TRF7960TB HF RFID Reader Module

User's Guide

Literature Number: SLOU297
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TRF7960TB HF RFID Reader Module

1 Purpose

This document provides direction for TRF796x users implementing a 13.56-MHz RFID reader solution using the TRF796x IC connected to a Texas Instruments embedded microcontroller or microprocessor development platform. Examples of such development platforms are the MSP-EXP430F5438 board, the ARM® Cortex™-M3 based DK-LM3S9B96 board, MAVRK™ Reference Kit, or any other TI embedded microcontroller platform with the EM socket headers populated.

2 Scope

This document describes the TRF7960TB module as it relates to using the module for evaluation and development purposes in conjunction with Texas Instruments Embedded Development platforms. This manual does not cover the in-depth details of the TRF796x reader IC family, as those details are documented in the data sheets for those parts, along with application notes that can be found on the product pages (see hyperlinks in Section 3).

3 References

- TRF7960 product page
- TRF796x data sheet: SLOU186
- TRF7960TB Schematic, BOM and Design files: SLOC221
- MSP-EXP430F5438 Users Guide: SLAU263
- LM3S9B96 DK Users Guide: SPMU036
- TPS61222DCKT product page
- TI ISO15693/ISO18000-3 Inlays/Tags Parametric Search
- Samtec Header and Mate Information:
  SFM Series Overview
  TFM Series Overview
- Smith Chart Simulation Tool (licensed copy)

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4 TRF7960TB Module Description

The TRF7960TB Evaluation Module (EVM) (see Figure 1) allows the software application developer to become familiar with the functionalities of TRF7960 Multi-Standard Fully Integrated 13.56-MHz RFID reader IC with the freedom to develop on the Texas Instruments embedded microcontroller development platform of choice.

The TRF7960TB module also allows customer-driven antenna tuning with onboard coil and customer-driven antenna form factor design.

The module is hardwired for SPI communications, supports slave select and TRF7960 Direct Mode 2 (default), Direct Mode 1, and Direct Mode 0 operations. The user also has access to and full control over the TRF7960 EN2 and EN lines, allowing for design and development of ultralow-power high-frequency (HF) RFID systems.

The module has an onboard boost converter (TPS61222DCKT) which boosts 3.3 VDC to 5 VDC out to TRF7960 IC for +23 dBm (full transmitter power out) operations.

An impedance-matching circuit from 4 Ω to 50 Ω is populated on the module, and this is connected to a tuned 50-Ω antenna circuit that consists of an onboard four-turn coil with series and parallel passive elements (capacitors and a resistor).

Test points are available on the board for checking firmware operations with oscilloscope or logic analyzer, impedance matching, and for attaching an external antenna.

Connection to Texas Instruments microcontroller platforms are made via Samtec EM headers located on the back of the board (connectors P1/RF1 and P2/RF2).

Figure 1. TRF7960TB Evaluation Module

5 TRF7960TB Connections/Technical Details

Table 1 and Table 2 describe the signals for connector P1/RF1 and P2/RF2, respectively.

Table 1. Connector P1/RF1

Pin No.	Signal Name	Description
1	GND	Ground
2	N/C	No connection
3	MOD	Direct mode, external modulation input
4	N/C	No connection
5	N/C	No connection
6	N/C	No connection
7	IRQ	Interrupt request (from TRF7960 to MCU)
8	N/C	No connection
9	SYS_CLK	Clock for microcontroller (3.39 / 6.78 / 13.56 MHz) at EN = 1 and EN2 = don't care If EN = 0 and EN2 = 1, then system clock is set to 60 kHz
10	EN	Chip enable input (If EN = 0, then chip is in power-down mode).
11	N/C	No connection
12	EN2	Pulse enable and selection of power down mode. If EN2 is connected to VIN, then VDD_X is active during power down to support the microcontroller. Pin can also be used for pulse wake-up from power-down mode.
13	N/C	No connection
14	SLAVE SELECT	Slave select, I/O 4 (active low)
15	N/C	No connection
16	DATA_CLK	Data clock input for microcontroller communication (from microcontroller)
17	N/C	No connection
18	MOSI	I/O 7, master out/slave in (data in from microcontroller)
19	GND	Ground
20	MISO	I/O 6, master in/slave out (data out from TRF7960)

Table 2. Connector P2/RF2

Pin No.	Signal Name	Description
1	N/C	No connection
2	N/C	No connection
3	N/C	No connection
4	N/C	No connection
5	N/C	No connection
6	N/C	No connection
7	+3.3VDC IN	+VDC in (to TPS61222DCKT for generation of 5 VDC)
8	N/C	No connection
9	+3.3VDC IN	+VDC in (to TPS61222DCKT for generation of 5 VDC)
10	N/C	No connection
11	N/C	No connection
12	N/C	No connection
13	N/C	No connection
14	N/C	No connection
15	N/C	No connection
16	N/C	No connection
17	N/C	No connection
18	ASK/OOK	Direct mode, selection between ASK and OOK modulation (0 = ASK, 1 = OOK) Also can be configured to provide the received analog signal output (ANA_OUT).
19	N/C	No connection
20	N/C	No connection

6 TRF7960TB Module Schematic

Figure 2 shows a schematic of the TRF7960TB module.

