eZ430-Chronos Wireless Watch Development Tool: Teardown & Getting Started

www.ti.com/chronoswiki

eZ430-Chronos for wireless networking applications

Complete hardware, software and support community

Simplify & inspire development with world’s first customizable tool within an intelligent sports watch

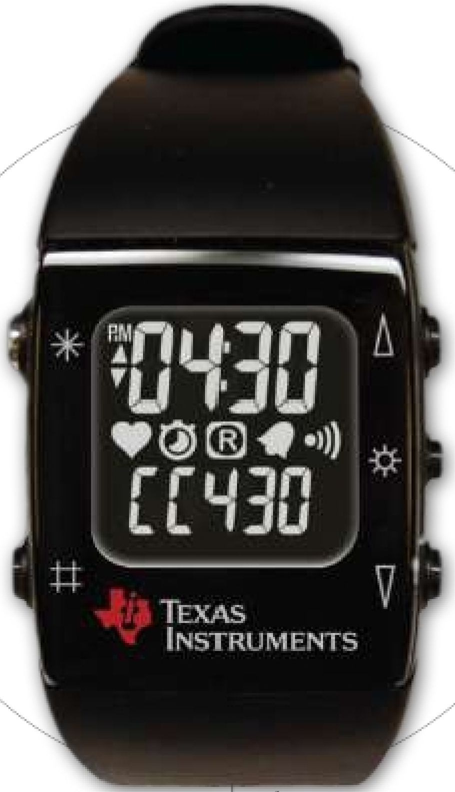
Unparalleled system integration and ultra-low power

