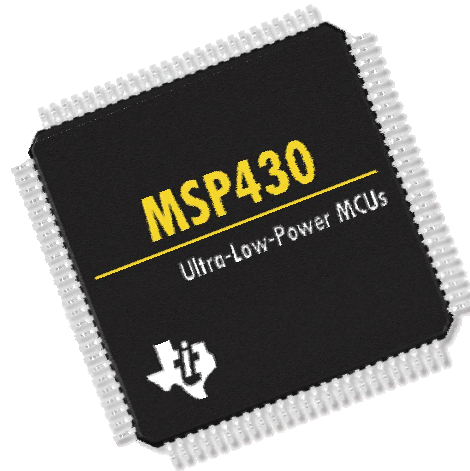# Using MSP430 with Low-Power RF Devices

Low Power Wireless

Texas Instruments

Agenda

- MSP430 and Chipcon Transceivers Key Features

- Interfacing MSP430 with Chipcon Transceivers

- Available hardware/software/kits

- Demonstration

MSP430 Key Features

- 0.1µA power down
- 0.8µA standby mode
- 250µA / 1MIPS
- <1µs clock start-up
- Zero-power BOR
- <50nA pin leakage

- Modern 16-bit RISC CPU
- 1K to 128KB+ ISP Flash
- 14- to 100-pin options
- Intelligent peripherals boost performance
- Embedded emulation

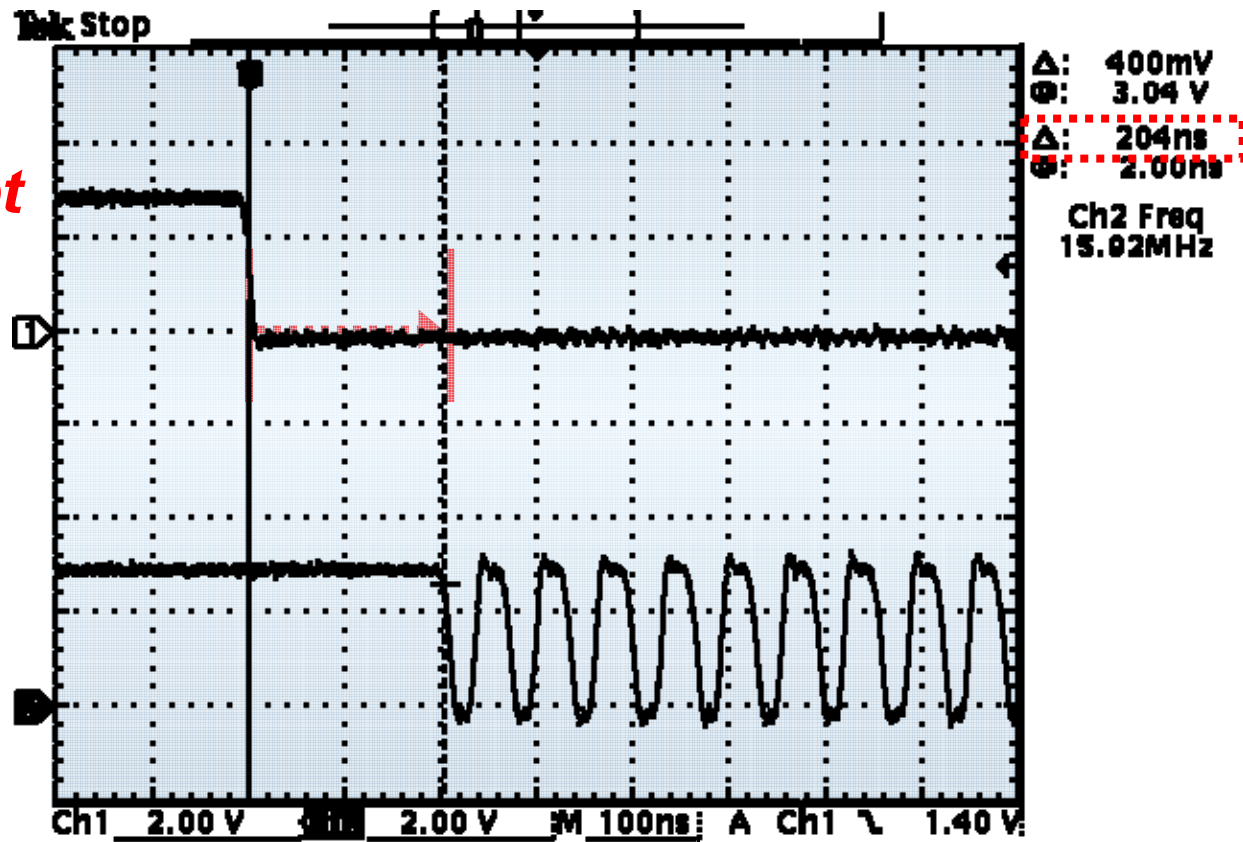Technology for Innovators™
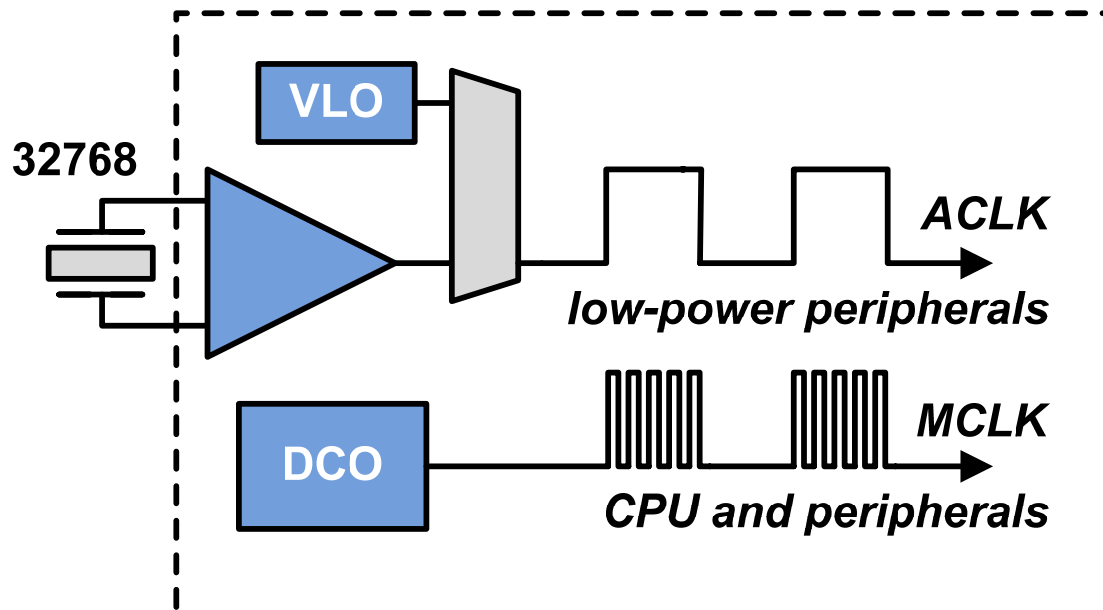
TEXAS INSTRUMENTS