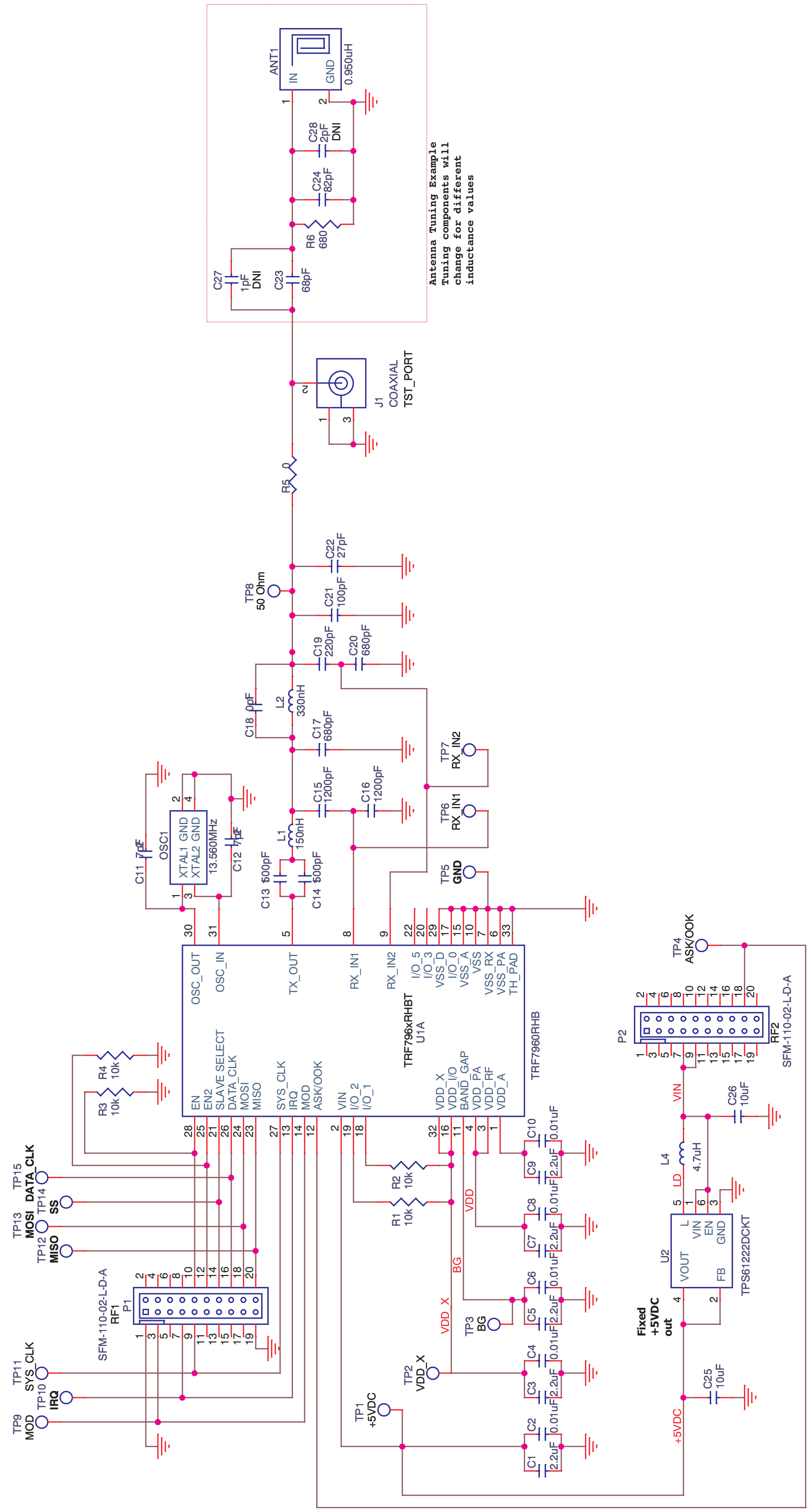

Figure 2. TRF7960TB Module Schematic

7 MSP-EXP430F5438 Experimenters Board

The MSP430F5438 Experimenter Board (MSP-EXP430F5438) is a development platform for the latest generation MSP430 MCUs. It features a 100-pin socket which supports the MSP430F5438 (data sheet) and other devices with similar pinouts. The socket allows for quick upgrades to newer devices or quick applications changes. It is also compatible with many TI low-power RF wireless evaluation modules such as the CC2520EMK and the TRF7960TB module discussed here in this document.

The Experimenter Board helps designers quickly learn and develop using the new F5xx MCUs, which provide the industry's lowest active power consumption, more memory and leading integration for applications such as energy harvesting, wireless sensing and automatic metering infrastructure (AMI).

A TI Flash Emulation Tool, like the MSP-FET430UIF, is required to program and debug the MSP430 devices on the experimenter board.

The TRF7960TB module plugs into the RF1 and RF2 headers on this MSP-EXP board (see Figure 3). For logic analyzer connection during firmware debug, user can use test points on TRF7960TB board or pins on header RF3.

