EmbeddedSeries

ARROW ELECTRONICS AND TEXAS INSTRUMENTS

MSP430™ Ultra-Low Power MCUs

Endless Possibilities

MSP430 Agenda

Why the MSP430? Solving your MCU needs

- MSP430-Enabled applications
- MSP430 Core Values

Features, Technologies, and Benefits

- Ultra-Low Power + Performance
- Integrated solutions
- Extensive Portfolio with low cost options

Development

- MSP430 is easy to get started
- Resources, support, code examples. Start here!

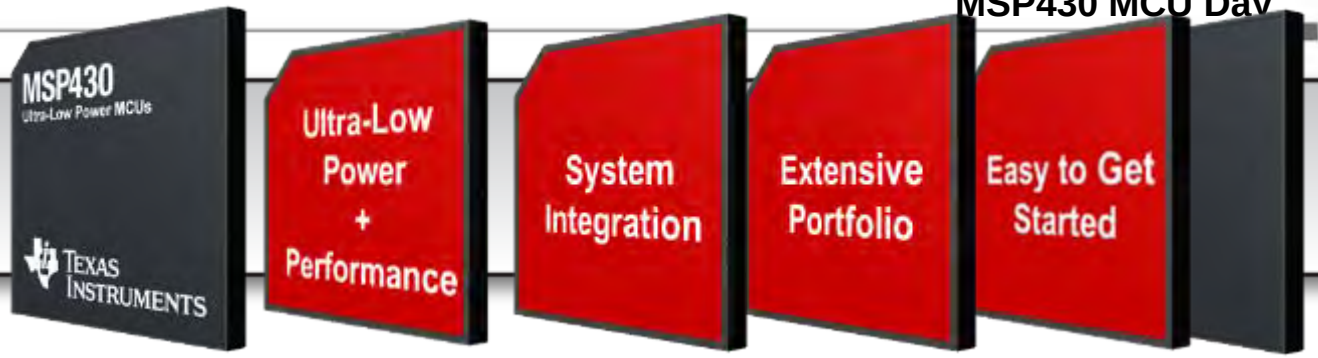
Products & Roadmap

- The future of the MSP430 product line

Why MSP430?

MSP430-Enabled Solutions at a Glance

MSP430 Overview



Ultra-Low Power + Performance

World's Lowest Power MCU Family

- Optimized Low Power Modes & Instant Wake-up
- 230µA/MIPS | 0.7 µA RTC | 0.1 µA RAM

Do More with MSP430

- Industry leading code density
- Increase speed and flexibility with advanced clocking, hardware acceleration, and up to 25 MIPS

System Integration

Intelligent Analog & Digital Peripherals

- Autonomous operation in low power modes
- 16-bit ADCs, DACs, DMA, MPY, Comparators, LCD, USB, RF, high-res timers, power management

COMING SOON

- FRAM memory technology
- Capacitive touch I/Os

Extensive Portfolio

Find the right MCU for you

- 200+ Devices with one consistent architecture
  Flash: 0.5 – 256 kB **Pins**: 14 - 113
  RAM: 128 B – 16 kB

NEW **MSP430 Value Line**

- Don't Settle | 16-bit Performance, 8-bit Price
- Starting @ $0.25 USD

Easy to Get Started

Consistent Development Environment

- One development tool for all MSP430 devices
- Code compatibility throughout portfolio

Get started now!

- Complete development kits @ $4.30 USD
- eZ430-Chronos development watch @ $49 USD
- Free code-limited IDEs