Ultra-Low Power Activity Profile
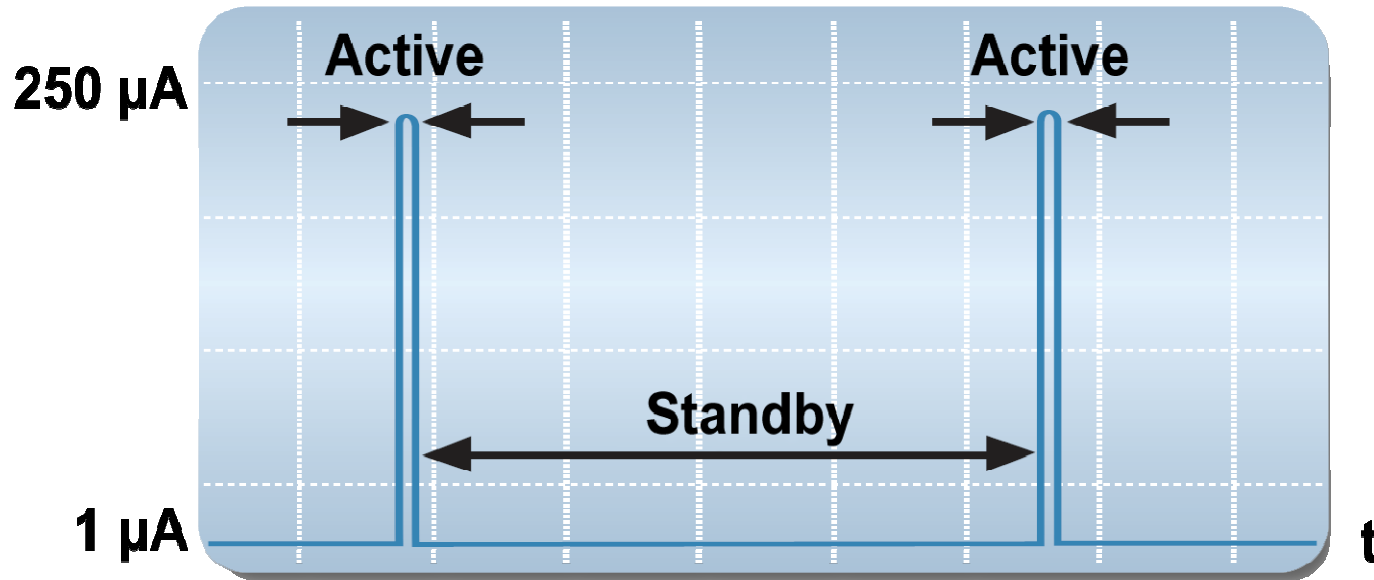
- Extended *Ultra-low Power* standby mode
- Minimum active duty cycle
- Interrupt driven performance on-demand

Performance on demand

Interrupt

- Always-on low-frequency ACLK
- On-demand high-speed DCO
- DCO on and *stable* in <1µs

Modern orthogonal 16-bit RISC CPU

- ## No accumulator bottleneck

- ## RISC architecture

  - 27 core instructions

  - 24 emulated instructions

  - 7 addressing modes

  - Constant generator

- ## Single-cycle register operations

- ## Memory-to-memory atomic addressing

- ## Bit, byte and word processing

- ## C-compiler friendly

MDB

MAB

15   0

R0/PC

R1/SP

R2/SR

R3/CG

R4

R5

R6

R7

R8

R9

R10

R11

R12

R13

R14

R15

16

16
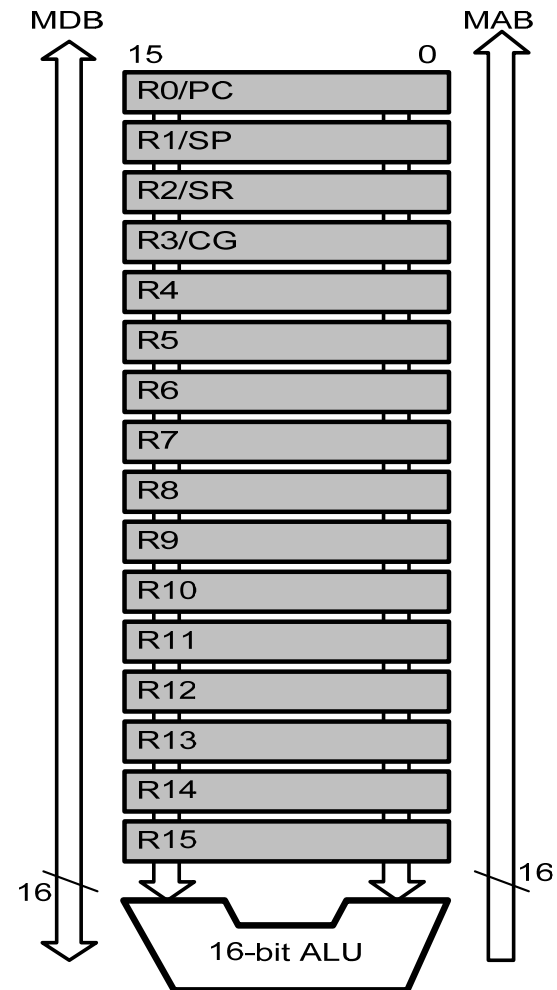
16-bit ALU

Intelligent Peripherals

- 10-/12-/16-bit ADC
- 12-bit DAC
- Comparator
- LCD driver
- Supply Voltage Supervisor (SVS)
- Operational amplifiers
- 16-bit and 8-bit timers

- Watchdog timer
- UART/LIN
- I2C
- SPI
- IrDA
- Hardware multiplier
- DMA controller
- Temperature sensor

