User's Guide

SLWU069B–February 2010–Revised November 2010

TRF3711xxEVM

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1 Introduction

1.1 Overview

This document is the user's guide for the TRF3711xxEVM. The TRF3711xx 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 WCDMA, WiMAX, and LTE modulation as well as with other high-bandwidth signal modulation schemes.

Note: Unless otherwise noted, the abbreviations *TRF3711xxEVM* and *TRF3711xx* are used in this document to refer to all members of this device family (including the TRF371109, TRF371125, and TRF371135). Table 1 summarizes the TRF3711xx device frequency options and lists the recommended balun for each device.

Table 1. TRF3711xx Device Frequencies and Recommended Baluns(1)

Frequency	Device	Recommended Balun
700 MHz	TRF371109, TRF371125	Murata LDB21897M05C
880 MHz	TRF371109, TRF371125	Murata LDB21881M05C
940 MHz	TRF371109, TRF371125	Murata LDB21942M05C
1740 MHz	TRF371125, TRF371135	Murata LDB211G8005C
1950 MHz	TRF371125, TRF371135	Murata LDB211G9005C
2025 MHz	TRF371125, TRF371135	Murata LDB211G9005C
2500 MHz	TRF371125, TRF371135	Murata LDB212G4005C
3550 MHz	TRF371125, TRF371135	Johanson 3600BL14M050E
5400 MHz	TRF371135	Johanson 5400BL15B050E

(1) There is considerable overlap in the operating frequency range of the TRF3711xx family of devices. Refer to the specific device data sheet and compare performance parameters at the frequencies of interest to select the best part for a particular application.

1.2 EVM Frequency Configuration Options

The TRF3711xx 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 to R105 to determine which balun is populated on the board.

1.3 System Block Diagram

The basic radio system block diagram in Figure 1 demonstrates where the TRF3711xx fits in the overall receiver architecture. The bold box highlights the TRF3711xx device.

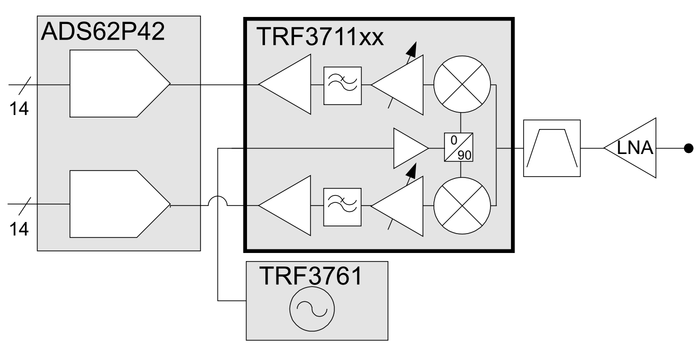


Figure 1. System Block Diagram

2 Software Control

2.1 Installation Instructions

1. Open the folder named TRF3711_Installer_vxpx (***xpx*** represents the latest version).
2. Run Setup.exe.
3. Follow the on-screen instructions.
4. Once installed, launch by clicking on the TRF3711_GUI_Verxpx program.
5. When plugging in the USB cable for the first time, you will be prompted to install the USB drivers.
   (a) When a pop-up screen opens, select *Continue Downloading*.
   (b) Follow the on-screen instructions to install the USB drivers.
   (c) If needed, the drivers can be accessed directly in the install directory.

2.2 Software Operation

The front panel control is shown in Figure 2. The registers are set in the respective default configurations. This section describes the functionality of the control registers.

