TRF6903 Demonstration and Evaluation Kit Overview

This chapter provides an overview of the TRF6903 demonstration and development kit.

Topic   **Page**

1.1 Description

The MSP-TRF6903-DEMO kit is used to demonstrate a bidirectional radio frequency (RF) data link without the need of an external computer and for prototyping by downloading new software code to the MSP430F449 through the JTAG connector. The schematics and layout of the board can be used as a reference design if desired, limited by the software system parameters of the demonstration firmware.

1.2 Contents

The TRF6903 demonstration and development kit contains:

❏ Two TRF6903 demonstration boards

❏ User's manual

Software is not included in the kit. Software and hardware documentation related to this kit can be downloaded at: http://www.ti.com/ismrf

1.3 Equipment Requirement

The following equipment is not included in this kit and is required to operate the MSP-TRF6903-DEMO kit:

❏ Four AAA batteries

❏ MSP430 bus expansion cable for the JTAG connector, required only for prototyping purposes

Demonstrating a Wireless Link

This chapter explains how to operate the MSP-TRF6903-DEMO kit to demonstrate a RF bidirectional link.

2.1 Board Description

The two circuit boards in the kit are identical. Each unit has a TRF6903 RF transceiver and a MSP430F449 microcontroller. Each board is capable of sending and receiving half-duplex wireless data on the European and North American/US ISM bands. The microcontroller firmware is configured to use the 902-MHz to 928-MHz ISM frequency band. Figure 2−1 shows top side and back side views of the circuit board.

Figure 2−1. Top Side, Back Side of the Demonstration Board
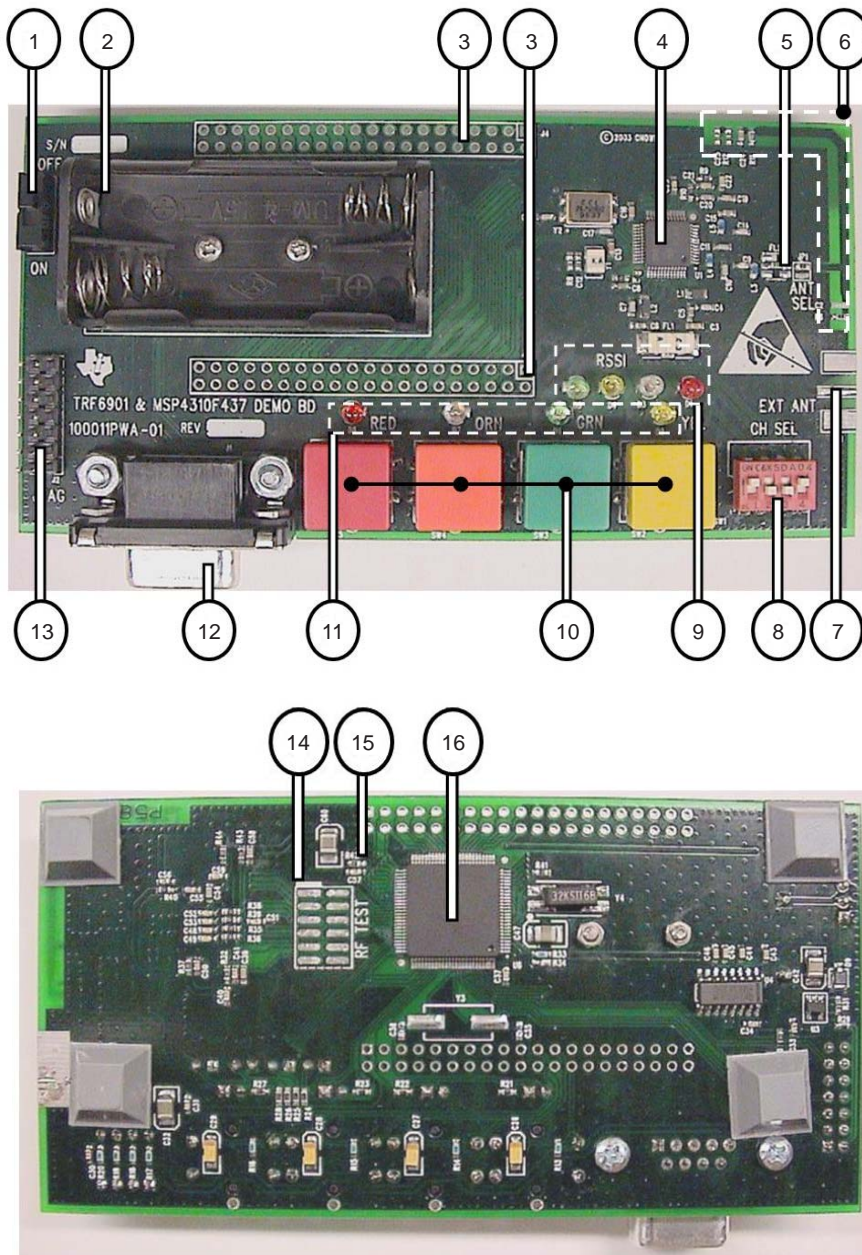
Circuit board features:

1) On/Off switch

2) Battery holder for two AAA batteries in series (batteries not included)

3) Headers used to access the MSP430F449 I/O ports

4) TRF6903 RF transceiver

5) Antenna jumper (0-Ω resistor) used to select either the SMA connector or PCB antenna (selecting both not recommended).

6) On board PCB antenna (default configuration). The antenna has modest gain and radiates in the direction of the bend in the long arm.

7) SMA connector footprint for an external antenna or test equipment (SMA connector not included).

8) 4-bit DIP switch used in the link demonstration mode to change the transmit/receive frequencies. The switch is connected to MSP430 I/O ports P3.0, P3.1, P3.2, and P3.3.

9) Receive signal strength indicator (RSSI) LEDs, connected to MSP430 I/O ports P6.0 through P6.3.

10) Four buttons used for the demonstration game application, connected to MSP430 I/O ports P1.0 through P1.3.

11) Four LEDs used for the demonstration game application, connected to MSP430 I/O ports P1.3 through P1.7.

12) RS–232C connector

13) JTAG connector

14) TRF6903 I/O header used to monitor or control the TRF6903.

15) 0-Ω resistor R42, remove to disable the MSP430F449 (or short reset to ground at JTAG connector).

16) MSP430F449 microcontroller

2.2 Operation

A simple game is implemented in the firmware to demonstrate bidirectional RF communication. The first user starts the game by pushing any sequence of four colored buttons. The second user on the receive side responds by pushing the same button sequence; after this response, the initial transmitter's board illuminates one of three LEDs depending on the information provided by the receiving board:

❏ Successful user response and communication: the green LED illuminates if the packet was delivered to the receiving board and the user on the receiving board pressed the correct sequence of buttons.

❏ Successful communication and user error: the orange LED illuminates if the packet was delivered to the receiving board and the user on the receiving board pressed the incorrect sequence of buttons.

❏ Communication error: the red LED illuminates if there was a communication error.

2.2.1   Preparing for Operation

Before you start operating the units as a demonstration make sure that you have done the following:

❑   Slide the on/off switch to ON

❑   Place two AAA batteries on each demonstration board

❑   Have the same 4-bit DIP switch (SW1) configuration on both boards

Table 2–1 shows the transmit frequencies selected with the 4-bit DIP switch (SW1). Both circuit boards must have the same channel switch settings in order for the demonstration game to operate correctly.