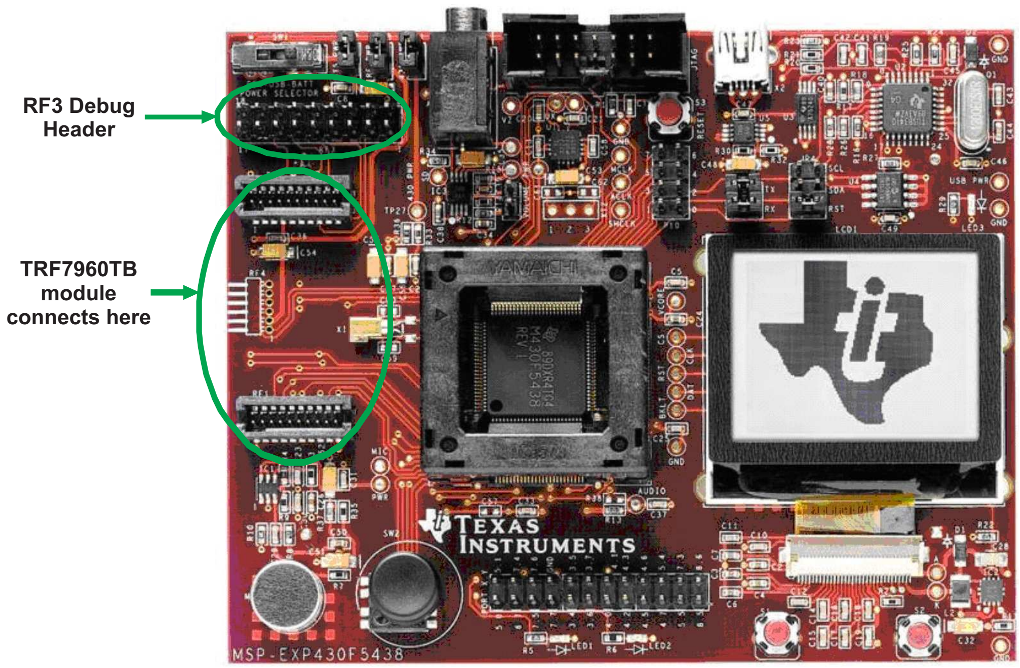

Figure 3. MSP-EXP430F5438 Development Board

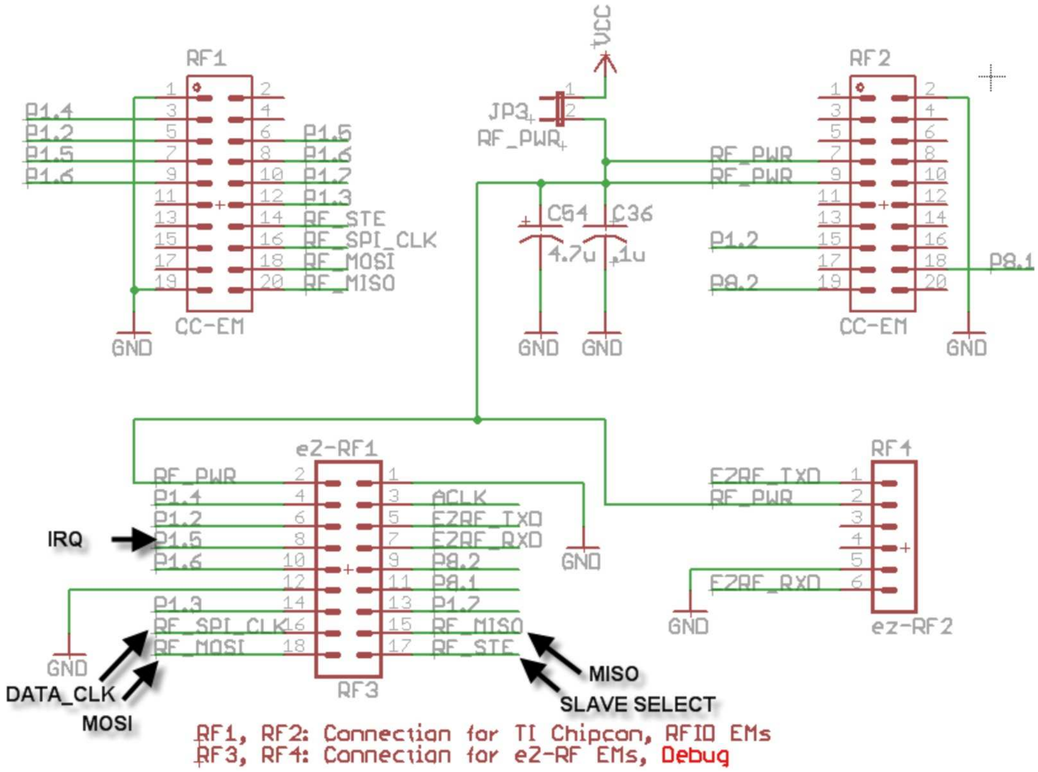

Figure 4. Debug Header (RF3) Logic Analyzer Connections for Monitoring SPI Communications Between MSP430F5438A and TRF796x on TRF7960TB Module

