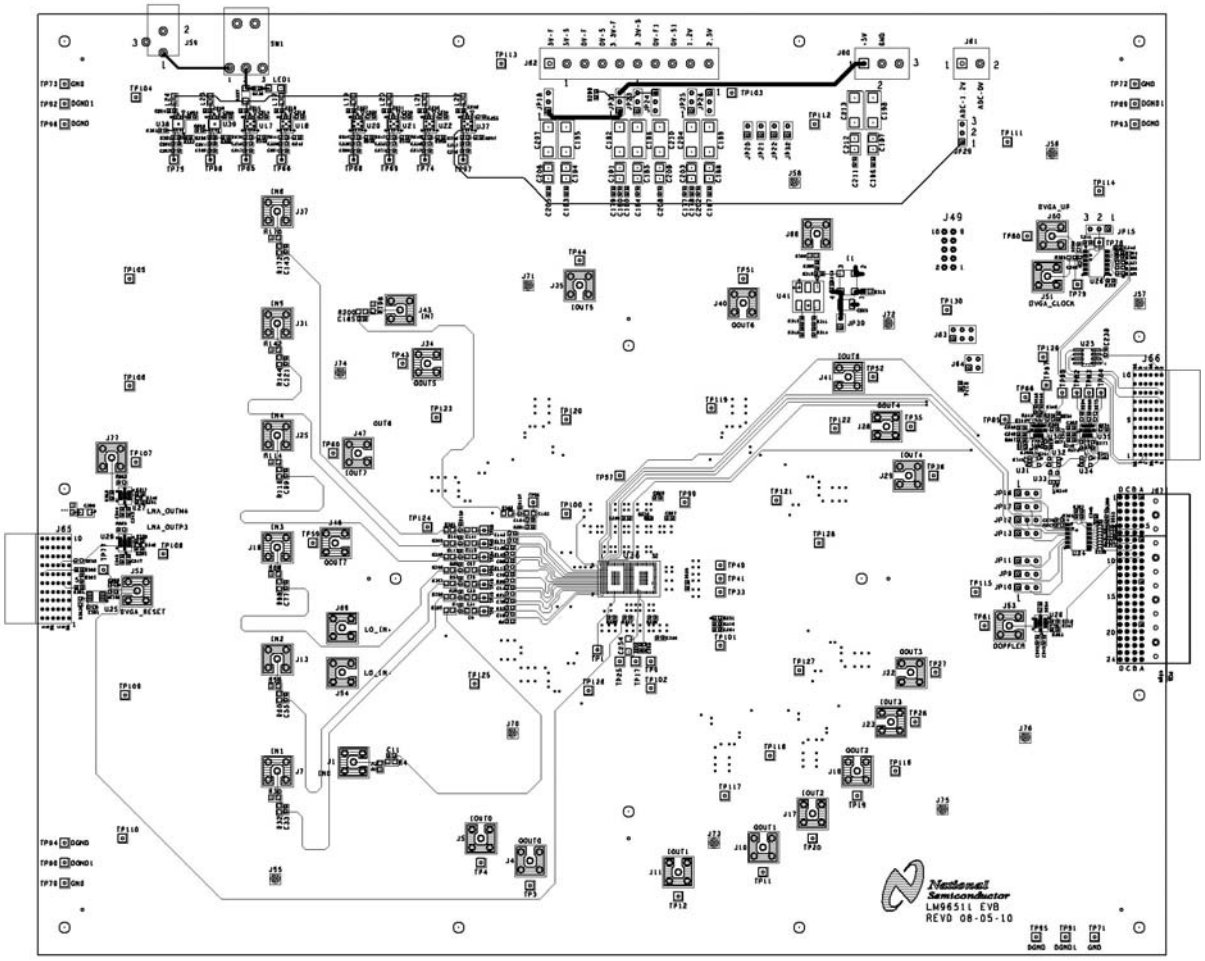
National Semiconductor

August 2010

LM96511 Ultrasound Receive Analog Front End (AFE) Evaluation Board User's Guide



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1.0 GENERAL DESCRIPTION

The LM96511 Evaluation Board is used to evaluate the LM96511 8-Channel Ultrasound Receive Analog Front End consisting of an integrated Low Noise Amplifier (LNA), Digital Variable Gain Amplifier (DVGA), CW Doppler Demodulator, and a 12-Bit Continuous Time ΣΔ ADC.