Table 2–1. 4-Bit DIP Switch (SW1) Settings and Transmit Frequencies

1234 SW1 Setting (1 = On, 0 = Off)	TX Frequency (MHz)	RX Frequency (MHz)
0000	902.3988	891.6992
0001	903.218	892.5184
0010	904.4468	893.7472
0011	905.266	894.5664
0100	906.0852	895.3856
0101	907.7236	897.024
0110	909.362	898.6624
0111	910.1812	899.4816
1000	911.8196	901.12
1001	912.6388	901.9392
1010	913.458	902.7584
1011	914.2772	903.5776
1100	915.506	904.8064
1101	916.3252	905.6256
1110	917.554	906.8544
1111	918.3732	907.6736

2.2.2   Power Up

Slide the power switch to ON. All the LEDs should blink to indicate power up condition. After the power-up initialization, both units go into receive mode to monitor for any transmit activity. The RSSI indicator LED is lighted to indicate the signal strength in the frequency channel of operation. Red indicates the lowest signal strength and green indicates the highest.

2.2.3   Wireless Demonstration

Either board can initiate wireless communication. Here we assume that Board A transmits the first four-button transmitted sequence and **Board B** receives the first transmission.

Use **Board A** to start the wireless demonstration by pressing the four colored buttons in any sequence with about 1/2 second between successive buttons. Once the four buttons are pushed, **Board A** initiates the transmission, and waits for a reply.

Once the transmission is received by **Board B**, the LEDs are turned on in the same sequence as the buttons were pushed at the transmitter side. Immediately after the last LED is displayed, the user responds by pushing the buttons in the exact sequence that the LEDs were lighted on **Board B**.

If the response sequence matches, the green LED on **Board A** lights up. If there are errors due to poor or lost transmission, the red LED lights up. The orange LED lights if the user presses an incorrect sequence of buttons in response. This concludes the basic demonstration of the two-way RF communication.

On completion, both boards go back to receive mode to listen for a new button sequence.

2.2.4   RSSI Indicator

The boards are equipped with a receive signal strength indicator (RSSI) that will illustrate the signal strength on the receiver. Four levels are used to indicate signal strength. Red is the lowest and means no signal was received, while green indicates the highest level of signal strength. The RSSI will show transmission activity when the other board is transmitting a data stream on the same DIP switch configuration or when there is another external RF source broadcasting at that channel frequency. For best results, the two boards should be in the same plane of orientation, with the bend in the long antenna arm pointed towards each other.

2.2.5   Error Conditions

Cycle the system power to reinitialize the hardware if you get error conditions that persist. Error conditions are defined as lost communication, mismatch in response sequences, or response time outs. In some cases, antenna orientation, signal multipath, or another interfering signal can increase errors.

Prototyping

This chapter explains how to operate the MSP-TRF6903-DEMO kit to prototype new applications.

3.1 Connecting to the MSP430 JTAG

The MSP-TRF6903-DEMO is designed for rapid application development. The MSP430 MCU flash memory can repeatedly be erased and reprogrammed. The on-chip emulation logic allows real-time debugging and fast code development. The MSP-TRF6903-DEMO and the MSP430 Flash Emulation Tool provide everything that is required to develop an entire firmware project.

For information go to http://www.msp430.com

Connector J2 provides access to the JTAG port of the MSP430 microcontroller on the MSP-TRF6903-DEMO circuit board. The MSP-FET430 Flash Emulation Tool (FET) interface board MSP-FETP430IF (not included in this kit) connects to J2 and allows real-time in-system emulation. Programming the MSP430, assembler/C source-level debugging, single stepping, multiple hardware breakpoints, full-speed operation and peripheral access are fully supported in-system using the JTAG connector. Figure 3–1 shows the connections of the MSP-TRF6903-DEMO to the JTAG cable provided by the MSP430 FET interface board.

Figure 3–1. JTAG Connector
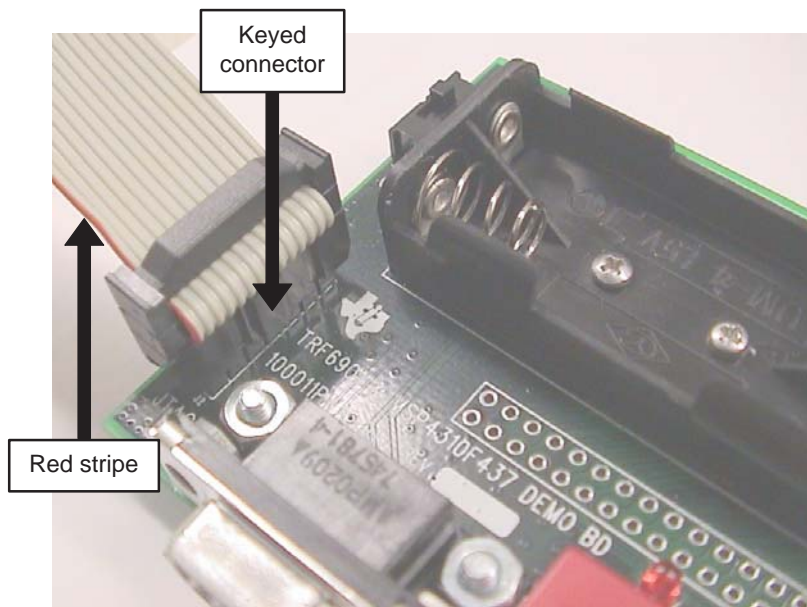
3.2   Loading the MSP430 With the Firmware

The MSP−TRF6903−DEMO comes with source code installed on the MSP430 to run the demo program. The user can develop new application software that can be downloaded to the MSP430 MCU through the JTAG connector. Since the Compiled C code size is greater than 4kB, only unrestricted versions of the IAR development environment (not the Kickstart version) must be used for downloading and modifying the code.

The workspace file for compiling the demo source code is TRF6903Demo_US.eww, developed with IAR compiler version 3.20a.

The following steps show how to open the project file and program the MSP430.

Step 1:   Insert the two AAA batteries and slide the on/off switch to ON.

Step 2:   Start the Workbench (START−>PROGRAMS−>IAR SYSTEMS−> IAR EMBEDDED WORKBENCH.

Step 3:   Use FILE−>OPEN WORKSPACE to open the workspace file at: <Installation root>\…\ TRF6903Demo_US.eww.

Step 4:   Use PROJECT−>BUILD ALL to compile and link the source code. You can view the source code by double-clicking *Common Sources*, and then double-clicking on the source files in the workspace window.

Step 5:   Ensure that the C−SPY Debugger is properly configured for the parallel port used. (Choose PROJECT−>OPTIONS−>FET DEBUGGER and select −>LPT1 (default) or LPT2 or LPT3 for the parallel port configuration.)

Step 6:   Use PROJECT−>DEBUG to start C−SPY. C−SPY erases the device Flash and downloads the application object file.

Step 7:   In C−SPY, use DEBUG−>GO to start the application.

Step 8:   In C−SPY, use DEBUG−>STOP DEBUGGING to exit C−SPY.

Step 9:   In Workbench, use FILE−>EXIT to exit Workbench.

The MSP430 is now programmed with the game demonstration code and ready to operate.

PCB Hardware Overview

This chapter provides the default PCB hardware documentation in detail and provides alternate configurations that the user may want to implement.

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4.1 Hardware Overview

The TRF6903 ISM-band transceiver IC operates from 315 MHz to 950 MHz. It has low power consumption and an operating voltage of 2.2 V to 3.6 V. It features an integer-N PLL synthesizer and supports FSK and OOK operation. Other features include on-chip clock recovery, brownout detector, and XTAL frequency trimming in software.

