

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

Eddie LaCost

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>.

Contents

1	Reference Design Hardware	2
2	Typical Operation	2
3	Wake on NFC/RFID Field Detection Operation.....	3
4	How to Implement With MSP-EXP430FR5739 + RF430CL330HTB Hardware	5
5	Test Results	6
6	References	7

List of Figures

1	RF430CL330HTB + MSP-EXP430FR5739	2
2	Typical Operation Flow Diagram.....	3
3	Wake Circuit	4
4	Typical Wake Up Operation Flow Diagram.....	4
5	RF430CL330HTB With Wake Up Circuit Populated	5
6	Power to I2C Communication	6

List of Tables

1	RF Enabled Current Consumption	6
2	Power Modes	6
3	Wake up vs. Communication Range	7

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>

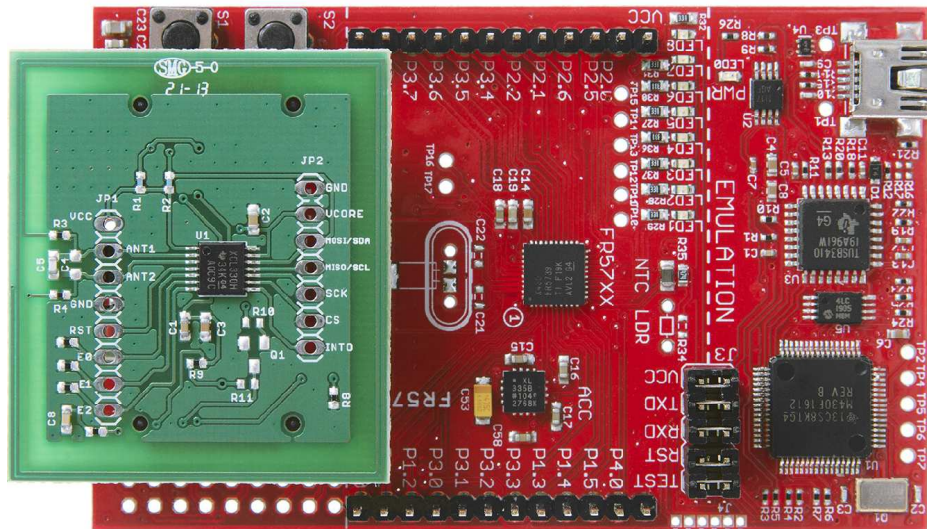


Figure 1. RF430CL330HTB + MSP-EXP430FR5739

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, INT0, as needed and enable the RF interface.
4. Wait for interrupt signaled by INT0.
5. Disable RF interface (but keep INT0 settings unchanged).
6. Read interrupt flag register to determine interrupt sources.
7. Clear interrupt flags. INT0 returns to inactive state.
8. Read and modify NDEF memory as needed.
9. Enable RF interface again (keeping INT0 settings unchanged).

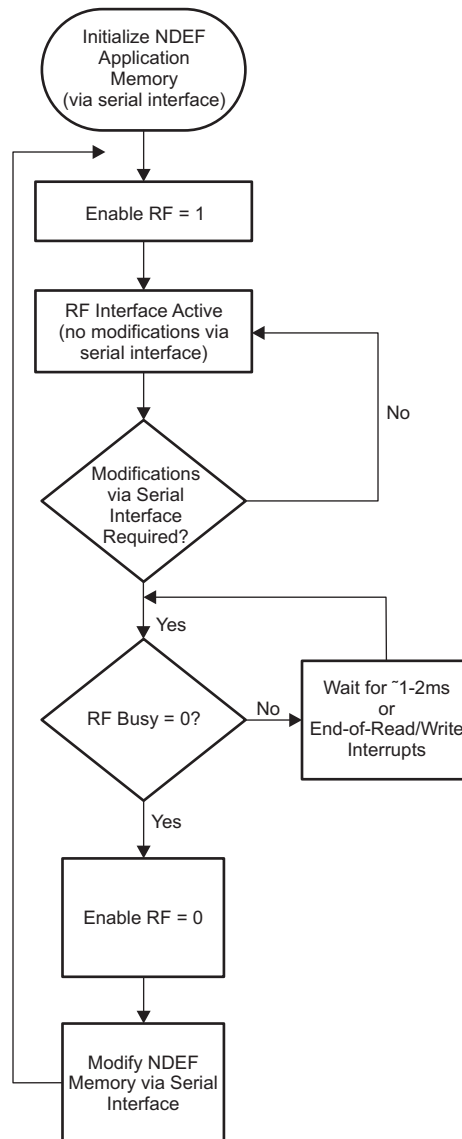


Figure 2. Typical Operation Flow Diagram

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 μ A.

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).

