Texas Instruments

TRF6901

with MSP430 Demonstration and Development Evaluation Kit

User's Guide

June 2004 *Digital Radio RF Group*

SLWU008B

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Preface

Read This First

About This Manual

This document presents the contents of the TRF6901 demonstration and development tool kit. The user's manual provides a thorough understanding on how to operate the MSP-TRF6901-DEMO kit and provides a detailed description of its hardware and software. Some level of product understanding regarding the MSP430F449 and the TRF6901 is required to obtain the full benefit of this user's guide.

How to Use This Manual

Different topics covered in this manual may require different levels of expertise. If this is the first time you are using the MSP-TRF6901-DEMO kit, you should start with the first three Chapters. Chapter 1, *TRF6901 Demonstration and Development Kit Overview*, provides a general overview of the kit. Chapter 2, *Demonstrating*, and Chapter 3, *Prototyping* are focused on how to operate the kit.

If your ultimate goal is to prototype with this kit, you should then review, in detail, Chapter 4, *PCB Hardware Overview* and Chapter 5, *Software Overview*, to get an understanding on how the wireless bidirectional link demonstration works. These two chapters cover hardware and software ideas that you may require some additional level of expertise.

Notational Conventions

ACK	Acknowledgement packet
JTAG	Scan-based embedded system emulation
MSP-TRF6901-DEMO	TRF6901 demonstration and development kit
RF	Radio frequency
RSSI	Receive signal strength indicator

Information About Cautions and Warnings

This book may contain cautions and warnings.

This is an example of a caution statement.

A caution statement describes a situation that could potentially damage your software or equipment.

CAUTION

This is an example of a warning statement.

A warning statement describes a situation that could potentially cause harm to you.

WARNING

The information in a caution or a warning is provided for your protection. Please read each caution and warning carefully.

Related Documentation From Texas Instruments

Other related documents that may be helpful are:

- TRF6901 datasheet - http://focus.ti.com/lit/ds/symlink/trf6901.pdf
- MSP430F449 data sheet - http://focus.ti.com/lit/ds/symlink/msp430f449.pdf
- TRF6901 design guide - http://focus.ti.com/lit/an/swra035/swra035.pdf
- TRF6901 FAQ - http://focus.ti.com/lit/misc/slad008/slad008.pdf

If You Need Assistance

For more design and product information related to the TRF6901 and the MSP430 go to the following two web sites:

- http://www.msp430.com
- http://www.ti.com/ismrf

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 their own expense will be required to take whatever measures may be required to correct this interference.

Disclaimer

Please note that the enclosed demonstration boards are experimental printed circuit boards and are therefore only intended for device evaluation

We would like to draw your attention to the fact that these boards have been processed through one or more of Texas Instruments' external subcontractors which have not been production qualified. Device parameters measured, using these boards, are not representative of any final data sheet or of a final production version. Texas Instruments does not represent or guarantee that a final version will be made available after device evaluation.

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The demonstration board may be operated only for product demonstration or evaluation purposes and then only in nonresidential areas. Texas Instruments understanding is that the customers' products using the RF parts listed shall be designed to comply with all applicable FCC and appropriate regulatory agency requirements and will, upon testing, comply with these requirements. Operation of this device is subject to the conditions that it does not cause harmful interference and that it must accept any interference.

Contents

Figures

Tables

Chapter 1

TRF6901 Demonstration and Development Kit Overview

This chapter provides an overview of the TRF6901 demonstration and development kit.

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1.1 Description

The MSP-TRF6901-DEMO kit is used to demonstrate a bidirectional RF (radio frequency) link without the need of a personal computer and to prototype by downloading new software code to the MSP430F449 using a JTAG connector. The schematics and layout of the board can be used as a reference design if desired, limited by the software system parameters provided for the demonstration.

1.2 Contents

Contained within the TRF6901 demonstration and development kit are the following:

- ❏ Two TRF6901 demonstration boards
- ❏ This user's guide

Software code 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-TRF6901-DEMO kit:

- ❏ Four (4) AAA batteries
- ❏ MSP430 bus expansion cable for the JTAG connector, required only for prototyping purposes

Chapter 2

Demonstrating

This chapter explains how to operate the MSP-TRF6901-DEMO kit to demonstrate a RF bidirectional link

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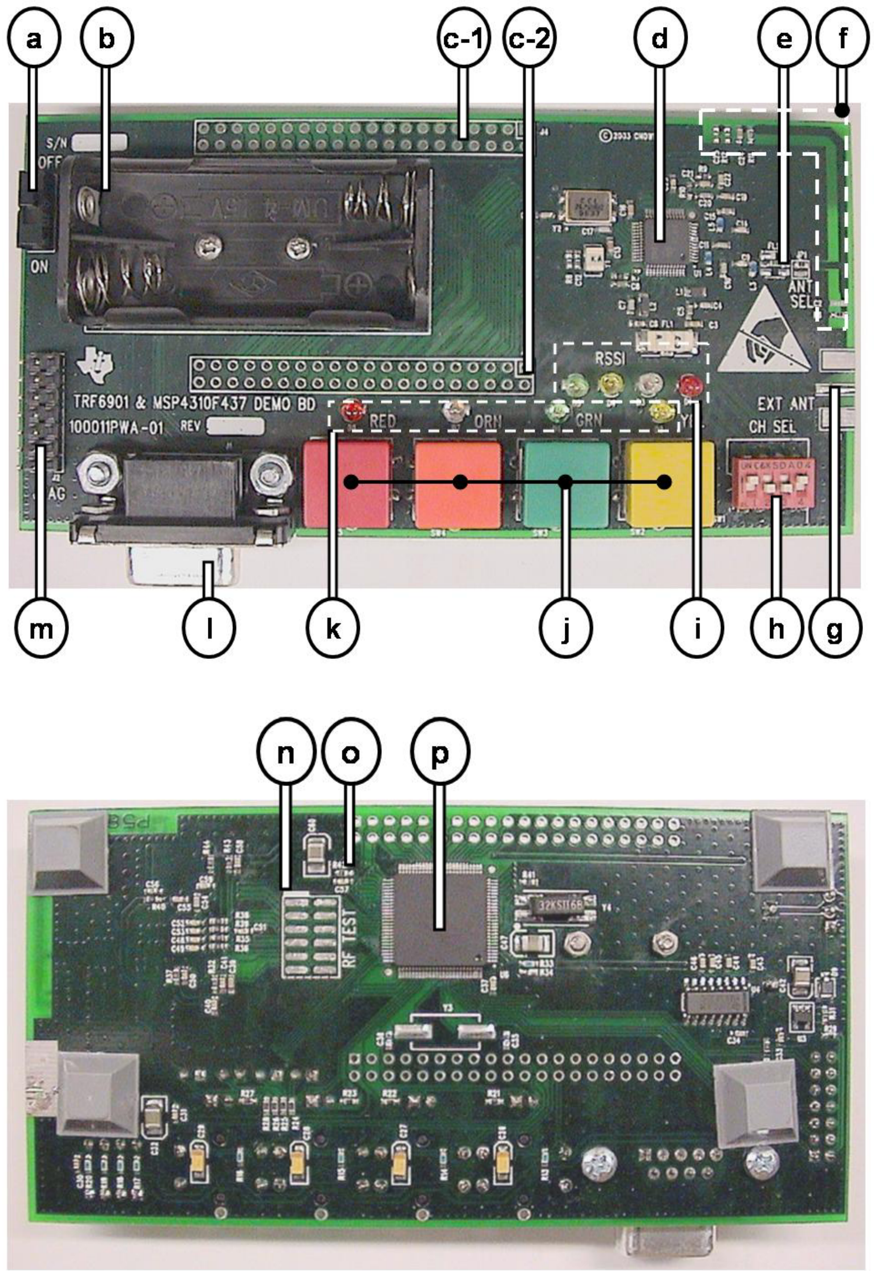
2.1 Board Description