Easily enable wireless connectivity, longer battery life, improved ergonomics

Low cost development kit at $49

Increase accessibility and reduce development cost

Chronos | Advanced Integration



CC430F6137 MCU

<1GHz RF
- 433, 868 & 915 MHz

2-Wire JTAG Access

96 segment LCD

Buzzer

3-Axis VTI Accelerometer

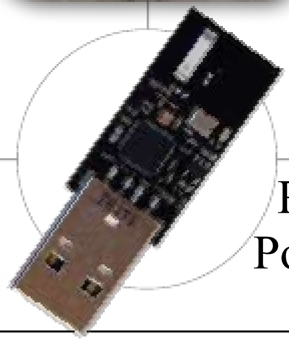
VTI Pressure & Altitude Sensor

Temperature Sensor

Voltage & Battery Sensor

CR2032 Battery

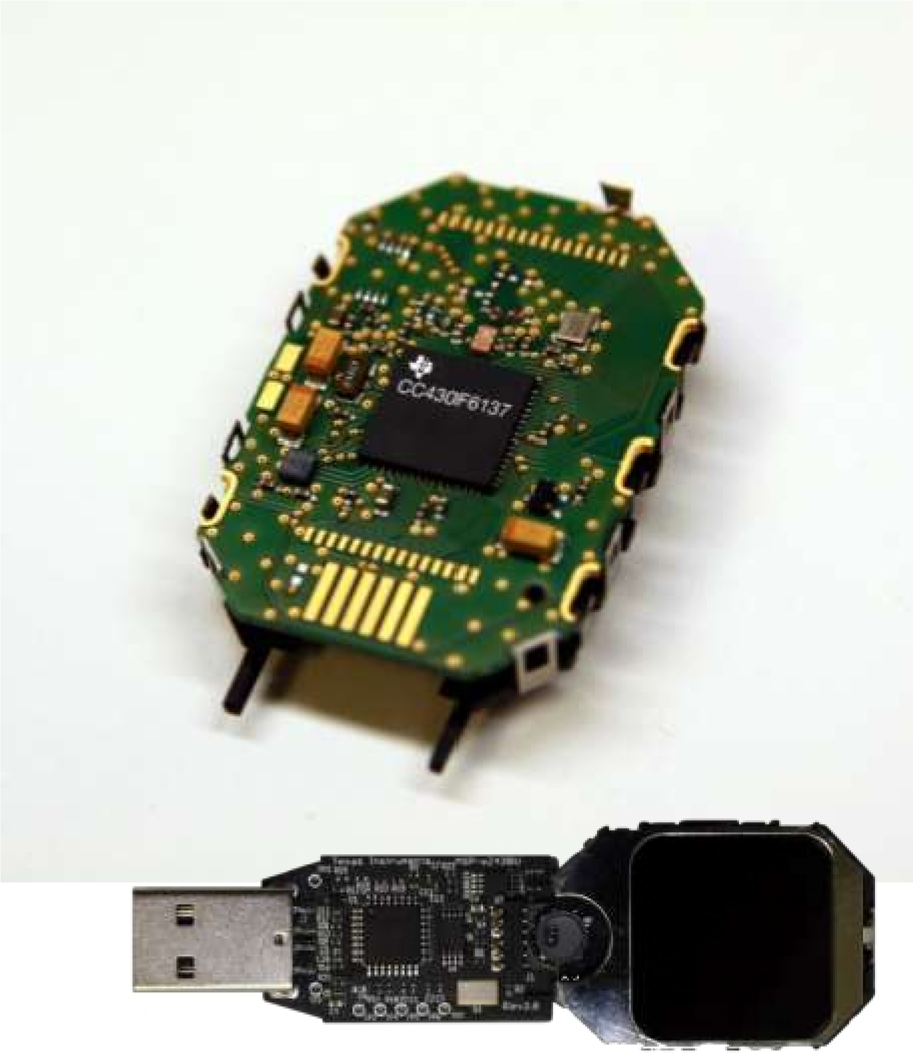
eZ430 Programmer

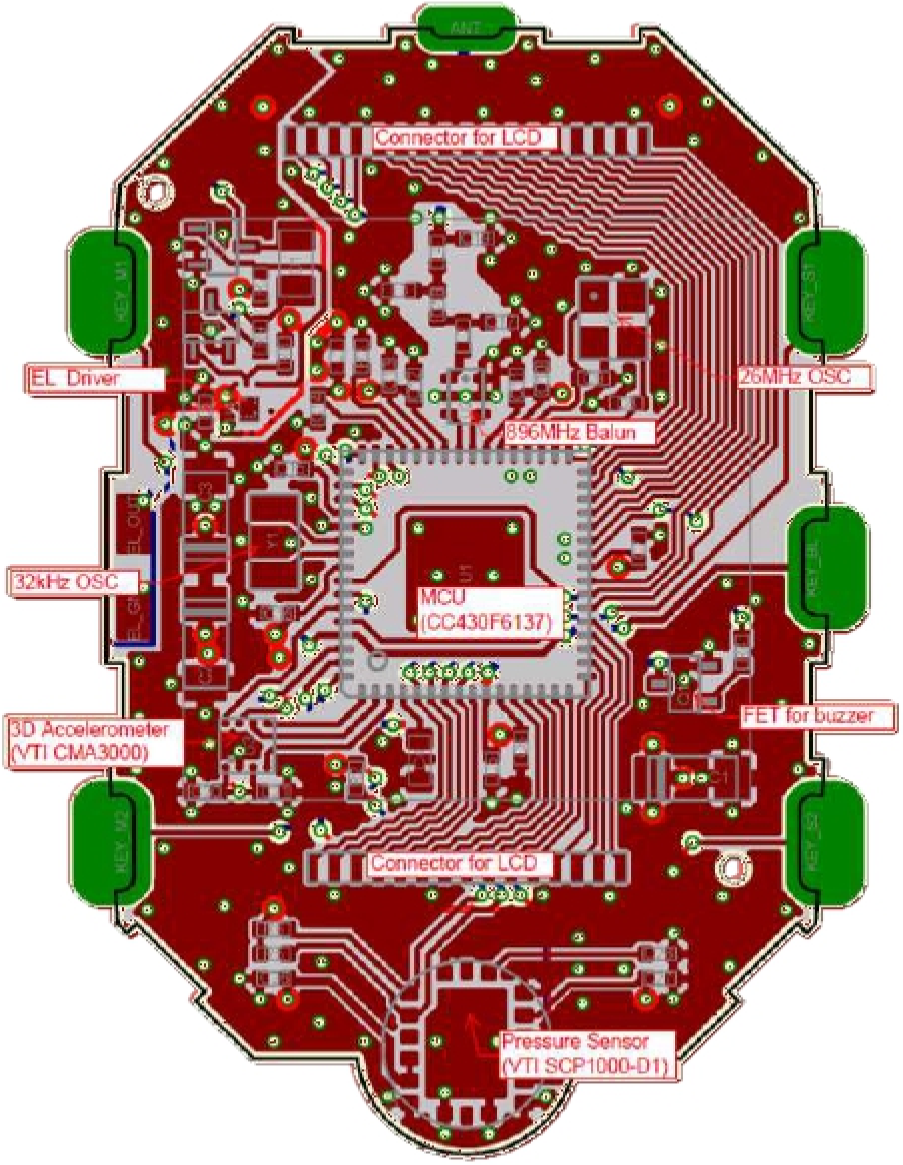


RF Access Point

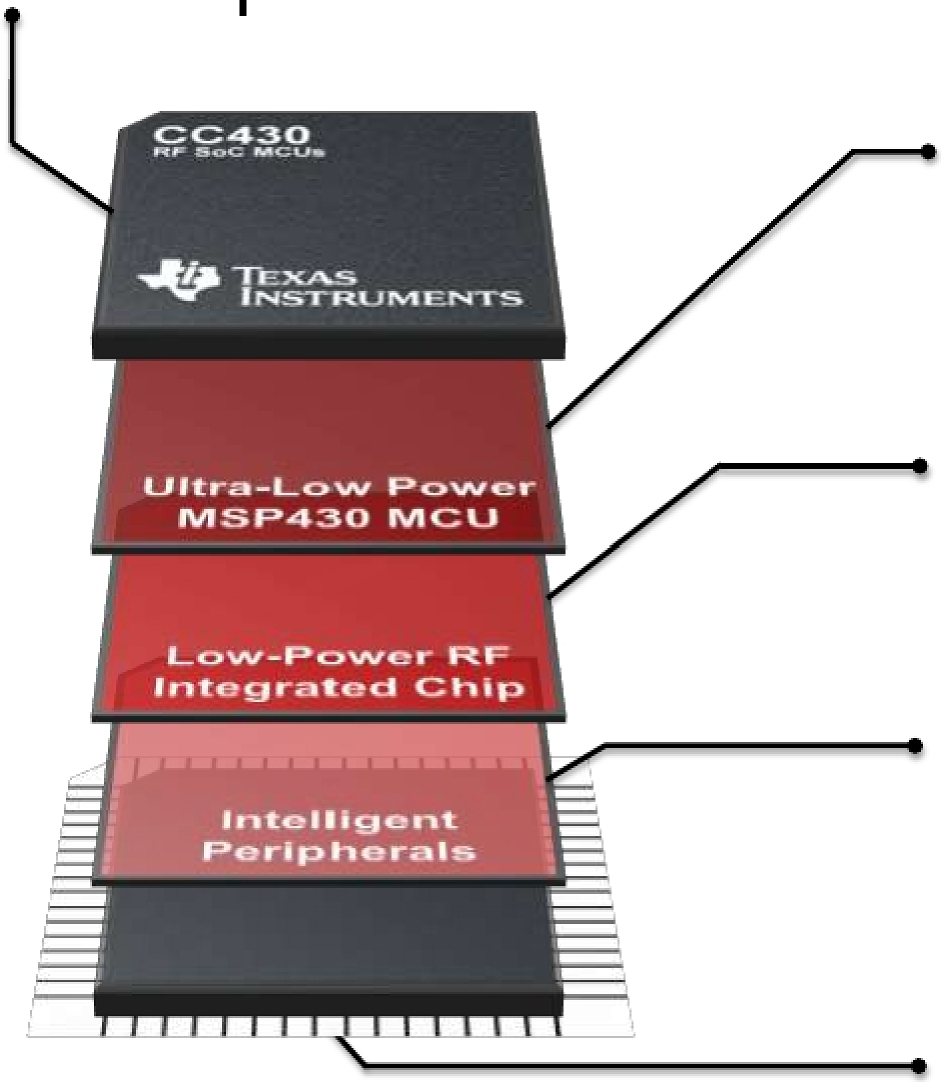
