GC6016 Quick Start Guide

User's Guide

Literature Number: SLWU072
March 2011

1 Overview

This document outlines the basic steps and functions that are required to ensure the proper operation of the GC6016EVM. This guide will help the user quickly evaluate the performance of the GC6016 in a repeater application mode of operation.

The GC6016EVM consists of the following modules:

- GC6016EVM board (Figure 1).
- Ethernet switch and cables.
- USB-to-Ethernet adapter
- 19VDC Power supply for the GC6016EVM.

The GC6016EVM is shown in Figure 1.

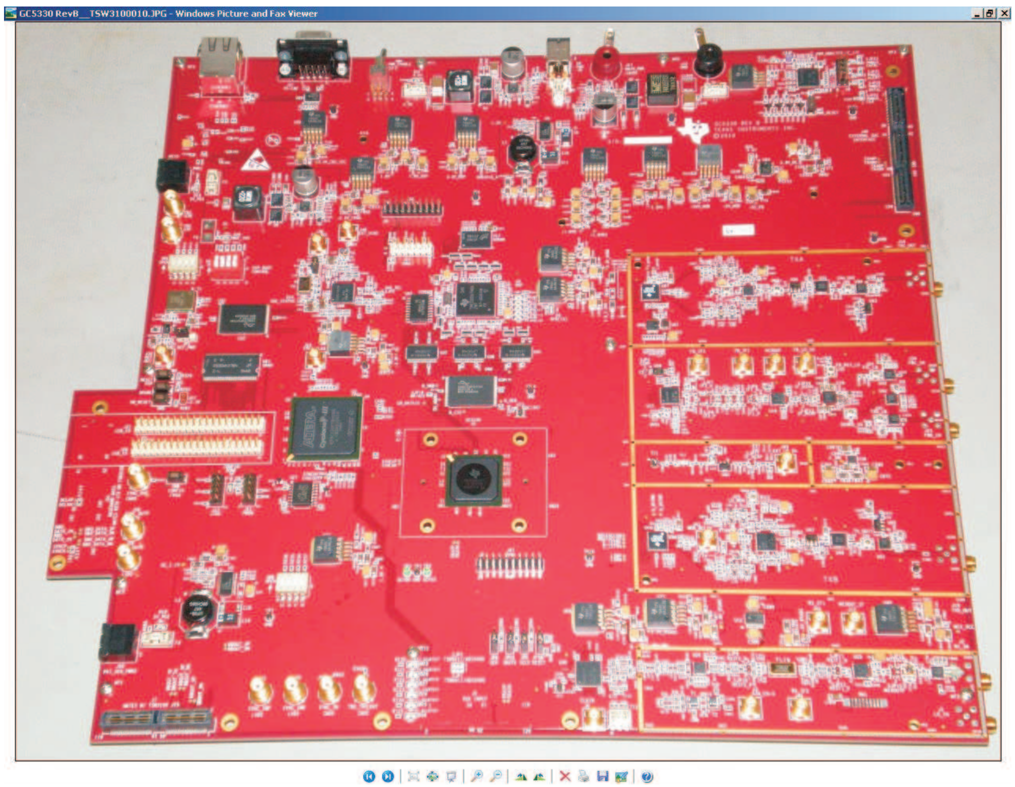

Figure 1. GC6016EVM

2 GC6016EVM General Description

The GC6016EVM is fully controlled by a single PC through two Ethernet connections (one for each EVM when using the TSW3100). It is highly recommended to use an Ethernet hub between the host PC and the two boards.

The GC6016 repeater configuration, is an example of a simple repeater that does not require additional baseband external signal processing.

The ADCA or ADCB input busses can accommodate 1 - 4 ADCs; they can be real or complex pairs. The ADC sampled output has alias components, depending on the selected Nyquist zone and filtering. The ADC input is sent to the internal Receive (Rx) block down converter for processing. The Rx block down converter translates the IF center frequency to zero. The block down converter can filter, and decimate the signal to attenuate out of band signals. The filtered zero IF center frequency stream(s) are sent through a Receive Equalizer, and IQ correction block.

The Rx block down converter has interleaved IQ stream outputs. These are distributed to the two Digital Down Converters (DDC). Each Rx block stream output can be connected to a set of Mixer/CIC connections within the Rx DDC (DDUC).

Each DDC can process 2, 4, 6, 8, or 12 channels of a common IQ rate. The DDC tunes individual carriers within the stream to zero IF. The CIC, Resampler, and PFIR provide filtering and decimation to attenuate out of band signals.

The DDC output goes to the baseband block where gain or backend AGC gain is added. In this simple repeater example, the data is internally connected to the Transmit (Tx) BB signals. If the internal switching is used, DDUC3 (Rx) goes to DDUC2 (Tx), and DDUC1 (Rx) goes to DDUC0 (Tx). The Tx BB signals have gain applied, and are input to the Tx-DUC (DDUC).

The Tx DDUC has interpolation and filtering in the PFIR, Resampler, and CIC. The Mixers translate the zero IF individual carriers to the desired offset frequency. The Tx DDUC outputs go to the SumChain, where specific carriers from CIC Mixer connections are combined (summed) and scaled.

The two summed streams are sent to the Crest Factor Reduction (CFR) block for gain scaling, CFR, and post CFR gain scaling. In addition the CFR block contains (2) sets of interpolating filters.

The output from the CFR block goes to the BUC block. The BUC block provides further interpolation, stream IF offset frequency translation, and summing. The BUC output goes to the DAC formatting block to provide the DAC outputs.

The Rx ADC, Rx-Block Down Converter output, and CFR output can be sent to the capture buffer for monitoring of the signal quality and amplitude. These, as well as the BB Rx output, can also be monitored by power meters.

2.1 GC6016EVM

The digital portion of the GC6016 EVM consists of a ultra-wideband highly-integrated transmit and receive processor (GC6016), which is used to receive, reformat, and generate transmit data. The control of the GC6016EVM is provided by a TMS320C6748 Digital Signal Processor (DSP). The EVM communicates to a host PC via an Ethernet interface.

The RF section of the GC6016EVM can flexibly support different RF standards between 900 and 2.7 GHz. Using the on-board TRF3720 (integrated IQ modulator PLL/VCO), the user can generate a LO source for RF bands between 300 and 4000 MHz. Options are provided to use external LO sources either combined or separate TX and RX sources.

The system clock is provided by an on board VCXO which is divided by a CDCE72010 to provide the required clocks for the DAC’s, ADC’s, GC6016, TRF3720 and TSW3100 pattern generator. The default VCXO is 614.4. MHz, although this can be substituted with another VCXO or bypassed by using an external clock source.

The board has two complete TX streams. Each stream uses a DAC3283 (16-bit, 800 MSPS, dual channel). One stream uses a TRF3703 for the TX conversion to RF. This is followed by an amplifier, programmable attenuator and switch (for optional on board loopback to feedback path). The second stream is identical with the exception of a TRF3720 used in place of the TRF3703.

The board has two complete Rx paths. One path consists of a switch, VGA, amplifier, mixer to convert to IF. At IF, there is an amplifier and ADS61B49 ADC (14-bit, 250 MSPS).

The second Rx path uses a dual ADC (ADS62P49). One ADC path consists of a mixer, VGA, filter, and amplifier, to generate IF data. The second Rx path requires external IF data that is brought in through MCX connector J3. This path takes the signal ended input and converts it to differential data through two transformers.

The block diagram of the GC6016EVM is shown in Figure 2.

