

# TRF7970A + MSP430G2xx NFC/RFID Module Reference Design

John Crutchfield

## ABSTRACT

This application report is intended to provide a complete hardware and firmware reference design for use in NFC/RFID applications, using the TRF7970A NFC/RFID transceiver combined with a MSP430G2xx series 16-bit microcontroller. The reference design is intended to be easy to incorporate into new and existing designs. The MSP430G2xx MCU plus TRF7970A handles basic NFC/RFID task while communicating back to a host.

Two reference designs are presented that share the same basic hardware configuration. Each uses a separate means of communication to a host. There is an I2C NFC/RFID module and an universal asynchronous receiver/transmitter (UART) NFC/RFID module, known as the eZ430-TRF7970A. These modules are presented as a paper reference design. This means they include schematics, Gerber files, and example firmware, but the modules themselves are not supplied by Texas Instruments.

There are also associated example code projects for each module with detailed descriptions and explanations of how to utilize the projects given within. The code examples demonstrate basic NFC/RFID Reader functionality, interacting with ISO15693, ISO14443A, ISO14443B, and FeliCa.

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**NOTE:** Any members of the TRF79xx family could be substituted in place of the TRF7970A based on system requirements.

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## 1 Theory of Operation

According to the Near Field Communication (NFC) Forum Specifications, there are two types of devices in NFC Reader/Writer mode. There are “readers,” known as Proximity Coupling Devices (PCDs), and there are “tags,” known as Proximity Integrated Circuit Cards (PICCs). The PCD is active, which means it radiates a 13.56MHz RF field while a PICC is passive, which means it modulates the PCD’s field. A PCD communicates with PICCs in a master/slave relationship. The PCD is the master and communicates with the PICC over the air using ISO standard commands and protocols. There are several standard PICCs which include ISO15693, ISO14443A, ISO14443B, and FeliCa. The different PICCs support different modulation schemes and commands.

The TRF7970A has the ability to be a PCD reading all these PICC types and is able to emulate an ISO14443A/B PICC. In this application reference design, the TRF7970A in PCD mode is presented on two hardware platforms. Each platform has an onboard microcontroller; one uses a UART as an interface to external devices and one uses I2C.

## 2 Overview

### 2.1 Example Operation of eZ430-TRF7970A UART Module

The example code for the eZ430-TRF7970A UART module demonstrates basic NFC reader operation. The provided example code will allow the eZ430-TRF7970A boards to read the Unique Identification numbers (UIDs) of ISO15693, ISO14443A, ISO14443B, and FeliCa tags. It reads the UIDs as well as each tag’s associated RSSI value, a field signal strength indicator. The eZ430-TRF7970A will send this data out over a UART interface.

### 2.2 Example Operation I2C NFC/RFID Module

The example code for the I2C NFC module will also demonstrate the same NFC reader/writer operation seen on the eZ430-TRF7970A. The I2C NFC/RFID module will be an I2C slave device, so a host controller must play the role of I2C master. In this example, the master is another MSP430G2553 on the MSP430™ LaunchPad™. Code for the master is also provided for reference.

The I2C NFC/RFID Module will poll for tags every 350 ms. Once the module finds a tag, it drives a GPIO line low to signal the master that the tag data is ready to be read. The master then reads this data from the I2C NFC/RFID module, and transmits the data out of a UART port for demonstration purposes.

## 3 Hardware Description

### 3.1 TRF7970A – NFC/RFID Transceiver IC

TRF7970A is a high performance 13.56MHz HF RFID/NFC Transceiver IC composed of an integrated analog front end (AFE) and a built-in data framing engine for ISO15693, ISO14443A, ISO14443B, and FeliCa. This includes data rates up to 848kbps for ISO14443 with all framing and synchronization tasks on board (in default mode). The TRF7970A also supports NFC Tag Type 1, 2, 3, and 4 operations. This architecture enables the customer to build a complete cost-effective yet high-performance multi-protocol 13.56MHz RFID/NFC system together with a low-cost microcontroller (for example, MSP430).

### 3.2 MSP430G2553 – 16-Bit RISC Mixed Signal Microcontroller

The Texas Instruments MSP430 family of ultra-low-power microcontrollers consists of several devices featuring different sets of peripherals targeted for various applications. The architecture, combined with five low-power modes, is optimized to achieve extended battery life in portable measurement applications. The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in less than 1  $\mu$ s.

The MSP430G2x53 series are ultra-low-power mixed signal microcontrollers with built-in 16-bit timers, up to 24 I/O capacitive-touch enabled pins, a versatile analog comparator, and built-in communication capability using the universal serial communication interface. In addition, the MSP430G2x53 family members have a 10-bit analog-to-digital converter (ADC).

### 3.3 NFC/RFID Transceiver Reference Modules

The two reference designs presented both use TRF7970A + MSP430G2553 NFC/RFID modules. The modules use serial communication to transfer tag data to outside devices.

The onboard MSP430G2553 can drive a small NFC/RFID reader firmware stack that will handle basic NFC/RFID Communication. It uses SPI to communicate with the TRF7970A, as shown in [Figure 1](#).

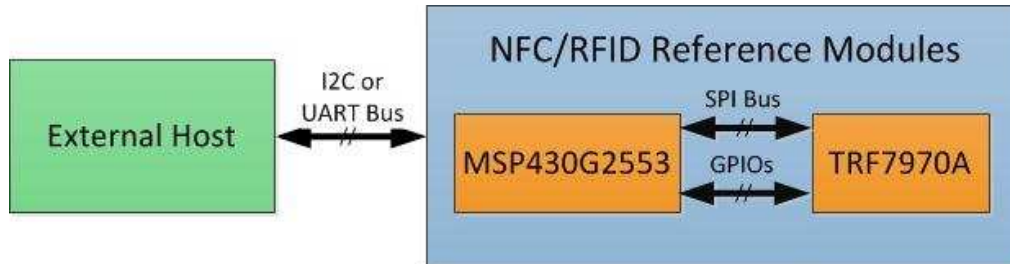


Figure 1. Hardware Block Diagram

#### 3.3.1 eZ430-TRF7970A UART Module

The eZ430-TRF7970A follows Texas Instrument’s eZ430™ connector standard. The eZ430-TRF7970A connector can connect to many of TI’s evaluation boards and uses UART for serial communication.

The eZ430-TRF7970A has an onboard PCB antenna, as well as an UFL connector pads to connect to an external antenna. The passive components are for the RF signal path and antenna tuning. It also has two LEDs on board that indicate when a tag is read.

The UART is running at 9600 Baud. It could be run faster, but the UART to the USB bridge on the MSP-EXP430G2 Launch pad is limited to 9600 Baud.



