Texas Instruments

TRF6901 with MSP430 Evaluation Kit – US

User's Guide

April 2002

Mixed-Signal RF Products

SWRU005A

EVM IMPORTANT NOTICE

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

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Should this evaluation kit not meet the specifications indicated in the EVM User's Guide, the kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

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Please read the EVM User's Guide and, specifically, the EVM Warnings and Restrictions notice in the EVM User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact the TI application engineer.

Persons handling the product must have electronics training and observe good laboratory practice standards.

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Mailing Address:

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the specified input and output ranges described in the EVM User's Guide.

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 60°C. The EVM is designed to operate properly with certain components above 60°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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Preface

Read This First

About This Manual

This document presents the contents of the TRF6901 902 MHz to 928 MHz RF tool kit. Both hardware and software are described in detail. The first half of the document addresses the TRF6901 RF EVM in a stand-alone evaluation environment. The second half of the document addresses the TRF6901 serial port module that is used to support the TRF6901 RF EVM evaluation in a system environment configuration.

It is important when reading this document to remember that the TRF6901 serial port module is a support module provided along with the TFR6901 RF EVM contained in the TRF6901 RF tool kit. The TRF6901 serial port module is NOT to be considered a stand-alone tool.

Using this document, the user will understand the features of the TRF6901 RF EVM as well as the features of the TRF6901 serial port module as it relates to the TRF6901 RF EVM. Also, the user will become familiar with the features and functionality of both the TRF6901 EVM and the TRF6901 serial port tools software packages.

With the TRF6901 EVM software package, the user will understand how to evaluate the functionality of the TRF6901 on the TRF6901 RF EVM via a PC parallel port. With the serial port software package, the user will understand how to use the programming tool to evaluate the TRF6901 via the PC serial port connection to the TRF6901 serial port module.

Finally, along with being exposed to the basic structure and protocol of an RF link example, the user will be able to use the system mode tool contained within the TRF6901 serial port tools software to establish a basic RF link using two TRF6901 RF tool kits.

Evaluation Board Disclaimer

Please note that the enclosed evaluation 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.

The fee associated with the evaluation modules (EVM) is a partial nonrecurring engineering fee (NRE) to partially defray the engineering costs associated with the EVM development and applications support for the RF integrated semiconductor product. The EVM is a tool for evaluating the RF semiconductors supplied by Texas Instruments. The EVM is supplied to prospective component customers to provide services and software allowing the prospect customers to evaluate the RF semiconductors in products they would build.

The EVM may be operated only for product evaluation purposes and then only in nonresidential areas. TI's 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.

How to Use This Manual

This document contains the following chapters:

- ❏ Chapter 1—TRF6901 RF Tool Kit Overview
- ❏ Chapter 2—TRF6901 RF EVM PCB Hardware
- ❏ Chapter 3—TRF6901 EVM Control Software
- ❏ Chapter 4—TRF6901 Serial Port Tool Overview
- ❏ Chapter 5—TRF6901 Serial Port Module PCB Hardware
- ❏ Chapter 6—TRF6901 RF Tool Kit System Mode
- ❏ Chapter 7—TRF6901 Serial Port Tools Software

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.

This is an example of a warning statement.

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

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

Contents

Figures

Chapter 1

TRF6901 RF Tool Kit Overview

This chapter provides an overview of the TRF6901 RF tool kit.

Topic **Page**

1.1 Description

The TRF6901 RF tool kit is to be used to evaluate the functionality and system performance of Texas Instrument's TRF6901 ISM-band transceiver. It is intended to be an evaluation tool and is not to be considered a reference design. It is important to remember that board layout is a critical parameter affecting the performance of any RF device. The performance of the TRF6901 on the TRF6901 RF EVM demonstrates one implementation of a TRF6901 transceiver layout.

1.2 Contents

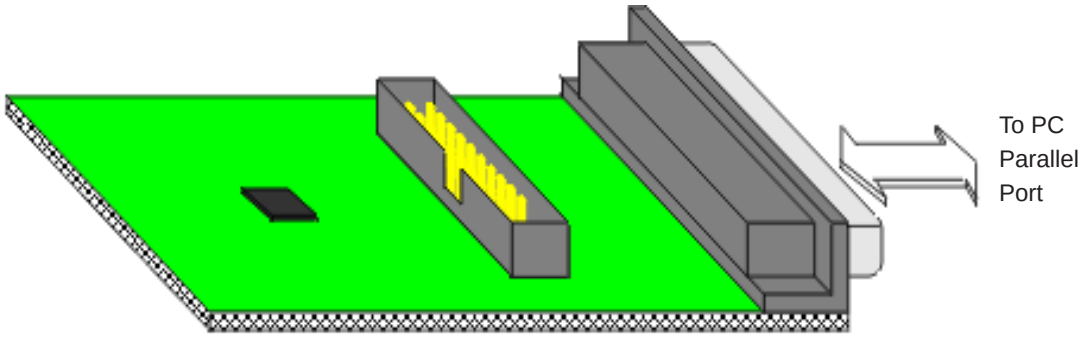
Contained within the TRF6901 RF tool kit are the following:

- ❑ TRF6901 RF EVM board
- ❑ TRF6901 serial port module
- ❑ Serial port cable
- ❑ Parallel port cable
- ❑ CD ROM
- ❑ Software diskette

1.3 TRF6901 EVM/Parallel Port Configuration

The TRF6901 EVM/parallel port configuration, as shown in Figure 1−1, is to be used when observing the functionality of the TRF6901 on the TRF6901 RF EVM stand alone via a standard PC parallel port. Chapter 2—*TRF6901 RF EVM PCB Hardware* covers the TRF6901 RF EVM in detail.

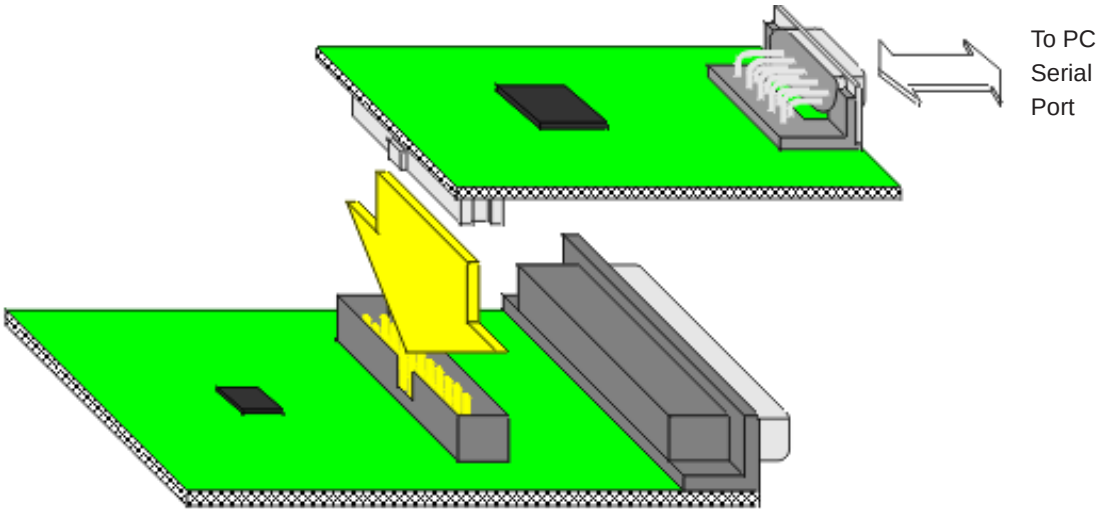
Figure 1−1. TRF6901 EVM/Parallel Port Configuration



1.4 TRF6901 EVM/Serial Port Module Configuration

The TRF6901 EVM/serial port module configuration, as shown in Figure 1−2, is to be used when observing the functionality of the TRF6901 on the TRF6901 RF EVM with the serial port module via a standard PC serial port. With this configuration, the system mode functionality can also be observed. See Chapter 6—*TRF6901 RF Tool Kit System Mode* for further details on the system mode operation.

Figure 1−2. TRF6901 EVM/Serial Port Module Configuration



Chapter 2

TRF6901 RF EVM PCB Hardware

This chapter describes the PCB hardware of the TRF6901 RF EVM.

Topic **Page**

2.1 Hardware Overview

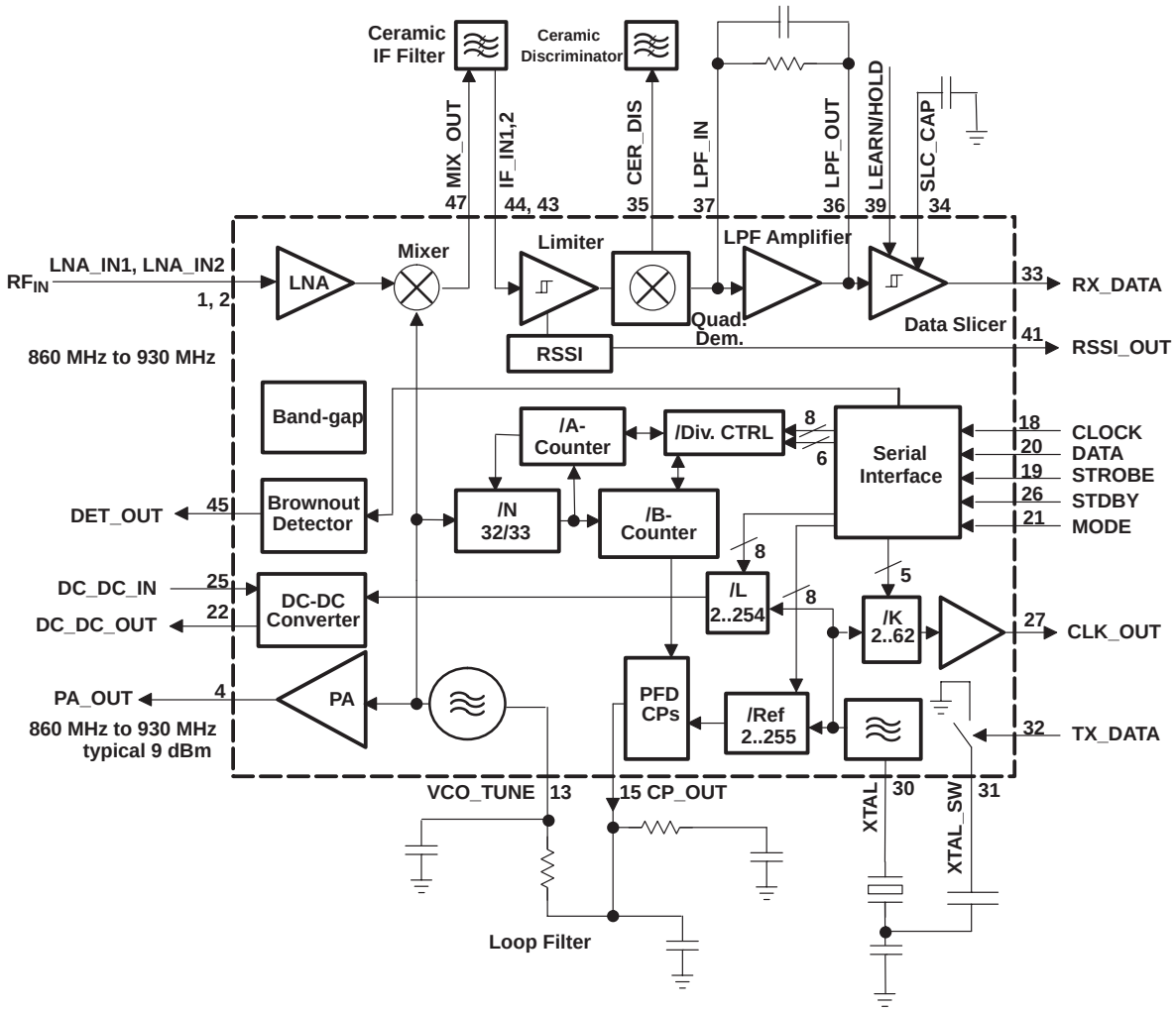
The TRF6901 ISM-band transceiver IC operates from 860 MHz to 930 MHz. It has low power consumption and an operating voltage of 1.8 V to 3.6 V. It uses an integer-N synthesizer and supports FSK/OOK operation. Other features include an on-chip reference oscillator, phase lock loop, Brownout detector, and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

The TRF6901 RF evaluation module (EVM) provides a platform for lab prototype evaluation of the Texas Instruments TRF6901 transceiver IC. The EVM is used to evaluate the RF performance of the TRF6901. It contains a PC parallel port interface. The transmitted signal can be viewed on a spectrum analyzer as either a single output frequency or in FSK mode. Although higher data rates are achievable with the TRF6901, the TRF6901 EVM is designed to operate at bit rates up to 32-kbps NRZ, with a deviation of approximately ±50 kHz, at room temperature.

2.2 TRF6901 RF Block Diagram

Figure 2−1 shows the block diagram of the TRF6901 ISM transceiver IC.

Figure 2−1. TRF6901 Block Diagram



2.3 TRF6901 RF EVM Schematics

Figure 2−2 shows the TRF6901 RF EVM schematics.

Figure 2−2. TRF6901 RF EVM Schematics (1 of 4)

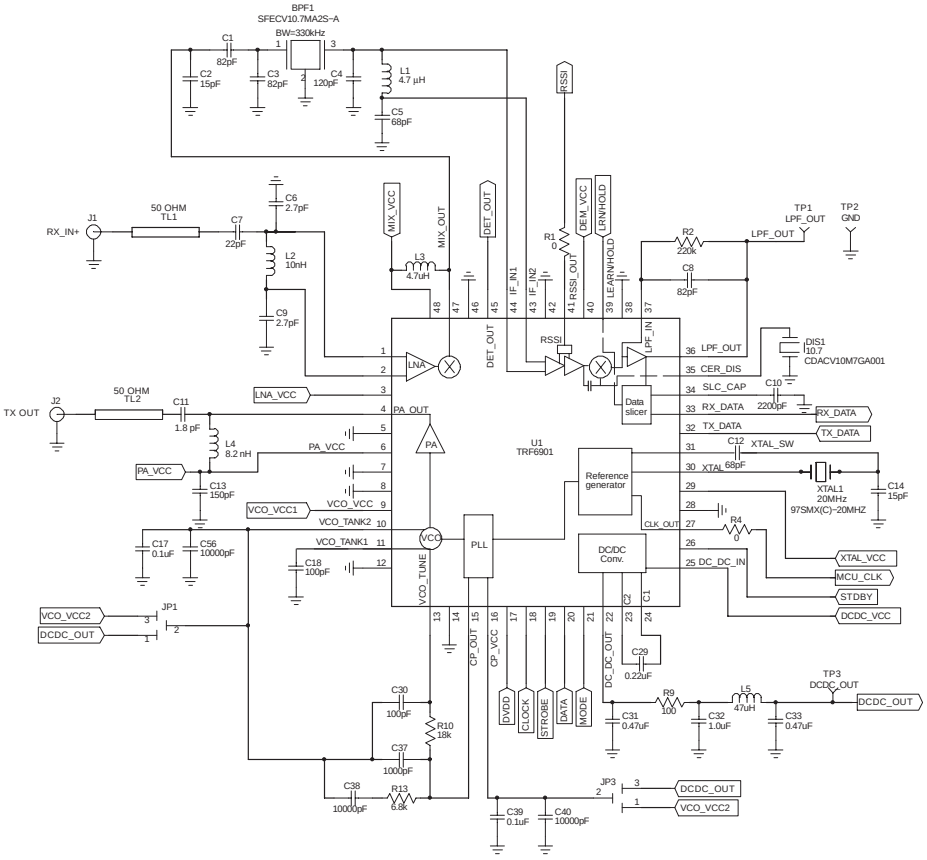


Figure 2−2. TRF6901 RF EVM Schematics (2 of 4)

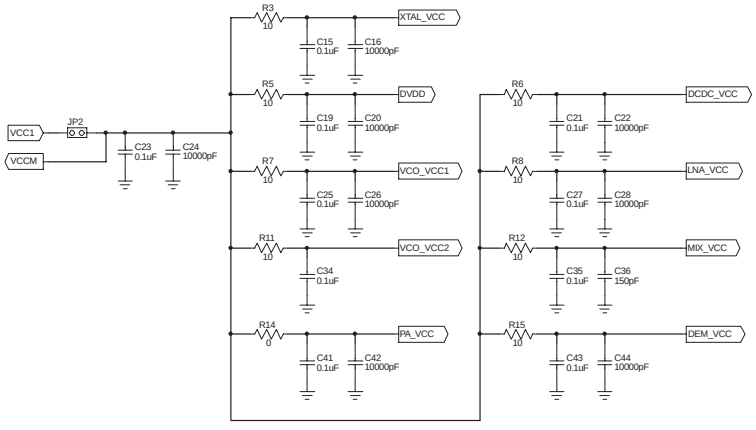


Figure 2−2. TRF6901 RF EVM Schematics (3 of 4)

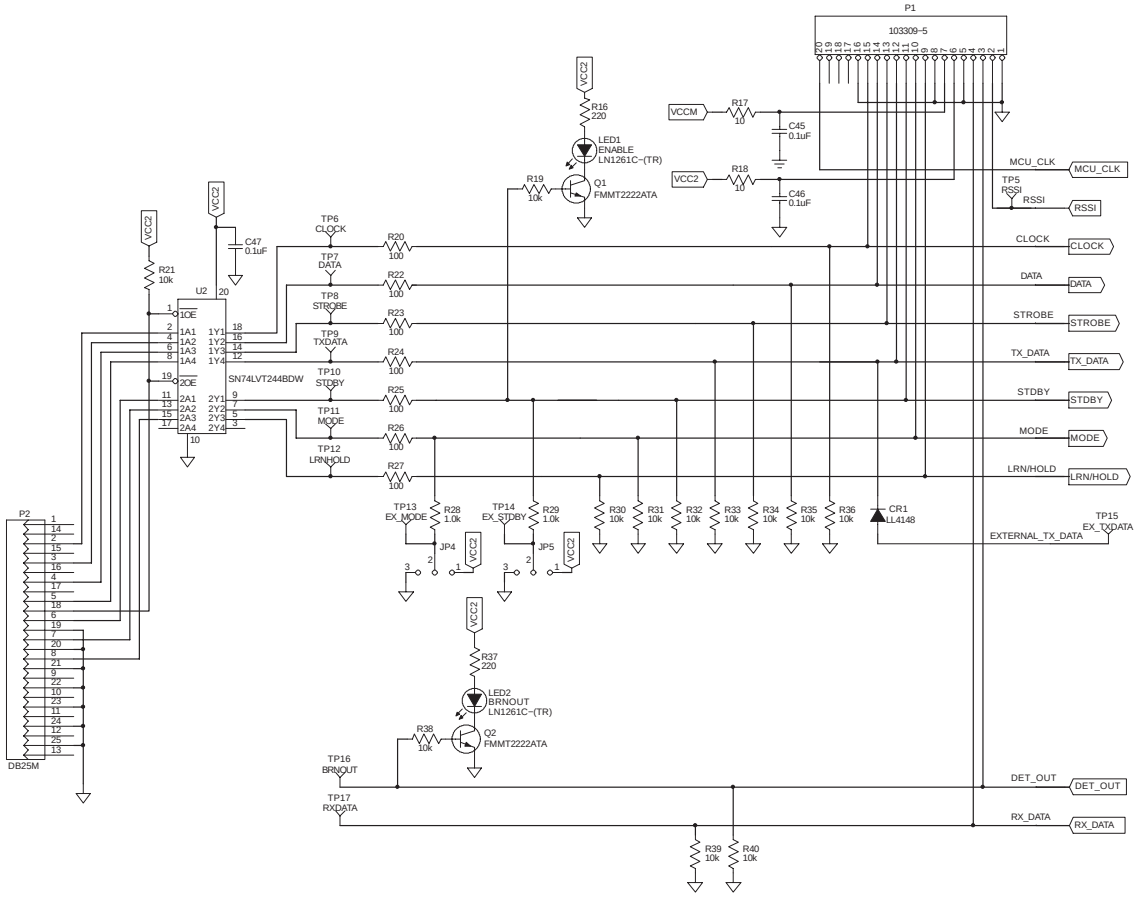
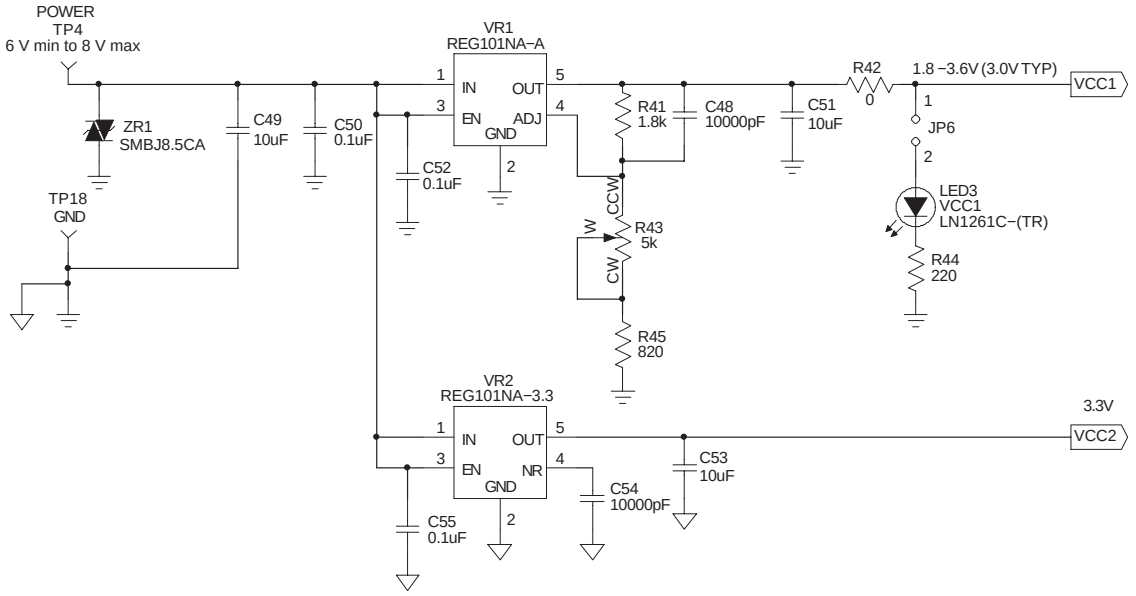


Figure 2−2. TRF6901 RF EVM Schematics (4 of 4)



2.4 Top- and Bottom-Side Silkscreen and Drawing

Figure 2−3 shows the top-side silkscreen of the TRF6901 RF EVM and Figure 2−4 shows the bottom-side silkscreen.