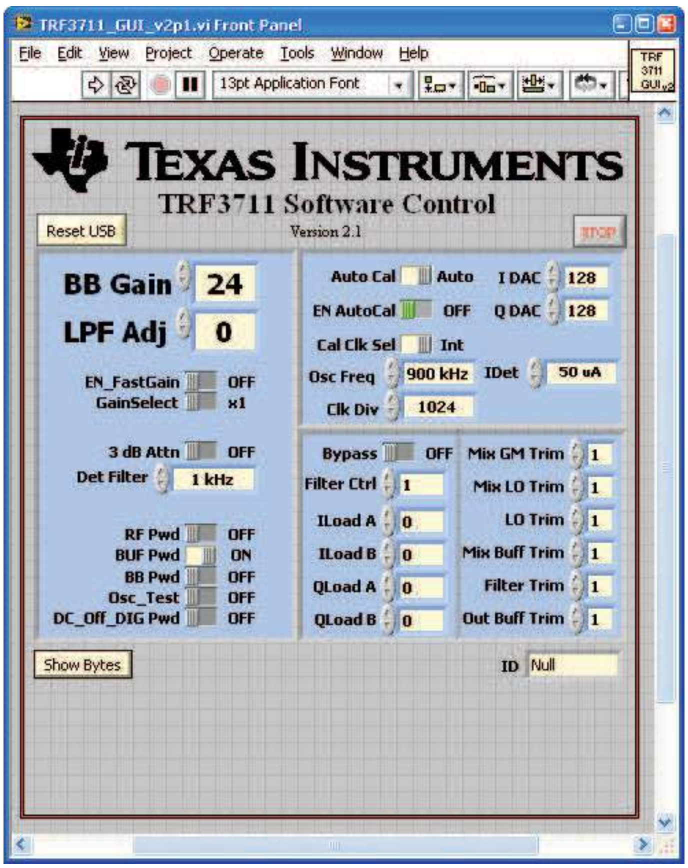


Figure 2. TRF3711xx GUI Front Panel

2.2.1 Register 1

- BB Gain: The programmable-gain amplifiers (PGA) setting; range is 0 to 24.
- LPFAdj: Sets the bandwidth of the BB filters. Setting 0 is maximum (bandwidth ≥ 15 MHz); setting 255 is minimum (BW ≤ 700 kHz). See the specific device data sheet for comprehensive curves.
- EN_FastGain: Enables the fast-gain option to adjust PGA gain with external bits

- Gain Select: Selects whether each bit in the fast-gain control is either 1 dB or 2 dB.
- 3 dB Attn: Engages the 3-dB attenuator at the baseband output.
- Det Filter Selects the internal detector filter used in dc offset calibration.
- RF Pwd Enables SW-controlled power down of RF stages inside device.
- BUF Pwd Enables power down on test buffer for mixer output; default is powered down.
- Osc_Test Enables dc offset oscillator to the READBACK pin on the TRF3711.
- DC_OFF_DIG Pwd Enables SW-controlled power down of dc offset-correction circuitry.

2.2.2 Register 2

- Auto Cal *Manual* mode allows the dc offset DACs to be user-configurable; *Auto* mode uses the internally stored values.
- En Auto Cal: When toggled, an Auto Cal is initiated. Note, *Auto Cal* must be in *Auto* mode.
- IQ DAC: Shows the setting of the dc offset I and Q DAC when in manual mode; range is 0 to 255.
- 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 must be slowed down. Value chosen in conjunction with Det Filter setting for optimal averaging.
- IDet: Selects the resolution of the I and Q DAC.

2.2.3 Register 3

- I/QLoadA/B: Selects the mixer gain for the differential BB paths. Typically, modification of these registers is not required, but they can be tweaked for minor I/Q amplitude adjustment.
- Filter Ctrl: Trims the peaking response of the BB LPF response.
- Bypass Engages the bypass feature of the BB LPF.

2.2.4 Register 5

- Mix GM Trim No adjustment of this register required.
- Mix LO Trim No adjustment of this register required.
- LO Trim No adjustment of this register required.
- Mix Buff Trim No adjustment of this register required.
- Filter Trim No adjustment of this register required.
- Out Buff Trim No adjustment of this register required.

2.2.5 Misc Settings

- Reset USB: Toggle this button if the USB port is not responding. This generates a new USB handle address.
- Show Bytes: Shows the 32-bit word that is sent for each register.
- Stop Stops the program.

3 EVM Test Configuration

3.1 Test Block Diagram

The test setup for general testing of the TRF3711xx is shown in Figure 3.