Figure 2. eZ430-TRF7970A UART Module

Table 1. eZ430-TRF7970A UART Module Pin Out

Connector Pin	Function
1	RX
2	VCC
3	TEST/SBWTCK
4	RST_NMI/SBWDIO
5	GND
6	TX

**NOTE:** The schematic and layout for the eZ430-TRF7970A UART Module can be found in [Appendix B](#).

### 3.3.2 I2C NFC/RFID Module

The I2C NFC/RFID module uses a standard header connector. The I2C NFC/RFID Module supports both 1.8 and 3.3V communication levels, but requires a 3.3V supply for NFC/RFID functionality. It has included onboard pull up resistors for the I2C lines as well as a level shifter.

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**NOTE:** For 3.3 V communication, supply the Level Shifter Communication Voltage pin with 3.3 V, and do not populate R12. For more information, see the schematic in [Appendix A](#).

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The I2C NFC/RFID module has an onboard PCB antenna and pads for an UFL connector allowing you to connect to an external antenna. There are also passive components for the RF signal path matching and antenna tuning.



**Figure 3. I2C NFC/RFID Module**

**Table 2. I2C NFC/RFID Module**

Connector Pin	Function
1	SDA
2	SCL
3	Level Shifter Communication Voltage
4	GND
5	3.3 V
6	TEST/SBWTCK
7	RST_NMI/SBWDIO
8	1.8 V GPIO

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**NOTE:** The schematic and layout for the eZ430-TRF7970A UART Module can be found in [Appendix B](#).

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## 4 Firmware Description

The example firmware is discussed over three sections:

- General Overview: a high level description of the functionality
- eZ430-TRF7970A Detailed Firmware Description
- I2C NFC/RFID Module Detailed Firmware Description

### 4.1 General Overview

#### 4.1.1 Code Description

The provided code examples demonstrate the TRF7970A as a NFC/RFID reader. The module polls for ISO15693, ISO14443A, ISO14443B, and FeliCa tags every 350 ms. It then transmits the UID and associated RSSI values for any tags found in the field back to a host, as seen in [Figure 4](#).

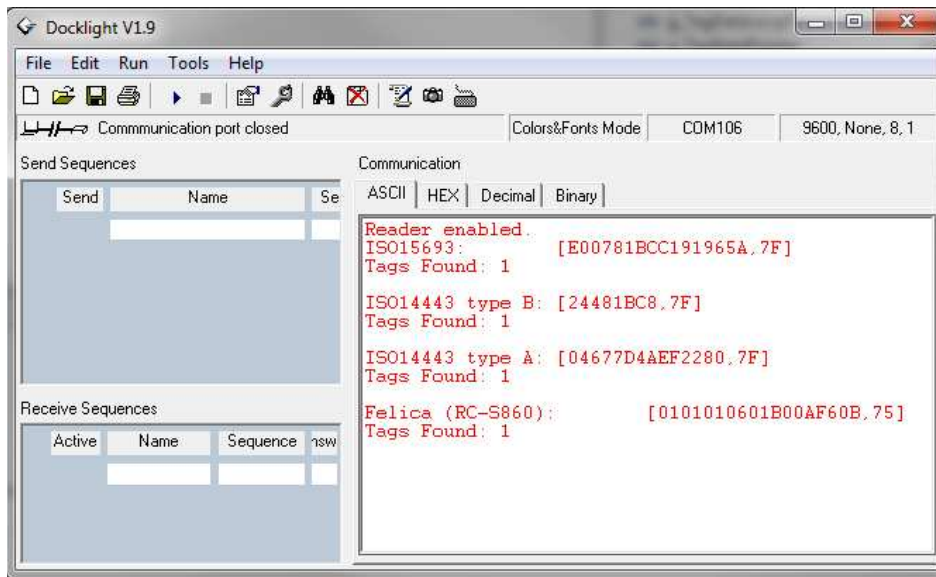


Figure 4. eZ430-TRF7970A Output to Host

Between polling cycles, the TRF7970A and the MSP430G2xx are placed into low-power modes to demonstrate power savings.

4.1.2 Flow Diagram Overview

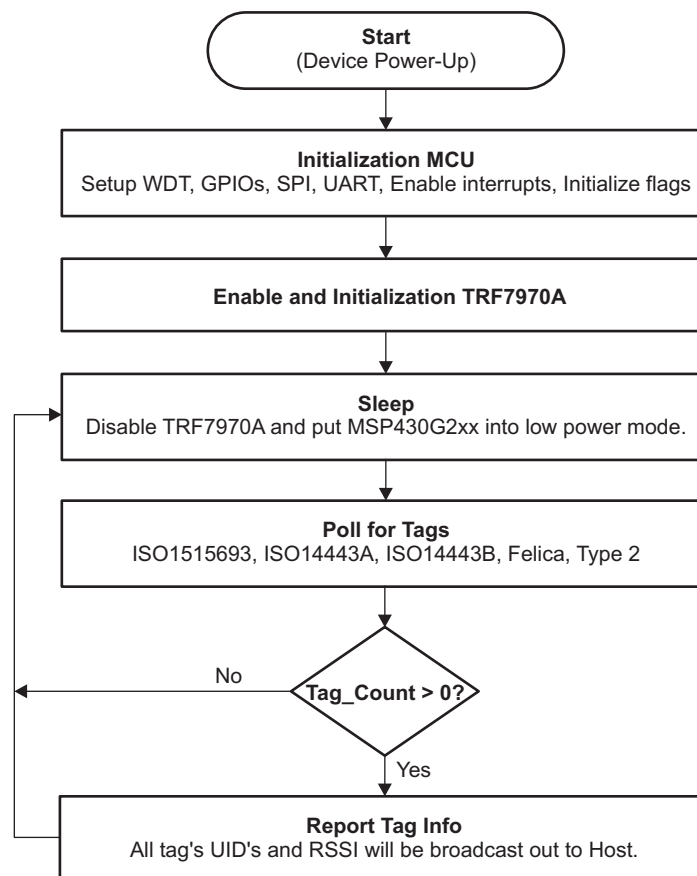


Figure 5. General Overview Flow Diagram

## 4.2 eZ430-TRF7970A Detailed Firmware Description

The example firmware for the eZ430-TRF7970A scans for tags and sends their UID's to a host via UART. The easiest way to use this module is with a UART to USB converter to allow you to talk with a PC, as shown in Figure 6. The MSP-EXP430G2 LaunchPad comes with an eZ430 header and can be easily used as a bridge for programming and talking directly with a PC.