Chronos Disassembly Tool

Chronos | Teardown





CC430 | RF + Ultra-Low Power MCU



MSP430™ Microcontroller

- Industry‟s lowest power MCU
- 16-bit RISC architecture
- 20 MHz processor
- High-performance analog
- Sensor interface

CC1101 <1GHz RF Transceiver

- High sensitivity
- Low current consumption
- Excellent blocking performance
- Flexible data rate & modulation format

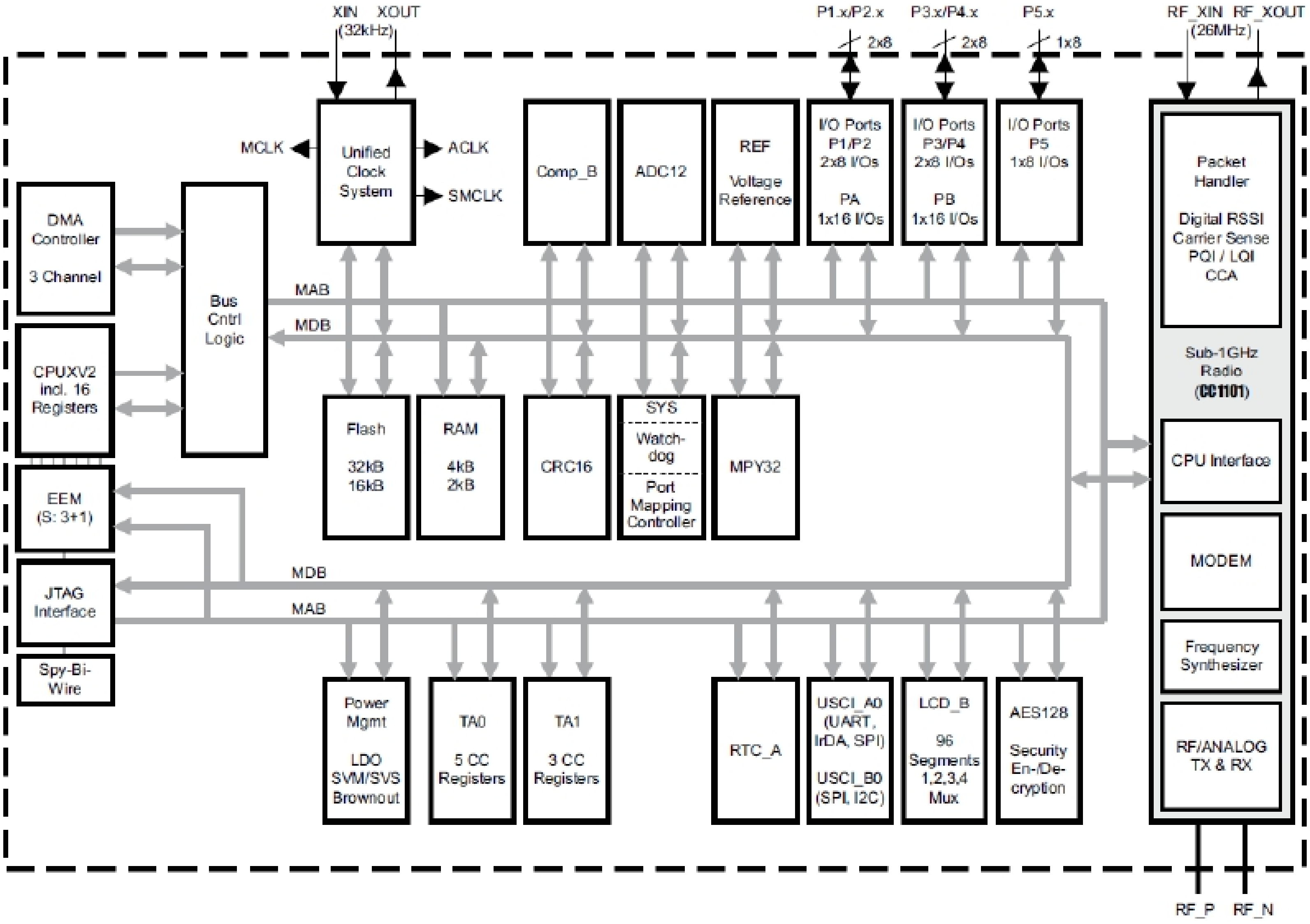
Intelligent Peripherals

- 100 nA comparator
- 8ch 12-bit ADC offering 200-ksps
- 96 segment LCD controller
- 128-bit AES security encryption/ decryption coprocessor

