

Battery-Less NFC Sensor Tag with programmable “On Tag” Data Pre-Processing

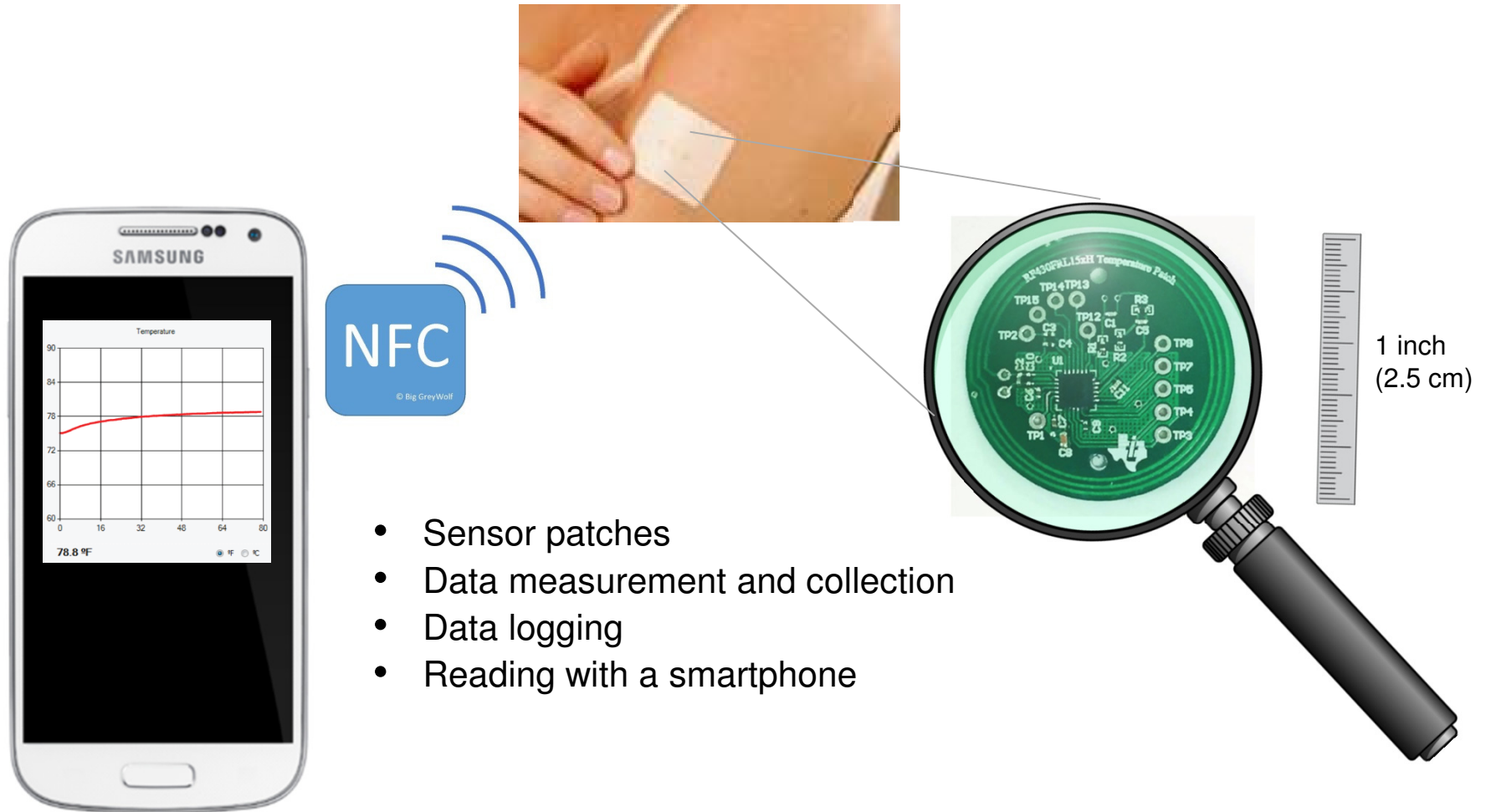
Peter Steffan

Texas Instruments Deutschland GmbH

MCU Safety & Security

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Battery-Less Sensor Data Monitoring



- Sensor patches
- Data measurement and collection
- Data logging
- Reading with a smartphone

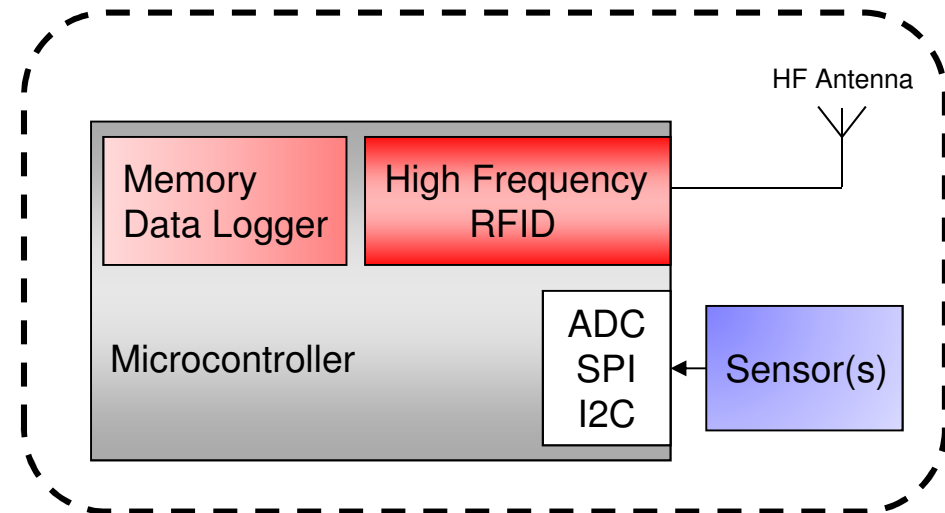
Application Example - Temperature Monitor

Temperature Monitoring



Special characteristics for Sensor Networks

- ... passive, autonomous HF to trigger Sensor activities
- ... NFC Technology allows interoperability to other networks
- ... due to RFID technology access to Data Logger Memory even without battery
- ... 13.56 MHz technology allows cheap and small form factor antennas
- ... semi-passive operation possible due to HF energy harvesting



The NFC technology in the cell phones is the “interoperability enabler” – with other applications and networks. (details see <http://www.nfcworld.com/nfc-phones-list/>)

RF430FRL15xH – Low Power Microcontroller

Features

- Package: VQFN (24), 4 mm x 4 mm
- Fully programmable 16-Bit MSP430 microcontroller
- Ultra Low Power Consumption
 - 140 μ A/MHz (Active Mode)
 - 16 μ A (Standby Mode)
- Data Preprocessing
- Data Logging
- Supply voltage 1.5V
- Powered by RF field or battery



Device	RAM(KB)	FRAM(KB)	USCI	SD 14
RF430FRL151H	1	2	Yes	Yes
RF430FRL152H	4	2	Yes	Yes
RF430FRL153H	4	2	No	Yes
RF430FRL154H	4	2	Yes	No

RF430FRL15xH (Smart Sensor Tag IC)

16-bit RISC MCU

4 MHz

Memory	Debug
2 kB FRAM	JTAG
8 kB ROM	Embedded Emulation
4 kB SRAM	
Clock	Power
4 MHz HF clock	1.5 V Battery
256 kHz LF clock	13.56 MHz RF field

Connectivity

- ISO 15693 (AFE 26 kbps)
- ISO 15693 encode/decode
- 1× USCI B (I²C/SPI)
- 8 General Purpose I/Os