The two boards that you have received with your kit are identical. Each unit has a TRF6901 single-IC RF transceiver and a MSP430F449 micro-controller. Each board is capable of sending and receiving half-duplex wireless data on the European and US ISM bands. The boards are pre-configured to use the 902 to 928 MHz ISM band out of the box. Figure 2-1 shows a top-side and back-side picture of each board.

Figure 2-1. Top-Side and Back-Side Picture of the Demonstration Board



Each board features the following functions:

a) On/Off switch

b) Battery holder: stores two AAA batteries in series (batteries are not included)

c) MSP430 headers: used to access the I/O ports of the MSP430F449

d) TRF6901 component

e) Antenna selection jumper used to select either the SMA connector or PCB antenna.

f) On board PCB antenna (default configuration)

g) SMA footprint connector used to add an external antenna (SMA connector not included)

h) 4-bit DIP switch used in the demonstration to change the frequency configuration. The MSP430 I/O ports P2.3, P2.6, P2.7, and P3.0 connect to the 4-bit DIP switch.

i) Receive signal strength indicator (RSSI) LEDs – used as the RSSI for the demonstration. The LEDs are tied to the MSP430 P6.0 to P6.3 I/O ports.

j) Four buttons used for the demonstration application; connected to the MSP430 P1.0 to P1.3 I/O ports.

k) Four LEDs used for the demonstration application; connected to the MSP430 P1.3 to P1.7 I/O ports.

l) RS-232C connector footprint (RS-232C circuitry is not included in the kit)

m) JTAG connector

n) TRF6901 I/O header used to control or monitor the TRF6901 component externally.

o) MSP430 disable jumper used to disable the MSP430F449 component

p) MSP430F449 component

2.2 Operation

A simple game is implemented in the firmware to demonstrate bidirectional RF communication. The transmit side initiates the game by pushing any sequence of four buttons. The user on the receive side responds by pushing the same button sequence. After a complete roundtrip, the transmit side illuminates one of three LEDs depending on the feedback 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 Getting Ready

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

- ❑ Slide the on/off switch to off
- ❑ Place two AAA batteries on each demonstration board
- ❑ Have the same 4-bit DIP switch (SW1) configuration on both boards

See Table 2-1 for a list of the US ISM band frequencies supported using the 4-bit DIP switch (SW1). It does not matter what 4-bit DIP switch setting you choose to operate the demo, as long as both boards have the same configuration.

Table 2-1. 4-bit DIP Switch (SW1) Frequency Configuration

1234 SW1 setting (1=On, 0=Off)	Frequency (MHz)
0000	902
0001	903
0010	904
0011	905
0100	906
0101	907
0110	908
0111	909
1000	910
1001	911
1010	912
1011	913
1100	914
1101	915
1110	916
1111	917

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 activities. The RSSI indicator LED is lit up to indicate the signal strength in the frequency of operation. Red indicates the lowest signal strength while green indicates the highest.

2.2.3 Wireless Demonstration

Either board can initiate a wireless communication. For explanation purposes, call **Board-A** the board that you use to transmit the first four-button sequence and **Board-B** the board that you are using to receive the first four-button transmission.

Use **Board-A** to start the wireless demonstration by pressing any sequence of four buttons with about 1/2 second in between. 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, respond by pushing the buttons in the exact sequence that the LED is displayed on **Board-B**.

If the response sequence matches, the green LED on **Board A** lights up. If there are errors due to bad transmission, lost transmission, or not matching response sequence, the red LED lights up. This completes the round trip RF communication demonstration.

On completion, both boards go back to listen mode to accept a new sequence.

2.2.4 RSSI Indicator

The boards are equipped with a receive signal strength indicator that will illustrate the signal strength on the receiver. 4 levels are used to indicate signal strength. Red is the lowest and means no signal received at all, 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 there is another external source interfering with that channel.

2.2.5 Error Conditions

Cycle power the system 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.

Chapter 3

Prototyping

This chapter explains how to operate the MSP-TRF6901-DEMO kit to prototype new applications

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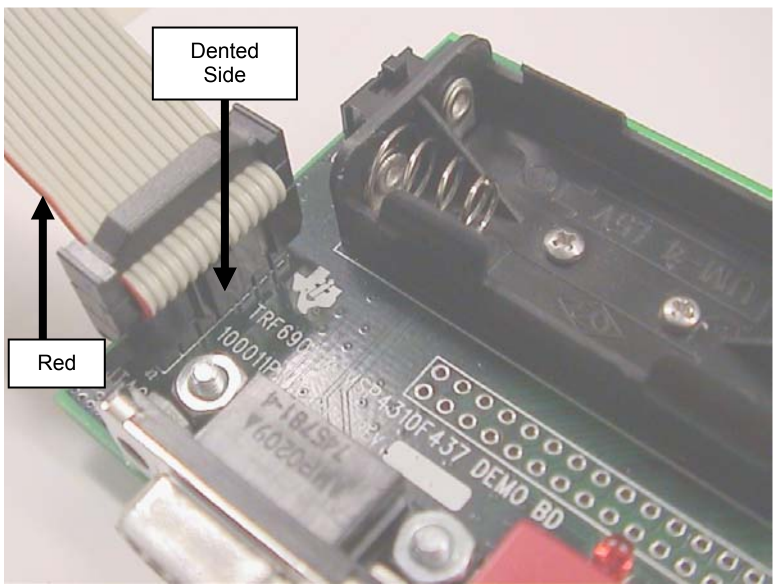
3.1 Connecting to the MSP430 JTAG

The MSP-TRF6901-DEMO is designed for rapid application development. This is made possible by the MSP430 MCU with flash memory that can be erased and programmed several times. Additionally, the on-chip emulation logic allows real-time debugging and fast code development.

BEFORE CONNECTING TO THE MSP430 JTAG, THE 2 AAA BATTERIES MUST BE REMOVED OR THE ON-OFF SWITCH MUST BE IN THE OFF POSITION.