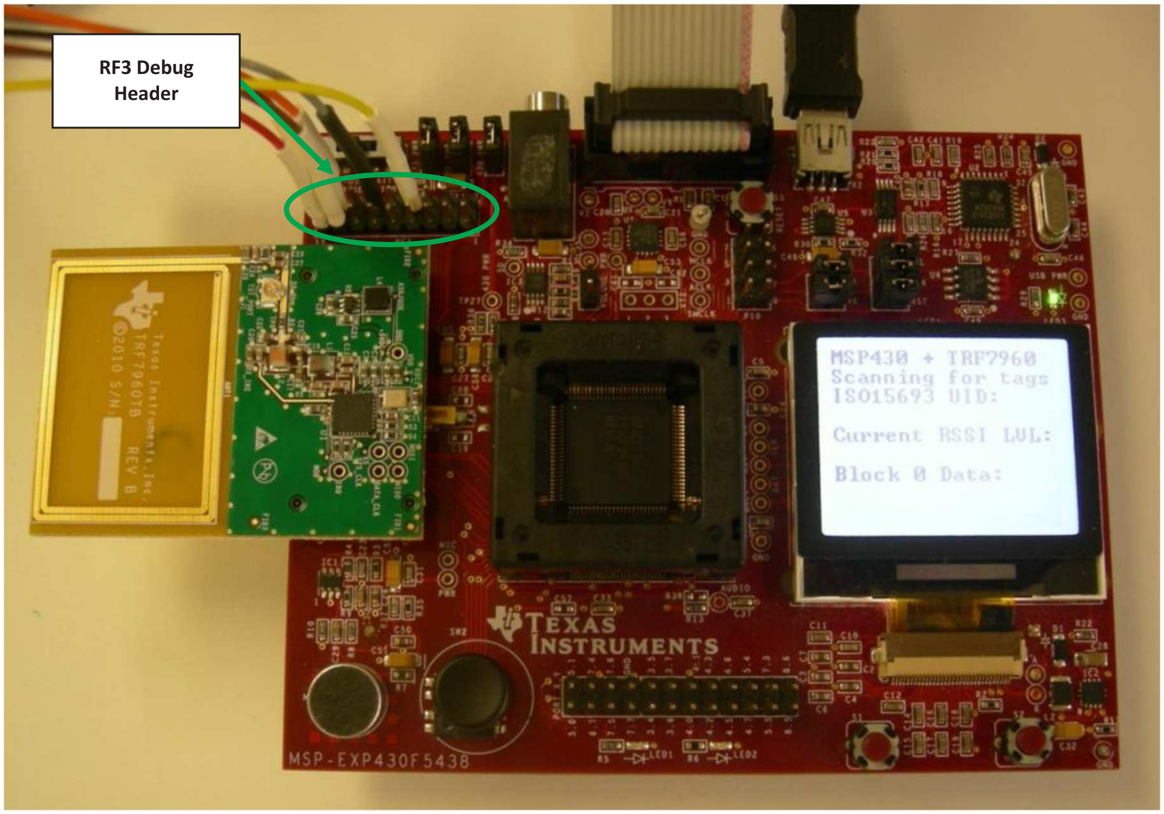

Figure 5. Firmware Development\Debug Setup for MSP-EXP430F5438 Experimenters Board

8 DK-LM3S9B96-EM2-TRF7960R ARM® Cortex™-M3 Development Board

The Stellaris™ DK-LM3S9B96-EM2-TRF7960R Development Kit provides a feature-rich development platform for Ethernet, USB OTG/Host/Device, and CAN-enabled Stellaris ARM Cortex-M3 based microcontrollers. Each board has an In-Circuit Debug Interface (ICDI) that provides hardware debugging functionality not only for the on-board Stellaris devices, but also for any Stellaris microcontroller-based target board. The development kit contains all cables, software, and documentation needed to develop and run applications for Stellaris microcontrollers easily and quickly. The Stellaris DK-LM3S9B96-EM2-TRF7960R Development Kit features: StellarisWare® Peripheral Library, USB Library, and Graphics Library in conjunction with ARM development tools from ARM tools partners. An EPI header to EM header interface board (DK-LM3S9B96-EM2) is needed for use with the TRF7960TB module.

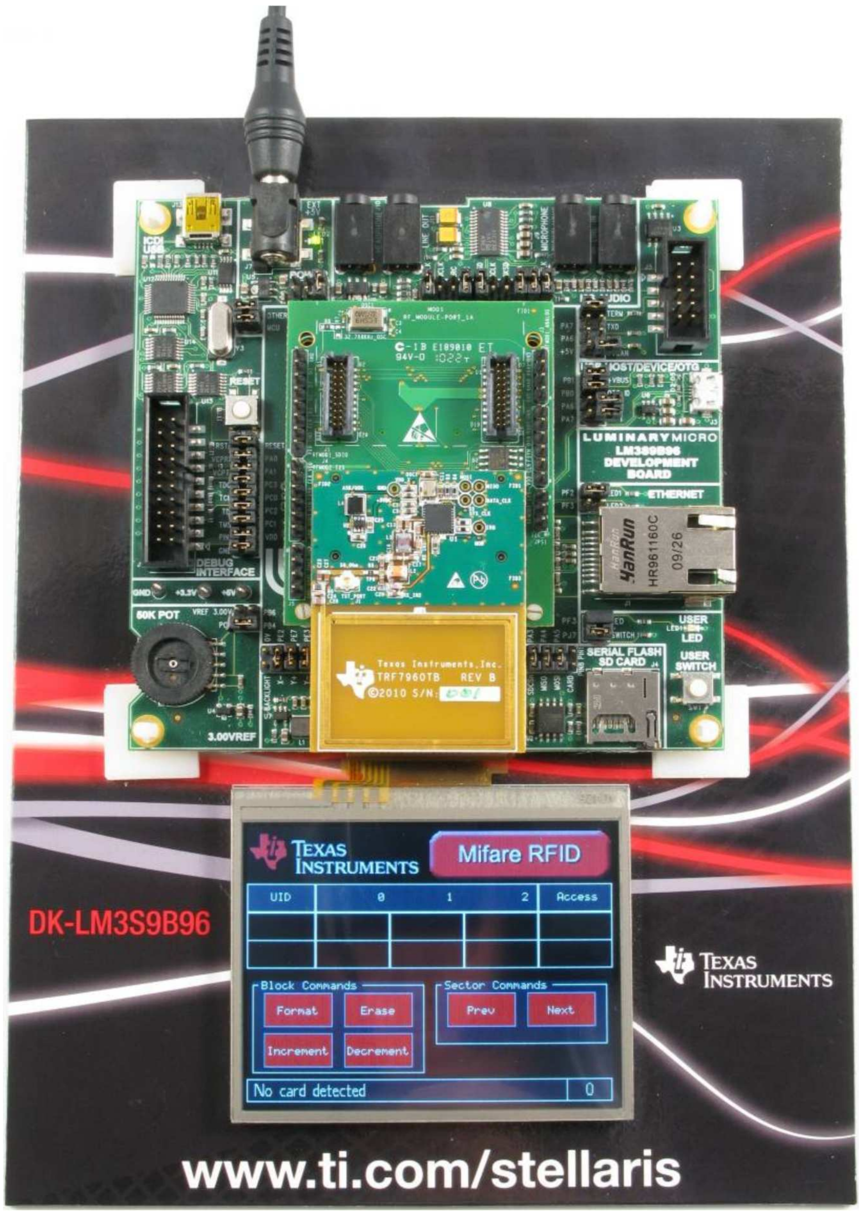

Figure 6. DK-LM3S9B96-EM2-TRF7960R Development Platform

9 Quick Start

1. Plug the TRF7960TB module into the microcontroller development platform of choice.

NOTE: If using the DK-LM3S9B96 board, remove the SDRAM module and replace it with the DK-LM3S9B96-EM2 interface board before mounting the TRF7960TB module.