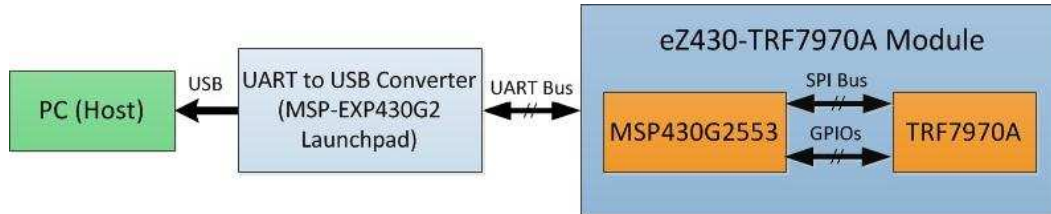


Figure 6. eZ430-TRF7970A System Description

### 4.2.1 Module Initialization

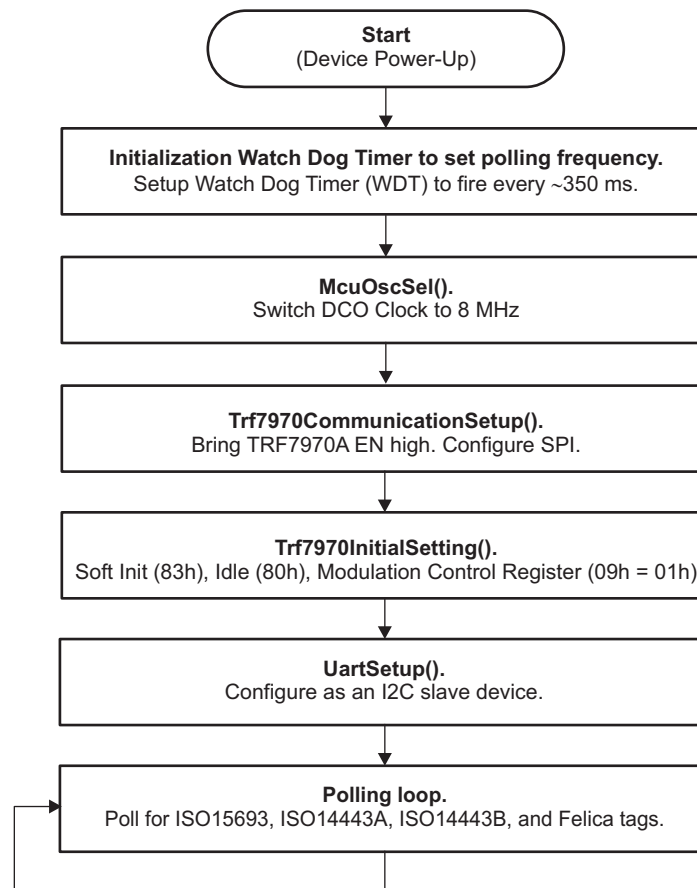


Figure 7. eZ430-TRF7970A Firmware Initialization Flowchart

## 4.2.2 Tag Polling Loop

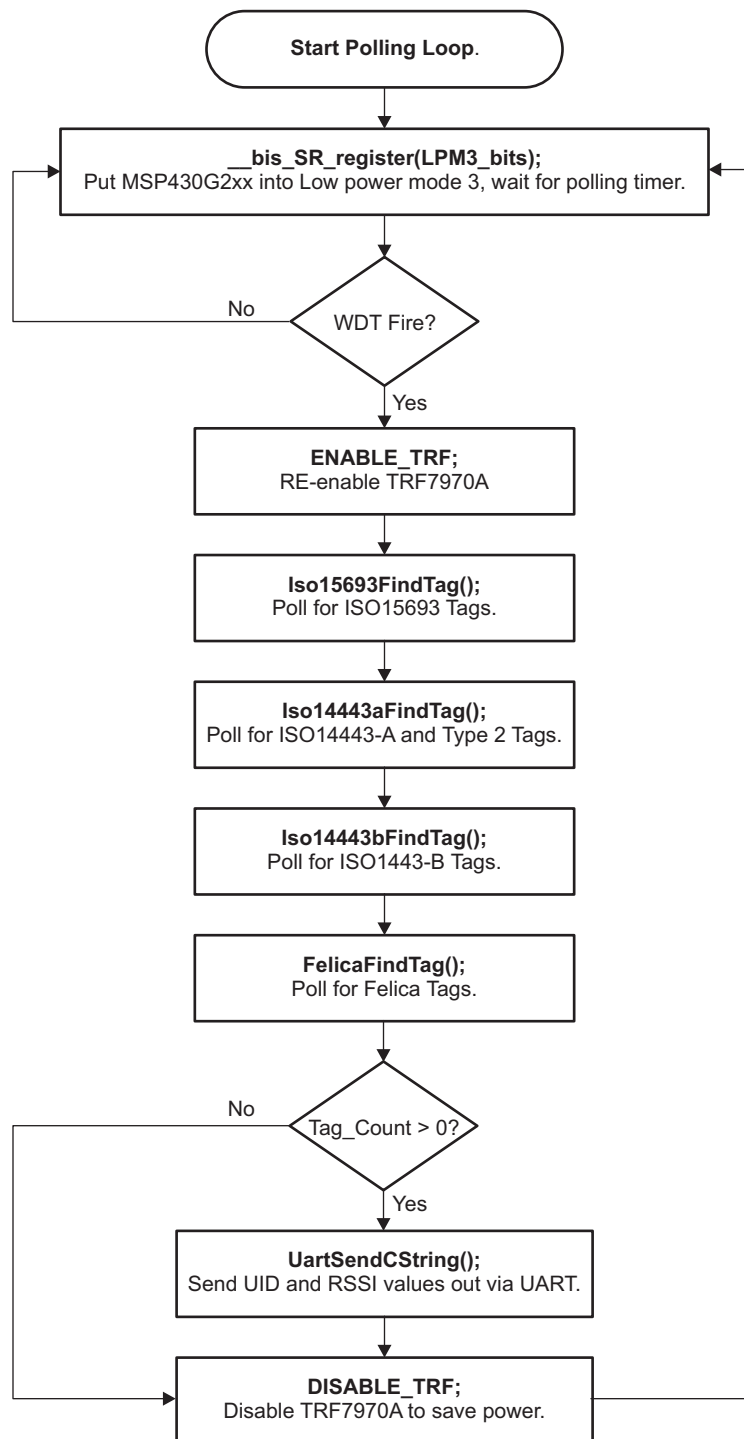


Figure 8. eZ430-TRF7970A Tag Polling Loop Flowchart

## 4.3 I2C NFC/RFID Module Detailed Firmware Description

The example firmware for the I2C NFC/RFID Module scans for tags and sends their UID's to a host via I2C. The I2C NFC/RFID Module is configured as an I2C Slave which requires an I2C Master to initiate communication. The I2C NFC/RFID Module generates a signal, INTO, to the master to signal data is ready.