Figure 2−3. Top-Side Silkscreen and Drawing of TRF6901

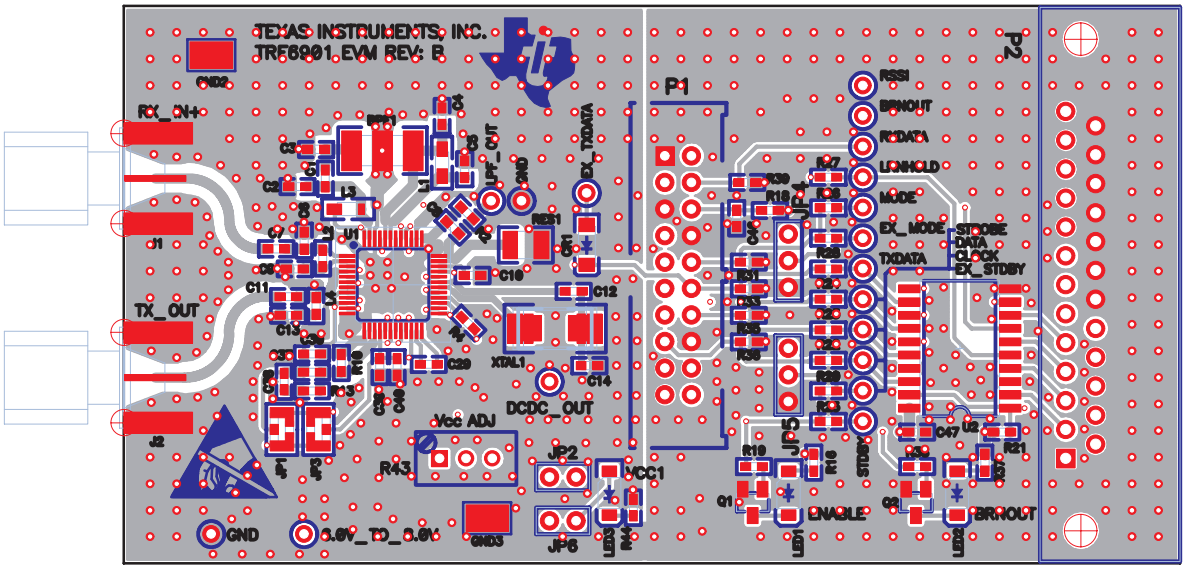
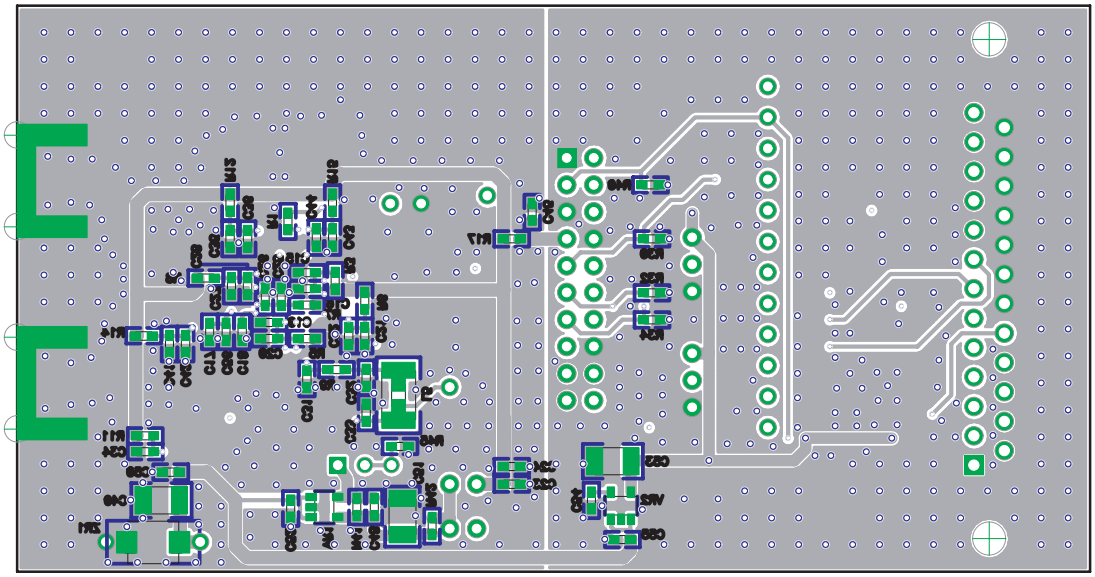


Figure 2−4. Bottom-Side Silkscreen of TRF6901 RF EVM



2.5 Parts List

Count	RefDes	Value	Note	Pattern Name	Description	Part Number	Manufacturer	Distributor P/N	Distributor
1	BPF1		BW = 330 kHz	SFECV10.7	Surface mounted chip Piezoelectric ceramics filters for AM and FM applications	SFECV10.7MA2S−A−TC	Murata	SFECV10.7MA2S−A−TC	Murata
18	C15, C17, C19, C21, C23, C25, C27, C34, C35, C39, C41, C43, C45−C47, C50, C52, C55	0.1 µF		0603	Ceramic chip capacitor	GRM39X7R104J016AD	Murata	GRM39X7R104J016AD	Murata
1	C29	0.22 µF		0603	Ceramic chip capacitor	GRM39X7R224J010AD	Murata	GRM39X7R224J010AD	Murata
2	C31, C33	0.47 µF		0603	Ceramic chip capacitor	GRM39Y5V474J010AD	Murata	GRM39Y5V474J010AD	Murata
1	C32	1 µF		0603	Ceramic chip capacitor	GRM39Y5V105J010AD	Murata	GRM39Y5V105J010AD	Murata
1	C11	1.8 pF		0603	Ceramic chip capacitor	GRM39C02R2C050AD	Murata	GRM39C02R2C050AD	Murata
2	C6, C9	2.7 pF		0603	Ceramic chip capacitor	GRM39C02R7C050AD	Murata	GRM39C02R7C050AD	Murata
3	C49, C51, C53	10 µF		1210	Monolithic chip capacitor—tantalum replacement	GRM235Y5V106Z016AD	Murata	GRM235Y5V106Z016AD	Murata
2	C2, C14	15 pF		0603	Ceramic chip capacitor	GRM39C0150J050AD	Murata	GRM39C0150J050AD	Murata
1	C7	22 pF		0603	Ceramic chip capacitor	GRM39C0220J050AD	Murata	GRM39C0220J050AD	Murata
2	C5, C12	68 pF		0603	Ceramic chip capacitor	GRM39C0680J050AD	Murata	GRM39C0680J050AD	Murata
3	C1, C3, C8	82 pF		0603	Ceramic chip capacitor	GRM39C0820J050AD	Murata	GRM39C0820J050AD	Murata

Count	RefDes	Value	Note	Pattern Name	Description	Part Number	Manufacturer	Distributor P/N	Distributor
2	C18, C30	100 pF		0603	Ceramic chip capacitor	GRM39C0101 J050AD	Murata	GRM39C0101J050AD	Murata
1	C4	120 pF		0603	Ceramic chip capacitor	GRM39C0121 J050AD	Murata	GRM39C0121J050AD	Murata
2	C13, C36	150 pF		0603	Ceramic chip capacitor	GRM39C0151 J050AD	Murata	GRM39C0151J050AD	Murata
1	C37	1000 pF		0603	Ceramic chip capacitor	GRM39X7R10 2J050AD	Murata	GRM39X7R102J050AD	Murata
1	C10	2200 pF		0603	Ceramic chip capacitor	GRM39X7R22 2J050AD	Murata	GRM39X7R222J050AD	Murata
13	C16, C20, C22, C24, C26, C28, C38, C40, C42, C44, C48, C54, C56	10000 pF		0603	Ceramic chip capacitor	GRM39X7R10 3J050AD	Murata	GRM39X7R103J050AD	Murata
1	CR1			MELF3 (MINIMELF)	Fast switching diode	LL4148	Diode INC	LL4148CT−ND	Digi-Key
2	J1, J2			SMA_H	SMA brass connector − horizontal/PC mount 0.062 Thk	142−0701−801	Johnson Components	90F2624	Newark
2	JP1, JP3			SMD−3 way-JP	Jumper-3 Way-SMD				
2	JP2, JP6			Jumper-2 pin	Breakaway headers	4−103239−0	AMP	90F7725	Newark
2	JP4, JP5			Jumper-3 pin	Breakaway headers	4−103239−0	AMP	90F7725	Newark
2	L1, L3	4.7 µH		0805−Murata	Chip inductor	LQG21C4R7N 00T1	Murata	LQG21C4R7N00T1	Murata
1	L4	8.2 nH		0603	Chip inductor	LQW1608A8N 2D00	Murata	LQW1608A8N2D00	Murata
1	L2	10 nH		0603	Chip inductor	LQW1608A10 NJ00T1	Murata	LQW1608A10NJ00T1	Murata
1	L5	47 µH		0805−1812	Chip inductor (Shielded)	S1812−473K	API Delevan	DN1132TR−ND	Digi-Key
3	LED1, LED2, LED3	ENABLE BRNOUT VCC1		LED, GW type	Surface mount LED-gull wing-GW Type-Red	LN1261C−(TR)	Panasonic	P503TR−ND	Digi-Key

Count	RefDes	Value	Note	Pattern Name	Description	Part Number	Manufacturer	Distributor P/N	Distributor
4	R1, R4, R14, R42	0 Ω		0603	Chip resistor	CR0603−16W−000T	Venkel	CR0603−16W−000T	Venkel
2	R28, R29	1 kΩ		0603	Chip resistor	CR0603−16W−102JT	Venkel	CR0603−16W−102JT	Venkel
1	R41	1.8 kΩ		0603	Chip resistor	CR0603−16W−182JT	Venkel	CR0603−16W−182JT	Venkel
1	R43	5 kΩ		3296W Bourns	3/8-inch square trimming potentiometer	3296W−1−XXX	Bourns	3296W−XXX−ND	Digi-Key
1	R13	6.8 kΩ		0603	Chip resistor	CR0603−16W−682JT	Venkel	CR0603−16W−682JT	Venkel
10	R3, R5−R8, R11, R12, R15, R17, R18	10 Ω		0603	Chip resistor	CR0603−16W−100JT	Venkel	CR0603−16W−100JT	Venkel
12	R19, R21, R30−R36, R38−R40	10 kΩ		0603	Chip resistor	CR0603−16W−103JT	Venkel	CR0603−16W−103JT	Venkel
1	R10	18 kΩ		0603	Chip resistor	CR0603−16W−183JT	Venkel	CR0603−16W−183JT	Venkel
8	R9, R20, R22−R27	100 Ω		0603	Chip resistor	CR0603−16W−101JT	Venkel	CR0603−16W−101JT	Venkel
3	R16, R37, R44	220 Ω		0603	Chip resistor	CR0603−16W−221JT	Venkel	CR0603−16W−221JT	Venkel
1	R2	220 kΩ		0603	Chip resistor	CR0603−16W−224JT	Venkel	CR0603−16W−224JT	Venkel
1	R45	820 Ω		0603	Chip resistor	CR0603−16W−821JT	Venkel	CR0603−16W−821JT	Venkel
1	DIS1	10.7 MHz		CDACV Type	Ceramic discriminator for FM receiver	CDACV10M7GA001−R0	Murata	CDACV10M7GA001−R0	Murata
1	TP4			P.C. test point	Color coded P.C. test point (Red)	TP−105−01−02	Components Corp.	97B3257	Newark
2	TP2, TP18	GND		P.C. test point	Color coded P.C. test point (Black)	TP−105−01−00	Components Corp.	97B3259	Newark
15	TP16	BRNOUT		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark

Count	RefDes	Value	Note	Pattern Name	Description	Part Number	Manufacturer	Distributor P/N	Distributor
	TP6	CLOCK		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
	TP7	DATA		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
	TP3	DCDC_OUT		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
	TP13	EX_MODE		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
	TP14	EX_STDBY		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
	TP15	EX_TXDATA		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
	TP1	LPF_OUT		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
	TP12	LRNHOLD		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
	TP11	MODE		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
	TP5	RSSI		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
	TP17	RXDATA		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
	TP10	STDBY		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
	TP8	STROBE		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
	TP9	TXDATA		P.C. test point	Color coded P.C. test point (White)	TP−105−01−09	Components Corp.	97B3253	Newark
1	P1			103309−5	Amp−latch low profile header assembly	103309−5	AMP	A26274−ND	Digi-Key
1	P2			DB25M	Subminiature D connector-25 pin-right angle-male	747238−4	AMP	A2098−ND	Digi-Key
2	Q1, Q2			SOT23	NPN switching transistor − 330 mW	FMMT2222ATA	Zetex	FMMT2222ACT−ND	Digi-Key

Count	RefDes	Value	Note	Pattern Name	Description	Part Number	Manufacturer	Distributor P/N	Distributor
1	U1			TQFP48	Transceiver	TRF6901	Texas Instruments		Digi-Key
1	U2			SO20WB	Octal buffers and line drivers with 3-state outputs	SN74LVT244B DW	Texas Instruments	296−1707−5−ND	Digi-Key
1	VR1			SOT23−5	100-mA low-dropout regulator	REG101NA−A	Burr−Brown	REG101NA−A−ND	Digi-Key
1	VR2			SOT23−5	100-mA low-dropout regulator	REG101NA−3.3	Burr−Brown	REG101NA−3.3−ND	Digi-Key
1	XTAL1	20 MHz		97SMX(C)	Quartz crystal	97M200−20(C)	SMI	97M200−20(C)	SMI
1	XTAL1A	20 MHz	DNP	93SMX	Quartz crystal	93M200−20	SMI	93M200−20	SMI
1	ZR1			SMBJ−BI	Transient voltage suppressor	SMBJ8.5CA	Vishay/Liteon	SMBJ8.5AGICT−ND	Digi-Key
2	GND2, GND3			SMD test point	Surface mount test point	TP−107−01	Components Corp.	97B2647	Newark

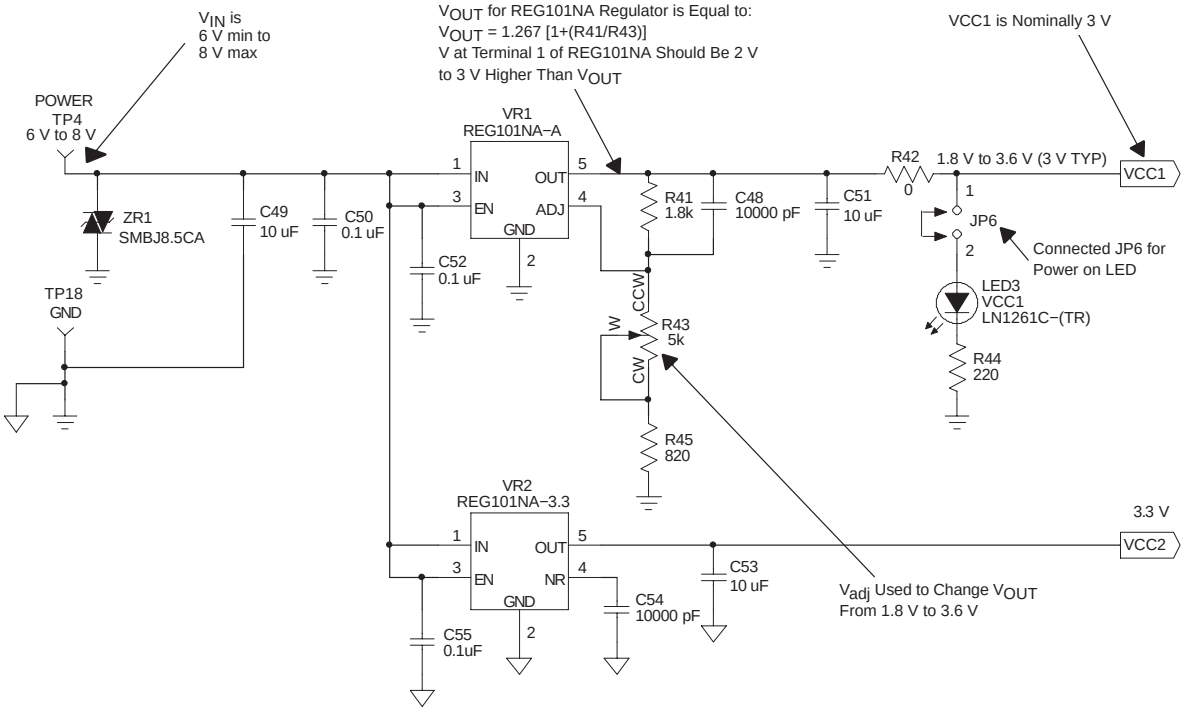
2.6 TRF6901 RF EVM Regulated Supply Configuration

The evaluation board should be used with a dc power supply voltage of 6 V to 8 V nominal. Figure 2−5 details the dc voltage supply setup for the TRF6901 RF-only EVM.

There are three powering sources on the TRF6901 and the EVM. The adjustable output VCC1 powers all the blocks of the TRF6901 IC. The fixed output VCC2 powers all the components external to the TRF6901, such as LEDs and the digital I/O portions of the EVM. This separation of sources eliminates noise and other potential interferences. The third source is a dc-dc converter which is internal to the TRF6901 IC. The dc-dc converter can provide an adequate voltage to the charge pumps and VCO core in the event an external power supply, such as a battery, drops down to 1.8 V. Hence, increasing the operational period of the TRF6901.

VCC1 output branches out into VCO_VCC1, VCO_VCC2, XTAL_VCC, DVDD, PA_VCC, DCDC_VCC, LNA_VCC, MIX_VCC, and DEM_VCC when JP2 (see *Jumper Description*) is connected. These are utilized in powering various blocks of the TRF6901 IC. Prior to using the RF EVM, ensure that VCC1 is set to the nominal voltage of approximately 3 V by adjusting R43, if necessary.

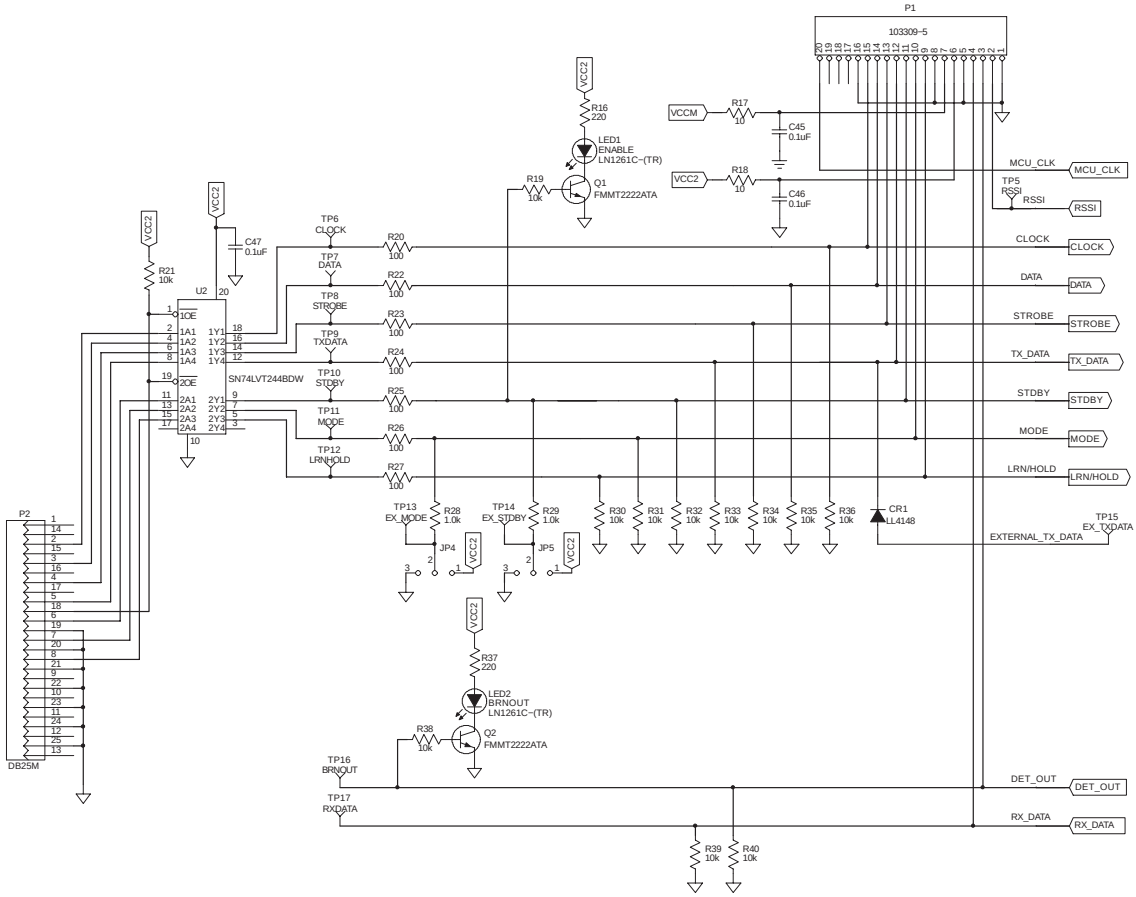
Figure 2−5. TRF6901 EVM DC Voltage Setup



2.7 TRF6901 Parallel Port Module Interface

Figure 2−6 details the parallel port interface portion of the TRF6901 RF EVM.

Figure 2−6. TRF6901 RF EVM Parallel Port Interface



2.8 TRF6901 RF EVM Jumpers

2.8.1 Jumper Connections

Figure 2−7 shows the default position of the jumpers on the TRF6901 RF EVM.

Figure 2−7. TRF6901 RF EVM Jumper Locations and Default Configurations of the EVM (Sheet 1 of 2)

