Using RF430CL330H VCORE Pin to Wake Up Host MCU via a Presented NFC/RFID High Frequency Magnetic Field

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ABSTRACT

In battery powered applications, current consumption is always a key concern. NFC/RFID is now commonly being used in many market segments such as Medical, Consumer, Retail, Industrial, Automotive and Smart Grid. Many of the application use cases inside these segments operate from battery power and efficient use of the battery is expected. This report describes an approach to reduce the overall current consumption of a dynamic NFC/RFID tag system utilizing the RF430CL330H by leveraging the application of an external field and the VCORE pin level driving a simple transistor circuit to 'wake-up' the attached host microcontroller. This circuit layout is implemented on the RF430CL330HTB PCB.

Project collateral and source code discussed in this application report can be downloaded from the following URL: http://www.ti.com/lit/zip/sloa200.

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1 Reference Design Hardware

1.1 RF430CL330HTB + MSP-EXP430FR5739

In this document, the RF430CL330HTB and MSP-EXP430FR5739 evaluation boards are referenced as hardware examples. Example code projects are written for the MSP430FR5739, but could be ported to other platforms as required. The example code uses an I2C communication between the MSP430FR5739 and RF430CL330H. For more information on the RF430CL330HTB board and RF430CL330H device, see the following links:

- RF430CL330H Target Board: http://www.ti.com/tool/rf430cl330htb
- RF430CL330H IC: http://www.ti.com/lit/gpn/rf430cl330h

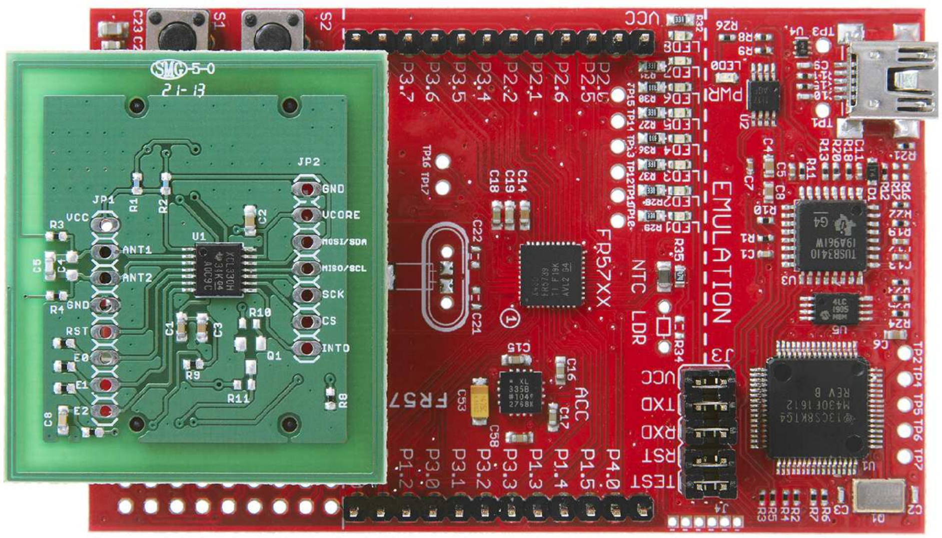

Figure 1. RF430CL330HTB + MSP-EXP430FR5739

2 Typical Operation

The typical usage scenario of the RF430CL330H can be seen in figure 2 and in the steps below.

1. Write capability container and messages into the NDEF memory (starting from address 0) using the serial interface.
2. Enable interrupts as needed (typically End of Read and End of Write interrupts).
3. Configure the interrupt pin, INTO, as needed and enable the RF interface.
4. Wait for interrupt signaled by INTO.
5. Disable RF interface (but keep INTO settings unchanged).
6. Read interrupt flag register to determine interrupt sources.
7. Clear interrupt flags. INTO returns to inactive state.
8. Read and modify NDEF memory as needed.
9. Enable RF interface again (keeping INTO settings unchanged).

