Application Report
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TRF7970A NFC Reader Antenna Multiplexing

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ABSTRACT

This application report describes the implementation of multiple reader antennas with a single TRF7970A NFC transceiver IC. For demonstration purposes, the MSP430F5529 LaunchPad™ development kit with TRF7970A BoosterPack™ plug-in module are used. The PE42359 UltraCMOS® RF Switch from Peregrine Semiconductors is used for switching due to its simple control methodology and low power loss during switching. The demo supports ISO/IEC 15693, ISO/IEC 14443A, and ISO/IEC 14443B communication protocols.

This application report describes a simple demo of antenna multiplexing that can help when using the TRF7970A in applications with multiple antennas. This application report is an addition to the advanced demo for multiplexing 16 antennas that is described in *TRF7960A RFID Multiplexer Example System* (SLOA167). This application report uses an alternative switching device and an easier control strategy. The control algorithm can be easily written and added to the existing firmware.

The NFC firmware code used for this application can be downloaded from the TI website. Further information about the installation and setup of the GUI and the devices can be found in the design guide for the Near Field Communication (NFC) Reader/Writer Reference Design.

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1 Theory of Operation

NOTE: In this document, *MSP430F5529LP* is used to refer to the MSP430F5529 USB LaunchPad development kit (MSP-EXP430F5529LP), and *TRF7970ABP* is used to refer to the TRF7970A NFC Transceiver BoosterPack plug-in module (DLP-7970ABP).

Antenna multiplexing is the concept of switching between multiple antennas connected to a single TRF7970A NFC transceiver IC. To multiplex antennas, it is necessary to switch between the antennas and to identify the antenna used. To keep the complexity of the design low, a low power loss switch with simple control methods has been used.

The block diagram in Figure 1 shows the working concept of the demo. From a host PC, the TI NFC v1.7 GUI is used. The MSP430F5529LP has two onboard buttons (S1 and S2). The antennas are switched by pressing button S1 (Port 2.1) or S2 (Port 1.1). The PE42359 acts as a relay to switch between antennas. By default and when button S1 is pressed, antenna 1 is turned ON and antenna 2 is turned OFF. When button S2 is pressed, antenna 2 is turned ON and antenna 1 is turned OFF.