CC1101/CC2500 Key Features
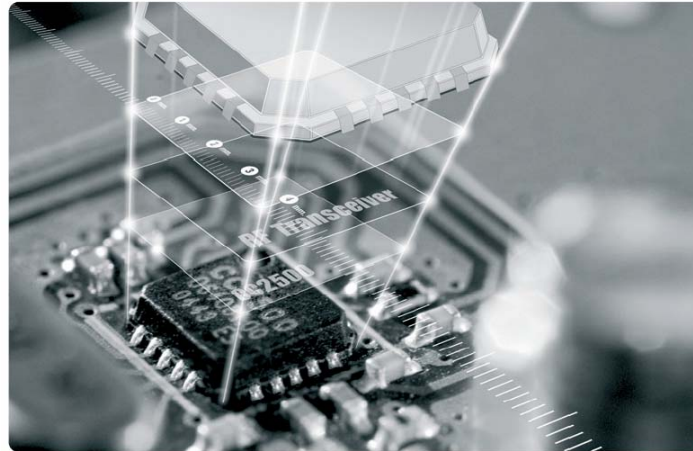
- High sensitivity

- Excellent selectivity and blocking performance

- Low power consumption (400 nA in SLEEP)

- Fast startup time

- Fast state transitions

- Very few low cost external components required

- Small footprint

- Easy to configure

- Flexible operation

- Packet handling with separate 64 byte RX and TX data buffers

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CC2420 Key Features

- 2.4 GHz RF transceiver for IEEE 802.15.4 and ZigBee™ applications
- Very few low cost external components required
- No external RF switch/filter needed
- Packet handling with separate 128 byte RX and TX data buffers
- Hardware MAC encryption and authentication
- Low current consumption
- Low supply voltage with internal voltage regulator
- Programmable output power
- Excellent selectivity and blocking performance

Typical Applications

CC1100/CC1101

315/433/868/915 MHz

- Home and building automation
- Automatic meter reading (AMR)
- Wireless alarm and security systems
- Industrial monitoring and control
- Wireless sensor networks
- Consumer electronics

CC2500

2.4 GHz

- Wireless game controllers
- Wireless keyboard/mouse
- Wireless audio
- Sports and leisure equipment
- Consumer electronics

CC2420 - ZigBee

Why MSP430 and CCxxxx?

- Target many of the same applications
  - Battery powered applications
  - Wireless sensor applications
  - AMR
- Designed for low power
  - Low power consumption
  - Low operating voltage (1.8V .. 3.6V)
  - Fast startup from sleep
- Few external components
- Transceivers compatible with all MSP430

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Interfacing MSP430 with CC1101 and CC2500

- The radio is configured via a simple 4-wire SPI compatible interface where the radio is the slave and the MCU is the master

MCU	Radio
SCLK	SCLK
MOSI	SI
MISO	SO
Px.x	CS
Px.x	GDO0
Px.x	GDO2
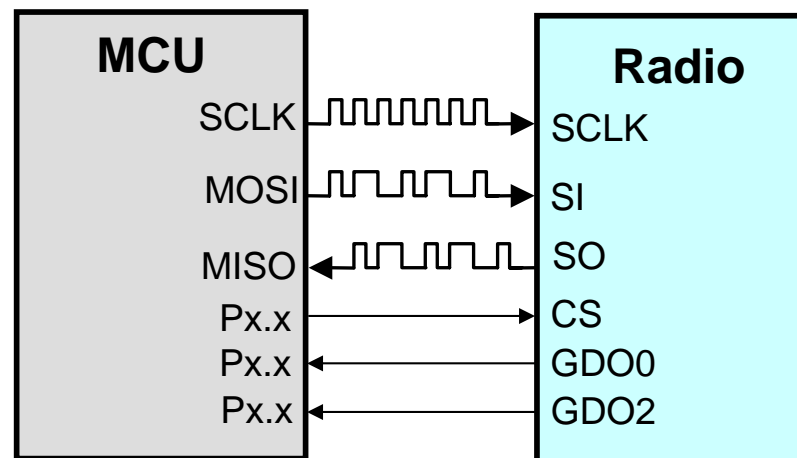
- 2 (3) generic digital outputs can be used for waking up the MSP430, triggering interrupts

Possible Interfaces on MSP430

Px.x (/CS) →
P3.3 / UCLK0 →
P3.2 / SOMI0 ←
P3.1 / SIMO0 →
P1.x or P2.x (GDO0) ←

USARTn

Px.x (/CS) →
P1.5 / SCLK →
P1.6 / SDO ←
P1.7 / SDI →
P1.x (GDO0) ←

USI

Px.x (/CS) →
P7.3 / UCA0CLK →
P7.2 / UCA0SOMI ←
P7.1 / UCA0SIMO →
P1.x or P2.x (GDO0) ←

USCI_A/B_n

Px.x (/CS) →
Px.x (CLK) →
Px.x (MO) ←
Px.x (MI) →
P1.x or P2.x (GDO0) ←
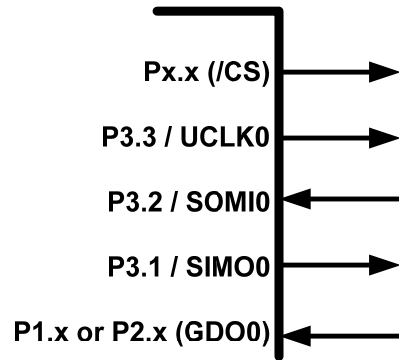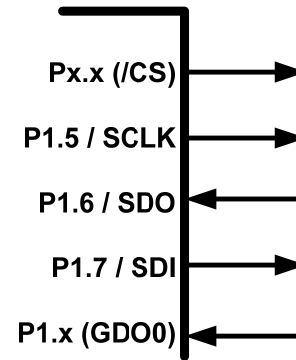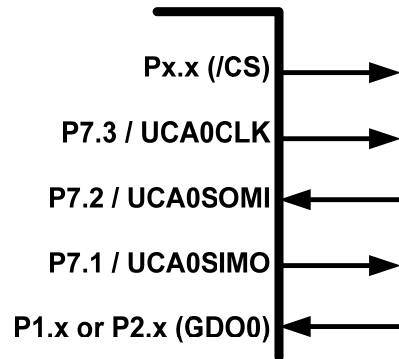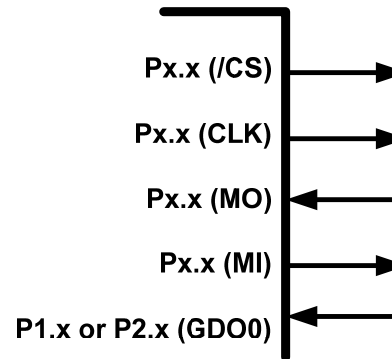
BIT-BANG

SPI Interface

- MSP430 is master

- All address and data transfers on the SPI interface is done most significant bit first.