The evaluation board is designed for use with the WaveVision5™ Data Capture Board via USB connection to a PC running the WaveVision5™ software. This ADC data capture board and software offer time domain plots, frequency domain plots, and calculates dynamic performance of the LM96511 such as SNR, SINAD, THD, SFDR, and ENOB.

The evaluation board offers provisions for externally synchronizing the gain ramp period of the DVGA for Time Gain Compensation (TGC) operation. The evaluation board allows the user to measure the I&Q outputs for each of the eight Doppler Demodulator channels.

In addition to performing data capture and FFTs, the WaveVision5™ software also provides the user with parametric controls such as amplifier gains, TGC rate, and selectable Doppler phase rotation angles.

NOTE: National Semiconductor also features a separate reference design board for the LM96511 Ultrasound Receive AFE, which demonstrates the end-to-end signal path performance in an ultrasound application. Please contact your local NSC Field Applications Engineer for a live demonstration.

1.1 Packing List

The LM96511 Evaluation Kit consists of the following components:

- ☑ LM96511 Evaluation Board
- ☑ 110V-240V AC to +6V DC Power Adapter
- ☑ CD ROM containing the WaveVision5™ software installation package, WaveVision5™ documentation, the LM96511 datasheet, LM96511 Evaluation board Bill of Materials, and schematic.
- ☑ LM96511 Evaluation Board User's Guide

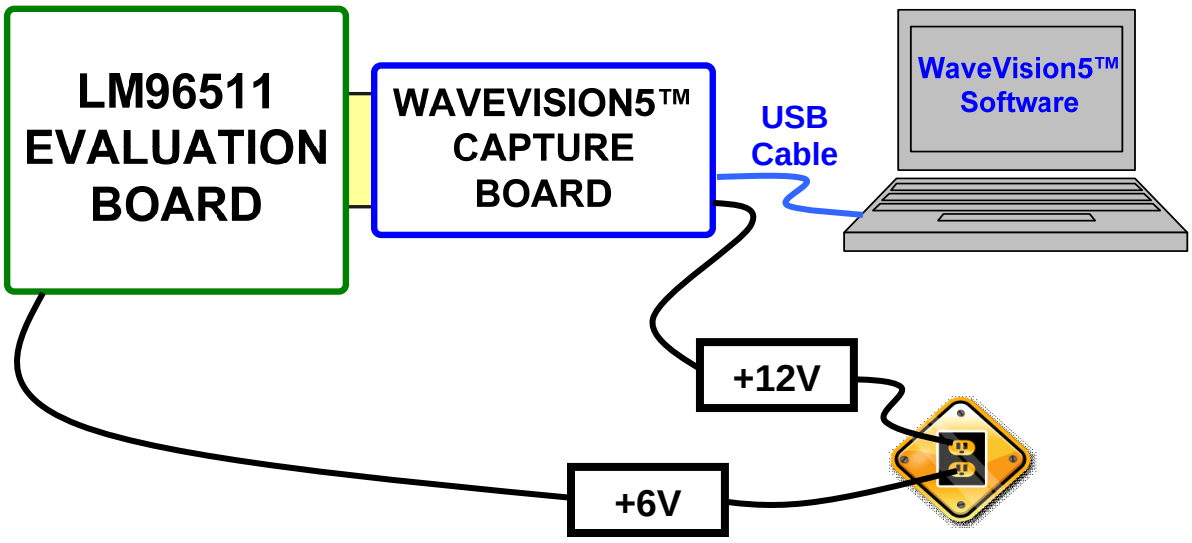
1.2 References

- ☑ LM96511 Datasheet
- ☑ WaveVision5™ Software User Guide
- ☑ WaveVision5™ Data Capture Board User Guide

2.0 BOARD ASSEMBLY & ORIENTATION

The LM96511 Evaluation Board is shipped pre-assembled for quick turn-key evaluation. Refer to the Bill of Materials for a description of the components.

Please refer to the Board Schematic along with *Figure 1* for board orientation and major component locations.