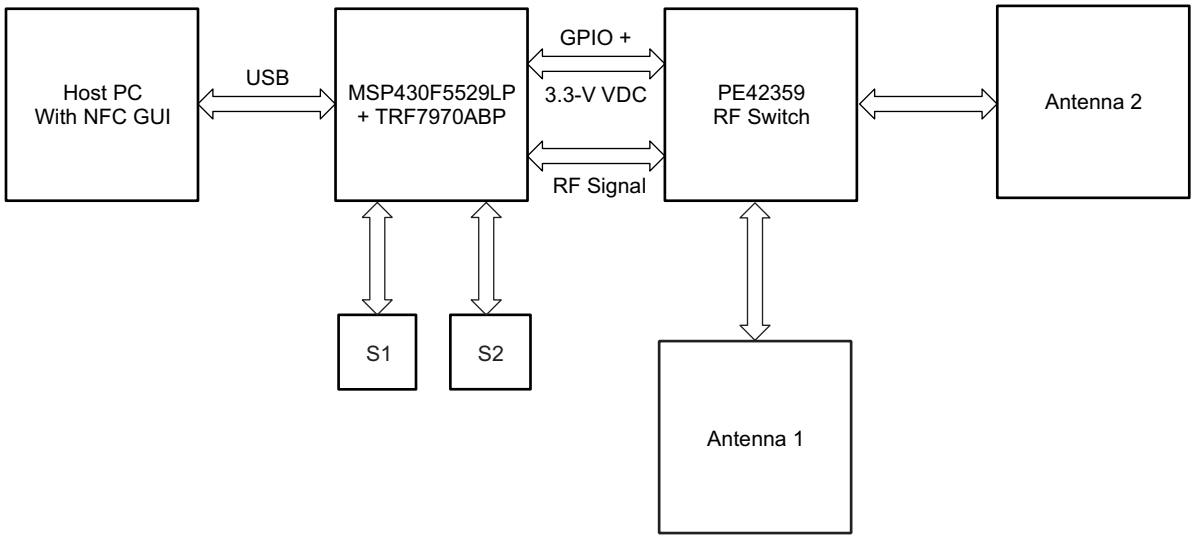


Figure 1. Block Diagram of Reader Antenna Multiplexing Demo

2 Hardware Information

The MSP430F5529LP includes an easy-to-use microcontroller. The onboard buttons and the LEDs can be freely defined and used as required. One advantage of this development kit is the 40-pin access headers with both 5.0-VDC and 3.3-VDC supplies. These headers can be used to add a wide range of BoosterPack plug-in modules. One such module is the TRF7970ABP.

The MSP430F5529LP must be connected to the host PC through USB. After the setup is complete, run the GUI (see Figure 10). The kit can automatically connect to the GUI on the host PC when you select the hardware device. For instructions on how to connect the kit and to get familiar with the GUI, see the *TIDM-NFC-RW Design Guide*. By activating the READ/WRITE mode, the MSP430F5529LP + TRF7970ABP starts to establish a NFC/RFID communication with the transponders. Figure 2 shows the MSP430F5529LP.

The TRF7970ABP uses the 3.3-V supply voltage. The 5.0-VDC pins are free and can be used for the application. The TRF7970ABP extends the MSP430F5529LP functionality with a NFC/RFID wireless communication interface.

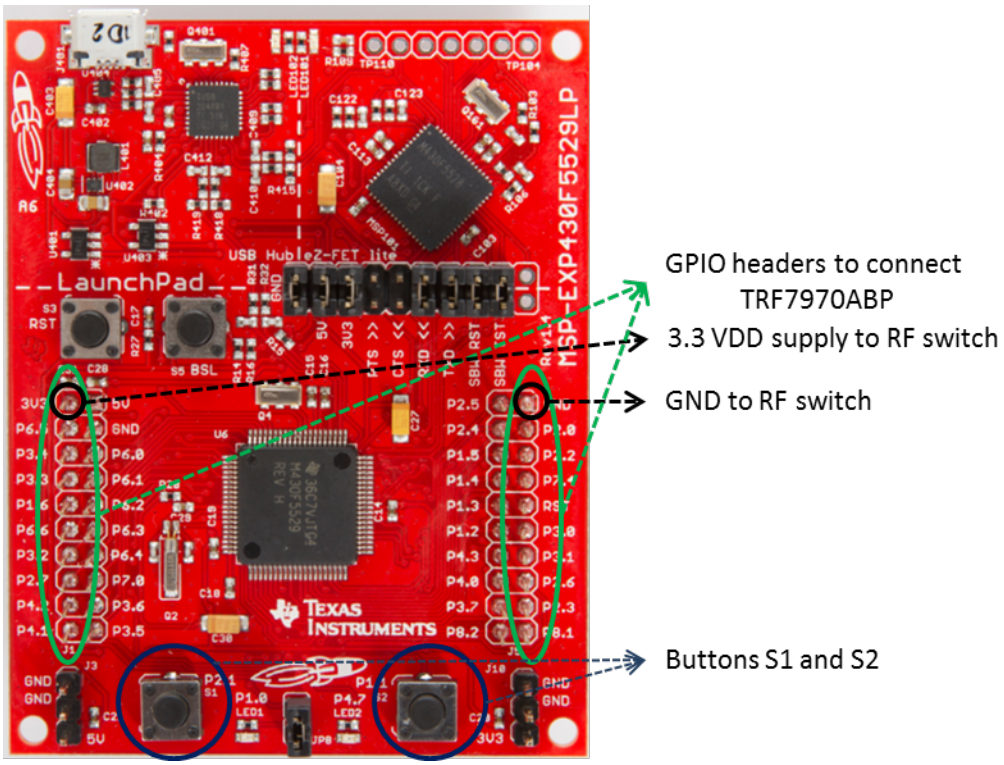


Figure 2. MSP430F5529 LaunchPad Development Kit

Figure 3 shows the TRF7970ABP modifications to add an SMA antenna connector for an external antenna. After this modification, the onboard antenna is disabled.