The TRF6903 demonstration and development kit (MSP−TRF6903−DEMO) provides a stand-alone demonstration of a bidirectional link using the MSP430F449 and the TRF6903 RF transceiver.

4.2 TRF6903 RF Block Diagram

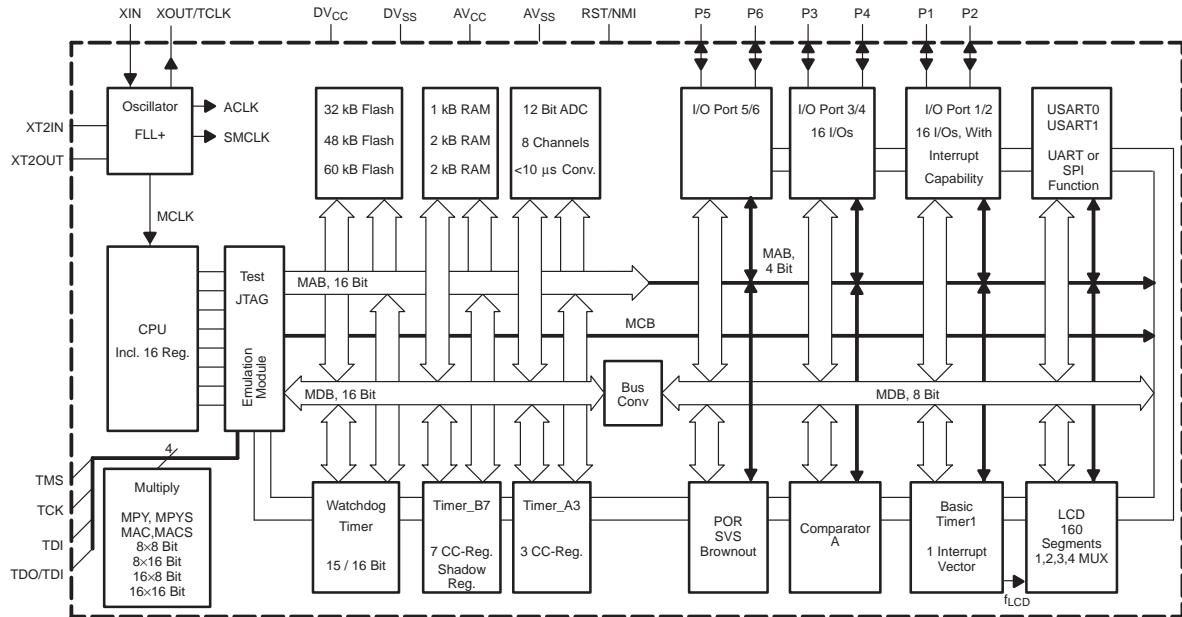Figure 4−1 shows the block diagram of the TRF6903 ISM transceiver IC.

Figure 4−1. TRF6903 Block Diagram
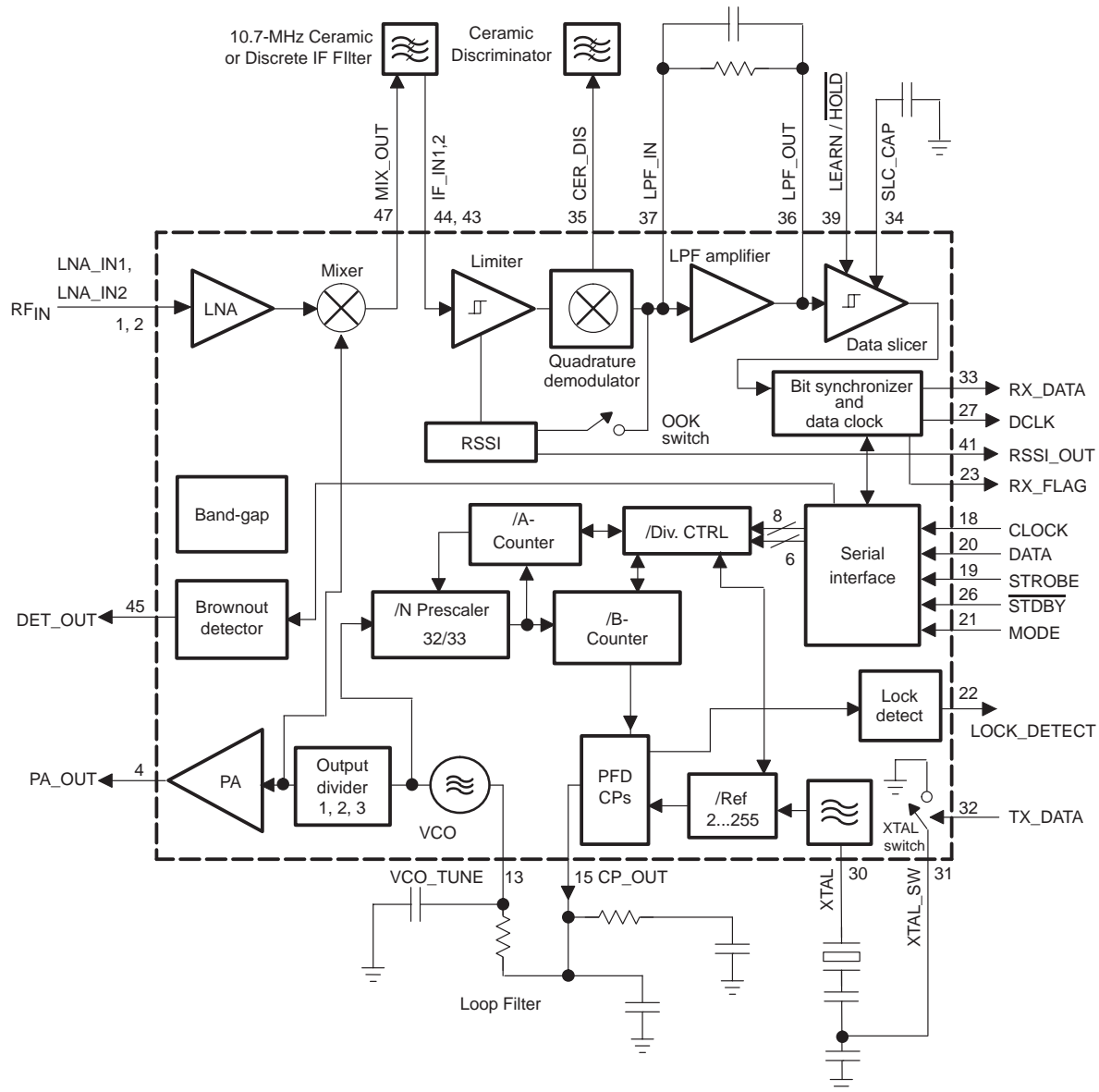
4.3 MSP430F449 Block Diagram

Figure 4–2 shows the block diagram of the MSP430F449 microcontroller IC.

Figure 4–2. Block Diagram of the MSP430F44x

4.4 Demo Board Schematics

All the schematics for the demonstration boards can be found at
http://www−s.ti.com/sc/techzip/slwc0xx.zip.

