









**TI Technology Days 2010**

# **Die neue Generation des MSP430**

**Von kleinem Preis bis höchste Leistung**

**Andreas Görgner, Texas Instruments**

# TI Embedded Processing Portfolio

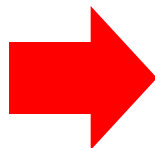
Microcontrollers			ARM-Based		DSP
16-bit MCU	32-bit Real-time MCU	32-bit ARM MCU	ARM+	ARM + DSP	DSP
<b>MSP430</b> Ultra-Low Power Up to 25 MHz Flash 1 KB to 256 KB Analog I/O, ADC, LCD, USB, RF Measurement, Sensing, General Purpose \$0.25 to \$9.00 	<b>C2000™</b> Fixed & Floating Point Up to 300 MHz Flash 32 KB to 512 KB PWM, ADC, CAN, SPI, I²C Motor Control, Digital Power, Lighting, Sensing \$1.50 to \$20.00 	<b>Stellaris Cortex M3</b> Industry Std Low Power Up to 100 MHz Flash 8 KB to 256KB USB, ENET, ADC, PWM, CAN Host Control, communications, motor control \$1.00 to \$7.00 	<b>ARM9 Cortex A-8</b> Industry-Std Core, High-Perf GPP Accelerators MMU USB, LCD, MMC, EMAC Linux/WinCE User Apps \$8.00 to \$35.00 	<b>C64x+ plus ARM9/Cortex A-8</b> Industry-Std Core + DSP for Signal Proc. 4800 MMACs/ 1.07 DMIPS/MHz MMU, Cache VPSS, USB, EMAC, MMC Linux/Win + Video, Imaging, Multimedia \$12.00 to \$65.00 	<b>C647x, C64x+, C55x</b> Leadership DSP Performance 24,000 MMACS Up to 3 MB L2 Cache 1G EMAC, SRIO, DDR2, PCI-66 Comm, WiMAX, Industrial/ Medical Imaging \$4.00 to \$99.00+ 



# MSP430 Overview & Roadmap

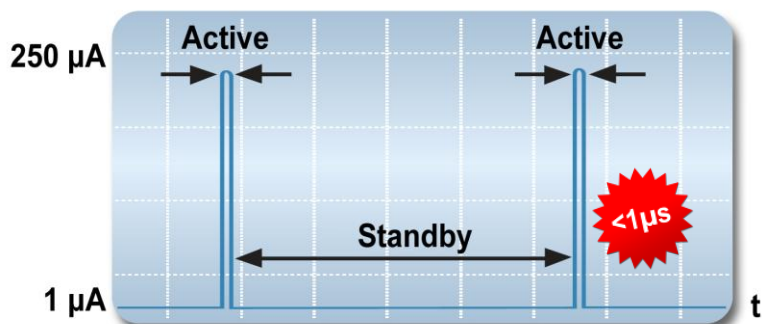
# Ultra-Low-Power is in Our DNA

- Every aspect of the MSP430 designed for ULP
- Peripherals optimized to reduce power and minimize CPU usage
- Intelligent, low power peripherals can operate independently of CPU and let the system stay in a lower power mode longer



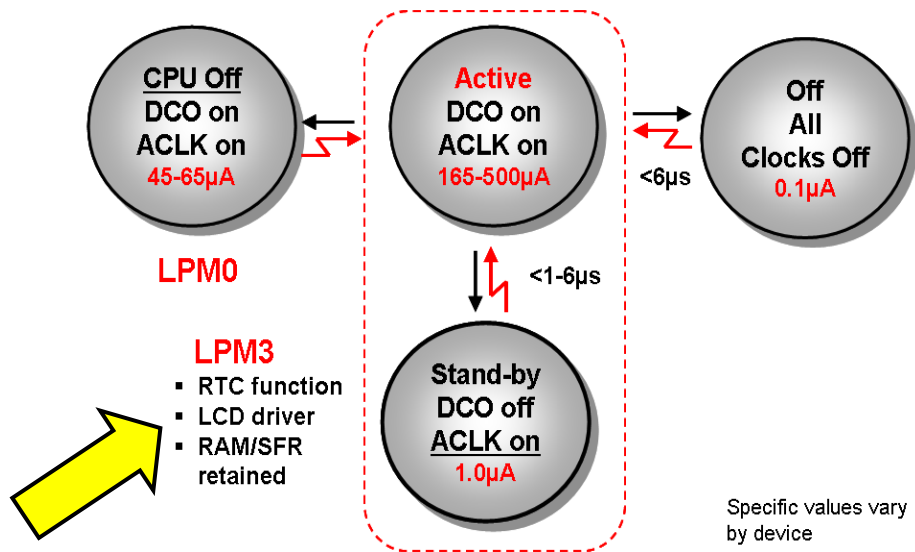
- ✓ Multiple operating modes
  - 0.1µA power down; 0.8µA standby; 160µA / MIPS
- ✓ Instant-on **stable** high-speed clock
- ✓ 1.8 - 3.6V **single-supply** operation
- ✓ **Zero-power** BOR
- ✓ **<50nA** pin leakage
- ✓ CPU that minimizes cycles per task
- ✓ Low-power intelligent peripherals
  - ADC that automatically transfers data
  - Timers that consume negligible power
  - 100 nA analog comparators
- ✓ Performance over required operating conditions

## Ultra-Low Power Activity Profile



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

## MSP430 Low Power Modes



# Ultra-Low-Power + High Performance



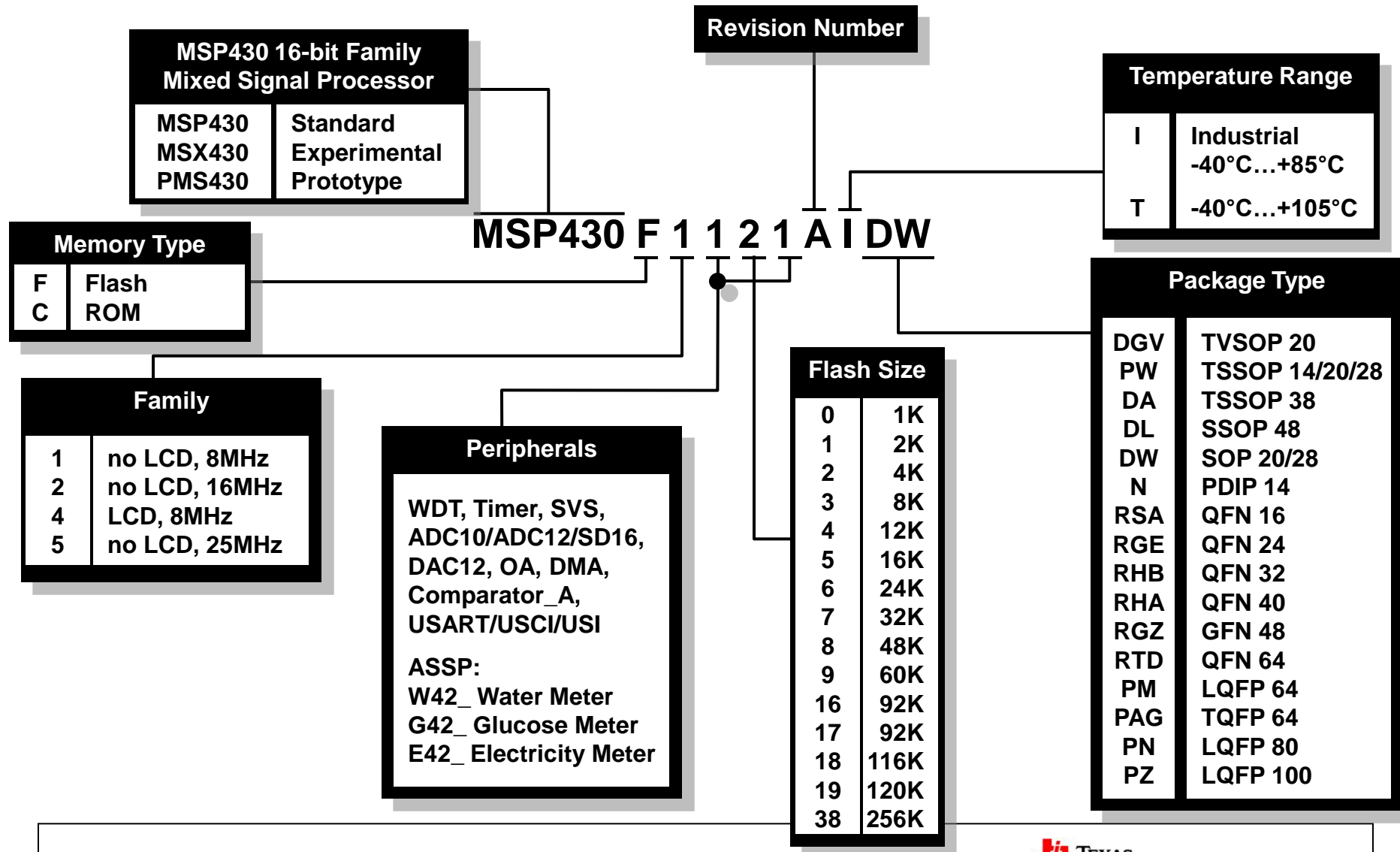
## **Device Configurations**

- 16-bit RISC CPU up to 25MHz
- 1-KB to 256-KB ISP Flash
- RAM up to 16 KB
- 0.1uA power down, 0.8uA standby
- 160uA/Mhz
- 1us clock startup
- 14- to 113-pin options