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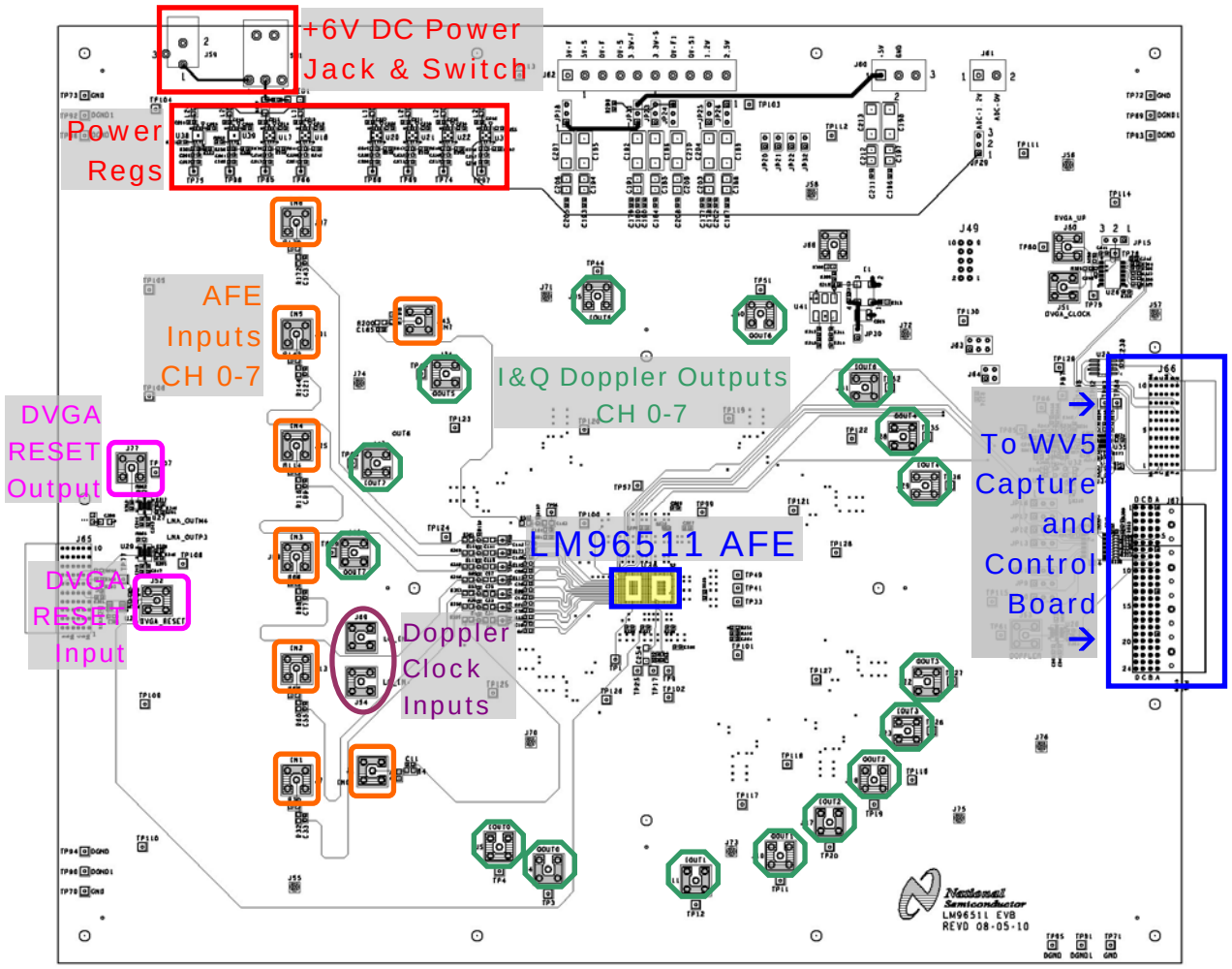


Figure 1. LM96511 Evaluation Board Orientation

Component Description	Component Designator	Notes
+6V DC Power jack	J59	
Power switch	SW1	
On-board power regulators	U17, U18, U20, U21, U22, U37, U39	
AFE Inputs (Channels 0–7)	J1, J7, J13, J19, J25, J31, J37, J43	
DVGA RESET Output	J77	For B-Mode TGC gated data acquisition
DVGA RESET Input	J52	
CW Doppler Demodulator LO / Differential Clock Inputs	J54, J69	Local Oscillator differential clock input
CW Doppler Demodulator I&Q Outputs Channels (0–7)	J4, J5, J10, J11, J16, J17, J22, J23, J28, J29, J34, J35, J40, J41, J46, J47	
High Speed Mating Port with WV5 Board	J66	
Control Path Mating Port with WV5 Board	J67	

Table 1. Key Board Input and Output Connectors

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3.0 QUICK START-UP INSTRUCTIONS

The following are step by step instructions for starting up the evaluation kit for the first time. These steps should be performed in the exact sequence presented below.