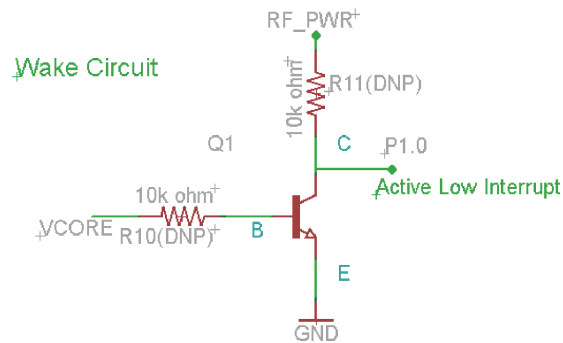


Figure 3. Wake Circuit

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

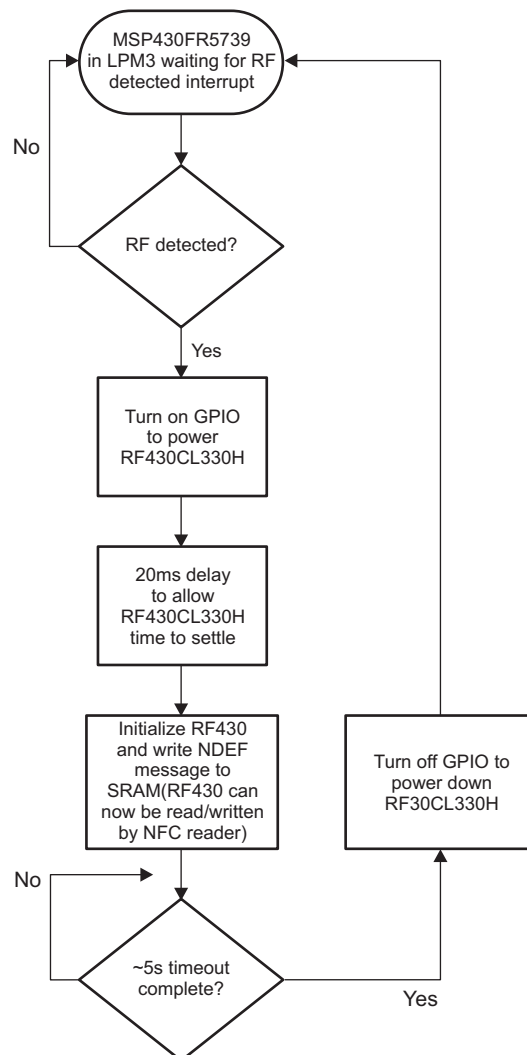


Figure 4. Typical Wake Up Operation Flow Diagram

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. (10k Ω , 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.

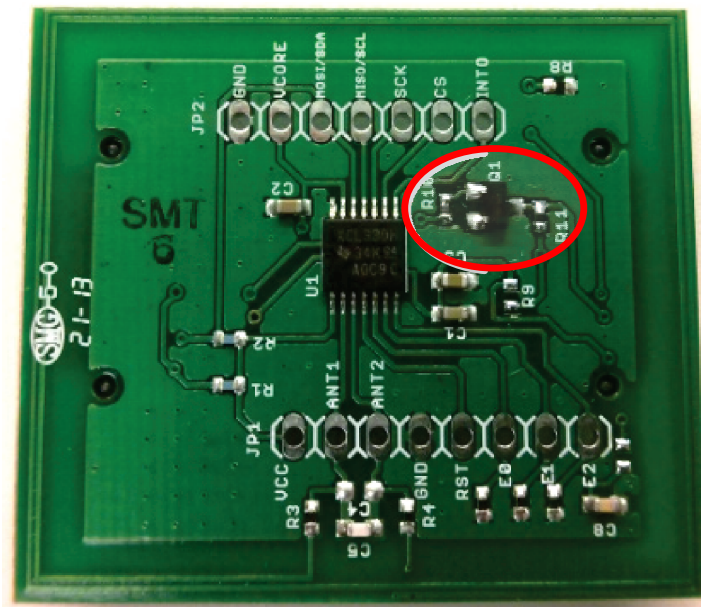


Figure 5. RF430CL330HTB With Wake Up Circuit Populated

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 $V_{CC} < 3.0\text{ V}$ 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)	$\sim 100\text{ nA}$
RF active	40 μA

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

5.2 Timing

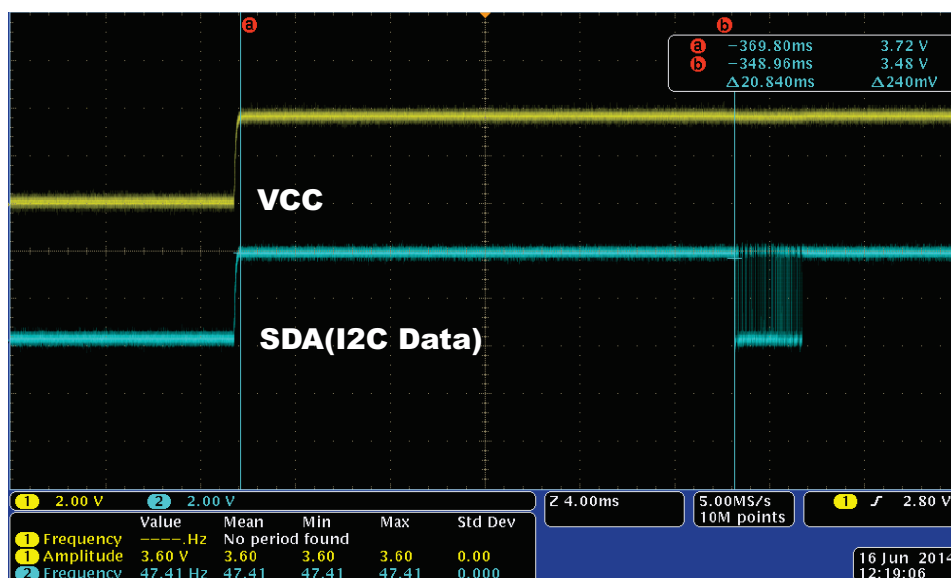


Figure 6. Power to I2C Communication

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>)

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com