2. Apply power
3. Load base application firmware specific to platform working with.
4. Test for basic communication and functionality.
5. Modify and debug code as desired for specific application or protocol.
6. Test for advanced functionality as implemented by modified code.

10 Base Application Firmware

TRF7960TB Module Base Application Firmware for various Texas Instruments microcontrollers and microprocessors is available from:

MSP430F23xx (CCS or IAR): SLOC203
MSP430F5438A product page
LM3S9B96 product page

11 Platform Specific Details

- DK-LM3S9B96 Platform
  - MIFARE™-specific standalone demo source code available
    This code demonstrates (on up to two cards at a time) reading, authenticating, and interacting with the blocks and sectors of MIFARE Classic 1k and 4k transponders
- MSP-EXP430F5438A Experimenters Board
  - Code example interfaces with standard TRF7960EVM GUI
    TRF7960EVM GUI Software (SLOC134)
    TRF7960EVM User's Guide (SLOU192)
  - ISO15693 UID and Block 0 Read/Automatic Product ID Demo
    This code displays a single ISO15693 UID, RSSI Value, and Block 0 Read/Automatic Product ID Demo on the LCD. If more tags are in the field, or if a different protocol is desired, this code requires use of the TRF7960 PC-based GUI to display multiple tags or interact with other protocol-based transponders.

12 Mechanical/Physical Information

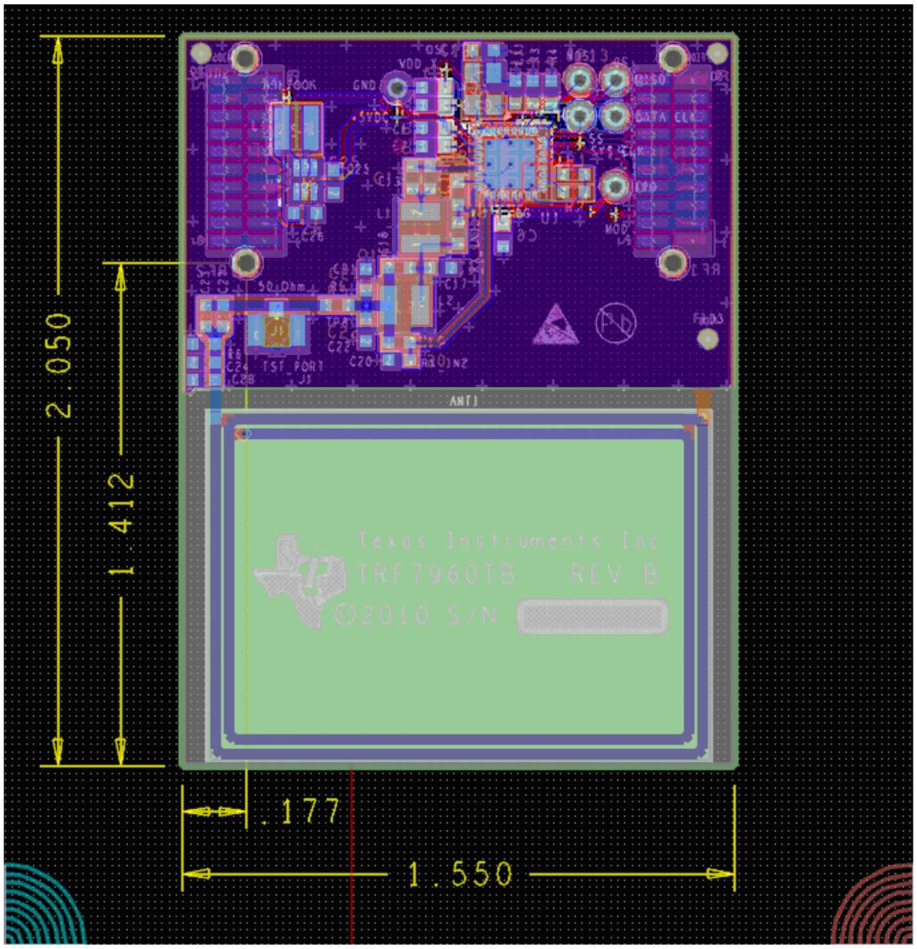

Figure 7. Mechanical/Physical Information

13 Antenna Tuning Details

Module antenna as shipped is tuned for 50-Ω impedance at 13.56 MHz. It has a nominal bandwidth of 1.3 MHz, which results in a quality factor of approximately 10. Module antenna circuit has a board mounted UFL connector installed for users to experiment with different tuning solutions or disconnect the onboard antenna and experiment with antennas of their own design or application. Below are some design/application notes to reference when changing the antenna Q factor or experimenting further to improve a particular application.

TRF7960TB coil antenna tuning details starts with calculations to produce the theoretical values shown below (and based on measurements of antenna coil on Rev B board.) Coil value nominally measures 0.95 µH at 13.56 MHz and XL = 0.8 + j80.8 = 0.990 at 63.4°.

To calculate the necessary values required for course resonance tuning and proper Q setting of the antenna, Equation 1 is used.

$$C_{RES(total)} = \frac{1}{\omega^2 L} \qquad (1)$$

Where, $\omega = 2\pi f$

Therefore,

$$C_{RES(total)} = \frac{1}{(2\pi \times 13.56\ \text{MHz})^2 \times 0.95\ \mu\text{H}} \qquad (2)$$

$$C_{RES(total)} = 145.157\ \text{pF} \qquad (3)$$

The dampening resistor value can now be calculated for a desired Q value using Equation 4.

$$Q = \frac{R_{PAR}}{2\pi f L} \qquad (4)$$

Therefore,

$$R_{PAR} = 2\pi f L Q \qquad (5)$$

For Q = ~20 (ISO15693 operations):

$$R_{PAR} = 1.29\ \text{k}\Omega \qquad (6)$$

Use standard value of 1.3 kΩ.

