LMH6515

Application Note 1580 LMH6515EL Digital Controlled, Variable Gain

Amplifier Evaluation Board



Literature Number: SNOA482A

LMH6515EL Digital Controlled, Variable Gain Amplifier Evaluation Board

General Description

The LMH6515EL evaluation board is designed to aid in the characterization of National Semiconductor's High Speed LMH6515 Digital Controlled Variable Gain Amplifier.

Use the evaluation board as a guide for high frequency layout and as a tool to aid in device testing and characterization.

Basic Operation

The LMH6515 DVGA has differential input and differential output. The LMH6515 will also support single ended to differential conversion with no transformer required on the input. To aid evaluation with 50Ω single ended test equipment the LMH6515EL evaluation board provides for input and output transformers. For driving the evaluation board from a differential source, symmetrical signal paths are provided. Both input and output paths support fully differential signal paths. For component locations refer to the schematic in *Figure 1*.

The evaluation board uses end mounted SMA connectors. On the IN+ input, resistor R1 provides input termination. The analog supply (VCCA) can be from 4V to 5.25V. The capacitor C5 is a supply bypass capacitor and should be low ESR ceramic. Resistors R11 and R12 as well as capacitor C4 should be left empty.

The LMH6515EL evaluation board is designed for transformers with DC isloation between the primary and secondary windings. If baluns (transmission line transformers with no DC blocking) are used make sure to have DC isolation for all transformer pads.

Transformer T1 can provide both impedance matching as well as single ended to differential conversion. The 2:1 transformer matches 50Ω equipment with the 200Ω input impedance of the LMH6515 DVGA and there is an optional capacitor at C3 if additional stability is required. Do not connect the transformer secondary winding directly to ground. The LMH6515 has a self biased input common mode voltage of approximately 1.3V. The amplifier will bias up to the optimal input common mode point. The resistors R2, R24, and R25 are normally left empty. These resistors can be used to force the LMH6515 input common mode to a value different than it's self biased state. Most applications will not require this function.

If using a transmission line transformer for T1, capacitor C1 is necessary to preserve the proper input common mode volt-

National Semiconductor Application Note 1580 Loren Siebert October 31, 2007



age. For single ended inputs to the amplifier see Figure 7 and Figure 8

The LMH6515EL evaluation board is shipped with a transformer to facilitate testing with single ended equipment. To drive the LMH6515 evaluation board with a differential signal transformer T1 must be removed. Then, load capacitor C1 and C16 and cut the trace connecting the capacitor C2. R1 and R5 should be loaded with appropriate valued resistors (normally 50Ω). The C3 capacitor is not needed for this case and the transformer pads should be shorted with a low inductance wire: pad 6 to pad 1 and pad 4 to pad 3.

On the output side of the board is transformer T2. C11 isolates the output common mode voltage from the output transformer primary windings. The output coupling capacitors C13 and C14 are necessary for Balun transformers which provide no DC isolation between the primary and secondary windings, and are also necessary when driving differential loads.

For differential output signals remove transformer T2. Capacitor C11 can be left empty. Do not install resistor R4. Using the transformer T2 pads, place coupling capacitors between pads 3 and 4 and between pads 1 and 6 where the transformer would have been. These should be low ESR ceramic capacitors with a value of 1nF. These output coupling capacitors are necessary to isolate the output common mode voltage of the LMH6515 from the test equipment. The pads for capacitors C13 and C14 can be used as series output matching resistors. There is no copper between transformer pad #6 and C14. A low impedance short will have to be added manually. Resistors R3 and R4 are normally left empty in this configuration.

The evaluation board supports two gain options. As shipped the evaluation board provides for a low gain, 200Ω output impedance configuration. In order to use the high gain 400Ω configuration, the traces from pins 13 and 16 to VCCA can be cut. See *Figure 6* for a detail of the trace cuts required.

SW1 is used to set the five gain control bits. When the Latch position of SW1 is in 0 or OFF position, changes in the Gain 0 to Gain 5 bits are processed by the LMH6515. When the Latch switch is in 1 or ON position, the last loaded state is held and Gain bit switch changes have no affect. Landings for SMA connectors are also provided for high speed triggering of the gain bits.

The LMH6515EL evaluation board is a four layer board; all four layers are detailed in *Figure 2* through *Figure 5*.





AN-1580



FIGURE 2. Evaluation Board Top Layer



NATIONAL SEMICONDUCTOR LAYER4 SILK

FIGURE 3. Evaluation Board Bottom Layer

AN-1580

NATIONAL SEMICONDUCTOR LAYER2 0 0 2 Ċ o 0 o o 0 ō C ō. o ø o ~ 30008105

FIGURE 4. Evaluation Board Layer 2

NATIONAL SEMICONDUCTOR LAYER3 3

www.national.com

FIGURE 5. Evaluation Board Layer 3

30008106



AN-1580



FIGURE 6. Trace Cuts for High Gain (400 Ω Load) Operation



30008108

FIGURE 7. Single Ended Input — No Transformer



FIGURE 8. Schematic for Single Ended Input

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		

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

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



N-1580

1

National Semiconductor Americas Customer Support Center Email: 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 Deutsch Tei: +49 (0) 69 9508 6208 English Tel: +49 (0) 870 24 0 2171 Français Tei: +33 (0) 1 41 91 8790 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

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Audio	www.ti.com/audio	Communications and Telecom	www.ti.com/communications
Amplifiers	amplifier.ti.com	Computers and Peripherals	www.ti.com/computers
Data Converters	dataconverter.ti.com	Consumer Electronics	www.ti.com/consumer-apps
DLP® Products	www.dlp.com	Energy and Lighting	www.ti.com/energy
DSP	dsp.ti.com	Industrial	www.ti.com/industrial
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Security	www.ti.com/security
Logic	logic.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Power Mgmt	power.ti.com	Transportation and Automotive	www.ti.com/automotive
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Mobile Processors	www.ti.com/omap		
Wireless Connectivity	www.ti.com/wirelessconnectivity		

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265 Copyright © 2011, Texas Instruments Incorporated