Connector J2 provides access to the JTAG port of the MSP430 device in the MSP-TRF6901-DEMO kit. The MSP-FET430 flash emulation tool 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 debug, single stepping, multiple hardware breakpoints, full-speed operation and peripheral access are fully supported in-system using the JTAG. The MSP-TRF6901-DEMO and the MSP430 Flash Emulation Tool (FET) provide everything that is required to develop an entire project. Figure 3-1 shows the connections of the MSP-TRF6901-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-TRF6901-DEMO comes with complete source code to program the MSP430 to run the demo program. The user can develop new application software that can be downloaded to the MSP430 MCU using the JTAG connector. For practical purposes, the following procedure illustrates how to download the demo source code to the MSP430.

The project file for compiling the demo source code is trf6901_demo.prj. The following steps show how to open this project and program the MSP430:

Step 1. Remove the two AAA batteries or slide the On/Off switch to Off.

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

Step 3. Use FILE->OPEN to open the project file at: <Installation root>\…\ trf6901_demo.prj.

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 trf6901_demo.prj window.

Step 5. Ensure that C-SPY is properly configured (With DEBUG selected, PROJECT->OPTIONS->C-SPY); 1. PARALLEL PORT->PARALLEL PORT->LPT1 (default) or LPT2 or LPT3

Step 6. Use PROJECT->DEBUGGER to start C-SPY. C-SPY erases the device Flash, and then download to the device Flash the application object file.

Step 7. In C-SPY, use EXECUTE->GO to start the application.

Step 8. In C-SPY, use FILE->EXIT to exit C-SPY.

Step 9. In the Workbench, use FILE->EXIT to exit the Workbench.

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

Chapter 4

PCB Hardware Overview

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

Topic **Page**

4.1 Hardware Overview

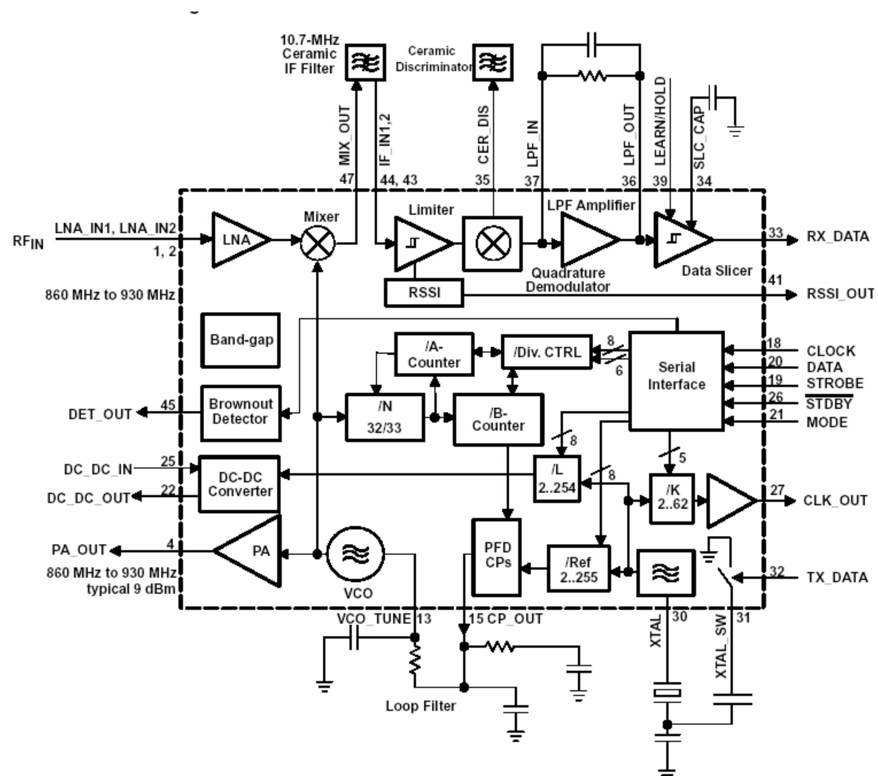
The TRF6901 ISM-band transceiver IC operates from 860 MHz to 930 MHz. It has low power consumption and an operating voltage of 1.8 V to 3.6 V. It uses an integer-N synthesizer and supports FSK operation. Other features include an on-chip reference oscillator, phase lock loop, brownout detector, and XTAL software trimming.

The TRF6901 demonstration and development kit (MSP-TRF6901-DEMO) provides a stand alone demonstration of a bidirectional link using the MSP430F449 and the TRF6901

4.2 TRF6901 RF Block Diagram

Figure 4-1 shows the block diagram of the TRF6901 ISM transceiver IC.

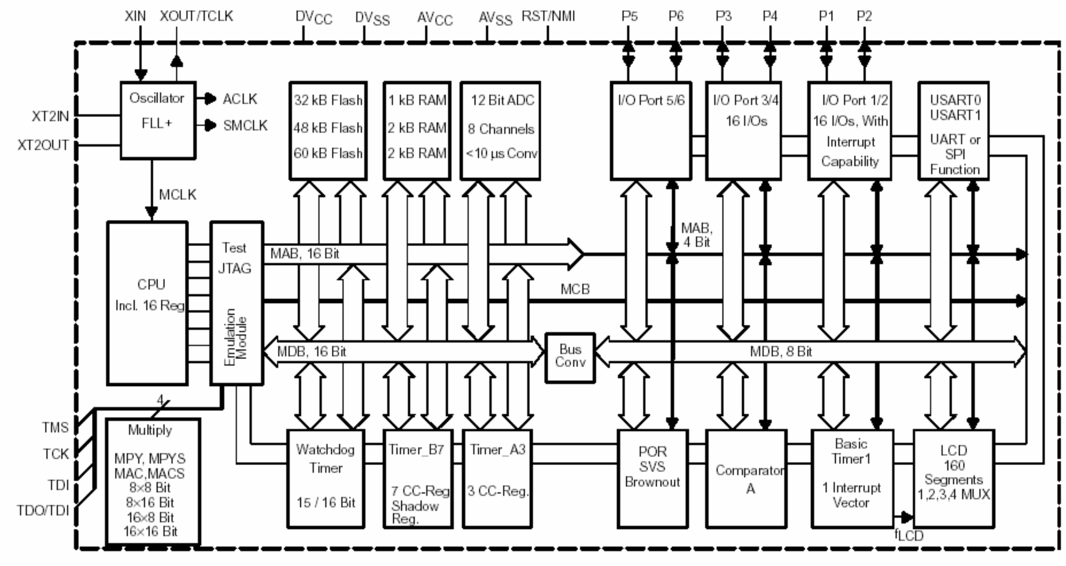
Figure 4-1. TRF6901 Block Diagram



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/slwc036.zip.

4.5 Top and Bottom Silk Screen and Drawing

Figure 4-3 shows the top-side silkscreen of the demo board and Figure 4-4 shows the bottom-side silkscreen.