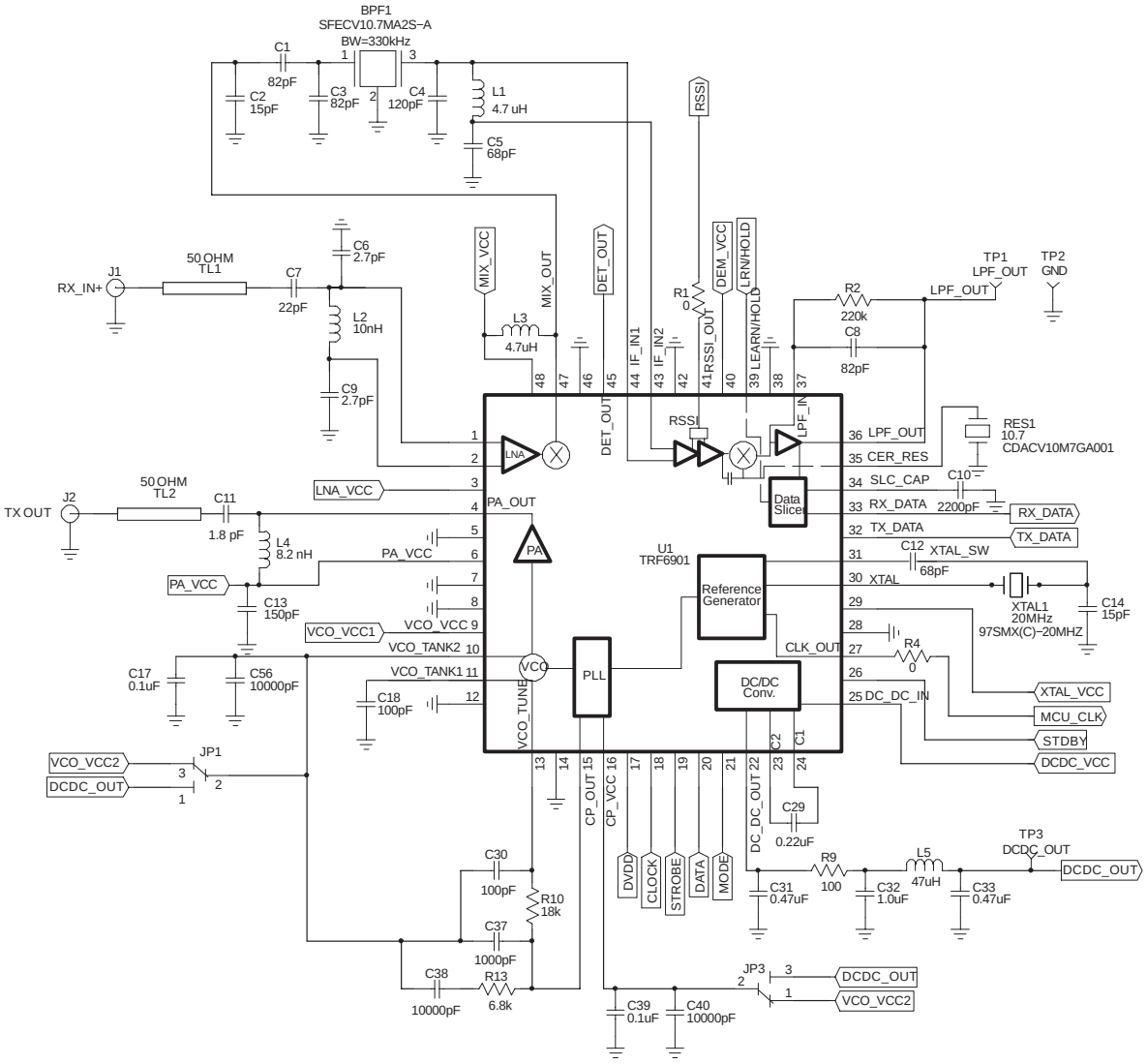
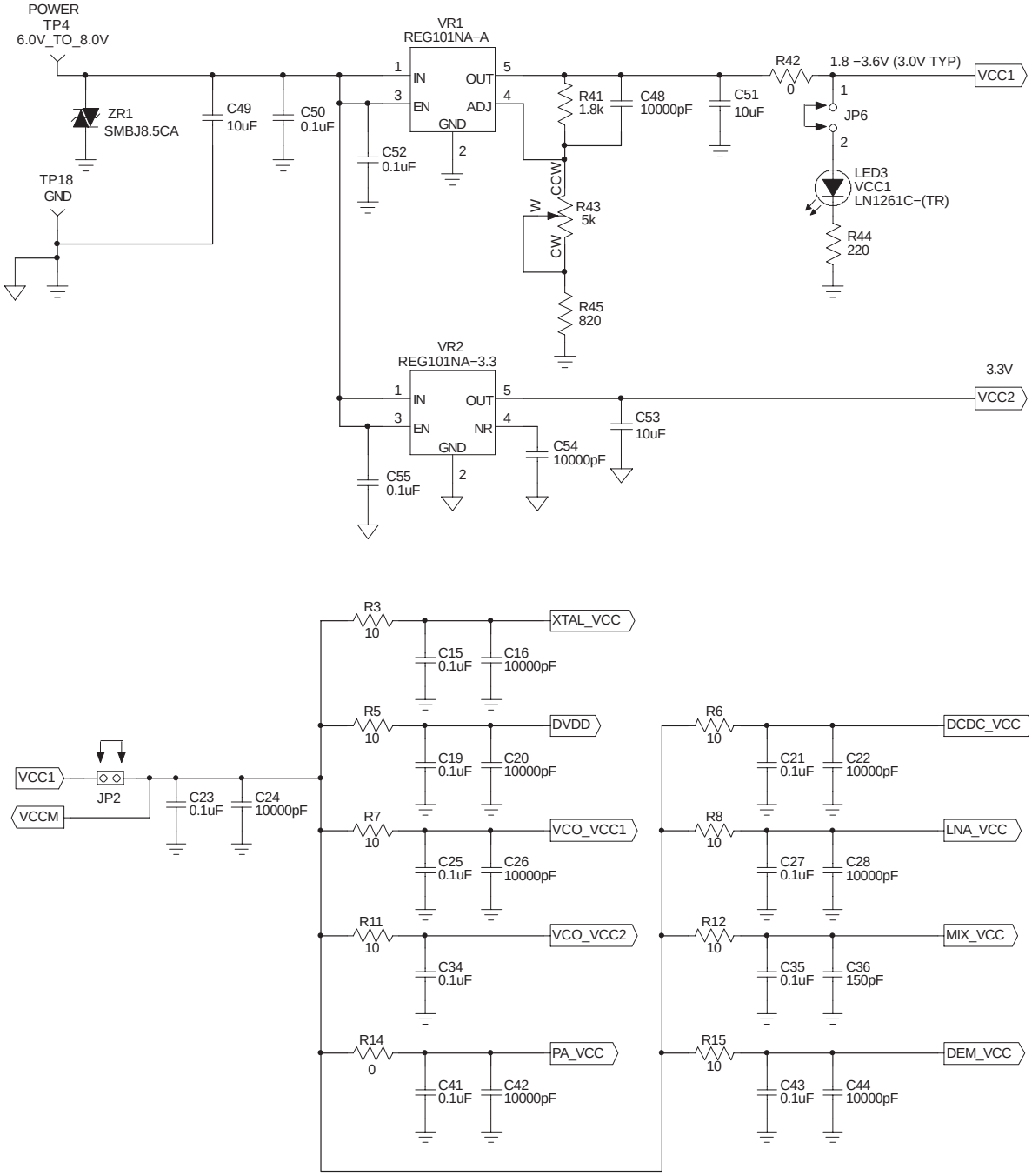
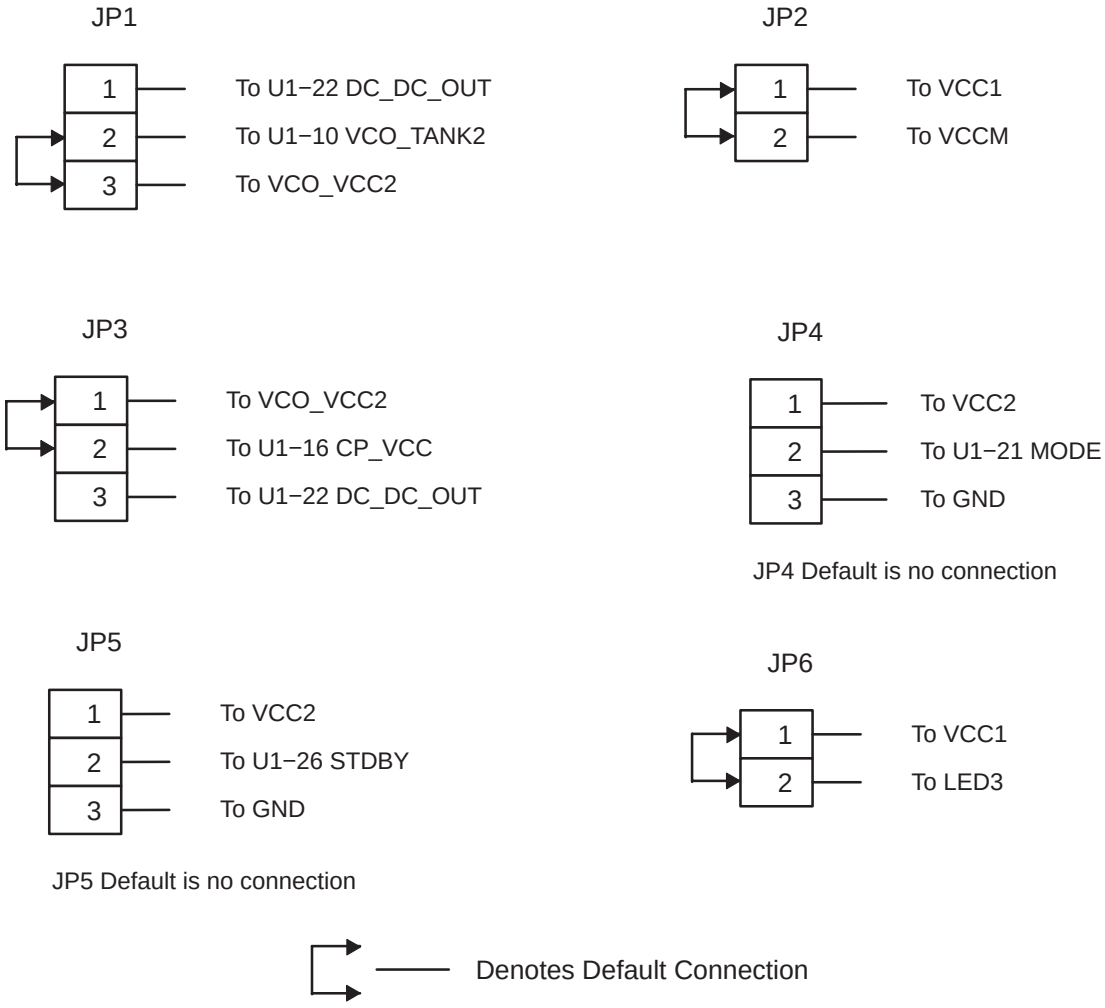


Figure 2−7. TRF6901 RF EVM Jumper Locations and Default Configurations of the EVM (Sheet 2 of 2)



2.8.2 Default Jumper Connections



2.8.3 Jumper Description

The jumpers on the TRF6901 RF-only EVM, as shown in Figure 2−7, are used for the following purposes.

- JP1

  This jumper selects one source that is either VCO_VCC2 or DC_DC_OUT for the VCO. When JP1−3 is connected to JP1−2, VCO_VCC2 is fed to the VCO. If JP1−2 is connected to JP1−1, DCDC_OUT is connected to the VCO. The default connection is JP1−3 to JP1−2.

- JP2

  This jumper connects VCC1 input to VCCM. It also connects VCC1 input to filtering networks that lead to various outputs such as XTAL_VCC, DVDD, VCO_VCC1, VCO_VCC2, and PA_VCC. These are then used to power various blocks of the TRF6901 IC. An advantage of using this jumper is that when removed, the two disconnected nodes can be connected through an ammeter that allows the user to measure the

current consumption. Also, the user can insert a power supply after the REG101NA voltage regulators. Since there is no regulation stage after this jumper, make sure that any supply connected to this jumper is noise free and is set between 1.8 V to 3.6 V.

- JP3

  This jumper connects one source that is either VCC_VCC2 or DC_DC_OUT to the charge pumps of the phase lock loop. When JP3−1 is connected to JP3−2, VCO_VCC2 is fed to the charge pumps of the PLL through terminal U1−16 CP_VCC. If JP3−2 is connected to JP3−3, DCDC_OUT is connected to the charge pumps. The default connection is JP3−2 to JP3−1.

- JP4

  This jumper either acts as a pullup or a pulldown for the MODE terminal. When JP4−1 is connected to JP4−2, then R28 acts as a pullup resistor. On the other hand, when JP4−2 is connected to JP4−3, then R28 acts as a pulldown resistor. The default configuration for JP4 is no connection.

- JP5

  This jumper either acts as a pullup or a pulldown for the STDBY terminal. When JP5−1 is connected to JP5−2, then R29 acts as a pullup resistor. On the other hand, when JP5−2 is connected to JP5−3, then R29 acts as a pulldown resistor. The default configuration for JP5 is no connection.

- JP6

  This jumper connects the VCC1 regulated power output to LED3 when JP6−1 is connected to JP6−2. This LED verifies EVM dc voltage is applied.

2.9 Connectors

The following are descriptions of the TRF6901 EVM connectors and test points.

- P1

  P1 is a 20-terminal connector that is used to connect to an external microprocessor or DSP that provides the DATA, CLOCK, STROBE, TX_DATA, STDBY, MODE, and LRN/HOLD inputs to the TRF6901. In this case, the TRF6901 is controlled by an external microprocessor or DSP rather than the control software on the PC. This port also connects to the serial port module that contains the MSP430F149 via a 20-pin cable. P1 can also be used to interface directly to the TRF6901, bypassing the parallel port interface circuitry on the EVM.

- P2

  P2 is the PC parallel port interface and is a male DB25 connector. P2 is connected to the LPT1 or LPT2 port of the computer on which the control software of TRF6901 is running.

- J1 RX_IN+

  J1 RX_IN+ is an SMA female connector that feeds the received signal into the input of the LNA.

- J2 TX_OUT

  J2 TX_OUT is an SMA female connector which is connected to the transmitter output of the TRF6901.

2.10 Test Points (TP)

- LPF_OUT TP1

  The LPF_OUT test point is used to monitor the output signal of the LPF stage before passing through the data slicer.

- GND TP2 and TP18

  These test points are used for ground connections.

- DCDC_OUT TP3

  The DCDC_OUT test point is used to monitor the DCDC_OUT signal from U1−22 DC_DC_OUT terminal.

- POWER TP4

  This test point is used to connect the output voltage of the power supply to the TRF6901 RF EVM. The nominal values for the external power supply are from 6 V to 8 V.

- RSSI TP5

  The RSSI test point is used to monitor the RSSI level from U1−41 RSSI_OUT terminal.

- CLOCK TP6

  The CLOCK test point is used to monitor the clock signal from the PC parallel port (P2) that connects to U1−18 CLOCK terminal.

- DATA TP7

  The DATA test point is used to monitor the DATA signal from the PC parallel port (P2) i.e., the words (see Chapter 3, *TRF6901 RF EVM Control Software*) sent from the control software of TRF6901. This test point connects to U1−20 DATA terminal.

- STROBE TP8

  The STROBE test point is used to monitor the STROBE signal from the PC parallel port (P2). This test point connects to U1−19 STROBE terminal.

- TXDATA TP9

  The TXDATA test point is used to monitor the transmitted data coming from PC parallel port (P2). This test point connects to U1−32 TX_DATA terminal.

- STDBY TP10

  The STDBY test point is used to monitor the STDBY signal from the PC parallel port (P2). This test point connects to U1−26 STDBY terminal.

- MODE TP11

  The MODE test point is used to monitor the MODE signal from the PC parallel port (P2). This test point connects to U1−21 MODE terminal.

- LRNHOLD TP12

  The LRNHOLD test point is used to monitor the LRNHOLD signal from the PC parallel port (P2). This signal determines whether the TRF6901 is in LEARN mode or HOLD mode. This test point connects to U1−39 LEARN/HOLD terminal.

- EX_MODE TP13

  The EX_MODE test point allows inputting the MODE signal externally from another source into U1−21 MODE terminal.

- EX_STDBY TP14

  The EX_STDBY test point allows inputting the STDBY signal externally from another source into U1−26 STDBY terminal.

- EX_TXDATA TP15

  The EX_TXDATA TP is used to inject data from an external source into U1−32 TX_DATA terminal. This test point is utilized during the FSK modulation and transmitter test (see Chapter 3, *TRF6901 RF EVM Control Software*).

- BRNOUT TP16

  The BRNOUT test point is used to monitor the signal from U1−45 DET_OUT terminal. This signal indicates whether the brownout detector is activated.

- RXDATA TP17

  The RXDATA test point is used to monitor the received data from U1−33 RX_DATA. This test point is used during the receiver testing (see Chapter 3, *TRF6901 RF EVM Control Software*).

2.11 Adjustments

Resistor R43 is varied to adjust the VCC1 voltage applied to U1 (TRF6901).

2.12 LED Indicators

- VCC1 LED3

  If JP6 is installed, the VCC LED is illuminated when voltage is applied to U1.

- ENABLE LED1

  The ENABLE LED is illuminated when the STDBY line from computer is in a high state. The STDBY line is in a high state when the TRF6901 is commanded to STDBY.

- BRNOUT LED2

  Indicates whether the brownout detector is activated.

Chapter 3

TRF6901 RF EVM Control Software

This chapter describes the installation and use of the TRF6901 RF EVM control software. The features and functionality of this tool are described.

Topic **Page**

3.1 TRF6901 RF EVM Control Software Overview

The TRF6901 comes with control software that is designed to control the TRF6901 EVM ISM-band transceiver IC by PC via the parallel port. This software is a Windows-based GUI interface that allows the user to control different components and settings of the transmitter and receiver. This software also has the capability of running an FSK test. This software is an effective tool for evaluating the TRF6901. The user can connect measuring and testing equipment to the TRF6901 EVM and use this software to observe different parameters and features of the TRF6901.

3.2 TRF6901 RF EVM Control Software Installation

The software is intended for use in either a Windows 95/98 or Windows NT/2000 environment. The IOPort.sys driver is needed for computers running either Windows NT or Windows 2000 operating system. The user must put the IOPort.sys driver in the directory ***c:\WINNT\system32\drivers*** in order to write to the parallel port. However, if the operating system is Windows 95/98, the software application can run on its own.

Both the Windows NT/2000 Driver and the TRF6901 software are provided on disk. Your system administrator must install the Windows NT/2000 driver if you do not have administrative rights to the computer. The TRF6901 can run from the floppy disk by following these steps:

1) Click on the *Start Button* on the desktop.

2) Click on the *Run button*.

3) Type A:\ TRF6901.exe and press *OK*.

Or you can:

1) Open the *My Computer* icon on the desktop.

2) Open the A:\ directory.

3) Right click on TRF6901.exe.

4) Paste TRF6901.exe onto the desktop.

Note:

This software is available on the CD ROM and a floppy diskette.

3.3 TRF6901 RF EVM Setup With Control Software

The 3.5-inch diskette supplied with the TRF6901 contains the control software required to demonstrate the TRF6901. Complete the following steps to set up the TRF6901 for evaluation.

1) Place the 3.5-inch diskette into the floppy disk drive of the computer being used to evaluate the TRF6901.

2) Follow the installation instructions described in TRF6901 RF EVM Control Software Installation.

3) Connect a DB25 female to DB25 male cable between the TRF6901 evaluation board and the PC parallel port. The DB25 female end of the cable is connected to the TRF6901. The DB25 male end of the cable is connected to the desired LPT port of the PC (LPT1 or LPT2).

4) Connect a dc power supply capable of 8 V 200 mA between the red power supply terminal and ground on the TRF6901 evaluation board.

5) Verify that the power supply output is set between 6 V and 8 V.

6) Turn the power supply on.

7) If the jumper at JP6 is installed, verify that LED3 (the red power-on LED) is illuminated.

8) Run the TRF6901.exe file on the PC.

9) Press the *Send All Words* (F7) button on the program screen.

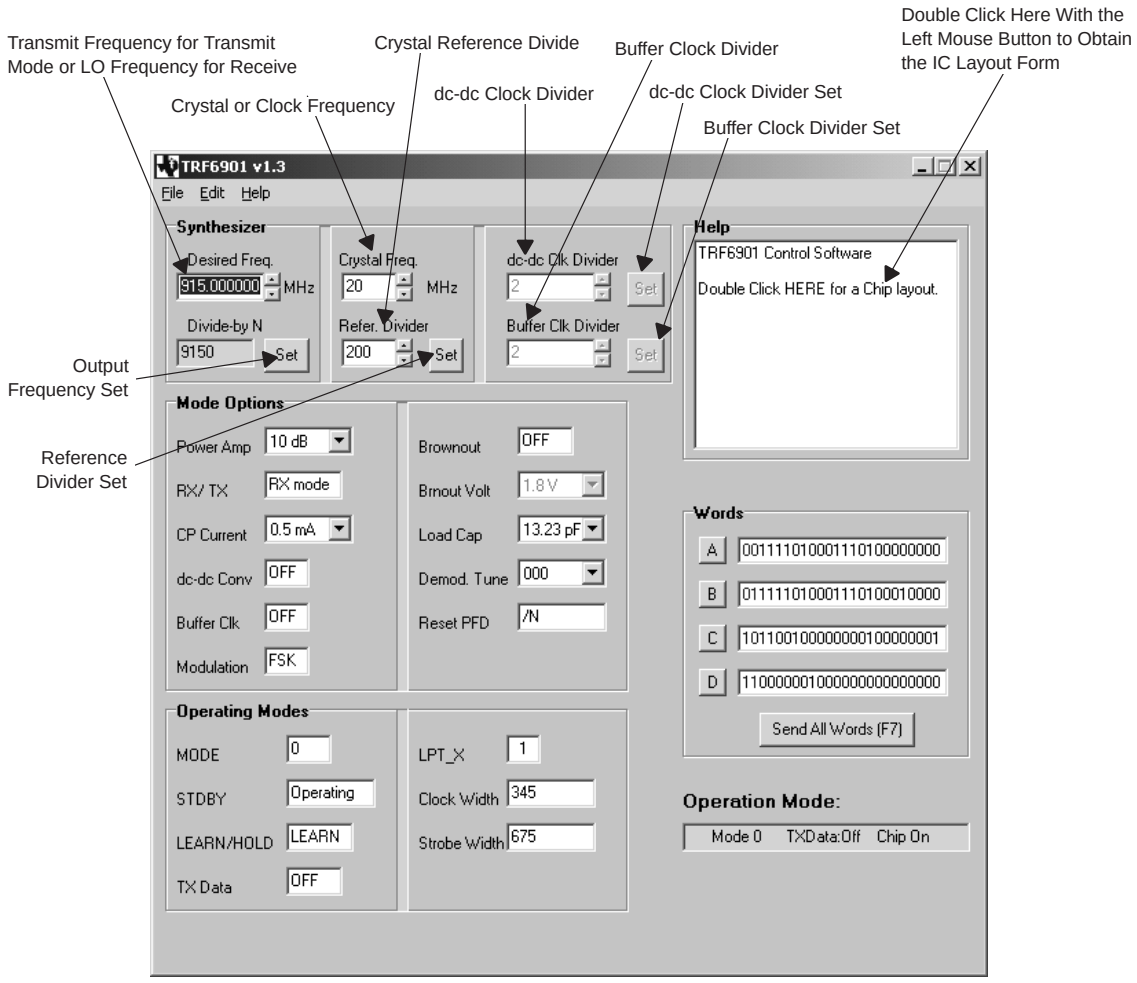
3.4 How to Use the TRF6901 Control Software

The main program screen appears when you open the TRF6901.exe file. The TRF6901 control software has two screens, the main program screen, and the IC layout screen. The main program screen and the IC layout screen offer the same functionality, with the only major difference being that the IC layout screen is a replica of the TRF6901 block diagram.

3.5 Main Program Screen

The main program screen is divided into six main parts: Synthesizer, Mode Options, Operating Modes, Help, Words, and Operation Mode. All the fields in each section can be changed either by typing in the box or by double clicking it.

Figure 3−1. Main Program Screen



Note: When words are displayed in RED, it indicates that you need to send the change to the TRF6901. Pressing the Word *A, B, C, D,* or the *Send All Words Button* sends the update to the TRF6901.

3.5.1 Synthesizer

The following is a brief summary of the controls in this section.

❑ Output Frequency {Desired Freq.}

Sets the output frequency to the value typed inside the field. In transmit mode, the desired frequency is the frequency of the signal transmitted out of the PA. In receive mode the desired frequency is the LO frequency for the mixer. The appropriate frequency range for TRF6901 is 860 MHz to 930 MHz.

Note:

This field is used with the *Set* button right below the box. Press the *Set* button before clicking *Send Words* to make sure that the entry is valid.

❑ Output Frequency Set Button {Set} (Beside Divide by-N field)

This button checks the frequency entered by the user to make sure that it is a multiple integer of the reference frequency. Click this button after

entering the desired frequency. If the entered frequency is not a multiple of the reference frequency, then it is rounded down to the closest frequency that satisfies this requirement.

- Feedback Divider {Div−by N}

  The software calculates the feedback divider from the desired frequency, crystal clock frequency, and the reference divider value of the integer-N PLL. This field cannot be edited.

- Crystal Frequency {Crystal Freq.}

  The default crystal installed on the TRF6901 RF EVM board is 20 MHz, hence the default value for this field is 20 MHz. It can be varied from 10 MHz to 20 MHz. For example, if the user removes the 20-MHz crystal and instead installs a 15-MHz crystal on the TRF6901 RF EVM, then the frequency entered in this field should be 15 MHz.

Note:

Input the frequency of the crystal that has been installed on the TRF6901 RF-only board. Changing the crystal frequency also changes the reference frequency which effects the output frequency. Hence, by changing the crystal frequency, the contents of the the output frequency may change.

- Reference Divider {Refer. Divider}

  Sets the crystal reference divider. The typical range for this parameter is 2−255. Any number entered that is equal to 0, 1, or is greater than 255 causes an error message ERR to display. In this state, the control software does not allow to Send Words. To erase the message, highlight the ERR message by holding on to the left button of the mouse and then type in the desired number. The arrows to the right of the box can also be used to change the parameter.

Note:

This field is used with the *Set* button right next to the box. Press the *Set* button before clicking *Send Words* to make sure that the entry is valid.

- Reference Frequency Set Button {Set} (Beside Refer Divider Field)

  This button checks whether the output frequency entered is a multiple integer of the reference frequency. Click this button after entering the reference frequency. If the output frequency is not a multiple of the reference frequency, then the output frequency is rounded down to the closest frequency that satisfies this requirement.

- dc-dc Converter Clock Divider {dc-dc Clk Divider}

  Sets the dc-dc converter clock divider. The typical range for this parameter is 2−254. Any number entered that is equal to 1, is greater than 254 or is an odd number causes an error message ERR to display after the *Set* button is pressed. In this state, the control software does not allow to *Send*

Words. To erase the message, highlight the ERR message by holding on to the left button of the mouse and then type in the desired number. The arrows to the right of the box, which increments are divided by 2, can also be used to change this parameter. Inputting 0 causes the dc-dc converter to turn off.