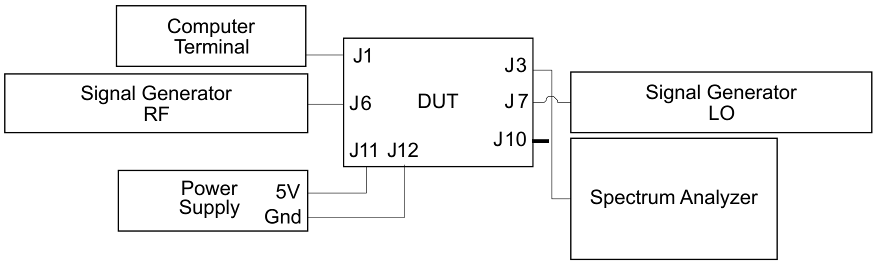


Figure 3. Test Setup Block Diagram

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 because of the high-frequency signals.

NOTE: There is approximately 1 dB of insertion loss for the input traces and balun on the printed circuit board (PCB).

- Measure the insertion loss of the RF input cable and use this value to compensate for the desired input power.
- Measure the insertion loss of the LO input cable and use this value to compensate for the desired LO power.
- BB loss factor: If using the onboard transformers to interface with 50-Ω test equipment, then there is approximately 12 dB of loss associated with the voltage transformation and transformer loss.

4 Basic Test Procedure

This section outlines the basic test procedure for testing the EVM. This section is divided into three test sections: *DC Test*, *Basic RF Test*, and *Advanced RF Test*. 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 setup. Only Section 4.1 and Section 4.2 are required to ensure basic functionality.

4.1 DC Test

1. Connect +5 V to J11; connect ground to J12.
2. Engage power supplies.
3. Verify current is 385 mA ± 25 mA.

4.2 Basic RF Test

Determine which balun device is placed on the board by inspecting which jumper resistor is installed at the R101 to R105 locations. This information determines the proper RF frequencies for which the board is configured. Table 2 summarizes the frequency band allocations.

Table 2. Frequency Allocations

Band	Frequency Band	F_LO	F_RF
1G9	1800 MHz to 2000 MHz	1.9 GHz	1.9 GHz
2G4	2.3 GHz to 2.7 GHz	2.4 GHz	2.4 GHz
3G5	3.5 GHZ to 3.8 GHz	3.5 GHz	3.5 GHz
1G7	1600 MHz to 1800 MHz	1.7 GHz	1.7 GHz
900M	700 MHz to 1000 MHz	900 MHz	900 MHz

1. 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.
2. Verify USB cable is connected.
3. Launch TRF3711_GUI_vxpx.
4. Toggle Auto Cal En on the GUI to complete a dc offset calibration.
5. 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 ±35 mV.
6. 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.
7. Connect spectrum analyzer at J3 (I).
8. Set Spectrum analyzer center frequency to 300 kHz:
   (a) Set span to 500 Hz.
   (b) Set reference level to 0 dBm.
   (c) Set analyzer to dc coupling.
   (d) Set RBW to 3 Hz.
   (e) Set VBW to 10 Hz.
9. Measure the signal at 300 kHz and verify signal at –12 dBm ±4 dB; note there is at least 12 dB of loss associated through the onboard transformer. Also note that the device gain depends on the frequency, and thus the output levels differ, depending on the frequency of the test.
10. Adjust BB gain to 20; verify signal reduces 4 dB ±1 dB.
11. Switch output cable to J10 (Q) and repeat the basic RF test beginning with Step 9..

4.3 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 limits 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 and J8/J13 offer direct access to the driver amplifier outputs for the differential I and Q signals, respectively. Note, these ports cannot drive 50-Ω test equipment directly. For best performance, the connections to the transformer should be severed by removing jumpers at W4, W5, W6, and W7.

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.