Figure 4-3. Top-Side Silk Screen

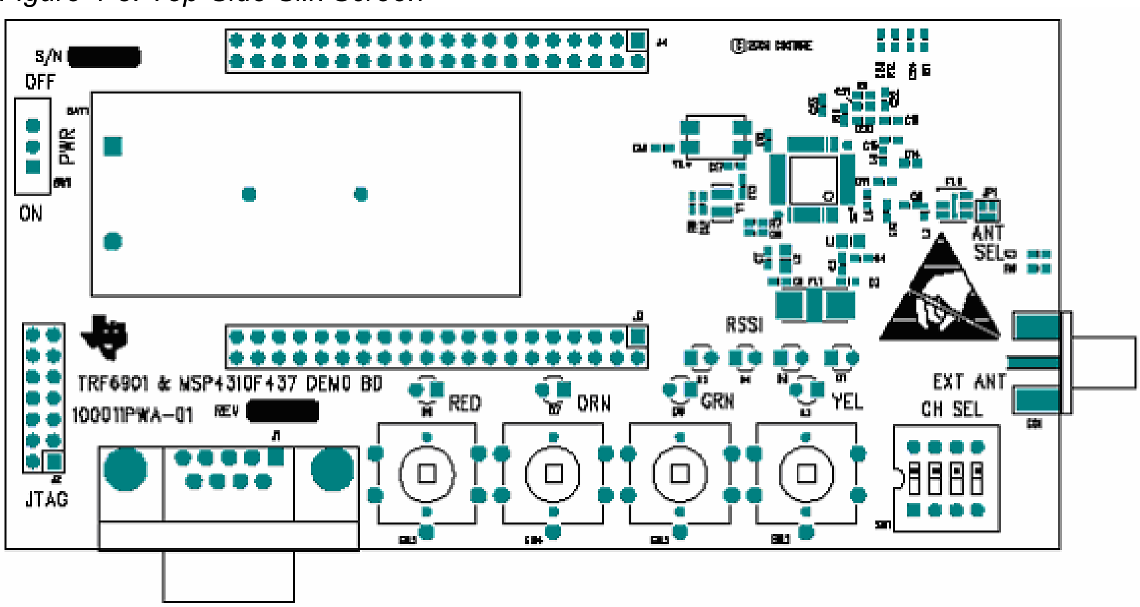
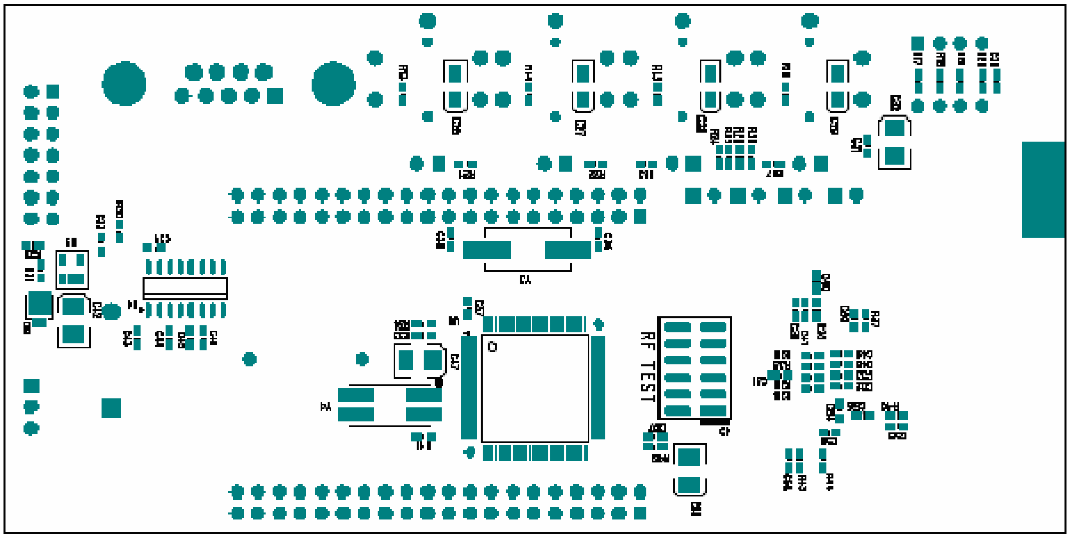


Figure 4-4. Bottom-Side Silk Screen



4.6 Parts List

Item	Qty	Value	Source	Part Number	Description	Reference
1	1	BAT 2 CELL	MEMORY PROTECTION DEVICES	BC2AAAPC	BATTERY HOLDER, 2 X AAA, PCB MOUNT	BAT1
2	1				CONN, COAX, SMA, EDGE, SMT, 0.062THK PCB	CO1
3	1	4.7pF	AVX	06035A4R7CAT2A	CAP, CER, 0603, 50V, +/-.25PF, 4.7PF	C2
4	2	82pF	AVX	06035A820JAT2A	CAP, CER, 0603, 50V, 5%, 82PF	C3,C5
5	3	15pF	AVX	06035A150GAT2A	CAP, CER, 0603, 50V, 2%, 15PF	C18,C4,C8
6	1	120pF	AVX	06035A121JAT2A	CAP, CER, 0603, 50V, 5%, 120PF	C6
7	2	68pF	AVX	06035A680JAT2A	CAP, CER, 0603, 50V, 5%, 68PF	C7,C17
8	1	22pF	AVX	06035A220FAT2A	CAP, CER, 0603, 50V, 1% , 22PF	C9
9	2	2.7pF	AVX	06035A2R7CAT2A	CAP, CER, 0603, 50V, +/-.25PF, 2.7PF	C11,C10
10	2	100pF	AVX	06035A101FAT2A	CAP, CER, 0603, 50V, 1%, 100PF	C20,C54
11	1	2200pF	AVX	06035A222JAT2A	CAP, CER, 0603, 50V, 5%, 2200PF	C13
12	1	2.2pF	AVX	06035A2R2CAT2A	CAP, CER, 0603, 50V, +/-.25PF, 2.2PF	C14
13	1	150pF	AVX	06035A151FAT2A	CAP, CER, 0603, 50V, 1%, 150PF	C15
14	3	1000pF	AVX	06035A102JAT2A	CAP, CER, 0603, 50V, 5%, 1000PF	C16,C21,C39
15	24	.1uF	AVX	0603YC104KAT2A	CAP, CER, 0603, 16V, 10%, 0.1UF	C19,C23,C30,C31,C33,C34,C37,C40,C41,C43,C44,C45,C46,C48,C49,C50,C51,C52,C53,C55,C56,C57,C58,C59
16	1	.01uF	AVX	06035C103KAT2A	CAP, CER, 0603, 50V, 10%, 0.01UF	C22
17	1	0.5pF	AVX	06035A0R5CAT2A	CAP, CER, 0603, 50V, +/-.25PF, 0.5PF	C24
18	4	1.0uF	KEMET	T491A105K016AS	CAP, TANT, 3216, 16V, 10%, 1.0UF	C26,C27,C28,C29
19	4	22uF	CAL CHIP	GMC32Z5U226Z16NT	CAP, CER, 1210, 16V, -20 +80%, 22UF	C32,C42,C47,C60
20	2	10pF	AVX	06035A100DAT2A	CAP, CER, 0603, 50V, +/-.5PF, 10PF	C36,C35
21	2	RED	LITEON	LTL-4222N	DIODE, LED, T1, RED, 12.5MCD @ 20MA	D8,D1
22	2	YEL	LITEON	LTL-4252N	DIODE, LED, T1, YEL, 12.5MCD @ 20MA	D2,D4
23	2	ORN	LITEON	LTL-4296N	DIODE, LED, T1, ORN, 12.5MCD @ 20MA	D7,D3
24	2	GRN	LITEON	LTL-4232N	DIODE, LED, T1, GRN, 12.5MCD @ 20MA	D6,D5
25	1	MBRM120LT3	MOTOROLA	MBRM120LT3	DIODE, SCHOTTKY, 20PIV,1A, DO-216AA	D9
26	1	SFECV10.7MS2S-A	MURATA	SFECV10.7MS2S-A-TC	FILTER, BP, SMT, 10.7000MHZ CEN, 230KHZ BW	FL1
27	1	47nH	MURATA	LQW1608A47NG00	IND, SMD, 0603 +/- 2%, 380mA, 47nH	JP1
28	1	HEADER 7X2	SAMTEC	TSW-107-07-T-D	CONN, HDR, P, 14, 7X2X0.1, TTH	J2
29	2	4.7uH	MURATA	LQG21C4R7N00T1	IND, SMD, 0805, 30%, 30mA, 4.7UH	L2,L1
30	1	8.2nH	MURATA	LQW1608A8N2D00	IND, SMD, 0603, +/- .5nH, 650mA, 8.2nH	L3
31	1	10nH	MURATA	LQW1608A10NG00	IND, SMD, 0603, +/- 2%, 650mA, 10nH	L4
32	1	6.8nH	MURATA	LQW1608A6N8D00	IND, SMD, 0603, +/- .5nH, ?mA, 6.8nH	L5
33	6	0	AVX	CJ10-000-T	RES, 0603, 5%, 0 OHM	R6,R29,R31,R34,R41,R42
34	1	220K			RES, 0603, 5%, 220K OHM	R7
35	9	10K			RES, 0603, 5%, 10K OHM	R13,R14,R15,R16,R17,R18,R19,R20,R33
36	1	6.8K			RES, 0603, 5%, 6.8K OHM	R9
37	1	18K			RES, 0603, 5%, 18K OHM	R10
38	1	1K			RES, 0603, 5%, 1K OHM	R11
39	8	100			RES, 0603, 5%, 100 OHM	R21,R22,R23,R24,R25,R26, R27, R28
40	1	82K			RES, 0603, 5%, 82K OHM	R30

