# TRF3710EVM

This is the user's guide for the TRF3710 EVM. The TRF3710 is a receiver direct downconvert quadrature demodulator that includes programmable baseband filters, adjustable dc offset correction, and buffer amplifiers to directly drive ADCs. The device is suited for operation with CDMA and WCDMA modulation as well as with WiMAX™ signals.

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# 1 Introduction

## 1.1 EVM Frequency Configuration Options

The TRF3710 device is inherently broadband; however, the RF input and LO input require differential input which is generally achieved with the use of an RF balun. The EVM can be configured with a different balun to facilitate operation in the desired band. Inspect the board at R101, R102, and R103 to determine which balun is populated on the board.

## 1.2 System Block Diagram

The basic radio system block diagram in Figure 1 demonstrates where the TRF3710 fits in the overall receiver. The **bold** box highlights the TRF3710 device.

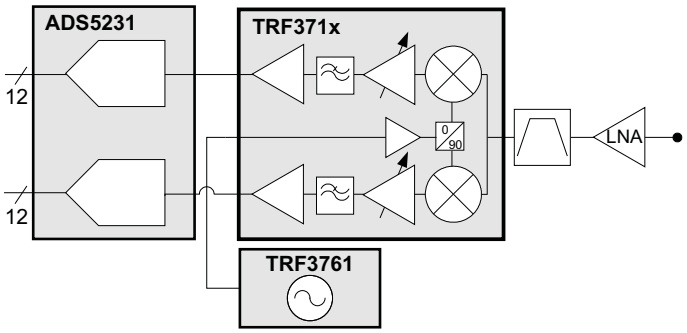



**Figure 1. System Block Diagram**

# 2 Software Control

## 2.1 Installation Instructions

- Open folder named TRF3710_GUI_Installer_Verxpx.fdr (xpx represents the latest version)
- Run Setup.exe
- Follow the on-screen instructions
- Once installed, launch by clicking on the TRF3710_GUI program
- When plugging in the USB cable for the first time, the user is prompted to install the USB drivers.
  - When a pop-up screen opens, select *Continue Downloading*.
  - Follow the on screen instructions to install the USB drivers
  - If needed, the user can access the drivers directly in the install directory

## 2.2 Software Operation

The front panel control is shown in Figure 2. The registers are set in their default configuration. The functionality of the control registers is described below.

### 2.2.1 Register 0

- BB Gain: Sets the gain of the PGA (Programmable Gain Amplifiers); range is 0 to 24.
- BBFreq Ctrl: Sets the bandwidth of the BB filters. Setting 7 is generally suited for WCDMA applications. Setting 90 is generally suited for CDMA applications. See data sheet for comprehensive curves.
- PWD_Mix/LO/Buf1/Filt/Buf2: Enables SW controlled power down of respective stages inside device.
- DC Offset Cal: Selects source for common mode voltage adjustment; Digital setting allows internal registers to fulfill this function.
- Cal Reset: Resets the internally stored dc offset values for I and Q back to 128.
- Readback: If On, it allows the Readback to be enabled.
- Readback En: When On, the internal I and Q DAC DC offset settings are readback (only in *Auto Cal* = *Auto* mode)

### 2.2.2 Register 1

- Auto Cal *Manual* mode allows the DC offset DACs to be user configurable; *Auto* mode uses the internally stored values.
- Auto Cal En: When toggled, an Auto Cal is initiated. Note, *Auto Cal* must be in *Auto* mode.
- I/Q DAC: Shows the setting of the dc offset I and Q DAC; range is 0 to 255.
- I/Q Det: Selects the resolution of the I and Q DAC.
- Cal Clk Sel: Toggle between using an externally supplied SPI clock or internal oscillator clock.
- Osc. Freq. Selects the oscillator frequency for the internal clock.
- Clk Div: Sets the clock divider if the control clocks need to be slowed down.

### 2.2.3 Register 2

- Mxr I/QOffA/B: Selects the mixer gain for the differential BB paths. Typically, these registers need no modification.