For demonstration and evaluation purposes, firmware for a MSP430G2553 as an I2C Master to UART bridge is provided for the MSP-EXP430G2 LaunchPad. On the MSP-EXP430G2 Launchpad there is a UART to USB converter to allow you to talk with a PC, as shown in Figure 9

The MSP-EXP430G2 LaunchPad comes with standard headers that can be connected via jumper wire. The LaunchPad can also be easily used as a bridge for programming.

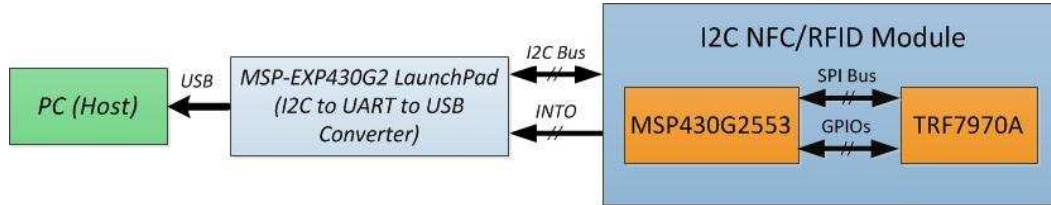


Figure 9. I2C NFC/RFID Module System Description

### 4.3.1 Module Initialization

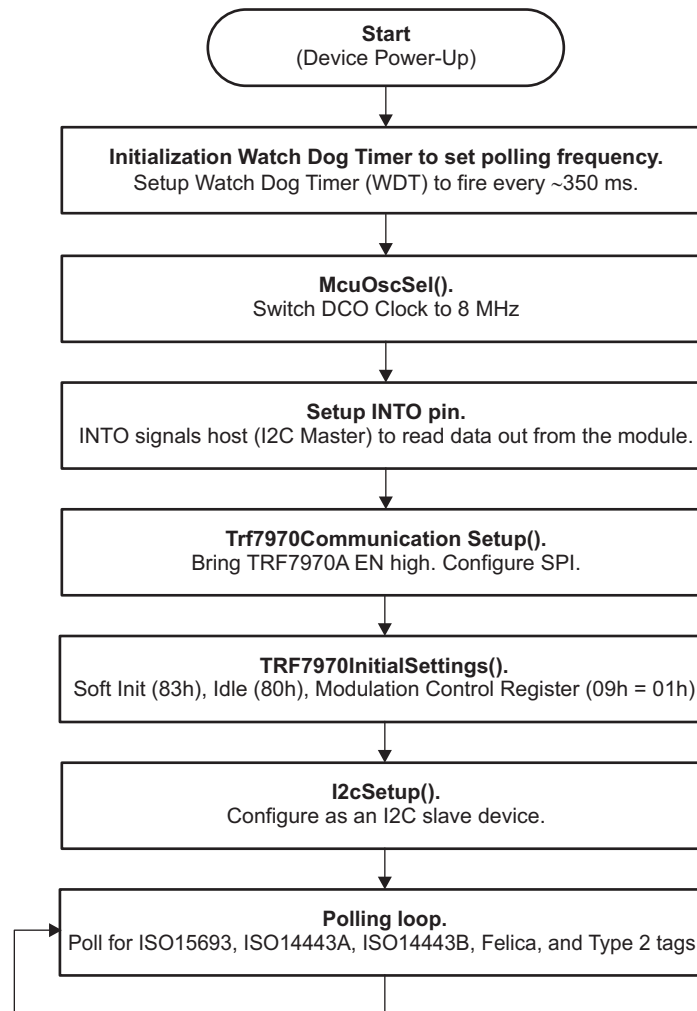
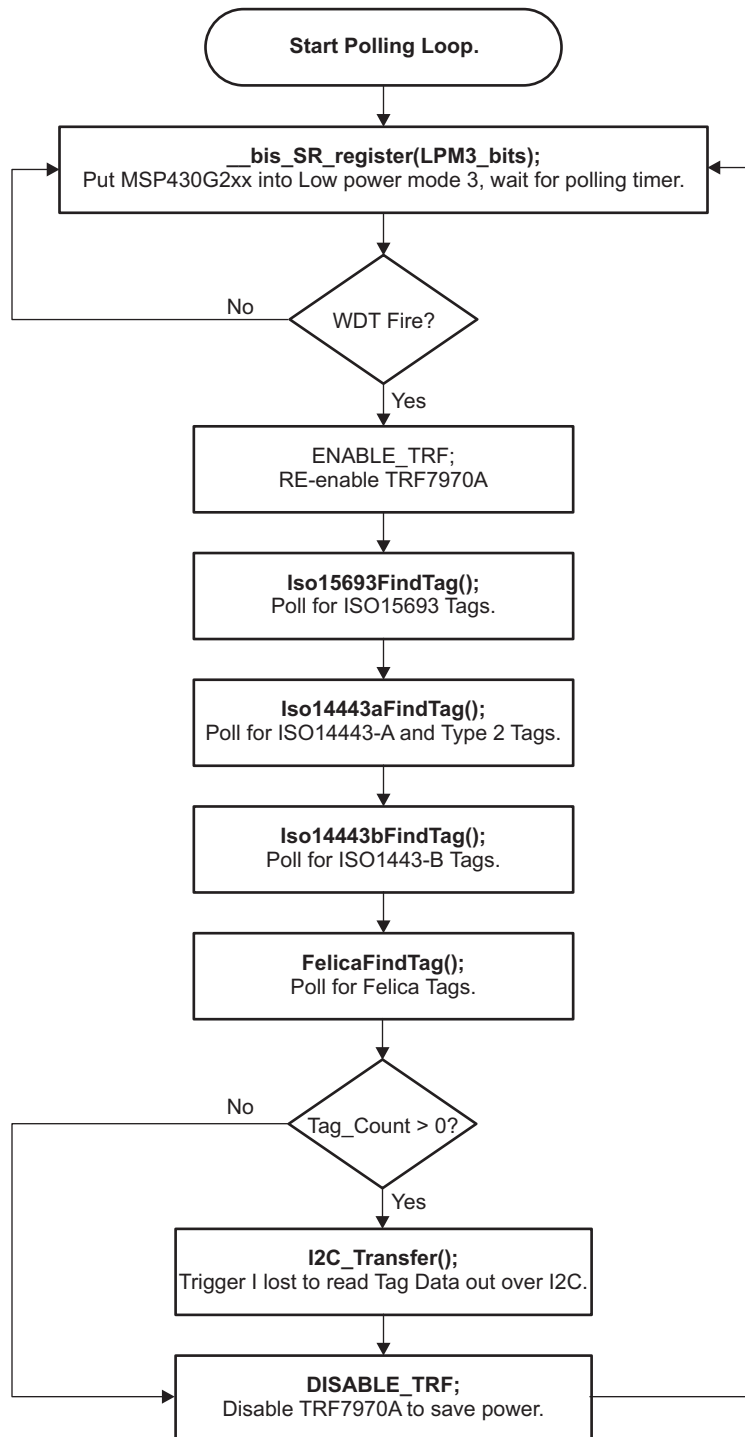


