TSW500x

This user's guide provides information for operating the TSW5003/TSW5002 Reference Design. The reference board is a RF/Analog transceiver operating in TDD mode designed to merge with a digital baseband processing card. For stand alone evaluation, the reference board can be merged with the interface board to facilitate programming the board and piping RF signals into and out to RF test equipment.

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1.1 Block Diagram

The basic block diagram of the reference design is shown in Figure 1.

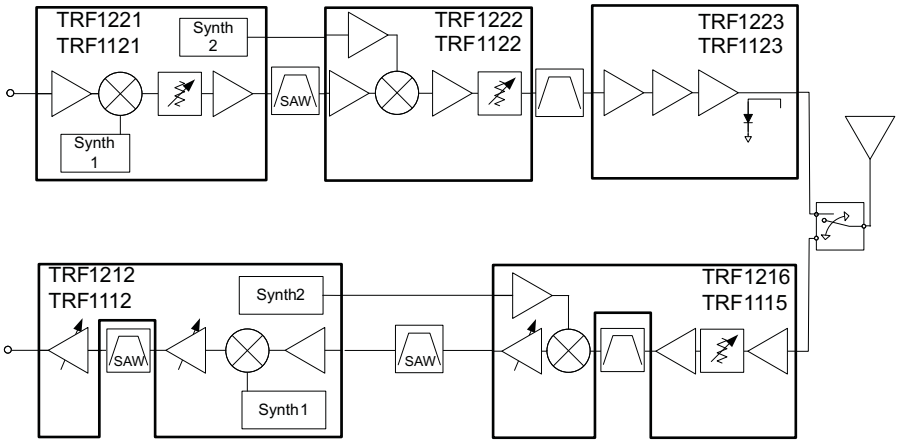

Figure 1. RF Transceiver Block Diagram

1.2 Key TI Components

1.2.1 TRF1X21

The TRF1221 (TRF1121) is a TX IF upconverter that includes two internal synthesizers: one lower frequency synthesizer for the internal mixer and one higher frequency synthesizer that is piped externally for the RF upconverter. The device also includes a 5-bit 1-dB digital attenuator as well as gain stages for the low and intermediate IF frequencies.

1.2.2 TRF1X22

The TRF1222 (TRF1122) is a TX RF upconverter that accepts its LO frequency from the TRF1221. It also includes IF and RF gain stages, and the option for external image reject filtering.

1.2.3 TRF1X23

The TRF1223 (TRF1123) is a RF PA device with 30 dB of gain and CW power capability of over 30 dBm in the high-power mode. For more efficient operation, the device can be operated in the low power mode.

1.2.4 TRF1216/TRF1115

The TRF1216 (TRF1115) is an integrated LNA and mixer. It has the option for external image reject filtering, and it also includes an IF gain control amplifier.

1.2.5 TRF1X12

The TRF1X12 (TRF1212) is a TX IF downconverter that includes two integrated synthesizers: one lower frequency synthesizer for the internal mixer and one higher frequency synthesizer that is piped externally for RF downconverter. The device also includes AGC amplifiers with over 90 dB of dynamic range and the option to include two switchable IF filters for different signal bandwidth requirements.

2 Software Control

2.1 Installation Instructions

- Open folder named WiMAX_GUI_Installer_Verx.x.fdr
- Run Setup.exe
- Follow the on-screen instructions

2.2 Software Launch Instructions

- Start the program by clicking on the TI_WIMAX_GUI program
- The main screen appears as in Figure 2.
- Select the TSW500x radial button

2.3 Software Operation

The TSW500x corresponds to the following WiMAX reference designs: the TSW5003 operating in the 3.5-GHz band and the TSW5002 operating in the 2.5-GHz band.