Note:

This button is used with the *Set* button right next to the box. Press the *Set* button before sending words to make sure that the entry is valid.

❑ dc-dc Clock Divider Set {Set} *(Next to the dc-dc Clk Divider Box)*

This button should be pressed after entering the dc-dc Clk divider. The software checks the entry and makes sure that it is within constraints.

Note:

This does not *Send Words,* since the changed bits still remain highlighted even after pressing this button.

❑ Buffer Clock Divider {Buffer Clk Divider}

Sets the buffer clock divider. The typical range for this parameter is 2 to 62. Any number entered that is equal to 1, is greater than 62, or is an odd number causes an error message ERR to display after the *Set* button is pressed. In this state, the control software does not allow to *Send Words*. To erase the message, highlight the ERR message by holding on to the left button of the mouse and then type in the desired number. The arrows to the right of the box, which increment by divider by 2, can also be used to change this parameter. Inputting 0 causes the buffer clock to turn off.

Note:

This button is used with the *Set* button right next to the box. Press the *Set* button before sending words to make sure that the entry is valid.

❑ Buffer Clock Divider Set {Set} *(Next to the Buffer Clk. Divider Box)*

This button should be pressed after entering the Buffer Clk Divider.

Note:

This button checks the entry and makes sure that it is within constraints. This does not *Send Words,* since the changed bits still remain highlighted even after pressing this button.

3.5.2 Mode Options

This section allows you to control the TRF6901. The following is a brief summary of the 11 controls:

- Power Amplifier {Power AMP}

  Allows the power amplifier to be set to 0-dB, 10-dB, and 20-dB attenuation. The user can observe the changes caused by this feature with the use of a spectrum analyzer.

- Receive/Transmit Mode {RX/TX}

  Sets the IC to receive or transmit mode. The MODE selects appropriate registers (A and D or B and C) at a time while RX/TX only impacts bit 5 of Word A in Mode 0 and bit 5 of Word B in Mode 1.

Note:

Keep in mind that this field is not related to MODE under the *Operating Mode* section.

- Charge Pump Current {CP Current}

  Allows the charge pump current to be set to 0.5 mA, 1 mA, or 0.25 mA.

- dc-dc Converter Enable {dc-dc Conv}

  Turns the dc-dc converter On or Off. Enables or disables the dc-dc clock divider and the dc-dc clock divider set.

- Buffer Clock Enable {Buffer Clk}

  Turns the buffer clock on or off. Enables or disables the buffer clock divider and the buffer clock divider set.

- Modulation Select {Modulation}

  Sets the modulation to FSK or OOK.

- Brownout Detector Enable {Brn Out}

  Sets the brownout detector on or off. Enables or disables the (brownout voltage) settings.

- Brownout Detector Threshold Voltage {Brn Out Voltage}

  Allows the threshold voltage for the brownout detector to be set to 1.8 V, 2 V, 2.2 V, or 2.4 V.

- XTAL Internal Tuning Capacitor {Internal Cap}

  Allows the desired XTAL frequency to be fine-tuned by setting the value of an internal trim capacitor. The capacitor can be set to 13.23 pF, 15.56 pF, 17.9 pF, 20.23 pF, 22.57 pF, 24.9 pF, 27.24 pF, or 29.57 pF.

- Demodulator Tune {Tune}

  Allows the resonant frequency of the external demodulation tank to be tuned. Default is 000.

- Reset Signal for the PFD {Reset PFD}

  Selects the reset signal to be derived from the XTAL (crystal) or derived from the feedback divider (/N).

3.5.3 Operating Modes

This section allows the user to do the following:

- MODE

  Select mode 0 or mode 1. These two modes are independent of each other and allow a user to save two different TRF6901 settings. In other words, the user, while in mode 0, can type in the desired parameter to set the TRF6901 to transmit a signal and then change the mode to 1 and enter the parameters to set the TRF6901 to receive a signal. Another way of using MODE, is to have two different transmit frequencies stored in MODE, and by toggling between 0 and 1, the user can observe the change in frequency on the spectrum analyzer.

- STDBY

  Turns the TRF6901 IC on or to standby.

- Learn/Hold

  Sets the data slicer to LEARN or HOLD mode.

  During LEARN mode, the data slicer is constantly integrating the incoming signal and charging C10 (see the schematic diagram) to a dc voltage level (V_{ref}) that is proportional to the average demodulation dc level. Capacitor C10 is connected to terminal 34 of the TRF6901 (SLC_CAP).

  During HOLD mode, the data slicer stops integrating and uses the dc-voltage level stored on capacitor C10 as the decision threshold between logic 1 and logic 0 as measured on terminal 33 *RX_DATA*. For receiver measurements, the output of terminal 33 *RX_DATA* is measured at the RXDATA test point (TP17).

- TX DATA

  Sets the TX data output high or low.

  This option allows the user to observe the deviation between the frequencies for transmitting 1 and 0 if the output connector J2 of TRF6901 EVM is connected to a spectrum analyzer.

- LPT_X

  Set the LPT to port 1 or port 2.

- Clock Width

  Sets the pulse width for the data and clock signals.

- Strobe Width

  Sets the pulse width for the strobe signal.

  The clock and strobe width operations allow the user to alter the timing of the words and hence the baud rate through the PC parallel port.

3.5.4 Help Box

Gives a brief description of each control box. For example, clicking on the *Reset PFD* box in the Mode Options section, the Help Box reads:

Reset Signal for the PFD

0: Derived from XTAL
1: Derived from /N

Valid in Mode 0 or 1.

Most of the other control boxes follow this format. The first line indicates what portion of the TRF6901 is controlled. The next two lines indicate the bit value. The last line indicates that the control works in mode 0 and 1.

Double clicking the Help box activates the IC layout screen.

3.5.5 Words

This section updates the binary words after changes are made to the control options. Clicking on the box next to the word can individually send each word. Clicking *Send Words Now* or pressing F7 sends all the words to the TRF6901.

3.5.6 Operation Mode

Operation Mode shows if:

The TRF6901 is enabled or disabled.

The transmit (TX) data line is on or off.

Mode is 0 or 1.

This field cannot be edited.

3.5.7 The Menu Bar

The Menu Bar has three options: File, Edit, and Help.

- File Menu

  Allows the user to open a file, save a file, and close the program. Hence, the users can store their preferred settings in a file and then restore it conveniently any time.

- Edit Menu

  Allows the user to edit, copy, or paste data.

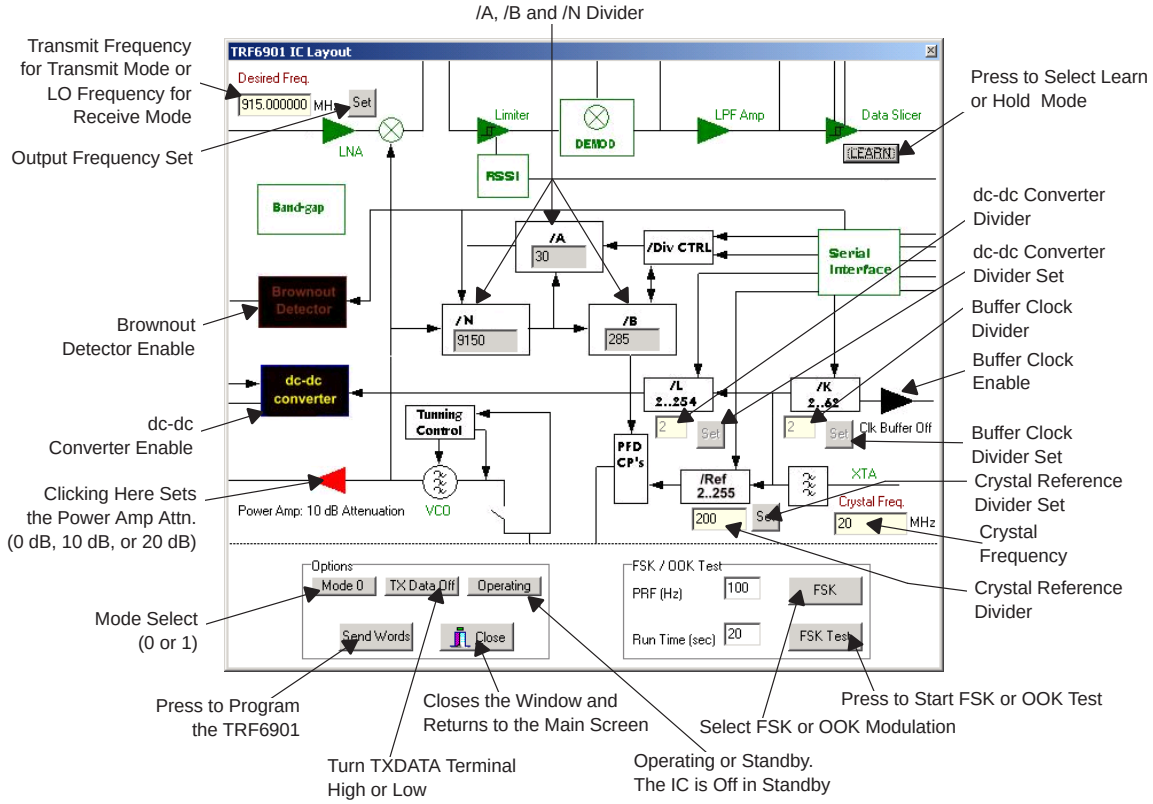
- Help Menu

  Allows the user to view the Help file, and the About file.

3.6 IC Layout Screen

Figure 3−2 shows the IC layout screen of the TRF6901 control software. Double clicking the Help window on the main program screen with the left mouse button, displays the IC layout screen. The IC layout screen is a replica of the main program screen of the program that gives the user a convenient environment to control the TRF6901 IC. All changes on either form, are updated promptly on both forms. This form consists of three sections.

Figure 3−2. TRF6901 IC Layout Screen



3.6.1 Main IC Layout Form

The main IC layout form has the following options.

❑ Desired Output Frequency {Desired Freq.}

This field is similar to the *Desired Freq.* field on the main program screen. It sets the output frequency to the value typed inside the field. The appropriate frequency range for TRF6901 is 860 MHz to 930 MHz.

Note:

This field is used with the *Set* button right next to the box. Press the *Set* button before clicking *Send Words* to make sure that the entry is valid.

❑ Output Frequency Set Button {Set} *(Beside the Desired Freq. Field)*

This button checks the output frequency to make sure that it is a multiple integer of the reference frequency. Click this button after entering the

desired frequency. If the entered output frequency is not a multiple of the reference frequency, then it is rounded down to the closest frequency that satisfies this requirement.

- LEARN/HOLD Mode Button

  This button toggles the data-slicer in the TRF6901 IC between LEARN and HOLD mode and performs the same function as the LEARN/HOLD field on the main program screen.

- Brownout Detector Enable {Brownout Detector}

  By clicking on the *Brownout Detector box*, the user can turn it on or off. If the out detector is colored black, then it is turned off and when it is colored white, it is turned on. The default status of brownout detector is Off. The brownout field on the main program screen has the same functionality.

- DC-DC Converter Enable {dc-dc Converter}

  By clicking on the *dc-dc Converter* box, the dc-dc converter can be enabled or disabled. If the *dc-dc Converter* box is colored black, then it is turned off. When it is colored white, it is turned on. The default status of the dc-dc converter is off. The *dc-dc Conv* field on the main program screen has the same functionality.

- Buffer Clock Divider Enable {Clk Buffer}

  By clicking on the *Clk Buffer* arrow, the buffer clock divider can be enabled or disabled. If the *Clk Buffer* is colored black, then it is turned off. When it is colored green, it is turned on. The default status of buffer clock divider is off. The *Buffer Clk* field on the main program screen has the same functionality.

- Feedback Divider, A Counter, and B Counter {/N, /A. /B}

  These fields are automatically calculated by the software and displayed on the IC layout screen. These fields cannot be edited by the user. However, the user can vary the crystal frequency, output frequency, and the reference divider to change these parameters.

- DC-DC Clock Divider {/L 2..254}

  This field represents the dc-dc clock divider value and is similar to *dc-dc Clk Divid*er on the main program screen. This field can be edited after the dc-dc converter has been enabled.

- DC-DC Clock Divider Set Button {Set} *(Right Next to dc-dc Clock Divider Field)*

  This button is similar to the *dc-dc Clock Divider Set* button on the main program screen. For more details, please see the *Synthesizer* section of this chapter.

- ❏ Buffer Clock Divider {/K 2..62}

  This field represents the buffer clock divider value and is similar to *Buffer Clk* on the main program screen. This field can be edited after the clock buffer has been enabled.

- ❏ Buffer Clock Divider Set Button {Set} *(Right Next to Buffer Clock Divider Field)*

  This button is similar to the *Buffer Clock Divider Set* button on the main program screen. For more details, please see the *Synthesizer* section of this chapter.

- ❏ Crystal Frequency {Crystal Freq.}

  This field is similar to *Crystal Freq.* field on the main program screen. The allowable range is 10 MHz to 20 MHz.

- ❏ Reference Divider {/Ref 2..255}

  This field sets the value for the reference divider and is similar to the *Refer. Divider* field on the main program screen.

Note:

This field is used with the *Set* button right next to the box. Press the *Set* button before clicking *Send Words* to make sure that the entry is valid.

- ❏ Reference Frequency Set Button {Set} *(Beside the /Ref. Box)*

  This button checks the output frequency to make sure that it is a multiple integer of the reference frequency. Click this button after entering the reference frequency. If the output frequency is not a multiple of the reference frequency, then it is rounded down to the closest frequency that satisfies this requirement.

- ❏ Power Amplifier {Power Amp:}

  By clicking on the power amplifier, the user can set the attenuation level for the output signal. The *Power Amp* field on the main program screen performs a similar function.

3.6.2 Options

The Options Sections consists of the following:

- ❏ Mode 0/1

  By clicking on this button, the user can toggle the mode of the TRF6901. This field is similar to the *MODE* field on the main program screen.

- ❏ TXDATA 0/1

  This button toggles the TX_DATA terminal of the TRF6901.

- ❏ Operating/Powerdown

  This button enables or disables the TRF6901 IC. This field is similar to the *STDBY* field on the main program screen.

- Send Words

  This button is similar to *Send All Words (F7)* button on the main program screen and it sends out A, B, C, and D words to the TRF6901 through the parallel port.

- Close

  This button closes the IC layout form and returns to the main program screen.

3.6.3 FSK/OOK Test

The FSK/OOK Test section consists of the following:

- Pulse Frequency {PRF (Hz)}

  This field sets the frequency of the TX_DATA pulses that are fed to the TRF6901 during the FSK/OOK test. The pulse repetition frequency is always set to 100 Hz, which corresponds to an NRZ bit rate of 200 bps. This field cannot be modified. This feature is for the users convenience to observe low-data rate FSK spectrum.

  In order to test the transmitter at the desired data rate, it is recommended that the user feed the modulating signal via a signal generator to the TP15 EX_TXDATA test point with the desired frequency. More details are covered in the *Testing the Transmitter* section.

- FSK Test Duration {Run Time (sec)}

  This field displays the FSK test duration. It is always set to 20 seconds and cannot be modified.

- FSK or OOK Test Select {FSK/OOK}

  The user can toggle between FSK and OOK test by using this button.

- Execute FSK/OOK Test {FSK/OOK Test}

  This button starts the FSK/OOK test. The test continues for the duration that is specified in the *Run Time* field. The user cannot change any component status or field value during this interval.

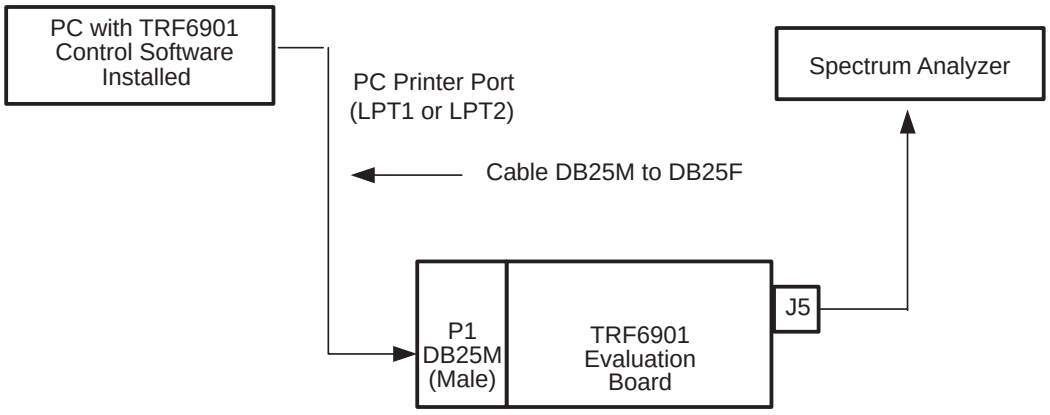
3.7 Testing the Transmitter

To perform test of the transmitter section of the TRF6901, perform the following steps.

3.7.1 Step 1: Test Setup

Set up the test bench as shown in Figure 3−3. Although 915-MHz quarter-wave antennas can be used for this test, for the best results, it is recommended to use RF cables to connect various equipment to the TRF6901 RF EVM. The antennas are more applicable during the system mode test detailed in Chapter 7.

Figure 3−3. Equipment Setup for Testing of the TRF6901 EVM Transmitter



3.7.2 Step 2: Software Programming

For testing the TRF6901 transmitter section in the FSK mode, set the main program screen and the IC layout screen as shown in Figure 3−4 and Figure 3−5.

Figure 3−4. Main Programming Screen Setup for Testing the Transmitter

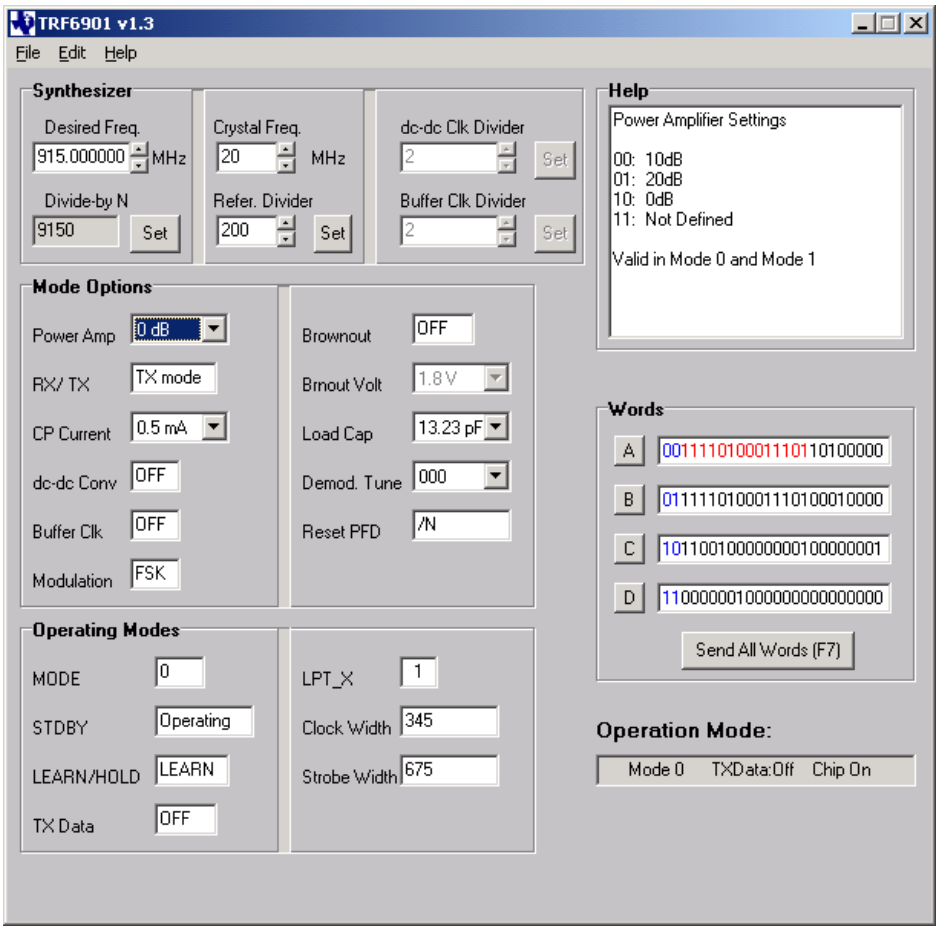
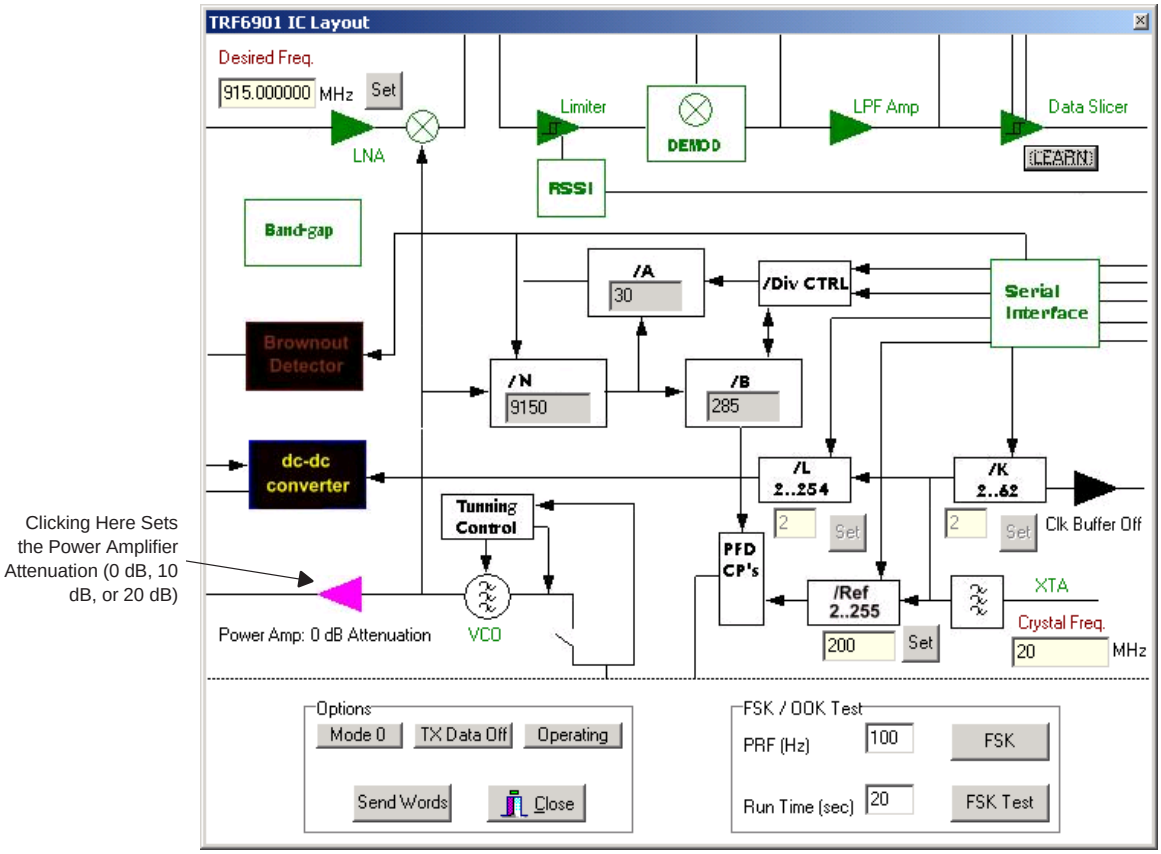


Figure 3−5. IC Layout Screen Setup for Testing the Transmitter



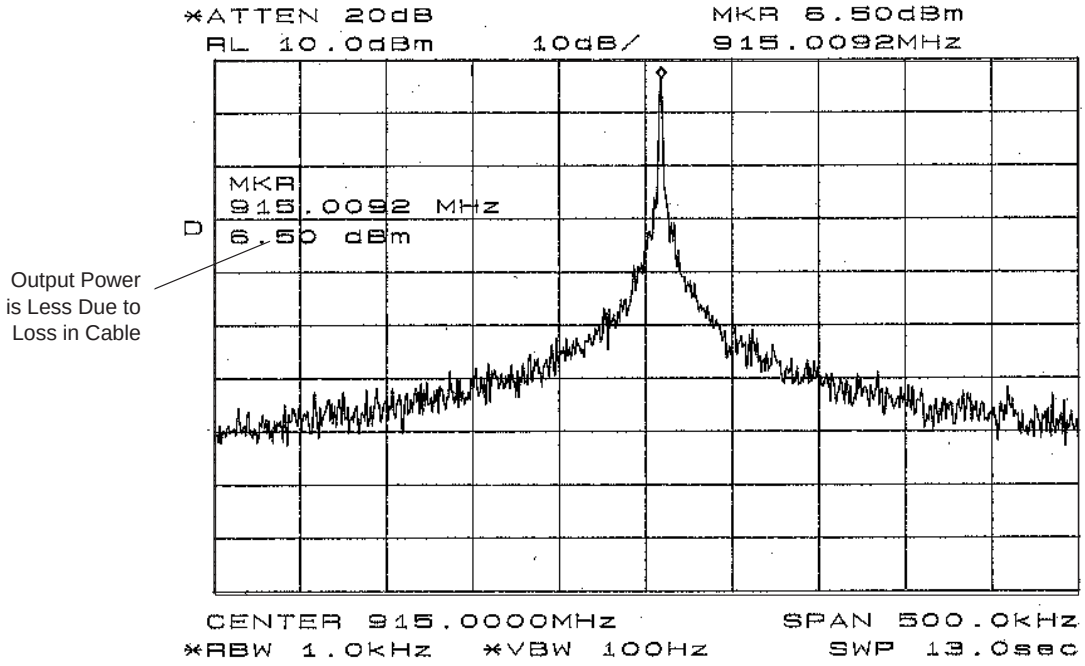
Clicking Here Sets the Power Amplifier Attenuation (0 dB, 10 dB, or 20 dB)

After setup is complete, press the *Send Words* button on the IC layout screen or the *Send All Words (F7)* button on the main program screen to send the programming words to the TRF6901.