- Clock Phase: Data must be centered on the first positive going edge of the SCLK period.

- Polarity: SCLK line should be low in idle state.
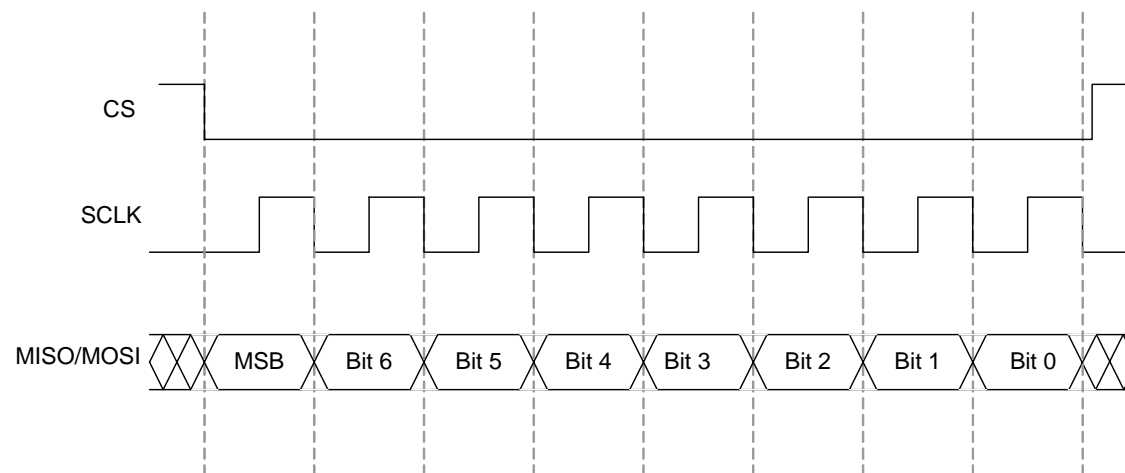
- 2 (3) general purpose output pins from the radio with more than 30 different functions

- Should be connected to interrupt capable ports on the MSP430 (Port 1 and Port 2)

- Use the same port – allows one interrupt vector for all radio events

- For bit-banging, consider using pins 1 to 4 on the port – the MSP430 can take advantage of its internal constant generator to create more efficient code

Which device to choose?

- Select an MSP430 that matches your application (peripherals, flash, ram, cost)
- Select a radio that matches the communication requirements
  - frequency (<1 GHz or 2.4 GHz)
  - protocol (proprietary or 802.15.4/ZigBee)
  - narrowband (channel occupancy)

Suggested Devices	Cost Efficient	General Purpose	High End
MSP430	F22xx F41x	F16x F23x/F24x	FG461x F261x

| Low Power Wireless | <1GHz | CC1xxx (CC1101) | |
| | 2.4GHz | CC2xxx (CC2420, CC2500) | |
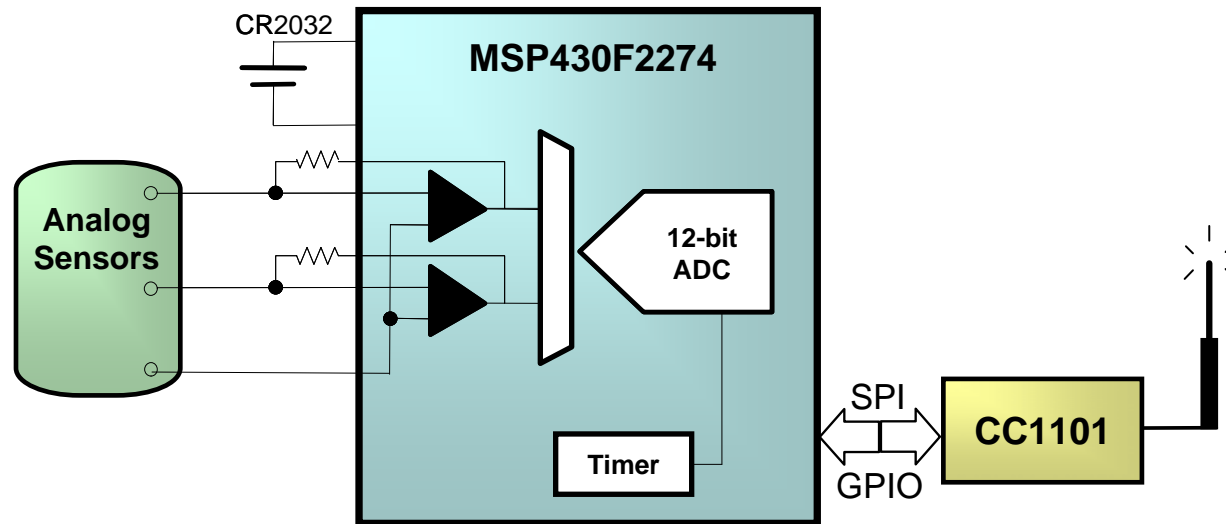
MSP430 ZigBee Coordinator
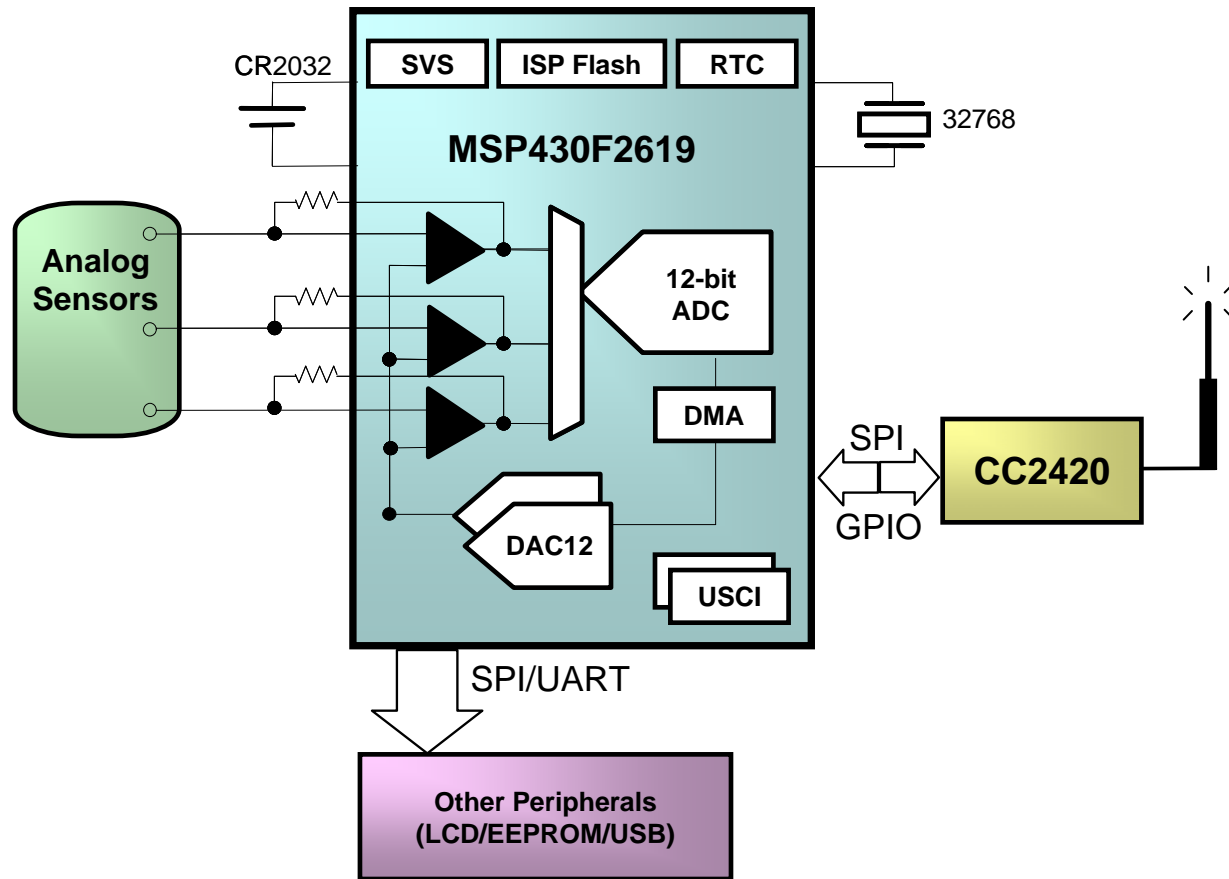
Agenda