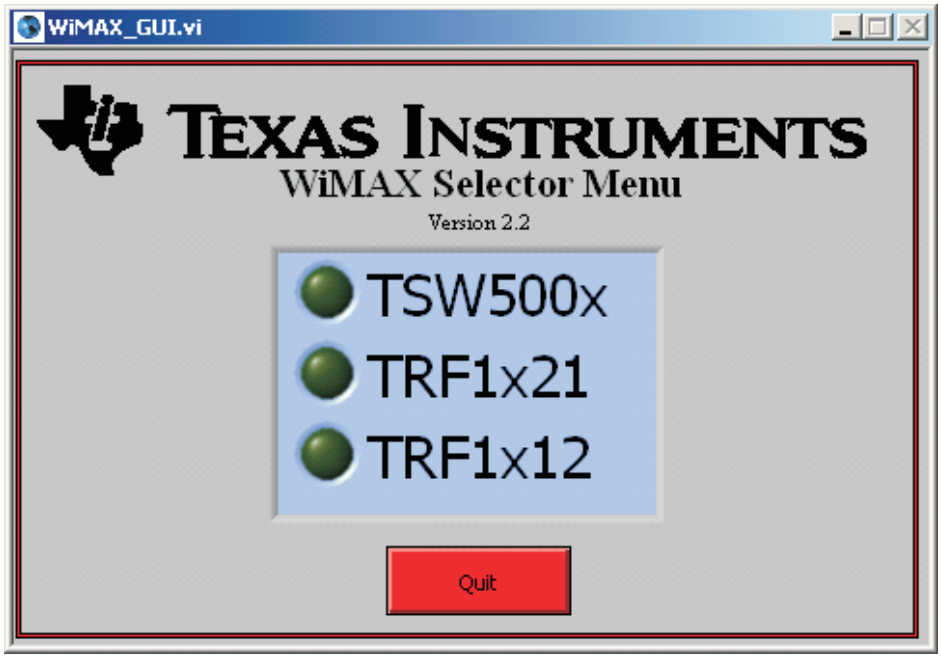

Figure 2. Main Window Software Screen

Selecting the TSW500x option opens up the GUI for the reference design. The initial screen is for the 3G5 control. Figure 3 shows the main screen for this software. To change to the 2G5 reference design control, toggle the switch in the upper left corner and the screen changes to the 2G5 GUI as shown in Figure 4.