4.5 Top and Bottom Silk Screen and Drawing

Figure 4−3 and Figure 4−4 show the top side and bottom side circuit board silkscreen.
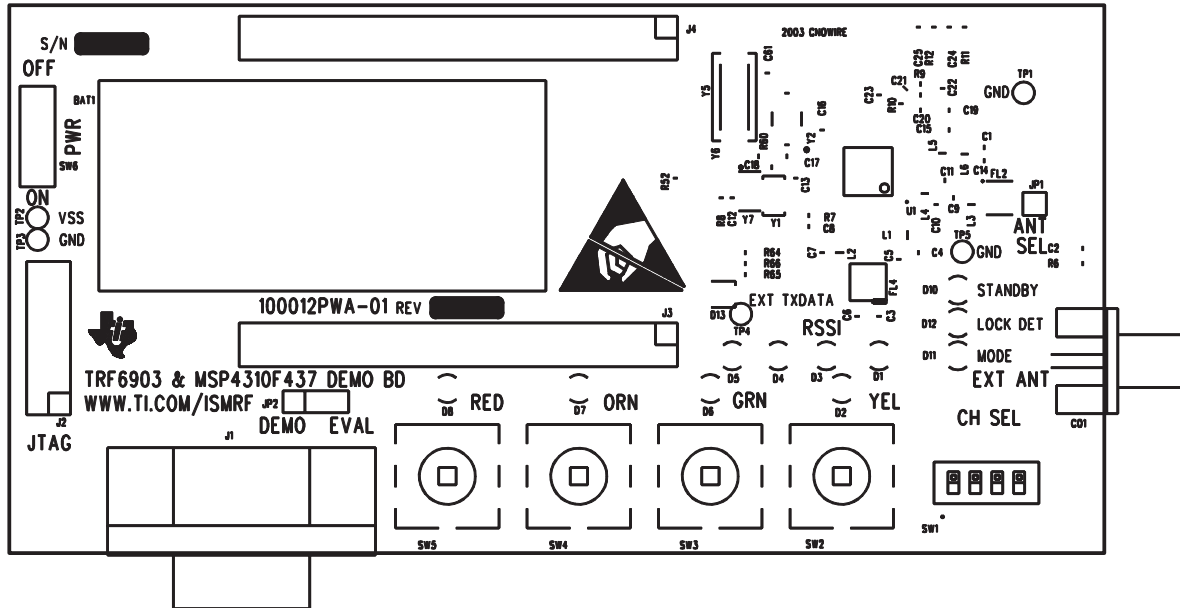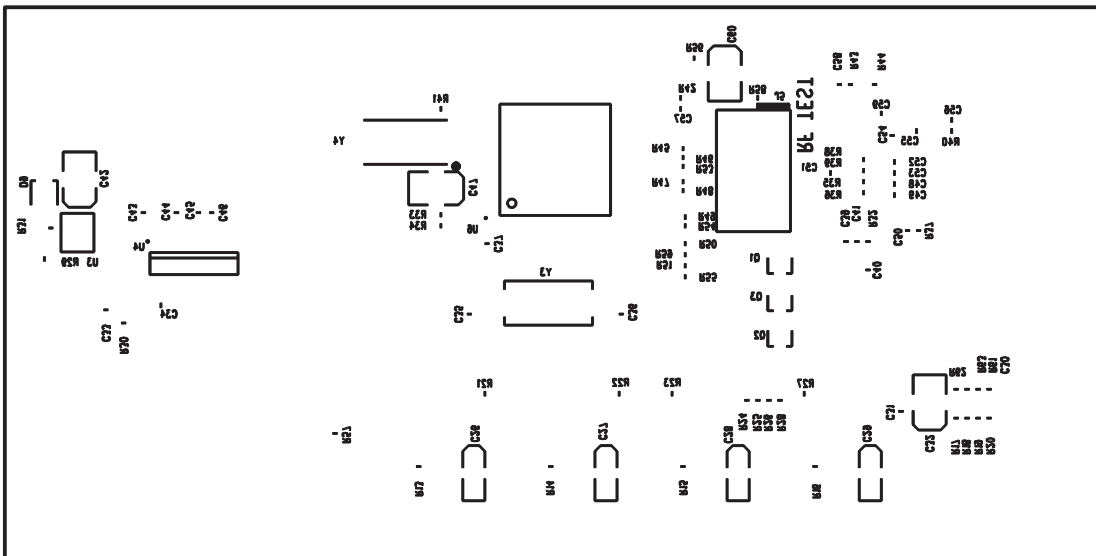
Figure 4−3. Top-Side Silk Screen

Figure 4−4. Bottom-Side Silk Screen

4.6 Parts List

Qty	Value	Mfg	Mfg Num	Description	Reference
1	0.5 pF	AVX	06035A0R5CAT2A	Capacitor, CER, 0603, 50 V, ±0.25 pF, 0.5 pF	C24
2	2.2 pF	AVX	06035A2R2CAT2A	Capacitor, CER, 0603, 50 V, ±0.25 pF, 2.2 pF	C10, 11, 14
2	22 pF	AVX	06035A220FAT2A	Capacitor, CER, 0603, 50 V, 1%, 22 pF	C8, 18
1	24 pF	AVX	06035A240FAT2A	Capacitor, CER, 0603, 50 V, 1%, 24 pF	C17
1	39 pF	AVX	06035A390FAT2A	Capacitor, CER, 0603, 50 V, 1%, 39 pF	C9, 15
3	100 pF	AVX	06035A101FAT2A	Capacitor, CER, 0603, 50 V, 1%, 100 pF	C3, 54, 63
1	75 pF	AVX	06035A750JAT2A	Capacitor, CER. 0603, 50 V, 5%, 75 pF	C20
2	82 pF	AVX	06035A820JAT2A	Capacitor, CER, 0603, 50 V, 5%, 82 pF	C5, 7
2	120 pF	AVX	06035A121JAT2A	Capacitor, CER, 0603, 50 V, 5%, 120 pF	C6, 21
1	1000 pF	AVX	06035A102JAT2A	Capacitor, CER, 0603, 50 V, 5%, 1000 pF	C39
2	5600 pF	AVX	06035A562JAT2A	Capacitor, CER, 0603, 50 V, 5%, 5600 pF	C13, 22
25	0.1 µF	AVX	0603YC104KAT2A	Capacitor, CER, 0603, 16 V, 10%, 0.1 µF	C19, 23, 30, 31, 33, 34, 37, 40, 41, 43, 44, 45, 46, 48, 49, 50, 51, 52, 53, 55, 56, 57, 58, 59, 66
4	1 µF	AVX	TAJA105K016R	Capacitor, TANT, 3216, 16 V, 10%, 1 µF	C26, 27, 28, 29
4	22 µF	CAL CHIP	GMC32Z5U226Z16NT	Capacitor, CER, 1210, 16 V, −20 +80%, 22 µF	C32, 42, 47, 60
5	RED	KingBrite	W934–IT	Diode, LED, T1, red, 12.5 MCD at 20 mA	D1, 8, 10, 11, 12
2	GRN	KingBrite	W934–GT	Diode, LED, T1, green, 12.5 MCD at 20 mA	D5, 6
2	YEL	KingBrite	W934–YT	Diode, LED, T1, yellow, 12.5 MCD at 20 mA	D2, 4
2	ORN	KingBrite	W934–??	Diode, LED, T1, orange, 12.5 MCD at 20 mA	D3, 7
2	MBRM120LT	Motorola	MBRM120LT1 or 3	Diode, Schottky, 20 PIV, 1A, DO–216AA	D9, 13
3	FMMT2222A	Central SEMI	CMPT2222A	XSTR, NPN, Gen Purp, 75 hfe, 40 Vceo, 600 mA, SOT23	Q1, 2, 3
1	10.7 MHz	Murata	SFECS10M7FA00-R0	Filter, BP, SMT, 10.7000 MHz CEN, 280 kHz, BW	FL4
1	8.2 nH	Murata	LQW1608A8N2D00	IND, SMD, 0603, ±0.5 nH, 650 mA, 8.2 nH	L5
1	9.1 nH	Murata	LQW1608A9N1D00	IND, SMD, 0603, ±0.5 nH, 650 mA, 9.1 nH	L4
2	4.7 µH	Murata	LQG21N4R7K10	IND, SMD, 0805, Hi-Q, 30 mA, 4.7 µH	L1, 2
10	0 Ω	AVX	CJ10-000-T	Resistor, 0603, 5%, 0 Ω	C62, FL2, JP1, L6, R6, 29, 41, 42, 56, 60
9	10 Ω			Resistor, 0603, 5%, 10 Ω	R32, 35, 36, 37, 38, 39, 40, 43, 44