3.1 WaveVision5™ Software Installation

The WaveVision5™ software is necessary for operating the evaluation board. The installation package is included in the CD-ROM folder:
D:\WV5 Installation Package

1. Double-click on the file **WV5Setup5.0.5.169.exe**
2. A "Release Notes" RTF file will pop up at the conclusion of the installation – close this file.
3. COPY the file, **ultrasound_patch_100614aa.exe**, FROM the folder **D:\WV5 Installation Package** → TO the newly created folder **C:\Program Files\NationalSemiconductor\WaveVision5**.
4. After the file **ultrasound_patch_100614aa.exe** is placed in this folder, double-click on it from inside that folder to execute the patch.
5. COPY the file, **wv5_xc4vlx25_sp1250mi02_int.reg.xml**, FROM the folder **D:\WV5 Installation Package** → TO the folder **C:\Program Files\NationalSemiconductor\WaveVision5\firmware**.
6. Software installation is now complete.
7. Please do not update this WaveVision5™ software after installation and ignore any update messages!

3.2 Default Jumper Settings

The board is shipped with the jumpers configured in the recommended default positions listed below. The jumpers should always remain in these configurations unless otherwise stated in the *Functional Description Section 3.3*.

Jumper	Description	Default
JP9-JP13, JP15-JP17	Optional manual override for Amplifier logic control signals	OPEN
JP18	Power source selection between on-board regulators and external bench power supplies.	DOWN (1-2)
JP23		DOWN (1-2)
JP24		DOWN (2-3)
JP25		DOWN (1-2)
JP26		DOWN (2-3)
JP29		DOWN (1-2)
JP31		DOWN (1-2)
J63		ALL CLOSED
JP30	Power on-board 50MHz osc.	CLOSED

Table 2. Default Jumper Settings

3.3 Powering Up and Connecting the Evaluation & WaveVision5™ Boards

1. Inspect the board to verify that all of the jumpers listed in *Table 2* are configured in their default positions.
2. Connect the WaveVision5™ board to the Evaluation board at its mating connectors J66 and J67.
3. Plug in the +12V power wall plug into the WV5 board at its power jack J2 and turn ON the its power switch SW1.
4. Plug in the USB Cable to the WV5 board connector J4.

> NOTE: ALWAYS Power up the WV5 Board FIRST before making physical USB connection with the PC to ensure proper initialization of the FPGA!

5. USB DRIVER INSTALLATION: Upon plugging in the USB cable, MS Windows should recognize the WV5 board as new hardware. Follow the steps in the New Hardware Wizard to install the USB driver. Be sure to click "*Continue Anyway*" at the final prompt.
6. Plug in the +6V power wall plug into the Evaluation board at its power jack J59 and turn ON its power switch SW1.
7. Launch the WaveVision5™ software.

> When launching the WaveVision5™ software on a PC for the very first time, CLICK on NO for automatic updating!

8. An FPGA image will load while the WaveVision5™software initializes.
9. In the WaveVision5™ software window, hover the mouse pointer over the 3rd vertical tab, "**Registers**", on the far right-hand side, and then click on the 3rd horizontal tab, "**Default**".
10. Now, the boards and software are ready for B-Mode and CW-Mode signal path tests.

> Always perform steps 1-9 for proper start-up.
>
> To Power Down, the steps should be performed in the exact reverse order:
> 1. Turn OFF the Evaluation board
> 2. Turn OFF the WV5 board
> 3. Disconnect the USB cable

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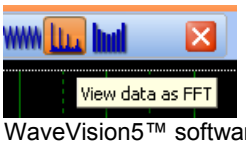
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3.4 B-Mode Signal Path Test

1. Connect a clean signal (e.g. from a 50Ω test source) to one of the AFE input channel SMA jacks (see *Table 1*).
2. Adjust the input signal amplitude to a level (e.g., 10mV$_{PP}$) suitable for applying larger gains to.
3. In the WaveVision5™ software window, hover the mouse pointer over the 3rd vertical tab, "**Registers**", on the far right-hand side, and then hover over the 3rd vertical tab, "**DVGA**", on the left-hand side of the Registers menu, and click and UNCHECK the "**Periodic Gated Captures**" box. See *Section 4.5* for further details regarding Periodic Gated Captures.
4. Initiate a data acquisition in "continuous mode" with "averaging" by clicking on the green icon first, followed by the white icon, and then the "A" icon shown below to display the data waveform in the Time Domain.