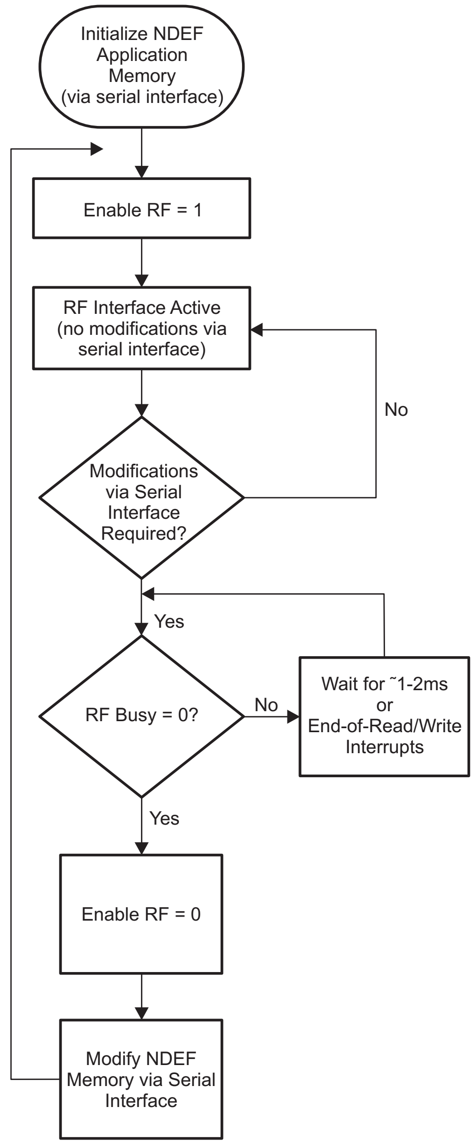

Figure 2. Typical Operation Flow Diagram

3 Wake on NFC/RFID Field Detection Operation

The typical operation is acceptable for many applications where ultra-low power is not a requirement, but total system current consumption can be reduced by leaving the RF430CL330H unpowered when it is not in use. In the typical use case, RF is enabled at step 3 as shown in Figure 2 and the device is waiting to receive commands from an NFC reader. When RF is enabled, the RF430CL330H has a typical current consumption of ~40 µA.

A simple NPN transistor switch circuit can be added to provide an active low interrupt to the connected microcontroller indicating that a 13.56 MHz RF field was detected and the RF430CL330H should be powered and configured, so that it can respond to the commands. The circuit is shown in Figure 3. When a 13.56 MHz field is applied, the RF430CL330H VCORE pin (pin 13 of the RF430CL330H) is raised to 1.5 V, which is then used to drive the base of the NPN transistor (acting as a switch) providing an active low interrupt signal to the connected microcontroller, at the correct GPIO voltage level for the MCU being used in this example system (3.6 V).

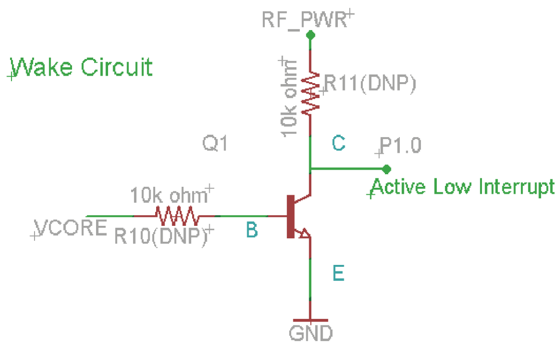

Figure 3. Wake Circuit

Figure 4 illustrates the typical wake up operation. The MSP430FR5739 example source code included with this application report follows this flow.