64QFN Pin Package

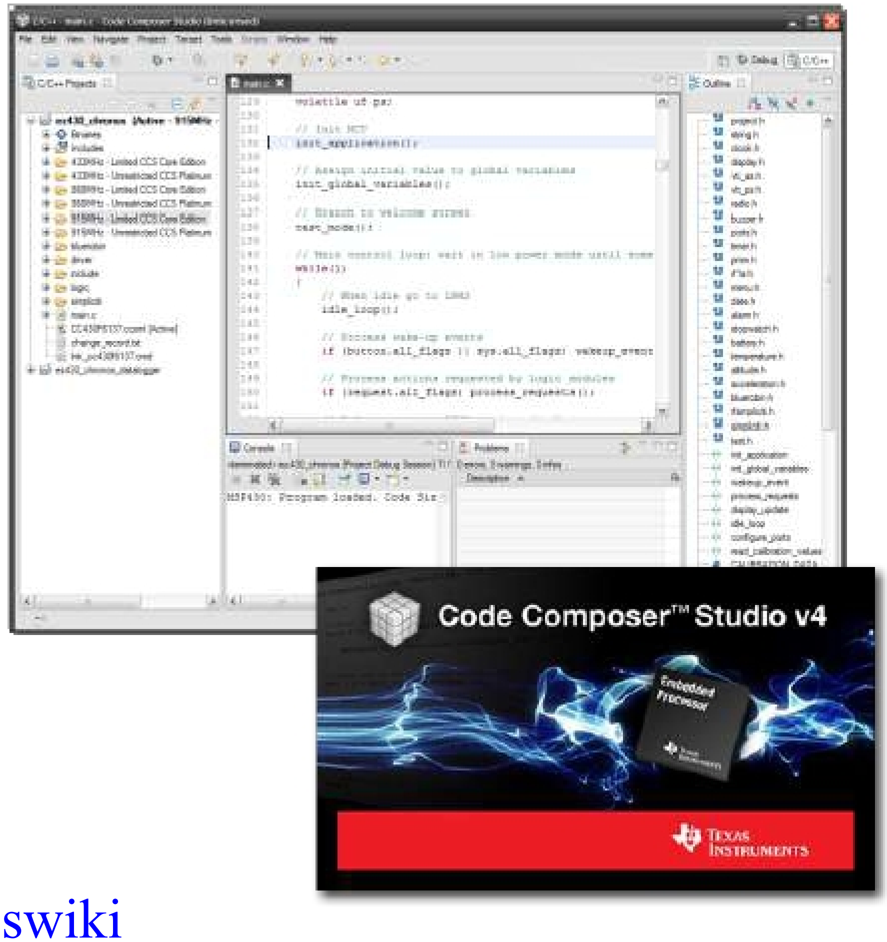
- 9.1 mm x 9.1 mm area

CC430 Block Diagram



Chronos | The Software

- Free development software
  - Code Composer Studio
  - IAR Embedded Workbench
  - MSPGCC*
- Production-ready, open-source projects
- RF stacks available
  - SimpliciTI
  - BlueRobin
  - W-Mbus
  - 6LoWPAN
  - More coming…
- User generated apps and support on www.ti.com/chronoswiki

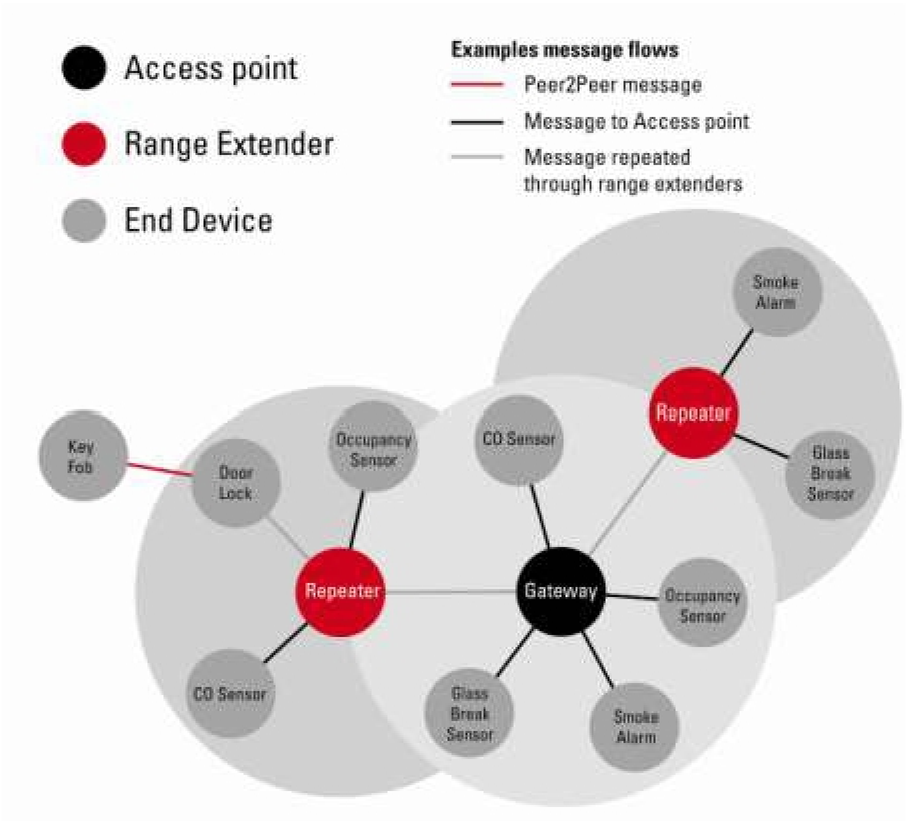


```
volatile u8 pa;

// Init MCU
init_application();

// Assign initial value to global variables
init_global_variables();

// Branch to welcome screen
test_mode();

// Main control loop: wait in low power mode until some
while(1)
{
    // When idle go to LPM3
    idle_loop();

    // Process wake-up events
    if (button.all_flags || sys.all_flags) wakeup_event

    // Process actions requested by logic modules
    if (request.all_flags) process_requests();
```

```
MSP430: Program loaded. Code Siz
```