Qty	Value	Mfg	Mfg Num	Description	Reference
21	100 Ω			Resistor, 0603, 5%, 100 Ω	R21, 22, 23, 24, 25, 26, 27, 28, 45, 46
3	200 Ω			Resistor, 0603, 5%, 200 Ω	R61, 62, 63
1	1 kΩ			Resistor, 0603, 5%, 1 kΩ	R11
1	7.5 kΩ			Resistor, 0603, 5%, 7.5 kΩ	R9
13	10 kΩ			Resistor, 0603, 5%, 10 kΩ	R13, 14, 15, 16, 17, 18, 19, 20, 33, 57, 64, 65, 66
1	15 kΩ			Resistor, 0603, 5%, 15 kΩ	R10
1	82 kΩ			Resistor, 0603, 5%, 82 kΩ	R30
1	220 kΩ			Resistor, 0603, 5%, 220 kΩ	R7
1	Header 7X2	SAMTEC	TSW–107–07–T–D	CONN, HDR, P, 14, 7X2X0.1, TTH	J2
1	Header 7x2x2mm	SAMTEC	TMM–107–01–T–D–SM	CONN, HDR, P, 14, 7×2×2 mm, SMT	J5
1	Header 3	MOLEX	22–28–4030	CONN, HDR, P, 3, 3X1X0.1, TTH	JP2
1	CONN DB–9	AMP	745781–4	CONN, PCB, DB9, F,RT	J1
1	SMA EDGE	Johnson Components	142–0701–801 (–801=Au Plate)	CONN, Coax, SMA, Edge, SMT, 0.062 thick PCB	CO1
1	4 x SPST	CTS	219–4MST	SW, Slide, 4 × SPST, 20V at 100 mA, SMT, Sealed	SW1
4	PB SPST, NO	OMRON	B3W–4050 + B or S	SW, PB–SPST, NO, 50 mA, 24V, TTH	SW2, 3, 4, 5
1	EG1218	E–Switch	EG1218	SW, Slide SPDT, PCB, 30V at 0.2a	SW6
1	AS179–92	SKYWORKS	AS179–92	IC, RF switch, 1P2T, 0.1–3GHz, SC–70	SW7
1	12 mm Switch Capacitor	OMRON	B32–1320	Capacitor, SW, 12 mm sq, fits B3W–4050, orange	
1	12 mm Switch Capacitor	OMRON	B32–1330	Capacitor, SW, 12 mm sq. fits B3W–4050, yellow	
1	12 mm Switch Capacitor	OMRON	B32–1350	Capacitor, SW, 12 mm sq. fits B3W–4050, green	
1	12 mm Switch Capacitor	OMRON	B32–1380	Capacitor, SW, 12 mm sq. fits B3W–4050, red	
1	2468	Mem ProtectionDev	BC2AAAPC	Battery holder, 2 X AAA, PCB mount	BAT1
1	TP Red	Components Corp	TP–105–01–02	Test Point, red, 0.037 TTH	TP2
3	TP Green	Components Corp	TP–105–01–05	Test Point, green, 0.037 TTH	TP1, 3, 5
1	TP White	Components Corp	TP–105–01–09	Test Point, white, 0.037 TTH	TP4
1	TRF6903PT	Texas Instruments	TRF6903PG2.0	IC, RF XCVR, 315–930 MHZ, FQFP48	U1
1	MSP430F449	Texas Instruments	MSP430F449IPZ	IC, MicroP ,MixSig, 16 Bit RISC, 32kb Flash, FQFP100	U6
0	TPS76330DBV	Texas Instruments	TPS76330DBVT	IC, PS LDO Regulator, 3 V at 150 mA, SOT32–5	U3
1	MAX3232–SOIC 16	Texas Instruments	MAX3232CD	IC, RS232 Driver, 2 Driver, 2 Receiver, SOIC16	U4

Qty	Value	Mfg	Mfg Num	Description	Reference
1	NC7SZ04P5X	Fairchild	NC7SZ04P5X	IC, INV, Single Gate, SO70–5	U7
1	10.7 MHz	Murata	CDSCB10M7GA119-R0	CER Discriminator, SMT, 10.7 MHz	Y7
1	19.6608 MHz	CRYSTEK Corp	017119	XTAL, SMT, 19.6608 MHz, LCC–5X7	Y2
1	32.768 kHz	Seiko	628–SPT1A–0368	XTAL, SMT, 32.768 kHz, CM202	Y4

4.7 Alternate Hardware Configurations

The MSP-TRF6903-DEMO kit is preconfigured to function under the following assumptions:

❏ North American ISM frequency band, 902–928 MHz

❏ NRZ (non-return to zero) coding

❏ FSK (frequency shift keying)

❏ 38.4K bps

❏ On-board PCB antenna

The kit can be reconfigured to a limited extent. These options are covered in this section.

4.7.1 European ISM Frequency Band

The European 868-MHz to 870-MHz ISM band is not covered in the preconfigured system, but it can be modified by changing software variables; download new software configurations through the JTAG connector. No hardware changes are needed, but the antenna matching is not optimized for this band. Go to www.ti.com/ismrf for more information.

4.7.2 External Antenna

Significant range performance may be achieved when an external antenna is used. The actual performance improvement depends on the antenna design and proper impedance matching. A solder pad for a SMA connector is provided on the circuit board. The antenna can be mounted onto the SMA connector. Jumper (JP1) setting must be moved to connect the external antenna to the rest of the RF front end. Shorting pins 2 and 3 of JP1 with a 0-Ω resistor connects the circuit board antenna. To connect an external antenna, open pins 2 and 3 and short pins 1 and 2 with a 0-Ω resistor. Figure 4–5 shows the pin-out configuration at the silk screen. Table 4–1 lists information for some antenna suppliers. If the PCB antenna is not used, leave it unconnected, remove the matching components from each end, and substitute one 100-Ω resistor at each end; this prevents unwanted coupling between the PCB antenna and the RF signal.
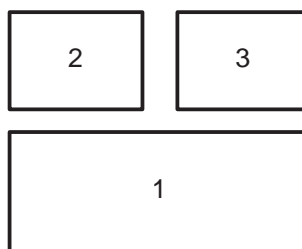
Figure 4–5. JP1 Pin-Out Configuration

Table 4–1. Antenna Suppliers

Supplier	Web Site	Part Number	ISM Band
Nearson	www.nearson.com	S467AM–915S	US European
MaxRad	www.maxrad.com	MEXR902SM	US
Mobilemark	www.mobilemark.com	PSWN3–925S	US European
W. Badland Ltd.	www.badland.co.uk	Various models	US/European
Radiall/Larsen	www.radialllarsen.com	Various models	US European

4.7.3 RS-232C Port

The circuit board is designed for communication to the MSP430 microcontroller through the RS232 serial port. The UART driver is implemented in firmware and is used in the RF evaluation mode.