### 2.2.4 Misc Settings

- Reset USB: Toggle this button if the USB port is not responding. This generates a new USB handle address.
- Write Regs: The registers are all written after each modification in the front panel; however, the user can toggle this button to ensure all the registers are loaded as seen on the screen.
- Show Bytes: Shows the 32-bit word that is sent for each register.
- Show Par Port: Shows the USB pin-out selection
- Stop: Stops the program

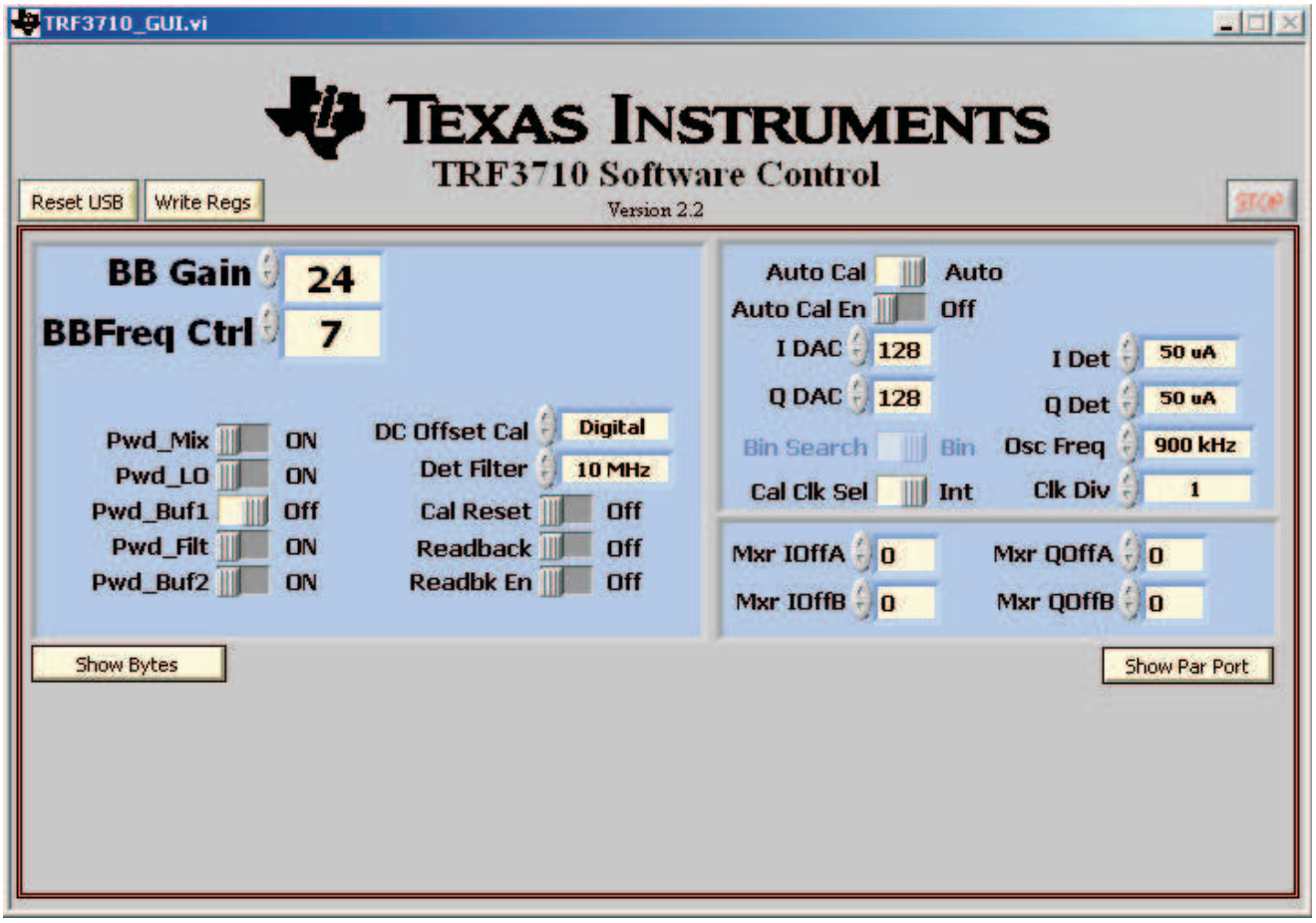



**Figure 2. TRF3710 GUI Front Panel**

## 3 EVM Test Configuration

### *3.1 Test Block Diagram*

The test set-up for general testing of the TRF3710 is shown in Figure 3.