41	8	10			RES, 0603, 5%, 10 OHM	R32,R35,R36,R37,R38,R39, R43,R44
42	1	1			RES, 0603, 5%, 1 OHM	R40
47	1	A6E-4104	OMRON	A6E-4104	SW, DIP, 4 X SPST, 24V @ 25mA, TTH	SW1
48	4	PB SPST, NO	OMRON	B3W-4050S	SW, PB-SPST, NO, 50MA, 24V, TTH	SW2,SW3,SW4,SW5
49	1	EG1218	E-SWITCH	EG1218	SW, SLIDE SPDT, PCB, 30V@0.2A	SW6
50	1	TRF6901PT	TI	TRF6901PT	IC, RF XCVR, 860-930MHZ, FQFP48	U1
51	1	MSP430F449	TI	MSP430F4449IPZ	IC, MICROCONTROLLER, MIXED SIGNAL, 16-BIT RISC, 32KB FLASH, FQFP100	U6
52	1	10.700MHZ	MURATA	CDSCA10M7GA119-R0	CER DISCRIMINATOR, SMT, 10.700MHZ,	Y1
53	1	20.000MHZ	CAL CRYSTAL LAB	CCL-SM7 20.00000MHZ J15F	XTAL, SMT, 20.0000MHZ, LCC4-7X5MM	Y2
54	1	32.768KHZ	CITIZEN	CM202-32.768KDZFT	XTAL, SMT, 32.768KHZ, CM202	Y4

4.7 Alternate Hardware Configurations

The MSP-TRF6901-DEMO kit is preconfigured to function under the following assumptions:

- ❑ US ISM-band
- ❑ NRZ (no return to zero)
- ❑ FSK (frequency shift keying)
- ❑ 38.4K bps
- ❑ On-board PCB antenna

The kit can cover some limited alternate configurations. These options are covered in this section.

4.7.1 European ISM-Band

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

4.7.2 External Antenna

Significant range performance may be achieved when an external antenna is used. The actual performance improvement will depend on the antenna design and proper impedance matching. A solder pad for SMA connector is designed into the 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 internal antenna. To connect the 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 provides some antenna supplier information.

Figure 4-5. JP1 Pin-Out Configuration

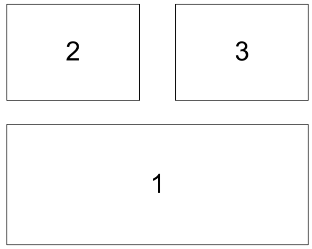


Table 4-1. Antenna Suppliers

Supplier	Web Site	Part number	ISM Band
MaxRad	www.maxrad.com	MEXR902SM	US
Mobilemark	www.mobilemark.com	PSWN3-925S PSTNS-900S	US European
W. Badland Ltd.	www.badland.co.uk	Various models	US / European
Radiall/Larsen	www.radialllarsen.com	Various models SPDA24832	US European

4.7.3 RS-232C Port

Provisions for communicating to the on-board processor through the RS232 serial link are designed onto the board. Populate the appropriate parts shown in the schematics for the physical link, including the Texas Instruments MAX3232 component. The UART driver must be implemented in firmware.

4.7.4 On-Board LDO Regulator

In normal operation, the battery voltage is directly connected to the power input to the processor through R31. Provision for LDO usage is provided in cases where higher voltage from an external supply is used instead of on-board battery. To add an LDO regulator, remove R31 and install U3 with a Texas Instruments TPS76330DBV component. The boards are shipped from factory with no installed LDO.

4.7.5 High-Frequency Crystal

The board has a foot print for high-frequency crystal operation (Y3) as well as the low-frequency crystal operation. The factory default uses standard 32-kHz watch crystal (Y4) for low-frequency operation. Internal frequency multiplier is used to generate system clock frequency of 2.4576 MHz.

4.7.6 SAW filter

A SAW filter is typically used to band-limit the received RF signal to reduce the interference from RF energy in the frequency band other than 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 at stop band. The part is also specified at ~4.5 dB signal loss in the pass band. This translates to corresponding loss in range of operation. The SAW filter is not installed for the factory default to give optimum range rather than optimum immunity. There are other cost-effective implementations that address the same objective with lower dB signal loss.

4.7.7 MSP430 Disable

In normal operation, the MSP430 on-board processor controls the TRF6901 component and the user interface. During evaluation, the RF section can be driven directly by external control signals. This can be accomplished by removing R42, which disables the voltage supply to the MSP430 processor. The TRF6901 can then be accessed directly using the TRF6901 header at J5.