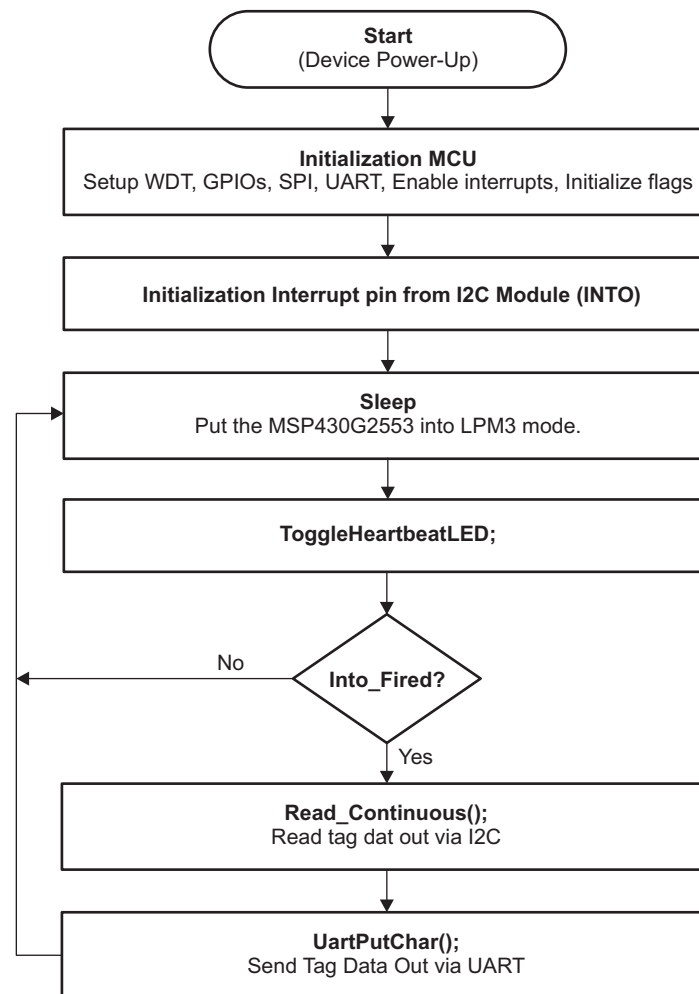
Figure 10. I2C NFC/RFID Module Firmware Initialization Flowchart

### 4.3.2 Tag Polling Loop



**Figure 11. I2C NFC/RFID Module Tag Polling Loop Flowchart**

### 4.3.3 Host Firmware



**Figure 12. I2C Host/Master Firmware Flowchart**

## 5 Conclusion

This paper reference design presents everything required to manufacture, build, and test these NFC modules. Both UART and I2C module designs have been provided for direct integration into most applications.

Project collateral and source code discussed in this application report can be downloaded from the following URL: <http://www.ti.com/lit/zip/sloc313>.

For follow up questions concerning this reference design, see the NFC E2E forums at the following URL: [http://e2e.ti.com/support/wireless\\_connectivity/f/667.aspx](http://e2e.ti.com/support/wireless_connectivity/f/667.aspx).

## 6 References

- *TRF7970A Multiprotocol Fully Integrated 13.56-MHz RFID and Near Field Communication (NFC) Transceiver IC Data Manual (SLOS743)*
- *MSP430x2xx Family User's Guide (SLAU144)*
- *NFC Forum Type 4 Tag Operation Specification: <http://members.nfc-forum.org/apps/org/workgroup/allmembers/download.php/17511/latest>*
- *Using TI Technology to Simplify Bluetooth Pairing Via NFC (SLAA512)*