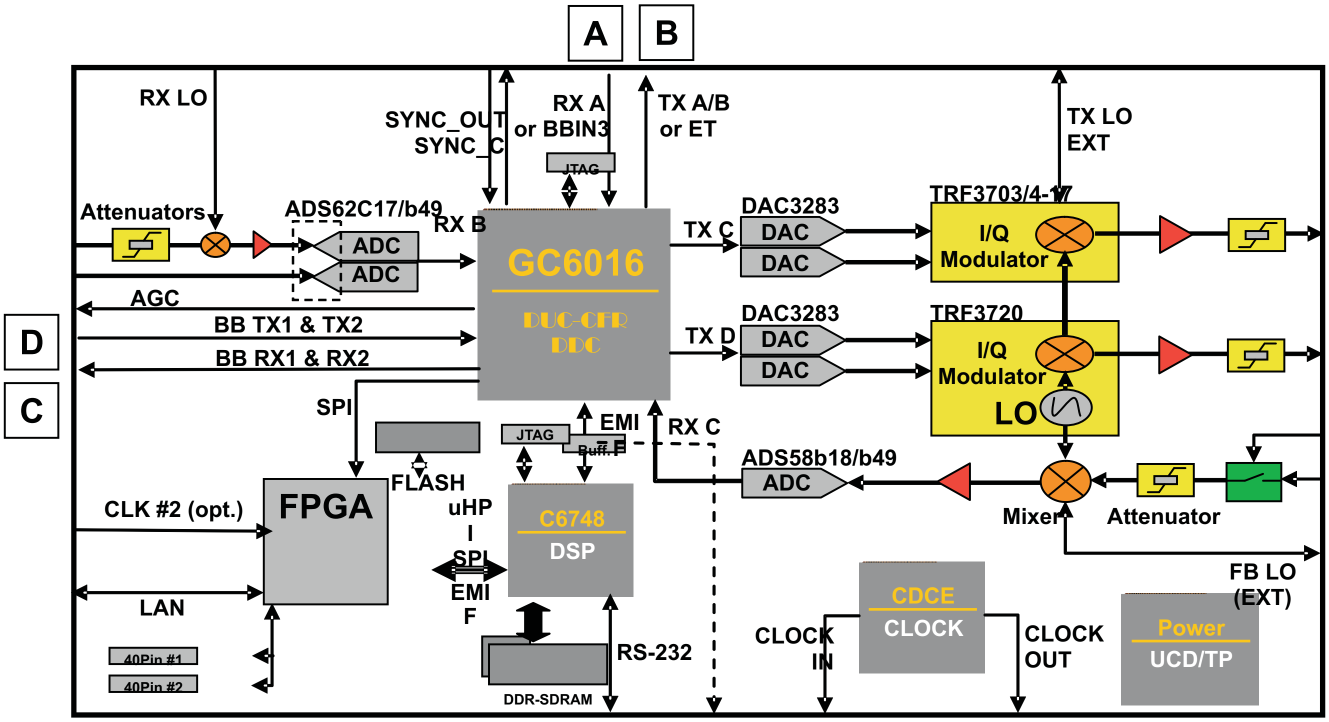

Figure 2. GC6016 EVM BLOCK DIAGRAM

The GC6016 EVM is programmed through an Ethernet cable (plugged into J9) via FTP commands issued by the GC6016GUI.

Power to the GC6016 EVM is provided from a single 19V supply (DELL) thru J4. Banana jack connectors J17 and J10 can also be used to provide input power if a Dell supply is unavailable. If these connectors are used, the external supply should be able to provide a minimum of 3 Amps at 19VDC. Switch SW4, located at the top of the EVM, is the main power ON/OFF control.

The two Transmit (TX) outputs are located at SMA connectors J16 and J19. The shared feedback (FB) inputs are located at SMA connectors J39 and J23. The RX input is located at SMA J2. The RX LO input source is located at J1. All of these SMA's are on the right edge of the GC6016 EVM as shown in Figure 3.

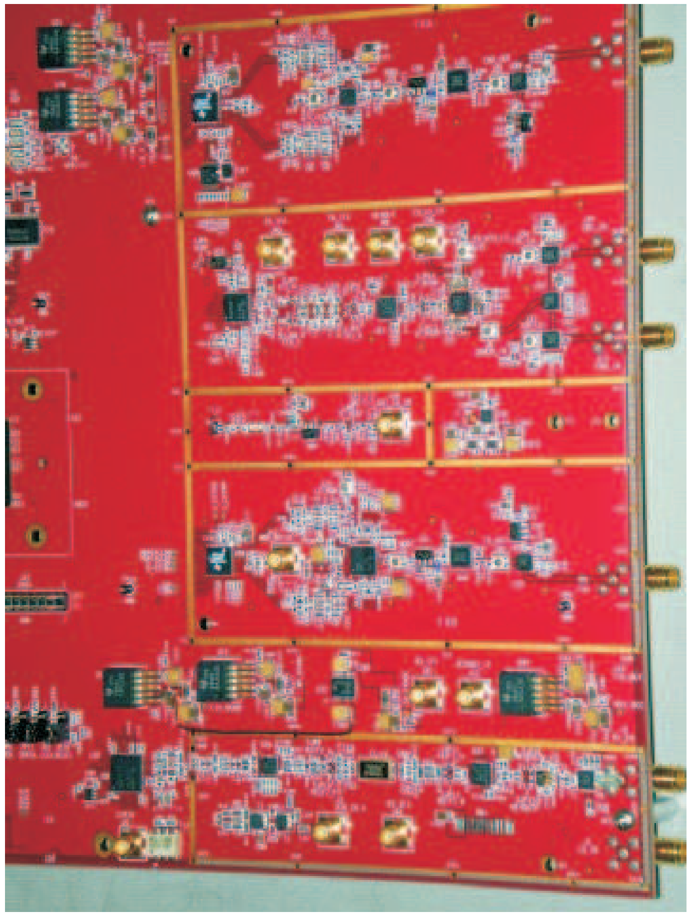

Figure 3. GC6016 EVM TX, FB and RX SMA's

Dip Switch settings on the GC6016 EVM board:

- SW1 – Currently not used.
- SW2 – DSP boot control. Switches S1, S3 and S4 should be "Closed". S2 should be "Open".
- SW9 – VCXO manual select. Switch S5 should be "ON". The other three are not used.

Jumper settings on the GC6016 EVM board:

- JP1 – 10 MHz reference power. Jumper installed between pins 1-2.
- JP2 – RX ADC SCLK select. Jumper installed between pins 2- 3 for SPI control.
- JP6 – RX ADC SEN select. Jumper installed between pins 2- 3 for SPI control.
- JP10 – RX ADC Reset select. Jumper installed between pins 2- 3 for SPI control.
- JP11 – RX ADC SDATA select. Jumper installed between pins 2- 3 for SPI control.
- JP12 – VCXO power enable. Jumper installed.

2.2 TSW3100EVM

The TSW3100EVM pattern generator is used to provide data for the baseband input port of the GC6016. The composite signal input patterns used by the GC6016 are generated by the TSW3100. The TSW3100 is programmed through an Ethernet cable via FTP commands issued by the GC6016GUI. The TSW3100 LVDS output header J74 connects to mating connector J54 on the bottom side of a GC6016 EVM. This interface provides LVDS level composite signal data, baseband clock, frame strobe and sync directly to the GC6016. This interface also provides the LVDS PLL clock to the TSW3100 from the clock generator located on the GC6016 EVM.