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MSP430 Experimenter's Board

- Connector for CC1100/CC1101/ CC2500/CC2420 EMs

- SW examples and function library available at www.ti.com/ccmsplib
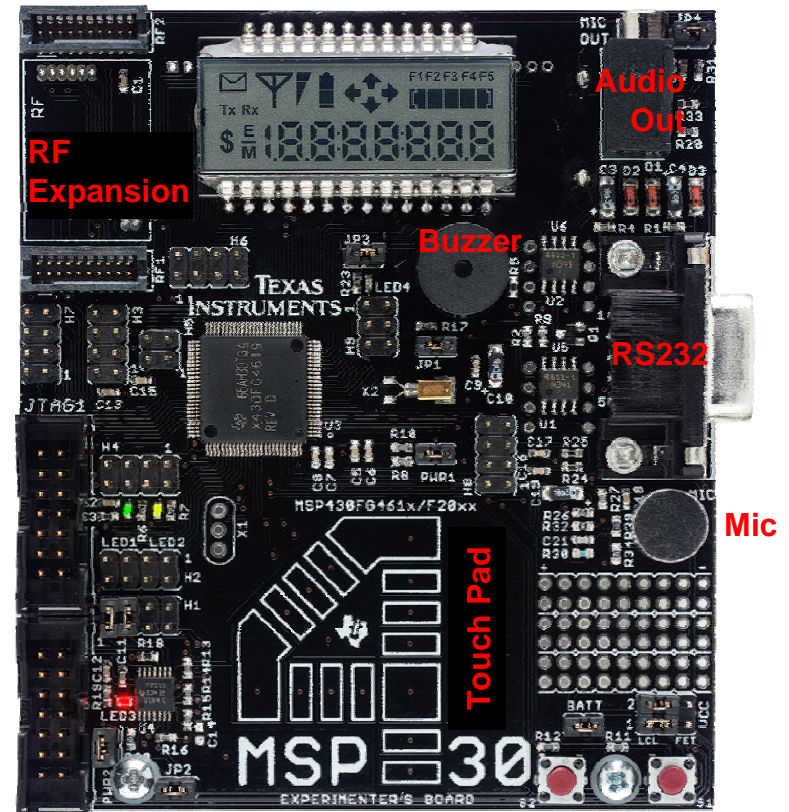
CC2420MSP430 ZigBee kit

- ● CC2420 + MSP430 Exp Board
  - – Hardware bought as separate parts
  - – (~ $300 w/o debugger)
- ● Complete ZigBee stack available
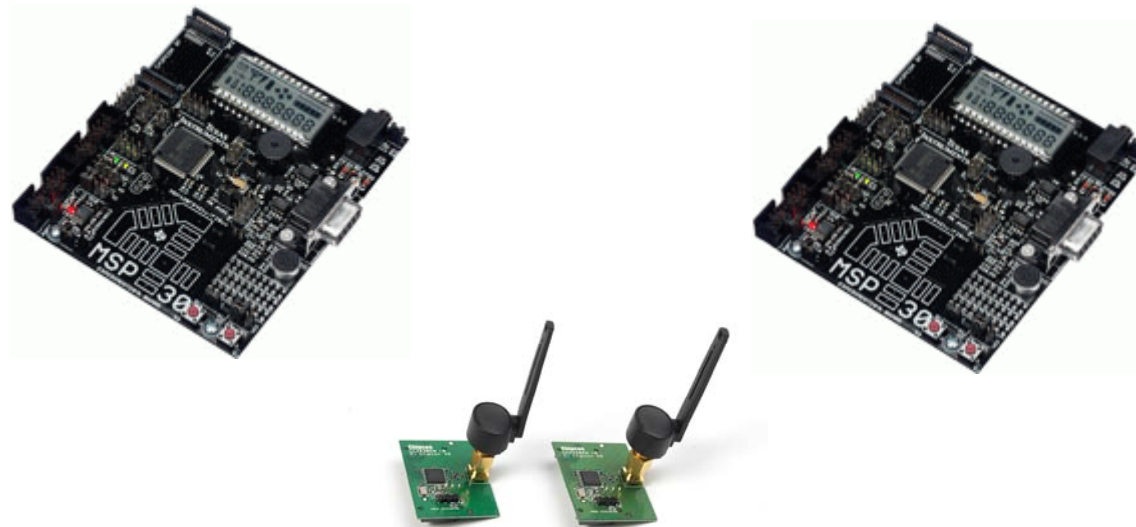
eZ430RF