## ***I2C NFC/RFID Module***

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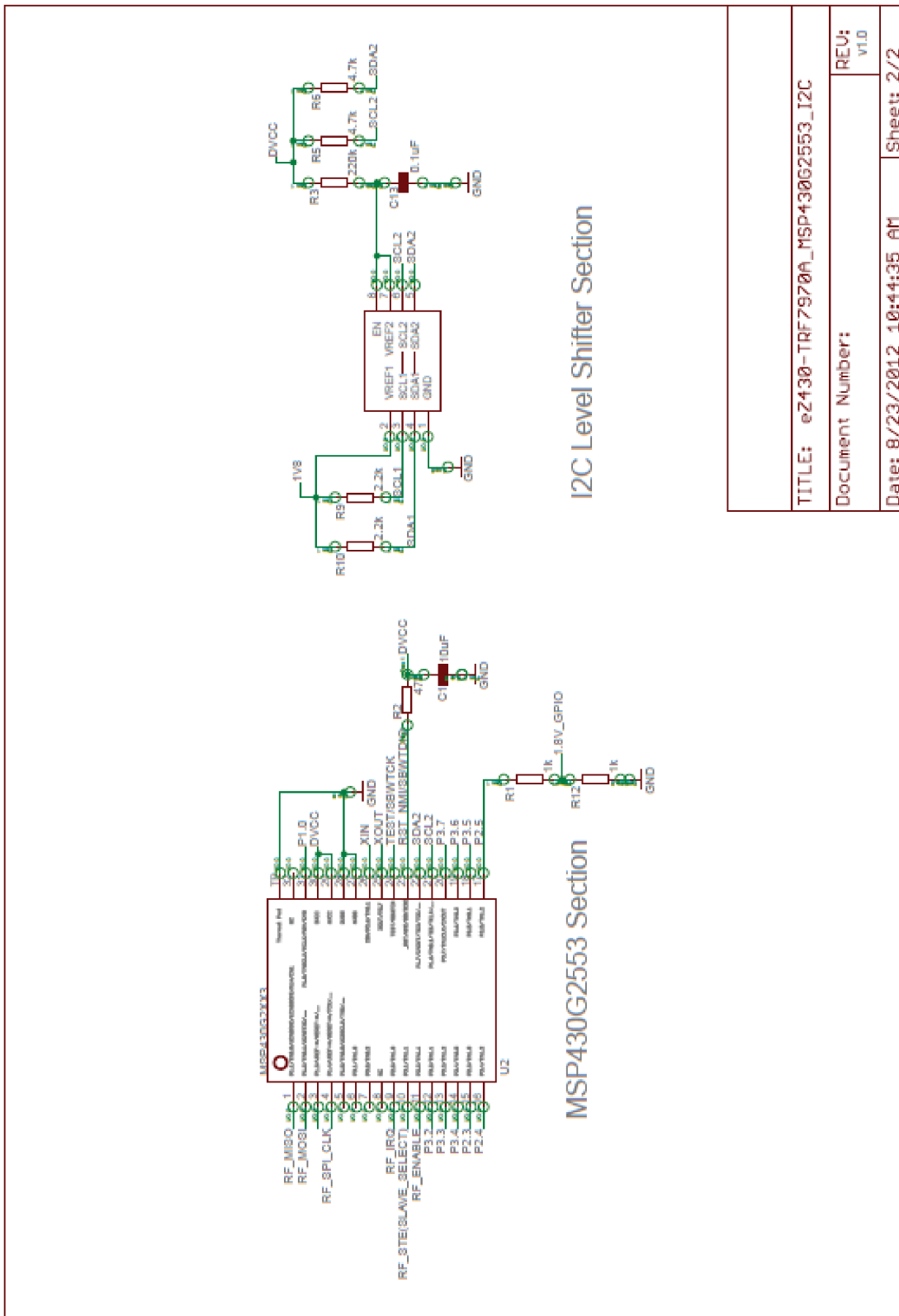
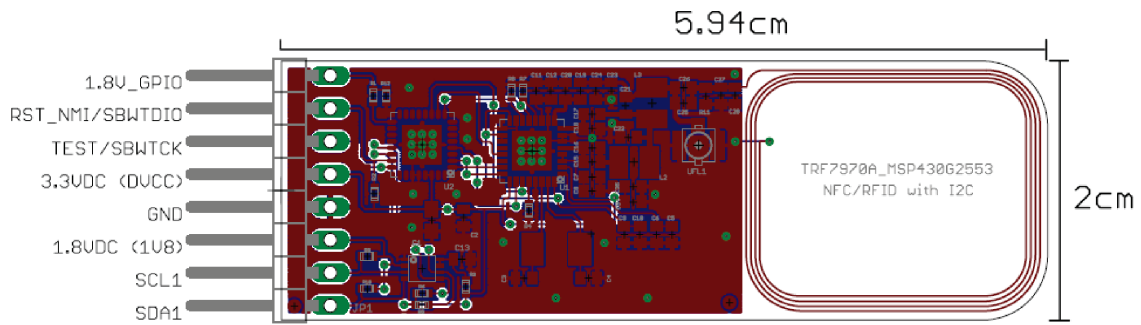


Figure 14. I2C Module Schematic - Part 2

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## A.2 Layout



**Figure 15. I2C Module Layout**

**A.3 Bill of Materials**
**Table 3. I2C NFC/RFID Module Bill of Materials**

Reference	Qty	Value	Part Description	Manufacturer Part Number	Package
C1	1	10 $\mu$ F	CAP CER 10UF 6.3 V 20% X5R 0603	C1608X5R0J106M	C0603
C2	1	220 nF	CAP CER 220NF 10 V 10% X7R 0402	GRM155R60J224KE01D	C0402
C3, C4, C24, C25, C26	5	27 pF	CAP CER 27PF 16 V 10% CH 0402	CC0402JRNPO9BN270	C0402
C5, C7, C9, C11, C34	4	2.2 $\mu$ F	CAP CER 2.2UF 10 V 10% X5R 0402	C1005X5R0G225M	C0402
C6, C8, C10, C12, C13, C35	6	0.1 $\mu$ F	CAP CER 0.1UF 10 V 10% X5R 0402	C1005X5R0J104K	C0402
C15, C16,	2	1500 pF	CAP CER 1500PF 16 V 10% X7R 040	GRM155R71H152KA01D	C0402
C17, C18	2	1200 pF	CAP CER 1200PF 10 V 10% X5R 0201	GRM155R71H122KA01D	C0402
C19	1	220 pF	CAP CER 220PF 16 V 10% X7R 0201	CC0402JRNPO8BN221	C0402
C20, C22	2	680 pF	CAP CER 680PF 16 V 10% X7R 0201	C1005X7R1H681K	C0402
C21, C27	2	10 pF	CAP CER 10PF 16 V 10% NP0 0402	CC0402JRNPO9BN100	C0402
C23	1	100 pF	CAP CER 100PF 16 V 10% NP0 0402	GRM1555C1H101JZ01D	C0402
L2	1	150 nH	INDUCTOR 150NH .80A WW 1008	744762215A	L2825P/ 1008
L3	1	330 nH	INDUCTOR 330NH .80A WW 1008	744762233A	L2825P/ 1008
R1, R7, R8, R12,	4	1k	RES 1.00K $\Omega$ 1/16W 1% 0402 SMD	RC0402FR-071KL	0402
R2	1	47k	RES 10K $\Omega$ 1/16W 1% 0402	RC1005F103CS	0402
R3	1	220k	RES 220K $\Omega$ 1/16W 1% 0402 SMD	RC0402FR-07220KL	0402
R4	1	10k	RES 10K $\Omega$ 1/16W 1% 0402	RC1005F103CS	0402
R5, R6	2	4.7k	RES 4.7K $\Omega$ 1/10W 1% 0402 SMD	ERJ-2RKF4701X	0402
R9, R10	2	2.2k	RES 2.20K $\Omega$ 1/16W 1% 0402 SMD	RC0402FR-072K2L	0402
R11	1	1.2k	RES 1.2K $\Omega$ 1/16W 1% 0402 SMD	MCR01MRTF1201	0402
U1	1	TRF7970A	IC RFID/NFC AFE 13.56MHZ 32QFN	TRF7970ARHBR	QFN32
U2	1	MSP430G2553	IC MCU 16BIT 16KB FLASH 20TSSOP	MSP430G2553IPW20R	RHB32
U3	1	I2C Translator	IC V-LEVL XLATR I2C/SMBUS 8X2SON	PCA9306DQER	PSOP-8
UFL1	1	UFL Connector	CONN UMC JACK STR 50 $\Omega$ SMD	U.FL-R-SMT(10)	U.FL
Y1	1	Crystal	13.56 MHz Crystal Oscillator	7A-13.560MAAJ-T	CRYSTAL- SMD-5X3.2