Power for the TSW3100 is made available from the GC6016 pattern generator power connector or an external 5VDC power supply thru J9. Switch SW1, located at the top left of the EVM, is the main power ON/OFF control. Auxiliary power is not used. Switch SW5, which enables this power, should always be “OFF”.

Dip Switch settings on the TSW3100 EVM board:

- SW2 – DIP0 and DIP1 set the lower byte of the board Ethernet IP address (192.168.1.123). All other switches should be in the “Open” position.
- SW3 – Spare.

Jumper settings on the GC6016 EVM board:

- J50 – Selects on board or external clock source. Jumper installed between pins 2-3 (on board clock).

3 SOFTWARE INSTALLATION

Install the MATLAB Runtime engine, version 2010a, if not already loaded on the host PC, using the program called “MCRInstaller.exe” on the provided CD. Follow the on-screen instructions.

Copy the GUI installer software called “GC5330_6016_GUI_setup.exe” on the provided CD to a local directory on the host PC.

Double click on this file to start the install. Follow the onscreen instructions to complete the installation. The software will create a new directory called “GC6016GUI. This directory will contain the GUI software along with default DSP code files, Baseband data files, RF configuration files, and GC6016 target configuration files. Additional GC6016 project files can be found on the customer provide CD. After the software is installed, copy these custom files to the GC6016GUI directory.

Inside the GC6016GUI directory on the host PC, double click on the executable program called “GC6016GUI.exe”. This will start the GC6016 EVM GUI.

The installation of the software, tools, libraries and drivers is now complete.

3.1 Ethernet Information

3.1.1 USB to Ethernet Adapter Installation

Connect the included USB to Ethernet adapter to a spare USB port of the host PC. The Windows Found New Hardware Wizard should open; if this is not the case make sure the cable is connected properly. Select “No, not this time” from the options available and then click “Next” to proceed with the installation.

Figure 4. Installation Wizard

Insert the USB to Ethernet Adapter installation CD, the installation should start automatically. If not, select the “Install the software automatically” option and click “Next”.

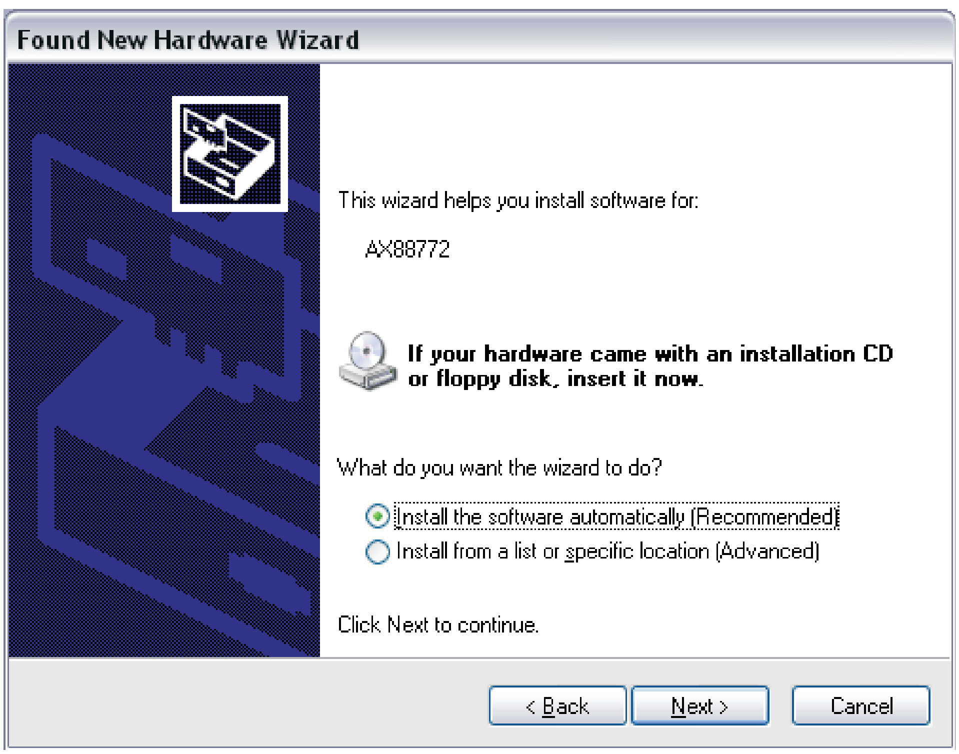

Figure 5. New Hardware Detected

Wait for the wizard to complete. Press “Finish” to complete the installation.

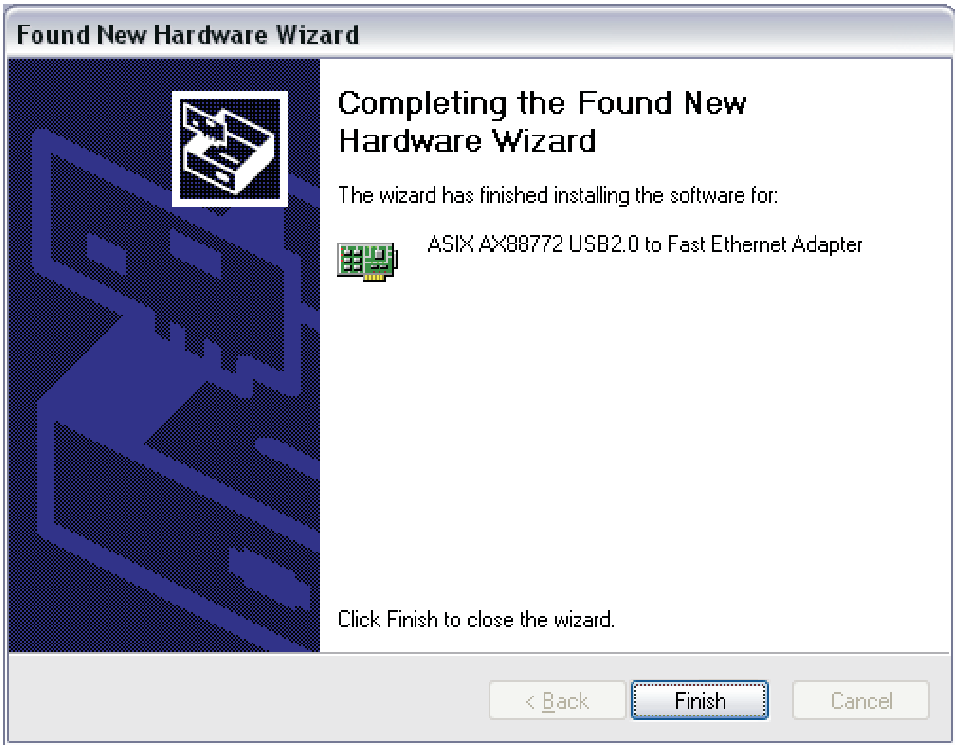

Figure 6. Installation Completed

Restart the computer if necessary.

To configure the USB to Ethernet network, from the Windows start menu, go to the Control Panel and select Network Connections. Double-click on the Local Area Connection whose device name is “ASIX AX88772 USB2.0 to Fast Ethernet Adapter”.

- Double-click on the “Internet Protocol (TCP/IP)” option from the General tab.