Chapter 5

Software Overview

This chapter describes the software flow used for the demonstration application that is preconfigured in each demonstration board.

Topic **Page**

5.1 Software Description

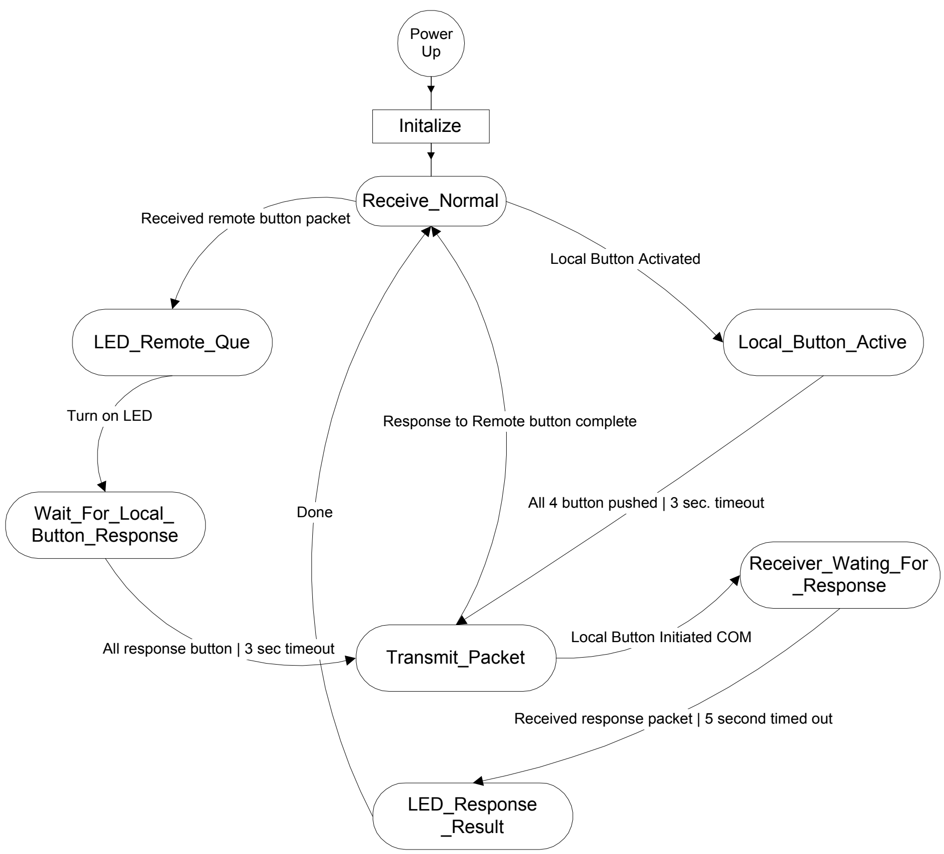
The software implements a simple game application demonstrating a bidirectional wireless link. Each board comes with identical software. The software was developed using IAR embedded workbench (www.iar.com). Below is the software files used:

- trf6901_demo.prj – Project file
- trf6901_demo.c – main body of the program written in C languge. All the subroutines are called from this program listing
- trf6901.s43 – assembly subroutine that is utilized to configure the registers of the TRF6901 component
- radio01.s43 – assembly subroutines used to execute wireless transmission and reception commands.

5.2 Flowchart

Upon power up initialization, a state machine is established to run the demonstration function. Figure 5-1 illustrates the state machine flowchart. Buttons and timer functions are handled through interrupt subroutines.

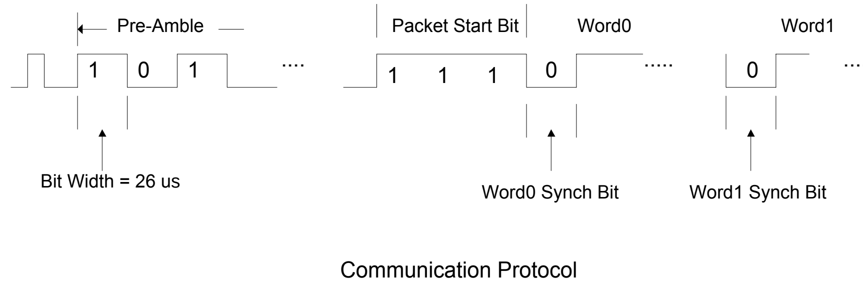
Figure 5-1. Game Application State Machine Architecture



5.3 Wireless Protocol Architecture

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

Figure 5-2. Communication Protocol



Preamble

The function of the preamble is to train the receive hardware to set the proper threshold to extract 1 and 0 patterns. The preamble typically consists of a train of alternating 1 and 0. A longer preamble may give better performance at a cost of more time needed to deliver the equivalent packet. For the current design, the preamble is 100 bits long, for 2.6-ms duration. Shorter length may be used for more time critical requirements.

5.3.1 Packet Start and Word-Synch-Bits

The packet start bit and the word synch bit are used by the receive routine to adjust timing for sampling the incoming data bit stream. The packet start bit occurs once at the beginning of the valid data to indicate the start of the data, and end of preamble. The synch 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 the tolerances of the components. 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 boundary, word boundary resynchronization is slightly more efficient.

5.3.2 Wireless Data Stream

The wireless data stream implemented for the game application was 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** goes to a wait state, where it waits to receive an acknowledgement packet sent by the other board. The (ACK) acknowledgement 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 waiting cycle, then it retries for up to six times

- ❑ Note that each time that **Board-B** receives a transmission packet, it acknowledges 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
OxFE	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 the overflow.

5.4 TRF6901 Registers

The TRF6901 needs to have its four (A thru D) registers initialized using the serial port interface (SPI) so that it can operate as desired. Table 5-1 shows the values used on the four registers of the TRF6901 when the program initializes.

Table 5-1. TRF6901 Game Application Register Values

Register	Parameter	Value
A	PA attenuation	0 dB
	Mode 0	Tx
	Charge Pump	0.5 mA
	DC/DC	Off
B	PA attenuation	0 dB
	Mode 1	Rx
	Modulation	FSK
	Brownout Threshold	1.8 V
	Brownout detector	Off
C	Reference Divider	60
	Reference Frequency	333.333 kHz
D	Crystal Tune	20.23 pF
	Reset Signal for PFD	Derived From Prescaler

5.5 Wireless Subroutines

The game application uses C functions to address the different communication tasks required to receive and send data. Read ahead for a brief description of these subroutines.