4.7.4 On-Board LDO Voltage Regulator

In normal operation, the battery is connected directly to the circuit board power through R31. There is a footprint for a low dropout (LDO) regulator for cases where a higher-voltage power supply is used instead of the on-board batteries. To add a LDO regulator, remove R31 and install Texas Instruments regulator TPS76330DBV at the U3 footprint.

4.7.5 High-Frequency Crystal

The board has a footprint for a high-frequency (4 MHz) microprocessor crystal (Y3) as well as the low-frequency crystal. The factory board configuration uses the 32-kHz watch crystal (Y4). An internal frequency multiplier generates the 2.4576-MHz system clock.

4.7.6 SAW Filter

A SAW filter is typically used to band-limit the received RF signal and reduce RF interference outside the ISM band. The SAW filter from Murata (SAFC915MA70N-TC11) gives a pass band typical of 902 MHz to 928 MHz, while providing about 30-dB attenuation in the stop band. Insertion loss in the

pass band is about 4.5 dB. This causes a corresponding loss in operational range due to signal attenuation. The SAW filter is not normally installed at the factory in order to maximize range rather than noise immunity. There are other hardware configurations for attenuating transmitter harmonics and filtering out-of-band received noise.

4.7.7   Disabling the MSP430

In normal operation, the MSP430 microprocessor controls the TRF6903 transceiver and the game user interface. The RF section can also be controlled directly with external computer software. To disable the microcontroller, either short the MSP430 reset pin (RST) to ground at the JTAG connector (preferred method), or remove R42, which disables the voltage supply to the MSP430. The TRF6903 can then be controlled directly through J5, the 14-pin surface-mount header.

4.7.8   Game and RF Operational Modes (Jumper JP2)

The circuit board comes with jumper JP2 set in the position for the game (demonstration link) mode, where two circuit boards communicate with each other in game mode to demonstrate a wireless link. In the other jumper position (RF evaluation mode), the TRF6903 is controlled from external software run on a PC and the commands are passed through the MSP430.

Software Overview

This chapter describes the link demonstration firmware that has been flashed to the microcontroller and external control software for RF test and evaluation.

5.1 Software Description

The demonstration software implements a simple two-way game application utilizing a half-duplex bidirectional wireless link. Each board comes with identical software. The software was developed using IAR's Embedded Workbench, version 1.26a (www.iar.com). The software files are:

❑ trf6903.prj – Project file

❑ trf6903_main.c – Main body of the program written in C language. All subroutines are called from this program

❑ trf6903.s43 – Assembly subroutine to configure the TRF6903 registers

❑ radio03.s43 – Assembly subroutines that execute wireless transmission and reception commands

If a newer version of the IAR compiler (Version 2.21B) is used for development, the old project file (.prj) needs to be converted to a workspace project file (.ewp). The conversion is one-way (not reversible). See the guide to run demo software on newer version (2.12B) of IAR compilers (SLWA029.pdf) for more detailed information.

5.2 Flowchart

After power up initialization, the controller is configured as a state machine to run the link demonstration. Figure 5–1 illustrates the state machine flowchart. Buttons and timer functions are handled through interrupt subroutines.

Figure 5–1. Game Application Flow Chart
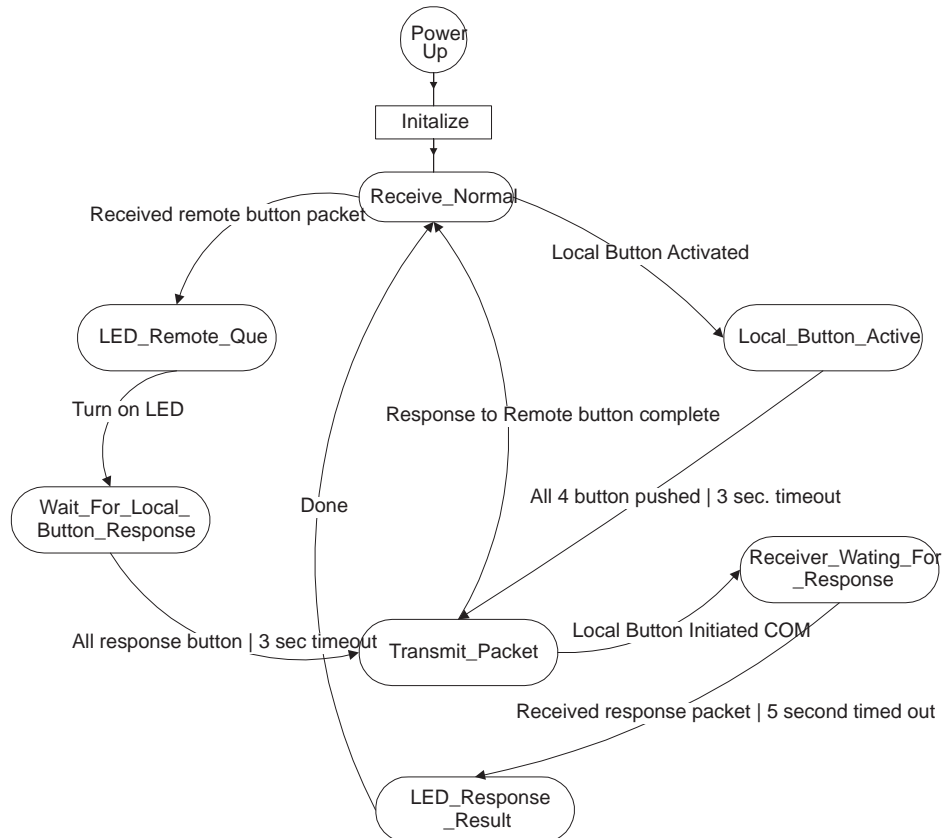
5.3 Wireless Protocol

The wireless data communication protocol is digital FSK at 38,400 bits per second with NRZ coding. The communication protocol used for the demonstration board includes preamble, packet start bit, and word-sync bit as illustrated in Figure 5–2.

Figure 5–2. Communication Protocol
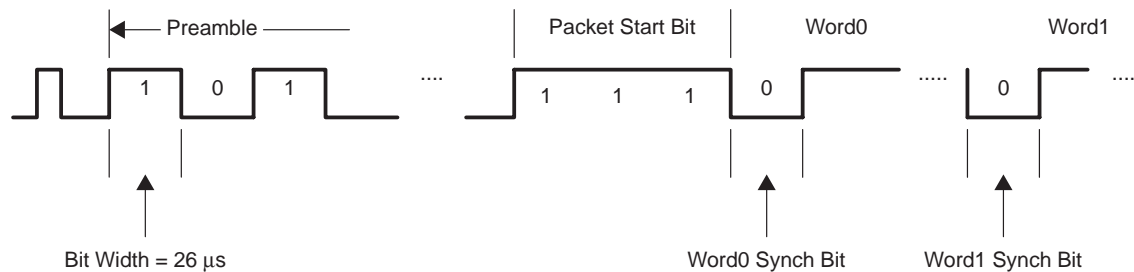
The function of the preamble is to train the receive hardware to set the proper reference voltage threshold to extract 1 and 0 data. The preamble consists of a train of alternating ones and zeros. A longer preamble may give better performance at a cost of more time to deliver an equivalent data packet. The current design has a preamble 100 bits long, or 2.6 ms in duration. Shorter lengths may be used for more time-critical applications.