SimpliciTI

- TI proprietary low-power RF network protocol
- Low Cost:
  - < 8K FLASH
  - <1K RAM
- Flexible:
  - simple star w/ extendor
  - p2p communication
- Simple: Utilizes a very basic core API
- Low Power: Supports sleeping devices



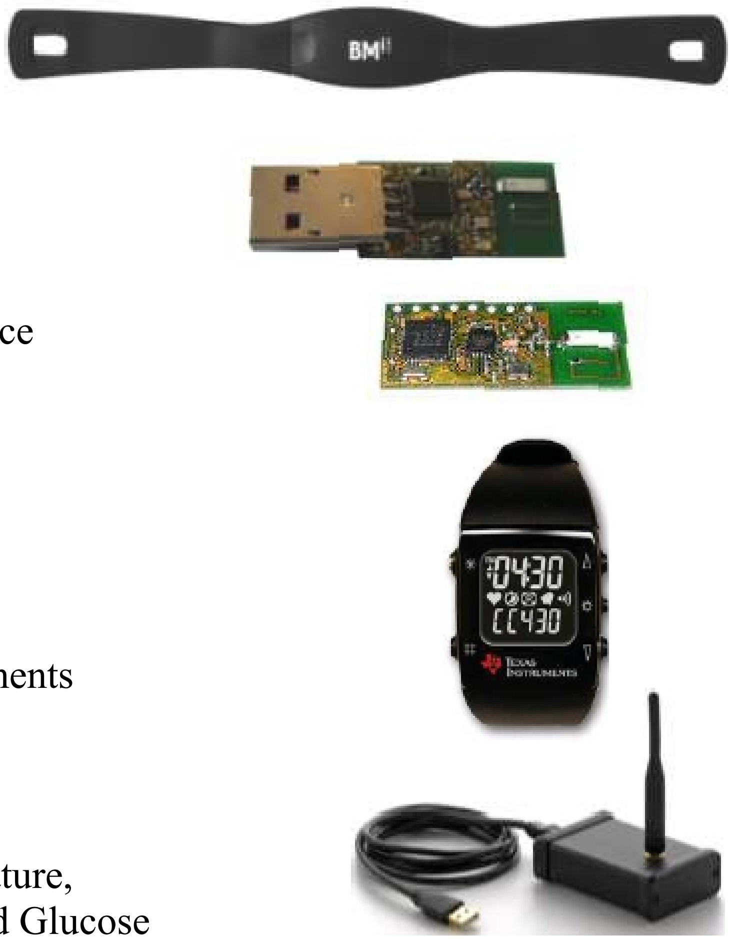
BM Wireless' BlueRobin Key Facts

- ***BlueRobin***™ targets at
  - body area networks
  - long range monitoring systems

- ***BlueRobin*** provides
  - ultra-low power operation in TX and RX mode
  - multi-user support with patented collision avoidance
  - bi-directional and long range communication
  - remote data storage with automatic data download
  - built-in data encryption

- ***BlueRobin*** offers flexibility through
  - hardware independent implementation
  - small memory footprint and low resource requirements
  - support of all ISM bands (433MHz to 2.4GHz)

- *BlueRobin* key apps
  - Heart Rate, Speed, Distance, Steps, GPS, Temperature,
  - Altitude, Rotations, Weight, Blood Pressure, Blood Glucose