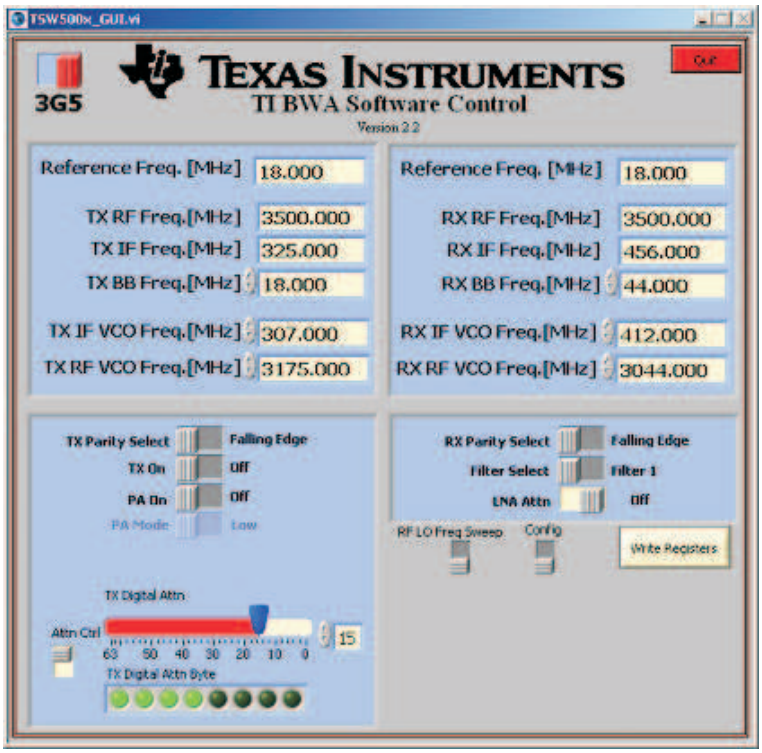

Figure 3. TSW5003 GUI

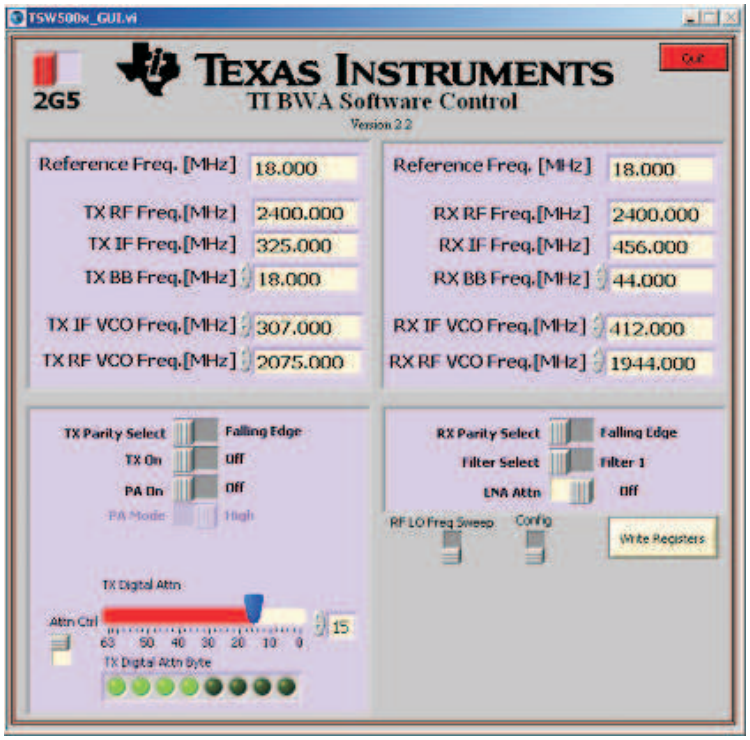

Figure 4. TSW5002 GUI

3 Test Configuration

3.1 Test Block Diagram

The TSW500x uses the TI Interface Board to facilitate powering the unit, programming the module, and gaining access to the analog input and output connections. The test set-up for transmitter operation is shown in Figure 5. The test set-up for receiver testing is shown in Figure 6.