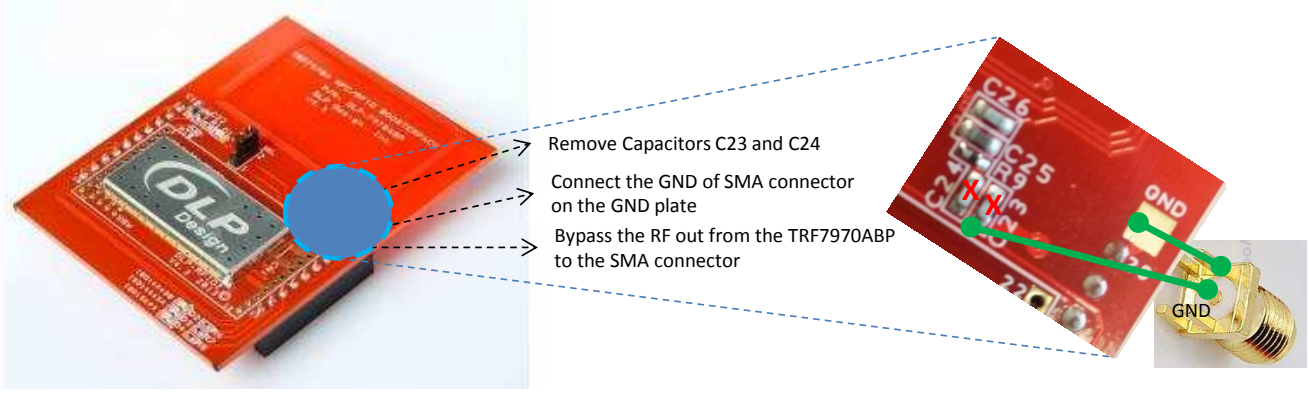
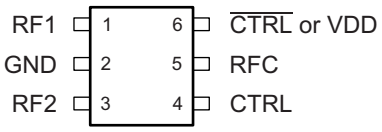


Figure 3. TRF7970A BP Modifications

Switching between antennas is performed through the PE42359 UltraCMOS RF switch from Peregrine Semiconductors. The PE42359 supports a broad range of frequencies from 10 MHz to 3 GHz. The RF switch is a 6-pin SC-70 package. Figure 4 shows the RF switch construction.



Pin Number	Description
1 – RF1	To antenna 1
2 – GND	Ground
3 – RF2	To antenna 2
4 – CRTL	Control pin (VDDH or VDDL)
5 – RFC	RF input from NFC IC
6 – $\overline{\text{CTRL}}$ or VDD	Input voltage (3.3 V)

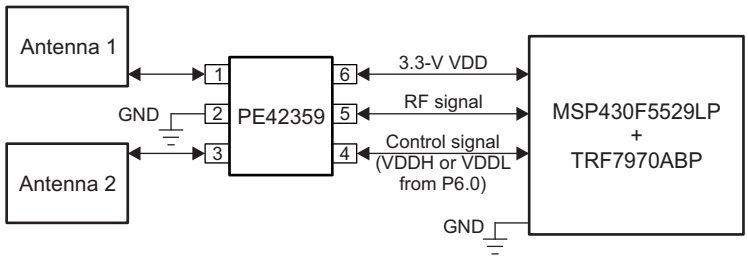
Figure 4. PE42359 RF Switch Pin Configuration and Description

3 Control Methodology

There are two modes of control methodology: single-pin control or complementary-pin control. The single-pin control method is the simplest way to control the switching process.

The antenna switch is supplied with a constant 3.3-V input to VDD (pin 6). The CTRL pin (pin 4) is connected to a GPIO pin of the MSP430F5529LP. Two control signal levels are generated in the MSP430F5529 GPIO pin. The signals are VDDH (VDD high signal, which is higher than 70% of 3.3 V) and VDDL (VDD low signal, which is lower than 30% of 3.3 V).

When VDDH is applied to the CTRL pin (pin 4), antenna 1 is turned ON and antenna 2 is turned OFF. When VDDL is applied to the CTRL pin (pin 4), antenna 2 is turned ON and antenna 1 is turned OFF. The signal levels VDDH and VDDL are generated by turning the GPIO pin on or off, respectively, in the MSP430F5529. Figure 5 shows the single-pin control method.