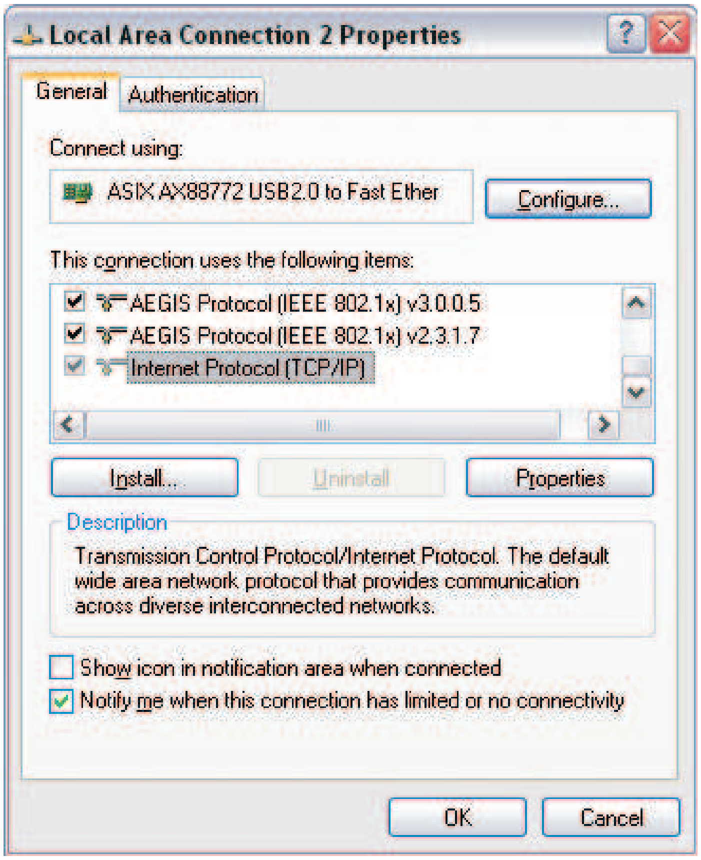

Figure 7. Internet Protocol

Select “Use the following IP address” and enter the values shown on the screen below. Press OK on both screens.

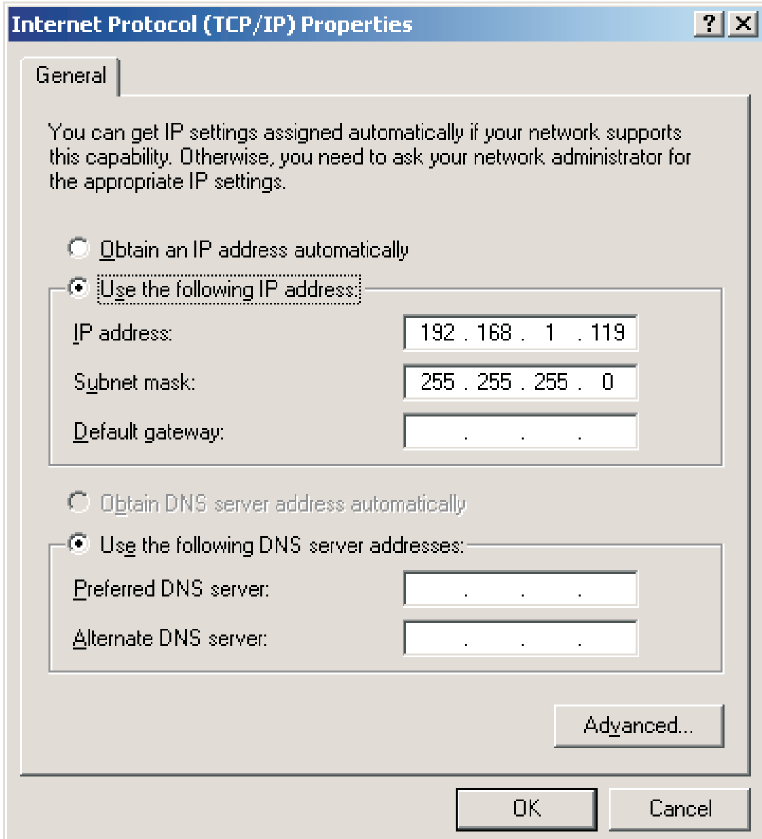

Figure 8. Assigning IP Address

Both the TSW3100 and GC6016 EVM's have a default IP address. If required, these addresses can be changed.

The GC6016EVM uses a static IP address (192.168.1.180) which is configurable from its uClinux shell.

If a new GC6016EVM address is required, do the following:

- Telnet into the GC6016EVM.
- Login as root without a password.
- Type "net_config" and follow the screen instruction to change IP and MAC.
- The new IP address and MAC are stored in EEPROM.
- Power cycle the board to activate the new address.

The TSW3100EVM uses a static IP address (192.168.1.123) which is configurable from SW2.

If a new TSW3100EVM address is required, do the following:

- Change DIP0 and/or DIP1 of SW2 to another value from their current setting. These will change the last digit of the address to either 0, 1, 2, or 3. The default value is "3".
- Power cycle the board to activate the new address.

4 POWER-UP SEQUENCE

The following power-up sequence will help insure the GC6016EVM system start-up is correct. Make sure the main power switch on both boards is in the “OFF” position. Plug in the GC6016 power source and Ethernet cable. If using the TSW3100 pattern generator, connect its Ethernet cable and connect the TSW3100 power input cable between J9 of the TSW3100 and J51 of the GC6016EVM.

Turn ON the GC6016EVM system power using switch SW4. Verify that the following **GC6016EVM** power and status LED’s are on:

Power LED’s

- D21 – 4.0 VDC main regulator.
- D22 – 5.5 VDC main regulator.
- D11 – 3.3 VDC power monitor supply.

Status LED’s

- D16 – CDC_Power_On
- D23 – On to indicate FPGA is in operational mode.
- D24 – Blinking to indicate FPGA is in operational mode.
- D8 – FPGA is configured.

Verify that the NIOS processor inside the FPGA is operational by checking that the Ethernet connector J9 LED is illuminated.

If using the TSW3100, turn on the TSW3100 EVM system power using switch SW1. Verify that the following TSW3100EVM power and status LED’s are on:

Power LED’s

- D3 – 2.5 VDC main regulator.
- D4 – 1.8 VDC main regulator.
- D5 – 1.2 VDC power monitor supply.
- D6 – 3.3 VDC power monitor supply.

Status LED’s

- D13 – Pattern Generator is in idle mode.
- D19 – DDR2 PLL is locked.
- D20 – NIOS PLL is locked.
- D25 – TSW3100 is configured for pattern generator operation.
- D11 – FPGA is configured.
- J13 – Ethernet connector LED’s.

5 GC6016EVM Graphical User Interface (GUI) Software

5.1 Starting the GUI software

If not done already, double click on GC6016EVMGUI.exe in the directory C:\GC6016GUI to start the GUI.

The program usually takes a few seconds to start. Both a DOS window and a GUI window will appear. The DOS window will display useful text during operation of the GUI. To enable the GUI, the user must click on the button labeled “Connect” in the upper left hand corner. If the communication between the GUI and GC6016EVM is successful, the EVM IP address window will turn green and the connection status window will now display “Disconnect” as shown in Figure 9.