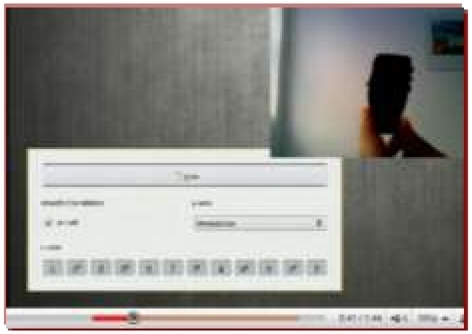


Chronos | Projects

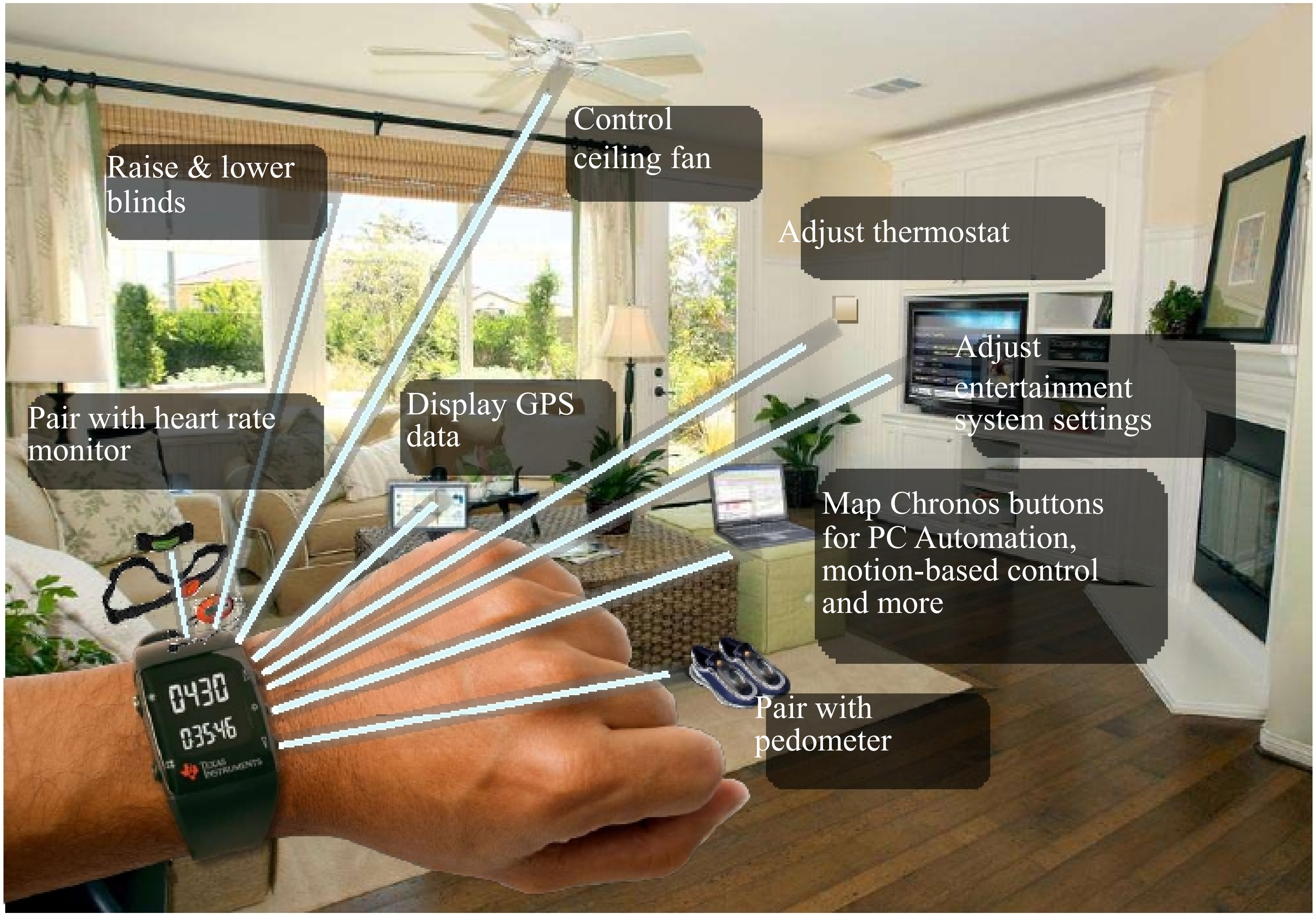
- Watch functions: time, date, alarm, stopwatch
- Fitness function: running speed, distance, heart rate, calories burned
- Sensor data logging w/ wireless PC download
- PowerPoint Control
- Media Remote
- Motion-based mouse/PC game control
- Wireless App Updating
- Wireless door lock
- Virtual Theremin
- Robotics control
- Blimp control

More apps to come…

www.ti.com/chronoswiki



Endless possibilities | Chronos serves as a central hub for nearby wireless sensors



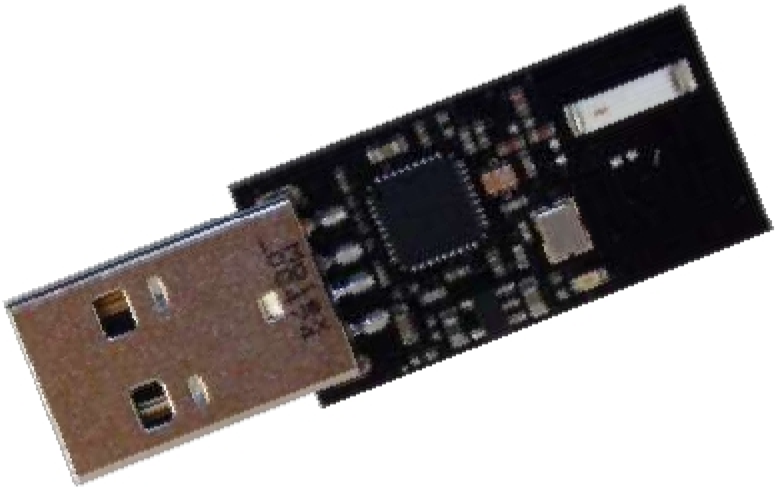
Control ceiling fan
Raise & lower blinds
Adjust thermostat
Adjust entertainment system settings
Pair with heart rate monitor
Display GPS data
Map Chronos buttons for PC Automation, motion-based control and more
Pair with pedometer
0430
03546
Texas Instruments

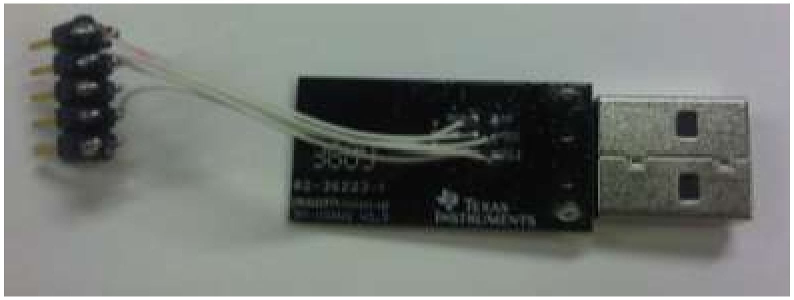
Chronos | Frequency Differences

- Available in 3 different frequencies
  - 433 MHz : Japan, India, WW
  - 868 MHz : Europe
  - 915 MHz : N. & S. America
- 868 & 915
  - Use identical watch hardware
  - Frequency is software selectable
  - 868 MHz RF Access Point has extra 0Ω R
- 433 MHz
  - Still in R&D
  - Available in June (estimated)
  - RF Range predicted to be *worse* than 868/915

Chronos | RF Access Point

- Based on CC1111
  w/ integrated USB + <1GHz RF
- “Fixed function” to communicate with Chronos & PC
- Can be manually reprogrammed with CC Debugger
- Supports wireless updating of Chronos firmware via RF BSL
  - RF BSL not included on first production batch