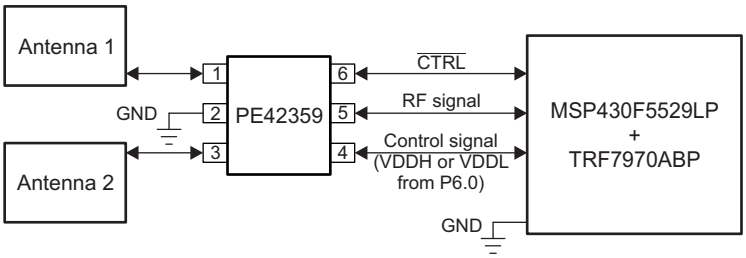


NOTE: 3.3 VDC is supplied to VDD pin.

Figure 5. Single-Pin Control Method

In this example, the GPIO pin P6.0 on the MSP430F5529LP is connected to the CTRL pin in the RF switch. The pins 3.3VDC and GND on the MSP430F5529LP (see Figure 5) are connected to VDD (pin 6) and ground (pin 2), respectively, on the RF switch.

The complementary-pin control method requires careful planning of GPIO pin allocations. It does not require a constant VDD supply; instead an inverted signal of the control signal is fed to VDD. If the CTRL pin is supplied with the VDDH signal, then the VDD pin is kept low and antenna 1 is turned ON. If the CTRL pin is supplied with VDDL, VDD is kept high (3.3 V), and antenna 2 is turned ON. The VDD and CTRL pins cannot be high or low simultaneously. Figure 6 shows the complementary-pin control method.



NOTE: The inverse signal of CTRL is supplied to pin 6.

Figure 6. Complementary-Pin Control Method

4 Software Information

In this example, the single-pin control mode method controls the switching of antennas. The reason for choosing this control method is the possibility for simple pin allocations. The following control algorithm has been written and added to the microcontroller firmware:

```
P6DIR |= (BIT0);          //Port 6.0 as output
P2DIR &= ~(BIT1);         //P2.1 as input
P1DIR &= ~(BIT1);         //P1.1 as input

    if(~P2IN&BIT1)        //switch p2.1
    {
        P6OUT |= BIT0;
    }
    if(~P1IN&BIT1)         //switch p1.1
    {
        P6OUT &= ~BIT0;
    }
```

The concept of the code is:

- **IF** Port 6.0 == ON **THEN** Antenna 1 == ON and Antenna 2 == OFF
- **IF** Port 6.0 == OFF **THEN** Antenna 1 == OFF and Antenna 2 == ON

```
270     T3T_init(g_ui8TxBuffer,256);
271     T4T_init(g_ui8TxBuffer,256);
272     T5T_init(g_ui8TxBuffer,256);
273
274     while(1)
275     {
276         eTempNFCState = NFC_run();
277
278         //Switching
279
280                 P6DIR |= (BIT0);                // Port 6.1 as output
281                 P2DIR &= ~(BIT1);               //P2.1 as input
282                 P1DIR &= ~(BIT1);               //P1.1 as input
283
284                 if(~P2IN&BIT1)                  //switch p2.1   ----> Switch S1, onboard MSP430F5529LP
285                                 {
286                                     P6OUT |= BIT0;
287                                 }
288
289
290                 if(~P1IN&BIT1)                  //switch p1.1   ----> Switch S2, onboard MSP430F5529LP
291                                 {
292                                     P6OUT &= ~BIT0;
293                                 }
294
295
296
297         if(eTempNFCState == NFC_DATA_EXCHANGE_PROTOCOL)
298         {
299             if(NFC_RW_getModeStatus(&sRWMode,&sRWBitrate))
300             {
301                 NFC_RW_LED_POUT |= NFC_RW_LED_BIT;
302
303                 if( sRWMode.bits.bNfcA == 1)
304                 {
305                     if(NFC_A_getSAK() == 0x00)
```

Codes to control switching

Figure 7. Insertion of Control Algorithm

The short algorithm explained is added to the program main.c between the lines 278 and 295. Code Composer Studio™ IDE v6.1 or higher is required to edit the firmware. After the installation of the example files, the example project can be found in the host PC in the folder C:\ti\msp430\TRF7970A_RW_1.02.05\examples\boards\MSP-EXP430F5529LP\F5529LP_TRF7970A_ALL_NFC_MODES.