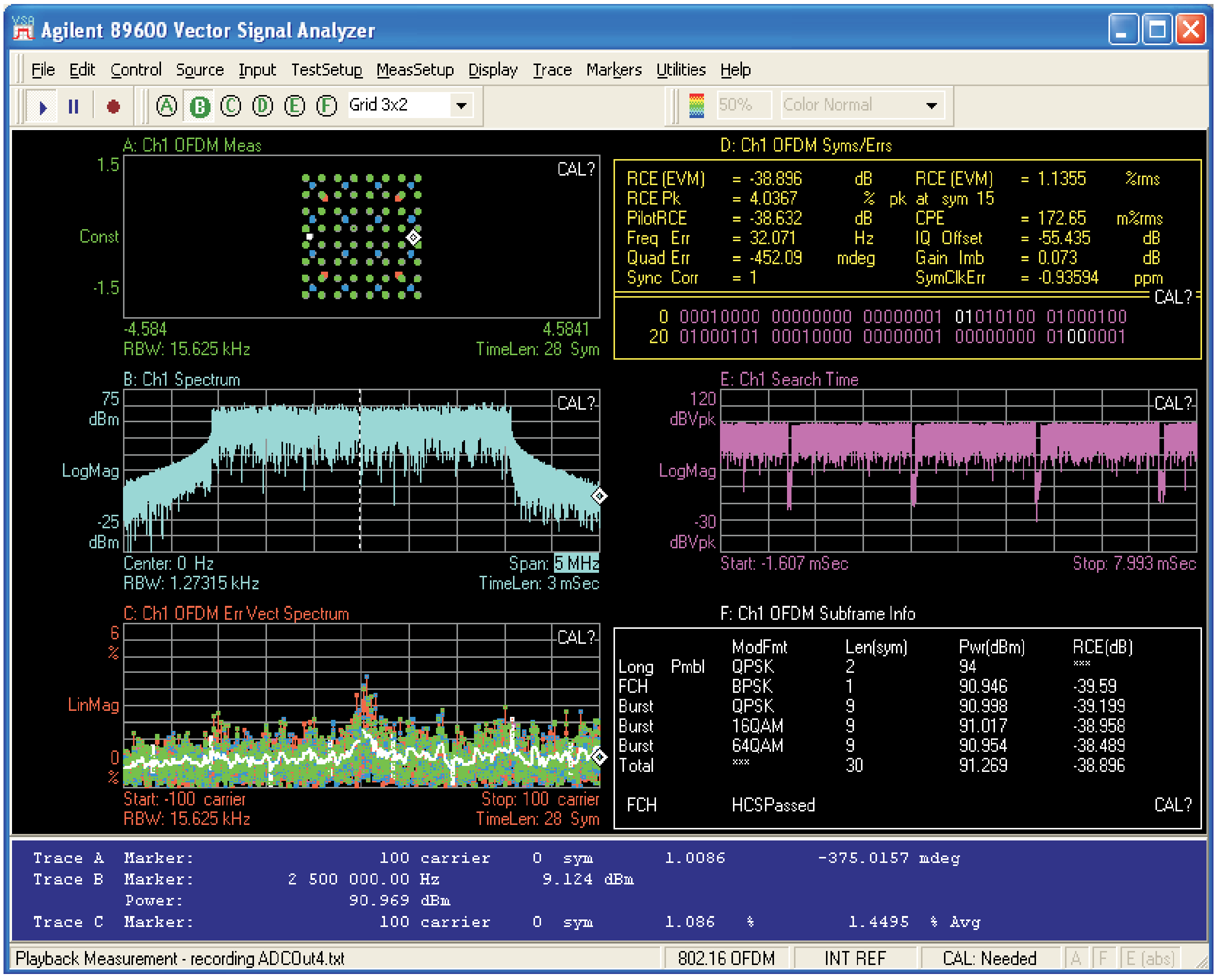


Figure 4. TRF371125 with ADS62P42 WiMAX 3.5-MHz Signal EVM Performance

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 *BUF Pwd* to *Off*.

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 is shifted if the input supply is not 5 V. Alternatively, this can be controlled via a potentiometer by:

- Removing R17, R18
- Placing 0-Ω jumper at R19
- Adjusting potentiometer R20.

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 W3
- Placing ADC common-mode voltage at 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 setting *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 detection filter is typically set to 1 kHz and the clock divider is set to 1024. With this configuration the dc offset calibration is most accurate and can be enabled with the RF signal present. If the RF input signal is disabled during the auto-cal procedure, then the detection filter bandwidth can be 10 MHz and the clock divider reduced to a value of 16. Other combinations of detector filter and clock divider are possible, depending on accuracy required and convergence time required.