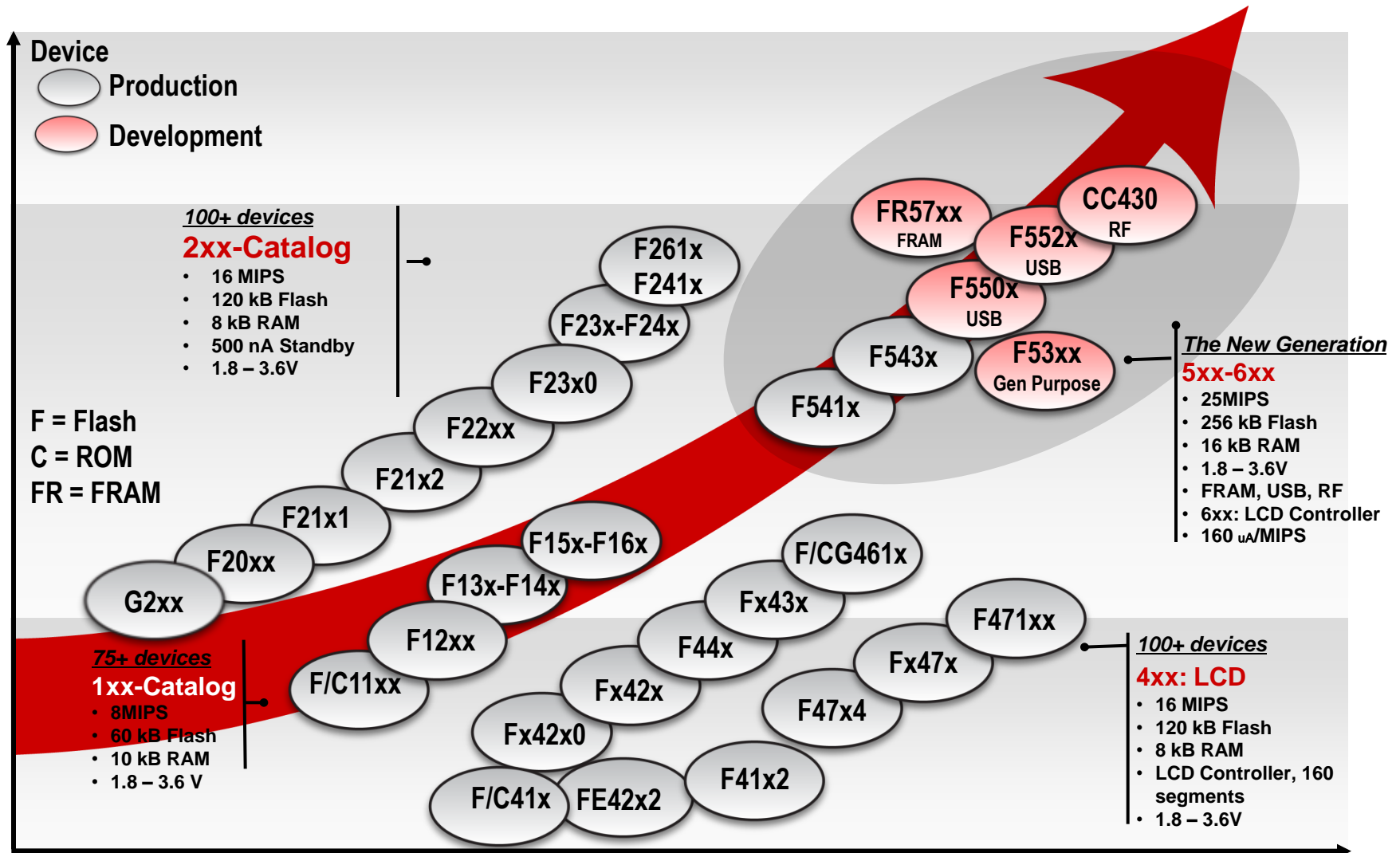
## **Integrated Peripherals**

- 10-/12-bit SAR ADC
- 16-bit Sigma Delta ADC
- 12-bit DAC
- Comparators and Op Amps
- LCD driver
- Supply Voltage Supervisor (SVS) & BOR
- 16-bit and 8-bit timers; WDT
- I2C, SPI, UART/LIN, IrDA
- 16 & 32-bit Hardware multipliers
- RTC
- DMA controller
- Temperature sensors

# MSP430 Nomenclature



# MSP430 Portfolio + Roadmap



# MSP430 Generations

1xx	2xx	4xx	5xx
Basic Clock System	Basic Clock System +	FLL, FLL +	Unified Clock System UCS
Core voltage same as supply voltage	Core voltage same as supply voltage	Core voltage same as supply voltage	Programmable Core Voltage with integrated PMM
16-bit CPU	16-bit CPU, CPUX	16-bit CPU, CPUX	16-bit CPUXV2
GPIO	GPIO w/ pull-up and pull-down	GPIO	GPIO w/pull-up and pull-down, drive strength
N/A	N/A	N/A	CRC16
Software RTC	Software RTC	Software RTC with Basic Timer, Basic Timer + RTC	True 32-bit RTC w/Alarms
USART	USCI, USI	USART, USCI	USCI, USB, RF
DMA up to 3-ch	DMA up to 3-ch	DMA up to 3-ch	DMA up to 8-ch
MPY16	MPY16	MPY16, MPY32	MPY32
ADC10,12	ADC10,12	ADC12	ADC12_A
4-wire JTAG	4-wire JTAG, some devices with Spy-Bi-Wire	4-wire JTAG	4-wire JTAG and Spy-Bi-Wire



# MSP430 Generations – Low Power Profile

		2xx	4xx	5xx
CPU Clock (Max)		16MHz	8 & 16 MHz	25MHz
Flash/RAM		2,4,8 KB / .25, .5, 1 kB (F21x2)	4, 8, 16, 32 kB/ .25, .5, 1 KB (F41x)	256KB / 16KB (F54xx)
Active Current (3.0V) µA/MIPS	1MHz	300 µA	240 µA	220µA
	8MHz	325 µA/MIPS	240 µA/MIPS	<u>160 µA/MIPS</u>
	16MHz(3.3V)	360 µA/MIPS	N/A	188 µA/MIPS
	25MHz	N/A	N/A	224 µA/MIPS
Standby Current (LPM3)		<u>0.3 – 0.8µA</u>	.7 – 1.5µA	2.6µA (w/ active true RTC)
Power Down Current (LPM4/5)		0.1µA	0.1µA	1.6µA (LPM4) / 0.1µA (LPM5)
Wake-up Time From LPM3		<u>1µs</u>	6µs	5µs
Flash ISP Minimum DV <sub>CC</sub>		2.2V	2.7V	<u>1.8V</u>
Port I/O Interrupt Capability		P1/P2	P1/P2	P1/P2 (F5438) Add'l pins in ...
Prog. Port Pin Drive Strength		N/A	N/A	All port pins
Prog. Pull-ups/-downs		All port pins	N/A	All port pins
Available MCLK Sources		DCO, VLO, LFXT1, XT2	FLL, LFXT1, XT2	FLL, VLO, REFO, XT1, XT2
FLL Reference Clocks		N/A	LFXT1	REFO, XT1, XT2

Lowest active power in the industry

Lowest stand-by

Fastest wakeup

Write to Flash at min Vcc

# MSP430 Package Options

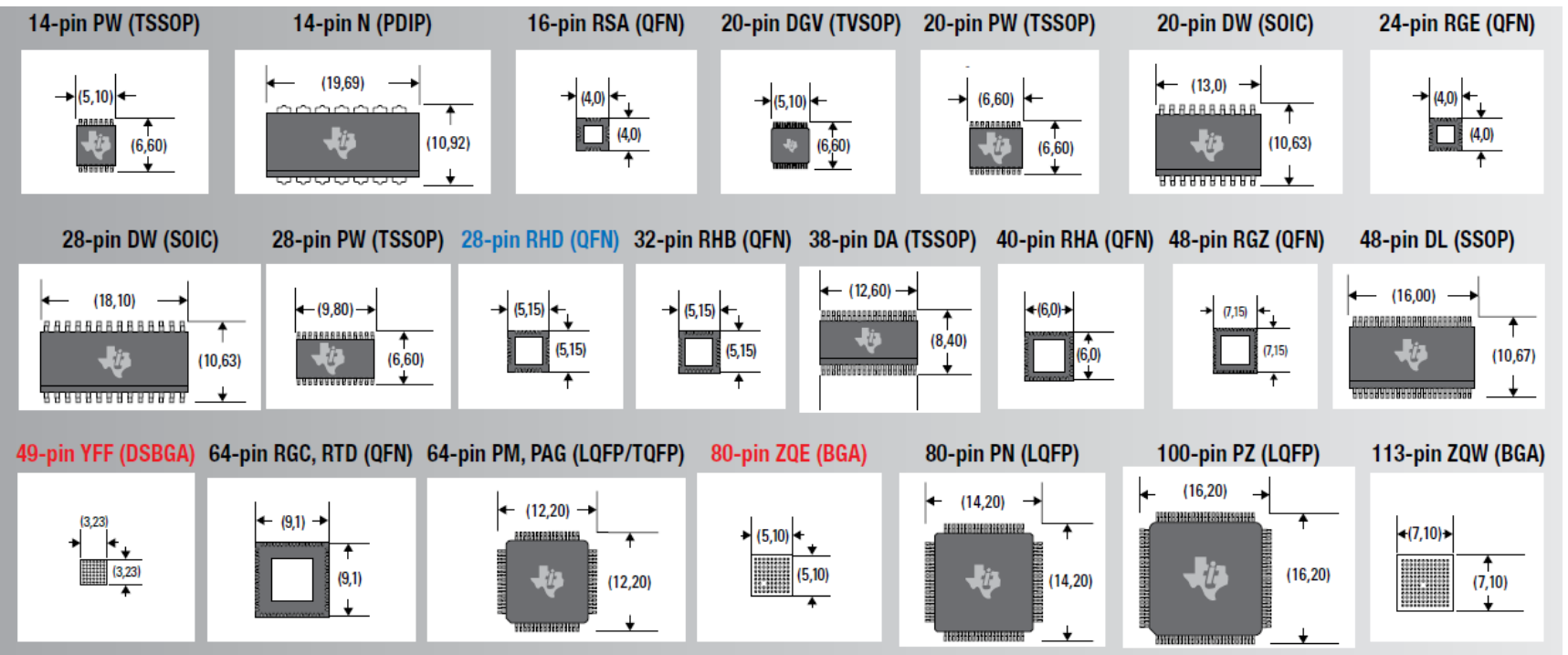
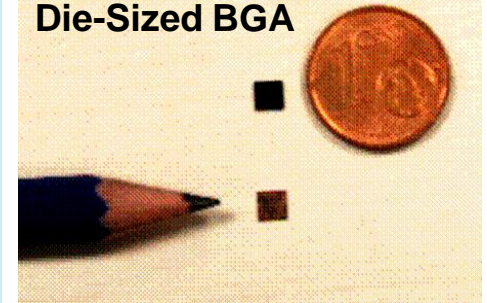
## Flexible Options to fit your need

- Many Package types
- Wide range from 14 to 113 pin devices

## Miniaturization to enable small-sized design

- MSP430F2370 available in Die-Sized BGA
- 49-pin; 3.232mm x 3.232mm

MSP430  
Die-Sized BGA



Red: New

Blue: Preview

# MSP430 with Full Speed USB

- **Ultra-low power MCUs + USB for smarter connectivity**
  - Embedded full-speed USB 2.0 (12 Mbps)
  - High flexibility with configurable 2K data buffers that can be used as RAM
  - Unused USB interface pins can function as high-current I/O (5v tolerant)
- **Analog and peripheral integration reduces system cost**
  - Multiple analog options with 10 or 12-bit ADC, DAC, comparator
  - Integrated 3.3V LDO for use with 5V USB bus power
  - Uses low-cost crystal for USB clock, with flexible, integrated PLL
- **44 New USB devices within next 12 months**
  - Wide range of memory configurations and package options, 8k-128k flash
  - Diverse peripheral mix in the MSP430F55xx family
  - Pricing as low as \$0.96 in volume

## USB Made Easy

### USB Bootstrap Loader

- Supporting device programming
- Field Firmware updates

### USB Descriptor Tool

- Configures stack functions via GUI

### Free USB stacks available:

- Communication Device Class (CDC)
- Human Interface Device (HID)
- Mass Storage Class (MSC)
- Additional stacks available from third parties



**FREE**  
Vendor ID/  
Product ID  
sharing  
program

**MSP430F5529 Sample Kit**

# MSP430 Value Line



# MSP430G2xx - Value Line Family

## Ultra Low Cost family:

- Volume pricing starting at **\$0.25**
- Maintains the MSP430 DNA (ULP, Analog Integration, Ease of Use)