- Demonstration kit with fully operable debug interface to MSP430

- CC2500 with chip antenna

- MSP430 and CC2500 reference design

- Ideal for prototyping

- Can be used with SimpliciTI

Spy Bi-Wire & UART Interface

Button

2x LEDs

CC2500

USB Powered

Chip Antenna

18 pins accessible
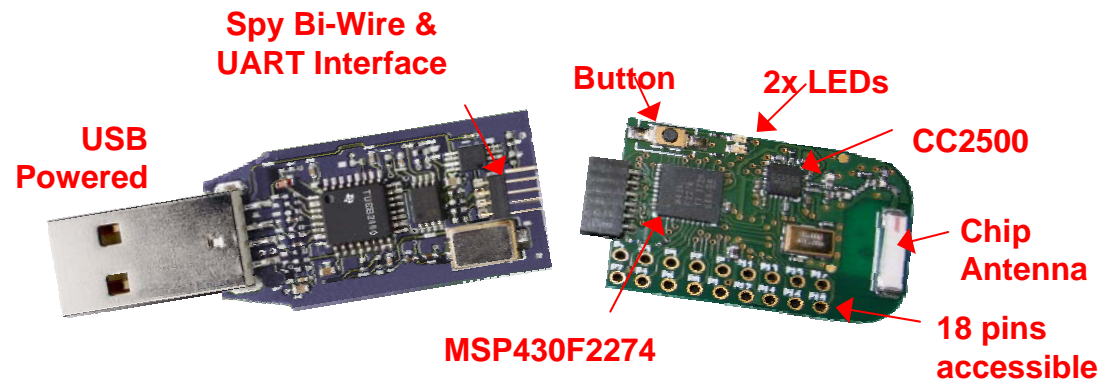
MSP430F2274

Z-Accel

- Demonstration kit with "ZigBee Processor"
- MSP430F2232 interfaces CC2430 over SPI
- CC2430 runs the ZigBee stack, MSP430 runs the application.
- Command interface supports the TI Z-Stack Simple API

Spy Bi-Wire & UART Interface

CC2430

USB Powered

MSP430F2232 (backside)
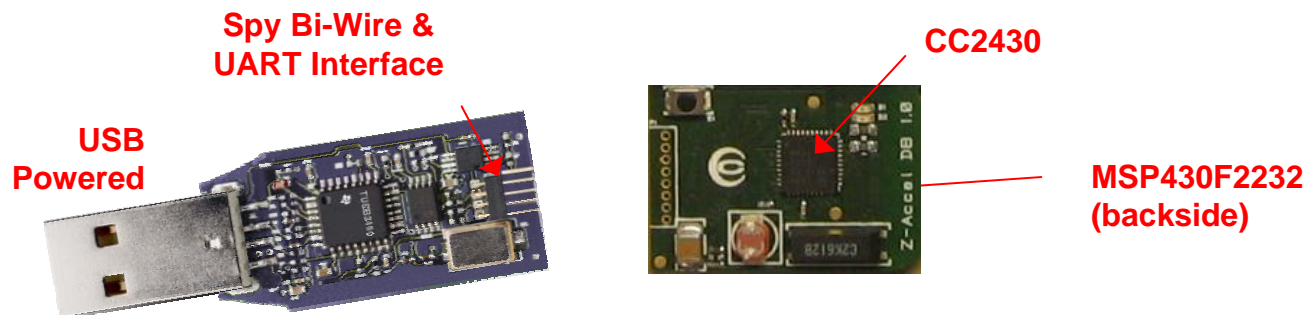
Available Software

"Software for CC1100/CC2500 and MSP430, Examples and Function Library"

www.ti.com/ccmsplib

SimpliciTI

TIMAC for MSP430 & CC2420

www.ti.com/timac

ZigBee Stack for MSP430 & CC2420

www.ti.com/z-stack

CC1101/CC2500 & MSP430 Lib

- Runs out of the box on MSP430 Experimenter's Board

- Provides functions for easy access to the CC1100/CC2500

- Recommended starting point for experimenting and developing SW
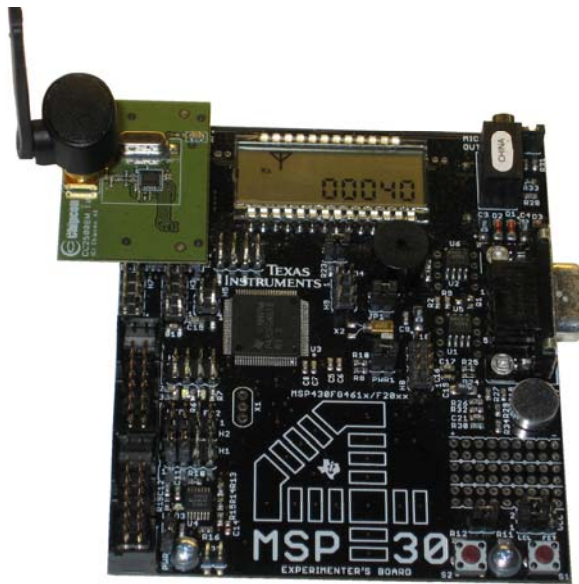

```
// Example:
// Reset chip and send packet
halRfReset();
halRfConfig(...);
halRfWriteFifo(data, length);
halRfStrobe(CC1100_STX);
```