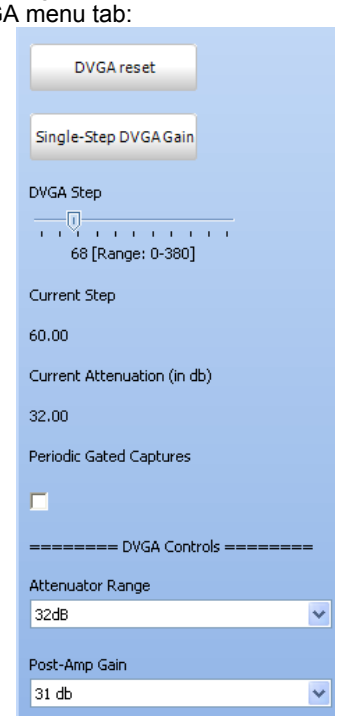


To display the FFT, click on the Frequency Domain icon.



Refer to the WaveVision5™ software user guide for further details regarding FFTs, etc.

5. The following DVGA parameters can be adjusted in the DVGA menu tab:



Refer to the LM96511 Datasheet for more details regarding these DVGA controls.

3.5 CW-Mode Signal Path Test

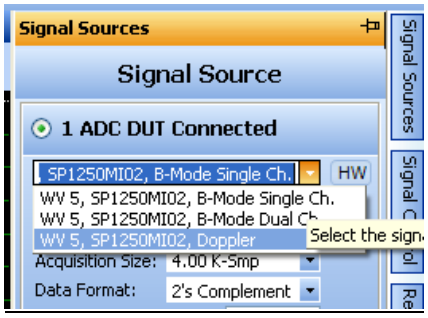
1. Connect a clean 50% duty cycle differential clock signal to the Local Oscillator (LO) / CW Clock Inputs at SMA Jacks J54 and J69 (see *Table 1*).

   The LO frequency signal should be 16 x the RF frequency (e.g., 16 x 5.0 = 80.0MHz). Its common mode level is typically 1.2V with a 400mV$_{PP}$ differential swing from a 100Ω differential source.

   See the board schematic and the CW Doppler Section in the LM96511 Datasheet for further details.
2. Connect a signal (e.g. from a 50Ω test source) to one of the AFE input channel SMA jacks (see *Table 1*).

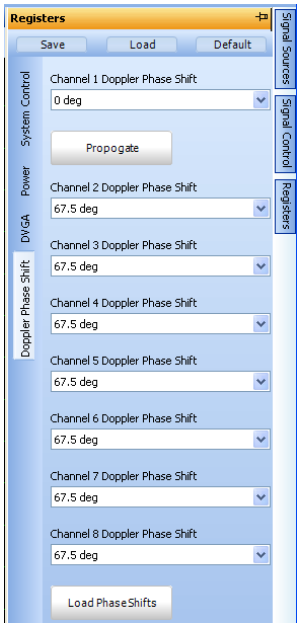
   This input signal frequency should be the RF frequency plus a user defined offset (e.g., 5.0 + 0.1 = 5.1MHz). The signal amplitude should be adjusted to suit the input range of the LM96511 (< 500mV$_{PP}$).

   See the CW Doppler Section and Electrical Specifications in the LM96511 Datasheet for further details.
3. In the WaveVision5™ software window, hover the mouse pointer over the 1st vertical tab, "**Signal Source**", on the far right-hand side and then access the pull-down menu to select "**WV5, SP1250MI02, Doppler**".



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4. In the WaveVision5™ software window, hover the mouse pointer over the 3rd vertical tab, "**Registers**", on the far right-hand side, and then hover over the 3rd vertical tab, "**Doppler Phase Shift**", on the left hand side of the Registers menu to display the CW Doppler – Phase Angle Rotation Selection controls.



Use the pull down menus to select phase rotation angles for each channel individually or click on the "**Propagate**" button to duplicate the angle for all channels. Click on the "Load Phase Shifts" button.