## Phase 1: Launch April 2010

- 0.5 KB – 2 KB Flash
- Analog/communication modules: Comparator, 10-bit ADC, SPI/I2C
- 3 package types (DIP, TSSOP, QFN)
- Pin compatibility across MSP430 Value Line family and MSP430F20xx family



Part Number	Flash (KB)	SRAM (B)	I/O	Timers		Watchdog	BOR	USI: I <sup>2</sup> C/SPI	Comp_A+	Temp Sensor	ADC Ch/Res	1kU Price <sup>#</sup>
				Total	A*							
MSP430G2001	0.512	128	10	1	2	■	■					\$0.34
MSP430G2101	1	128	10	1	2	■	■					\$0.44
MSP430G2121	1	128	10	1	2	■	■	1				\$0.46
MSP430G2201	2	128	10	1	2	■	■					\$0.47
MSP430G2221	2	128	10	1	2	■	■	1				\$0.48
MSP430G2111	1	128	10	1	2	■	■		■			\$0.46
MSP430G2211	2	128	10	1	2	■	■		■			\$0.48
MSP430G2131	1	128	10	1	2	■	■	1		■	8ch ADC10	\$0.49
MSP430G2231	2	128	10	1	2	■	■	1		■	8ch ADC10	\$0.52

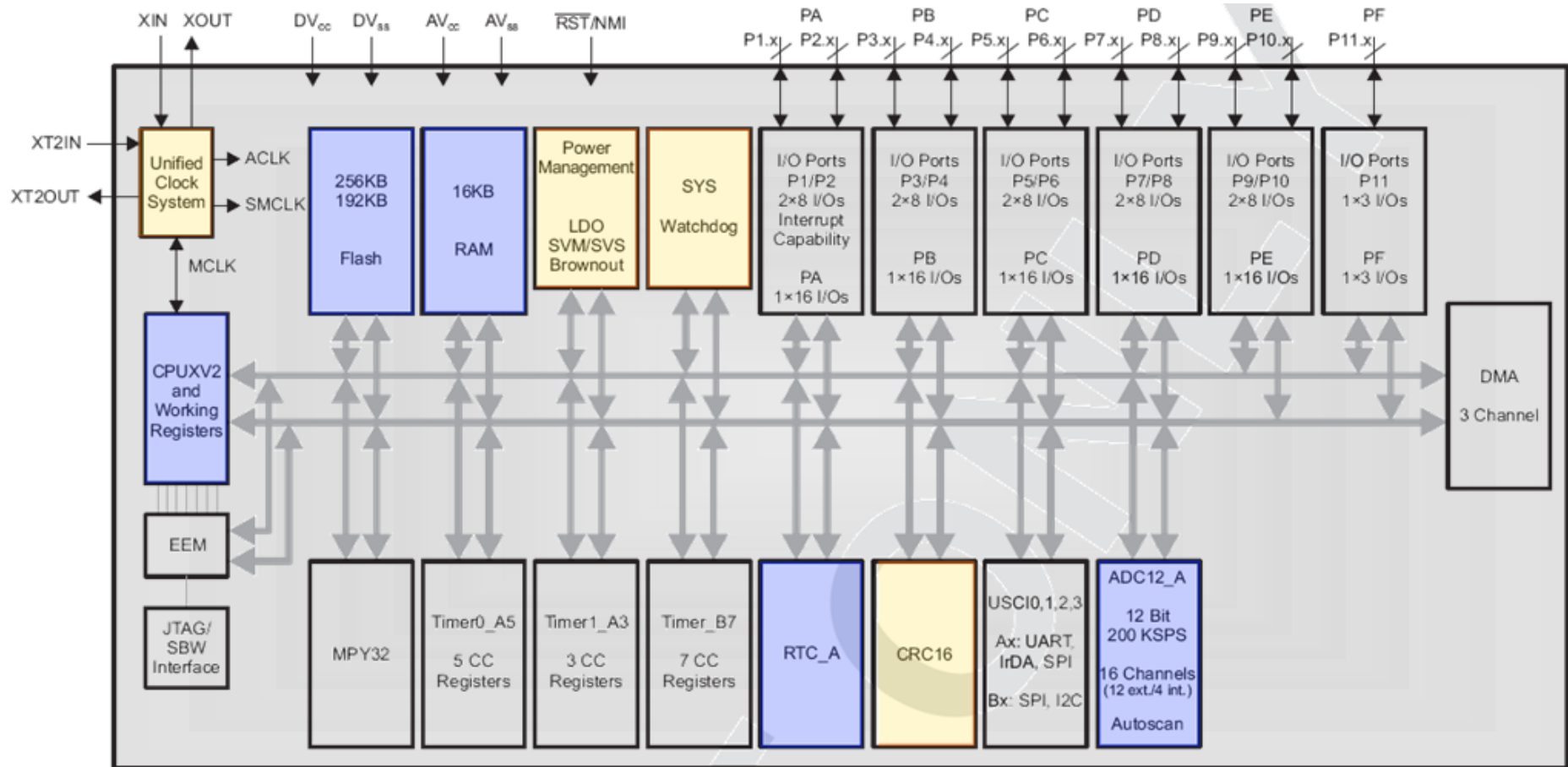
# Prices are quoted in U.S. dollars and represent year 2010 suggested resale price for TSSOP package.

\* Represents number of capture/compare registers per timer.