SimpliciTI

- Low Power: a TI proprietary low-power RF network protocol

- Low Cost: uses <4K / 8K FLASH, < 512 bytes / 1K RAM

- Flexible: simple star w/ extendor and/or p2p communication

- Simple: Utilizes a very basic core API

- Versatile: MSP430+CC1100/2500, CC1110/2510, and DSSS parts

- Low Power: Supports sleeping devices

Low Power

Simplicity

Low Cost

SimpliciTI
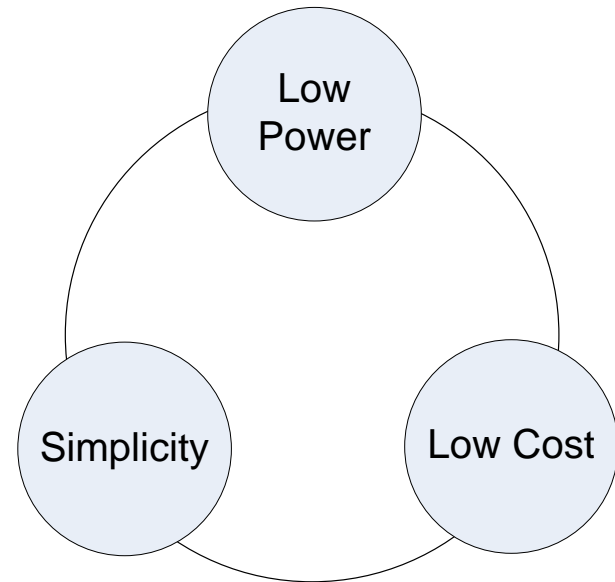
- # Device Configurations
  - – Access Point (AP)
  - – Repeater (RE)
  - – Sleeping Device (SD)
  - – Device (D)
  - – TX-Only Device (TD)
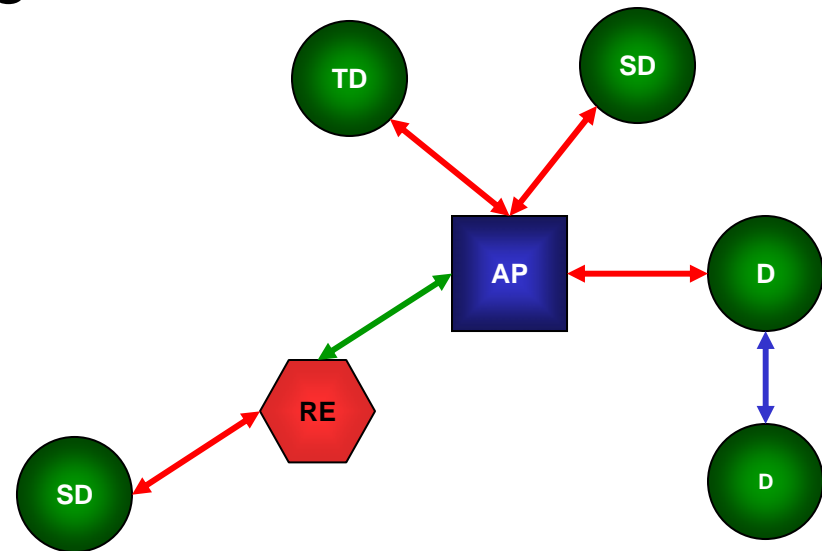
- # Topologies
  - – AP Star
  - – AP Star w/ Repeaters
  - – Peer2Peer
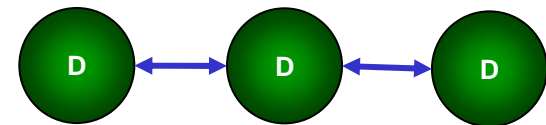
Go to www.ti.com/msp430wireless