MSP430 is Ultra-Low Power + Performance

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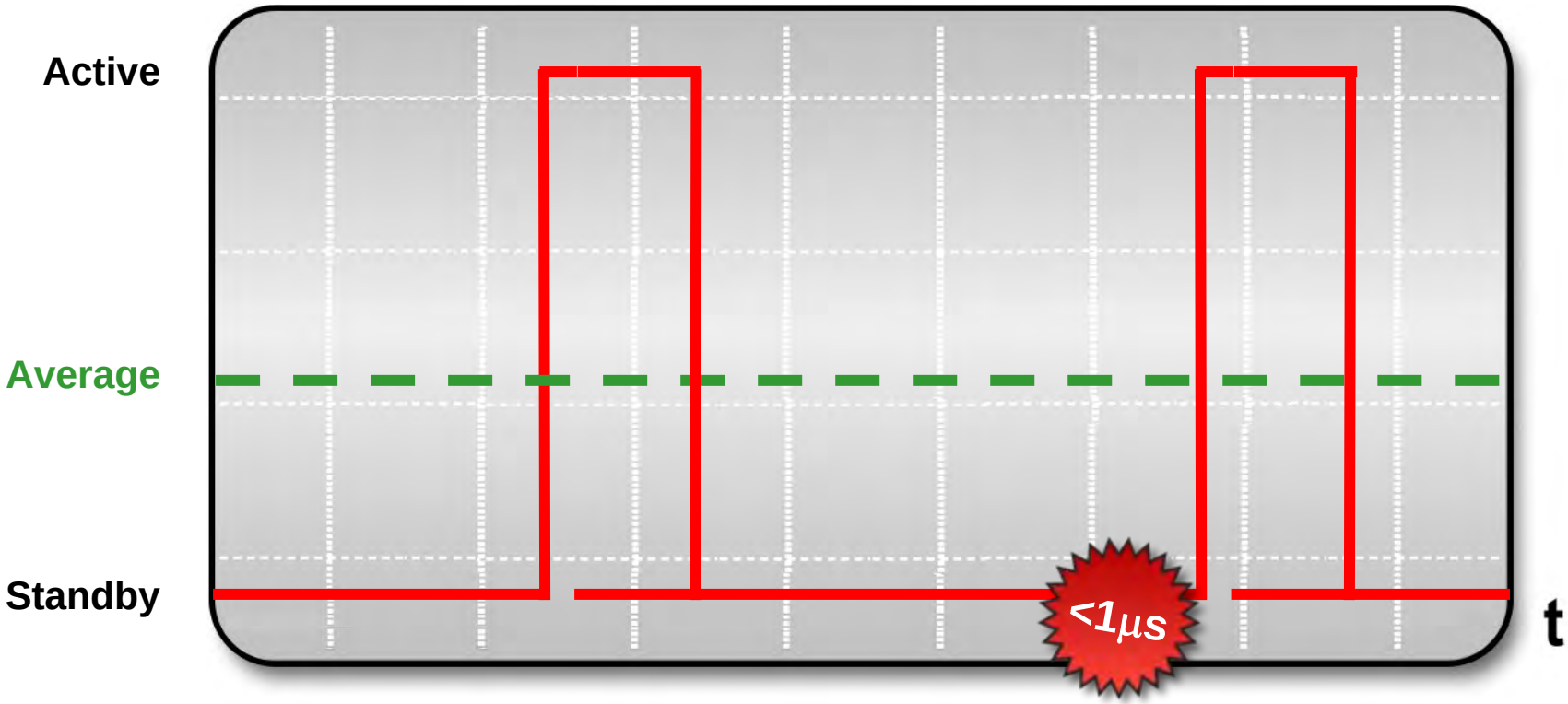
Ultra-Low Power Activity Profile



- Minimize active time
- Maximize time in Low Power Modes
- Interrupt driven performance on-demand with <1µs wakeup time
- Always-On, Zero-Power Brownout Reset (BOR)

Ultra-Low Power is in Our DNA

- MSP430 designed for ULP from ground up
- 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
  www.ti.com/ulp

✓ Multiple operating modes
  - 100 nA power down (RAM retained)
  - 0.3 µA standby
  - 110 µA / MIPS from RAM
  - 220 µA / MIPS from Flash