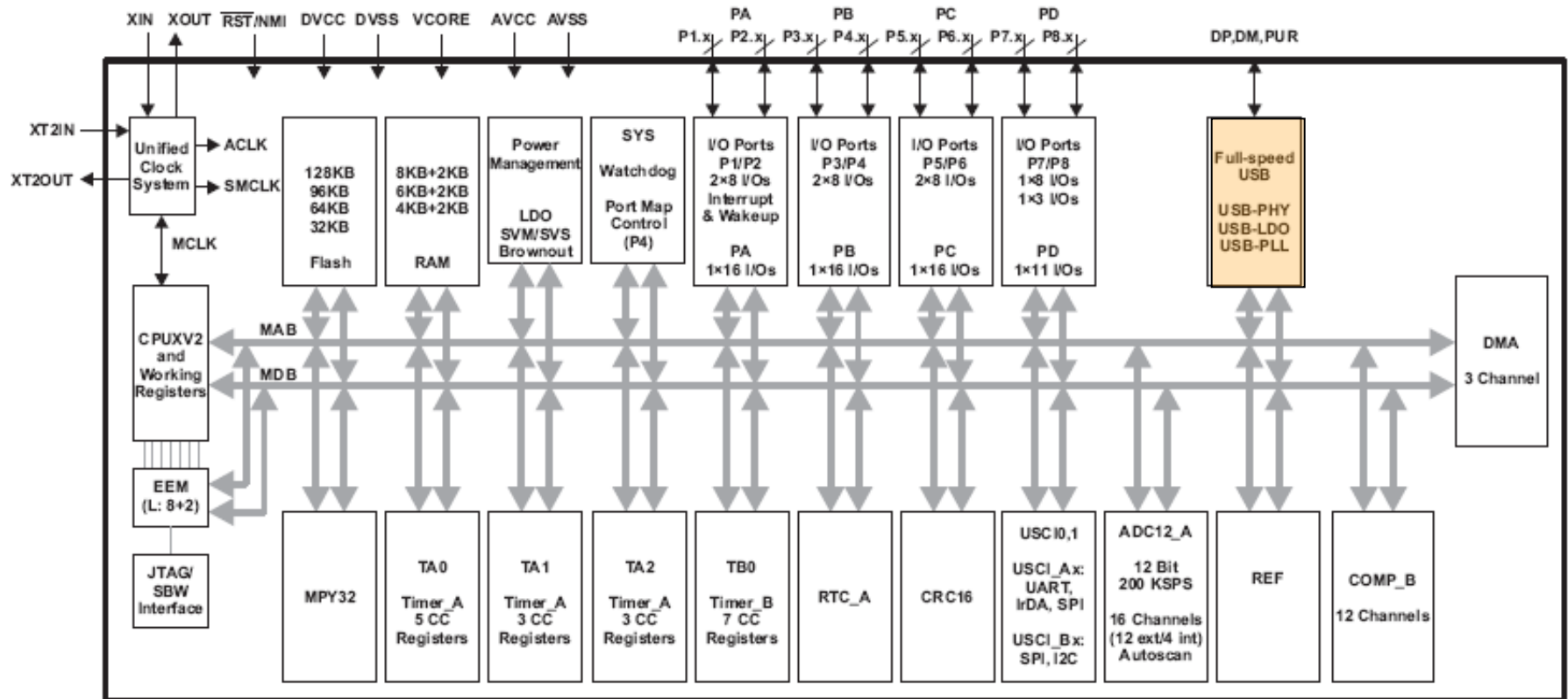
# MSP430F5x Generation



# Block Diagram MSP430F5438

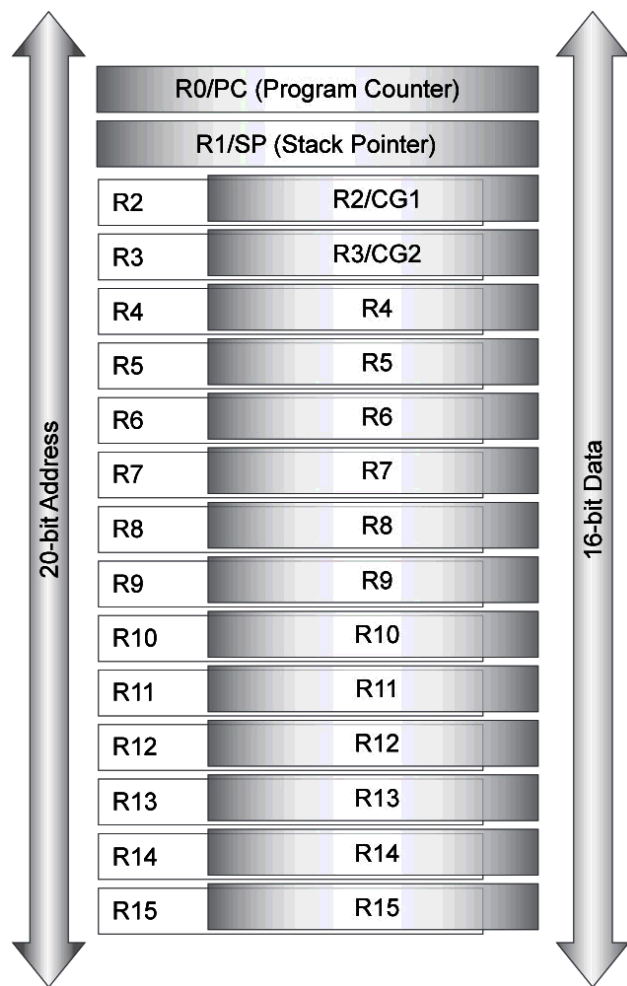


# Block Diagram MSP430F5529





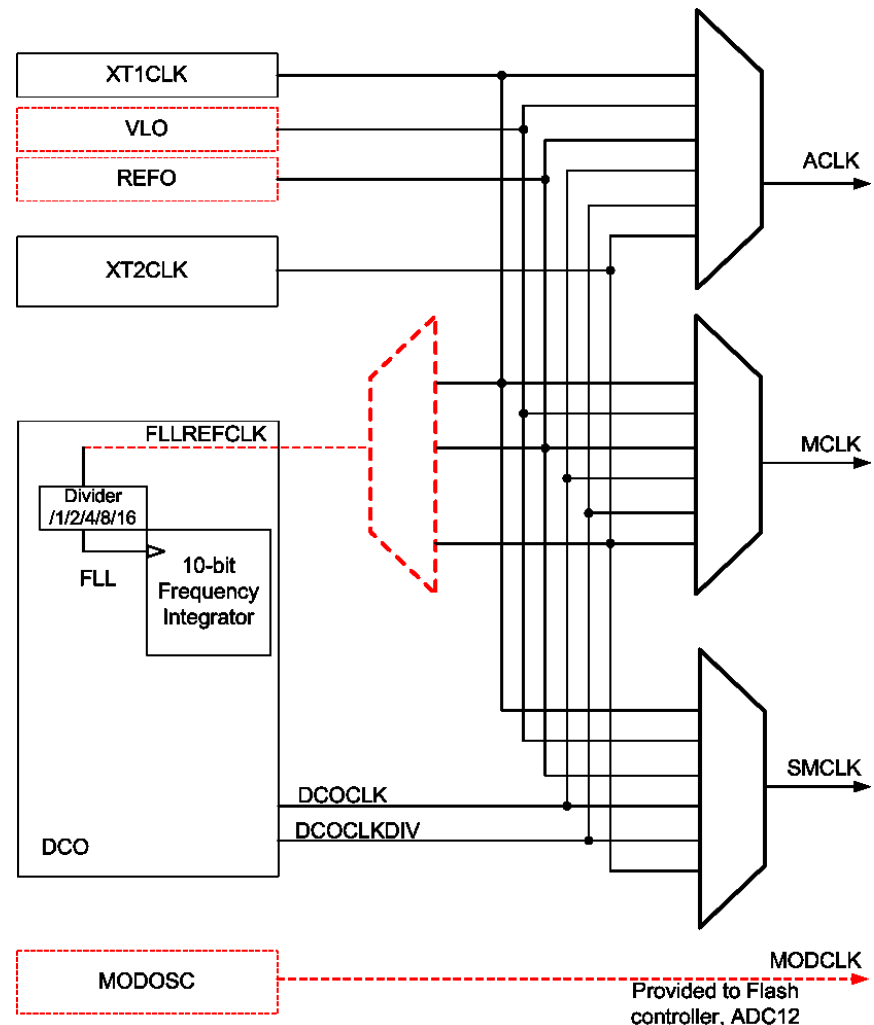
# 5xx MSP430Xv2 Orthogonal CPU



- C-compiler friendly
- Memory address increased to 1MB
- CPU registers increased to 20-bits
- Address-word instructions
  - Direct 20-bit CPU register access
  - Atomic (memory-to-memory) instructions
- Instruction compatible w/previous CPU
- Cycle count optimization
- Extension word allows all instructions
  - Direct access to 1MB address space
  - Bit, byte, word and address-word data
  - Repeat instruction function

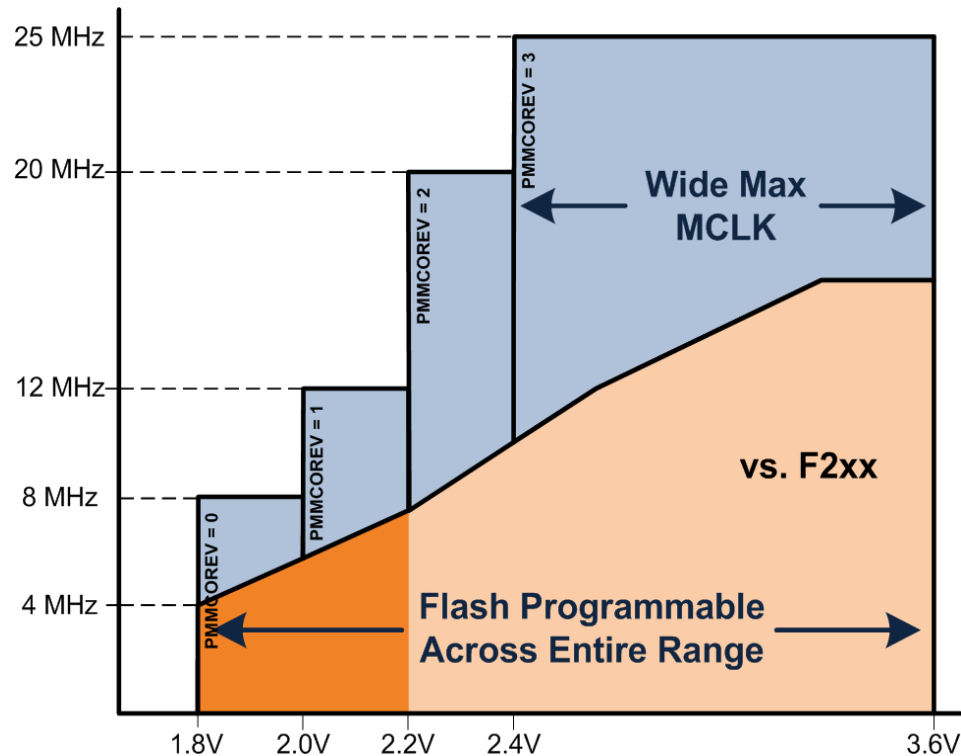
# Unified Clock System (UCS)

- Six independent clock sources
  - Low Freq
    - LFXT1 32768 Hz crystal
    - VLO 10 kHz
    - REFO 32 kHz
  - High Freq
    - XT1 4 – 32 MHz crystal
    - XT2 4 – 32 MHz crystal
    - DCO FLL multiple of reference clock
- FLL references are **divisible**
  - LFXT1 / XT1
  - REFO
  - XT2
- ACLK / SMCLK / MCLK tree is fully **orthogonal**
- MODOSC provided to modules
  - Flash controller & ADC12\_A
- Clocks **on demand**



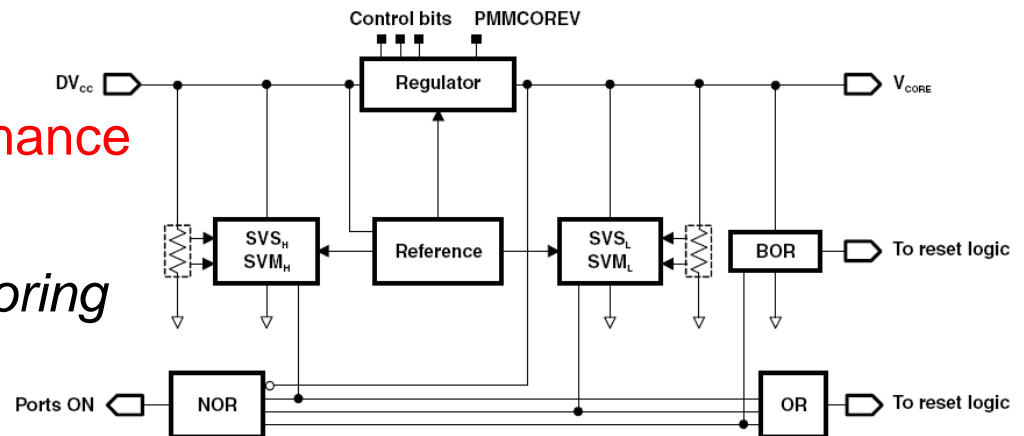
# 5xx Operating Range

- 25MHz peak performance
- More performance across  $V_{CC}$  range
  - **Flash ISP @ min.  $V_{CC}$**
  - **8MHz @ min.  $V_{CC}$**
  - **Up to 25MHz @ 2.4V-3.6V**
- Programmable  $V_{CORE}$  maximizes power efficiency
- Lowering  $V_{CC}$  or  $V_{CORE}$  reduces system current

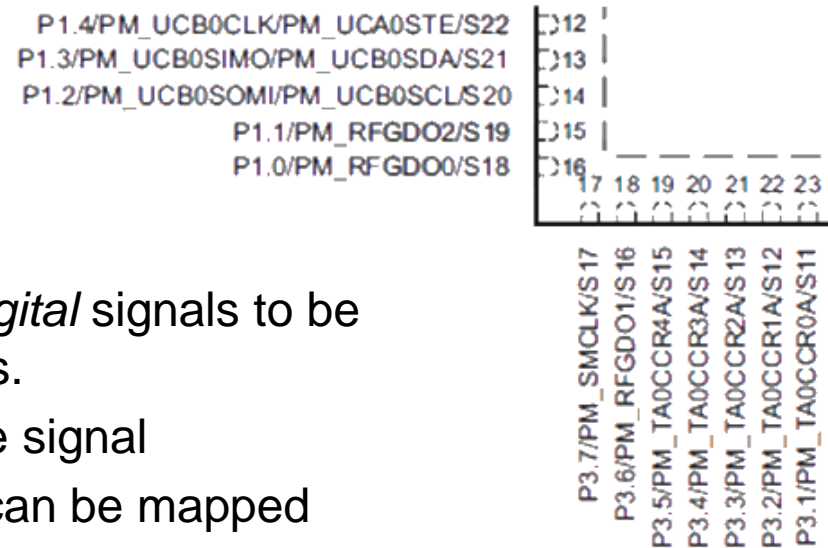


# Power Management Module (PMM)

- Integrated LDO
- $V_{\text{CORE}}$  level programmable
- Flexibility in processing performance vs. power
- Integrated *supervision & monitoring*
- *Zero-power* BOR
- Five integrated mechanisms
  - SVSH, SVSL, SVMH, SVML & BOR