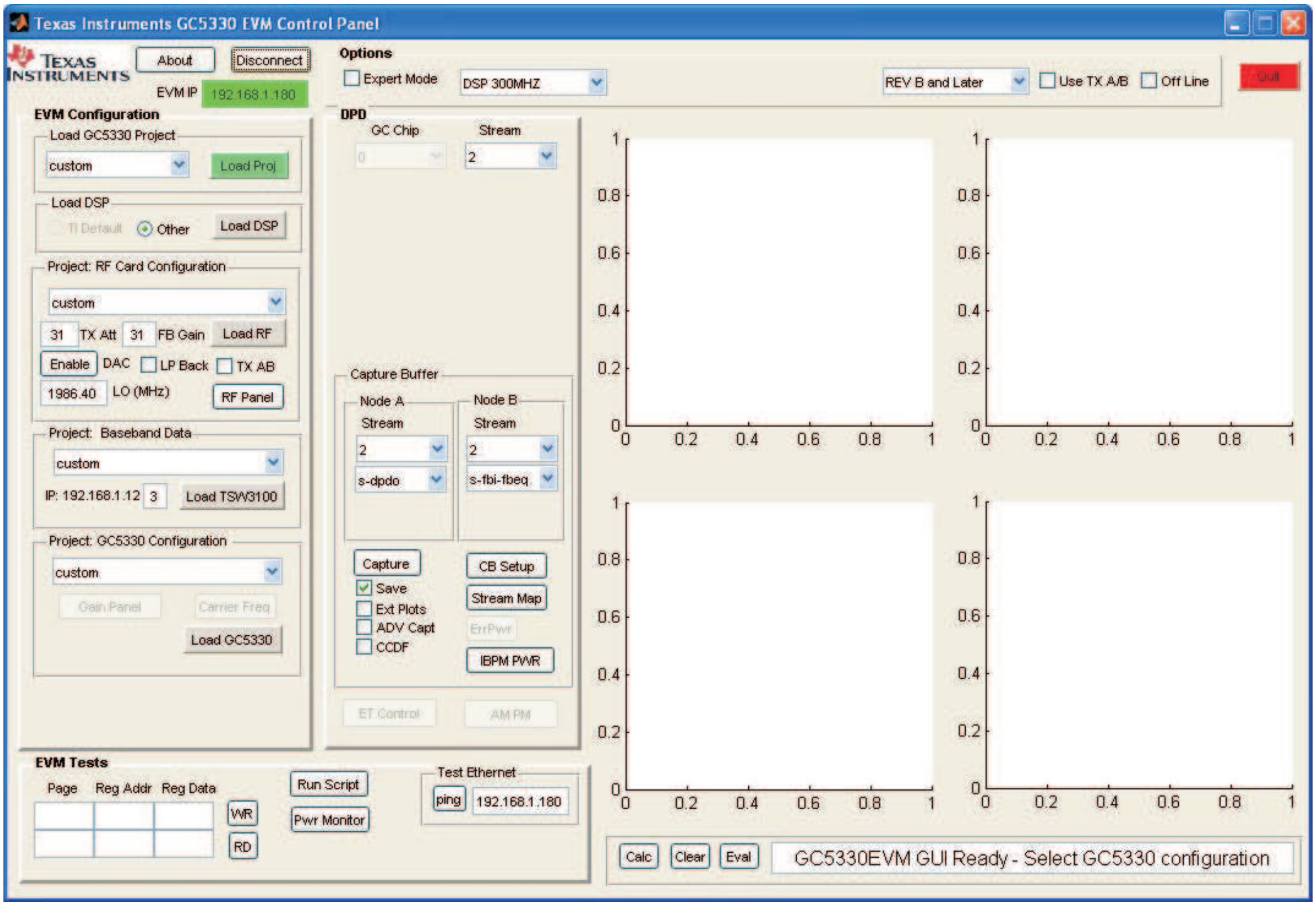

Figure 9. GC6016 Main GUI Panel

To disconnect, click this button again. This will disconnect the GUI and the status window will display "Connect". If there is a problem with this connection, an error message will appear as shown in Figure 11.

Figure 10. GC6016 GUI Successfully Connected

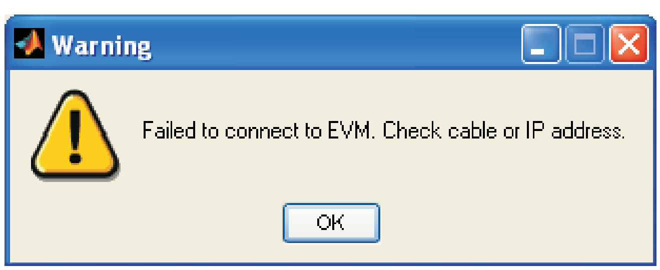

Figure 11. GUI Communication Error

If this message appears, make sure the Ethernet cable is installed, and the LED's under the Ethernet connector are illuminated.

5.1.1 Load the Project

The next step is to load the GC6016 project. Go to the EVM Configuration section of the GUI and click on the button labeled "Load Proj" (Figure 12).

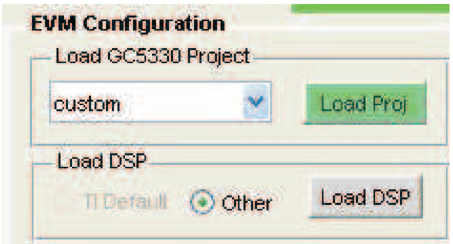

Figure 12. EVM Configuration

A new window will open. Navigate to the directory called "UMTS_repeater_proj". Click on the project file called "gc6016_proj_umts_repeater.proj". The software will first load the DSP code. A new window opens. Select the DSP image called "dpd-1p0p0p0RevD.bin, where XpXpXpX is the runtime version.

The image will now be loaded into the DSP memory.

After the code has loaded successfully, check for the following status LED's:

D1 - Illuminated indicating DSP has booted up properly.

D2 - Blinking, indicating that the DSP is running.

During operation of the GUI, if the following error message appears as shown in Figure 13, and LED D2 stops blinking, the DSP has encountered a fatal error and will need to be reloaded.

Figure 13. EVM Configuration

Anytime an Application Program Interface (API) command is issued from the GUI, LED D3 will alternate states, indicating that the command has been received by the DSP.

Next, a stream setting window panel will now open (Figure 14). Select the total number of streams based on the GC6016 hardware configuration. For this example, select "1".

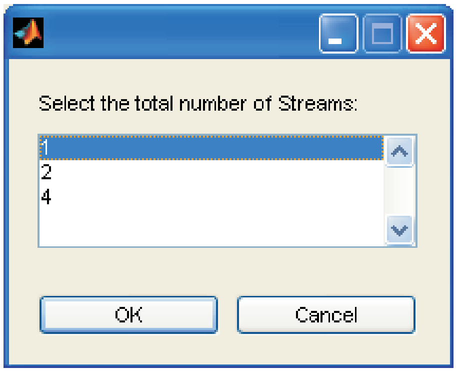

Figure 14. Stream Selection

When programming is complete, the status window located in the bottom of the GUI will display the following message:

GC5330 is programmed. sp_cfg is finished.

At this point the devices in the analog section, along with the clock generator, have all been programmed. The following status LED's should now be illuminated:

- D9 – CDC72010 clock generator PLL is locked to the on-board 10MHz reference source.
- D7 – TRF3720 is locked to a 30.72MHz reference source provided by the clock generator.

5.1.2 Configuring the GC6016EVM RF Section

The Project RF Card Configuration box of the GUI allows the user to program all of the devices in the analog portion of the board. The configuration box is shown in Figure 15.

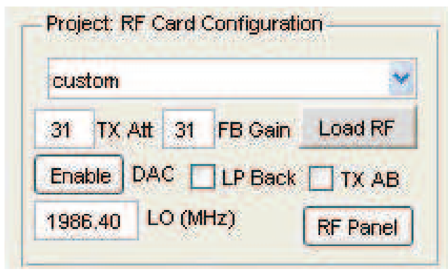

Figure 15. RF Card Configuration

At this level, the user can set the Tx attenuation for both transmit channels and the feedback gain. The GUI defaults to maximum Tx attenuation and minimum Rx gain. The LP Back option is not used with this version of EVM.