✓ Instant-on stable high-speed clock

✓ 1.8 - 3.6V single-supply operation

✓ Zero-power, always-on BOR

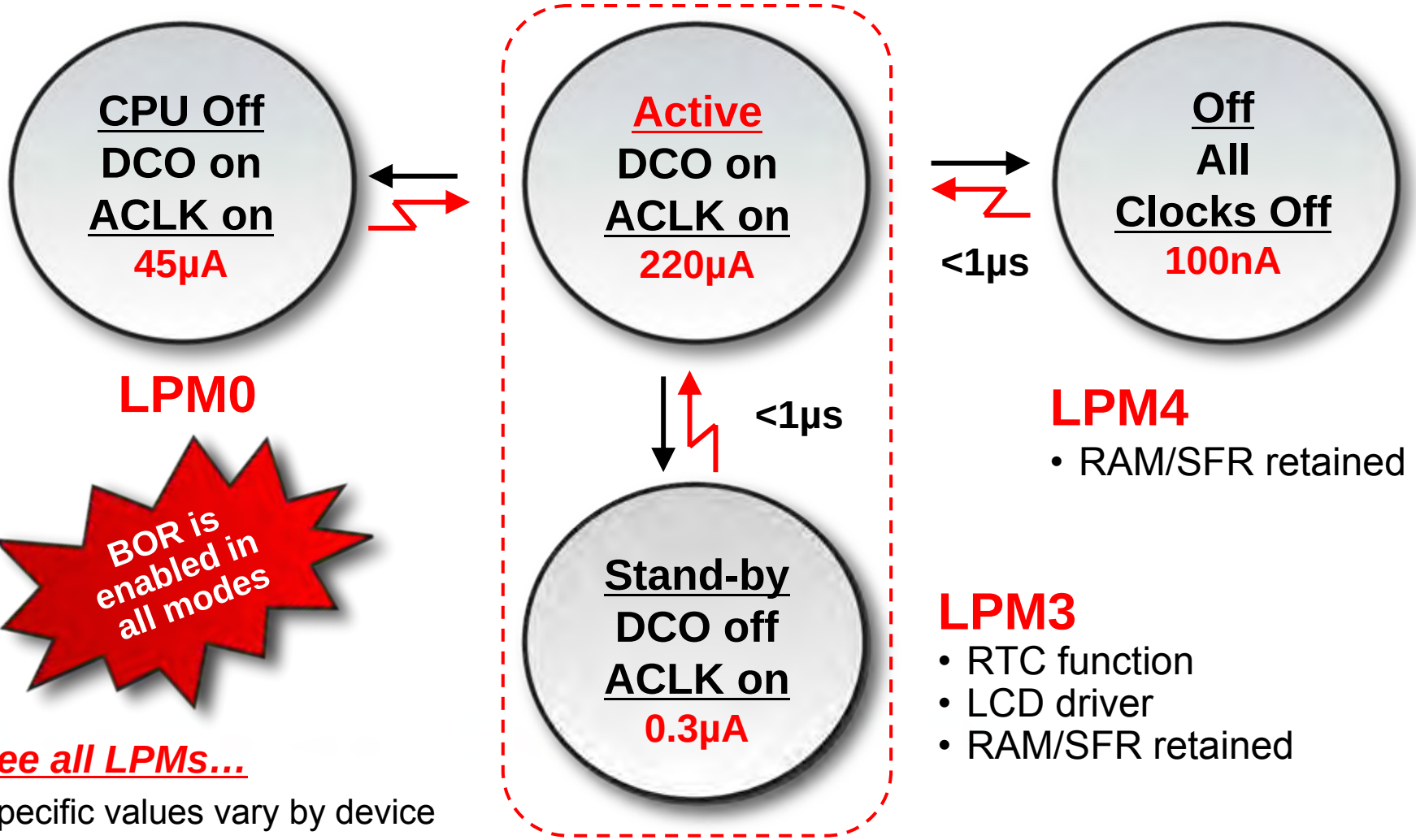
✓ <50nA pin leakage

✓ 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

MSP430 Low Power Modes



LPM0

BOR is enabled in all modes

LPM4

- RAM/SFR retained

LPM3

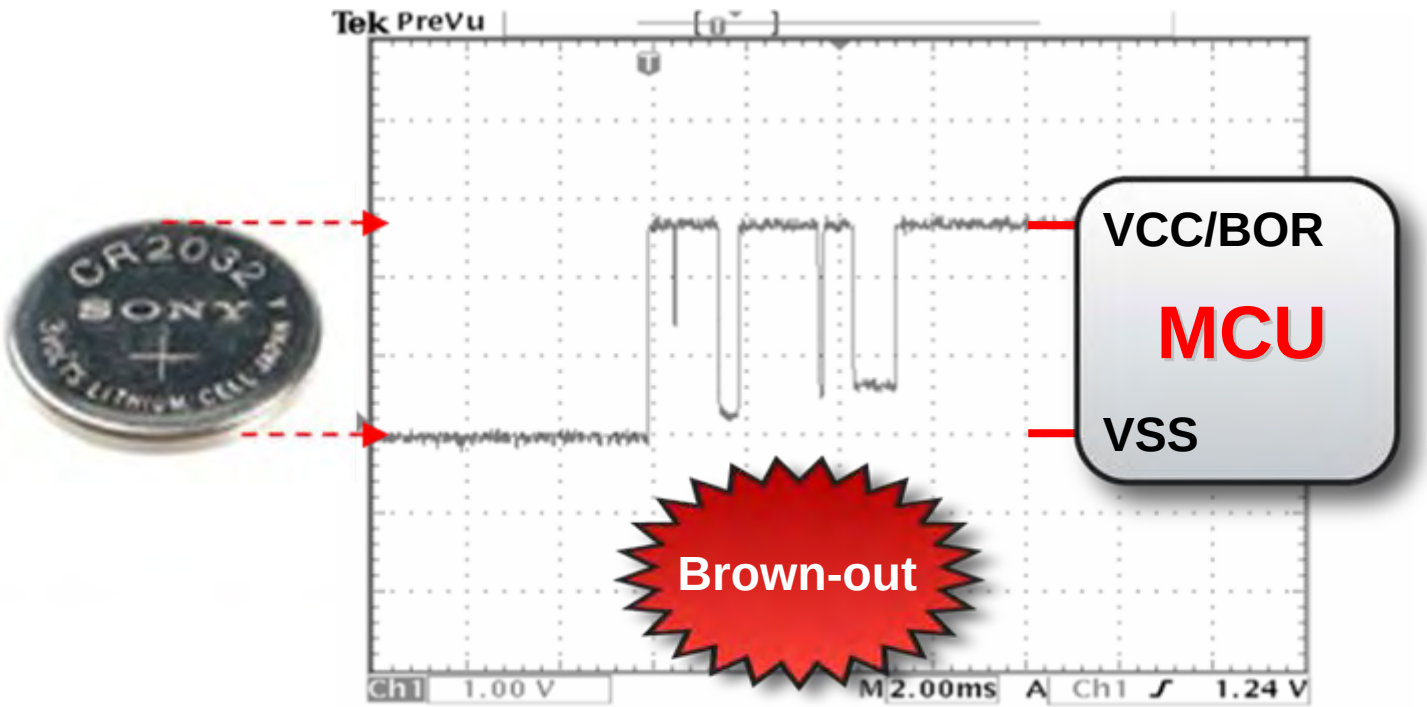
- RTC function
- LCD driver
- RAM/SFR retained