# 5xx Peripherals – Port Map Module

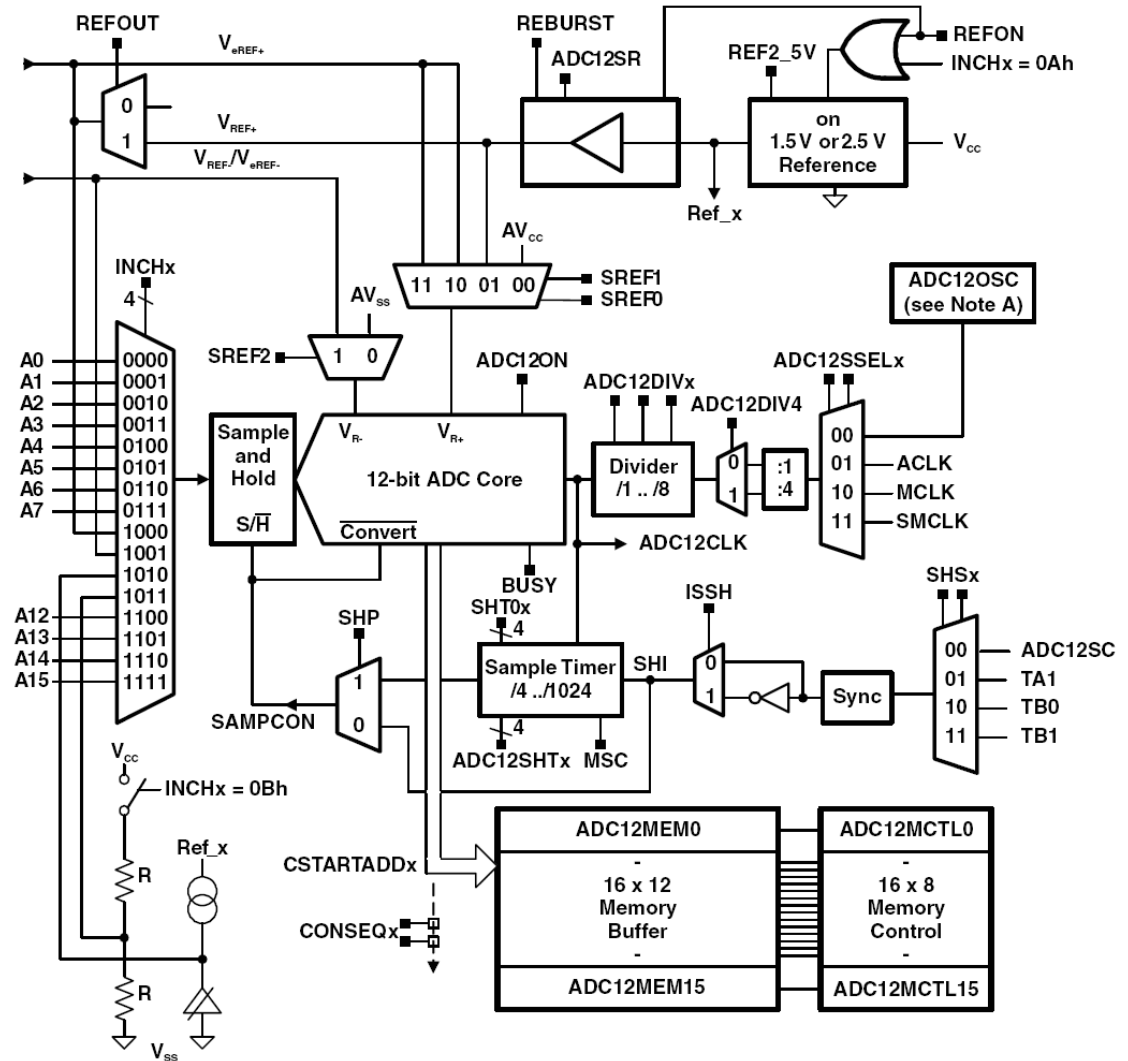


- Port mapping allows for additional *digital* signals to be mapped to one or several output pins.
  - PM\_xxx denotes a port-mappable signal
  - Datasheet specifies which ports can be mapped
- By default, single configuration per PUC reset
  - Port Mapping Reconfigure bit (PMRECNFG) allows for runtime re-configurations
- Port mapping configuration is password protected
- Available on select MSP430 families. Check the datasheet!

# ADC12\_A

## Improved ADC12:

- Higher supply voltage range 2.2V...3.6V
- Lower supply current 1.3mA -> 300uA
- Fast REF wake-up 17ms -> 40us
- 12 individually configurable external input channels

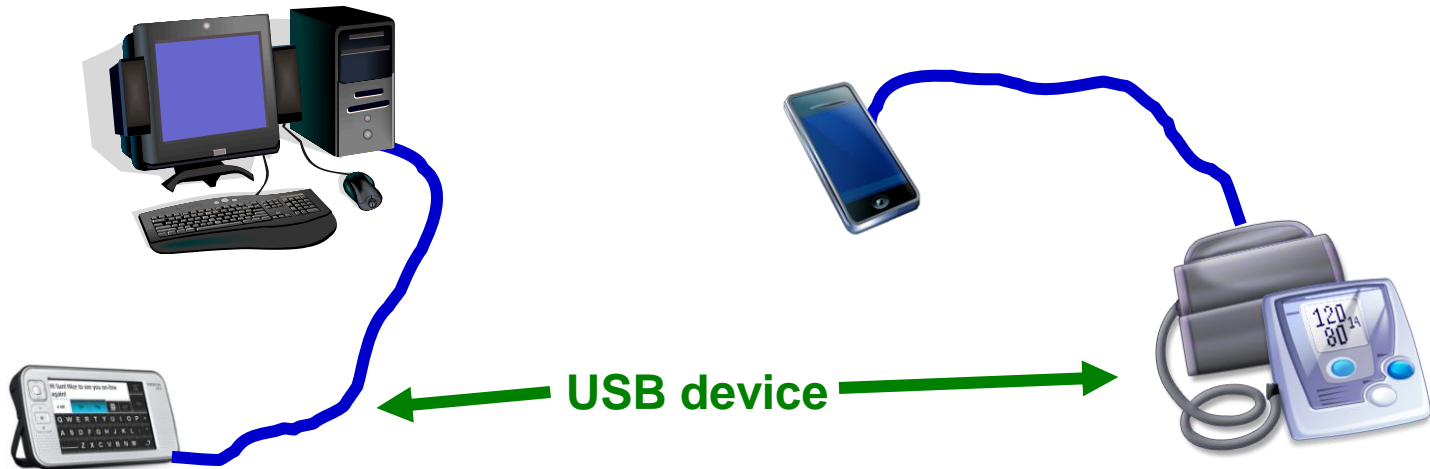


# MSP430F5x USB



# Bus Speed/Role

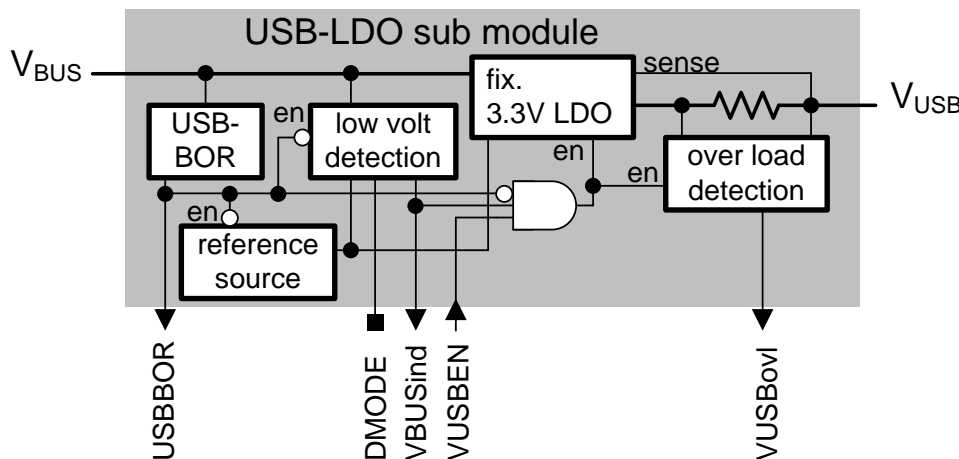
- **MSP430's USB is a full-speed *device***, for applications such as:
  - Uploading data from a mobile device to a host (PC, cell phone, PDA, etc.)
  - Downloading a firmware update from a host
  - Controlling/configuring the device from a host





# USB Module - Power System

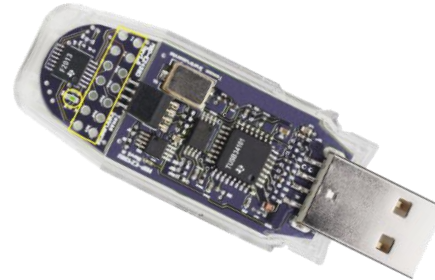
- Integrated LDO with 5V input and protection/monitoring functions, for use with USB bus power
- Outputs 20mA for MSP430 and system use
- Current limiting capability to  $IDET_{max}=60mA$  on  $V_{USB}$  (3.3V output)
- Independent from 5xx's power management module (PMM)
- Can be powered from USB upon device connection, even if no battery power available (low/no battery condition)



- Prepared for operation with USB battery chargers
- Concept prevents battery drainage to an unpowered, low-resistive USB network
- Controlled through the USB configuration registers

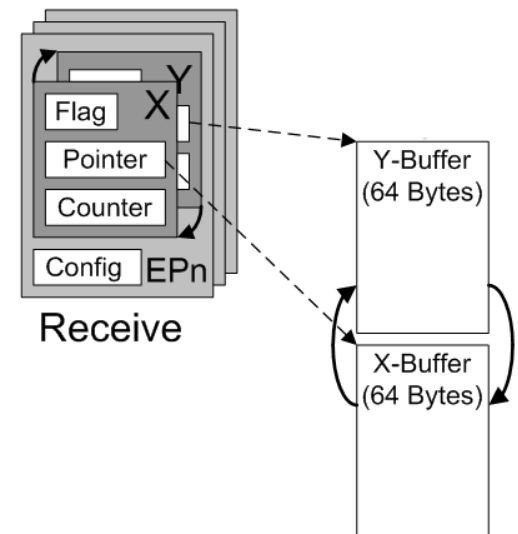
# Endpoints

- **MSP430's USB has:**
  - Eight input endpoints
  - Eight output endpoints
  - Complete flexibility!
- **Integrated *transceiver***
  - USB's term for the PHY
- **2KB USB buffer RAM**
  - Can also be used as system RAM if USB disabled
- **USB signalling pins (D+/D-) can serve as general-purpose high-current I/Os (~100mA)**
- **Timestamp generator, with 62.5ns resolution**