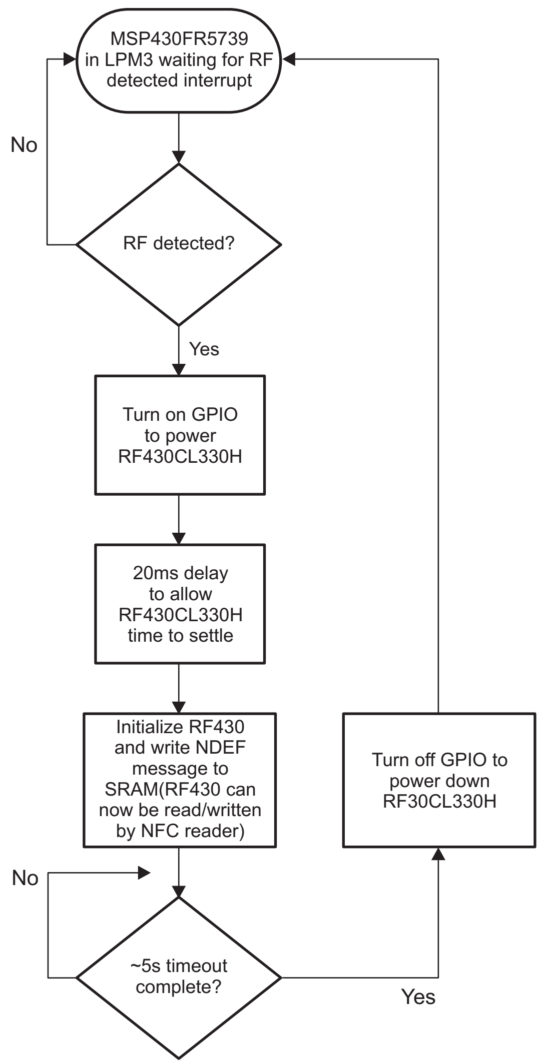

Figure 4. Typical Wake Up Operation Flow Diagram

4 How to Implement With MSP-EXP430FR5739 + RF430CL330HTB Hardware

The RF430CL330HTB is provisioned with unpopulated pads for the required wake up circuit. To enable this functionality, follow the steps shown below:

1. Remove R9 on the RF430CL330HTB to disconnect power being supplied to the RF430CL330H.
2. Remove R12 to prevent back powering.
3. Add Q1. This can be any general purpose NPN such as 2N2222 or 2N3904 in SOT-23 package.
4. Add R10 and R11. (10kΩ, 0402 package)
5. Load the updated firmware to the MSP-EXP430FR5739 board. Refer to Users Guide for details (http://www.ti.com/lit/pdf/slou373).
6. Connect the RF430CL330HTB with the hardware modifications.
7. Plug in USB to apply power.
8. Present NFC phone to the RF430CL330HTB antenna to read the tag.

When RF field is detected, LED5 will illuminate. Power and Initialization sequence then occurs. NFC phone will now read the “Hello, World!” message. RF430CL330H will stay active with RF enabled for a specified time out period (~3s) to allow all communication to complete.

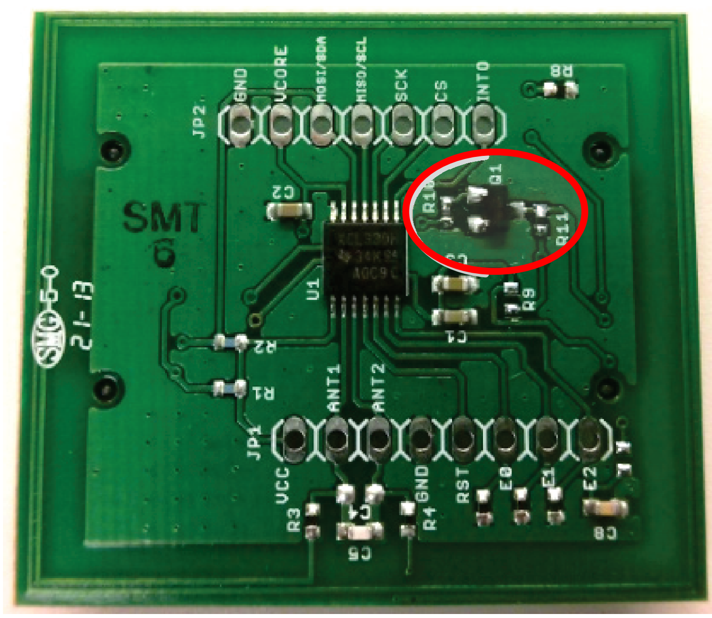

Figure 5. RF430CL330HTB With Wake Up Circuit Populated

5 Test Results

5.1 Current Consumption

When the RF field is not detected, the transistor (Q1) is off and only leakage current of the transistor is consumed. Typical general purpose NPN transistors have leakage current in the nanoamp range. Once the RF field is detected and RF is enabled on the RF430CL330H, the typical current consumption of the RF430CL330H is 40 µA as shown in Table 1. After communication is complete and the MSP430 has timed out, power is removed from the RF430CL330H and the board only consumes leakage current of the transistor once again.