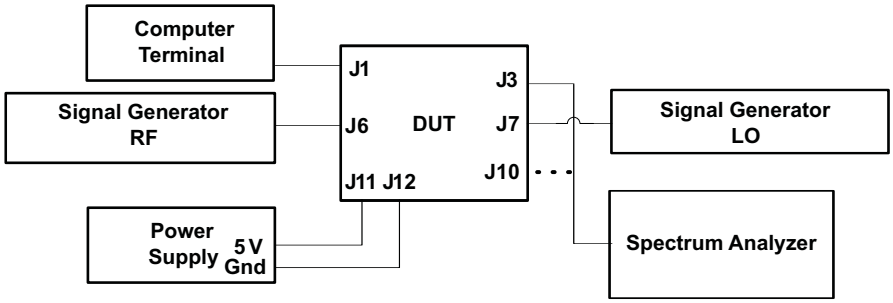



**Figure 3. Test Set-up Block Diagram**

### 3.2 Test Equipment

The following equipment is required for completing RF Testing:

- Power Supply with Current Readout — Agilent E3631 or Equivalent
- Signal Generator for input signal — Agilent E4438C or Equivalent
- Signal Generator for LO signal — Agilent E4438C or Equivalent
- Spectrum Analyzer — Agilent E4440A or Equivalent
- Programming Computer

### 3.3 Calibration

The RF cables should be good quality RF cables due to the high frequency signals.

- Measure the insertion loss of the RF input cable and use this value to compensate for the desired input power. Note, there is approximately 1 dB of insertion loss for the input traces and balun on the PCB board.
- Measure the insertion loss of the LO input cable and use this value to compensate for the desired LO power. Note, there is approximately 1 dB of insertion loss for the input traces and balun on the PCB board.
- BB Loss factor: If using the on-board transformers to interface with 50-Ω test equipment, then there is approximately 12.3 dB of loss associated with the voltage transformation.

## 4 Basic Test Procedure

This section outlines the basic test procedure for testing the EVM. This section is divided into three test sections: DC and Programmability, Basic CW RF, and Advanced RF Testing. The first section requires only power supply with current readout and a computer for programmability. The second section requires basic RF test equipment and basic technical know-how. The third section is for reference and requires specialized equipment and set-up. Only sections one and two are required to ensure basic functionality.

### 4.1 Initial Inspection

Determine which balun device is placed on the board by inspecting which jumper resistor is installed at the R101, R102, and R103 locations. This information determines the proper RF frequencies for which the board is set.

**Table 1. Frequency Allocations**

| Band | Frequency Band | F_LO | F_RF |
|---|---|---|---|
| 1G9 | 1800–2000 MHz | 1.9 GHz | 1.9 GHz |
| 2G4 | 2.3–2.7 GHz | 2.4 GHz | 2.4 GHz |
| 3G5 | 3.5–3.8 GHz | 3.5 GHz | 3.5 GHz |

### 4.2 DC Test

- Connect 5 V to J11; connect ground to J12.
- Engage power supplies.
- Verify current is 365 ±25 mA

## 4.3 Basic RF Test

- Inject LO signal at J7 at F_LO frequency at 0 dBm. Compensate for RF cable losses, including about 1 dB for input balun and transmission line losses.
- Verify USB cable is connected.
- Launch TRF3710EVM_GUI. Select *Write Regs* to verify programming to the board.
- Select *CLK Div* to 256.
- Toggle *Auto Cal En* on the GUI. Verify that no RF signal in present.
- Monitor the dc voltage are TP2 (IA) and TP7 (IB) and between TP10 (QA) and TP12 (QB) and verify that the dc offset voltage is 0 ± 15 mV.
- Inject RF signal at J6 at F_RF + 300 kHz at –40 dBm. Compensate for cable loss including about 1 dB for input transmission line losses and balun.
- Connect Spectrum Analyzer at J3 (I).
- Set Spectrum analyzer center frequency to 300 kHz; set span to 500 kHz; set reference level to 0 dBm; set analyzer to dc coupling.
- Measure signal at 300 kHz and verify signal at –9.3 dBm ±2 dB. Note, there is no compensation for transformer loss.
- Adjust BB Gain to 20; verify signal reduces 4 dB ±1 dB.
- Switch output cable to J10 (Q) and repeat the procedure above.