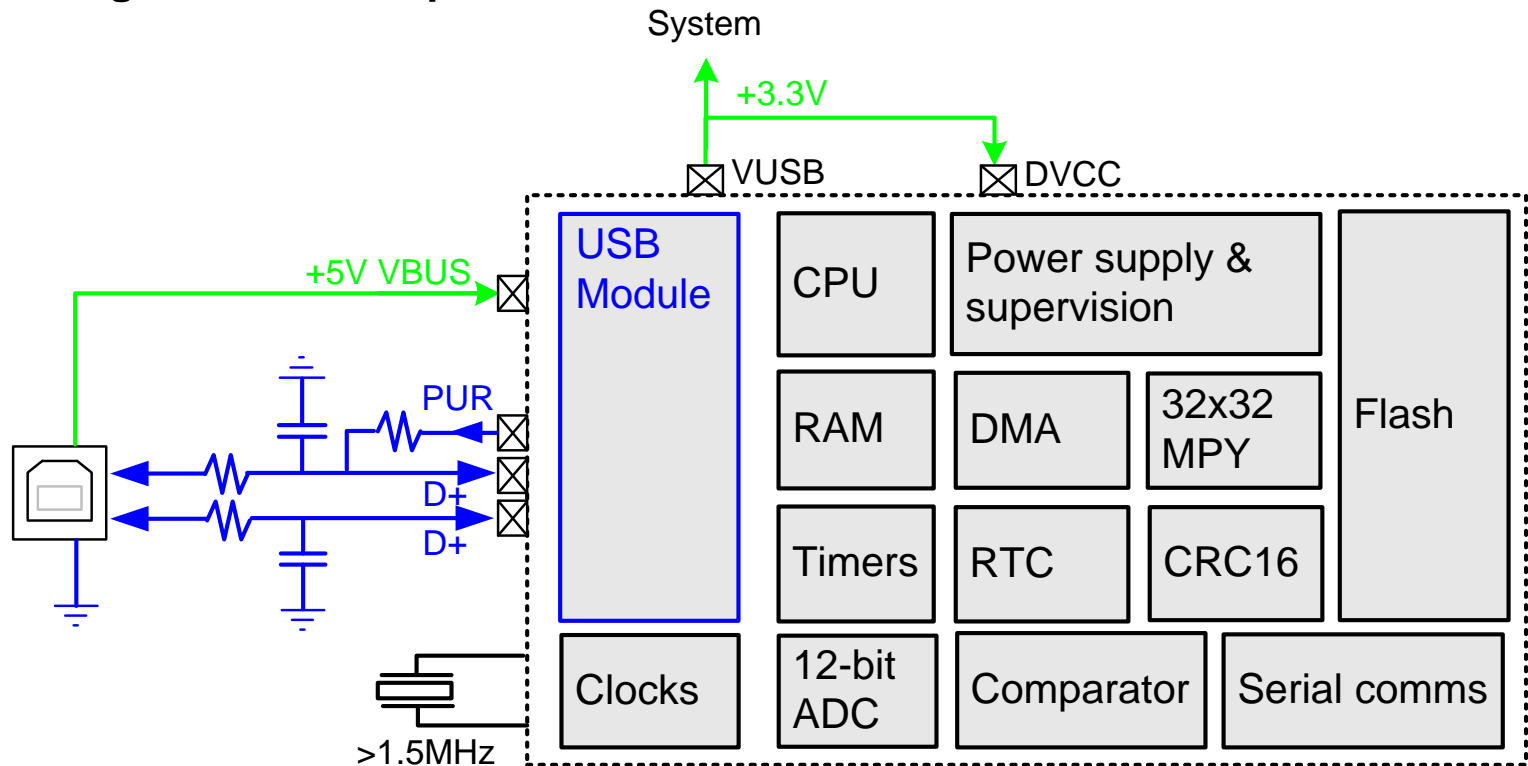
# USB Memory & Data Transfer

- 1904 bytes of configurable buffer space for IN/OUT endpoints 1-7
- Each endpoint uses an automatic double-buffered scheme
  - Automatically toggles between X/Y buffers
  - Aids throughput
- Each endpoint described by six registers
  - Endpoint type
  - X/Y buffer addresses in USB RAM
  - Buffer size
  - Number of bytes in X/Y buffers
- CPU/DMA loads data in/out of buffers; automatically TX/RX over USB



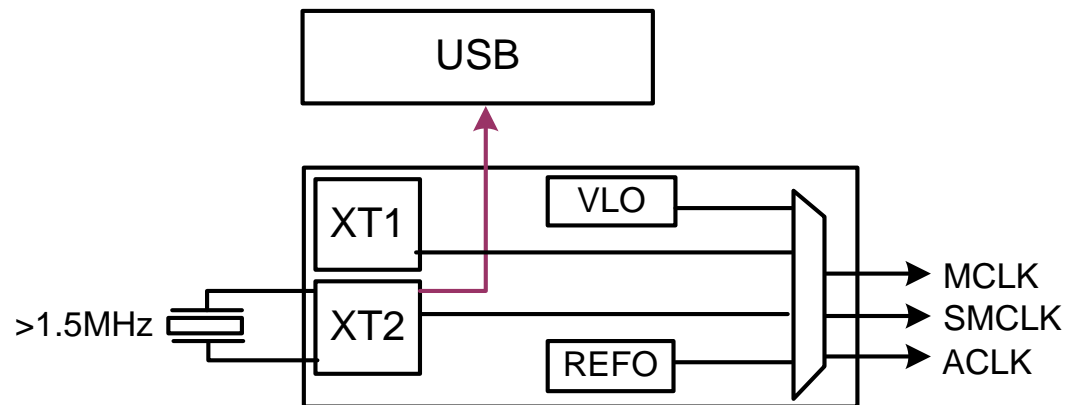
# MSP430 USB System

- Single-chip USB solution
- Just add USB connector & TI-supplied USB API software
- USB+analog and ultra-low-power!



# USB Clocking

- **USB clocked from HF crystal on XT2 xtal oscillator**
  - XT2 can also be used for system clocks, as usual
- **Integrated PLL revs to 48MHz, required when USB is active**
  - Can be powered down during USB suspend, & re-activated when resumed
  - USB clocked from LF source during suspend
- **PLL is very programmable – can adapt to any crystal freq**
  - Choose a frequency used elsewhere in the system
  - Or use the cheapest crystal you can find
  - Minimum crystal frequency = 1.5MHz



# Support Approach & API Stacks

- **USB looks simpler than it is**
  - Expected to “just work”
  - A lot of protocol is involved; not like a UART or SPI port
  - But, the right support from the silicon vendor CAN make it easy
- **MSP430’s USB support is designed for ease-of-use**
  - Let’s you focus on *using* USB in your app, rather than *learning* USB as a technology
  - Our goal has been: to make using USB similar to using a UART
- **Our primary support tool: API stacks**
  - Essentially libraries, based on standard USB device classes
  - Can be edited (but shouldn’t be necessary for most apps)
  - Each stack supported by a complete Programmer’s Guide
  - Stacks will exist for the most common device classes (CDC/HID/MSC)

# Example: CDC API Calls

```
void main(void)
{
    init_WDT_Ports_Clocks();           // Initialize the system

    USB_init();                       // Initialize USB module
    USB_setEnabledEvents(kUSB_VbusOnEvent + kUSB_receiveCompletedEvent);
                                     // Select the events you will handle
    if (USB_connectionStatus() & kUSB_vbusPresent) // If already attached to
        USB_handleVbusOnEvent();           // USB, begin enumeration

    while(1)                          // Main loop
    {
        status = USB_connectionStatus(); // Are we attached to a live bus?
        if (!(status & kUSB_Enumerated) || (status & kUSB_suspended))
            __bis_SR_register(LPM3_bits + GIE); // If not, go into LPM3
        if (S1_event)                        // Button S1 pushed; send data
        {
            ret = USBCDC_sendData(text, sizeof(text), 1);
            S1_event = 0;
        }
    }
}
```

# MSP430 USB Portfolio Summary

## USB class implementations

### **Communications Device Class (CDC)**

Presented to PC as a COM port

High bandwidth (>1-6Mbps) + reasonable simplicity, but has an install process

Must WHQL-certify the driver with Microsoft then distribute for install by customers

### **Human Interface Device Class (HID)**

Presented to PC as an HID device

Simplicity (no install) but has limited bandwidth (64 kB/sec)

### **Mass Storage Class (MSC)**

Presented to PC as a storage volume

Moves large amounts of bulk data quickly

No driver install required; no files must be distributed

High bandwidth + no install process, but higher complexity and more code space

Involves obtaining file system software (purchase, or open-source)

**To be supported by 3rd parties: IAR, HCC**

### **Composite Class**

Coming from Texas Instruments...



# Device Class Tradeoffs

	CDC	HID	MSC
Simplicity on host	Yes	Yes	Yes
Simplicity on MSP430	Yes	Yes	No
Avoids user install process	No	Yes	Yes
High bandwidth	Yes	No	Yes
Code size	4K	4K	10-20K

Each class provides a unique value proposition

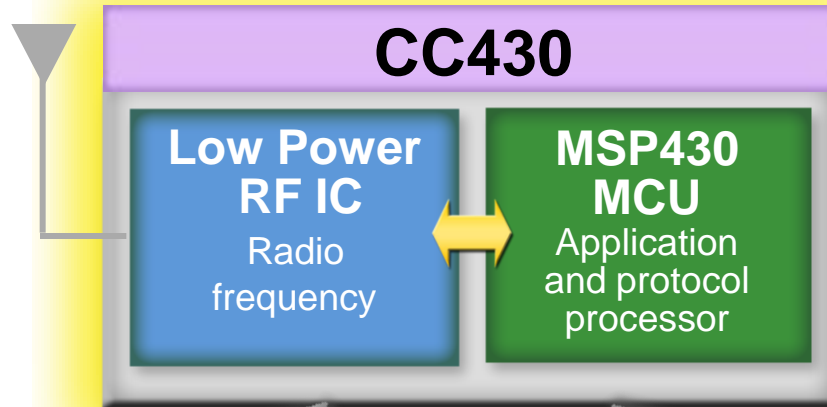


**MSP430F5x + LPRF = CC430**

# 5xx + Low-Power RF – The CC430

**Supports:**  
300-348MHz,  
387- 464MHz  
and 779-928MHz

**2.4 GHz MCM is  
intended for 2011**



**Low-power  
RF SoC**

**Low Power  
< 1 GHz RF  
Transceiver**

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

**MSP430  
5xx MCU**

- Ultra-low power
- High analog performance
- High level of integration
- Ease of development
- Sensor interface

**➔ For more information, attend our CC430 One-Day-Workshop!**

# MSP430 goes FRAM



# FRAM – The Wait Is Over

## Technology Attributes



Photo: forums.wow-europe.com



**Non-Volatile** – retains data without power

**Fast Write / Update** – RAM like performance. Up to ~ 50ns/byte access times today (> **1000x** faster than Flash/EEPROM)



**Low Power** - Needs **1.5V** to write compared to > **10-14V** for Flash/EEPROM → no charge pump

**Superior Data Reliability** - ‘Write Guarantee’ in case of power loss and > **100 Trillion** read/write cycles

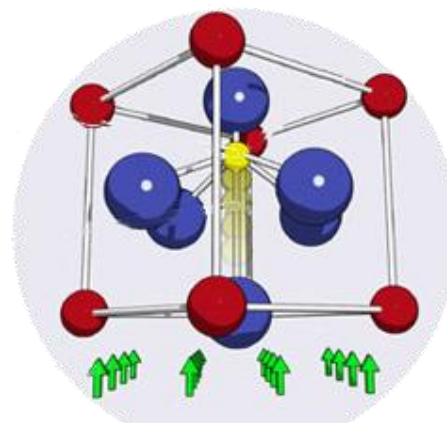
**RAMTRON**

*Automotive F-RAM Memory*

# What is FRAM Technology?

- FRAM

- Is like DRAM (1T-1C) except data stored in crystal state, not charge
  - Capable of read/write access and cycle times similar to DRAM
- Is a Random Access Memory - Each bit read/written individually
- Features a simple single step write process – no separate erase then write cycle (unlike Flash)



***Crystal  
Polarization  
Change***

Photo: Ramtron Corporation

# FRAM Technology Performance Comparison

	FRAM	EEPROM	Flash
Time to write 64 bytes to memory	1.6 $\mu$ s	2,200 $\mu$ s	6,400 $\mu$ s
Time to read 64 bytes from memory	1.6 $\mu$ s	4.5 $\mu$ s	4.5 $\mu$ s
Number of write cycles	100 trillion	500,000	100,000
Voltage needed to write	1.5 V	10 to 14 V	10 to 14 V
Manufacturing cycle time	–	>3×	3×
Resistance to gamma radiation	Yes	No	No