System

- 16-bit Timer_A0
- 3 CC Registers
- 16-bit CRC
- Watchdog

Sensor Interface

- 14-bit $\Sigma\Delta$ -A/D Converter

Sensor

- On-Chip Temp Sensor

Powering the Device

Battery-less – Powered by energy harvesting from the RF field

- The complete device and the connected sensors are powered by the energy harvested from the RF field of the reader/writer device (e.g. smartphone or tablet)
 - The device includes also a voltage double to support connected sensors or external circuitry with higher supply voltage requirements
-

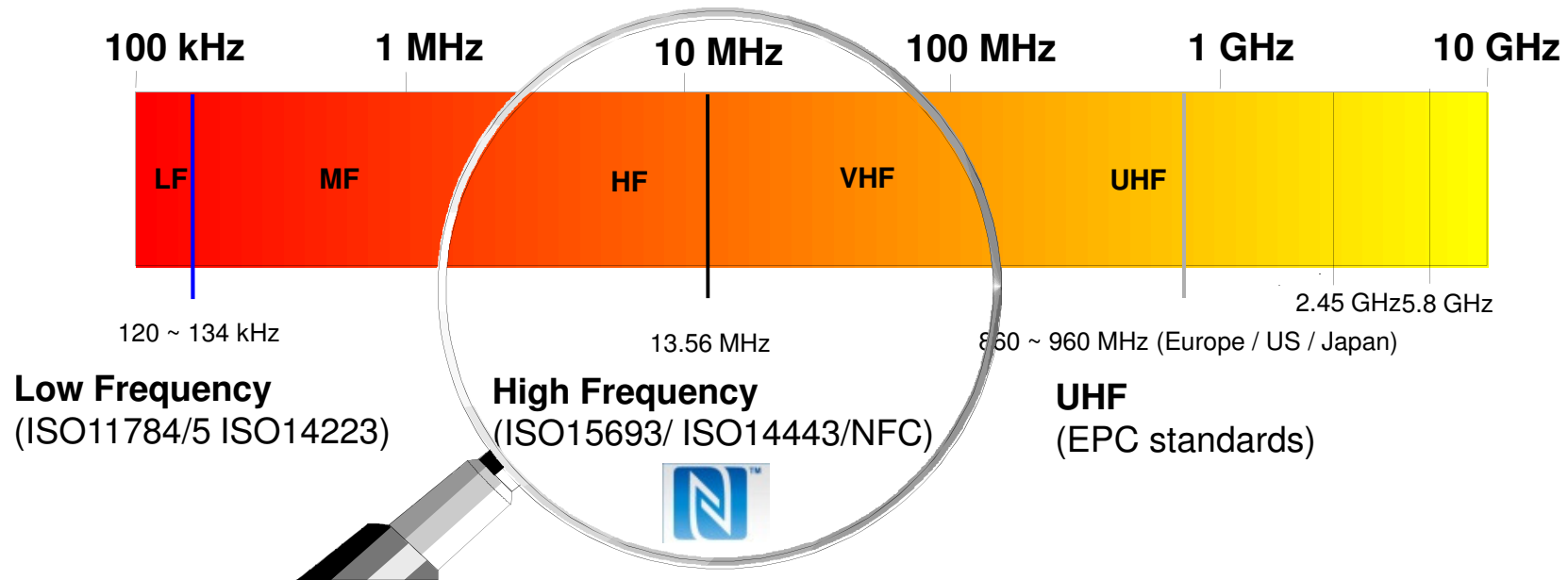
Powering through battery

- 1.5V single cell disposable battery support (e.g. Type 377)
 - Battery switch in the device ensures long battery life when device is stored with mounted battery
 - Ultra-low leakage of max. 20nA with battery switch open
 - Battery switch can be controlled through RF
-

Passive Radios – High Frequency (HF/NFC)

High Frequency Passive Radio Technology – NFC

The Radio Spectrum for classical passive RFID systems



High Frequency characteristics

- Well defined magnetic field; energy transfer possible
- Rather short read ranges: proximity / vicinity systems
- NFC allows wide interoperability e.g. Cell phones, PC, etc.

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Harvesting Elements for “No Power Radios”

“No Power” solutions for RFID Tag – inductive coupling solutions (9kHz ... 30MHz)

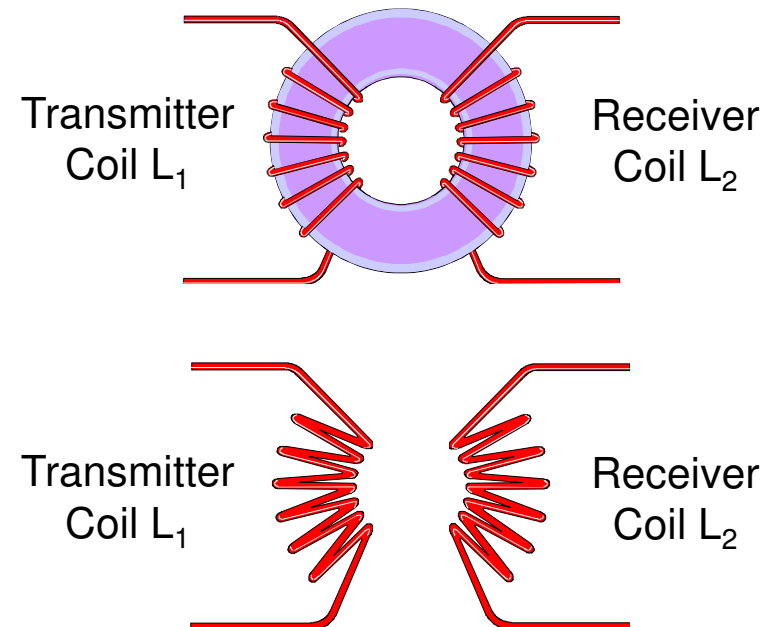
A Transmitter and Receiver Coil forms a magnetic coupled system. An alternating current generates a magnetic field which induces a voltage in the Receiver Coil. The efficiency of the power transfer depends on the coupling between the inductors and their quality factor.

Pro

- Proven technology
- Reasonable power transfer efficiency
 - ...no battery required!
- Compatible with many user models
- Can be combined with an UHF data-link