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.

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 *EN_FastGain* to *ON*. Then adjust for the gain through the binary combination of bits B0, B1, B2 that can be toggled at DIP switch SW1. For example, if the BB gain is set to 24 and the binary bits are set to *b101*, then the equivalent gain setting is 24 – 5 = 19. If the *GainSelect* is set to 2×, then the equivalent gain setting for the previous example is 24 – 2 × 5 = 14.

5.5 *Analog Device Disable*

The TRF3711xx can be disabled by removing the jumper at W2.

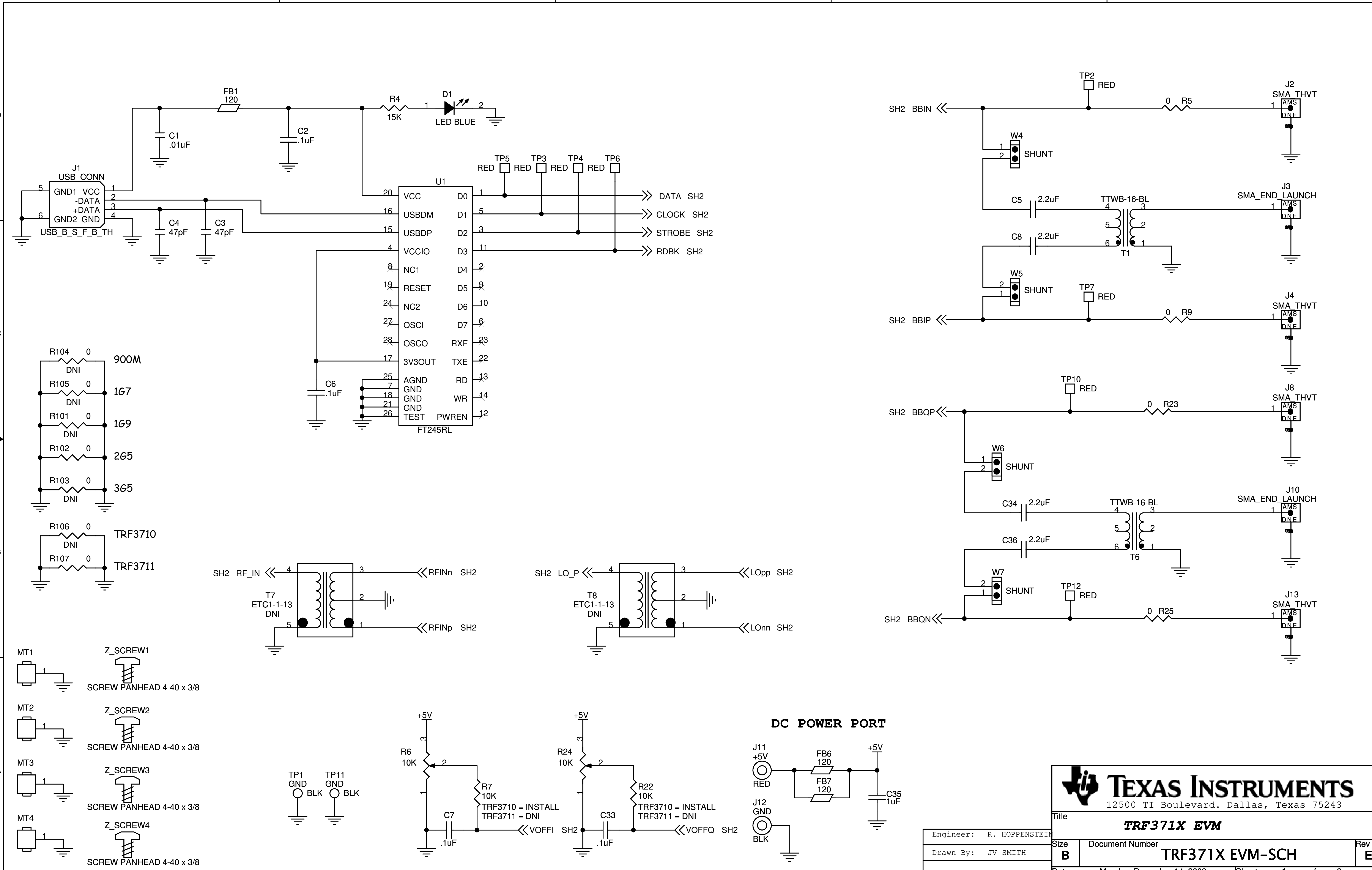
6 Schematics

Schematics for the TRF3711xxEVM are appended to this document.