See all LPMs…

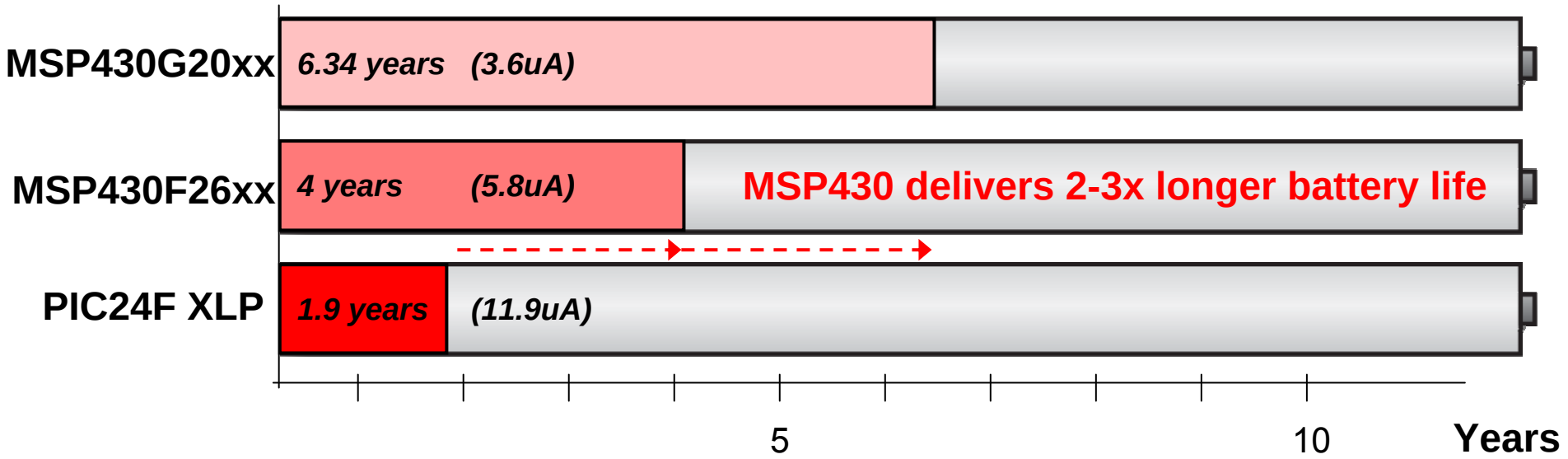
Specific values vary by device

Always-on Brownout Reset

- Brown-out reset (BOR) forces the MCU to reset both on power-up/down
  - When V_{CC} rises and when V_{CC} falls below normal operating range, a POR is triggered.
  - Zero-power Brown Out Reset
  - **Always-on and active in all modes of operation.**



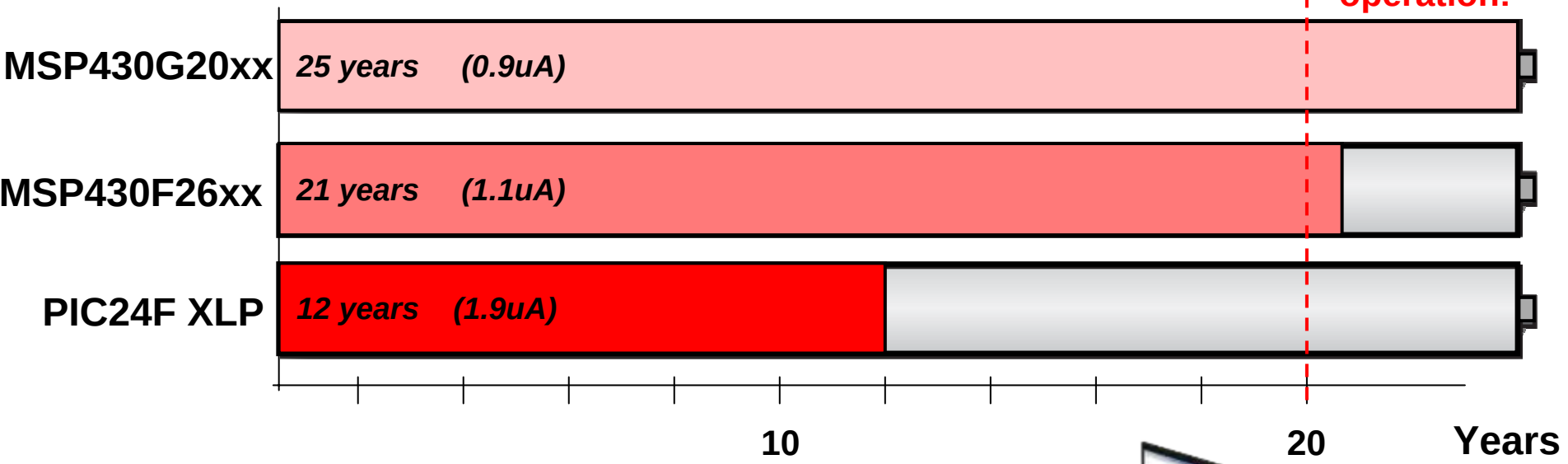
Average Current Consumption & Battery Life @ 1% Active (~14.4 Minutes)