Table 1. RF Enabled Current Consumption

Parameter		Test Conditions	VCC	TYP	MAX	Unit
$I_{CC(SPI)}$	SPI, $f_{SCK,MAX}$, SO = Open, Writing into NDEF memory		3.3 V	250		µA
$I_{CC(I2C)}$	I2C, 400 kHz, Writing into NDEF memory		3.3 V	250		µA
$I_{CC(RF\_enabled)}$	RF enabled, no RF field present		3.3 V	40		µA
$I_{CC(Inactive)}$	Standby enable = 0, RF disabled, no serial communication		3.3 V	15		µA
$I_{CC(Standby)}$	Standby enable = 1, RF disabled, no serial communication		3.3 V	10	45	µA
$\Delta I_{CC(StrongRF)}$	Additional current consumption with strong FR field present		3.0 V to 3.6 V		160	µA
$I_{CC(RF,lowVCC)}$	Current drawn from V_{CC} < 3.0 V with RF field present (passive operation)		2.0 V to 3.0 V		0	µA

Table 2. Power Modes (1)

Power Mode	Current
Standby (RF undetected)	~100 nA
RF active	40 µA

(1) Standby current can vary depending on the leakage current of the transistor.

5.2 Timing

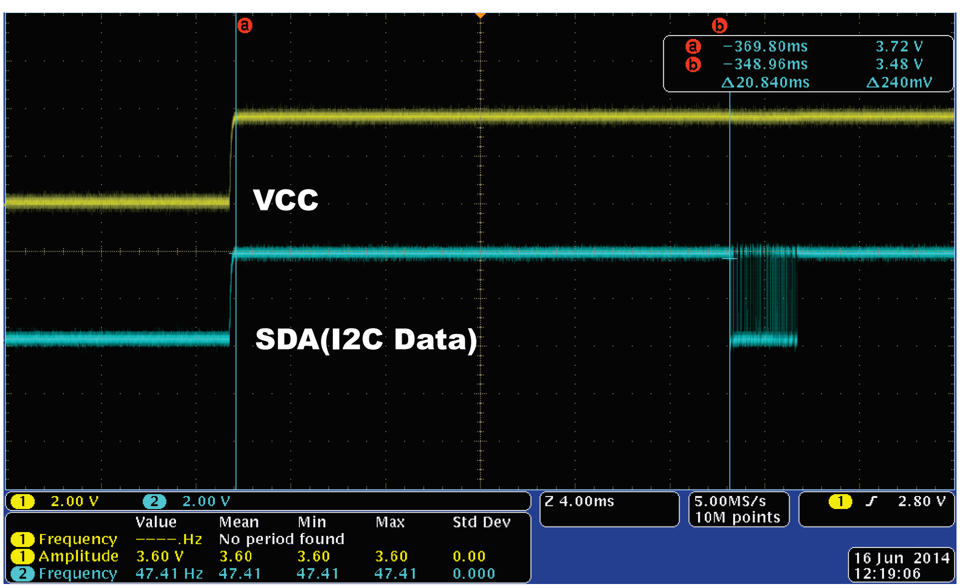

Figure 6. Power to I2C Communication

5.3 Range

It is important to note that the wake up range is slightly greater than the communication range as shown in Table 3. This provides time for the microcontroller to power up and initialize the RF430CL330H before the NFC reader device is within communication range for a seamless user experience. Figure 6 shows the time from power up until when I2C communication starts, which is 20 ms, per the RF430CL330H specification. The time required for the I2C communication can vary depending upon the size of the NDEF message and I2C data rate (400 kHz max). In the “Hello, World!” example shown in Figure 6, the time is ~3 ms.

Table 3. Wake up vs. Communication Range

NFC R/W Device	Wake up	Communication
TRF7970AEVM	7.5cm	6.5cm

6 References

- *RF430CL330H Dynamic NFC Interface Transponder Data Manual* (SLAS916)
- *RF430CL330H Target Board User's Guide* (SLOU373)
- MSP-EXP430FR5739 Experimenters Board (http://www.ti.com/tool/msp-exp430fr5739)