Con

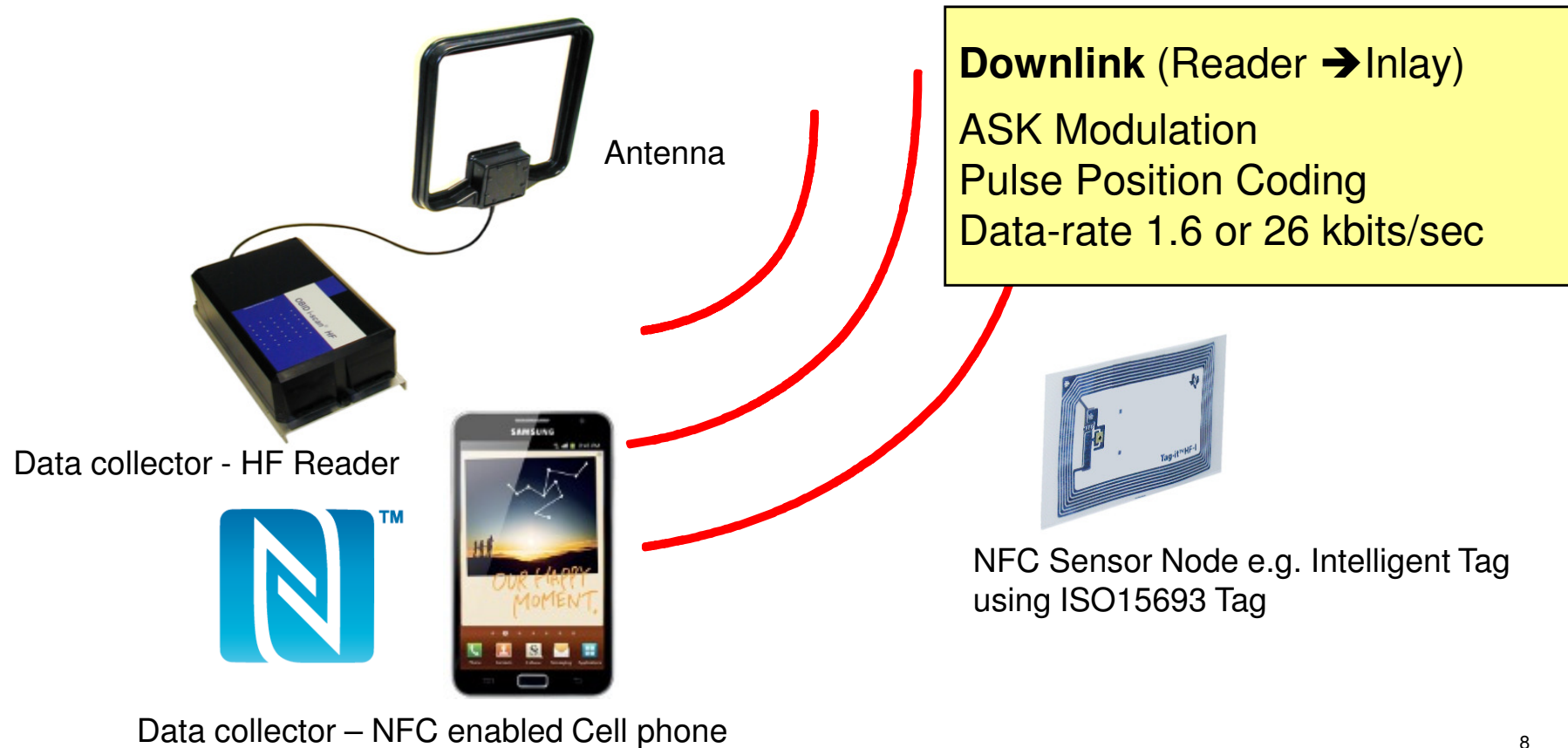
- Inductive coupled system => distance
 - Distance
 - May require tuning
- Energy coupling requirements may limit data rate (Q-factor)



Passive Radios – High Frequency (HF/NFC)

13.56MHz RFID System Overview – NFC / e.g. ISO15693

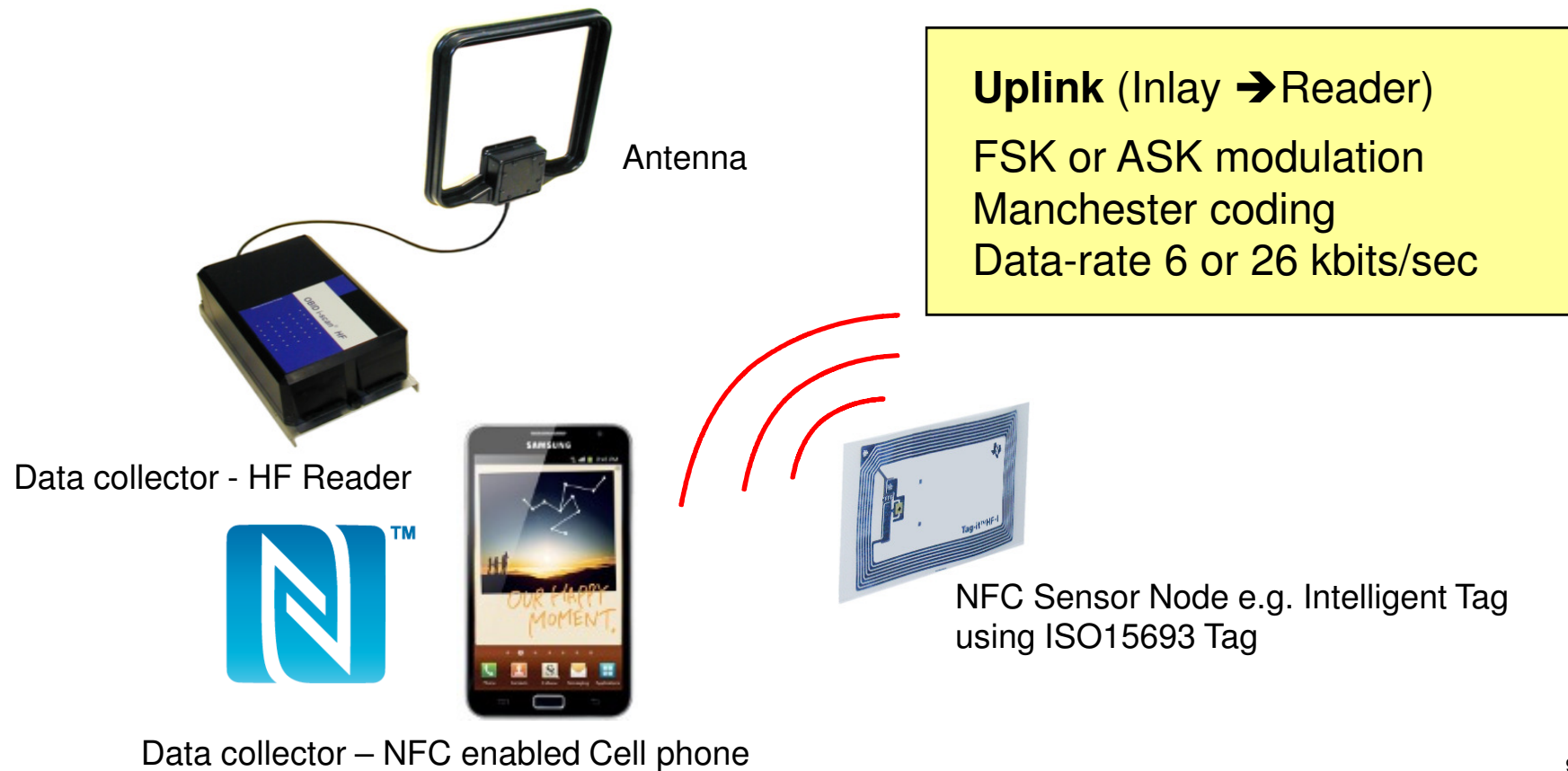
A battery-less tag gets its energy from the radio waves generated by the reader / NFC cell phone ...



Passive Radios – High Frequency (HF/NFC)

13.56MHz RFID System Overview – NFC / e.g. ISO15693

Communication from Inlay to Reader ...