# MSP430 Tools





# Easy To Use, Innovative Tools



## Flash Emulation Tools

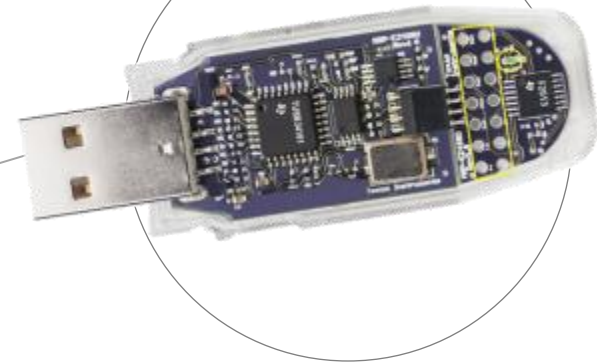
- Compatible with all devices
- Target boards available
- \$99 (\$149 w/ target board)
- Target boards available w/o FET
- Free IDEs included

## MSP430 Experimenter Boards

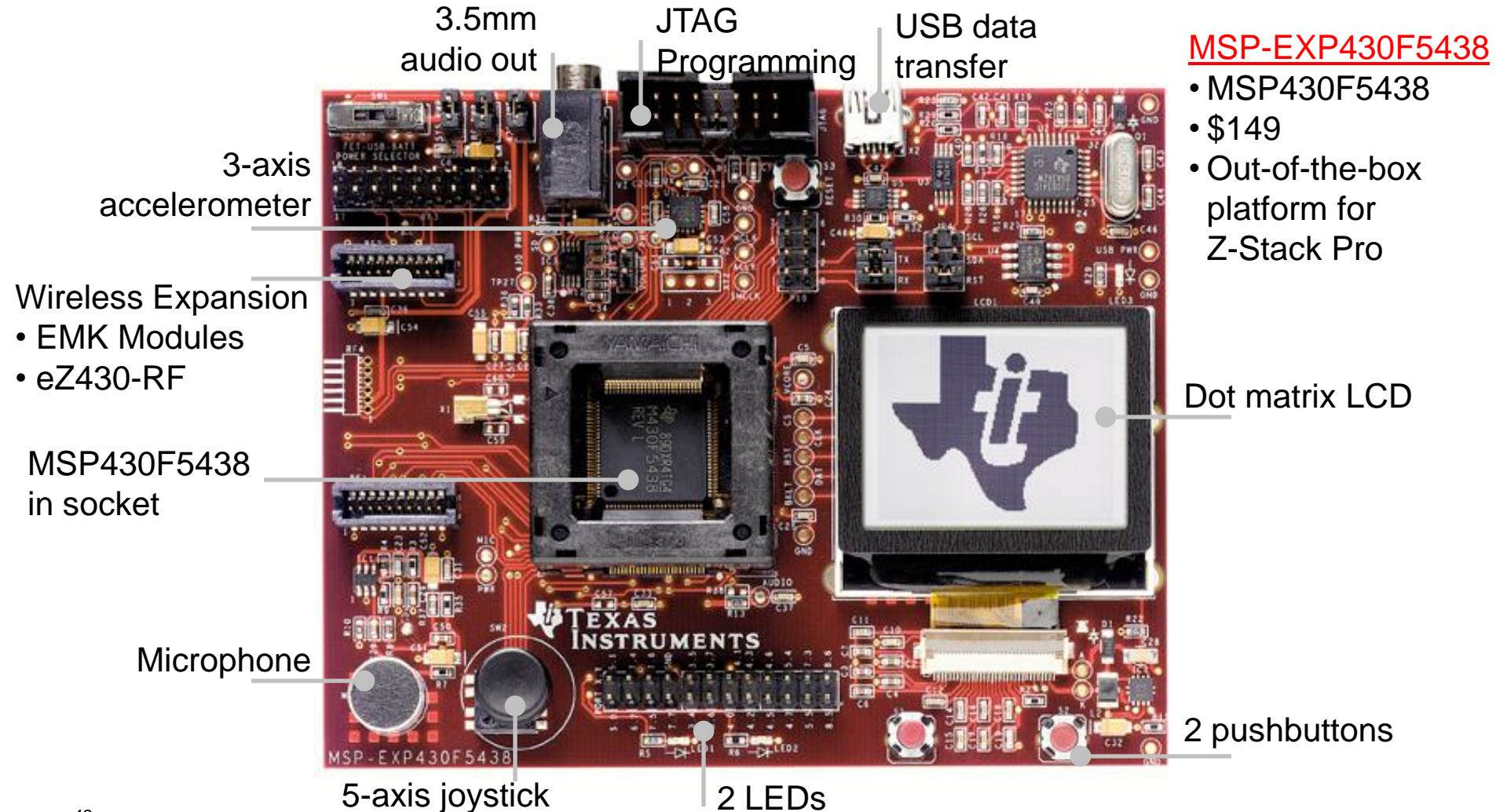
- Fully features prototyping system
- Available for FG4618 & F5438
- Starting at \$99

## eZ430 Tools

- Complete development system in USB stick
- Available for wireless and energy harvesting
- Starting at \$20



# EXP430F5438 Experimenter Board



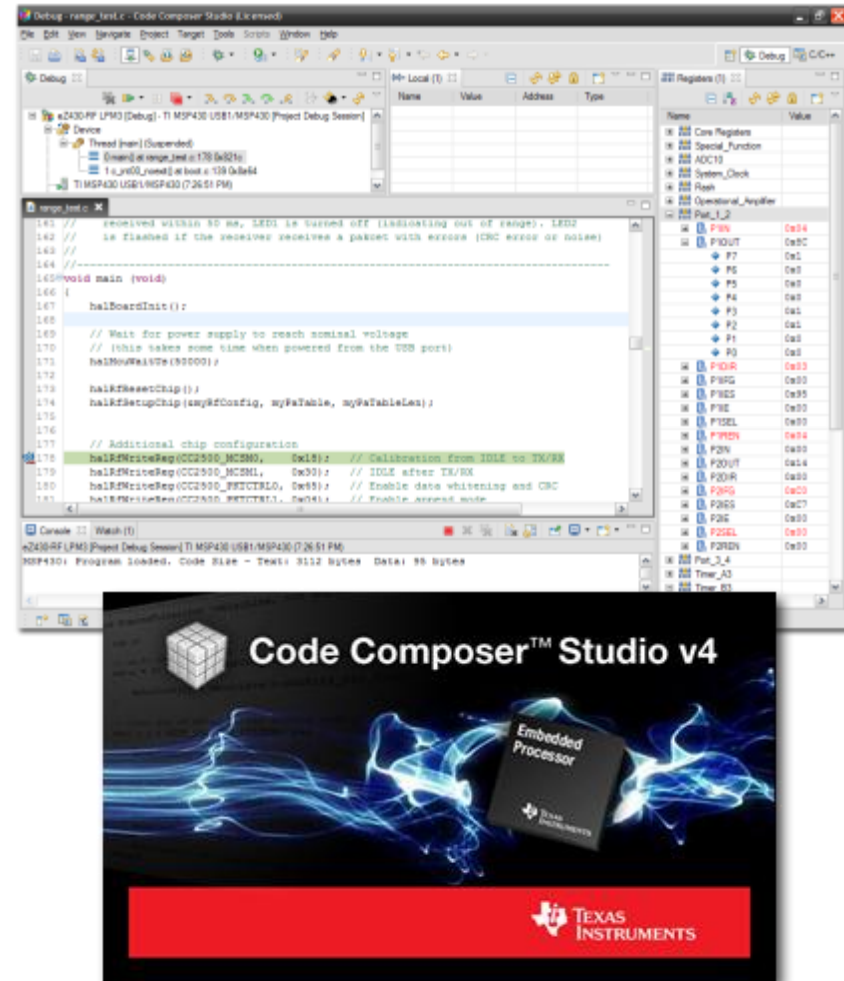
# USB Flash Emulation Tool (FET)

- MSP430 FET: real-time debug and programming tool
- Supports **ALL** MSP430 devices
  - 4-wire JTAG
  - 2-wire Spy Bi-Wire
- Available with socketed target board
  - Example:  
MSP-FET430U14 =  
FET + 14-pin target board
- Supported by all MSP430 IDEs
- Starting at \$99



# Code Composer Studio v4

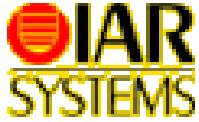
- Easy to use, Eclipse based IDE: Compiler, linker, more
- Supports **all MSP430** MCUs
- Enhancements since CCE v3:
  - Speed
  - Code size improvements
  - Auto-updating
- **\$495** for CCS v4 MCU Edition
- **Free** for apps <16KB
- Identical look and feel as Code Composer *Essentials*



[http://wiki.msp430.com/wiki/index.php?title=Category:Code\\_Compiler\\_Studio\\_v4](http://wiki.msp430.com/wiki/index.php?title=Category:Code_Compiler_Studio_v4)



# Third Party Integrated Development Tools



Baseline and full C-Compiler versions are available from IAR as enhancements to the 4-KB C-compiler included with TI's MSP430 tools.

[www.iar.com](http://www.iar.com)



Learn more about CrossWorks, Rowley's complete MSP430 development solution, which includes an optimized C-compiler and assembler at:

[www.rowley.co.uk](http://www.rowley.co.uk)



30-day trial version and unlimited C-compiler for only \$395...\$450 enables customers to develop and debug software.

[www.quadravox.com/AQ430.htm](http://www.quadravox.com/AQ430.htm)



Code Composer Studio v4.1 (CCS) is an integrated programming and debugging environment for MSP430 based on the industry standard Eclipse open source platform for \$495.

[www.ti.com/msp430](http://www.ti.com/msp430)



Open source GCC toolchain for MSP430. This includes the GNU C compiler (GCC), assembler and linker (binutils), debugger (GDB) and some other tools for the MSP430.

<http://mspgcc.sourceforge.net/>



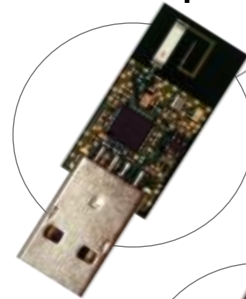
Standard C development tool available at \$199. Bundled standard tool with NoICE430 debugger available for \$249...\$549. Download a free 45-day demo at:

[www.imagecraft.com](http://www.imagecraft.com)

# eZ430-Chronos: CC430 Dev Tool

- CC430-based *wireless* development tool in a watch
- 915/868/433 MHz versions available
- Custom LCD driven directly by CC430
- Features:
  - 3-axis accelerometer
  - Altimeter
  - Temperature sensor
  - Buzzer
- Expandable to any personal area wireless network
- **Only \$49**