## **eZ430-TRF7970A UART Module**

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B.1 Schematics

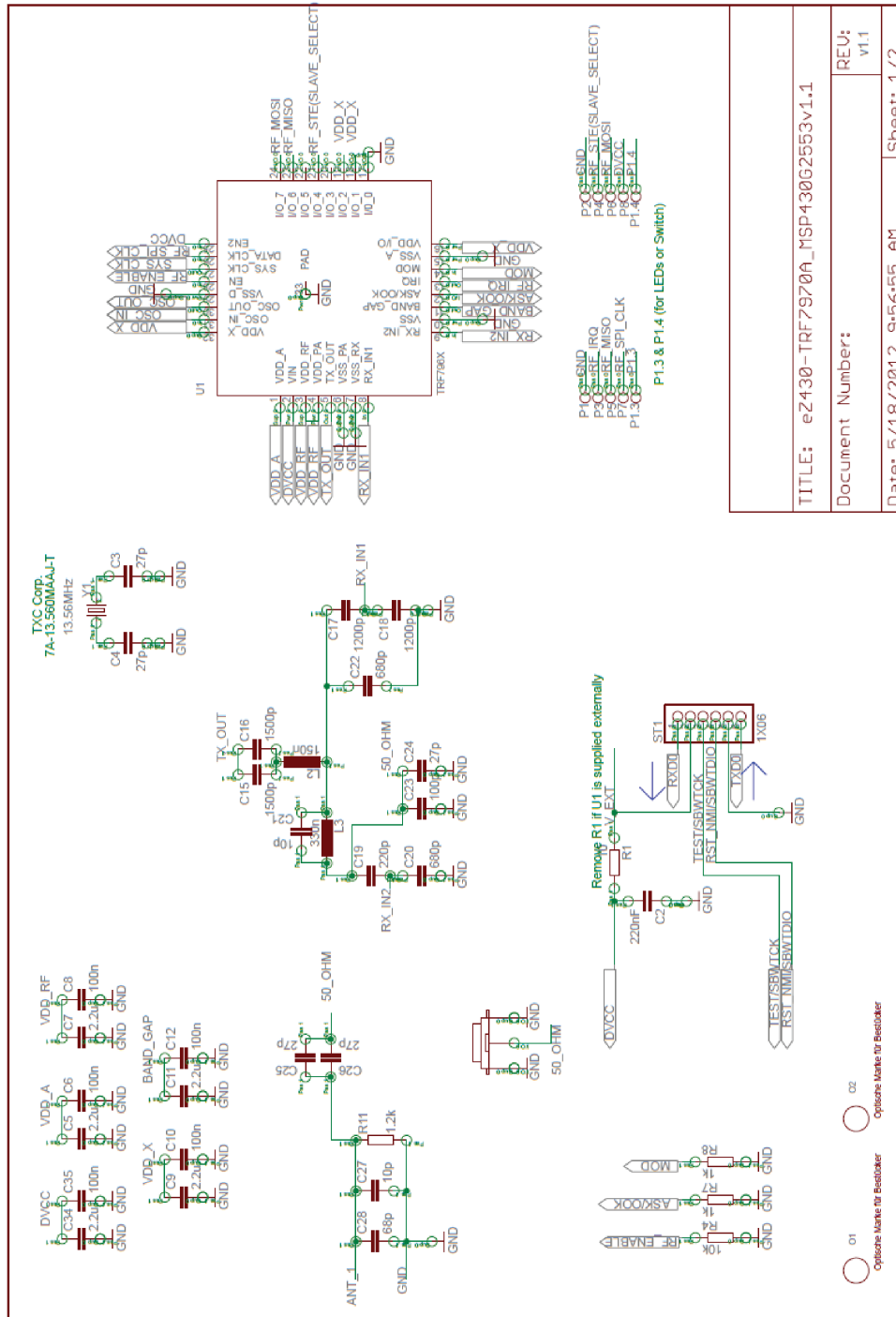
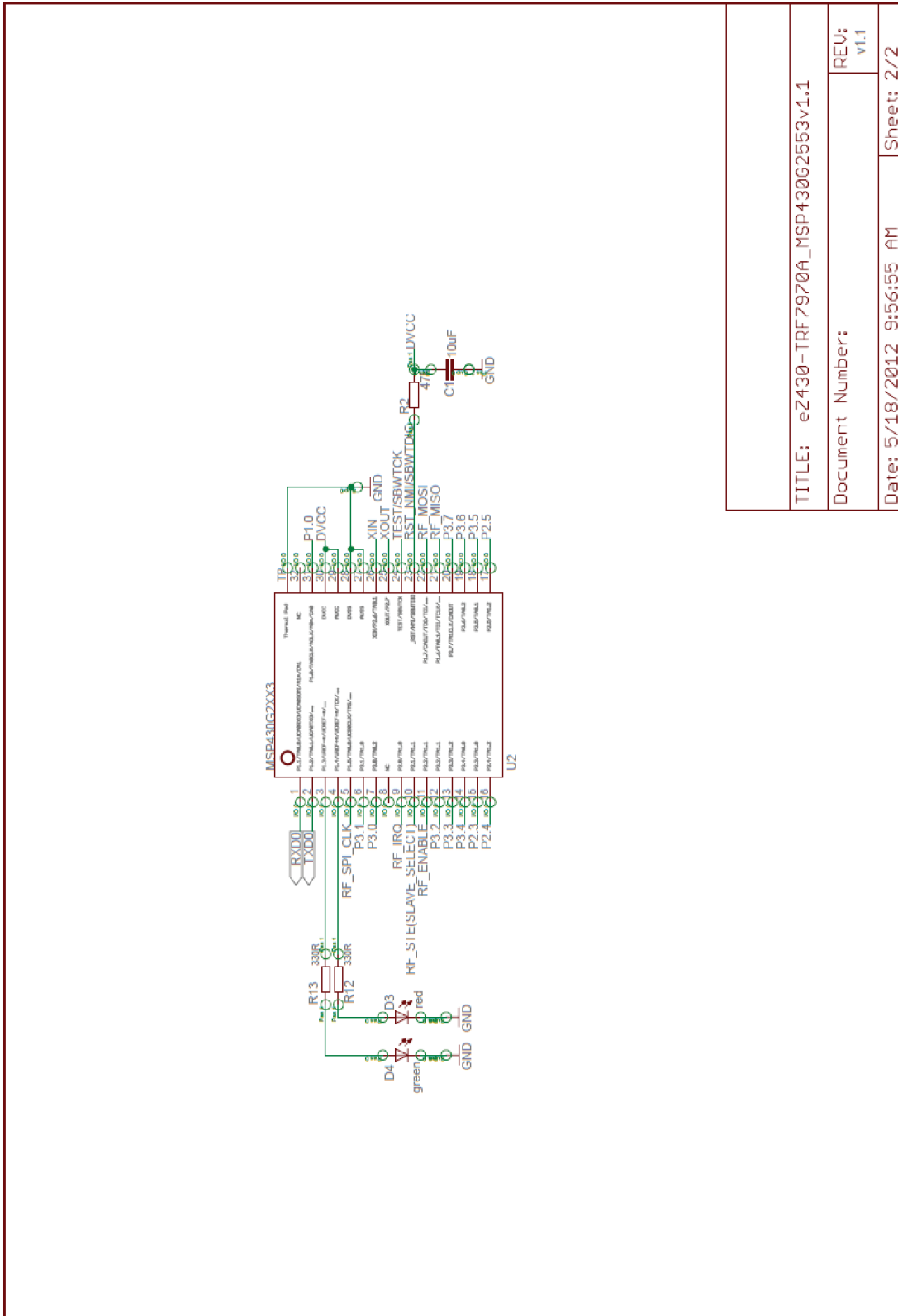


