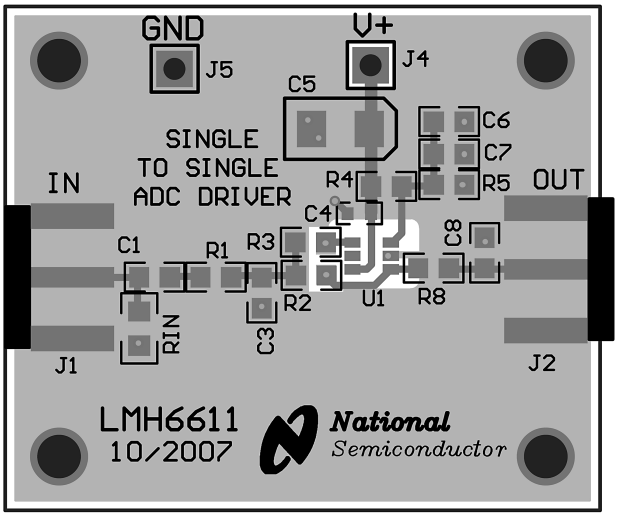
It is important to connect the input source ground with the supply ground. For each ADC driver configuration, it is important to account for the impedance of the signal source when setting up the resistor networks to ensure that the differential outputs have the same gain. For example, an audio precision signal generator has about 22Ω of source impedance and the typical board termination is 50Ω, so the gain and input signal must be adjusted in order to obtain the desired signal at the output of the op amp.

Layout Considerations

The following are recommendations for PCB layout in order to obtain the optimum high frequency performance:

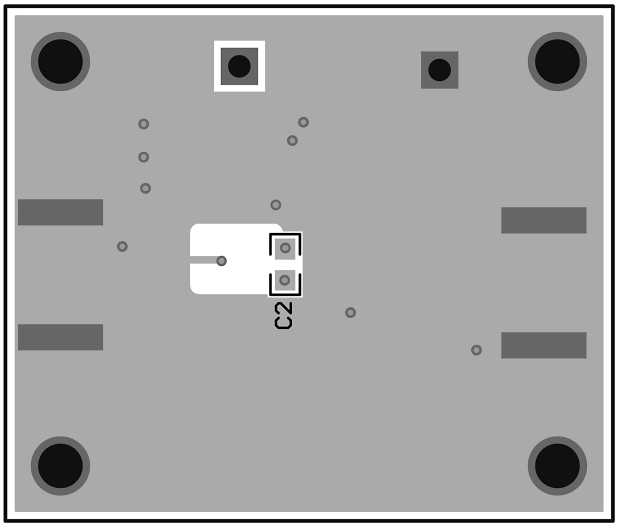
- Place the ADC and amplifier as close together as possible.
- Put the supply bypassing capacitors as close as possible to the device (<1").
- Utilize surface mount components instead of through-hole components.
- Keep the traces short where possible.
- Use terminated transmission lines for long traces.

The top and bottom layouts of all three ADC driver configurations are shown in Figure 4 below.