Includes USB RF  
access point

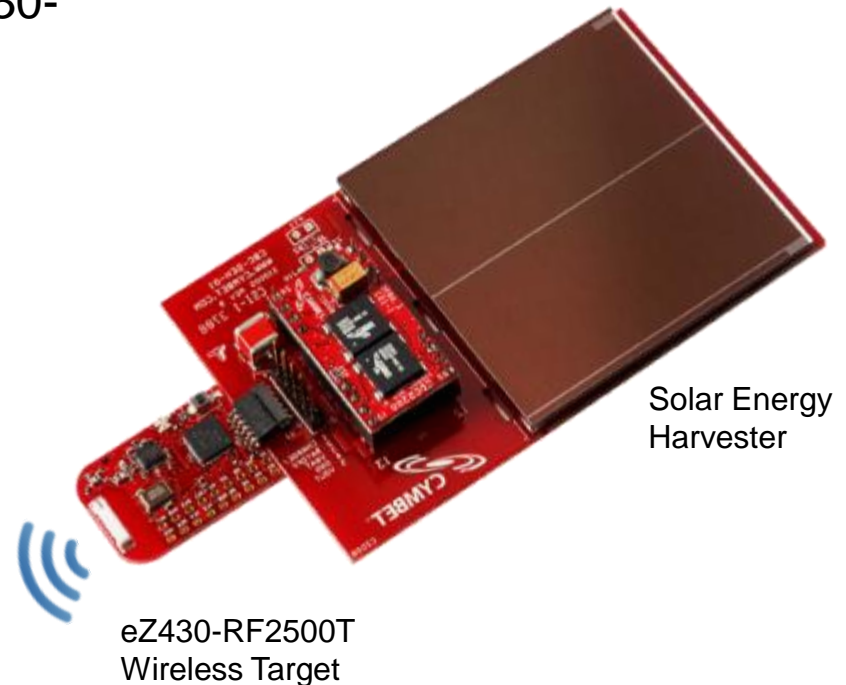


eZ430  
emulator for  
programming



# Self-Powered Solar Energy Harvester

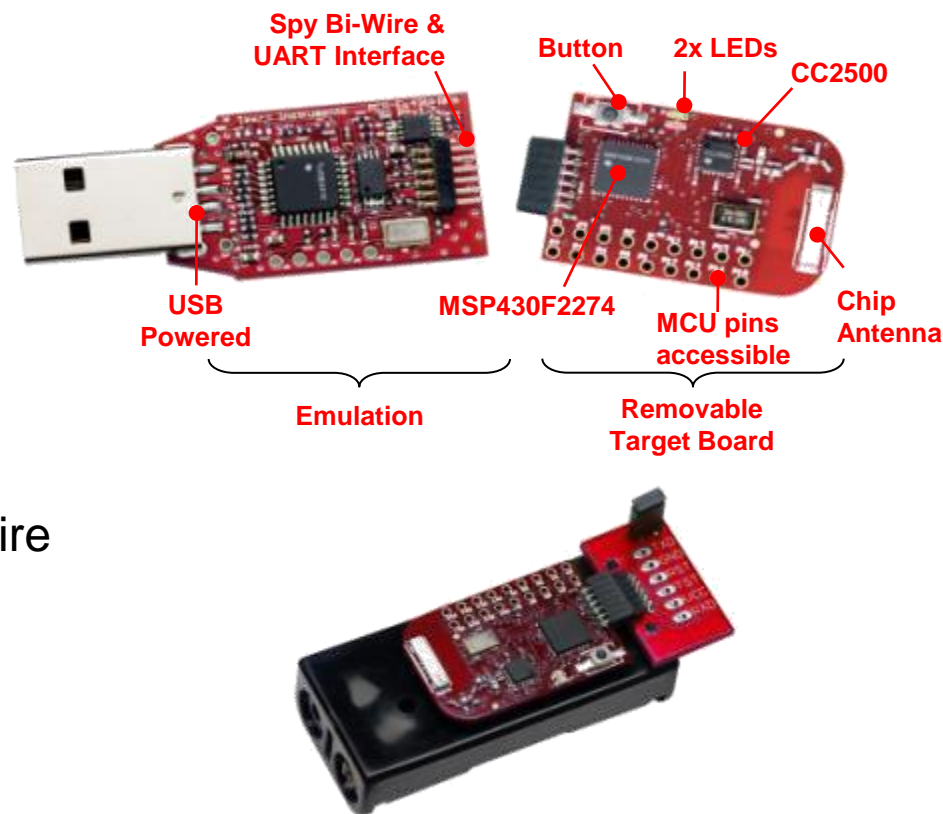
- Solar Energy Harvesting module for eZ430-RF2500
- **Battery-less** operation
- Works in low ambient light
- 400+ transmission with no light
- Adaptable to any sensor or RF network



- **\$149**
- **eZ430-RF2500-SEH**
- Based on SimpliciTI v1.1

# eZ430-RF2500 – Wireless Made Easy

- Easy to use, Wireless development tool
- Ultra Low Power:  
MSP430F2274 + CC2500
- 2.4 GHz ISM wireless
- Includes **SimpliciTI** Network Stack
- Includes Wireless Sensor Network Demo Project
- Compatible with all MSP430 Spy Bi-Wire devices
- \$49
- Standalone target boards & eZ430-RF2480 also available

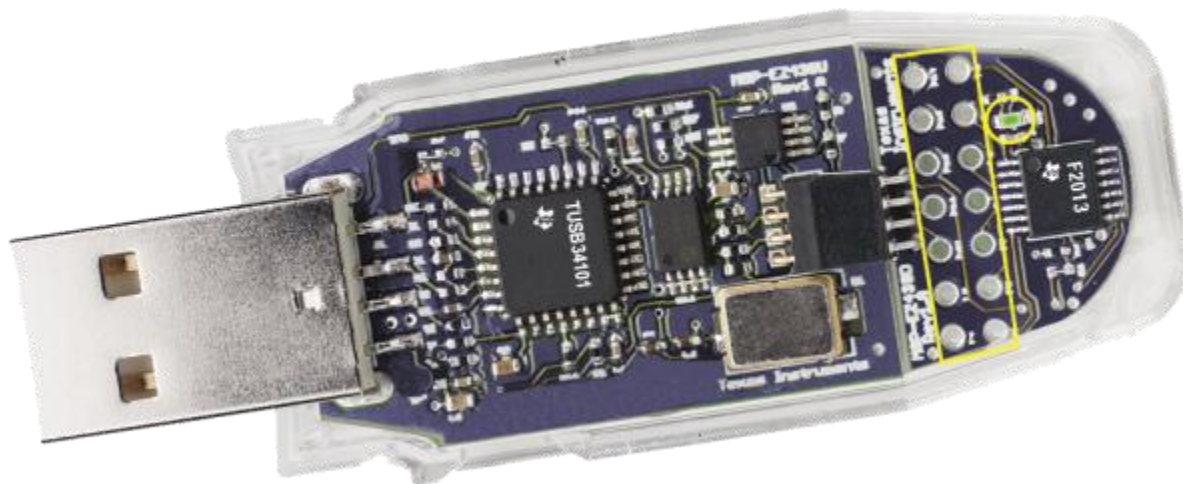


[www.ti.com/eZ430-rf](http://www.ti.com/eZ430-rf)



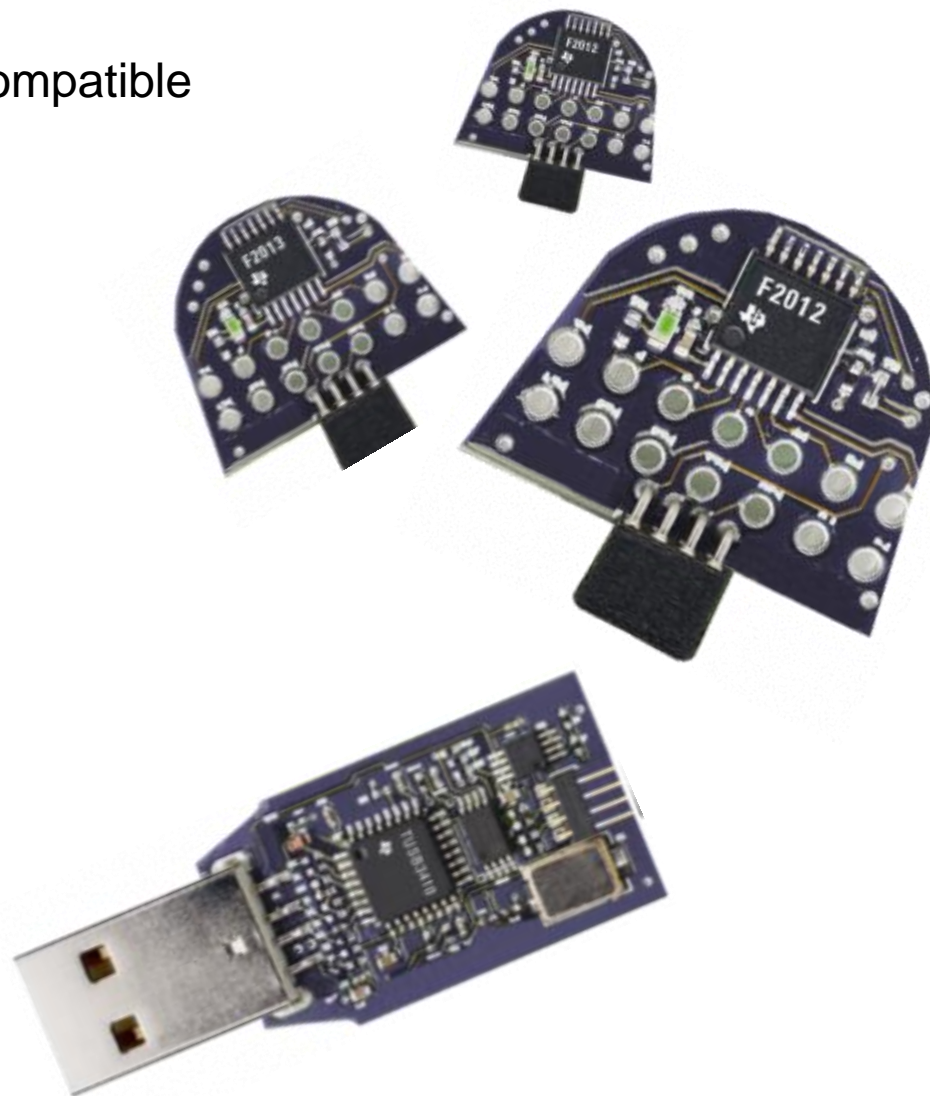
# eZ430-F2013 Development Tool

- Complete development tool that fits in your pocket
- Supports all 2xx Spy Bi-wire devices
- Unrestricted programming and debugging
- Fast, easy to use operation
- Supported by IAR & CCE
- \$20



# eZ430-T2012 Target Board

- **MSP430F2012**-based target boards compatible with eZ430
- 3 T2013 Boards per kit
- Emulator not included
- Pin & code compatible with F2013
- ADC10 – 10 bit SAR Core
  - Faster: >200kps
  - More Versatile: 8 external input Ch.
  - Easier to use: Single Ended input
- Available Today!
- \$10



# Third Party Development Resources

- Rowley CrossWorks

- Complete IDE solution
- High code density
- Simulator
- Windows, Linux, Mac

[www.rowley.co.uk](http://www.rowley.co.uk)



- MSPGCC Tool Chain

- Free
- Open Source
- GNU C Compiler, Assembler/Linker, GDB Debugger
- Windows, Linux, Unix

<http://mspgcc.sourceforge.net>



- Elprotronic

- MSP430, CC Chipcon, C2000 Programmers
- Fastest download speed
- Production programmers



- Amber Wireless

- Drop in wireless modules
- <1GHZ eZ430-RF target boards
- CC430 Development boards



- RTOS Options

- $\mu$ C/OS-II™
- CMX-Tiny+™
- embOS
- FreeRTOS™
- IAR PowerPac
- QP™
- Salvo™
- TinyOS

- USB Stacks

- IAR
- HCC

😊 The End 😊