5 Performance Analysis

The multiplexing of antennas application requires minimum signal losses. It is important to keep the RF signal losses to a minimum to avoid degradation of performance. To test the performance of the demo, several tests were executed, and the most important results are discussed here.

The performance of the PE42359 RF switch is tested. Three modes of operation were tested

- Mode 1: TRF7970ABP without PE42359 RF switch (one antenna only)
- Mode 2: TRF7970ABP with PE42359 RF switch (with VDD supply, single-pin control mode)
- Mode 3: TRF7970ABP with PE42359 RF switch (without VDD supply, complimentary-pin control mode)

The performance analysis related to field strength over distance measurements (see Figure 8) shows that the PE42359 RF switch works with negligible power loss.

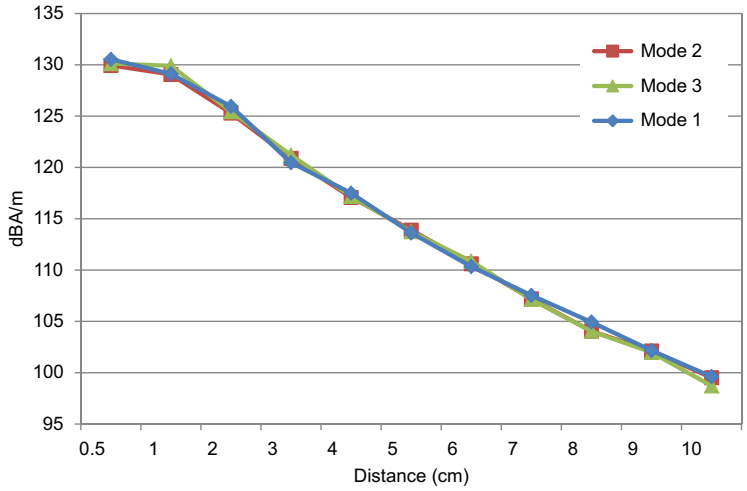


Figure 8. Output Power Comparison of TRF7970ABP With and Without PE42359

The influence of the RF switch and different control methods was analyzed. Figure 9 shows the demo.

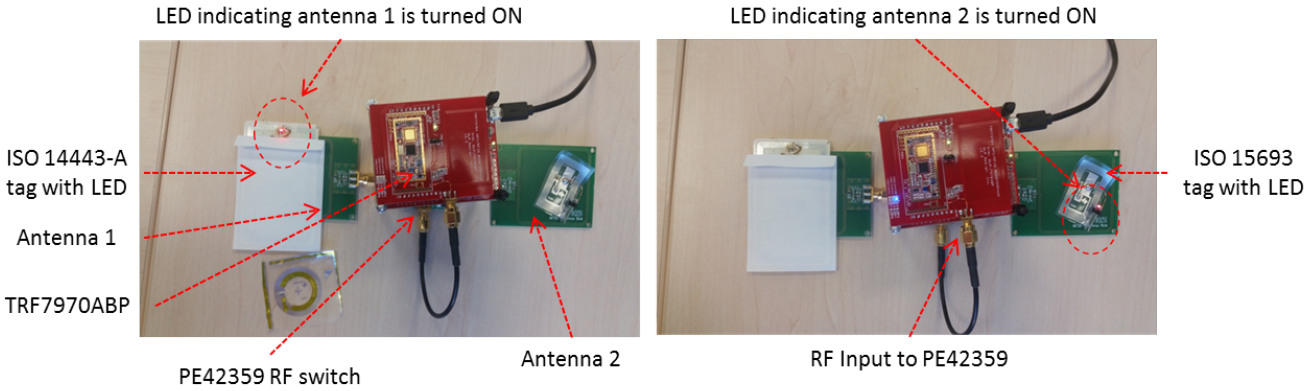


Figure 9. Prototype of TRF7970ABP + PE42359 RF Switch Demonstration

One advantage of using the GUI (see Figure 10) is that the received signal strength indication (RSSI) is available. RSSI is the measure of the power present in the received radio signal. Information about the type of card, bit rate, and the UID is also available in the GUI.