For Q = ~10 (ISO14443 and ISO15693 operations):

$$R_{PAR} = 647\ \Omega \qquad (7)$$

Use standard value of 680 Ω.

Figure 8 shows a Smith Chart simulation for R_{PAR} value = 1.3 kΩ. This chart indicates theoretical parallel and series capacitor values capacitor values to be 97 pF and 51 pF, respectively. This is less than a +2% change from the calculated total cap value.

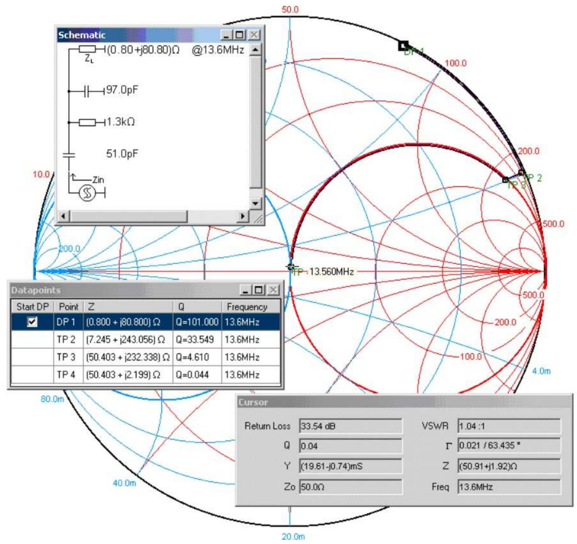

Figure 8. Smith Chart Simulation (R_{PAR} = 1.3 kΩ)

Figure 9 shows a Smith Chart simulation for R_{PAR} value = 680 Ω (standard value). This chart indicates theoretical parallel and series capacitor values to be 82 pF and 69 pF, respectively. This is less than a +4% change from the calculated value.

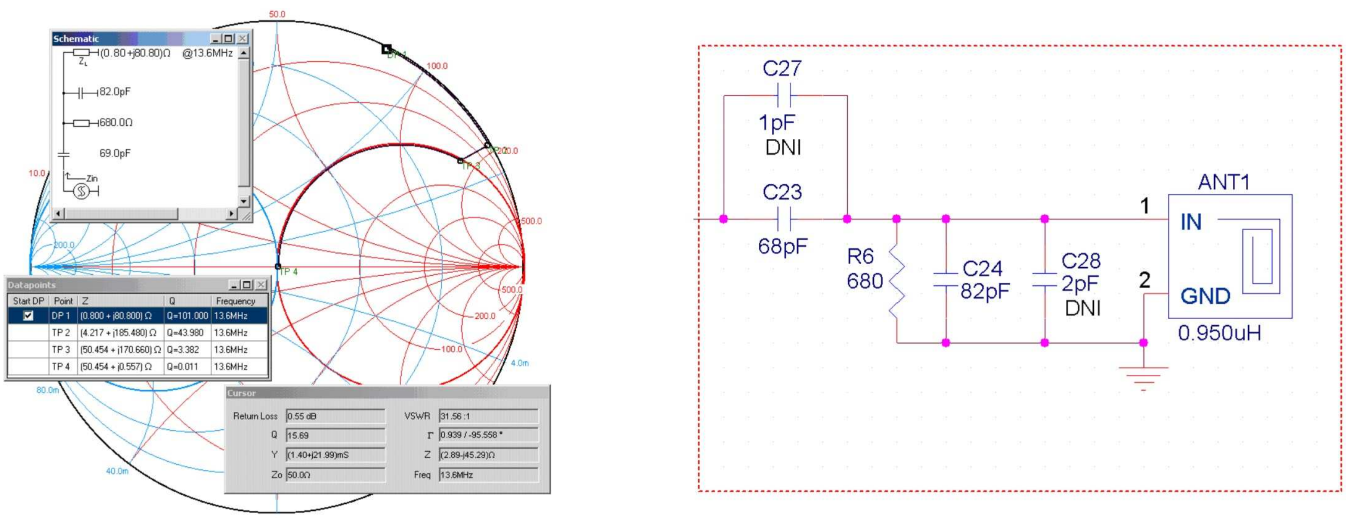

Figure 9. Smith Chart Simulation (R_{PAR} = 680 Ω)

The calculations and simulations for a desired Q range of 5 to 20 result in the graphs shown in Figure 10 and Figure 11, which indicate the required resistor and capacitance values that should be populated.