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Agenda

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Using a simplified protocol for sending the alarm message

```
                  ( HW Initialization )        ( Glass Break )
                                                ( Detected    )
                           |                         |
                           v                         v
                  +-----------------+        +-----------------+
                  | Reset and       |        | Prepare packet  |
                  | Configure radio |        +-----------------+
                  +-----------------+                 |
                           |                          v
                           v                 +-----------------+
                  +-----------------+         | Strobe TX       |<----+
                  | Strobe SPWD     |         +-----------------+     |
                  | (radio sleeping)|                 |              |
                  +-----------------+                 v              |
                           |                 +-----------------+    |
                           v                 | Write packet to |    |
                  +-----------------+         | FIFO            |    |
                  | Enable interrupts|        +-----------------+   N|
                  +-----------------+                 |             |
                           |                          v             |
                           v                 +-----------------+    |
                  |[ Enter LPM3 ]|           | Wait for packet |    |
                                             | to be sent      |    |
                                             +-----------------+    |
                                                      |             |
                                                      v             |
                                             +-----------------+    |
                                             | Wait for ACK    |    |
                                             | with timeout    |    |
                                             +-----------------+    |
                                                      |             |
                                                      v             |
                                                   /ACK or\ --------+
                                                  < max     >
                                                   \retries?/
                                                      |
                                                      Y
                                                      v
                                             +-----------------+
                                             | Strobe SPWD     |
                                             +-----------------+
                                                      |
                                                      v
                                             |[ Exit ISR ]|
```
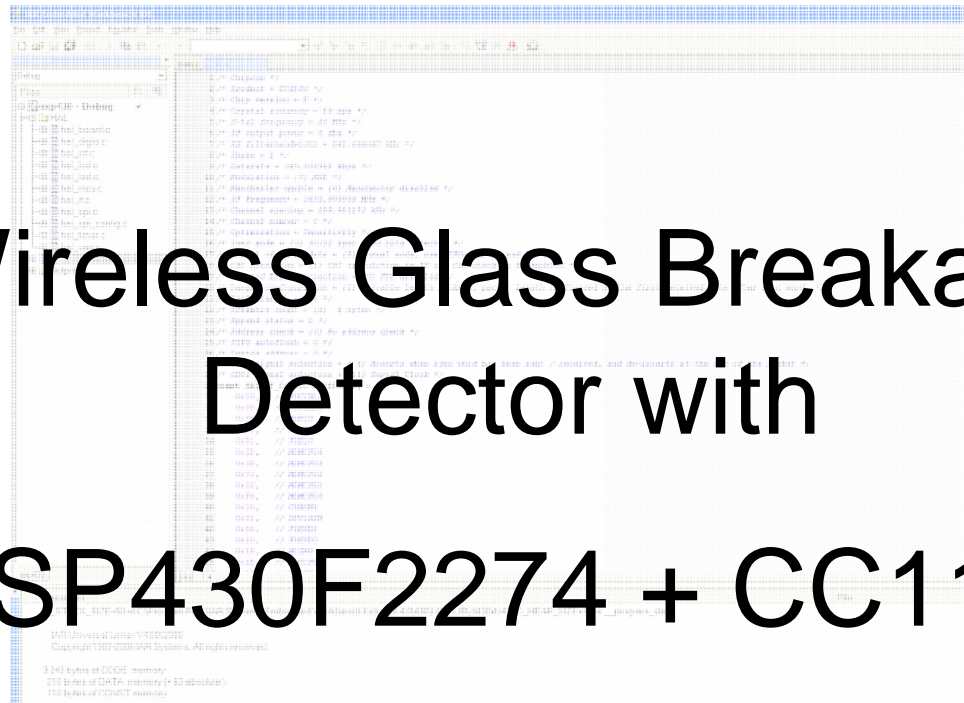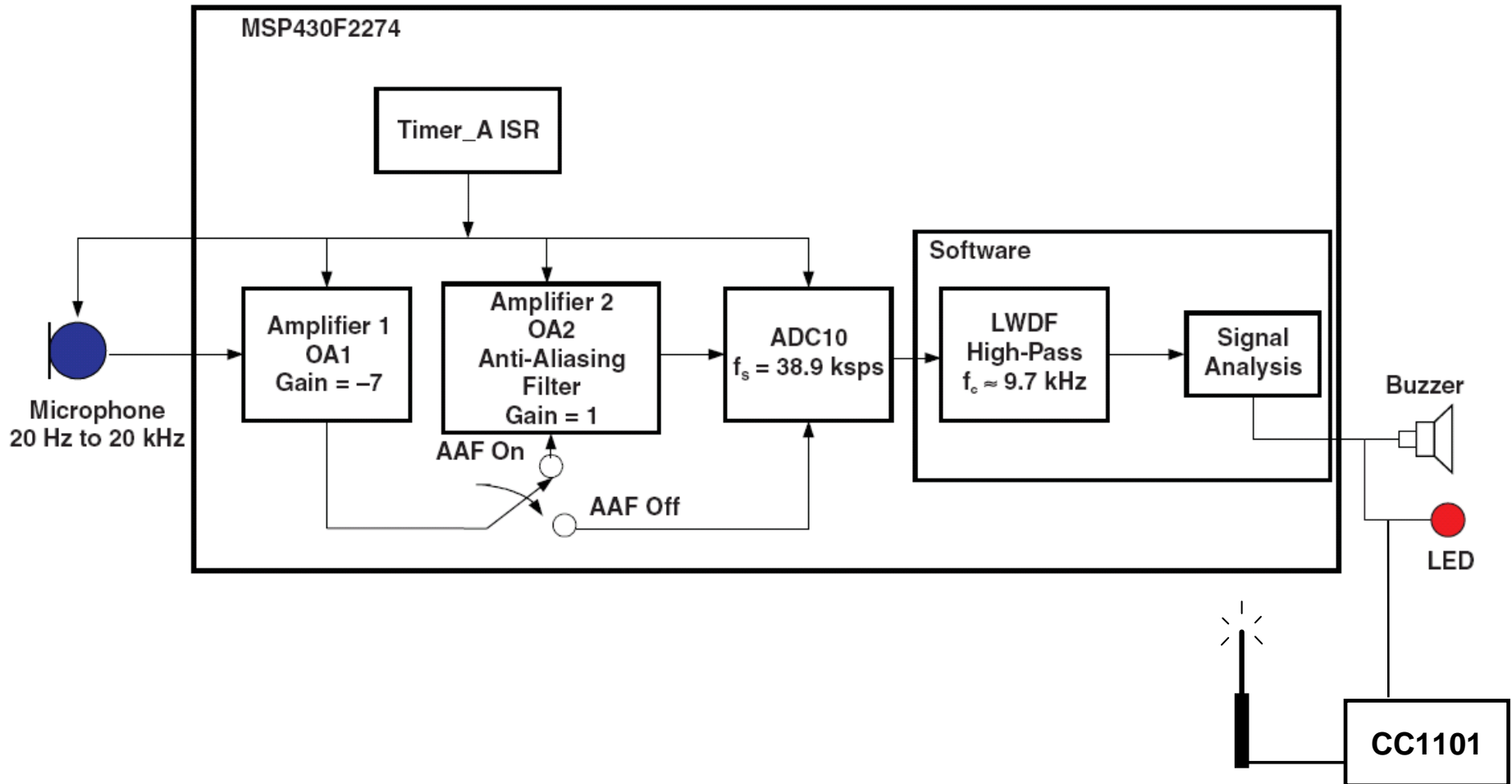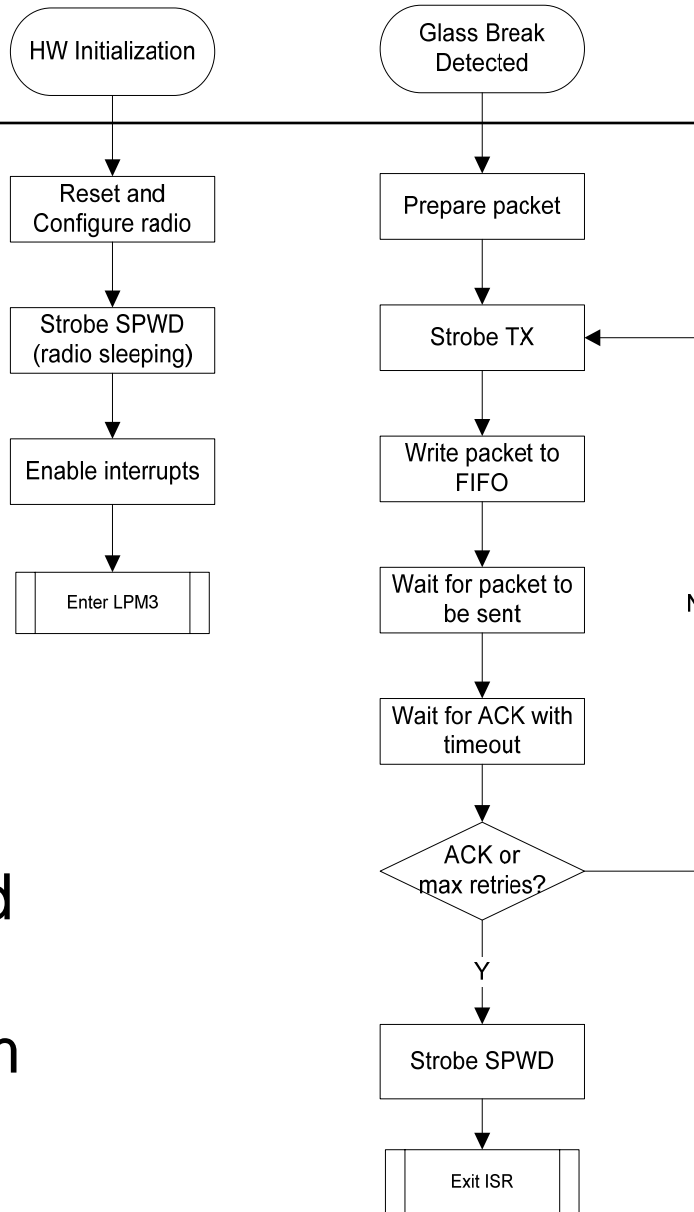
Protocol

Chipcon Products from Texas Instruments

Flowchart:

- HW Initialization
  - → Reset and configure radio
  - → Strobe SWOR
  - → SYNC received
    - N → MCU enters low power mode
    - Y → Read radio status
      - → IDLE?
        - N → FIFO overflow
          - N → Read radio status
        - Y → data available?
          - N → Clean up
          - Y → Packet OK?
            - N → Clean up
            - Y → Send ACK

- Sync received interrupt
  - → Set sync received flag
  - → MCU exits low power mode and returns from interrupt

Thank you for your attention!

Questions?

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