Example: Portable measurement system

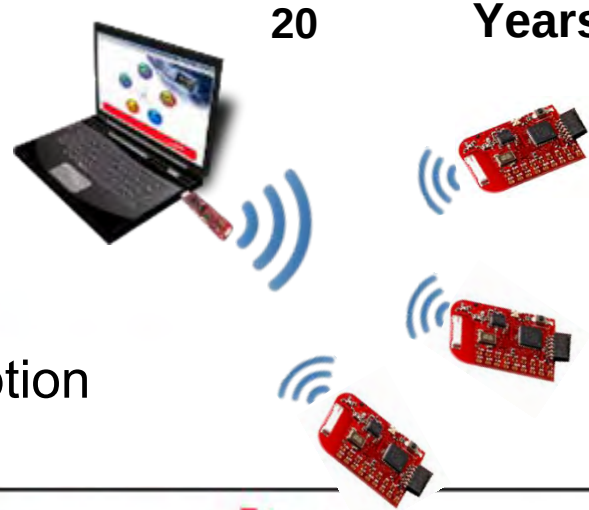
- Active power consumption is important in this example
- Average = Standby*(99%) + Active*(1%)
- Used peripherals will impact total current consumption

Average Current Consumption & Battery Life @ 0.1% Active (1.4 Minutes)

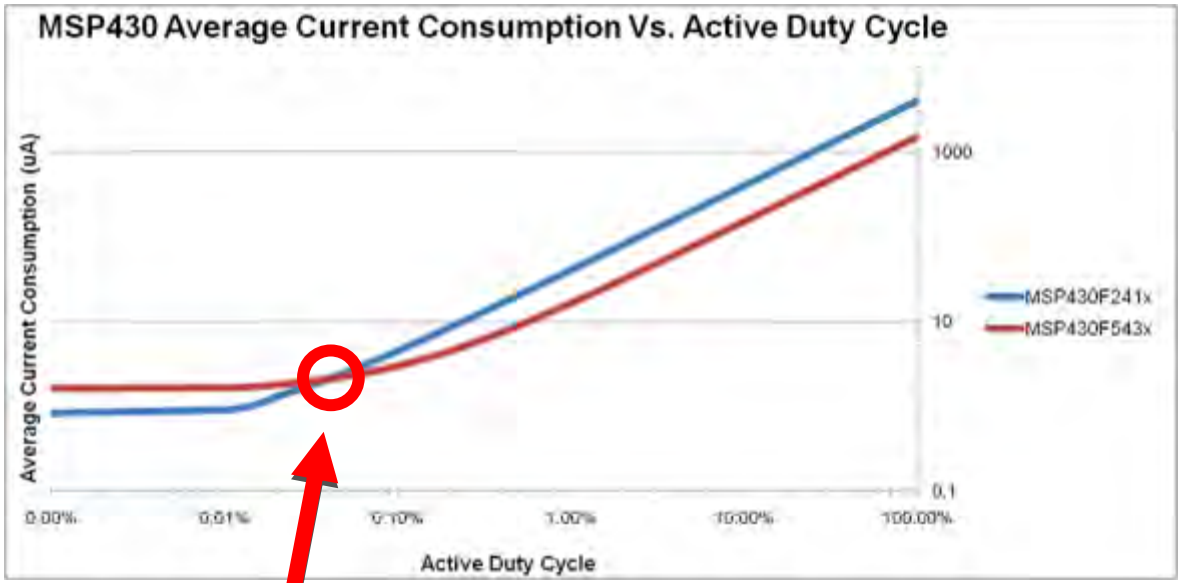


Example: Wireless sensor network

- Standby & Active power are equally important
- Average = Standby*(99.9%) + Active*(0.1%)
- Used peripherals will impact total current consumption



Which MCU? MSP430x2xx vs MSP430F5xx



	F241x	F543x
Active @ 8MHz	4.25 mA	1.32 mA
LPM3	0.8 uA	1.1 uA

- MSP430x2xx has lower LPM3 consumption
- MSP430F5xx thas lower active power consumption

The crossover is at ~0.04% Active

Or about 35 seconds/day

This means that if the CPU is Active >0.04% of the time (or >35 seconds per day), the lower Active Mode power of the F5xx outweighs the lower LPM3 current advantage of the F2xx device.

ULP is Easy!