5.5.1 program_trf69()

This function configures one of the four (A thru D) registers of the TRF6901 component. Here is a sample code on how to use this function so that you can program all the four registers:

```
struct trf69_control{
  unsigned int a_word_l, a_word_h, b_word_l, b_word_h;
  unsigned int c_word_l, c_word_h, d_word_l, d_word_h;
 }trf6901;
main()
{
unsigned long trf69;
int pointer;
trf69 = REGISTER_A; // REGISTER_A is a constant
trf6901.a_word_h = (unsigned int) (trf69>>16);
trf6901.a_word_l = (unsigned int) (trf69);
program_TRF69(trf6901.a_word_h,trf6901.a_word_l);

trf69 = REGISTER_B; // REGISTER_B is a constant */
trf6901.b_word_h = (unsigned int) (trf69>>16);
trf6901.b_word_l = (unsigned int) (trf69);
program_TRF69(trf6901.b_word_h,trf6901.b_word_l);
```

```
trf69 = REGISTER_C; // REGISTER_C is a constant */
trf6901.c_word_h = (unsigned int) (trf69>>16);
trf6901.c_word_l = (unsigned int) (trf69);
program_TRF69(trf6901.c_word_h,trf6901.c_word_l);

trf69 = REGISTER_D; // REGISTER_D is a constant */
trf6901.d_word_h = (unsigned int) (trf69>>16);
trf6901.d_word_l = (unsigned int) (trf69)
program_TRF69(trf6901.d_word_h,trf6901.d_word_l);
}
```

5.5.2 receive_RF(unsigned char, unsigned int)*

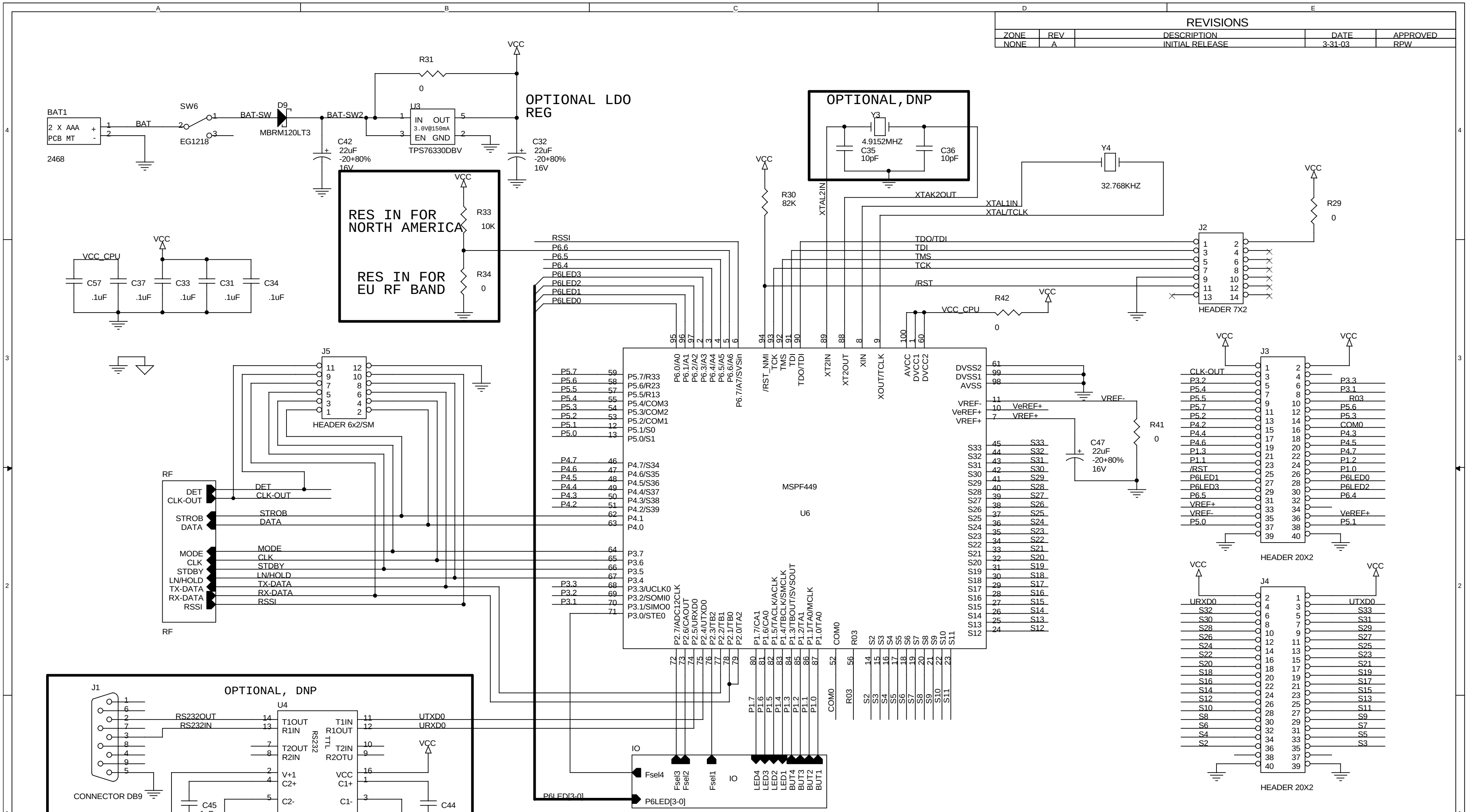
This function is used to receive a packet of wireless data stream. Here is an example of how it is used:

```
struct RF_XMIT_PACKET {
   int packetsize;
   unsigned int xmit[MAXWORD];
   unsigned int rcv[MAXWORD];
}buf;

Main()
{
int errorcode;
errorcode = receive_RF(buf.packetsize,buf.rcv);

// Packet stream stored in buf.rcv
// Packet size stored in buf.packetsize

}
```

5.5.3 send_RF(unsigned int, unsigned int)*

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

```
main()
{
buf.xmit[1]=ACK_CODE;
buf.xmit[0]=ACK_CODE;
ComFlag|=rf_X_buf_full;    //enable transmitter
send_RF(4,buf.xmit);
}
```



REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
NONE	A	INITIAL RELEASE	3-31-03	RPW

NOTES: UNLESS OTHERWISE SPECIFIED.

1. INTERPERT DRAWING IAW MIL-STD-100.
2. RESISTANCE VALUES ARE IN OHMS.
3. CAPACITANCE VALUES ARE IN FARADS.
4. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN FOR COMPLETE DESIGNATION, PREFIX WITH UNIT NUMBER, ASSY. DESIGNATION AND SUBASSEMBLY DESIGNATION.