5. The Doppler I&Q outputs can be measured at the output SMA jacks (see *Table 1*).

See the CW Doppler Section in the LM96511 Datasheet for further information.

4.0 FUNCTIONAL DESCRIPTIONS

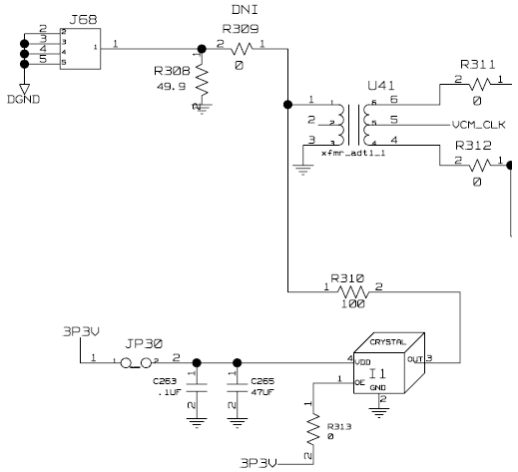
4.1 Analog Input (Channels 0 – 7)

The single-ended analog inputs are supplied via standard SMA connectors. A clean 50Ω test signal source should be used to ensure that the LM96511's dynamic performance can be properly evaluated.

4.2 ADC Input Clock

The LM96511's Continuous Time ΣΔ ADC is clocked at 40-50MHz, with a low jitter, low voltage differential clock.

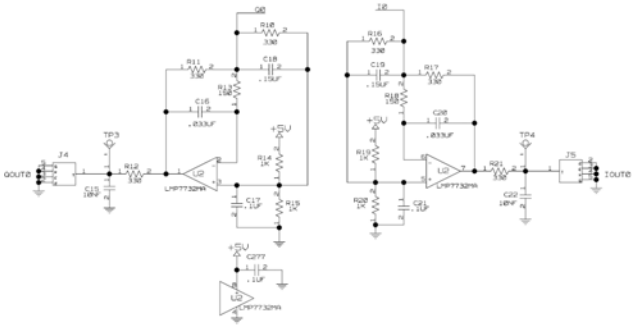
The LM96511 Evaluation board includes a transformer (U41), which generates a differential clock from a single-ended source. The board offers users with the option to either drive this single-ended source with an external clock (at J68) or with a 50MHz on-board crystal oscillator (I1).



The board is shipped with the default configuration, in which the on-board oscillator is selected as the clock source. See sheet 14 of the board schematic for details.

4.3 CW Doppler Demodulator I&Q Output (Channels 0 – 7)

The LM96511 Doppler Demodulator's I&Q current outputs are driven by the LMP7732 I-V conversion amplifier out to standard SMA connectors for convenient lab measurements and test points for waveform monitoring.



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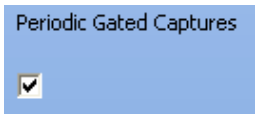
4.4 DVGA Controls

The LM96511 DVGA controls (Gain CLOCK, Gain RESET, and Gain Ramp DIRECTION) on the Evaluation board are typically controlled via the WaveVision5™ software. However, the board offers provisions for a user to externally control these signals at SMA connectors, J50, J51, and J52.

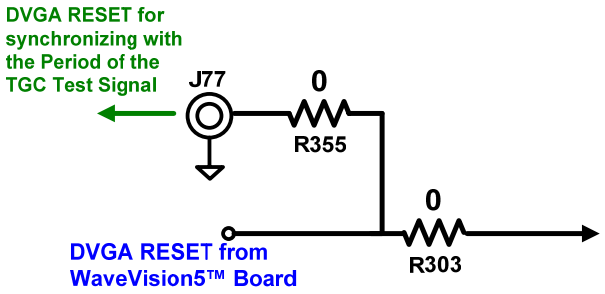
Refer to the LM96511 Datasheet for more details regarding these DVGA controls.