- Using our Low Power Modes are easy
- Enter low power mode with *1 line of code!*

```
void main(void)
{
    WDT_init();  // initialize Watchdog Timer
    while(1)
    {
        __bis_SR_register(LPM3_bits + GIE);     // Enter LPM3, enable interrupts
        activeMode();                           // in active mode. Do stuff!
    }
}

#pragma vector=WDT_VECTOR
__interrupt void watchdog_timer (void)
{
    __bic_SR_register_on_exit(LPM3_bits);     // Clear LPM3 bits from 0(SR), Leave LPM3, enter active mode
}
```

MSP430 for Energy Harvesting

"Self or Perpetual - Power" Apps

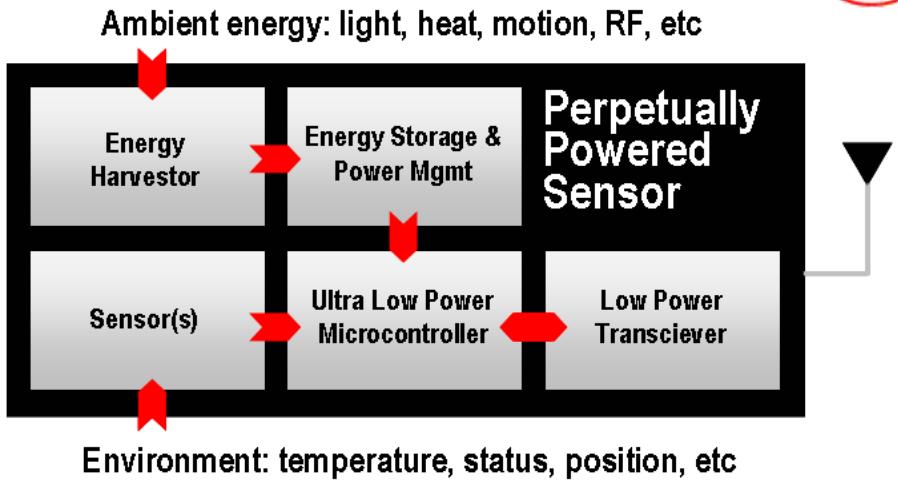
- Energy harvesting is the process by which energy is captured and stored
- Can substitute batteries that are costly to maintain and can extend system uptime
- Only possible with ultra-low power components
- Solar, kinetic, thermal, RF, salinity gradients, pH difference and other ambient sources available

Body worn monitoring devices powered by body heat, movement

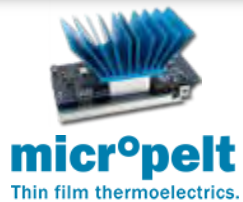
Monitor conditions on farm, winery, etc.

Mesh networking for environmental monitoring (e.g. forest fire detection)

Automotive monitoring (e.g. tire pressure gauges powered by vibration)

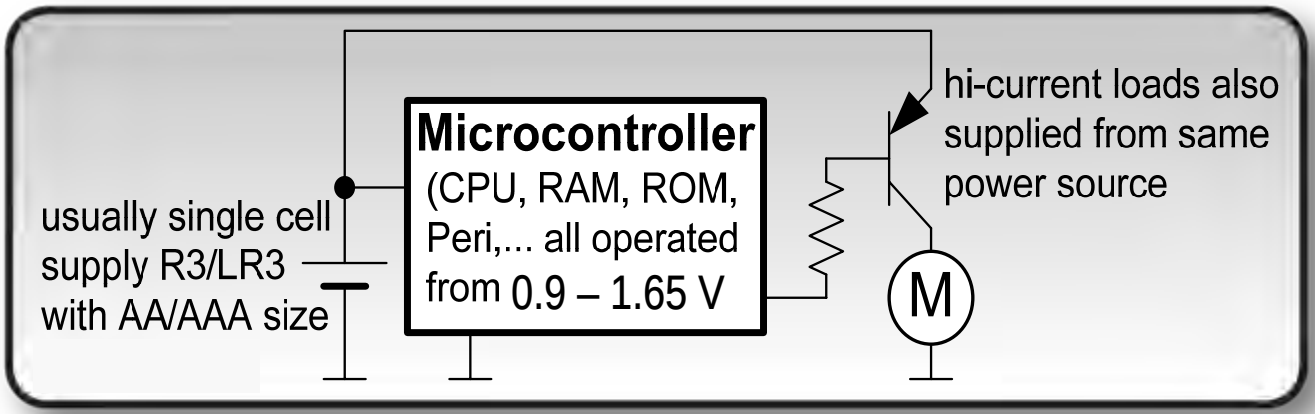


Energy Harvesting Made Easy – MSP430 Solutions



Native 0.9V Operation

- **Native Means…**
- The device, including peripherals operates at specified V_{cc}
- Additional components such as charge pump are **NOT** needed to support the full V_{cc} range
- Full functionality of the device is maintained within V_{cc} range
- The microcontroller and application are supplied from one common supply that goes down to min V_{cc}



Native 0.9V Target Applications

- General purpose low-cost MCU
- Consumer
  - Electric tooth brush, shavers, etc.
  - Toys
  - Games
- Security devices (door sensors, passive I/R)
- Sports applications
- Sensors (motion, pressure)