Powering the Device

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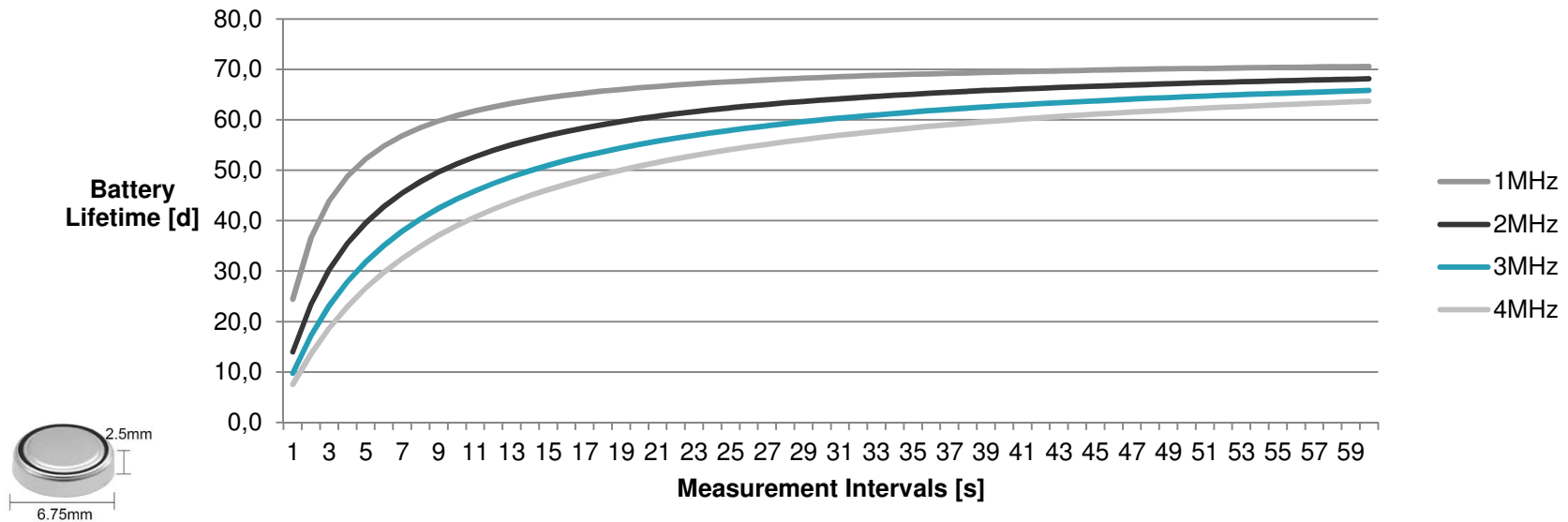
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-

The power management of the device supports operation from the RF field only, battery only, as well as RF field and battery together.

Battery Lifetime Calculation

- 1.5V Battery (Type 377): *1.5V / 28mAh*
- RF430FRL15xH Active Time per Measurement: *256ms*
- RF430FRL15xH Power Consumption: *140μA/MHz* (Active Mode)
16μA (Standby Mode)



Battery Lifetime with battery switch open (20nA leakage): *multiple years*

FRAM Microcontroller - What is FRAM?

Key FRAM Characteristics

FRAM= Ferroelectric **Random Access Memory**

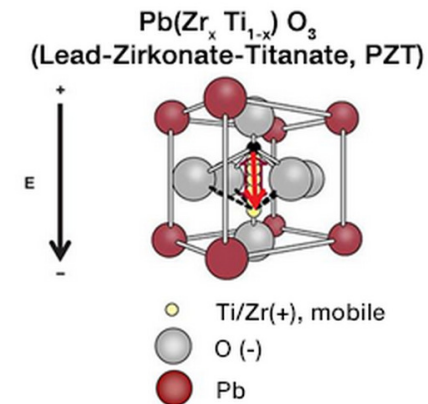
Similar to DRAM

- ... individual read and write of each bit possible
- ... no special write sequence
- ... fast write speeds
- ... very little current is needed to store data

Information is stored on (Fe-)Capacitor

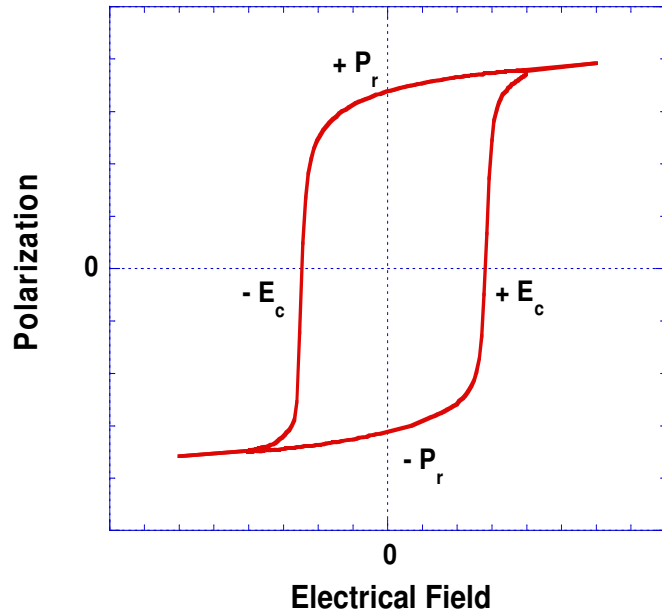
However:

- ... non-volatile
- ... no periodic refresh needed

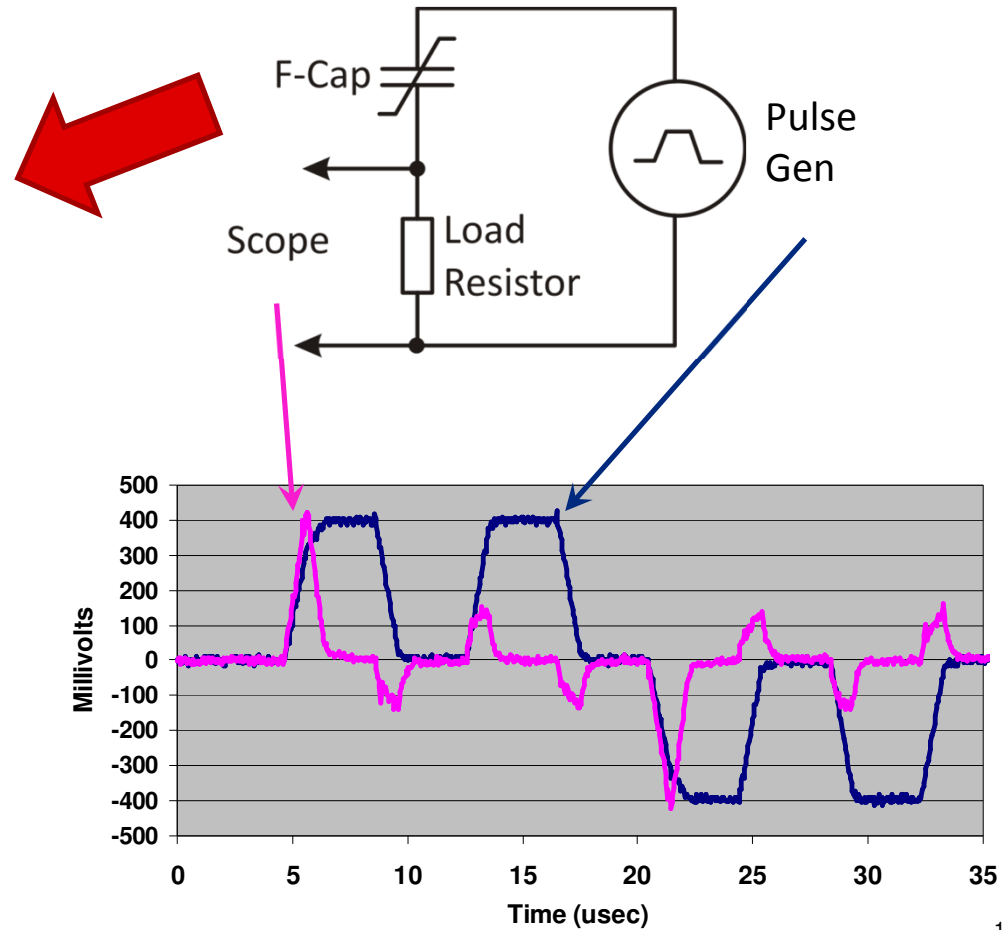


FRAM Microcontroller - What is FRAM?