5.3.1 Packet Start and Word-Sync Bits

The packet start bit and the word sync bit are used by the receive routine to adjust microprocessor timing for sampling the incoming data stream. The packet start bit occurs once at the beginning of the data packet to indicate the end of the preamble and the start of data. The sync bit is used to resynchronize the bit stream and the data sampling timer. Over time the receive timing could shift in phase relative to transmit timing due to the small variation in component tolerances and performance. This shows up as an error in sampled data. The problem gets worse as the packet size increases. Resynchronization minimizes this drift over time.

Although resynchronization can be done at byte boundaries, word boundary resynchronization is slightly more efficient.

The data clock recovery feature can also be used to synchronize data.

5.3.2 Wireless Data Stream

The wireless data stream for the game application is implemented as follows:

❑ User initiates an RF transmission on **Board A** by pushing four buttons in any sequence.

❑ User sequence is sent to **Board B** using the transmission data packet described in Figure 5–3, embedded in the communication protocol described in Figure 5–2. The transmission packet includes a header, four bytes with the button IDs and a checksum.

❑ **Board A** waits to receive an acknowledgement packet sent by the other board. The acknowledgement (ACK) package is illustrated in Figure 5−4. The ACK package is embedded in the protocol described in Figure 5−2. If **Board A** does not get the ACK package in the preprogrammed wait cycle, it retries up to six times.

❑ Note that each time that **Board B** receives a transmission packet, it sends an acknowledgment back to **Board A**. Figure 5−4 illustrates the ACK packet.

Figure 5−3. 6-Byte Transmission Data Packet

Header Byte	Button 1	Button 2	Button 3	Button 4	Checksum Byte
0xFE	ID Byte	ID Byte	ID Byte	ID Byte	

Figure 5−4. 4-Byte ACK Packet

0x06	0x06	0x06	0x06

5.3.3 Checksum Byte

Each packet has a checksum byte at the end of the data packet (see Figure 5−3). The checksum byte is calculated by summing the first 5 bytes of the packet and ignoring overflow.

5.4 TRF6903 Registers

The TRF6903 has five control registers (A through E) that are initialized using through an on-chip serial port interface (SPI). Table 5−1 shows the values loaded into the registers by the microprocessor during demo program initialization.

Table 5−1. TRF6903 Game Application Register Values

Register	Parameter	Value
A	PA attenuation Mode 0 Charge Pump Frequency Band	0 dB Tx 0.5 mA 915 MHz
B	PA attenuation Mode 1 Modulation Brownout threshold Brownout detector	0 dB Rx F2.2 VSK Off
C	Reference divider Reference frequency	48 409.6 kHz
D	Crystal Tune Reset Signal for PFD Crystal Switch	20.23 pF Derived From Prescaler Closed
E	Receive Data Mode (RXM) Dividers D1 D2 D3 Transmit Capture select	Self Train 38.4 kbps Set

5.5 Wireless Subroutines

The game application uses C language functions to implement different communication tasks that are required to receive and send data. Brief descriptions of these subroutines follow.

5.5.1 program_TRF6903_word()

This function configures one of the five registers of the TRF6903 transceiver. Below is a sample code on how to use this function so that you can program all five registers.

```
struct REGA_BITS {
unsigned long BND:2;
unsigned long CP_Acc:2
unsigned long PI:1;
unsigned long TX_RX0:1;
unsigned long PA0:2;
unsigned long B_DIV_M0:9;
unsigned long A_DIV_M0:5;
unsigned long ADDR:2; };
union TRF_REGA{
  unsigned long all;
  struct REGA_BITS bit;
};
struct TRF_REG{
  union TRF_REGA a;
  union TRF_REGB b;
  union TRF_REGC c;
  union TRF_REGD d;
  union TRF_REGE e;
};
void configure_trf6903(void)
{
    int pointer;
    P4OUT&=0xfe;
    pointer=(int)f_sel;
    trf6903.a.bit.B_DIV_M0=MAIN_B_T[pointer];
    trf6903.a.bit.A_DIV_M0=MAIN_A_T[pointer];
    program_TRF6903_word(trf6903.a.all);
    trf6903.b.bit.B_DIV_M1=MAIN_B_R[pointer];
    trf6903.b.bit.A_DIV_M1=MAIN_A_R[pointer];
    program_TRF6903_word(trf6903.b.all);
    program_TRF6903_word(trf6903.c.all);
    trf6903.d.bit.XTAL_Tune = XTAL_OFFSET;
    program_TRF6903_word(trf6903.d.all);
    program_TRF6903_word(trf6903.e.all);
```

5.5.2   receive_RF(unsigned char, unsigned int*)

This function is used to receive a packet of wireless data stream. Below is an example of how it is used.

```
union RF_RCV_PACKET{
   unsigned int w[MAXWORD];
   unsigned char b[MAXBYTE];
}rcv;
int ReceiveRFWithModeSelect(unsigned int ByteCnt)
 {
int error_stat;
switch(trf6903.e.bit.RXM){
case 0:
 error_stat = receive_RF(ByteCnt,rcv.w);
   break;
case 3:
 error_stat = receive_RF_DCLK(ByteCnt,rcv.w);
 break;
// Packet stream stored in rcv.w
// Packet size stored in ByteCnt
 }
}
```

5.5.3   send_RF(unsigned int, unsigned int*)

This function is used to transmit a packet of wireless data stream. Below is an example of how it is used.

```
union RF_XMIT_PACKET{
   unsigned int w[MAXWORD];
   unsigned char b[MAXBYTE];
}xmit;
void SendRFWithModeSelect(unsigned int ByteCnt)
{
switch(trf6903.e.bit.TXM){
case 0:
 send_RF(ByteCnt,xmit.w);
 break;
case 1:
 send_RF_DCLK(ByteCnt,xmit.w);
 break;
 }
}
```

5.6 External Control Software for RF Evaluation Mode

In the RF evaluation mode, the TRF6903 transceiver is controlled by external software run on a PC rather than by the game/demo firmware installed on the MSP430. There is no operational link in RF evaluation mode; the transceiver is set to one operational state at a time. Jumper JP2 sets the board operation mode to game/demo or RF evaluation.

The RF control software has a graphical user interface (GUI) for the user to set the transceiver state for mode (transmit, receive), frequency, power, etc. In RF mode the external software GUI controls the TRF6903 by passing control register words through the computer COM1 serial port, RS232 driver IC (MAX3232), and finally through the MSP430 microcontroller to the transceiver.

Figure 5–5 shows the graphical user interface that communicates with the circuit board through the COM1 RS232 serial port. The user must click on the adjacent COM1 button if its caption reads *Com1 Closed* in order to open the serial port. The RF evaluation GUI is written in Borland C++ Builder, version 6, and integrates utilities from Winsoft Ltd. to write to the serial port (ComPort). In RF evaluation mode, the serial port COM1 is used to control the TRF6903.

An example GUI setup for **transmit mode** is shown in Figure 5–5. Several boxes and pick lists have to be filled out by the user before clicking the *Send All* button to configure the RF transceiver. Some of the boxes will toggle state when the cursor is placed over the box contents and double clicked (Mode Enable).

The crystal frequency should be set to 19.6608 MHz. Set the reference divider to 48 (enter the value and click the *Set* button). The crystal tune capacitance should be set to an intermediate value like 17, 20, or 22 pF. The charge pump current is 0.5 mA. In the Mode Enable box, *A-Word* should be selected for transmit mode. The phase-frequency detector reset should be set to *Prescaler*. Enter the power amp output frequency and click the *Set Frequency* button; the software rounds off the output frequency to an integer multiple of the reference frequency. The output divider (BND) should be set to 1 for the 868-MHz and 915-MHz ISM bands. The Modulation box should be set to FSK. For initial evaluation, set TXM=0 and TXDATA to *Low*.