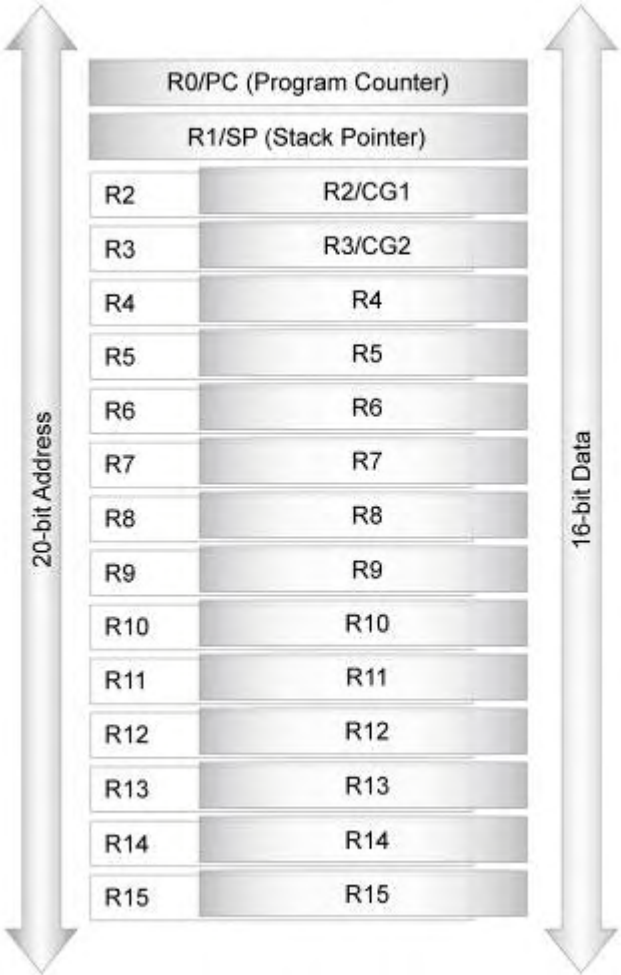
Don't Compromise: ULP *and* Performance

= **ULP** +

PERFORMANCE

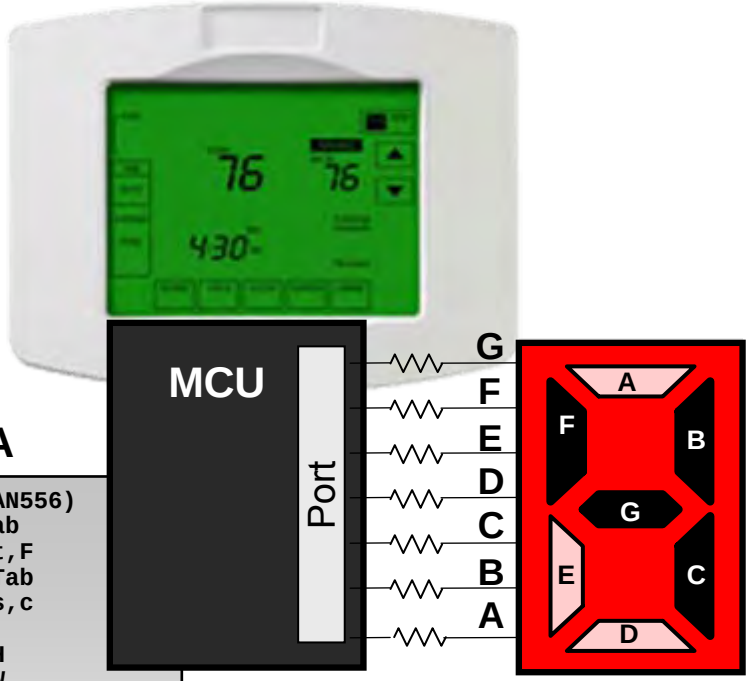
- 16-bit RISC architecture → Leading code efficiency
- Flexible and unified clocking system
- Up to 25 MIPS

16-bit Orthogonal RISC CPU



- Efficient, ultra-low power CPU
- C-compiler friendly
- 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
- 20-bit addressing on MSP430X for Flash >64KB

Higher Performance and Code Effectiveness



Competitor A

```
; Competitor A (AN556)
    movlw  LOW Tab
    addwf  offset,F
    movlw  HIGH Tab
    btfsc  status,c
    addlw  1
    movwf  PCLATH
    movwf  Data,W
    call   Tab
    movwf  PORTB
Tab addwf  PCL,F
    retlw  B'00111111'
    retlw  B'00000110'
    retlw  B'01011011'
    retlw  B'01001111'
    retlw  B'01100110'
    retlw  B'01101101'
    retlw  B'01111101'
    retlw  B'00000111'
    retlw  B'01111111'
    retlw  B'01101111'
```