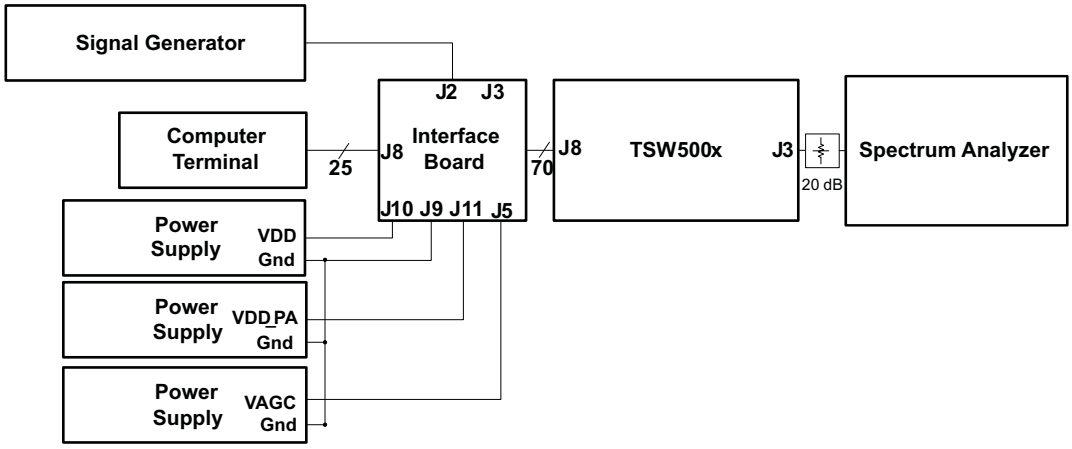

Figure 5. Transmitter Test Set-Up

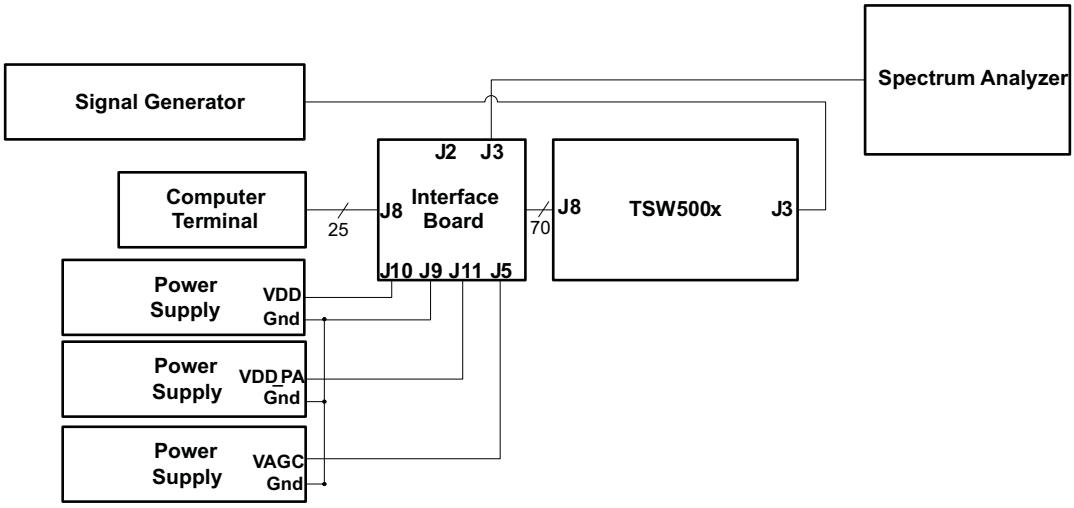

Figure 6. Receiver Test Set-Up

3.2 Test Equipment

The following equipment is required for completing RF Testing.

- Power Supply with Current Readout (x3) Agilent E3631 or Equivalent
- Signal Generator for input signal Agilent E4438C or Equivalent
- Spectrum Analyzer Agilent E4440A or Equivalent
- Computer with Parallel Port

3.3 Calibration

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

- Measure the insertion loss of the RF input/output cable at the frequency of interest. For Transmitter testing, measure the insertion loss of the attenuator and RF cable connected to the Spectrum Analyzer. For Receiver Testing, measure the insertion loss of the cable connected to the Signal Generator. Use the insertion loss to compensate for the input/output desired/measured power.

4 Basic Test Procedure

This section outlines the basic test procedure for testing the TSW500x using modulated WiMAX signals.

4.1 DC/Programmability Test

- Connect +6 V (VDD_Ext) to J10 on the interface board; connect ground to J11
- Connect +6.3 V (VDD_PA) to J9 on the interface board; connect ground to J11
- Connect 0.2 V to J5 on the interface board; connect ground to J11
- Engage power supplies
- Verify current on VDD_Ext is 1 A $\pm$ 400 mA
- Verify current on VDD_PA is 0.02 mA $\pm$ 0.01 mA (i.e. PA is off)
- Launch TI_WiMAX_GUI software
- Select the TSW500x radial button
- If using TSW5002, change switch to *2G5* in upper left corner
- Verify RX BB Freq. is 44 MHz; verify RX IF VCO Freq. is 412 MHz; verify RX RF VCO Freq. is 3044 MHz (TSW5003) or 1944 (TSW5002)
- Verify TX BB Freq. is 18 MHz; verify TX IF is 325 MHz; verify TX RF VCO Freq. is 3175 MHz (TSW5003) or 2075 MHz (TSW5002)
- Press the *Write Registers* button
- Verify LED D1 illuminates on the interface board indicating that the synthesizers have been properly programmed.