3.7.3 Step 3: Spectrum Analyzer Setup

Set up the spectrum analyzer to observe the following figure.

Figure 3−6. Carrier Signal on the Spectrum Analyzer



3.7.4 Step 4: FSK Modulation Output Test

The FSK deviation for the TRF6901 is set externally by C24 to approximately ±50 kHz. To run an FSK test:

1) Click the *Send Words* button from the main program screen or the IC layout screen.

2) From the IC layout screen, click on *FSK Test*.

3) Set up the spectrum analyzer to observe the spectrum analyzer display as shown in Figure 3−7.

Figure 3−7. FSK Output From Transmitter

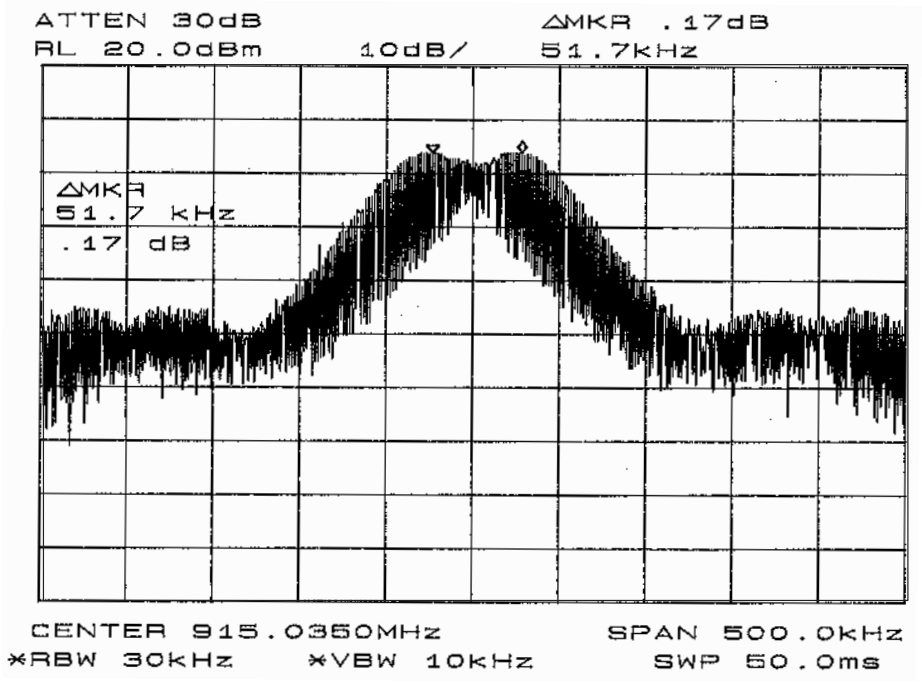
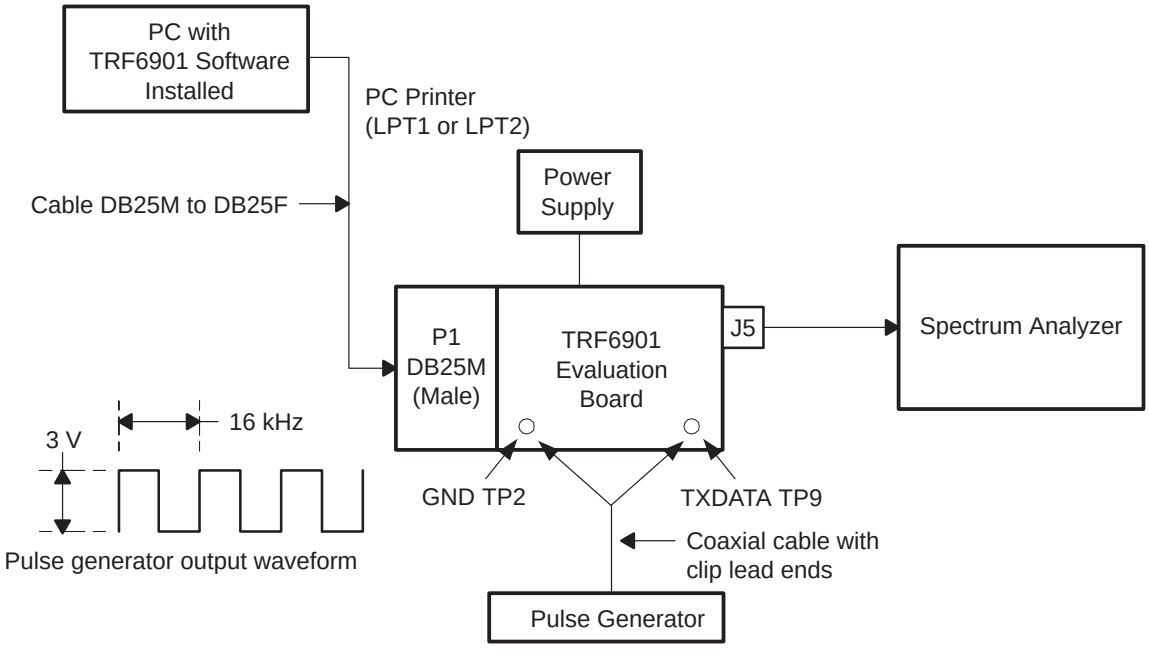


Figure 3−8. Equipment Setup for FSK Test With an External Modulation



3.7.5 FSK Test Using an External Source

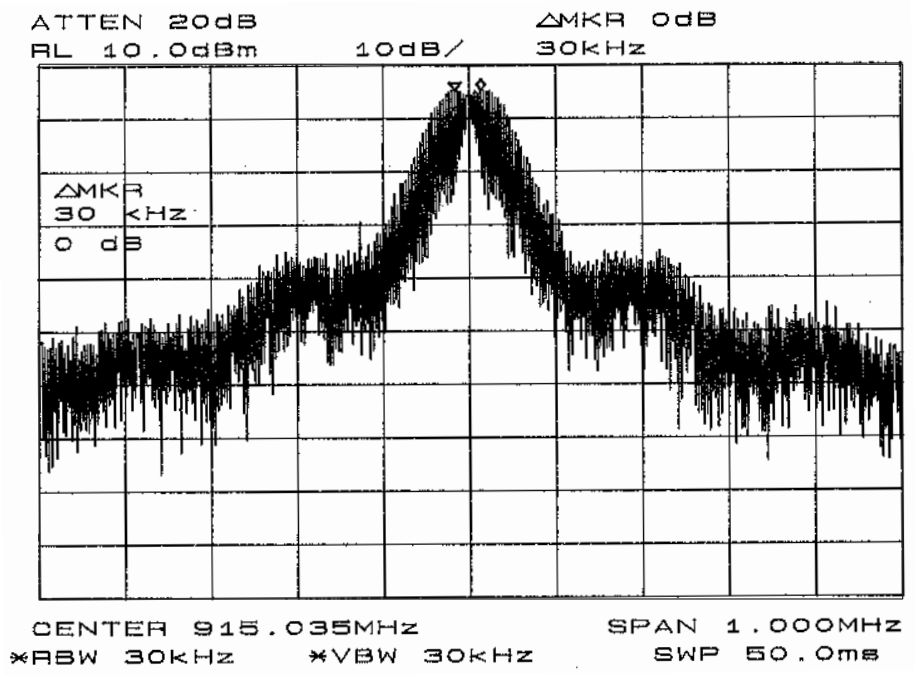
To use an external pulse generator to supply transmit data, set up the test bench as shown in Figure 3−8.

Perform the FSK modulation output test as described in the previous section. In this new setup, an external pulse generator provides modulation. The *FSK Test* button on the IC Layout screen does not need to be pressed to start the FSK Test.

At a data modulation rate of 16 kHz (corresponding to a NRZ bit rate of 32 kbps), set the reference divider to 100 or less (corresponding to a reference frequency of 200 kHz or higher). It is necessary that the PLL loop filter bandwidth be greater than the data modulation rate. For the TRF6901 EVM, the PLL loop filter bandwidth is designed to be approximately 20 kHz, which is greater than the required 16 kHz. As a general rule of thumb, the reference frequency should be at least five times greater than the PLL loop filter bandwidth. A reference frequency of 200 kHz exceeds this requirement.

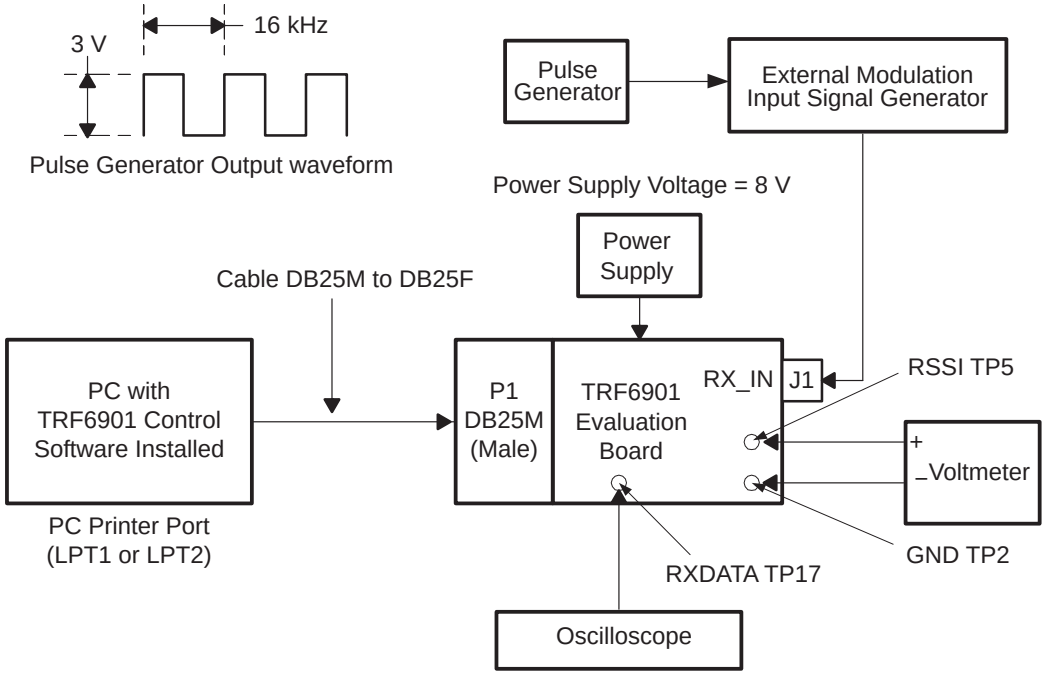
The nominal frequency deviation for the TRF6901 EVM is approximately ±50 kHz and is set by the capacitor connected to terminal 31.

Figure 3−9. FSK Output From Transmitter With an External Modulation



3.8 Testing of the Receiver

Figure 3−10. Test Setup for TRF6901 EVM Receiver Testing



3.8.1 Test Equipment Setup

Connect the TRF6901 RF EVM as shown in Figure 3−10. Set the channel of digital or analog oscilloscope to 20 μs Time/Division and 1 V/Division. Set the external signal generator according to the following:

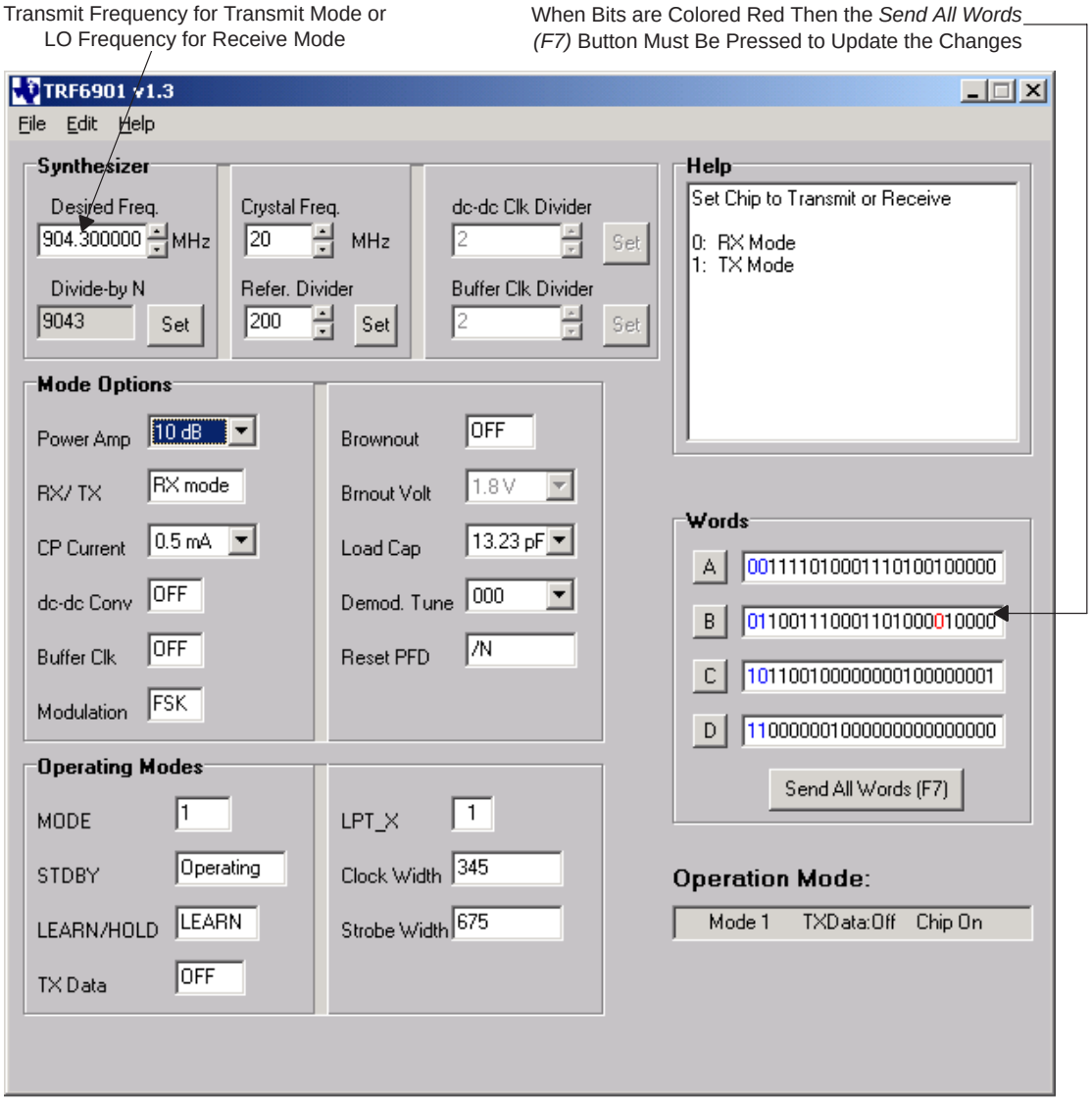
Center frequency	915 MHz
FM frequency deviation from carrier	±50 kHz
External modulation input	16 kHz
Signal level	−60 dBm

Do not feed a signal greater than −40 dBm, or it may overdrive the LNA in the TRF6901.

3.8.2 Software Programming for Receiver Testing

Set up the main program screen and the IC layout screen as shown in Figure 3−11 and Figure 3−12.

Figure 3−11. Main Program Screen Setup for Receiver Testing

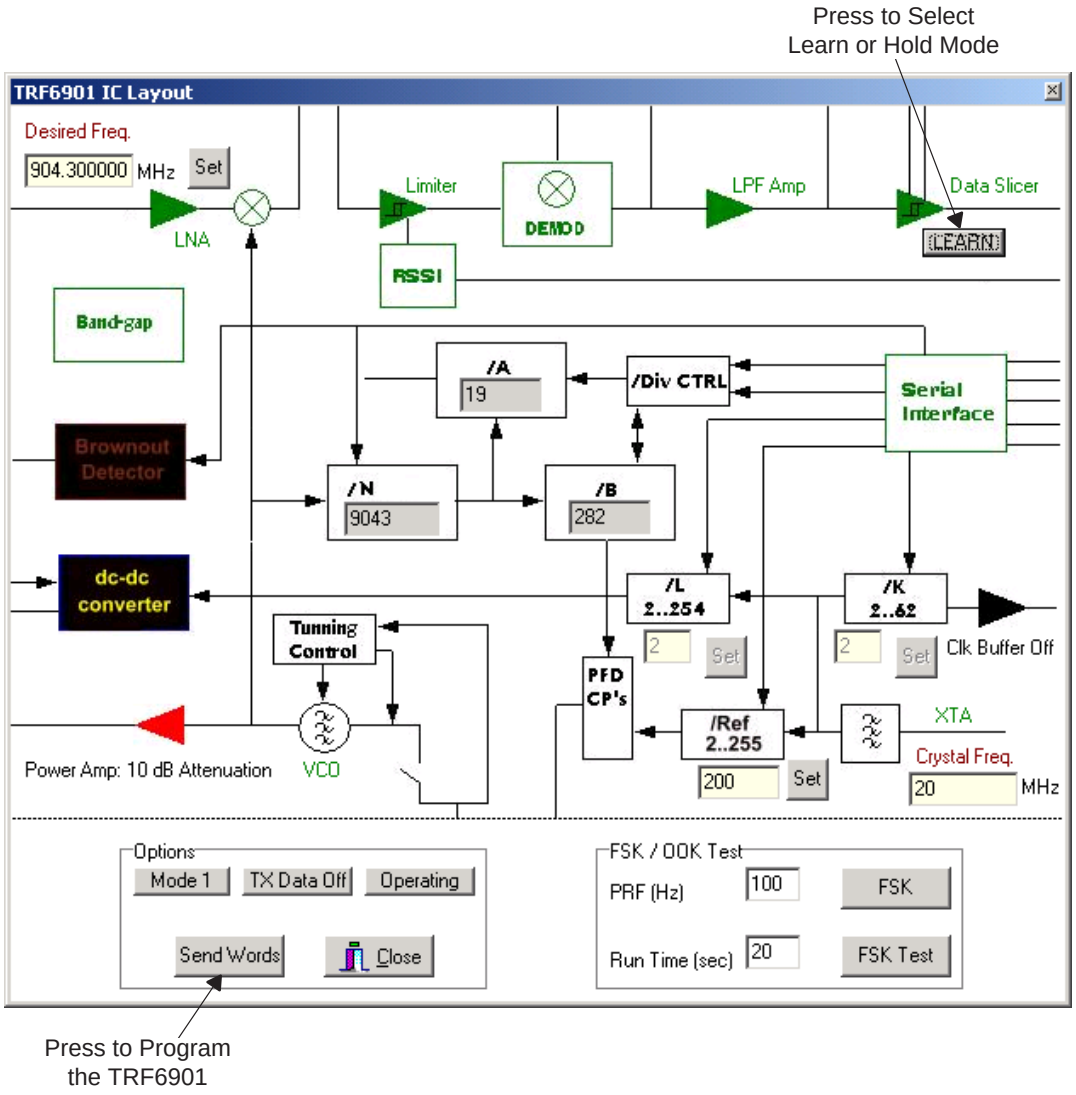


Note: The signal received by the TRF6901 has a frequency of 915 MHz. The TRF6901 is using a 10.7-MHz IF frequency. Therefore, the local oscillator (LO) is set to a frequency of 904.3 MHz.

LO Frequency = RF Frequency – IF Frequency = 915 MHz – 10.7 MHz = 904.3 MHz

The desired frequency block of the TRF6901 software control program is used to set the internal VCO frequency of the TRF6901. (See the Block Diagram)

Figure 3−12. IC Layout Screen for the Receiver Testing



3.8.3 LEARN and HOLD Modes

Set the data slicer to LEARN mode.

Received data is viewable through the RX_DATA terminal in HOLD mode for the data slicer. In practical applications, the data slicer is in LEARN mode until a valid training sequence (see *TRF6901 RF Tool Kit System Mode*) from the receiver is recognized. The data slicer is then switched to the HOLD mode. It is switched back to the LEARN mode as soon as the transmission of the data packet is complete.

3.8.4 Measured Receive Data

The data plots in Figure 3−13 and Figure 3−14, show the measured receive data at the RXDATA test points for input signals at –50 dBm and –90 dBm, respectively.