## 4.4 Advanced RF Test

The EVM is equipped with the differential outputs going to a 16:1 transformer for interfacing with 50-Ω test equipment. This configuration is suitable for completing basic RF test evaluation of the device; however, the inherent high pass nature of a transformer will limit performance at frequencies close to dc. As a result, this configuration is not suitable for analyzing true modulated signals. As an alternative, the ports at J2, J4, J8, J13 offer direct access to the driver amp outputs for the differential I and Q signals respectively. Note, these ports can not drive 50-Ω test equipment directly. For best performance, the connections to the transformer should be severed by removing capacitors C5, C8, C33, C35.

These ports can drive into an ADC directly or into a high impedance differential amplifier. These ports are dc coupled to provide the proper common mode offset voltage to the ADC. The typical EVM performance of the device using a modulated 3.5 MHz wide WiMAX signal captured by the ADC is shown in Figure 4.

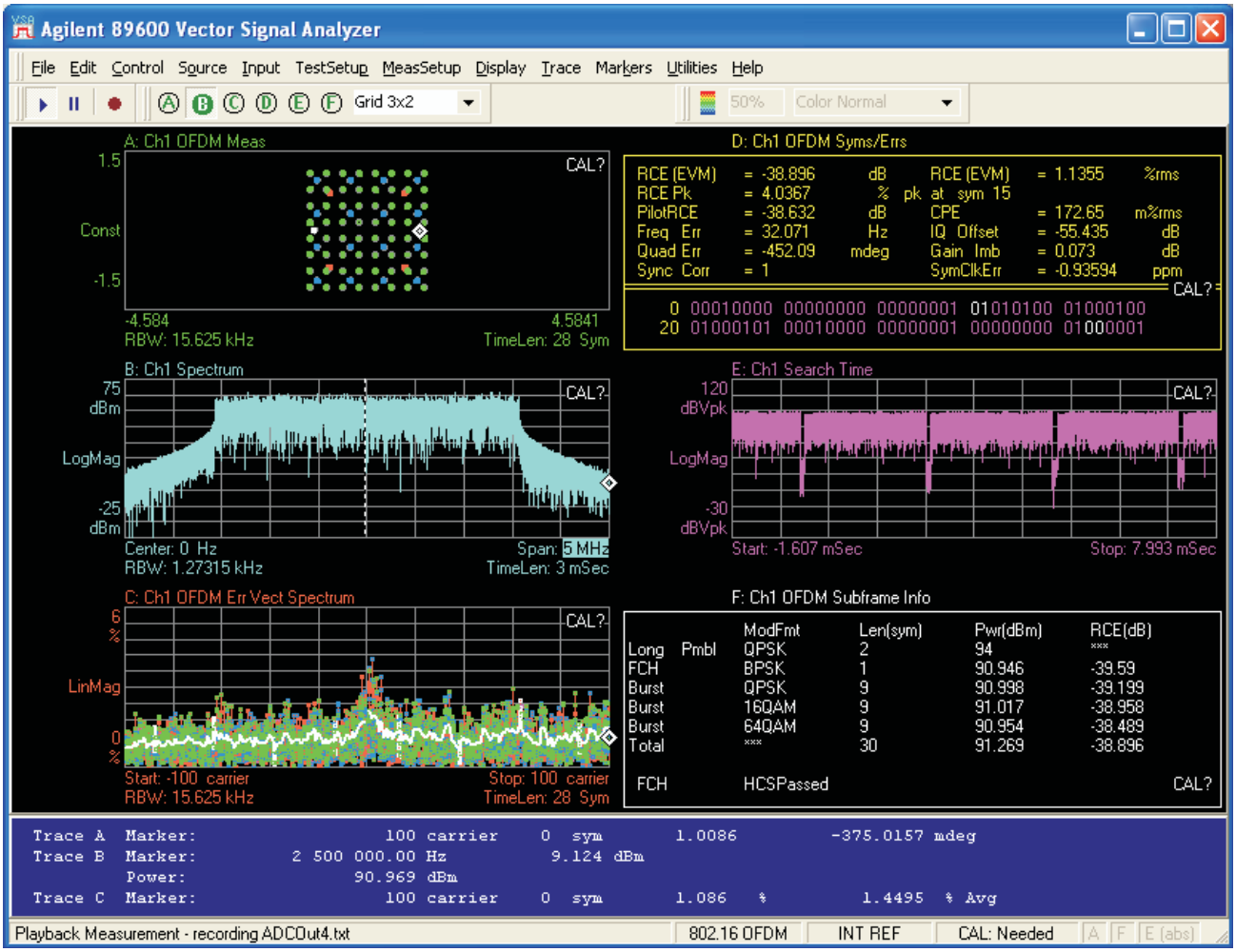



**Figure 4. TRF371x With ADS5232 WiMAX 3.5 MHz Signal EVM Performance**

# 5 Optional Configurations

## 5.1 Mixer Outputs

The mixer outputs can be fed directly to the transformers and to ports J5 and J9. This can be useful for measuring the RF performance of the mixer itself without the PGAs or filters. This feature is implemented by toggling the *PWD_Buf1* to *ON*.

## 5.2 Common Mode Voltage

The common mode voltage is set to a static 1.5 V by a resistor divider network. Note, the common mode voltage are shifted if the input supply is not 5 V. Alternatively, this is controlled via a resistive pot by:

- Removing R11, R12, R17, R18.
- Placing 0 Ω jumper at: R10 and R20.
- Adjusting pots at R13 and R19.

When cascading the device with an ADC it may be desirable to feed the common mode voltage from the ADC to the device. This can be accomplished by:

- Removing shunt at W1 and W3.
- Placing ADC common mode voltage at TP8 and TP9.