4.5 TGC and Periodic Gated Captures

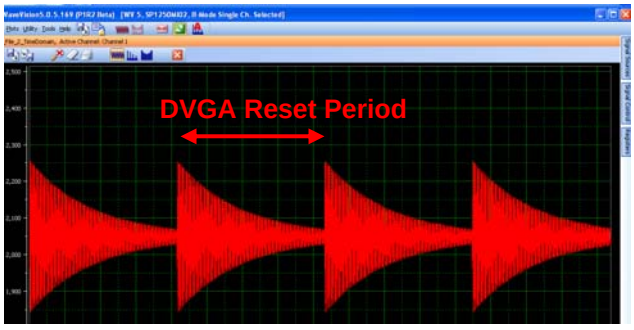
Checking the "Periodic Gated Captures" box in the DVGA Registers tab allows the user to gate the WaveVision5™ data capture with the DVGA RESET period. Thus each captured ADC data window will be synchronous with each DVGA Gain Ramp Period (i.e., Time Gain Compensation (TGC) Period).



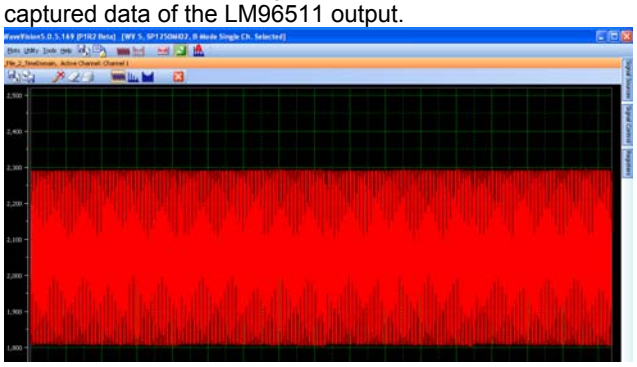
Furthermore, the period of a TGC test signal (e.g., periodic exponentially decaying sine wave) may be externally synchronized to the DVGA RESET period. The LM96511 Evaluation board provides SMA connectors to achieve this as shown below.



Shown below is WaveVision5™ captured data of an "un-time gain compensated" output from the LM96511. The Input is a TGC test signal with its period synchronized to the DVGA RESET signal from the WaveVision5™ board.



Now, after the LM96511 DVGA has time gain compensated the input signal, shown below is the captured data of the LM96511 output.



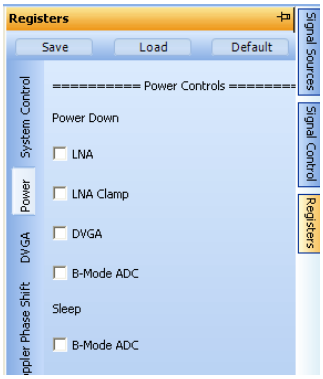
4.6 Global Logic Controls

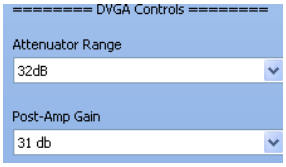
All logic controls for the LM96511 are typically set by the WaveVision5™ software. The board also offers provisions for a user to manually override these controls with jumpers and externally with a SMA connector.

	Logic Control Signals
JP9	DVGA Attenuation Range MSB
JP10	DVGA Attenuation Range LSB
JP11	Post Amplifier Gain Select
JP12	Low Noise Amplifier Shutdown
JP13	DVGA Shutdown
JP15	Amplifier SPI Reset
JP16	ADC Reset
JP17	ADC Sleep
J53	Doppler Mode Reset

Table 3. Manual Logic Controls

Nevertheless, it is recommended to primarily use the WaveVision5™ software to control these signals as shown below.





Refer to the LM96511 Datasheet for more details regarding these control signals.

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4.7 Power

The LM96511 Evaluation board is typically powered with a single AC to +6V DC Power Adapter. This +6V then sources multiple on-board voltage regulators that supply power to all of the devices on the board.

Alternatively, the required supply voltages can be sourced from external lab DC power supplies that are clean and well-regulated within ± 5% variation of the voltage range. This option is not recommended. The board is shipped with power source selection jumpers (*see Table 2*) in the default configuration which powers the board with the +6V DC Power Adapter.

See Table 2 and the board schematic for further details.

4.8 WaveVision5™ Mating Connectors

J66 is a high speed connection point that carries the LM96511 ΣΔ ADC's serial LVDS data and clock outputs as well as the LM96511's SPI lines, and DVGA control signals.

J67 is the control signal path connection point that carries the LM96511's control signals listed in *Table 3*.

4.9 Test Points

Test points and ground points are provided to measure the input and output signals using 10MΩ oscilloscope probes with ~10pF load capacitance.

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