Figure 3−13. RXDATA Signal at −50-dBm Input Signal to the Receiver

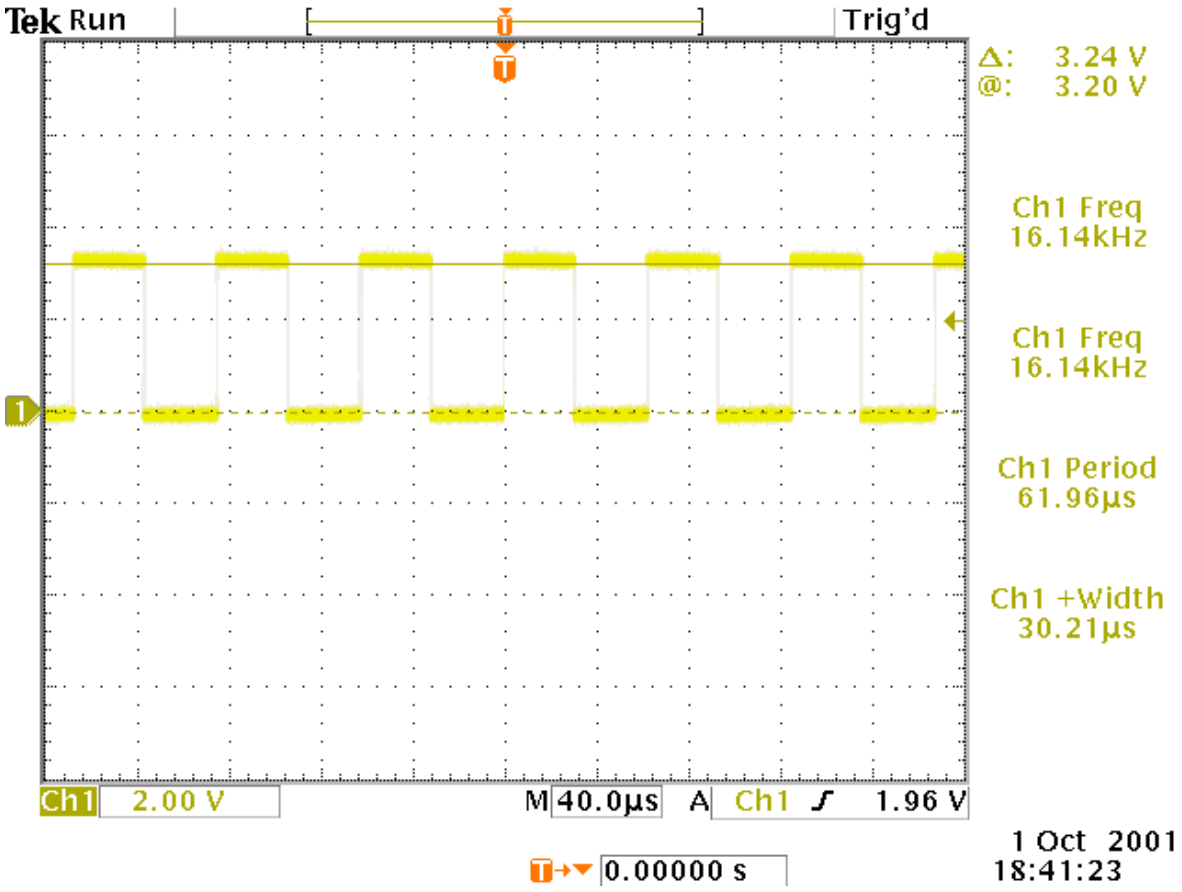
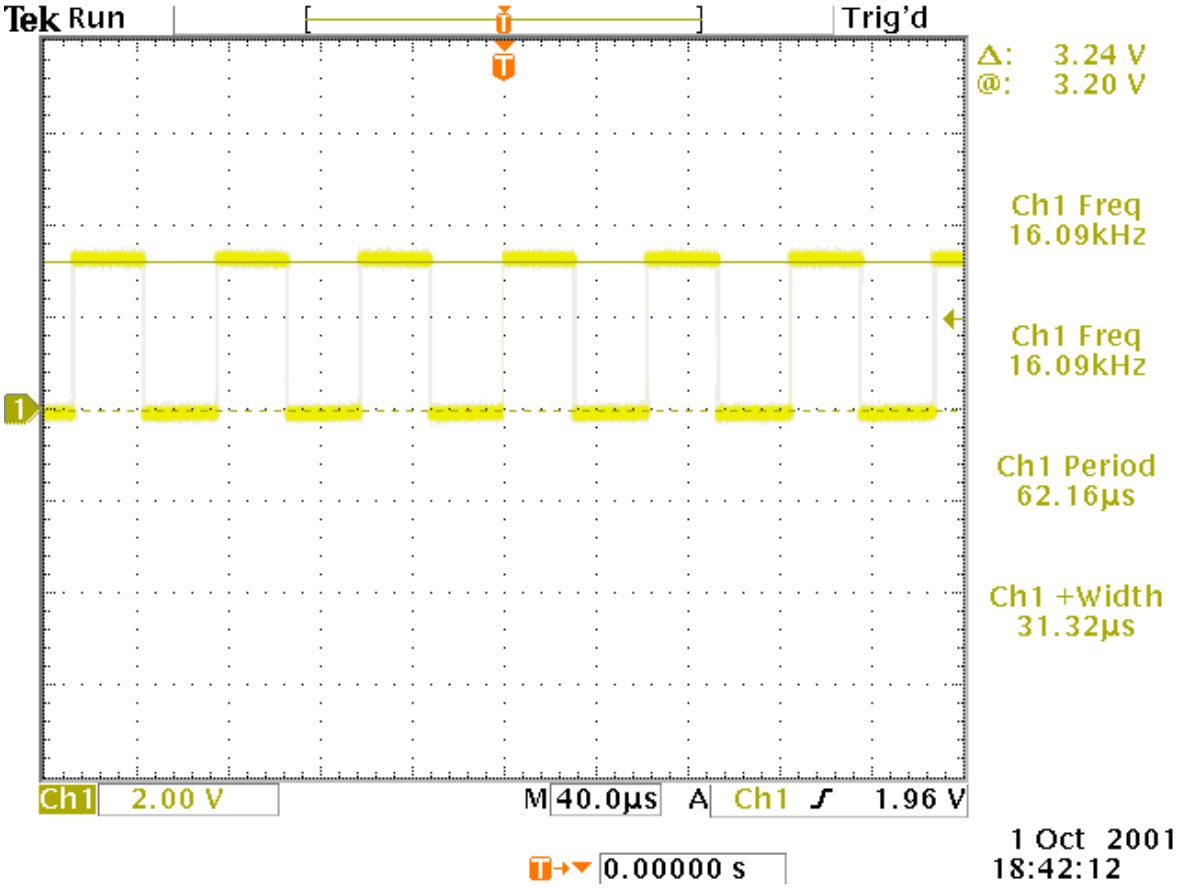


Figure 3−14. RXDATA Signal at −90-dBm Input Signal to the Receiver



Chapter 4

TRF6901 Serial Port Tool Overview

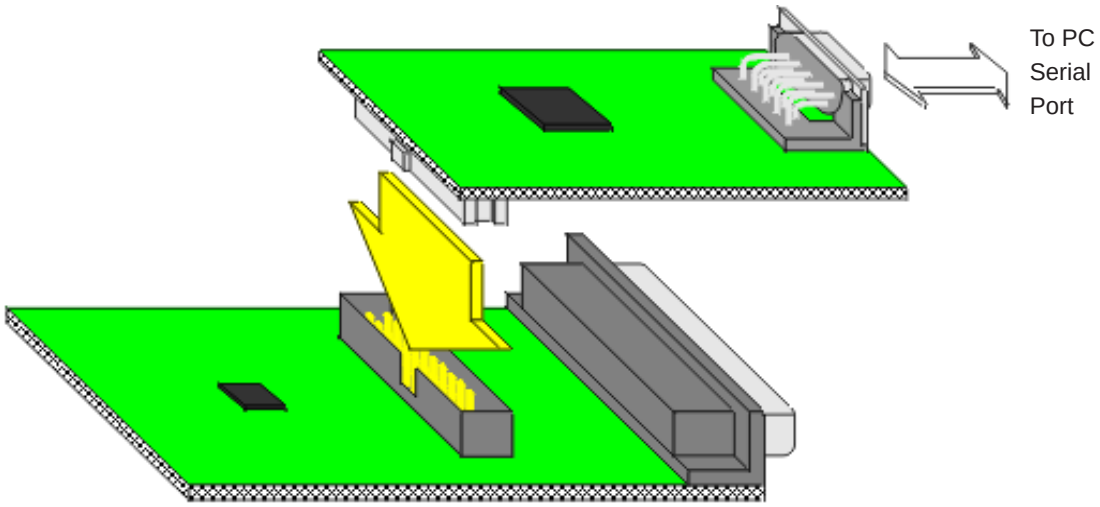
This chapter provides an overview of the TRF6901 serial port module supporting the TRF6901 RF EVM.

Topic **Page**

4.1 Purpose

The TRF6901 serial port module is intended to permit a user of the TRF6901 RF EVM to observe the performance of the TRF6901 via the programming tool software as well as to observe the real-time operation of the TRF6901 in an RF link example. The TRF6901 serial port module is contained along with the TRF6901 RF EVM in the TRF6901 RF tool kit. See Figure 4−1 for the TRF6901 RF tool kit.

Figure 4−1. TRF6901 RF Tool Kit



4.2 TRF6901 Serial Port Module Description

The TRF6901 serial port module (symbolized as *Baseband Board*) is based on the TI MSP430F149 ultralow power flash based micro controller. Firmware in the MSP430 maintains serial communication to the PC by an internal hardware UART and performs TRF6901 device programming through a general-purpose I/O port. The primary connector SV1 on the left of the board interfaces to the TRF6901 RF EVM. This connector receives power from the TRF6901 RF EVM as well as provides communication and control signal lines to the TRF6901 RF EVM. The serial port connector on the right of the board interfaces the MSP430 to a standard PC COM port.

Chapter 5

TRF6901 Serial Port Module PCB Hardware

This chapter describes the PCB hardware of the TRF6901 serial port module. The PC serial interface, MSP430 micro controller, TRF6901 RF EVM interface SV1, control interface J12, JTAG interface J13, miscellaneous MSP430 port terminals, and the LED status indicators are discussed in this chapter.

Topic **Page**

5.1 Hardware Overview

The TRF6901 serial port module's primary feature is the functionality of the MSP430. The MSP430 controls the module's operation in both evaluation and system modes. This allows the user to evaluate the performance of the TRF6901 on the TRF6901 RF EVM, or if the user is in possession of two RF tool kits, it permits the user to observe a real-time frequency shift keying (FSK) RF link operation with the TRF6901 RF EVM. Furthermore, if users are familiar with the MSP430 micro controller family and are in possession of the MSP430 flash emulation tool, they may develop firmware routines and download them to the MSP430 through the JTAG connector (J13). In addition, LED signals and connectors permit users to observe status conditions on the board.

Figure 5−1. TRF6901 Serial Port Module Schematic

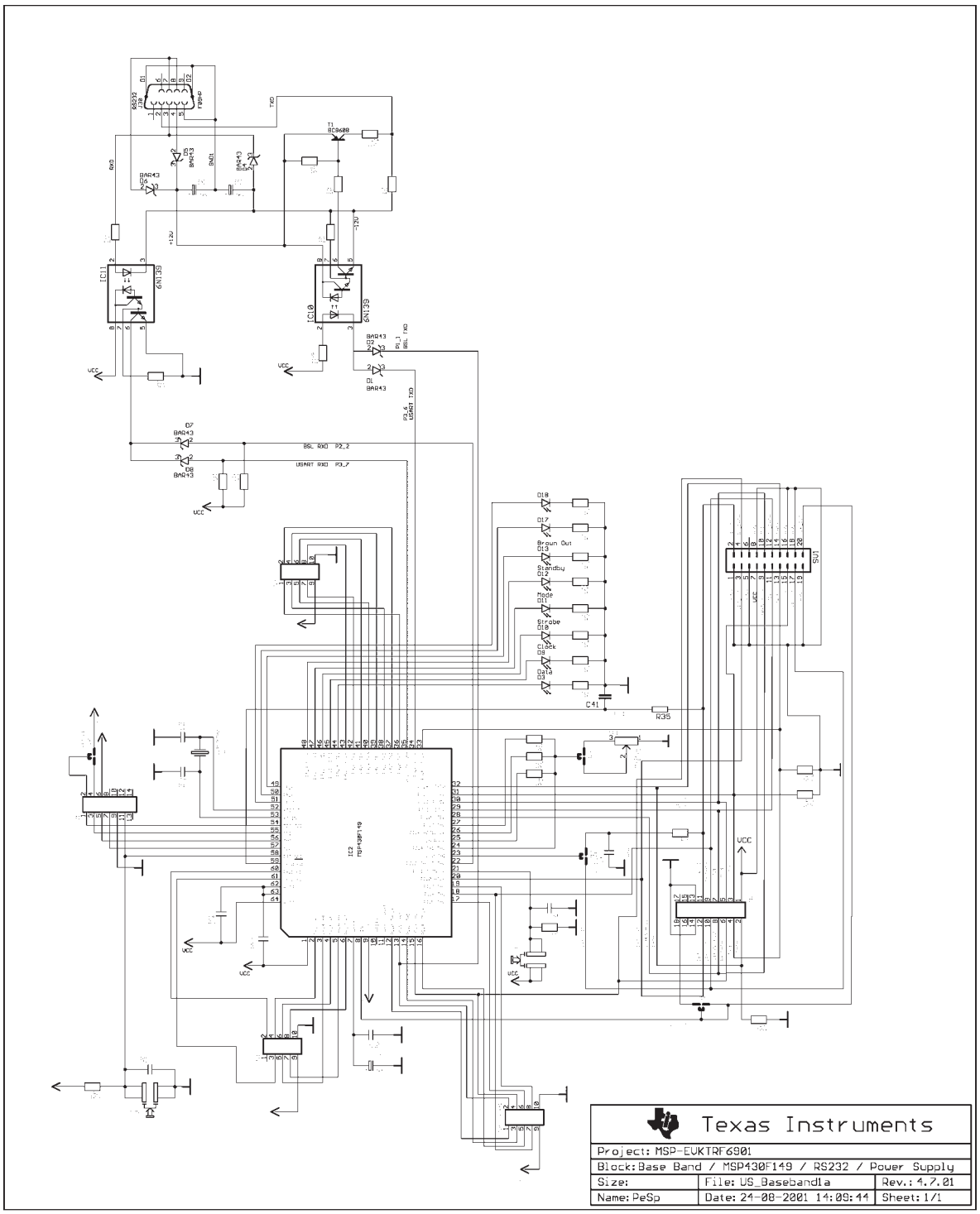
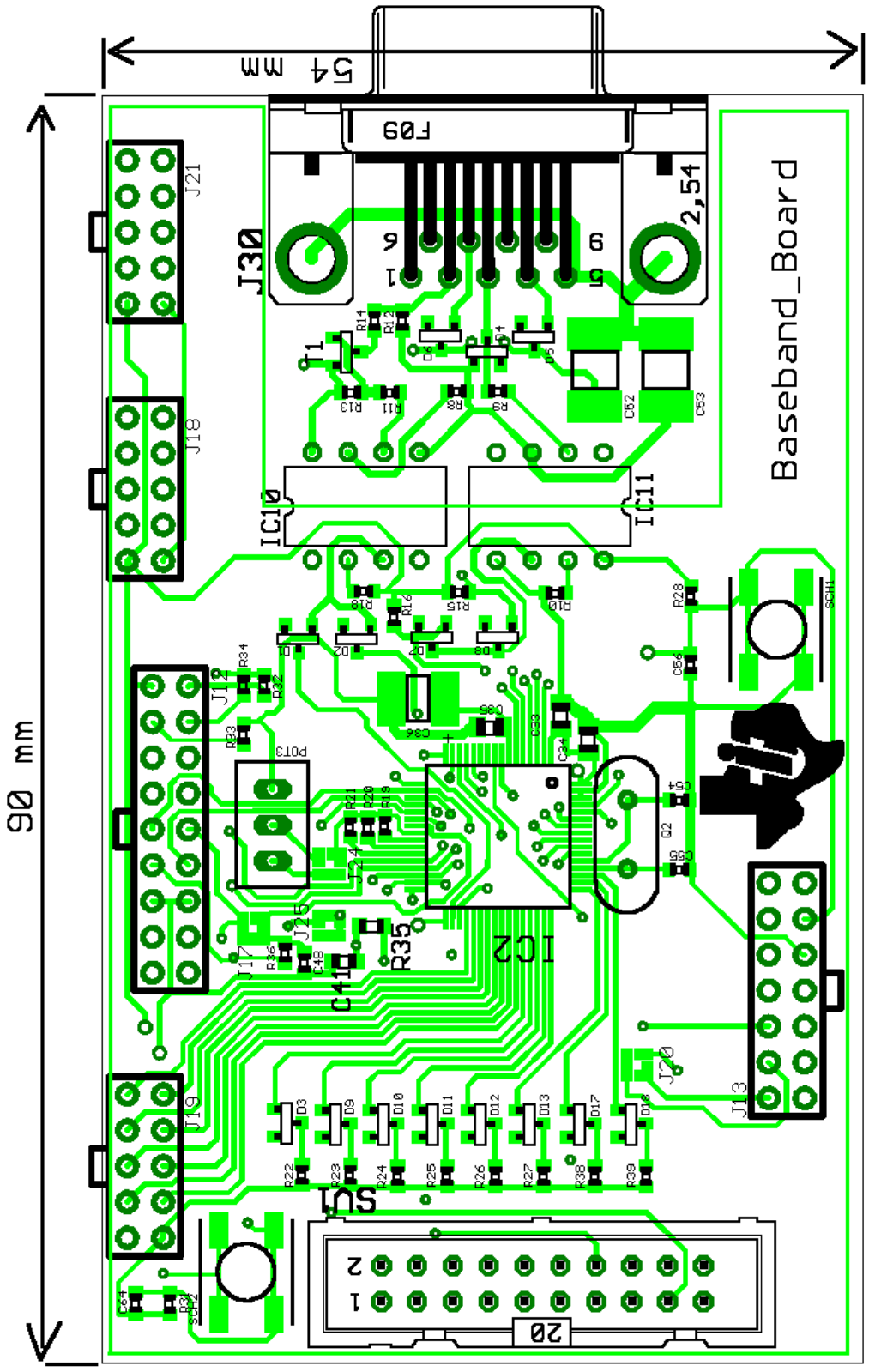


Figure 5−2. TRF6901 Serial Port Module Top Level Layout



5.2 PC Serial Port Interface

The PC serial port interface connector J30 on the right side of the board connects to a standard 9-terminal serial port cable connector. From the connector, signal levels are adjusted via two 6N130 opto-isolators to eliminate noise from coupling from the PC to the TRF6901, as well as prevent damage to the MSP430 hardware UART.

5.3 MSP430 Features

The device included on the TRF6901 serial port module is the MSP430F149. See the *MSP430x13x, MSP430x14x Mixed Signal Microcontroller* data sheet, literature number SLAS272 and the *MSP430x1xx Family User's Guide*, literature number SLAU049 for microcontroller details. The MSP430F149 is a 16-bit RISC architecture micro controller with the following additional features:

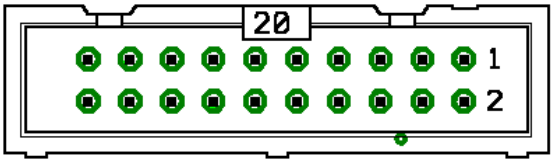
- 12-Bit A/D Converter With Internal Reference, Sample-and-Hold and Autoscan Feature
- 16-Bit Timer With Seven Capture/Compare-With-Shadow Registers, Timer_B
- 16-Bit Timer With Three Capture/Compare Registers, Timer_A
- On-IC Comparator
- Hardware UART
- 60KB + 256B Flash Memory, 2-KB RAM
- These features along with the five power-saving modes

In implementing the FSK RF link, many of these features are used with exceptional ease.

5.4 TRF6901 SV1 Interface

The TRF6901 serial port module SV1 interface is the direct connection to the TRF6901 RF EVM. See Figure 5−3 for terminal connections.

Figure 5−3. SV1 Terminal Connections



11	ACTIVE/STDBY	Digital output from the MSP430 for controlling the state of the TRF6901.
1, 5, 8, 16, 18, 19	AGND	This is the analog ground supplied for the entire board.
20	CLK_OUT	TRF6901 Xtal buffered clock output to the MSP430
15	CLOCK	Digital output from the MSP430 for the serial programming to the TRF6901
14	DATA	Digital output from the MSP430 for the serial programming to the TRF6901
3	DET_OUT	Digital output from the TRF6901 RF EVM displaying the state of the TRF6901 Brownout detector
9	LEARN/HOLD	Digital output from the MSP430 for the TRF6901 receive path
17	LPF_OUT	TRF6901 low-pass filter amplifier output to MSP430
10	MODE	Digital output from the MSP430 for selection on transmit or receive
6	N/C	
2	RSSI	Analog signal from the TRF6901 RF EVM
4	RX_DATA	Digital output from the TRF6901 RF EVM displaying the state of the TRF6901 data slicer
13	STROBE	Digital output from the MSP430 for the serial programming to the TRF6901
12	TX_DATA	Digital output from the MSP430 for controlling the state of the power amplifier (PA) output of the TRF6901.
7	VCC	Regulated supply from the TRF6901 RF EVM

5.5 Control Signal Interface J12

Interface (J12) duplicates signals that appear from the SV1 connector. Signals can be easily viewed at this interface with an oscilloscope, or if configured as high impedance inputs using the programming tool, control signals MODE, ACTIVE/STDBY, TXDATA, and LEARN/HOLD can be driven at their corresponding interface terminal.

5.6 JTAG Interface J13

Interface (J13) is the JTAG interface to the MSP430. Through this interface, the user may reprogram the MSP430 with the MSP430 flash emulation tool. See the *Reprogramming of the MSP430F149* section in chapter 7 for more details.

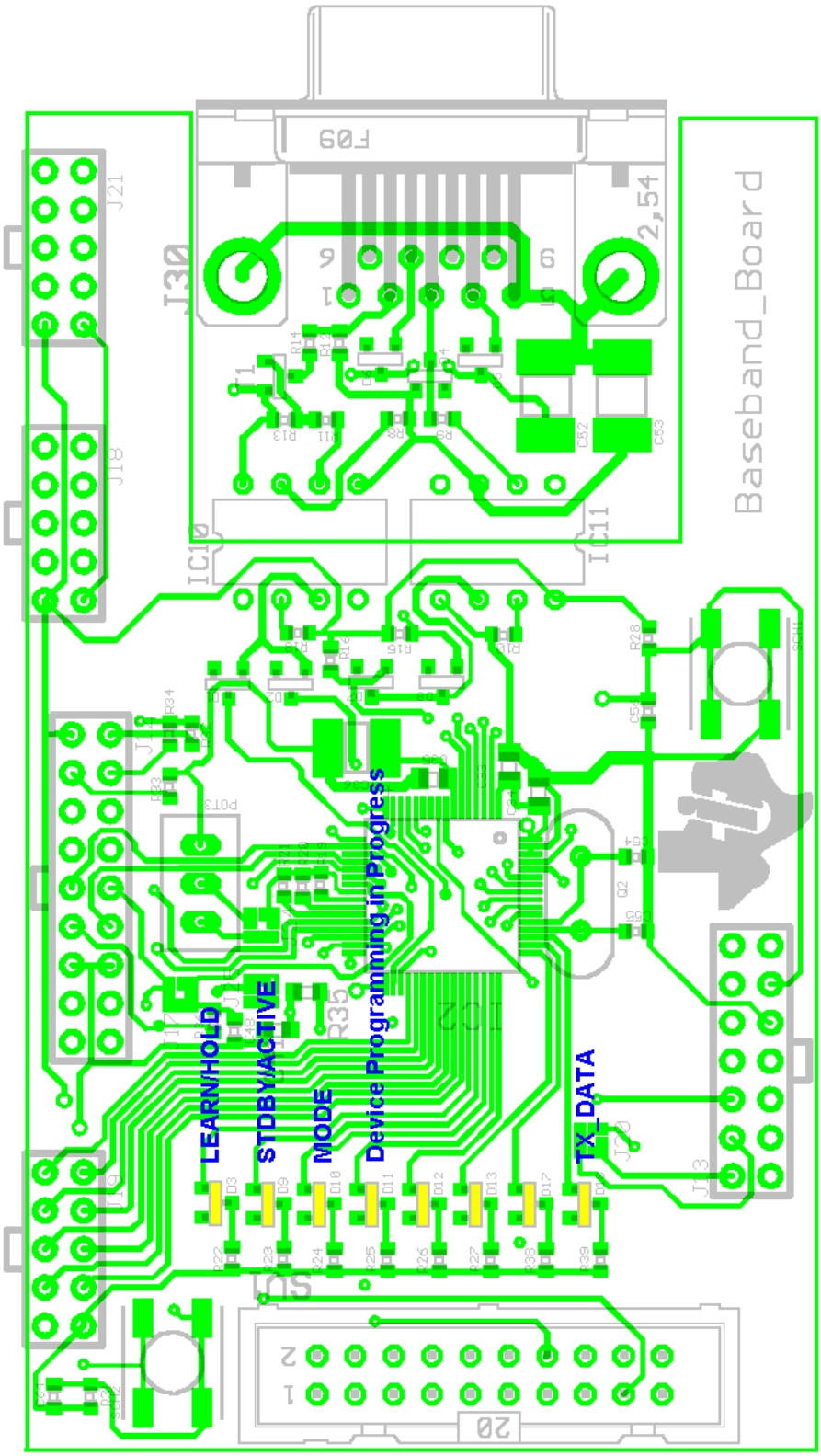
5.7 Miscellaneous MSP430 Port Terminals

Terminals (J18, J19, and J21) are direct connections from MSP430 ports 1, 4, and 6. These signals can be used if the user reprograms the MSP430 flash firmware. They are useful for debugging code execution as well as for implementing additional functional features such as ADC measurements of the RSSI signal.