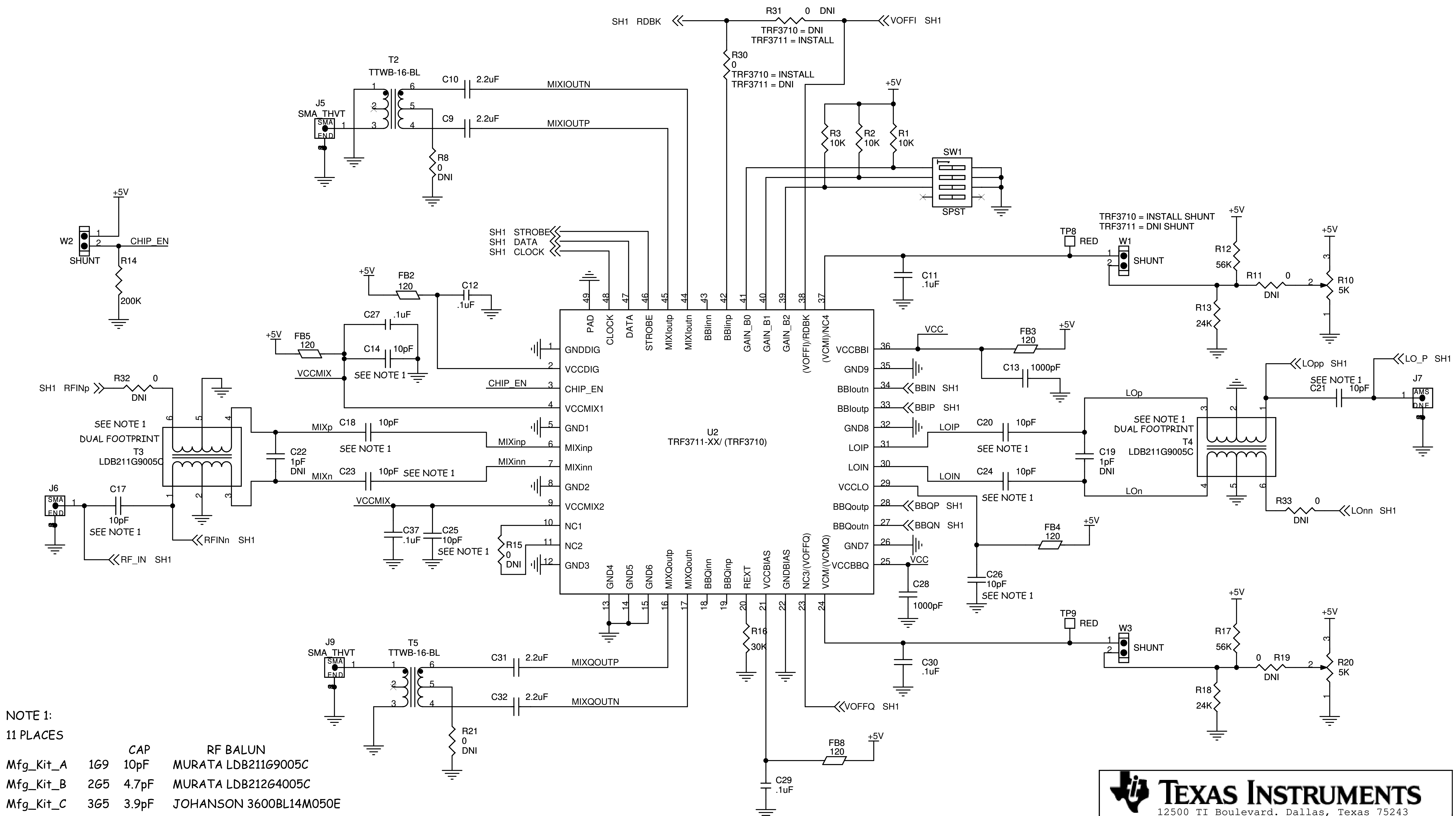
REVISION HISTORY

Changes from A Revision (March, 2010) to B Revision	Page
• Added TRF371109 device to products supported by EVM	1

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.