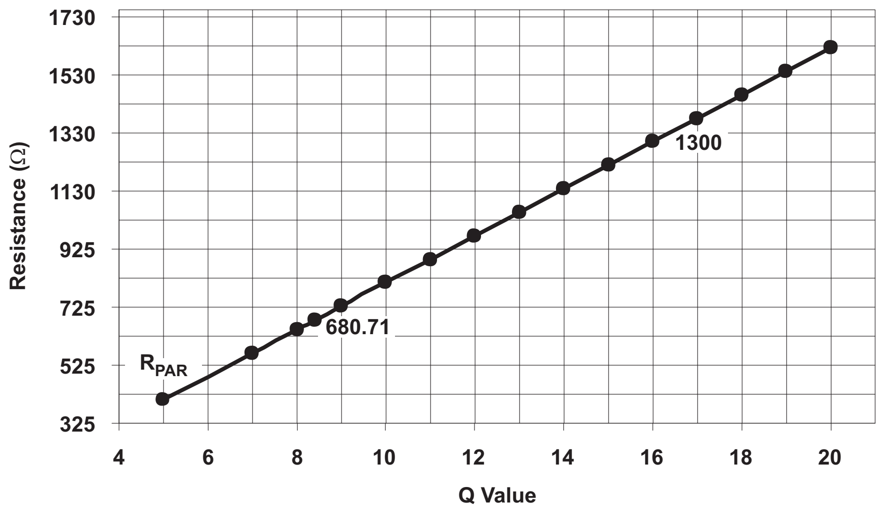

Figure 10. Theoretical Parallel Resistor Value for Desired Q

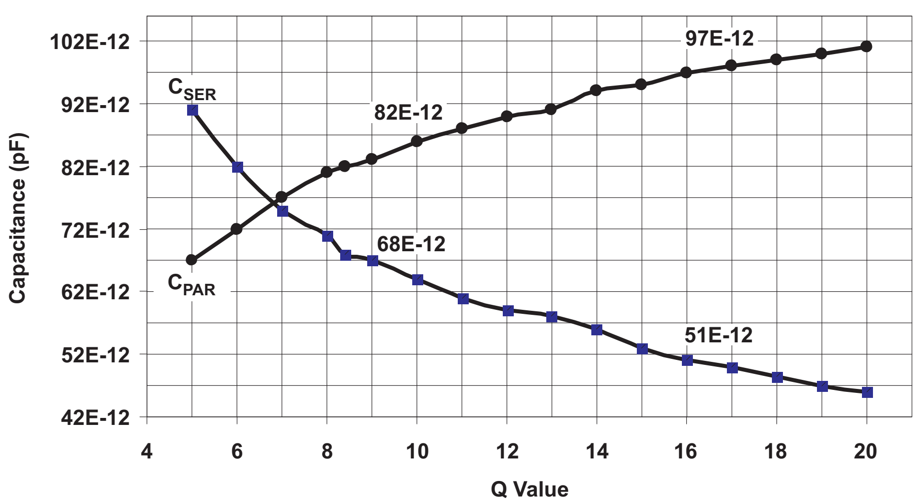

Figure 11. Theoretical Capacitance Values for Resonance at Desired Q

Figure 12 and Figure 13 show actual measurements on TRF7960TB module for high and lower Q value tuning solutions.

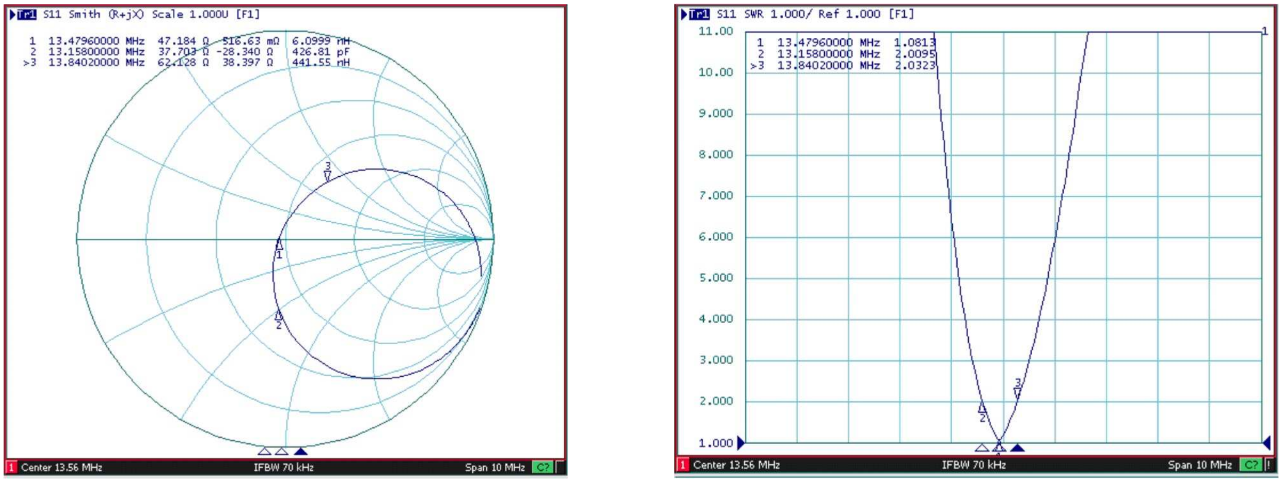

Figure 12. Higher Q Antenna Measurement Plots with Calculated Values (Q = ~20)

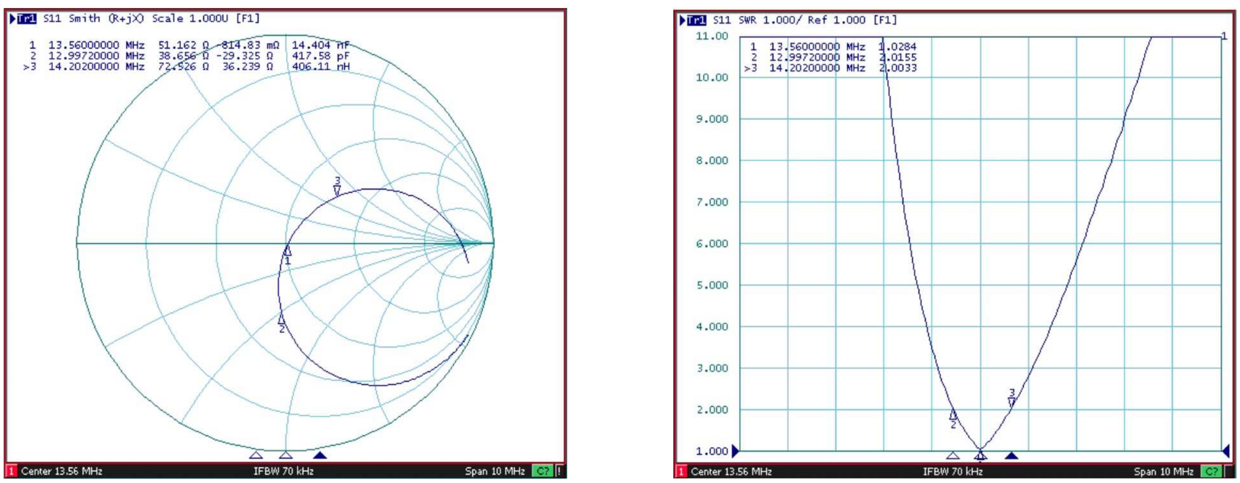

Figure 13. Lower Q Antenna Measurement Plots with Calculated Values (Q = ~10)

14 TRF7960TB Module Read Ranges

Figure 14 through Figure 16 show read ranges for the TRF7960TB using different ISO standards.