5.8 LED Status Indicators

On the TRF6901 serial port tool module, there are eight LED status indicators. Four indicators reflect the control signals applied to the TRF6901 RF EVM, and one indicates when a programming sequence is actively being sent to program the TRF6901. The remaining three LEDs are for future features. See Figure 5−4 for LED indicators.

Figure 5−4. TRF6901 Serial Port Module LED Indicators



Chapter 6

TRF6901 RF Tool Kit System Mode

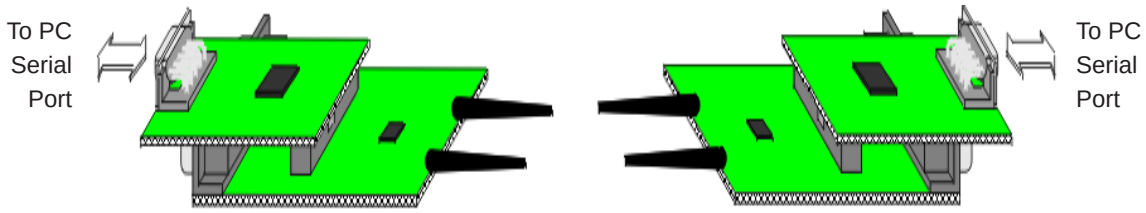
This chapter describes the system mode operation of the currently implemented RF link. This chapter gives the user a brief overview of the RF link protocol.

Topic **Page**

6.1 TRF6901 RF Tool Kit System Mode Overview

The TRF6901 RF tool kit features an application example for an RF link. This mode is called the system mode. In this mode, the MSP430F149 populated on the TRF6901 serial port module is driving the TRF6901 on the RF EVM. With two TRF6901 RF tool kits a simple RF link can be established. This is shown in Figure 6−1.

Figure 6−1. Setup of Two TRF6901 RF Tool Kits in the System Mode



6.1.1 Protocol Used by the System Mode RF Link

Data Format RS232:	32-bytes of data = 32 ASCII signs = 256 bits, Each byte: 1-start bit, 8-data bits, 1-stop bit, no parity
Data Bit Rate RF:	32 kbps
Data Format RF:	Training (learning) sequence, 1 ms, consisting of 31.25-µs pulses, followed by 1-start bit, 93.75 µs and the data sequence, consisting of 2 bytes checksum + 32 bytes of data
Data Coding (PCM):	Nonreturn-to-zero (NRZ)
Transmission Technique:	Bidirectional, half-duplex

6.1.2 Specification Followed for the System Mode RF Link Example

The following specification is used to set up the RF link in the 902-MHz to 928-MHz US ISM band.

RF carrier frequency:	915.605 MHz (see Note)
Modulation:	2 FSK, deviation ±50 kHz Deviation is fixed by hardware on the TRF6901 RF EVM.
IF frequency:	10.7 MHz, 330-kHz bandwidth

Note:

TX _DATA = 0 Frequency is set from the mode 0 VCO register settings.

TX_DATA = 1 Frequency is adjusted by external components on the TRF6901 RF EVM.

The carrier frequency is determined as the center between the two frequencies.

6.2 System Mode Description

6.2.1 System Mode Tool Kit Configuration

The MSP430F149 device is programmed to emulate a simple RF link. In this mode the user can investigate a simple, bidirectional half-duplex RF-data link. Whenever the TRF6901 serial port module is connected to the TRF6901 RF EVM, this mode is present by default.

6.2.2 System Mode Concerns

When using the TRF6901 RF EVM with the serial port module in the combined tool kit, configuration changes must be made to the TRF6901 RF EVM.

Caution:

It is important to remember before connecting the serial port module and applying power to the combined TRF6901 tool kit, remove jumpers J4 and J5 on the TRF6901 RF EVM and disconnect the parallel port cable if applied to the RF EVM. Otherwise, damage to the serial port module is possible. See *System Mode Concerns and Use* in chapter 7.

Furthermore, it is important to remember that changes to the hardware configuration on the RF EVM can result in improper operation of the system mode RF link.

6.2.3 System Mode Protocol Basics

In order to establish the RF link, two TRF6901 RF tool kits are required. In addition, at least one tool kit must be connected to a PC via the serial port.

On the PC, the TRF6901 serial port tools software, must be installed. The system mode tool in this software package enables the user together with two TRF6901 tool kits to establish the RF link. The communication protocol is described in detail further in this chapter.

After power up, the MSP430F149 initializes the TRF6901 for the RF link at 915.605 MHz. This means, all four registers of the TRF6901 are reprogrammed. Consult the TRF6901 product description SLWS110 for register descriptions.

As the TRF6901 features two preprogrammable modes, mode 0 is programmed with a VCO frequency of 915.555 MHz as the transmission (TX_DATA = 0) frequency, and mode 1 is programmed with a VCO frequency of 926.295 MHz to enable reception at 915.605 MHz. The RF link after power up is by default in receive mode. This means that the MSP430 is scanning the frequency band for a valid RF signal.

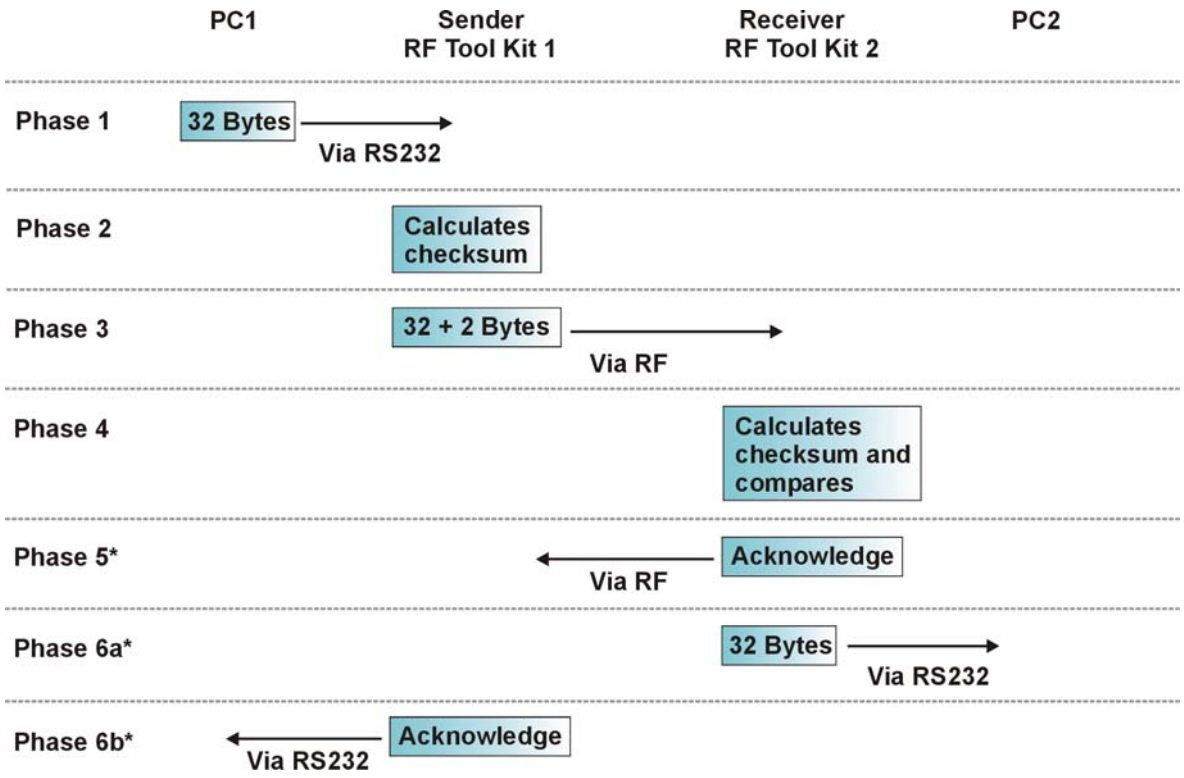
Along with being able to receive an RF package, the MSP430 is also ready to receive data from RS232 by interrupt. UART reception allows the RF tool kit to send a data package via RF. As soon as a data package from RS232 has been received (32 bytes), the MSP430F149 calculates the checksum of the data package. This checksum is then added to the RS232 received data package. After switching the TRF6901 to transmit mode, the data is immediately sent off via RF. Another TRF6901 RF tool kit can receive this RF transmitted signal. If this tool kit is connected to another PC terminal program, it displays the received package on the terminal window screen before sending an acknowledgement back to the original sending tool kit.

RF communication is also possible with only one tool kit connected to a PC. In this case, the second tool kit simply acknowledges the RF received package by replying the checksum.

6.2.4 System Mode Communication Flow

The system mode phases of the communication flow between TRF6901 RF tool kits is shown in Figure 6−2.

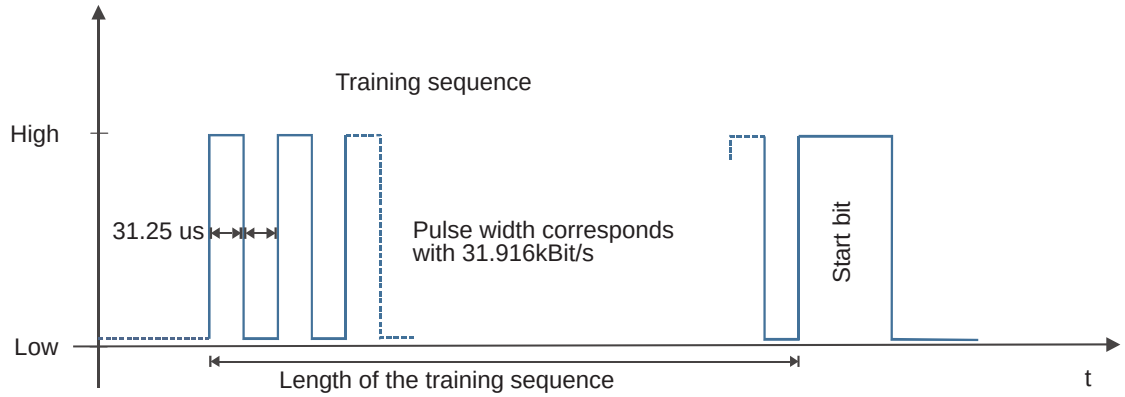
Figure 6−2. Phases of the Communication Flow



6.2.5 System Mode Transmission Protocol Details

The RF transmission protocol is shown in Figure 6−3.

Figure 6−3. TX-Data RF Transmission Sequence Control



Chapter 7

TRF6901 Serial Port Tools Software

This chapter describes the installation and use of the TRF6901 serial port tools software. The features and functionality of both the programming tool and system mode tool are described.

Topic **Page**

7.1 TRF6901 Serial Port Tools Software Overview

The TRF6901 serial port tools software contains two tool environments. The first, the programming tool, permits the user to configure the TRF6901 ISM transceiver registers and control signal states. The second, the system mode tool, allows the user to operate the TRF6901 RF tool kit in an RF link operation. For both window environments, communication with the software is implemented from the PC via the RS232 interface to the MSP430 on the TRF6901 serial port module.

Communication uses 19.2 kbps USART communication via the RS232 serial port on the PC. For the programming tool window, MSP430 firmware receives a 32-byte package from the PC and translates the data for TRF6901 register and control signal configuration. Upon applying the serial received data to the TRF6901, the MSP430 firmware sends the 32-byte data package back to the PC as an acknowledge. For the system mode window, MSP430 firmware receives a 32-byte package from the PC and translates the data for the RF link transmission.

If the serial connector communication is not valid or functional, a communication message appears to assist with debugging the problem.

7.2 TRF6901 Serial Port Tools Software Installation

This windows based software is necessary to evaluate the TRF6901 with the TRF6901 serial port module. This software is included in the TRF6901 RF tool kit, and can be installed from the included MSP430 / MSRF CDROM. The setup software can be started from the >> Home >> MSRF−ICset >> Tool Software.

The software runs with Win 95, Win 98, and Win NT.

Installing the TRF6901 Serial Port Tools Software

- ❑ Insert the MSP430 / MSRF CDROM.
- ❑ Go to >> Home >> MSRF−ICset >> Tool Software. On this page you will find a product table, which contains the TRF6901 serial port tools software.
- ❑ By clicking on the link *TRF6901 Serial Port Tools Software* the setup software is started.
- ❑ Follow the directives from the installation software.

7.3 TRF6901 Serial Port Tools Software Main Form

The TRF6901 serial port tools software main form provides the user access to the programming tool as well as the system mode tool. Each environment may be selected under *Options* on the main form's tool bar.

Figure 7−1. TRF6901 Serial Port Tools Software

7.3.1 Tool Bar Options

Options	
Programming Tool:	Displays the TRF6901 programming tool
System Mode Tool:	Displays the TRF6901 system mode tool
Exit:	Closes all TRF6901 serial port tools windows and exits the software

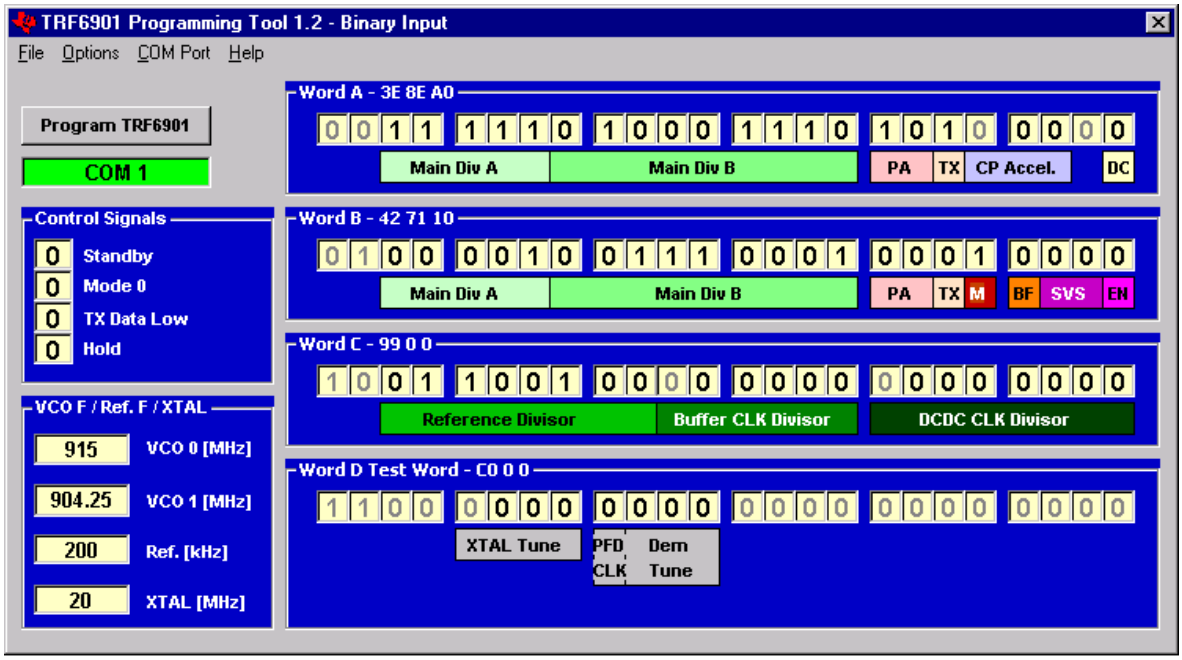
Help

About:	Displays information regarding the tool software revision

7.4 TRF6901 Programming Tool

7.4.1 Programming Tool Binary Input Form

Figure 7−2. Programming Tool Binary Input Form



7.4.1.1 Tool Bar Options

File

Save:	Permits the users to save a current configuration
Load:	Permits the users to load a specific configuration
Exit:	Closes all TRF6901 serial port tools windows and exits the software

Options

Visual:	Displays visual block diagram of TRF6901. Changes in the binary input form are reflected on this block diagram. Changes made in the visual form are reflected back to the binary input form.

COM Port

Select COM 1:	Selects PC COM Port 1 if available and attempts to communicate with the TRF6901 serial port tool module
Select COM 2:	Selects PC COM Port 2 if available and attempts to communicate with the TRF6901 serial port tool module

Help

About:	Displays information regarding the programming tool revision

7.4.1.2 Program TRF6901 Button

TRF6901 programmed with current setting.

TRF6901 not programmed with current setting.

UART communication was verified valid.

7.4.1.3 Control Settings

Settings are applied for Standby/Active, Mode 1/0, TX Data LOW/HIGH, and Learn/Hold. Control signals can be configured to 1, 0, or Z. 1 or 0, the controlling MSP430 port is configured as an output and is driven high or low. Z, the controlling MSP430 port is configured as to a high impedance input port and can be controlled externally from the J12 connector terminals 5, 7, 9, and 8.

7.4.1.4 VCO F/ Ref. F/ XTAL Settings

Manual numeric entry is applied to the Word A, B, and C selection boxes. If the exact numeric calculation is not matched, the entry box is updated to reflect the applied register settings that are possible.

7.4.2 Programming Tool Block Diagram Use

The programming tool block diagram is currently intended as a visual verification of the states configured in the programming tool main form. The user can set and control components by using the boxes around the block diagram.

Note:

For the fields that use arrows for input selection, make sure that the input is highlighted by clicking once on the view box. The input in the field box becomes blue and the corresponding changes are updated on the binary form.

7.4.2.1 Tool Bar Options

File

Save:	Permits the users to save a current configuration
Load:	Permits the users to load a specific configuration
Exit:	Closes all TRF6901 serial port tools windows and exits the software

Options

Binary:	Displays TRF6901 binary input form. Changes in the binary input form are reflected on this block diagram. Changes made in the visual form are reflected back to the binary input form.

COM Port

Select COM 1: Selects PC COM Port 1 if available and attempts to communicate with the TRF6901 serial port tool module.

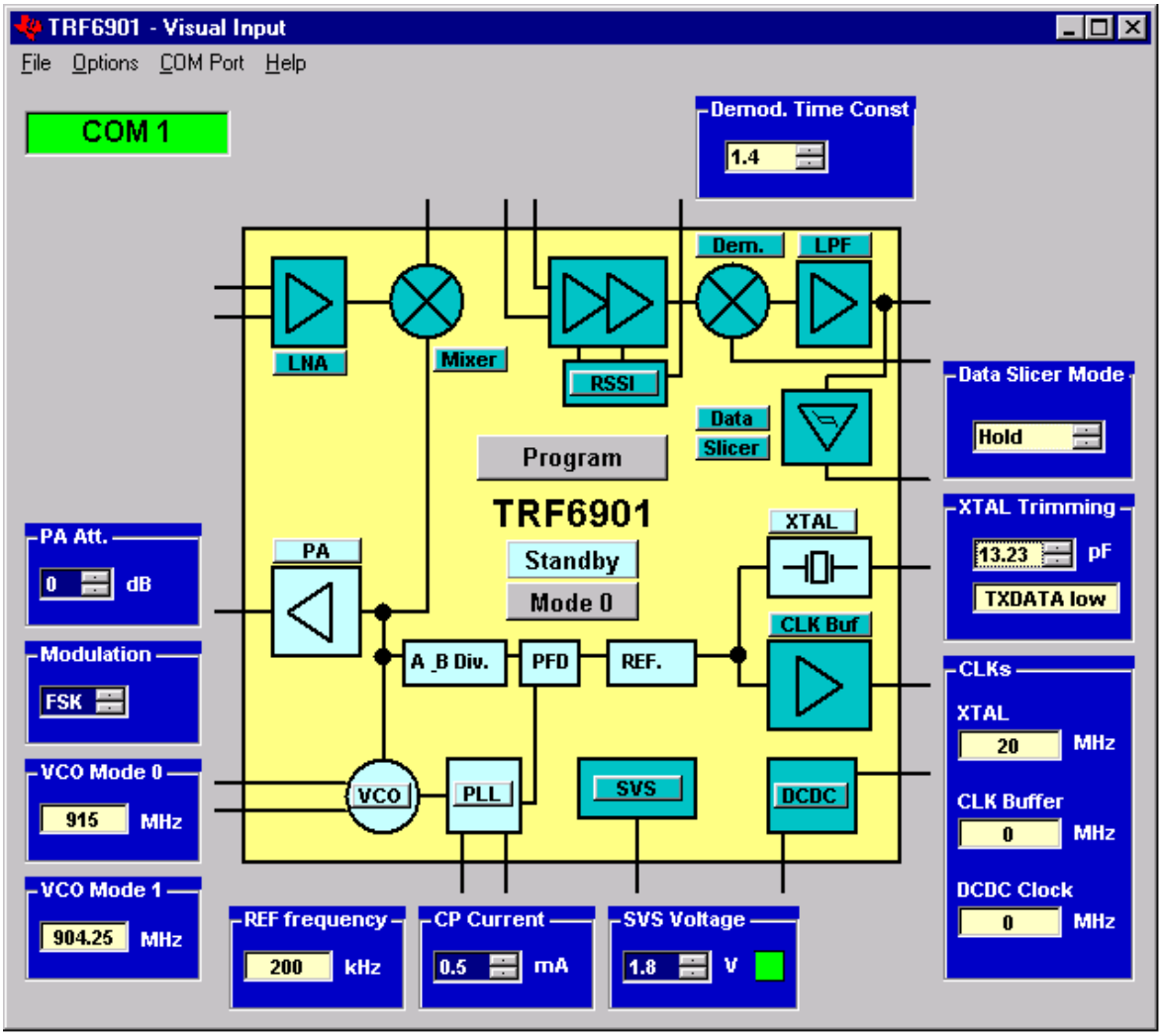
Select COM 2: Selects PC COM Port 2 if available and attempts to communicate with the TRF6901 serial port tool module.