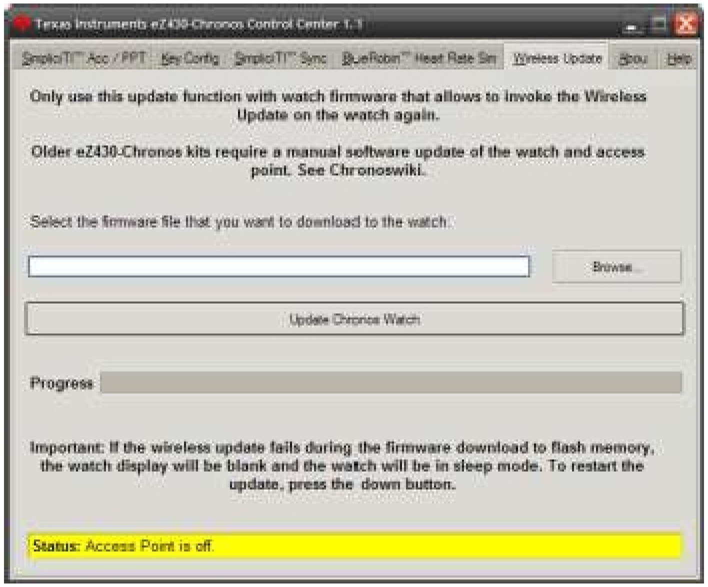


Header to JTAG signals
has to be manually added

RF BSL | Wireless Updating

- Wireless update of watch firmware
- Small RF Stack resides in BSL memory
- Application must include function to invoke BSL

- Pros:
  - ~10x faster than downloading code via SBW
  - No need to open enclosure
- Cons:
  - No debug capability
  - Power hog
  - Not supported out-of-the-box on early units (before 4/2010)



Only use this update function with watch firmware that allows to invoke the Wireless Update on the watch again.

Older eZ430-Chronos kits require a manual software update of the watch and access point. See Chronoswiki.

Select the firmware file that you want to download to the watch:

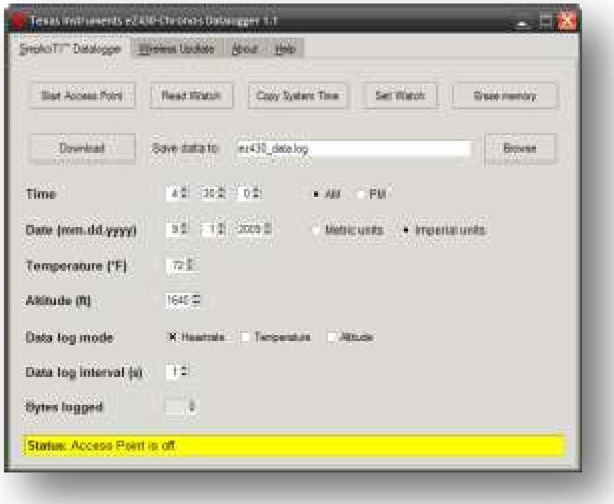
Progress

Important: If the wireless update fails during the firmware download to flash memory, the watch display will be blank and the watch will be in sleep mode. To restart the update, press the down button.

Status: Access Point is off.

Chronos | Data Logger

- Chronos can be used as a data logger for:
  - Heart rate
  - Temperature
  - Altitude
- User definable intervals
  - 1 to 255 seconds
- 8kB of Flash memory reserved
- The stored data can be transferred to a PC



Save data to: ez430_data.log

Time: 4 : 30 : 0 ● AM ○ PM

Date (mm.dd.yyyy): 9 . 1 . 2009 ○ Metric units ● Imperial units

Temperature (°F): 72

Altitude (ft): 1640

Data log mode: ☒ Heartrate □ Temperature □ Altitude

Data log interval (s): 1

Bytes logged: 0

Status: Access Point is off

PC/Chronos Communication

- RF Access Point open Virtual COM Port over USB

bps	115200
Data bits	8
Parity	None
Stop Bits	1
Flow Control	None

- Control Center automatically
  - Opens COM port
  - Transfers data
  - Decodes packets
  - Displays info
- API available for manual data transfer
- Scripts available for:
  - Python
  - Processing
  - Ruby
  - .net
- All community developed, supported

Chronos | Extra Hardware

- Heart Rate Monitors
  - BM-CS5 (800m)
  - BM-CS5SR (10m): 49€

- **Bike Sensors**
  - Speed and distance (according to BMi Q4 2010)
- **Compatible RF Development Boards**
  - AMB8423
  - EM430F6137RF900
  - CC1101EMK433
  - CC1111EMK868-915

Getting Started: What you need

www.ti.com/chronoswiki

- **Hardware**:
  1. eZ430-Chronos
  2. Computer: Windows / Linux
- **Software**:
  1. eZ430-Chronos Software Package:
     Windows (SLAC341), Linux (SLAC388)
  2. IDE: IAR or CCS
  3. Firmware Update tool (adds rfBSL)

- **Documentation**
  1. eZ430-Chronos User Guide (SLAU292): Technical details and instructions for Chronos
  2. CC430 User Guide: Technical user manual for CC430
  3. CC430F613x Datasheet: Electrical specs for CC430F613x