FRAM - Read and Write Access



Hysteresis Loop of the F-Cap material – PZT (Lead-Zirkonate-Titanate)



Key advantages of FRAM

Specifications	FRAM	SRAM	EEPROM	Flash
Non-volatile <i>Retains data w/o power</i>	Yes	No	Yes	Yes
Write speed <i>(13 KB)</i>	10ms	<10ms	2 secs	1 sec
Average active Power [μ A/MHz] <i>16 bit word access by the CPU</i>	100	<60	50,000+	230
Write endurance	10 ¹⁵	Unlimited	100,000	10,000
Soft Errors	Below Measurable Limits	Yes	Yes	Yes
Bit-wise programmable	Yes	Yes	No	No
Unified Memory <i>Flexible code and data partitioning</i>	Yes	No	No	No



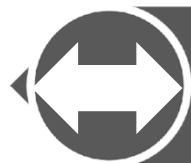
Write More

Collect more data over time with 100x faster writes than Flash
Extend product life and ditch the EEPROM with infinite endurance



Decrease Power

Extend battery life with 230x lower energy writes vs Flash
Minimize wireless system power by shortening memory update times



Unified Memory

Simple to use with unmatched flexibility
Bitwise programmable memory can be used for data or program storage

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Outlook



Ultra Low Power Sensor Tag

A diagram of an Ultra Low Power Sensor Tag. It features a black antenna icon at the top. Below it is a red-bordered box labeled 'Encryption'. At the bottom is a red-bordered box labeled 'Sensor'. A red arrow points from the 'Sensor' box to a graph. The graph shows 'PERCENT OF CHARGE' on the y-axis (0 to 100) and 'TIME' on the x-axis (0 to 5). The curve shows a 63.2% charge at time 1. Below the graph, it says 'RC Time Constant = 10.0 μsec'. At the bottom of the graph area, there are two dropdown menus: 'Resistance' set to '10 Ω' and 'Capacity' set to '1.0 μF'.

- Monitor health status autonomously
- Share data securely
- Connectivity to health service center



Decryption

Information & Demo

Google ti temperature patch

Web Shopping Bilder News Videos Mehr ▾ Suchoptionen


Ungefähr 837.000 Ergebnisse (0,53 Sekunden)

This Cool Little NFC/RFID Temperature Patch Is Battery-less ...
43oh.com/.../this-cool-little-nfc-rfid-temperature-pat... ▾ Diese Seite übersetzen
12.06.2015 - This Cool Little NFC/RFID Temperature Patch Is Battery-less And Firmware-less ... You will be one of the lucky few if you get it, as TI lists it as a ...
Sie haben diese Seite am 27.07.15 besucht.

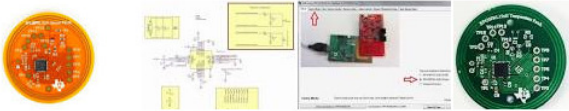
Battery-less NFC/RFID Temperature Sensing Patch - TIDM ...
www.ti.com ▾ TI Designs ▾ Microcontrollers (MCU) ▾ Diese Seite übersetzen
29.01.2015 - Battery-less sensor measurements that utilize energy harvesting from the RF field can be implemented in applications ranging from medical, ...

[PDF] Battery-Less NFC/RFID Temperature Sensing Patch - Te...
www.ti.com/cn/lit/pdf/sloa212 ▾ Diese Seite übersetzen
Battery-Less NFC/RFID Temperature Sensing Patch ... http://www.ti.com/lit/zip/sloc322. Contents. 1 ... RF430FRL152H NFC Temperature Sensor Board Layout .
Sie haben diese Seite am 27.07.15 besucht.

Battery-Less NFC/RFID Temperature Sensing Patch ...
www.ti.com ▾ Design Support ▾ Technical Documents ▾ Diese Seite übersetzen
Download TI technical document Battery-Less NFC/RFID Temperature Sensing Patch.

Temperature sensing via a wearable patch with secure NFC ...
 www.youtube.com/watch?v=qBCfB5JMbHE ▾
08.12.2014 - Hochgeladen von Texas Instruments
Learn how the RF430FRL152H can be used for real world sensing applications. See ti.com/rfpatch.

Bilder zu ti temperature patch Unangemessene Bilder melden



Weitere Bilder zu ti temperature patch

- Find more information about the Battery-less NFC/RFID Temperature Sensing Patch on

<http://www.ti.com/tool/TIDM-RF430-TEMPSENSE>

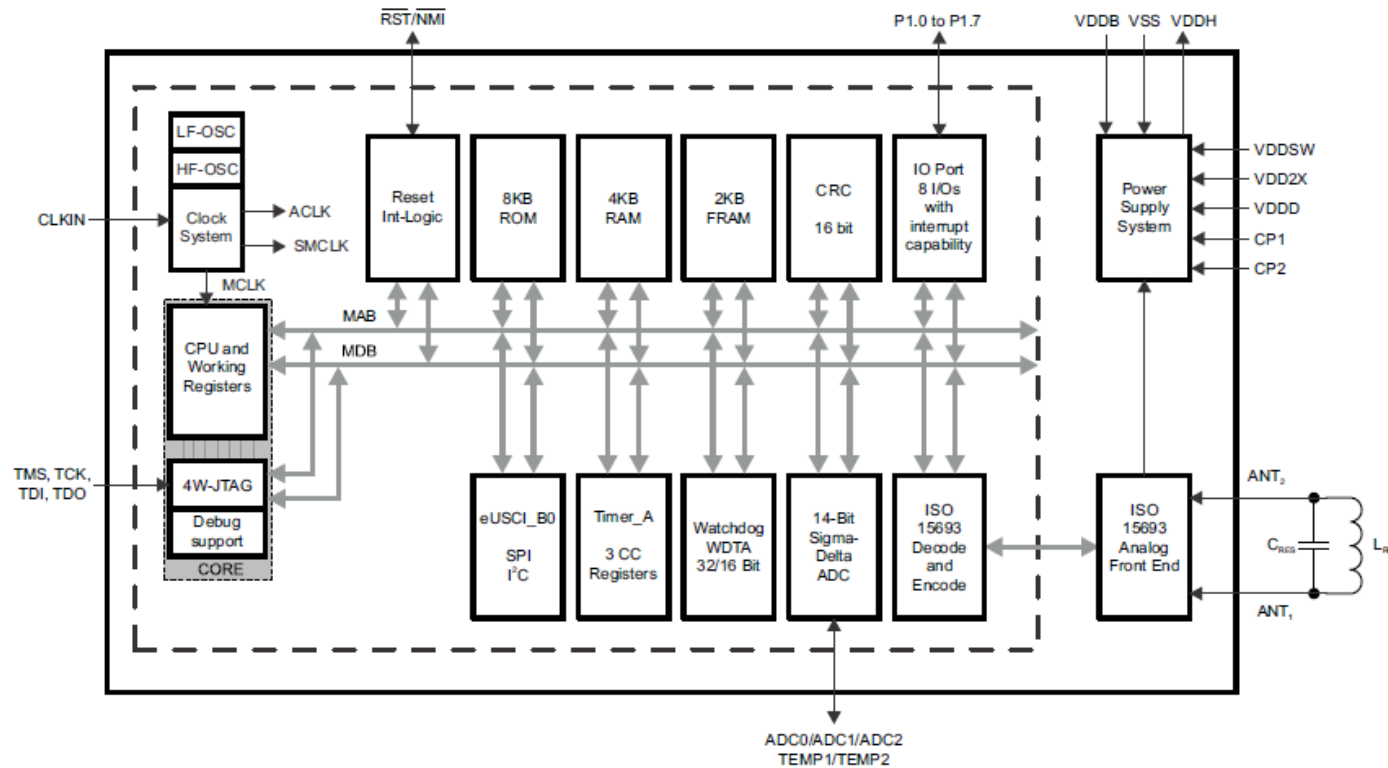
- Description
- Technical Documents
- Schematics with BOM

Thank you for your attention ...