FB1 120
C1 .01uF
C2 .1uF
R4 15K
D1 LED BLUE
J1 USB_CONN
USB_B_S_F_B_TH
GND1 VCC -DATA +DATA GND2 GND
C4 47pF
C3 47pF
U1 FT245RL
VCC USBDM USBDP VCCIO NC1 RESET NC2 OSCI OSCO 3V3OUT AGND GND GND GND TEST
D0 D1 D2 D3 D4 D5 D6 D7 RXF TXE RD WR PWREN
TP5 RED TP3 RED TP4 RED TP6 RED
DATA SH2
CLOCK SH2
STROBE SH2
RDBK SH2
C6 .1uF
R104 0 DNI 900M
R105 0 DNI 1G7
R101 0 DNI 1G9
R102 0 2G5
R103 0 DNI 3G5
R106 0 DNI TRF3710
R107 0 TRF3711
SH2 RF_IN
RFINn SH2
RFINp SH2
T7 ETC1-1-13 DNI
SH2 LO_P
LOpp SH2
LOnn SH2
T8 ETC1-1-13 DNI
MT1 MT2 MT3 MT4
Z_SCREW1 Z_SCREW2 Z_SCREW3 Z_SCREW4
SCREW PANHEAD 4-40 x 3/8
TP1 GND BLK
TP11 GND BLK
+5V
R6 10K
R7 10K
TRF3710 = INSTALL
TRF3711 = DNI
C7 .1uF
VOFFI SH2
R24 10K
R22 10K
C33 .1uF
VOFFQ SH2
DC POWER PORT
J11 +5V RED
J12 GND BLK
FB6 120
FB7 120
C35 1uF
SH2 BBIN
TP2 RED
R5 0
J2 SMA_THVT
W4 SHUNT
C5 2.2uF
C8 2.2uF
TTWB-16-BL
T1
J3 SMA_END_LAUNCH
W5 SHUNT
TP7 RED
SH2 BBIP
R9 0
J4 SMA_THVT
TP10 RED
SH2 BBQP
R23 0
J8 SMA_THVT
W6 SHUNT
C34 2.2uF
C36 2.2uF
T6
J10 SMA_END_LAUNCH
W7 SHUNT
TP12 RED
SH2 BBQN
R25 0
J13 SMA_THVT
AMS DNF
TEXAS INSTRUMENTS
12500 TI Boulevard. Dallas, Texas 75243
Engineer: R. HOPPENSTEIN
Drawn By: JV SMITH
Title TRF371X EVM
Size B
Document Number TRF371X EVM-SCH
Rev E
Date: Monday, December 14, 2009
Sheet 1 of 2



NOTE 1:

11 PLACES

		CAP	RF BALUN
Mfg_Kit_A	1G9	10pF	MURATA LDB211G9005C
Mfg_Kit_B	2G5	4.7pF	MURATA LDB212G4005C
Mfg_Kit_C	3G5	3.9pF	JOHANSON 3600BL14M050E
Mfg_Kit_D	1G7	10pF	MURATA LDB211G8005C
Mfg_Kit_E	900M	22pF	MURATA LDB21942M05C

TEXAS INSTRUMENTS

12500 TI Boulevard. Dallas, Texas 75243

Title: TRF371X EVM

Size: B | Document Number: TRF371X EVM-SCH | Rev: E

Date: Monday, December 14, 2009 | Sheet 2 of 2

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 4.5 V to 5.5 V and the output voltage range of 0 V to 4 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 55° C. The EVM is designed to operate properly with certain components above 55° 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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