Enable the DAC3283 by clicking on the word "Enable" inside the Project RF Card Configuration. To disable the DAC, simply click on this button again. The GUI default value is with the DAC's disabled.

The GC6016EVM uses the TRF3720 as the default LO source for both the TX and RX paths. To change the default value of the LO frequency, enter the desired value (in MHz) in the LO (MHz) box. For this example, set the LO to 1750.

NOTE: The frequency must be in the range the evm is currently configured for. This can vary from board to board. Check for any label indicating the LO frequency setting.

For this example, enter **1750**. The software will load the closet possible frequency based on the reference frequency and PLL divider settings. See the TRF3720 data sheet for more details.

Verify that LED D7 (Near the TRF3720, bottom right side of board) is still illuminated. If this LED is now off, verify that the LO frequency that was entered is a valid value with respect to the device data sheet.

6 C6016EVM Repeater Demo

Load the repeater project as described in section 5. This will enable a 4 carrier UMTS repeater application.

Connect TXC_OUT (SMA J16) to a spectrum analyzer.

Provide a sinewave source set to an output level of -15dBm to MCX connector J3. Set this sinewave source to sweep from 35MHz to 65MHz. This will place IF tones in the repeater band of interest from 41.2 to 61.2M. The RX If frequency is located at 51.2M. Due to the frequency plan chosen, the DDC are operating at 25.6Msps and can only handle 4 carriers of UMTS. Other configurations can be designed to handle more BW and channels.

The repeater application samples the input signal located at IF of 51.2M. Each carrier is then digitally mixed down to 0Hz and then filtered by the DDC channel. The data is then passed to the DUC channel where each carrier is filtered and then mixed back up to an arbitrary frequency. Each of the individual carriers can be filtered out (disabled) or moved to another frequency offset by using different mixer settings on the DUC NCO mixer. This allows complete control on which carriers are passed through the repeater and also allows frequency translation if needed.

The 4 carrier output at RF shall now be as shown in Figure 16.

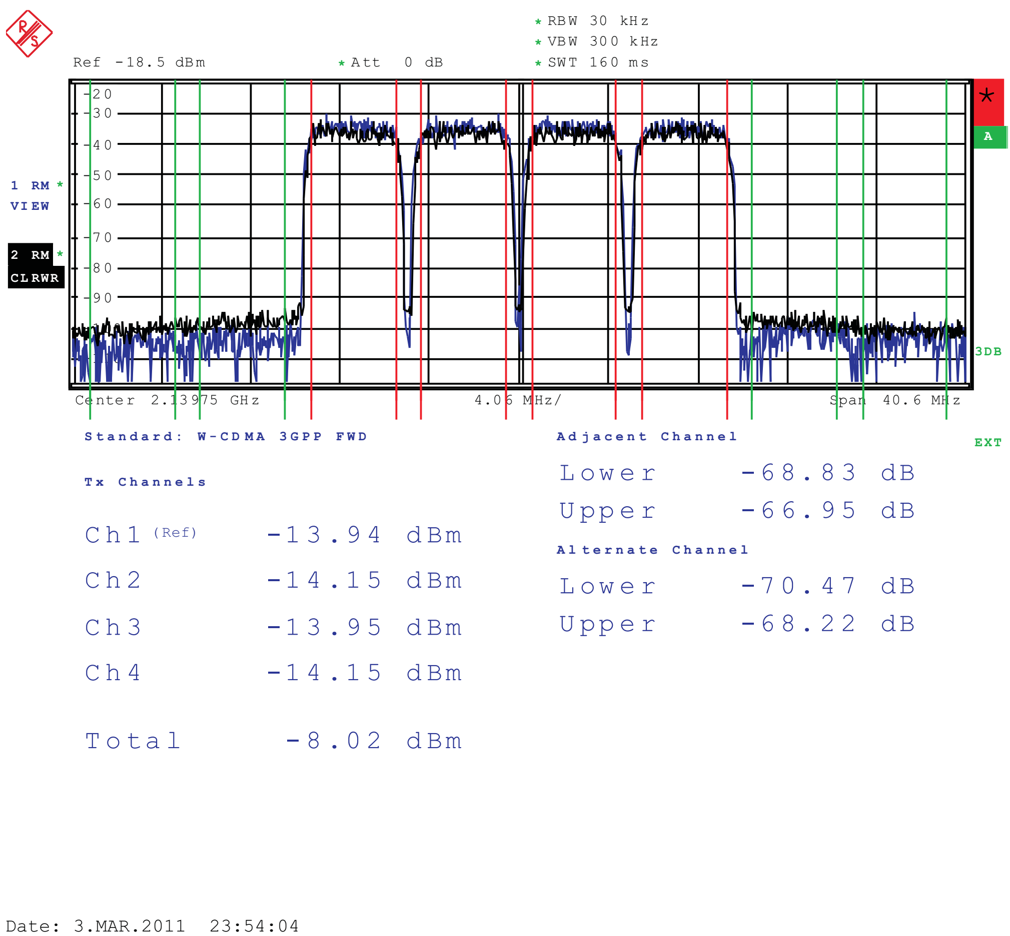

Figure 16. Carrier UMTS RF Output

If the user has successfully completed the preceding steps, the system should be operating in a repeater type application. Other test configurations may require special configuration files and the user is encouraged to request these from Texas Instruments through their local support group.

7 Other GC6016GUI Functions (Optional)

7.1 Analog Control Panel

Clicking on the “RF Panel” button will open the Analog Control Panel (Figure 17), which allows control over the entire analog section on the EVM as well as the clock generator.