Backup Slides

Passive (Battery-Less) NFC Solution

- Fully programmable ultra low power 16-Bit microcontroller **RF430FRL15xH**
- Low Power Consumption: 140 $\mu\text{A}/\text{MHz}$ (Active Mode); 16 μA (Standby Mode)
- CPU System Clock: 4 MHz
- Package: VQFN (24), 4 mm x 4 mm



Introducing RF430FRL15xH Sensor Transponder

ADC	<ul style="list-style-type: none"> Analog sensor interface Integrated temp sensor
NFC	<ul style="list-style-type: none"> Secure proximity pairing Secure data transfers
Serial IF	<ul style="list-style-type: none"> Digital sensor interface Connection to a gateway
FRAM	<ul style="list-style-type: none"> Non-volatile / fast access Data & program storage
CPU	<ul style="list-style-type: none"> Collection setup Data processing
Low power	<ul style="list-style-type: none"> Passive operation 1.5V battery

RF430FRL15xH NFC sensor transponder

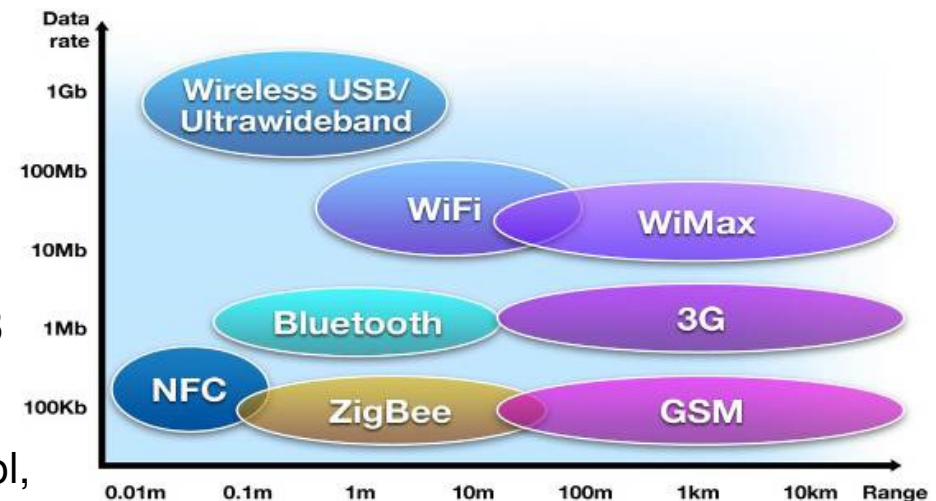
16-bit MSP430 Micro- controller core 4 MHz	Memory	Debug
	2 kB FRAM	JTAG
	8 kB ROM	Embedded Emulation
	4 kB SRAM	Power
Clock	4 MHz HF clock	1.5 V Battery
256 kHz LF clock	13.56 MHz RF field	

Connectivity	System
ISO 15693 (AFE 26 kbps) ISO 15693 encode/decode	16-bit Timer_A0 3 CC Registers
1× USCI B (I ² C/SPI)	16-bit CRC
8 General Purpose I/Os	Watchdog
Sensor Interface	
14-bit $\Sigma\Delta$ -A/D Converter	
Sensor	
On-Chip Temp Sensor	

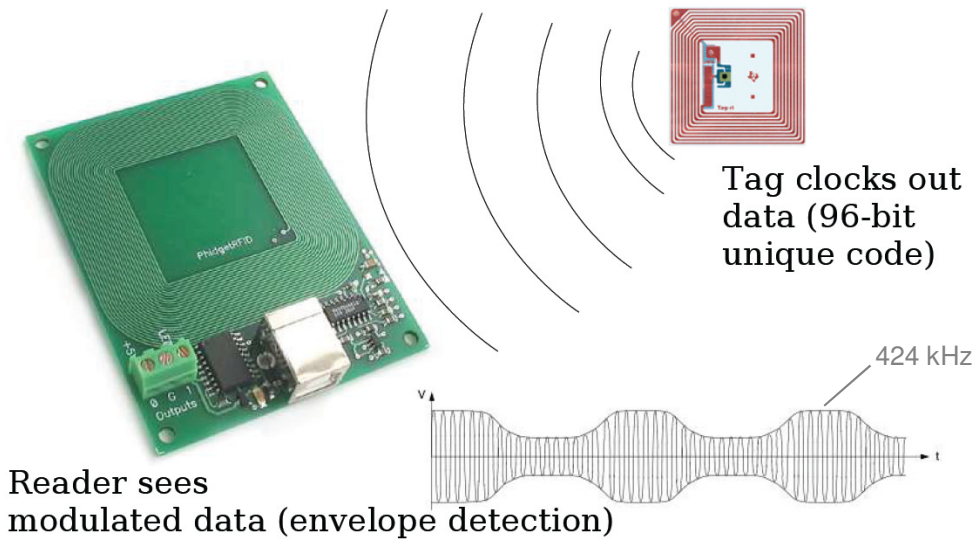
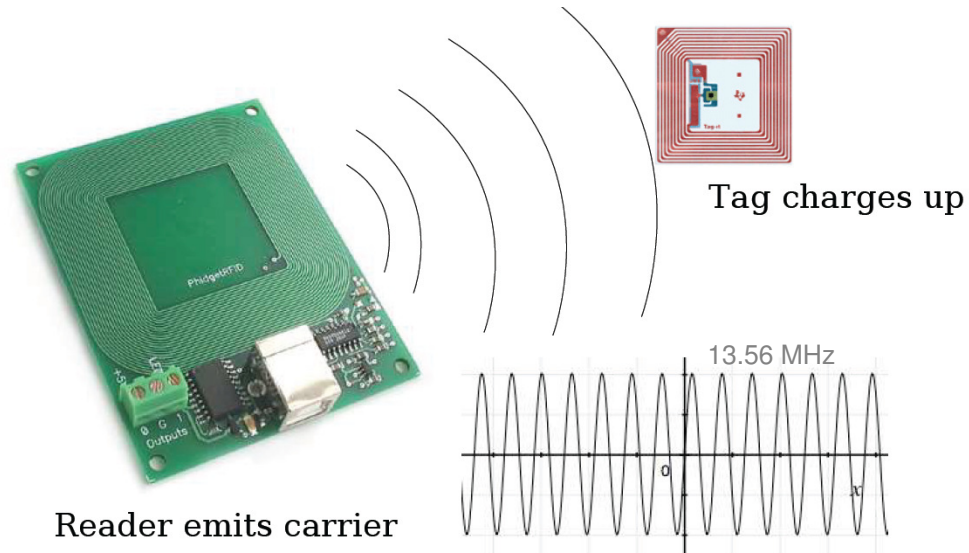
NFC (Near Field Communication) Basics



- **NFC:** wireless radio communication
- **Principal:** electromagnetic induction between two loop antennas
- **Radio Frequency:** ISM band of 13.56 MHz (unlicensed, globally available)
- **Modulation:** ASK (Amplitude-shift keying) using Manchester coding
- **Data Rates:** ranging from 106 kbit/s to 424 kbit/s
- **Distance:** 10 cm (3.9 in.) or less
- **Operating Modes:**
 - Active: generates an RF field
 - Passive: retrieves the power from the RF field
- **Communication Protocol:** ISO 15693
- **Typical applications:**
 - Ticketing, micro payment, access control,
 - Device pairing
 - Contactless token (Smart Card, RFID label, key fob)