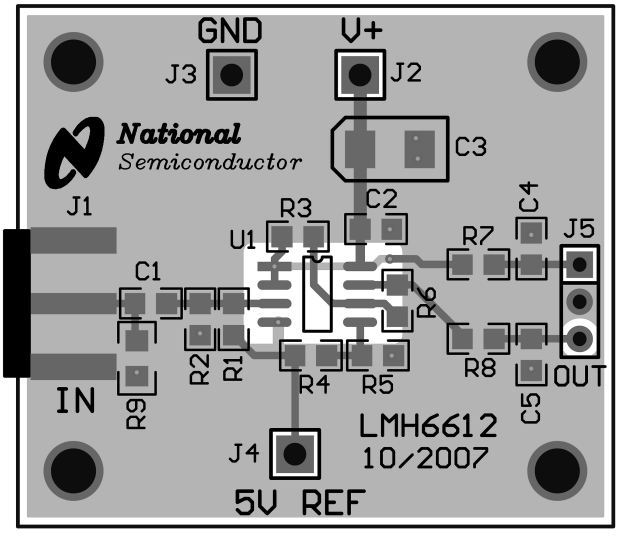
30056406

Single to Single Top Layer



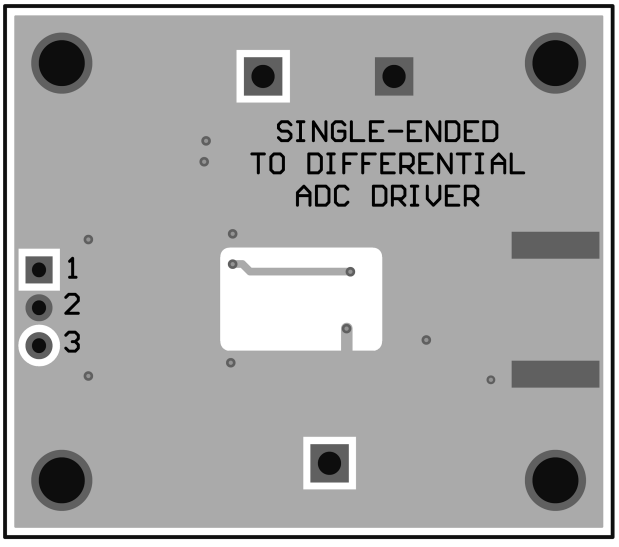
30056407

Single to Single Bottom Layer



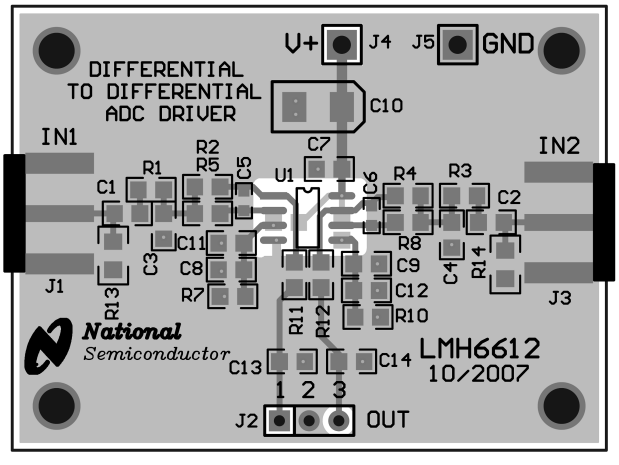
30056408

Single to Differential Top Layer



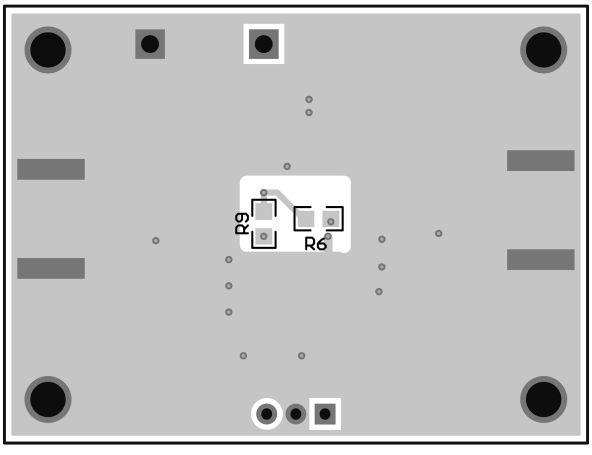
30056409

Single to Differential Bottom Layer



30056410

Differential to Differential Top Layer



30056411

Differential to Differential Bottom Layer

FIGURE 4. Top and Bottom Layouts of All Three ADC Driver Configurations

Notes

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

Products		Design Support	
Amplifiers	www.national.com/amplifiers	WEBENCH	www.national.com/webench
Audio	www.national.com/audio	Analog University	www.national.com/AU
Clock Conditioners	www.national.com/timing	App Notes	www.national.com/appnotes
Data Converters	www.national.com/adc	Distributors	www.national.com/contacts
Displays	www.national.com/displays	Green Compliance	www.national.com/quality/green
Ethernet	www.national.com/ethernet	Packaging	www.national.com/packaging
Interface	www.national.com/interface	Quality and Reliability	www.national.com/quality
LVDS	www.national.com/lvds	Reference Designs	www.national.com/refdesigns
Power Management	www.national.com/power	Feedback	www.national.com/feedback
Switching Regulators	www.national.com/switchers		
LDOs	www.national.com/ldo		
LED Lighting	www.national.com/led		
PowerWise	www.national.com/powerwise		
Serial Digital Interface (SDI)	www.national.com/sdi		
Temperature Sensors	www.national.com/tempsensors		
Wireless (PLL/VCO)	www.national.com/wireless		

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© 2008 National Semiconductor Corporation

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

National Semiconductor Americas Technical Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

National Semiconductor Europe Technical Support Center
Email: europe.support@nsc.com
German Tel: +49 (0) 180 5010 771
English Tel: +44 (0) 870 850 4288

National Semiconductor Asia Pacific Technical Support Center
Email: ap.support@nsc.com

National Semiconductor Japan Technical Support Center
Email: jpn.feedback@nsc.com