Figure 16. I2C Module eZ430-TRF7970A Schematics - Part 1

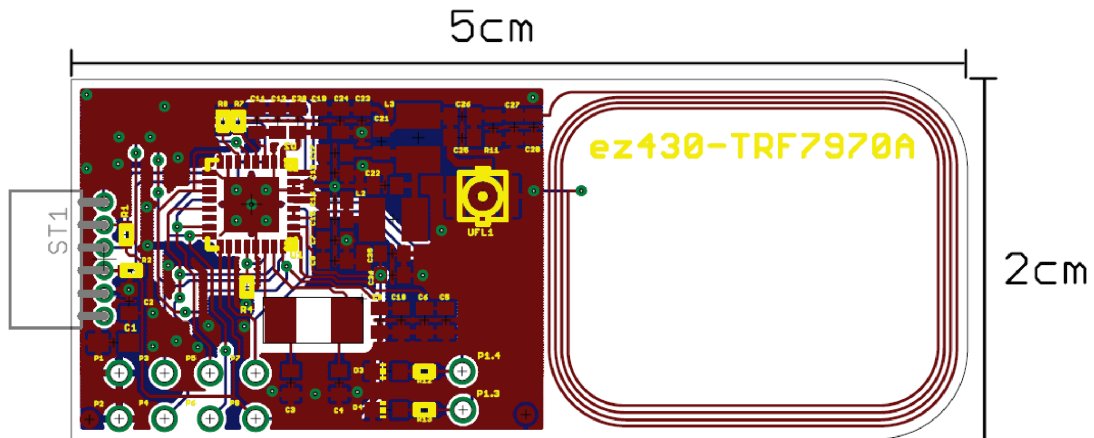
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Document Number:	REV: v1.1
Date: 5/18/2012 9:56:55 AM	Sheet: 2/2

Figure 17. I2C Module eZ430-TRF7970A Schematics - Part 2

**B.2 Layout**



**Figure 18. ez430-TRF7970A Module Layout**

### B.3 Bill of Materials

**Table 4. eZ430-TRF7970A Bill of Materials**

Reference	Qty	Value	Part Description	"Manufacturer Part Number"	Package
C1	1	10 $\mu$ F	CAP CER 10UF 6.3 V 20% X5R 0603	C1608X5R0J106M	C0603
C2	1	220 nF	CAP CER 220NF 10 V 10% X7R 0402	GRM155R60J224KE01D	C0402
C3, C4, C24, C25, C26	5	27 pF	CAP CER 27PF 16 V 10% CH 0402	CC0402JRNPO9BN270	C0402
C5, C7, C9, C11, C34	5	2.2 $\mu$ F	CAP CER 2.2UF 10 V 10% X5R 0402	C1005X5R0G225M	C0402
C6, C8, C10, C12, C35	5	100 nF	CAP CER 0.1UF 10 V 10% X5R 0402	C1005X5R0J104K	C0402
C15, C16	2	1500 pF	CAP CER 1500PF 16 V 10% X7R 040	GRM155R71H152KA01D	C0402
C17, C18	2	1200 pF	CAP CER 1200PF 10 V 10% X5R 0201	GRM155R71H122KA01D	C0402
C19	1	220 pF	CAP CER 220PF 16 V 10% X7R 0201	CC0402JRNPO8BN221	C0402
C20, C22	2	680 pF	CAP CER 680PF 16 V 10% X7R 0201	C1005X7R1H681K	C0402
C21, C27	2	10 pF	CAP CER 10PF 16 V 10% NP0 0402	CC0402JRNPO9BN100	C0402
C23	1	100 pF	CAP CER 100PF 16 V 10% NP0 0402	GRM1555C1H101JZ01D	C0402
C28	1	68 pF	CAP CER 68PF 50 V 5% NP0 0402	C1005C0G1H680J	C0402
D3	1	red	LED SUPER RED CLEAR 0603 SMD	LTST-C190KRKT	CHIP-LED0603
D4	1	green	LED SUPER GREEN CLEAR 0603 SMD	LTST-C190KGKT	CHIP-LED0603
L2	1	150 nH	INDUCTOR 150NH .80A WW 1008	744762215A	L2825P/1008
L3	1	330 nH	INDUCTOR 330NH .80A WW 1008	744762233A	L2825P/1008
R1	1	10	RES 10 $\Omega$ 1/16W 5% 0402 SMD	RC0402JR-0710RL	R0402_GE
R2	1	47k	RES 10K $\Omega$ 1/16W 1% 0402	RC0402JR-0747KL	R0402_GE
R4	1	10k	RES 10K $\Omega$ 1/16W 1% 0402	RC0402JR-0710KL	R0402_GE
R7, R8	2	1k	RES 1.00K $\Omega$ 1/16W 1% 0402 SMD	RC0402JR-071KL	R0402_GE
R11	1	1.2k	RES 1.2K $\Omega$ 1/16W 1% 0402 SMD	RC0402JR-071K2L	R0402
R12, R13	2	330R	RES 330 $\Omega$ 1/16W 5% 0402 SMD	RC0402JR-07330RL	R0402_GE
ST1	1	1X06	CONN HEADER .050" 6POS PCB GOLD	LPPB061NFFN-RC	1X06
U1	1	TRF7970A	IC RFID/NFC AFE 13.56MHZ 32QFN	TRF7970ARHBR/BT	QFN(RHB)32
U2	1	MSP430G2553	IC MCU 16BIT 16KB FLASH 20TSSOP	MSP430G2553RHBR/BT	RHB32
UFL1	1	U.FL	CONN UMC JACK STR 50 $\Omega$ SMD	U.FL-R-SMT-1(10)	U.FL
Y1	1	13.56 MHz	13.56 MHz Crystal Oscillator	7A-13.560MAAJ-T	CRYSTAL-SMD-5X3.2

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