An example GUI setup for **receive mode** is show in Figure 5–6. Set the Mode Enable box contents to *B-Word* and *Receive*. Set the incoming receive signal frequency and click the *Set Freq* button; the LO frequency will be set to an integer multiple of the reference frequency. The user can set the LO frequency 10.7 MHz above or below the received RF signal by clicking on the box for high-side Injection or low-side Injection. For initial evaluation, set the data slicer polarity to non-inverting, RXM=CLK Recovery, BRA=8, BRB=4, BRC=16, operational mode to Learn, TWO=0, TCOUNT=7, and Demod Tune to an intermediate value like 3 or 4. If the down-converted IF signal is shifted high in the 10.7-MHz filter bandwidth, try setting the RXS crystal switch to *Closed* during reception (and vice-versa).

The TRF6903 is capable of transmit or receive operation in both mode 0 and mode 1 (configured by the A and B register words), but due to the hardware

configuration for the transmit/receive switch, transmit must be done in mode 0 and receive in mode 1. The tx_enable and rx_enable control lines for the switch are derived from the TRF6903 mode control line. In other hardware designs the switch control lines can originate at the microcontroller and can be programmed for transmit/receive in either transceiver mode, 0 (Word A) or 1 (Word B).

Other communication utilities such as HyperTerminal or Procomm can be used in place of the external software GUI to control the TRF6903 in pass-through mode. Set the transmission raw data rate to 38.4 kbps, 8 bits data, no parity, 1 stop bit, no flow control, or handshake. Send the 24-bit control words for registers A through E in ASCII hex with a leading asterisk (hex 2A) and trailing carriage return (hex 0D), i.e. "*[A][B][C][D][E]<CR>".

Figure 5−5. TRF6903 Graphical User Interface for RF Evaluation, Transmit Mode
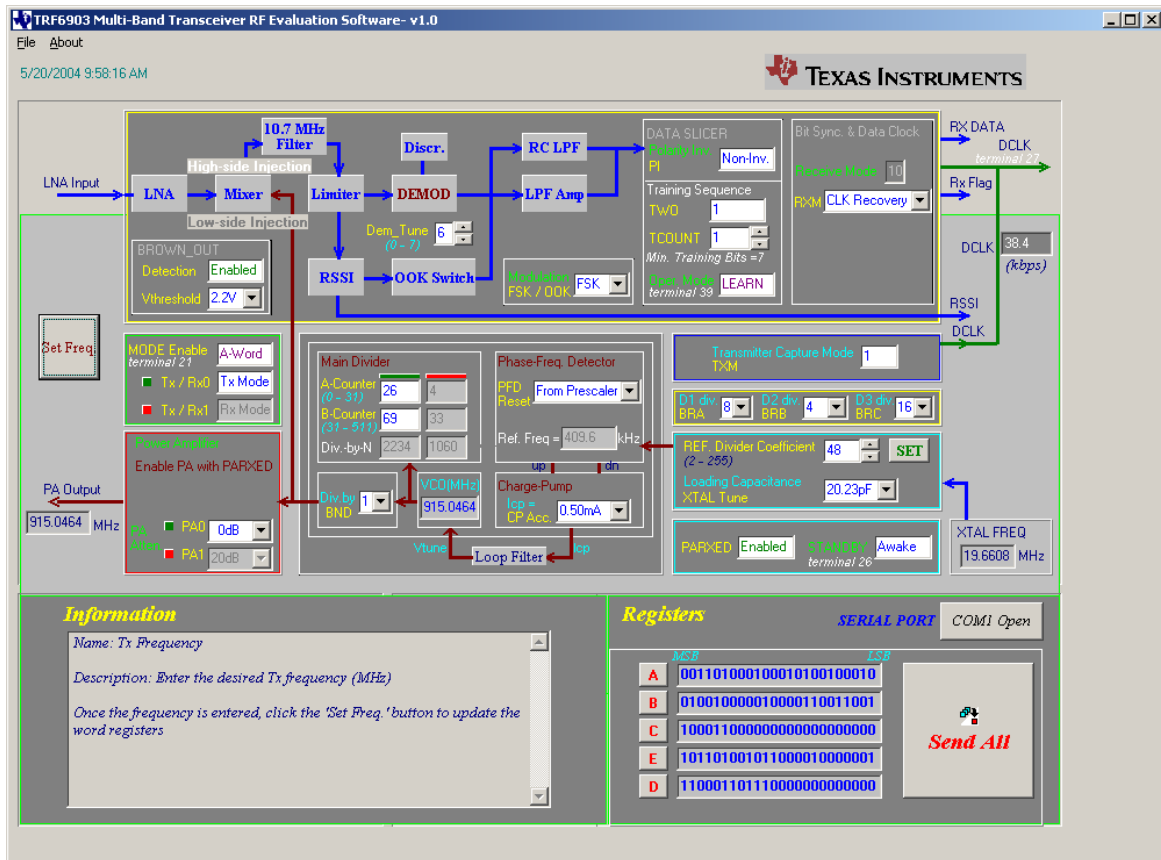
Figure 5–6. TRF6903 Graphical User Interface for RF Evaluation, Receive Mode

5.7 Operation of the Evaluation Kit in the European ISM Band

The European ISM band covers the frequency band from 868 MHz to 870 MHz. A different set of firmware needs to be downloaded to operate the evaluation kit at the EU band. The firmware can be downloaded from the **www.ti.com/ismrf** website. See the application report *Operating the TRF6903 with MSP430 Evaluation Kit in the 868-MHZ European ISM Band* (SWRA040) for detailed information on the 868-MHz EU operation mode.

Read This First

About This Manual

This document presents the contents of the TRF6903 demonstration and development tool kit. The user manual provides information on how to operate the MSP-TRF6903-DEMO kit and describes its hardware and software. Users should understand the MSP430F449 and the TRF6903 to obtain the full benefit of this user manual.

How to Use This Manual

Different topics covered in this manual may require different levels of expertise. The first two chapters are focused on how the kit operates.

If you want to build your own prototype, review the third chapter on how to load firmware. The later chapters cover hardware and software topics that may require some additional expertise.

This document contains the following chapters:

❏ Chapter 1 — TRF6903 Demonstration and Evaluation Kit Overview

❏ Chapter 2 — Demonstsration a Wireless Link

❏ Chapter 3 — Protoyping

❏ Chapter 4 — PCB Hardware Overview

❏ Chapter 5 — Software Overview

Related Documentation From Texas Instruments

Other related Texas Instruments documents that may be helpful are:

❏ TRF6903 data sheet – (SWRS022)

❏ MSP430F449 data sheet – http://focus.ti.com/lit/ds/symlink/msp430f449.pdf

❏ TRF6903 design guide – (SWRA0xx)

❏ TRF6901 FAQ – http://focus.ti.com/lit/misc/slad008/slad008.pdf

Product Websites

For design and product information related to the TRF6903, MSP430, and similar products, go to:

❑ http://www.ti.com/ismrf

❑ http://www.msp430.com

PDF documents and zip files may be located on Texas Instruments' website by typing in the literature number in the *Search* text box; for example, typing in *SWRS022* will locate the TRF6903 data sheet.

FCC Warning

This equipment is intended for use in a laboratory test environment only. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

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TRF6903 With MSP430 Demonstration and Development Evaluation Kit

User's Guide

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