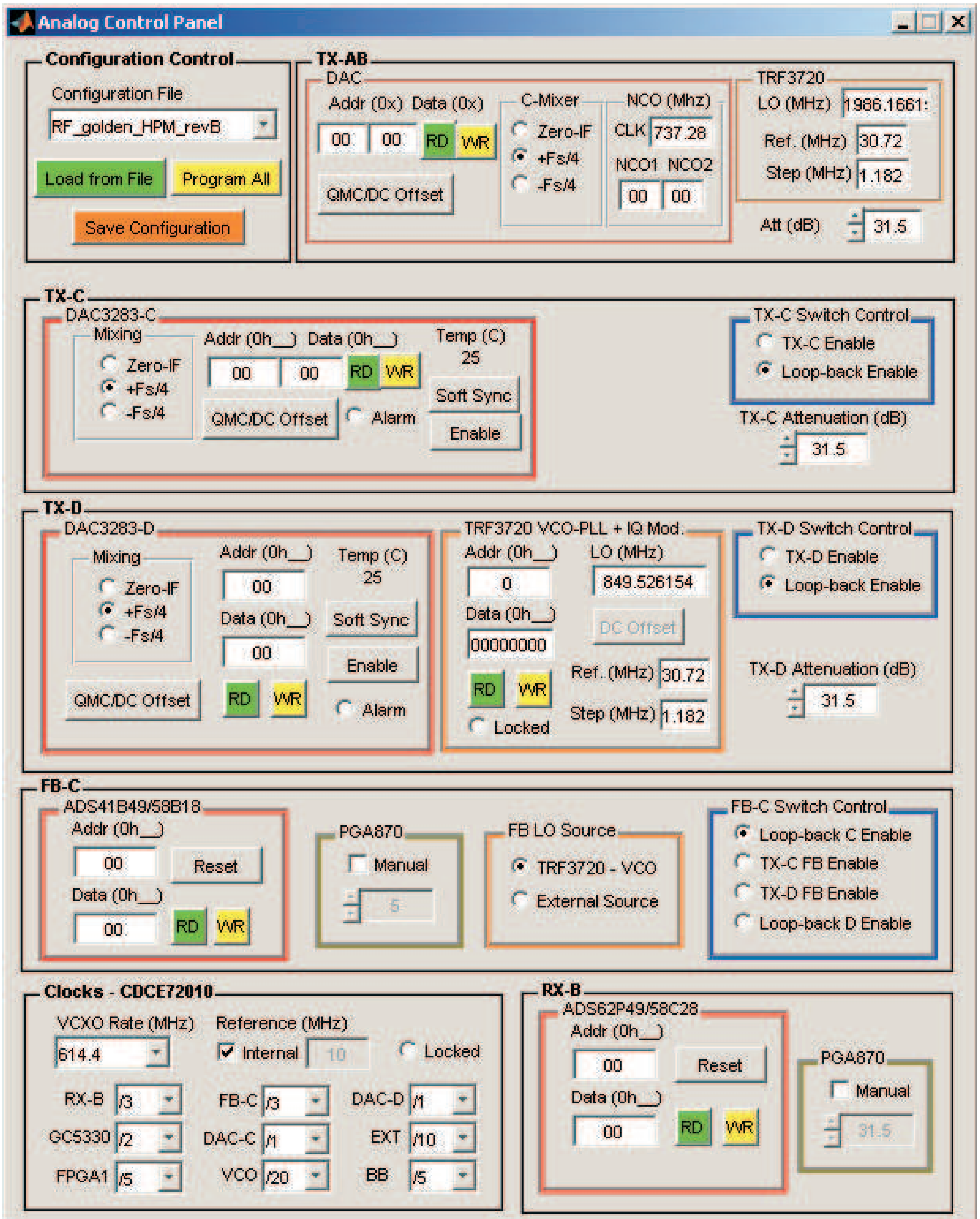

Figure 17. Analog Control Panel

The RF analog control panel is divided into sections, with each section representing a programmable device on the EVM.

For this example, the user should not open this panel as all required settings can be loaded from the top level GUI.

To load the RF section of the GC6016EVM using the Analog Control Panel, do the following steps:

- In the Configuration Control box (Figure 18) located in the main GUI window, click on the “Load from File” button inside the Configuration Control box.
- A “Select RF config file” pop up widow opens. Browse to the desired file and double click on it.
- The Analog Control Panel will show the new values to be loaded into the hardware.
- Click on the “Program All” button inside the Configuration Control box. This will now write the new values to the hardware.
- To save a custom file, after all new settings have been made to the Analog Control panel, click on the “Save Configuration” button. A pop up widow will open. Create a new file name, then browse to the desired directory where the file is to be saved.

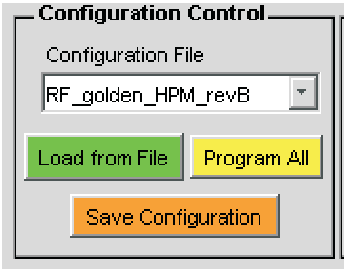

Figure 18. Configuration Control Box

7.1.1 Programming the DAC3283’s

The Analog Control Panel contains two DAC3283 control boxes (Figure 19).

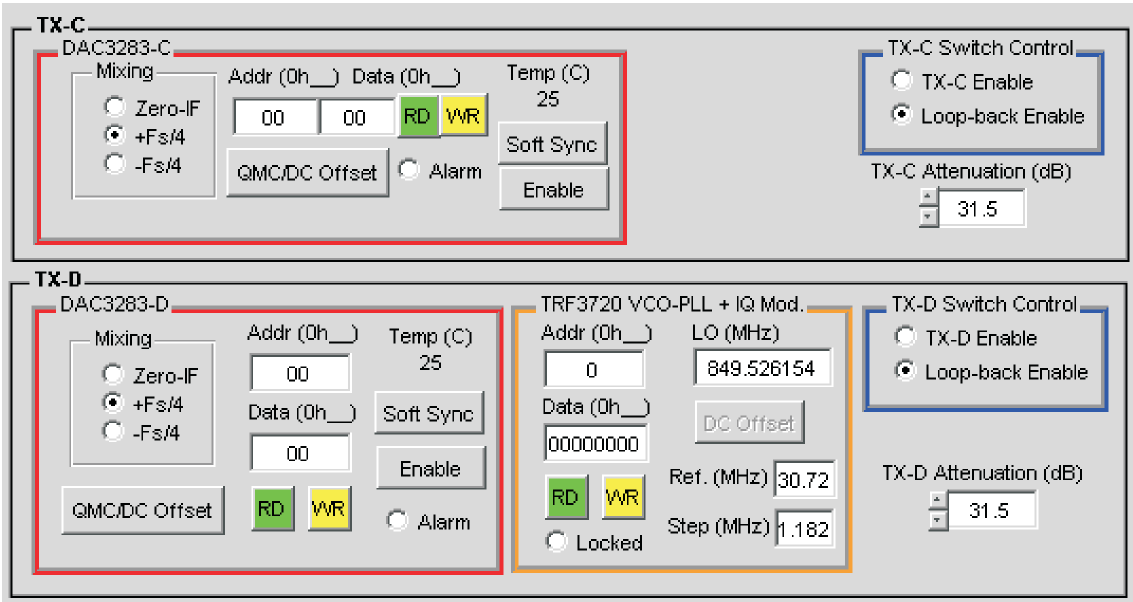

Figure 19. TXC and TXD Control boxes

To enable the two DAC3283's, first go to the DAC3282-C control box and click on the "Enable" button. This will enable the TXC DAC. The button will now change to read "Disable". Repeat this in the DAC3283-D control box to enable the TXD DAC. Clicking on either button again will disable the selected DAC output. These boxes also allow the user to set the Tx attenuator for both paths. The TX-C and TX-D Switch Control boxes are not used with this EVM version.

The control boxes allow the user to write and read from both DAC's. Enter the valid address and data values in hex in the Addr and Data sections then click on "WR" to perform a write, or "RD" to perform a read.

Clicking on the "Soft Sync" will perform a software sync to the DAC.

The "Mixing" section will set the DAC coarse mixer to the value selected.

Click on the "QMC/DC Offset" button to open the offset control buttons. A new pop up window will open (Figure 20).

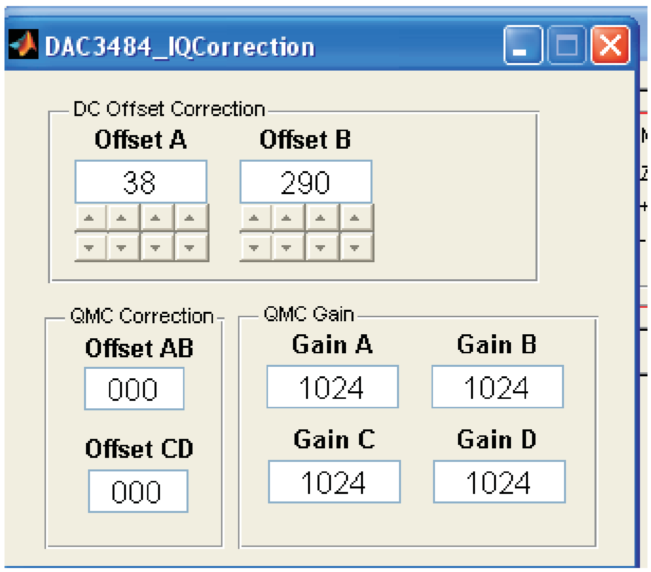

Figure 20. QMC/DC Correction Control

Adjust the Offset A, and Offset B to minimize the LO leakage. Start with the Offset A hundreds, up or down for minimum value, then Offset B hundreds up or down for minimum value. Work through the 10s and units values to drive the LO leakage to the noise floor. Save the final value for future initial values.