4.2 Transmitter Operation

The input frequency for the transmitter is 18 MHz. The IF frequency of the transmitter is 325 MHz. The default RF band as set by the RF filters is 3.4 to 3.6 GHz for the TSW5003 and 2.3 to 2.5 GHz for the TSW5002.

- Inject 18 MHz input signal at –20 dBm at J2 of the Interface board
- Connect RF output (J3 on the DUT) through 20 dB attenuator to Spectrum Analyzer. Be sure to compensate for actual attenuator and cable loss in the output power calculations.
- Set Spectrum Analyzer to output frequency of choice
- Verify TX Digital Attn is set to 15
- Verify TX BB Freq. is set to 18 MHz
- Verify TX IF VCO Freq. is set to 307 MHz
- Set TX RF VCO Freq. between 3075 and 3275 MHz (TSW5003) or between 1975 and 2175 MHz (TSW5002) to get the desired RF output frequency which is shown at TX RF Freq.
- Toggle TX ON switch to turn TX on
- Toggle PA ON switch to turn PA on
- Adjust TX Digital Attn value to get to desired output signal. Note, max output power does not correspond to 0 dB of attenuation. Max rated output power is 20 dBm modulated and generally corresponds to a digital attenuator setting between 2 and 10 dB.

Optional TX controls:

- Toggle Attn Ctrl switch to allow setting individual bits of the digital attenuator
- Toggle RF LO Freq Sweep to bring up a window which allows automatic RF VCO sweeping. This is useful for measuring the TX gain flatness over the RF band.

Notes:

- The TRF1x23 requires proper power sequencing. The negative supply should engage prior to the positive supply. The interface board has power supply protection built in to protect the device but caution should be observed. Generally, on power up, TX ON should be toggled first followed by the PA On. On power down, the procedure should be reversed.

4.3 Receiver Operation

The output base band frequency for the receiver is 44 MHz. The IF frequency of the receiver is 456 MHz. The default RF band as set by the RF filters is 3.4 to 3.6 GHz for the TSW5003 and 2.3 to 2.5 GHz for the TSW5002.

- Set AGC voltage to 0.2 V
- Inject RF input signal at frequency of choice at –45 dBm at J3 of the DUT. Be sure to compensate for cable loss by adjusting the input power to compensate.
- Connect BB output to Spectrum Analyzer at J3 of the Interface Board. Change Spectrum Analyzer frequency to 44 MHz.
- Set RX BB Freq. to 44 MHz
- Set RX IF VCO Freq. to 412 MHz
- Set RX RF VCO Freq. between 2944 and 3144 MHz (TSW5003) or between 1844 and 2044 MHz (TSW5002) to get the desired RF output frequency which is shown at RX RF Freq.
- Verify TX ON switch is turned Off; this turns on the RX
- Adjust the RXAGC voltage to get the desired output set-point of –20 dBm; RXAGC should not exceed 1.5 V.

Optional RX controls:

- Toggle the Filter Select switch to switch between two 44 MHz filters that have different bandwidths: 3.5 MHz and 7 MHz.
- Toggle LNA Attn switch to engage 10-dB attenuator in the RX LNA (TSW5003). For the TSW5002, it engages the bypass on the second LNA stage.

5 Specifications

5.1 DC and RF Performance Specifications

The DC and RF performance specifications are shown in Table 1.

Table 1. DC and RF Specifications

Parameter	Min	Typ		Max	Unit	Notes
DC						
I_{DD} (VDD_Ext)	0.6	1		1.4	A	Dependant on LED configuration of the Interface Board
V_{DD}		5			V	DUT only
I_{DD} (VDD) (TX On)		0.67			A	Just DUT in TX Mode
Power Dissipation (V_{DD})		3.35			W	
VDD_PA		5.5			V	
I_{DD} (VDPA)	0.5	0.6	0.65		A	TX ON: 2G5/3G5
Power Dissipation (VDD_PA)		3.3	3.58		W	TX ON: 2G5/3G5
Power Dissipation (Total)		6.7	6.9		W	TX Mode Only
RECEIVER						
NF		6			dB	Max Gain
Gain	15			65	dB	With AGC control
RX AGC	0			1.5	V	
Sensitivity		–85			dBm	At –16 dB EVM with 64 QAM signals
TRANSMITTER						
Gain		40			dB	At rated output power with –20 dBm input power
Digital Attenuator Step		1			dB	
Rated Output Power		20			dBm	≥ -30.5 dB EVM with 64 QAM signals
Spurious Output		–50		–40	dBm	