## 5.3 DC Offset Control

The easiest way to manage the dc offset control is to use the *Auto Cal* function. This is accomplished by selecting *Auto Cal* to *Auto* and toggling the *Auto Cal En* switch. Monitor the dc offset voltage at TP2 (IA) and TP7 (IB) and between TP10 (QA) and TP12 (QB) and verify that the procedure worked sufficiently. The user may also select *Readback* to *On* and *Readback En* to *On* and find the values of the I and Q DAC registers on the GUI.

If the RF input signal is disengaged during the auto-cal procedure, then the detection filter bandwidth can remain at 10 MHz and the clock divider can remain at 1. The clock divider can be changed to 256 to provide sufficient averaging for the detector to yield superior results. If the RF input signal is applied, reduce the detection filter bandwidth to 1 kHz and increase the clock divider to 1024 to increase the detector averaging.

Alternatively, this function can be accomplished by manually programming the I and Q DAC registers. Toggle *Auto Cal* to *Manual*. Adjust the I and Q DAC registers on the GUI directly. Monitor the dc offset values at TP2 (IA) and TP7 (IB) and between TP10 (QA) and TP12 (QB) until the dc offset is as close to 0 mV as possible.

A third option is to adjust the common mode through an analog voltage. The EVM is equipped with two pots at R6 and R24 that control this voltage. On the GUI, change the *DC Offset Cal* to *Analog* and adjust the pots at R6 and R24 while monitoring test points at TP2, TP7, TP10, TP12 to get dc offset near 0 mV.

## 5.4 Analog Gain Control

The device is equipped with three bits to control the PGA gain to facilitate an analog gain control loop that does not require the use of SPI. To use this function, set the *BBGain* on the GUI to 17. Then adjust for the last 7 states through the binary combination of bits B0, B1, B2 that can be toggled at DIP switch SW1.

## 5.5 Analog Device Disable

The device can be disabled by removing jumper at W2.

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## EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 5 V 0.5 V and the output voltage range of 5 V 0.5 V.

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.

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