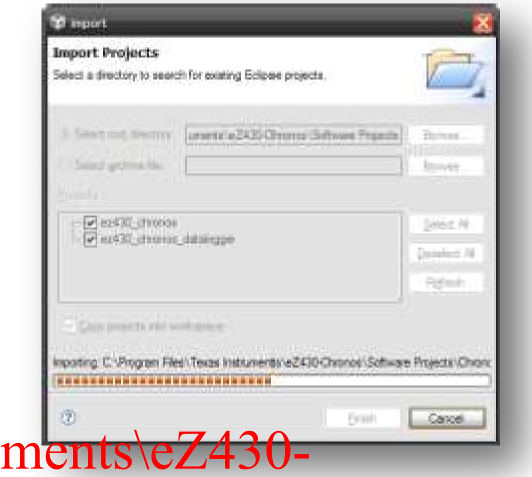
Chronos Software Package

- All files copied to C:\Program Files\Texas Instruments\eZ430-Chronos
- What‘‘s included:
  - Control Center
    - Control Center GUI binary
    - Data logger GUI binary
    - GUI source code
  - Documentation
    - Chronos User Guide
    - Schematics, Layout (Gerbers) & BOM
      - RF Access Point
      - eZ430 Debug Interface
      - Watch

- RF Access Point Driver
- Binary images (Recovery)
  - Sports watch/Chronos
  - Datalogger app
  - rfBSL
  - RF Access Point
- Software projects
  - Sports watch (CCS/IAR)
  - Datalogger (CCS/IAR)
  - RF Access Point (IAR)

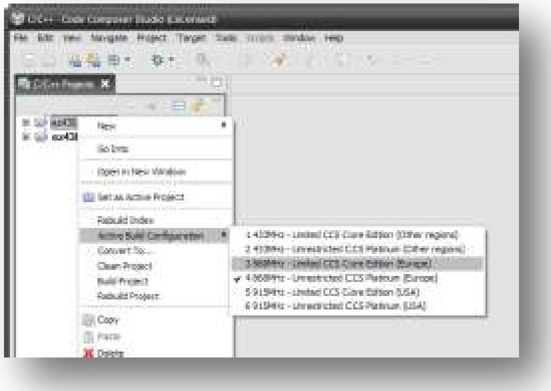
Working with the Chronos Project (CCS)

- Open CCS
  - Pick any workspace
  - Close welcome screen
- Import Project
  - Project > Import existing…
  - Browse to C:\Program Files\Texas Instruments\eZ430-Chronos\Software Projects
  - Select „Copy Projects into workspace"


Import
Import Projects
Select a directory to search for existing Eclipse projects.
○ Select root directory:
uments\eZ430-Chronos\Software Projects
Browse...
○ Select archive file:
Browse...
Projects:
☑ ez430_chronos
☑ ez430_chronos_datalogger
Select All
Deselect All
Refresh
□ Copy projects into workspace
Finish
Cancel

Importing: C:\Program Files\Texas Instruments\eZ430-Chronos\Software Projects\Chronc

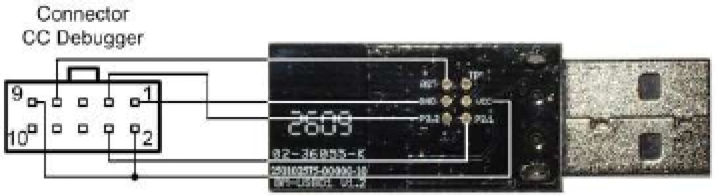
- Select „Active Project"
  - Right Click on project name
- Select „Active Build"
  - Select correct frequency & IDE version (core vs. full)
- Debug

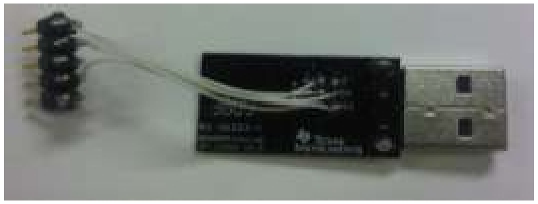

C/C++ - Code Composer Studio (Licensed)
File Edit View Navigate Project Target Tools Scripts Window Help
C/C++ Projects
ez430
ez430
New
Go Into
Open in New Window
Set as Active Project
Rebuild Index
Active Build Configuration
Convert To...
Clean Project
Build Project
Rebuild Project
Copy
Paste
Delete
1 433MHz - Limited CCS Core Edition (Other regions)
2 433MHz - Unrestricted CCS Platinum (Other regions)
3 868MHz - Limited CCS Core Edition (Europe)
✓ 4 868MHz - Unrestricted CCS Platinum (Europe)
5 915MHz - Limited CCS Core Edition (USA)
6 915MHz - Unrestricted CCS Platinum (USA)

Adding RFBSL to RF Access Point

- Hardware You‟ll need
  - – RF Access Point
  - – CC Debugger

- Add connector to RF AP





- Run “Smart RF Flash Programmer”
- Load RF Access Point

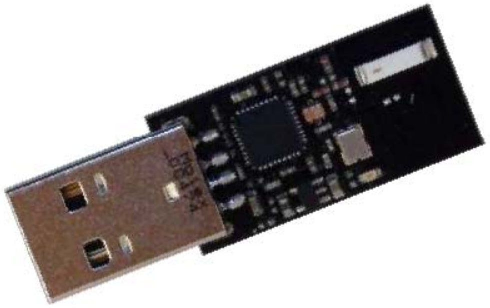
  Recovery image

- Erase, Program, & Verify

Adding RF BSL to Chronos Watch

- RF BSL includes a small RF protocol stack with error recovery
- Resides within reserved BSL memory
  - Accessing via IAR/CCS is *tricky*
- Easiest update method
  - Use Firmware Update Tool
  - Select correct script for watch frequency
  - Automatically updates BSL + User Application
- User App needs to be modified to invoke BSL from menus

Next lab:



1. get Chronos running with the default software. Demonstrate the accelerometer data on your PC.

2. Get Chronos talking to Amber wireless module

3. Use Chronos accelerometer to control remote LEDs

4. Stretch: Implement simple template-correlation-based gesture recognition to command remote LEDs to toggle