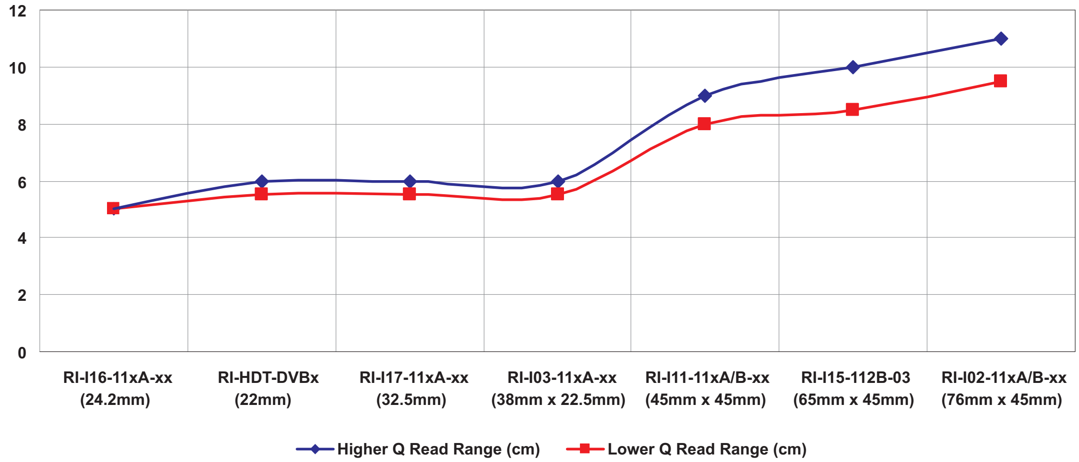

Figure 14. ISO15693 Transponder Read Ranges with TRF7960TB

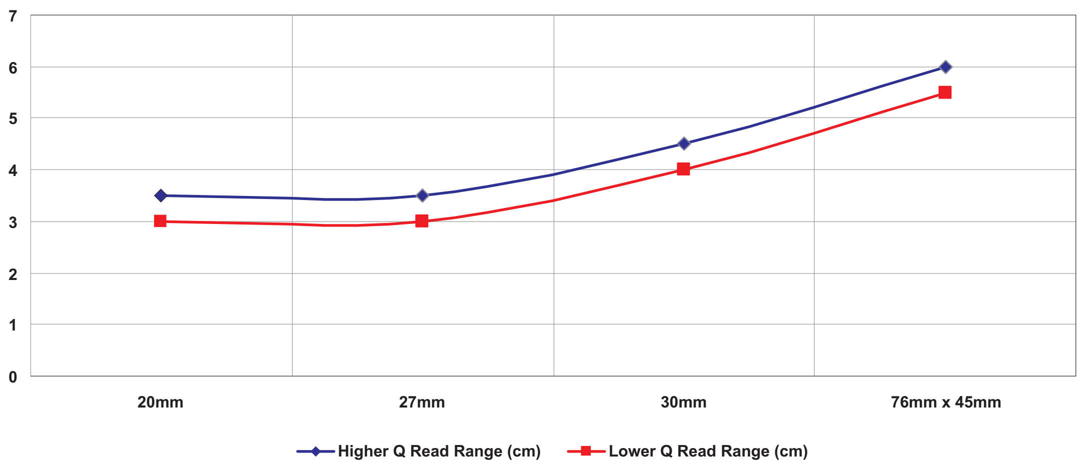

Figure 15. ISO14443A Transponder Read Ranges with TRF7960TB

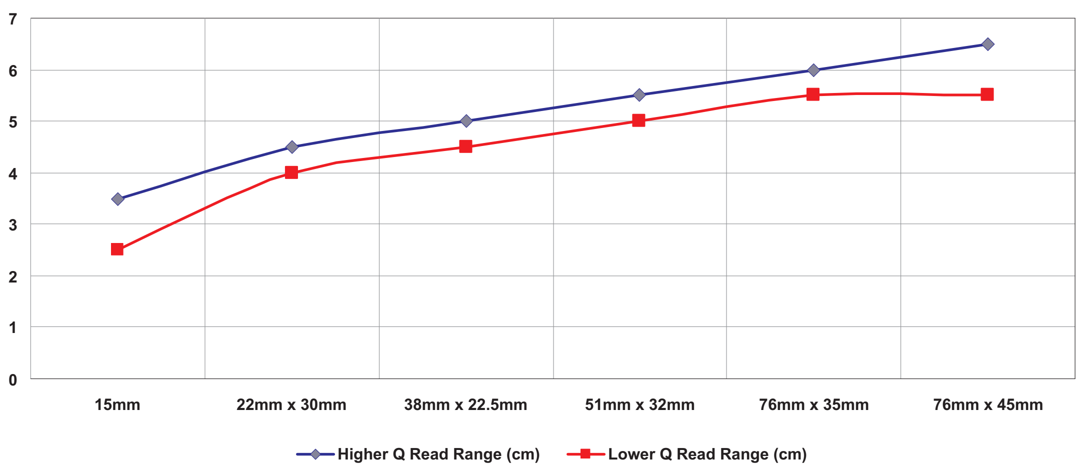

Figure 16. ISO14443B Transponder Read Ranges with TRF7960TB