5.2 EVM (Error Vector Magnitude) Performance

The Receiver and Transmitter EVM performance curves versus power are shown in Figure 7 and Figure 8 respectively. The modulated signal is 64 QAM.

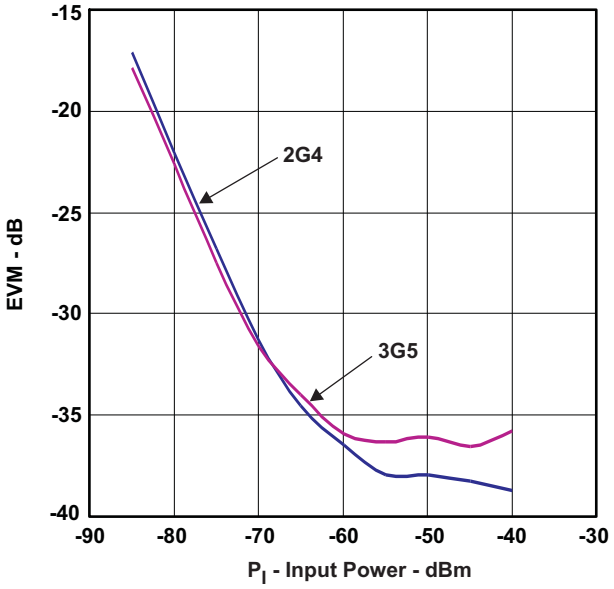

Figure 7. RX EVM Performance vs Input Power (64 QAM)

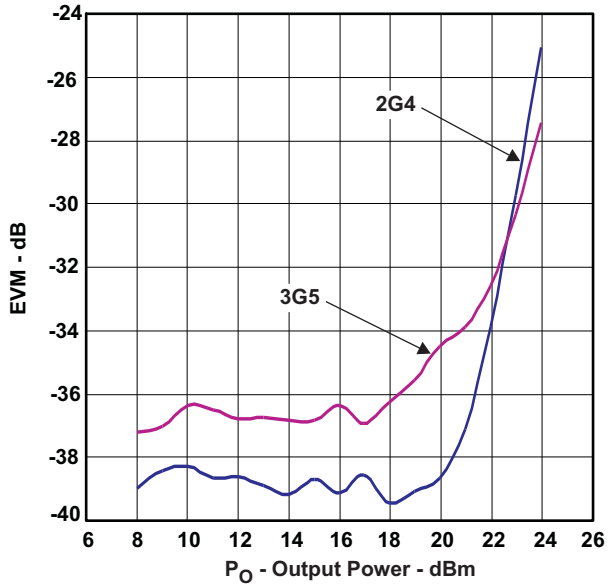

Figure 8. TX EVM vs Output Power (64 QAM)

6 Optional Configurations

6.1 Interface Board Power

The interface board can be powered independent from the DUT by completing the following reworks:

- Remove R82
- Inject +6V at TP20

6.2 Internal AGC

The RX AGC function can be controlled via a resistive pot instead of external supply. To implement this configuration, move jumper at W1 to connect pins 2 and 3. RX AGC voltage is controlled by pot at R49.

6.3 Manual TDD Switch Control

The TDD switch is normally controlled via the software. It can be controlled manually by applying TTL logic to J6 on the Interface Board when the jumper at W2 is shifted to *Ext*.

EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 0 V to 5 V and the output voltage range of 0 V to 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 85ï½C. The EVM is designed to operate properly with certain components above 85ï½C 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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