Help

About: Displays information regarding the programming tool revision

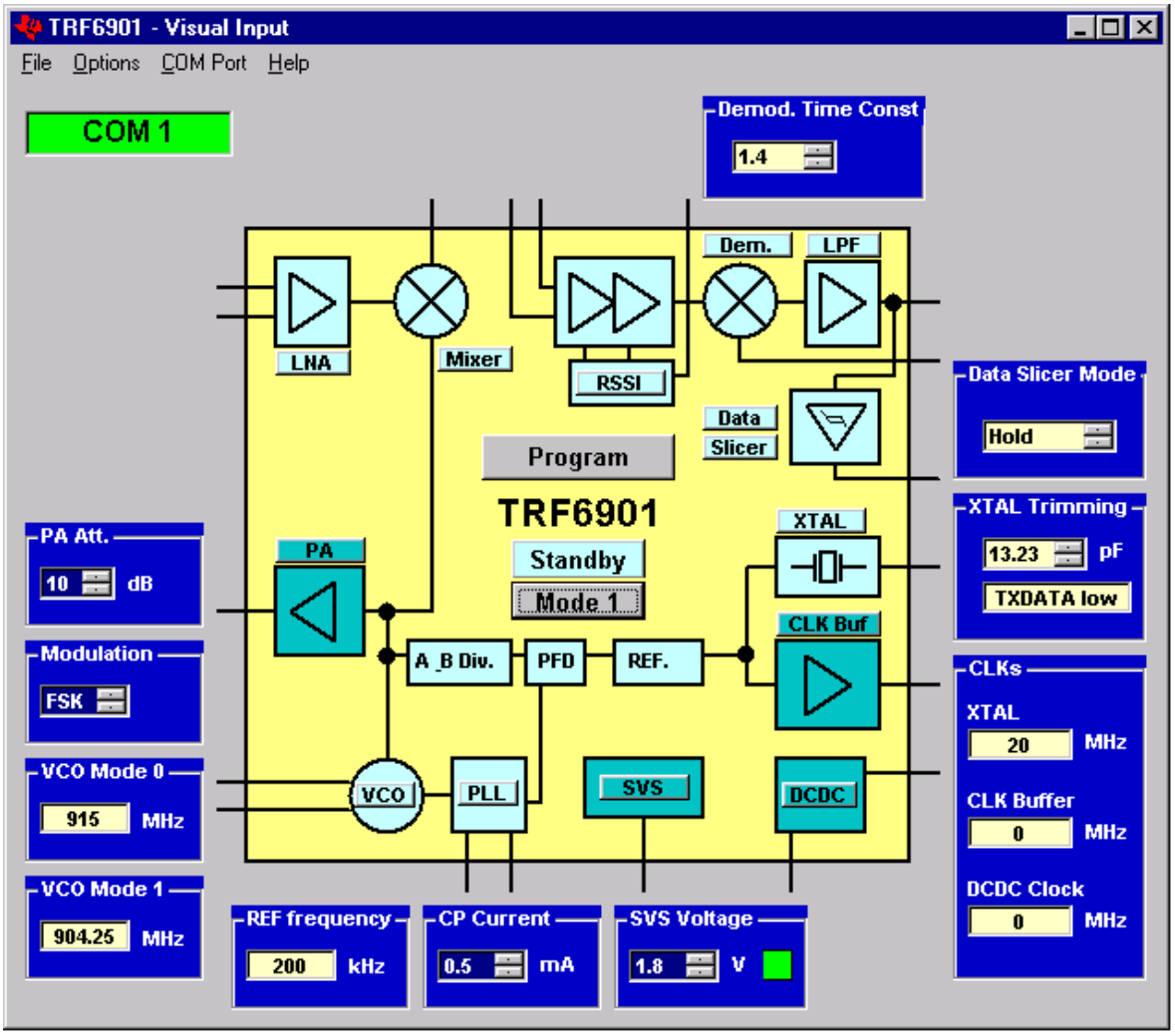
7.4.2.2 Standby

Figure 7−3. Programming Tool Block Diagram (Standby Mode 0 − Transmit)



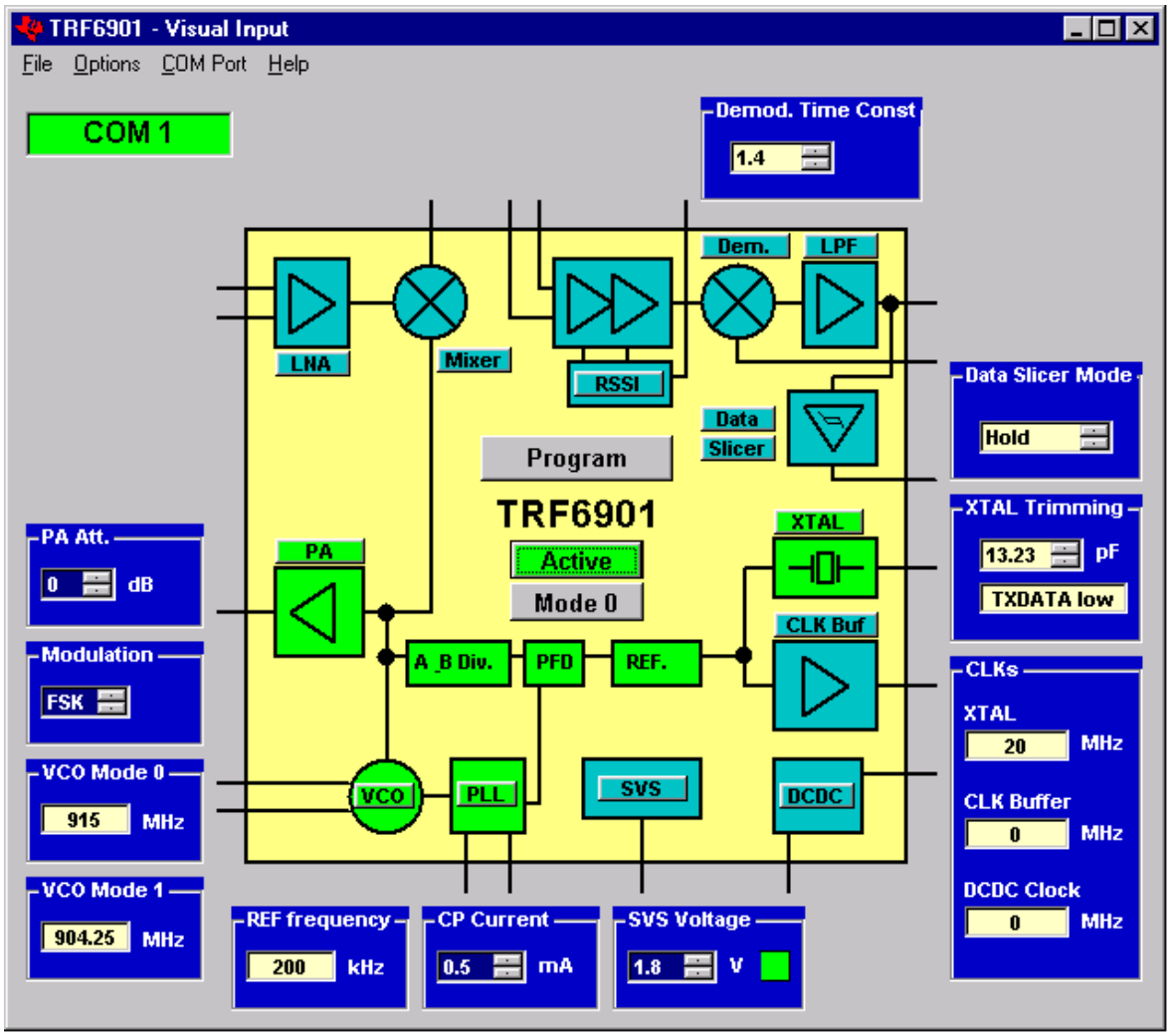
Standby: Modules that become active appear in light blue.

Figure 7−4. Programming Tool Block Diagram (Standby Mode 1 − Receive)



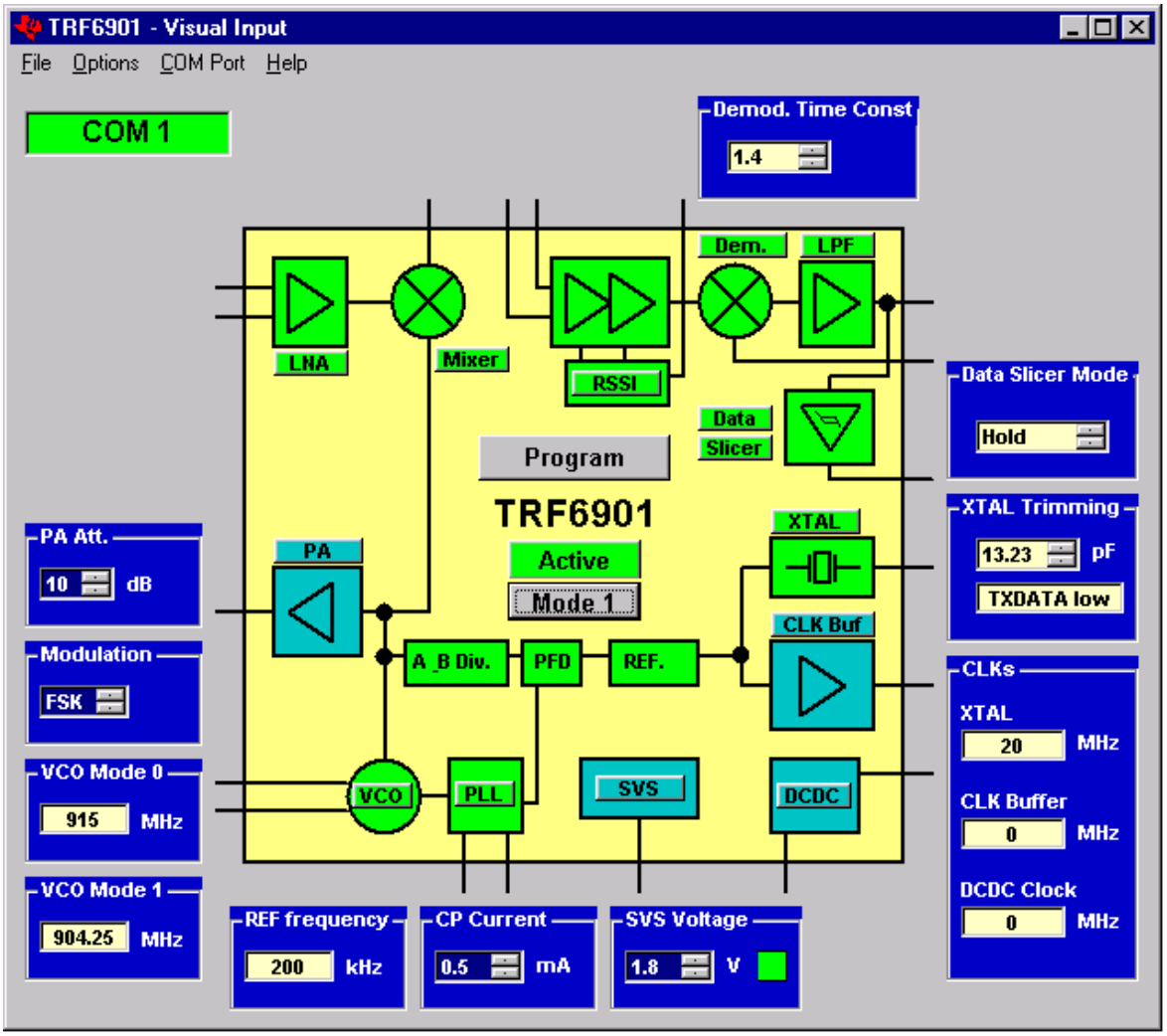
7.4.2.3 ACTIVE Mode 0 Transmit

Figure 7−5. Programming Tool Block DIagram (Active Mode Transmit)



7.4.2.4 ACTIVE Mode 1 Receive

Figure 7−6. Programming Tool Block DIagram (Active Mode Receive)



7.4.2.5 Control Signals in 3-State

When the programming tool configures any of the control signals as a high-impedance input, the visual input window indicates that a possible state change may arise from an external hardware stimulus to interface J12.

When the ACTIVE/STDBY control signal is Z, the modules that are active when this signal is high appear as green. When this signal is low, these modules appear as light blue.

When the MODE control signal is Z, the modules that reflect the mode 1 state appear green when this signal is high. When this signal is low, the modules that reflect the mode 0 state appear green.

When the LEARN/HOLD control signal is Z, the data slicer mode status indicates 3-state.

When the TXDATA control signal is Z, the TXDATA indicator in the Visual window toggles between TXDATA high and TXDATA low. However, this does not cause the control signal line to the TRF6901 to toggle. It is only to indicate that the port controlling the TXDATA signal is now configured as a high-impedance input.

When any of these indicators appear, the state of the control lines is not controlled by the MSP430. The MSP430 ports applying these control signals are configured as high-impedance inputs.

7.4.2.6 Scroll Box Item Selection

When making changes to the PA attenuation, modulation, charge pump current, SVS voltage, demodulator time constant, or XTAL trimming capacitance in each corresponding scroll box, it is important to click on the selected item to update the data.

Upon selection, a green display panel appears in the center of the visual input form. In addition, the *Program* button changes to red, indicating the device is not programmed with the current settings. After pressing the *Program* button, the current settings are programmed to the TRF6901. At this point, the *Program* button changes back to grey.

7.4.2.7 TRF6901 TX/RX Path and Functional Block Activation

When making changes to the visual mode environment, the user may select to activate the transmit or receive path as well as activate an independent block such as the dc/dc converter, buffered clock input, and brownout detector.

Clicking a button within either the transmit or receive path results in the entire path being enabled or disabled. For example, when the LNA button is clicked with the receive path disabled, the receive path becomes enabled and the PA (transmit path) becomes disabled. When the LNA button is clicked with the receive path enabled, the receive path becomes disabled and the PA (transmit path) becomes enabled.

It is important to remember that when selecting the TX/RX path, the state applies only to the currently selected mode. The other mode settings are retained.

7.5 TRF6901 System Mode Tool

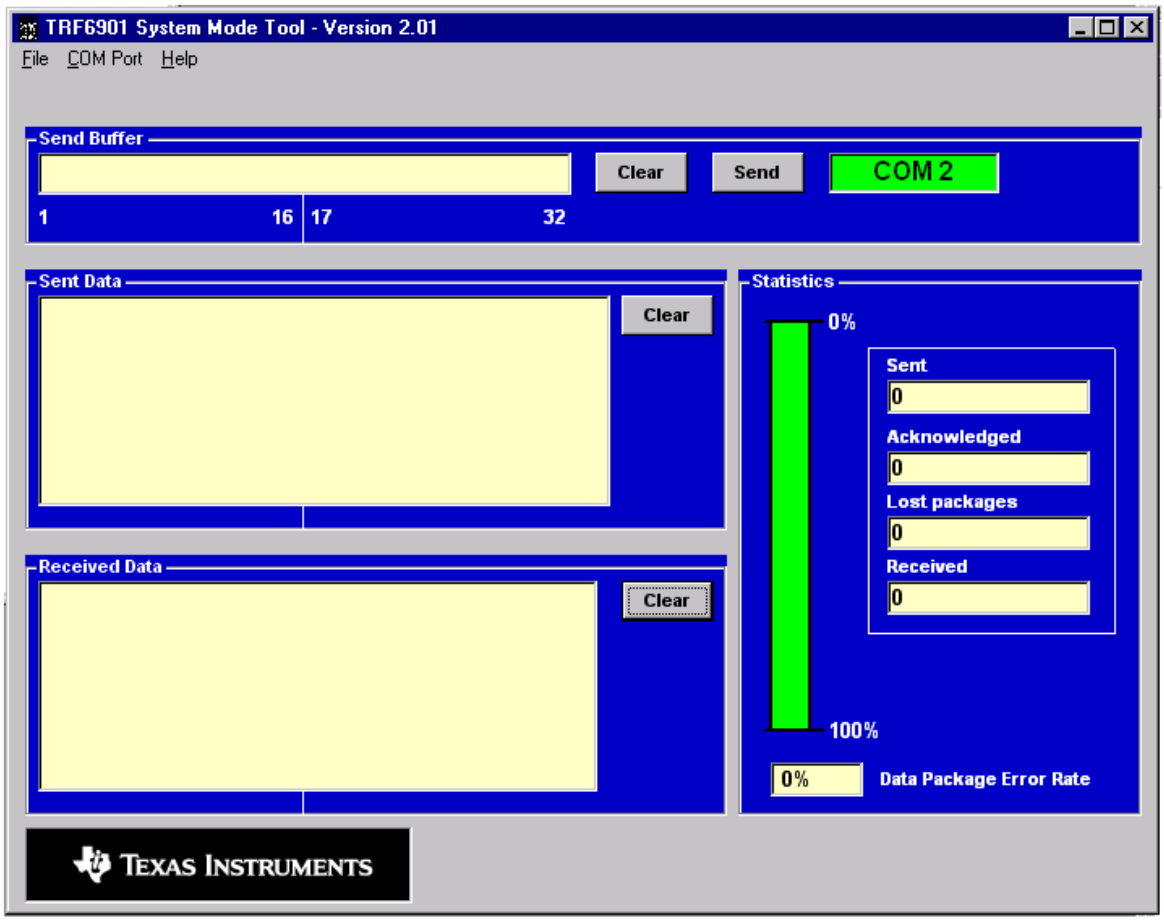
7.5.1 System Mode Software Overview

The user accesses the system mode software when attempting to observe a basic RF link. After configuring two setups (each with one TRF6901 RF EVM and one serial port module), the user may establish the RF link controlled through the MSP430F149 firmware implemented on the serial port module. Communication to/from the system mode tool on the user's PC is implemented via the serial port connector located on the serial port module.

After the user verifies that the two tool kits are configured with the proper jumpers setting and cable connections (see section 6.2.2 for proper configuration), upon supplying power to the tool kits, the setups are ready for the RF link. Simple text messages can then be entered into the system mode tool send buffer text box.

7.5.2 System Mode Form

Figure 7−7. System Mode Tool—Version 2.01



7.5.2.1 Tool Bar Options

File

Exit: Closes all TRF6901 serial port tools windows and exits the software

COM Port

Select COM 1: Selects PC COM port 1 if available and attempts to communicate with the TRF6901 serial port tool module.

Select COM 2: Selects PC COM port 2 if available and attempts to communicate with the TRF6901 serial port tool module.

Help Currently no features present.

7.5.3 System Mode Configuration

Configuring the TRF6901 RF Tool Kit in System Mode

Configure the TRF6901 RF EVM.

Apply supply jumpers JP2 and JP6.

Remove jumpers JP4 and JP5.

Disconnect the parallel port cable if applied to the EVM.

Connect P1 interface on the RF EVM to the to SV1 interface on the TRF6901 serial port tool module.

Supply power to the TRF6901 RF EVM.

LEDs, VCC1 and ENABLE on the RF EVM becomes active.

In addition, the LEDs MODE, ACTIVE, TXDATA, and LEARN on the TRF6901 serial port module becomes active.

Connect the RS232 port of the EVM to a PC, using the included RS232 cable.

Press the *Reset* button on TRF6901 serial port tool module to ensure a proper start up. Again all LEDs should turn on.

Start the TRF6901 baseband tool software and select the system mode tool.

Select the COM port that the TRF6901 serial port module is connected.

Now the program is ready to transmit data to the EVM. For this purpose data can be typed into the *Send Buffer* window, maximum of 32 ASCII characters.

Connecting the Two TRF6901 Units for System Mode

The two TRF6901 units can be connected by RF cables or four antennas.

If the user is using RF cables, it is recommended that on each of the two connections, i.e., from J2 TX_OUT of TRF6901 Unit1 to J1 RX_IN+ of TRF6901 Unit2 and J2 TX_OUT of TRF6901 Unit2 to J1 RX_IN+ of TRF6901 Unit1, a 20-dB attenuator should be implemented for proper transmission and reception if the cables are not too long.

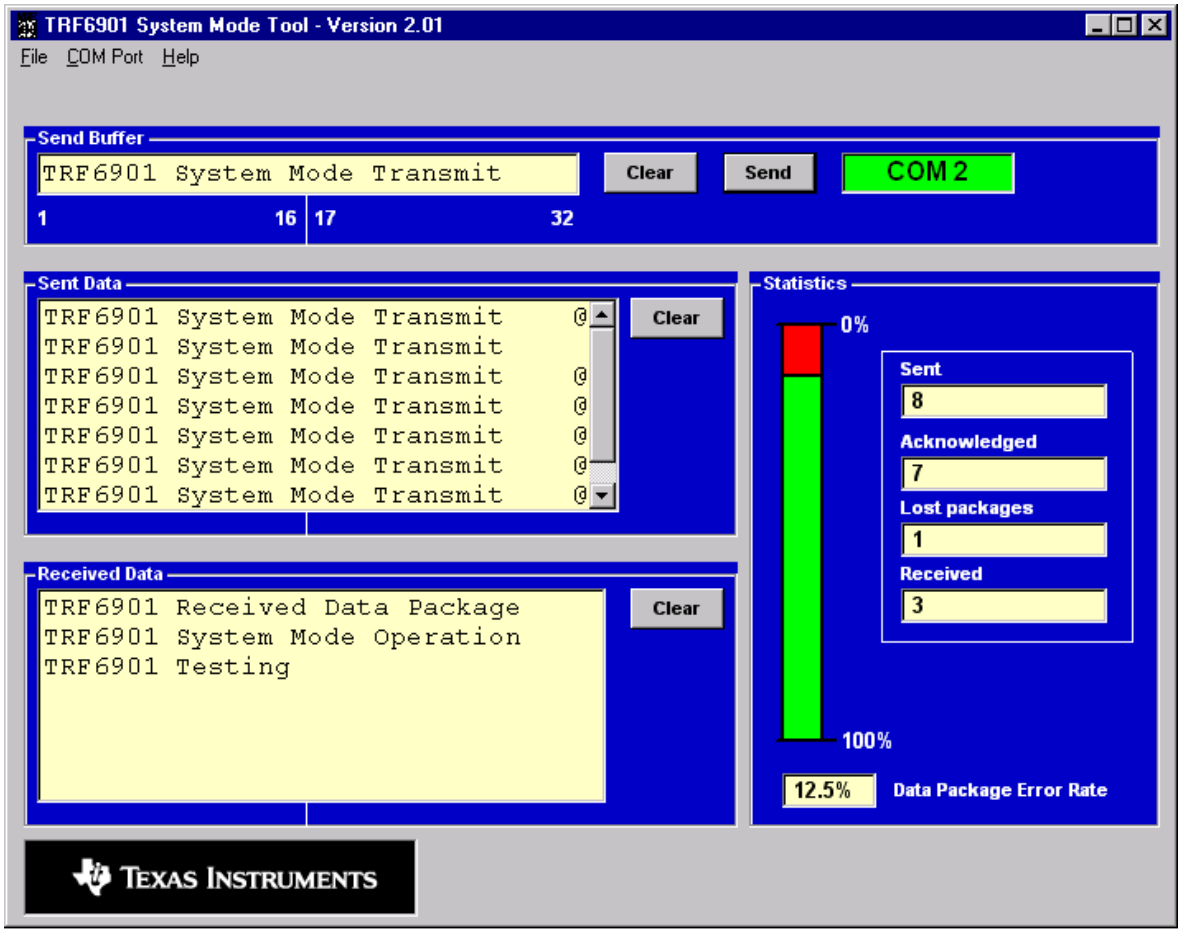
Antennas are also applicable for the this setup. It allows the user to evaluate the performance of the TRF6901 units at various distances. If the user is using an antenna, then 915-MHz quarter-wave antennas having an output impedance of 50 Ω is recommended. Each unit requires two of these antennas for proper RF link.

Establishing an RF link without the use of any of these devices would result in minimal performance. Even placing the TRF6901 within a few inches of each other does not assure a successful link, since the MSP430 firmware has a checksum scheme. The probability of missing a single bit out of 32 bytes is high and hence if a single bit is missed, the whole data packet is discarded and will not show on the system mode software.

7.5.4 System Mode Operation

In the Figure 7−8 the text *TRF6901 System Mode Transmit* was typed into the window. This data can be sent either by pressing *Enter* on the keyboard, or by clicking on the *Send* button.

Figure 7−8. System Mode Tool—Example Operation



There are two history windows, one for transmitted data, and one for received data. All sent data and received data packages are stored in these windows. As the implemented RF link supports acknowledge of the transmitted data packages, information regarding whether the transmitted data package has been received or not is visible. The acknowledged data packages are marked by an @ at the end of the data package in the *Sent Data* window. (see Figure 7−8) In this example the second data package was lost. No acknowledge has been received.

In the *Statistics* frame additional information about the numbers of transmitted, acknowledged, and lost and received packages is displayed. The DPER (data package error rate) is displayed as a numeric value in % as well as a bar graph. The number of received packages stands for the number of received packages, data that has been transmitted from the counterpart. This has nothing to do with the received acknowledgements.

7.6 Reprogramming of the MSP430F149

There are various options to reprogram the MSP430F149, populated on the baseband board. The JTAG interface connector J13 is ready for reprogramming the FLASH device with the MSP−FET430x140 FLASH emulation tool. For further information see the MSP430 web page.

http:/www.ti.com/sc/docs/products/micro/msp430/msp430.htm

On this page the user finds links to application reports that describe the capabilities of the MSP430 microcontroller family and the various reprogramming techniques.

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