Adjust the QMC Gain A or QMC Gain B from 1024 to get a minimum sideband value. The adjustment is normally done by adjusting QMC Gain A for a minimum, with QMC Gain B at 1024. After this, re-adjust QMC Gain B for minimum. After the minimum QMC Image is adjusted using the QMC Gain, the QMC AB Offset can be used for the final step. (Record the QMC Gain A, QMC Gain B, Offset AB for later initial values).

7.1.2 Programming the Rx ADC

The Analog Control Panel contains a RX-B control box (Figure 21). This box allows the user to write and read to the Rx ADC. The VGA device in this path is also controlled by this box. To adjust attenuator of the PGA870, click on the "Manual" button then enter a value from 0 to 31.5 or use the drop up/down arrow.

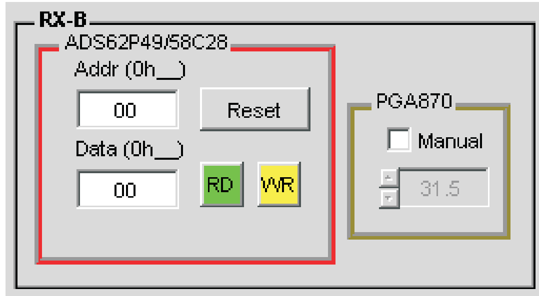

Figure 21. Analog Control Panel

7.1.3 Programming the FB ADC (RX path #2)

The Analog Control Panel contains a Feedback control box (Figure 22). This box allows the user to write and read to the feedback ADC. The VGA device in this path is also controlled by this box. To adjust attenuator of the PGA870, click on the “Manual” button then enter a value from 0 to 31.5 or use the drop up/down arrow. The feedback mixer LO source can provided from the on-board TRF3720 (default) or an external source through connector J36. Set the FB LO Source to “External Source” when using this option and use a power level of ~ 0dBm for the external source.

The FB-C Switch Control determines which FB data path is routed to this path. The board is setup for shared feedback and only one of the two feedback paths can be used at a time.

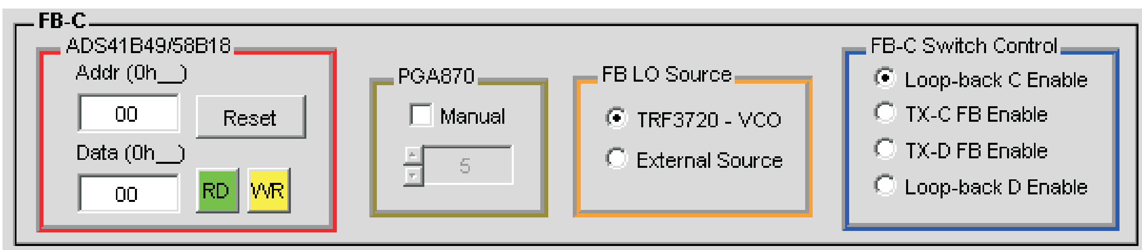

Figure 22. Analog Control Panel

7.1.4 Programming the Clock Generator

The Analog Control Panel contains a clock generator control box as shown in Figure 23.

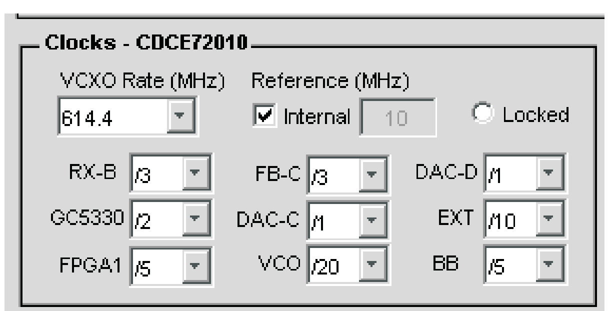

Figure 23. Analog Control Panel

This box is used to set the divide ratio for the following devices:

Table 1.

RX-B Rx Path ADC input clock	FB-C Feedback Path ADC input clock	DAC-D clock	DAC input	Tx-D Path
GC5330 GC6016 input clock	DAC-C Tx-C Path	DAC input clock	EXT	SMA J28 & J15 output clock
FPGA1 FPGA input clock	VCO	VCXO reference clock	BB	TSW3100 input clock

The setting in the VCXO Rate box must match the value of the on-board VCXO (Y4). The board provides an option to use an external VCXO source. To use this option, click on the drop down arrow located in this box, and select “EXT”.

7.1.5 Programming the LO source

The GC6016EVM uses the TRF3720 as the default LO source for both the TX and RX paths. To change the default value of the LO frequency, go to the “TRF3720 VCO-PLL + IQ Mod” control box (Figure 22) inside the Analog Control Panel and do the following:

Click on the LO (MHz) frequency box and enter the desired LO frequency in MHZ.

Verify that LED D7 (Near the TRF3720, bottom right side of board) is still illuminated. If this LED is now off, verify that the LO frequency that was entered is a valid value with respect to the device data sheet. The control box shall now look as shown in Figure 24.

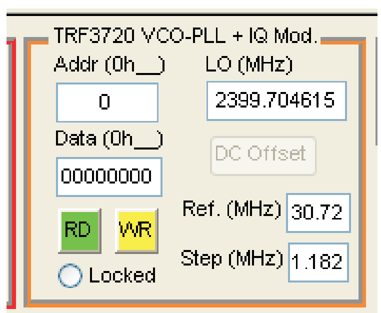

Figure 24. TRF3720 Control Box

7.2 Loading the TSW3100EVM Pattern Generator (If used)

Go back to the main GUI window. To load the input test data, go to the Baseband Data control box as shown in Figure 25.

Click on the “Load TSW3100” button. A “Select TSW3100 Mat file” pop up window opens. Select the desired file to be loaded.

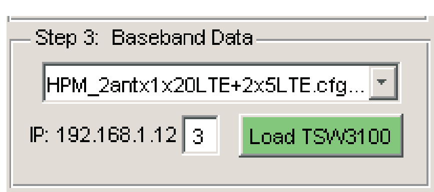

Figure 25. Baseband Data Control Box

If another file is to be used, just navigate to the desired location to find the data file to be used, which will end with “_tsw”.

Click “Open”. The test data will now be loaded into the TSW3100EVM. A window will open showing a plot of the test pattern data. Click on the “X” to close it. After about 30 seconds, the main GUI message window will display the following: “TSW3100 Loading Complete!”

The following status LED’s on the TSW3100EVM shall now be illuminated:

- D13 – Pattern Generator is in idle mode.
- D14 – Pattern Generator Clock present.
- D15 – Pattern Generator is running.
- D18 – LVDS PLL is locked.
- D19 – DDR2 PLL is locked.
- D20 – NIOS PLL is locked.
- D24 – LVDS mode.
- D25 – TSW3100 is configured for pattern generator operation.

The signal is now flowing from the TSW3100 through the GC6016 and through the TX section of the EVM.

8 GC6016EVM Power Down Sequence

If used, turn of TSW3100EVM power using SW1.

Turn off GC6016EVM power using SW4.

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 15 VDC to 22 VDC and the output voltage range of 3.3 VDC to 5 VDC.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 85°C. The EVM is designed to operate properly with certain components above 85°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.