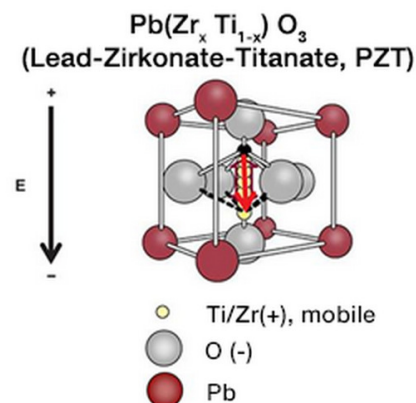


Active - Passive NFC Communication



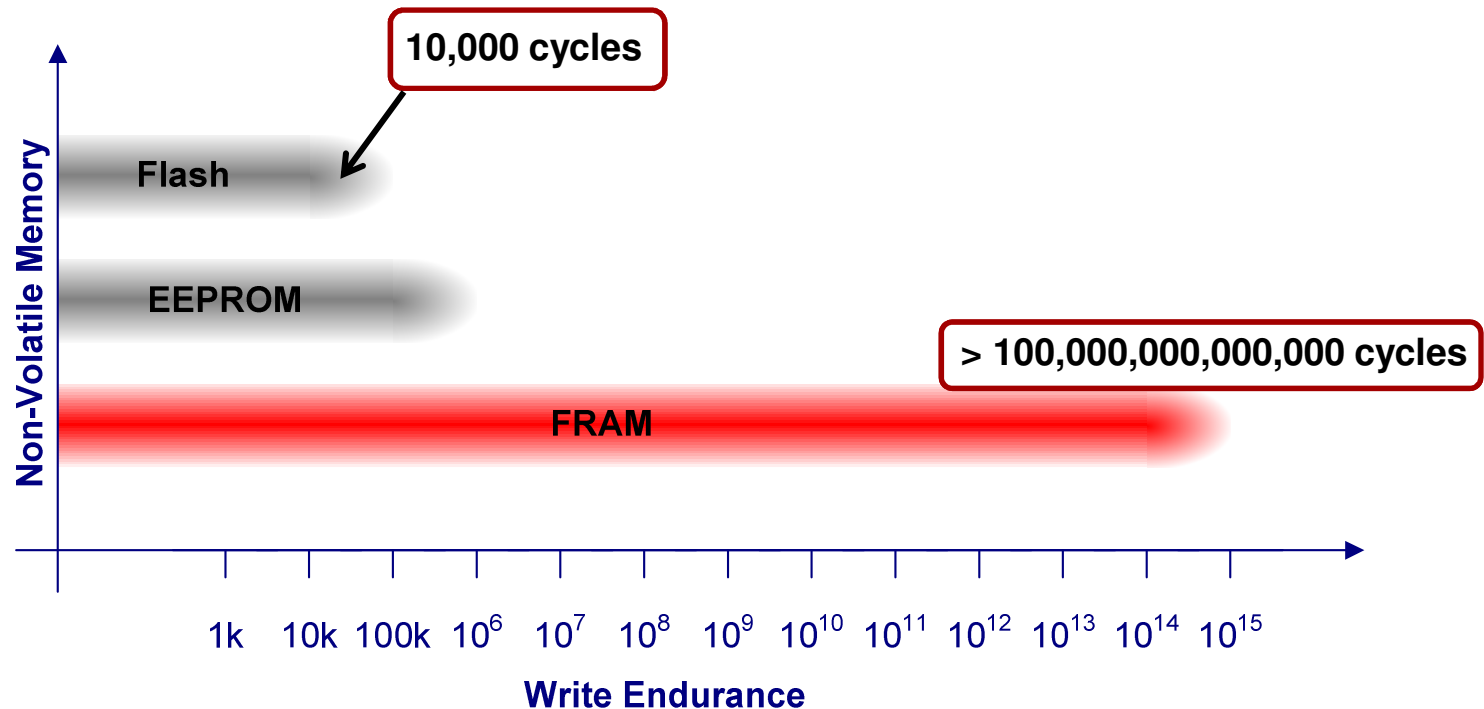
Ferroelectric RAM (FRAM)

- **Nonvolatile memory**
 - for storage of program code or user data such as calibration and measurement data
- **Low power consumption**
 - Access to the FRAM cell at low voltage
 - Very little current is needed to change the data
 - Low average and peak write power leads to low average and peak power consumption of the MCU
- **Fast Write Speeds**
 - Writes are completed within the instruction cycle time
 - No data buffering required
 - No charge pump needed
 - Fast wake-up time



FRAM Microcontroller – Advantages

FRAM - Write Endurance



1 write per second (same address, no wear leveling):

- **Flash:** < 3 hours
- **FRAM:** > 3million years

Jan. 2013

FRAM Microcontroller – Advantages

FRAM – Energy Efficient Non-Volatile Storage

- ... significant faster programming compared to Flash
- ... no pre-erase of the memory required
- ... requires only 1/1000 of the Flash programming energy
- ... individual Byte programming possible, no “sector” programming
- ... FRAM allows re-programming during program execution
- ... FRAM is best suited for “over-the-air” software updates

Flash-based MCU:

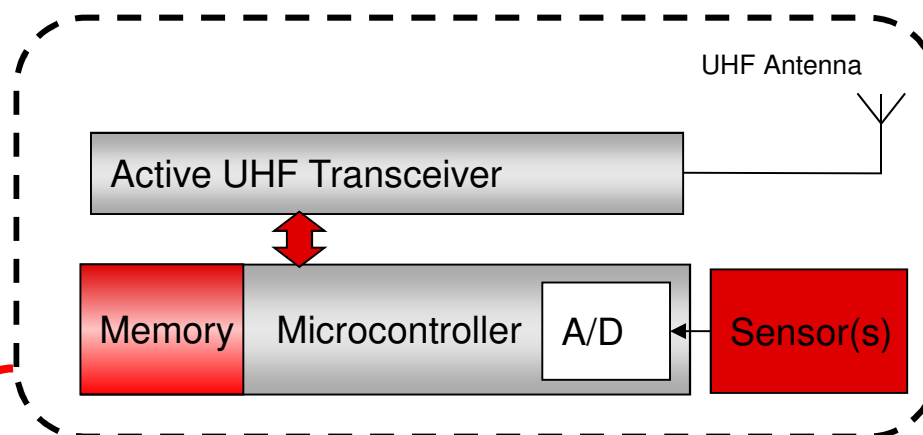
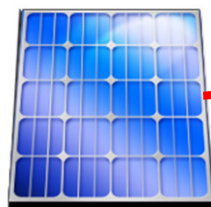
Programming of 16 bit:

$$\sim 100\mu\text{s} * 2\text{mA} = 200\text{nC} / 16 \text{ bit}$$

FRAM-based MCU

Programming of 16 bit:

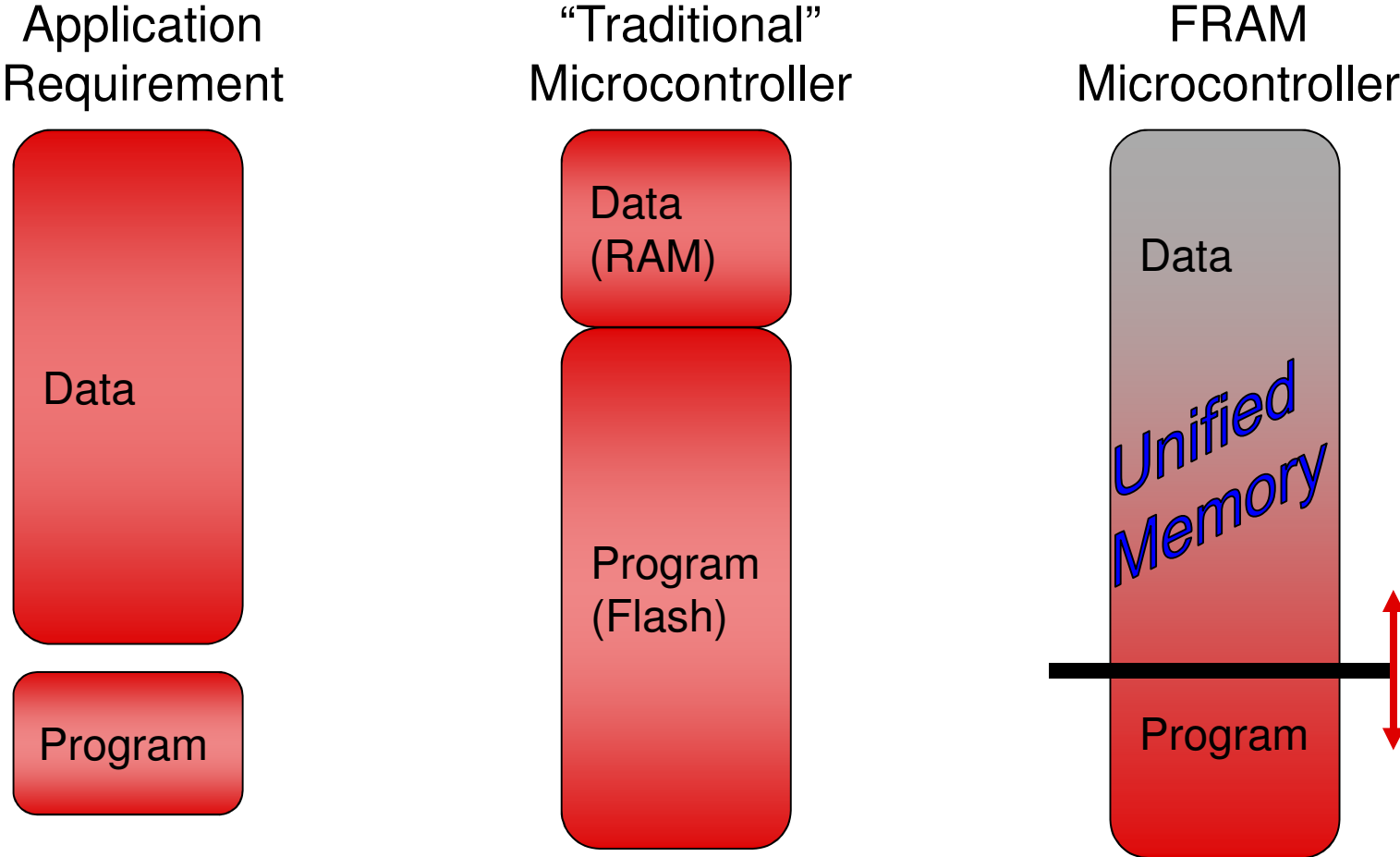
$$\sim 100\text{ns} * 4\text{mA} = 400\text{pC} / 16 \text{ bit}$$



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FRAM Microcontroller – Advantages

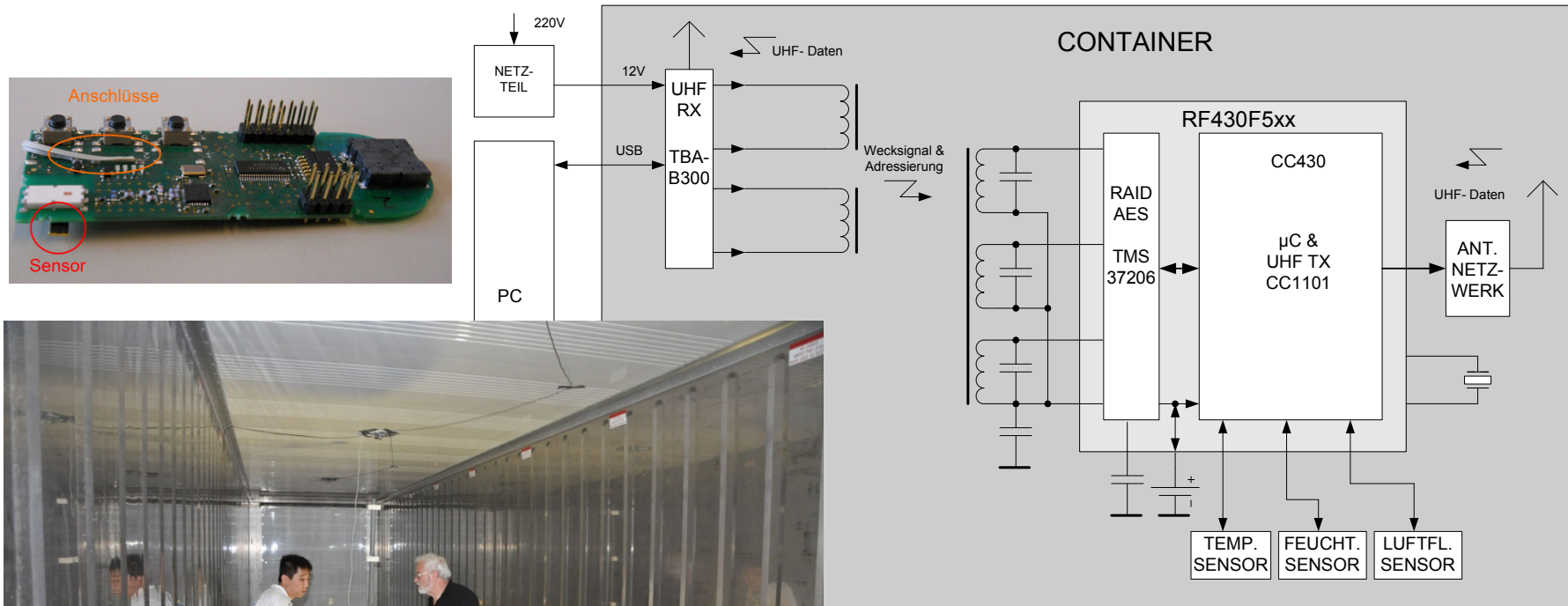
FRAM – Unified Memory



Application Example

Intelligent Container – IMSAS Uni Bremen

Vernetzte, intelligente Objekte in der Logistik.



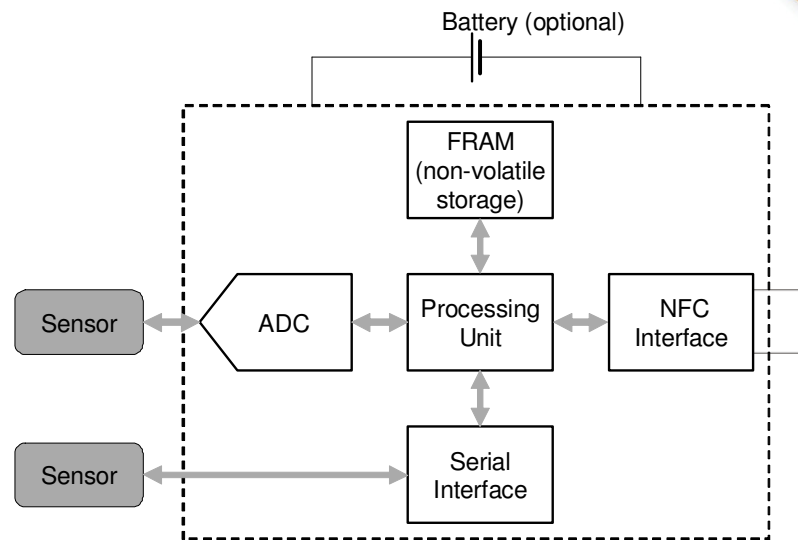
<http://www.intelligentercontainer.de>

Application Example

Medical

- The NFC enabled phones allows consumers to readout information from NFC enabled medical sensors (passive measurement on the spot or battery supported data logging) and transfer data to remote healthcare center for analysis and instruction

- Blood pressure
- Temperature
- Glucose
- Pulse
- EKG
- EMG



Application Example 2

Monitoring of physiological Parameters

- EEG monitor
- ECG monitor
- Pulse-Ox monitor
- Hydration monitor
- Heart rate monitor
- Temperature monitor
- Mental health monitor
- Blood glucose monitor
- Activity (calorie) monitor