DWN RICH WILLIAMS	DATE 3/12/03	
CHK X	XX/XX/XX	
APRVD X	XX/XX/XX	
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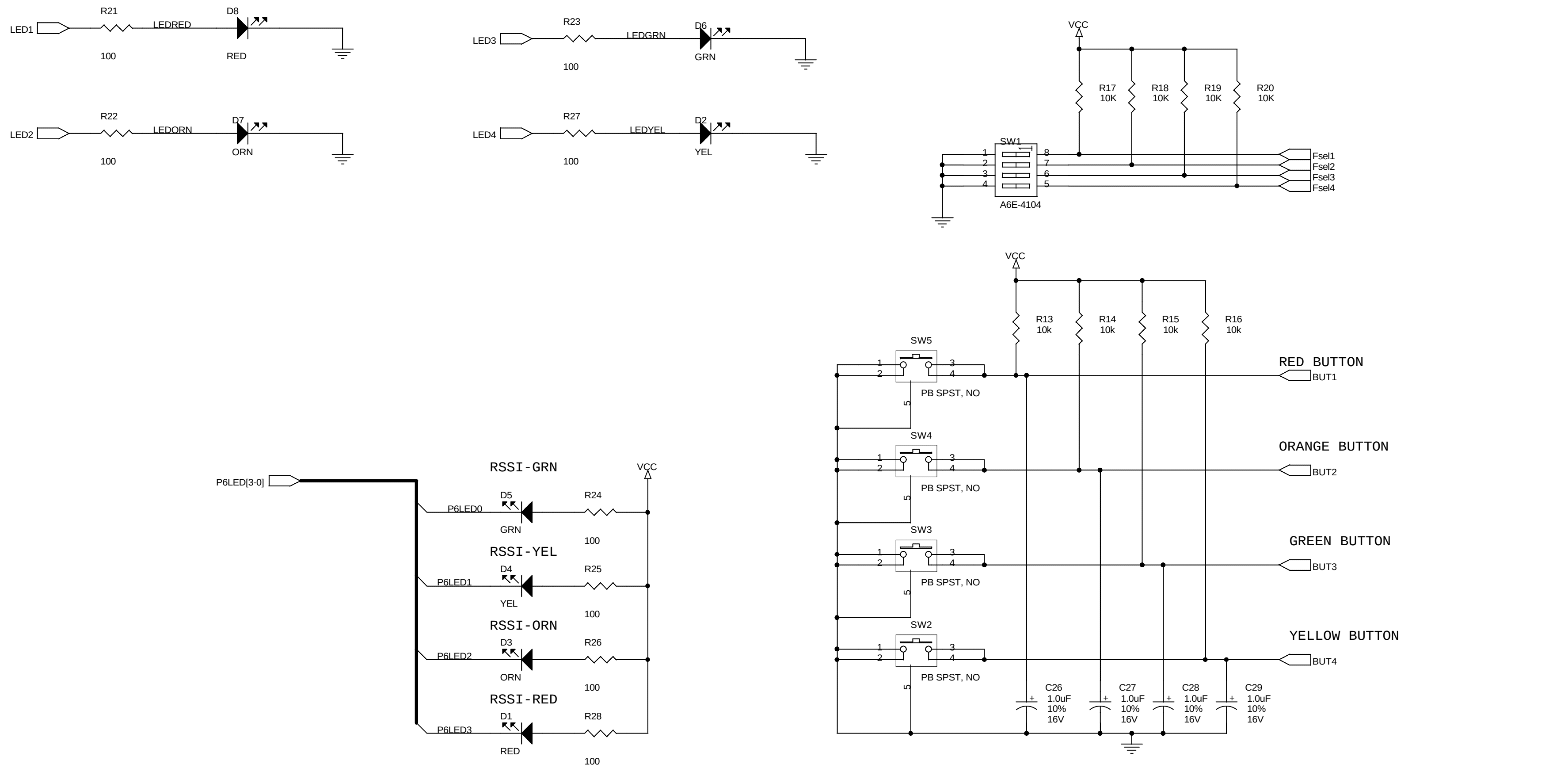

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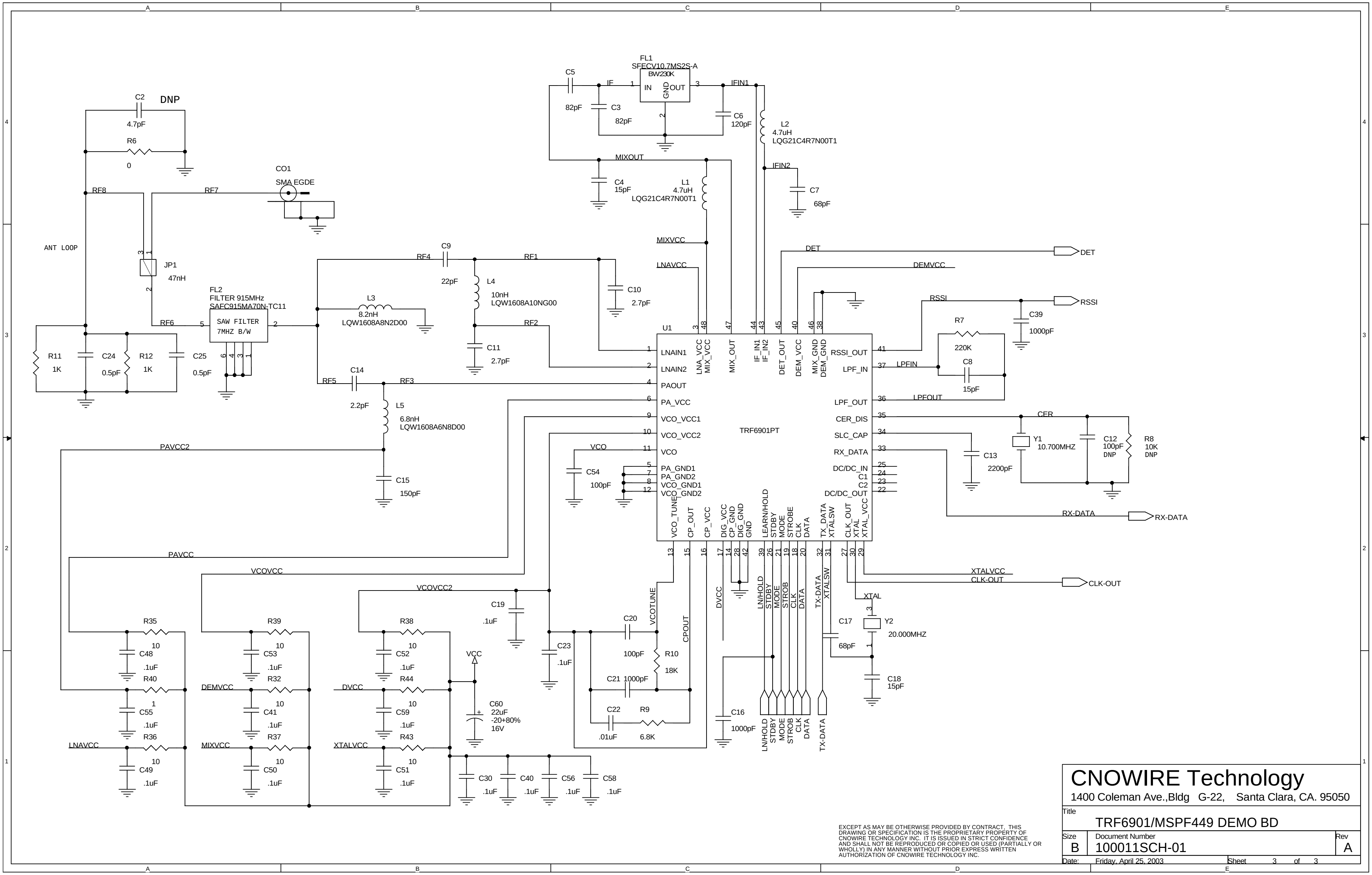

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