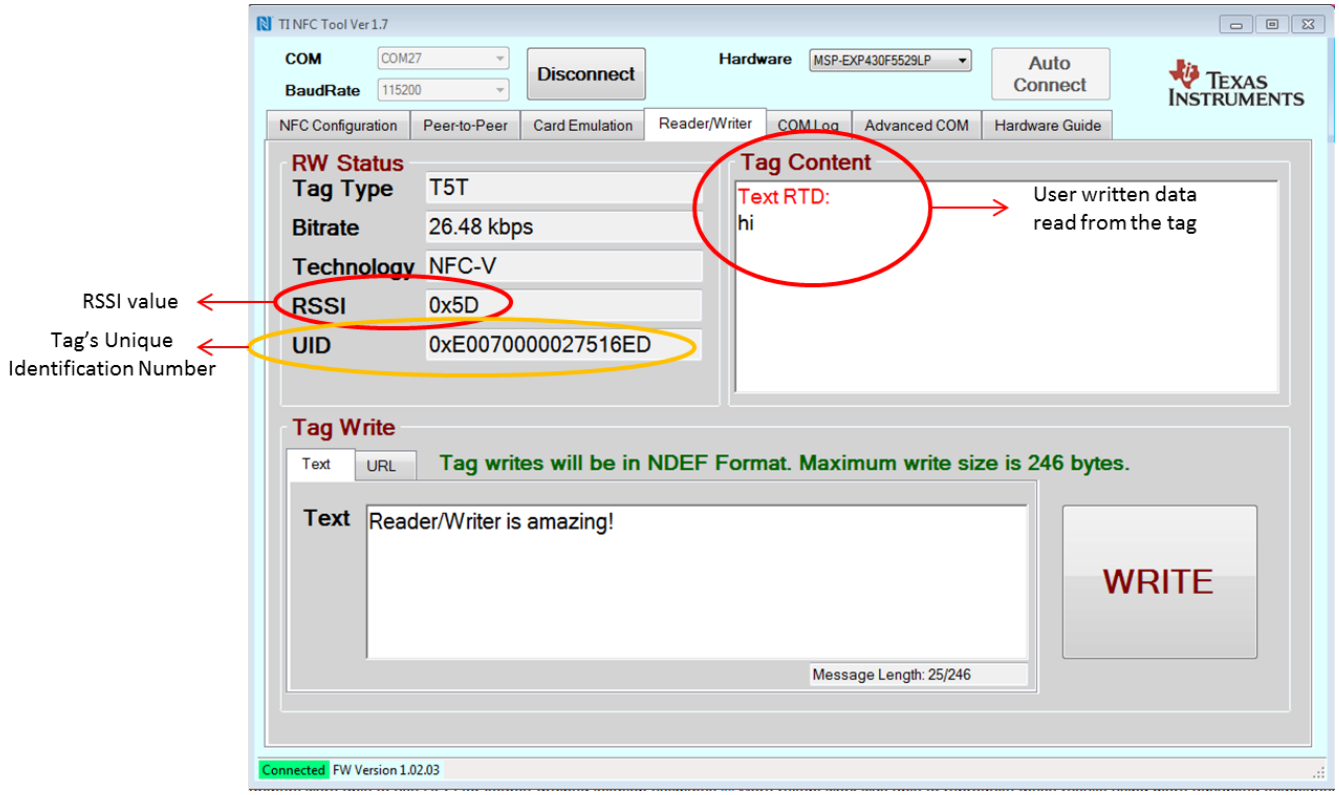


Figure 10. NFC Tool GUI in Reader/Writer Mode

6 References

1. *MSP430F5529 LaunchPad Development Kit (MSP-EXP430F5529LP) User's Guide*
2. *TRF7970A Multi-Protocol Fully Integrated 13.56-MHz RFID and NFC Transceiver IC*
3. *NFC/HF RFID Reader/Writer Using the TRF7970A*
4. *PE42359 SPDT UltraCMOS® RF Switch 10 MHz – 3 GHz*
5. *TRF7960A RFID Multiplexer Example System*
6. *TIDM-NFC-RW Design Guide*

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