280 bits / 52 cycles

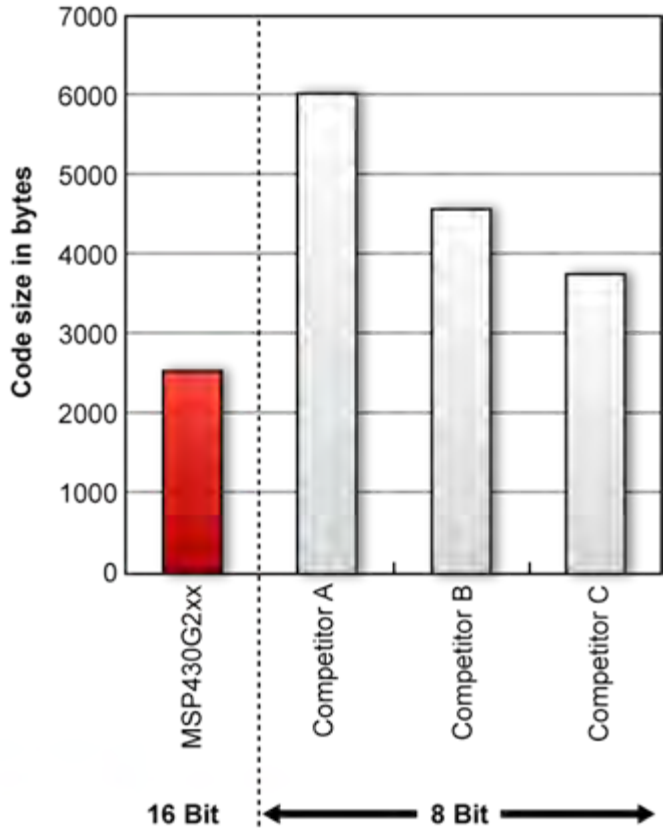
MSP430

8X reduction in Cycles/Task

```
;   MSP430
;   mov.b Tab(Data),P1OUT
Tab DW    0063Fh
    DW    04F5Bh
    DW    06E66h
    DW    0077Ch
    DW    0677Fh
```

128 bits / 6 cycles

Total code size for simple math 8-bit vs 16-bit processing



Microcontroller

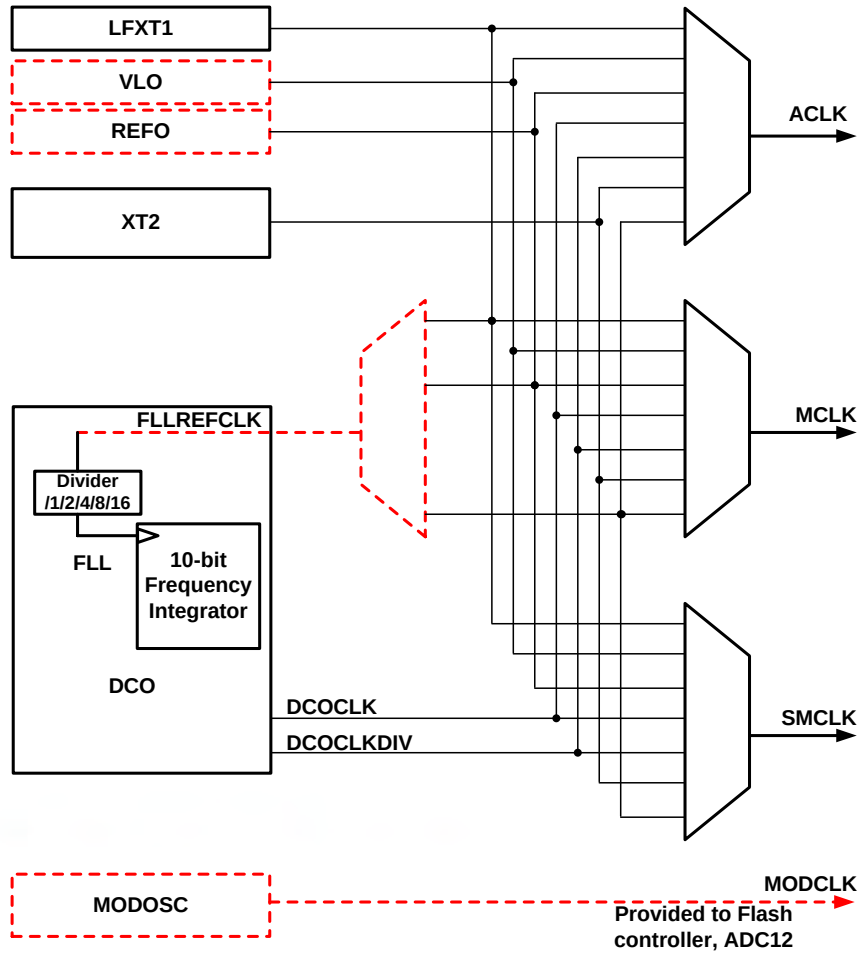
Maximize Speed & Flexibility | Unified Clock System

Features

- Orthogonal clock system
  - Any source can drive any clock signal
- 2 Integrated clock sources:
  - REFO: 32kHz, trimmed osc.
  - VLO: 12kHz, ultra-low power
- DCO & FLL provide high frequency accurate timing
- MODOSC provides bullet proof timing for Flash
- Crystal pins muxed with I/O function

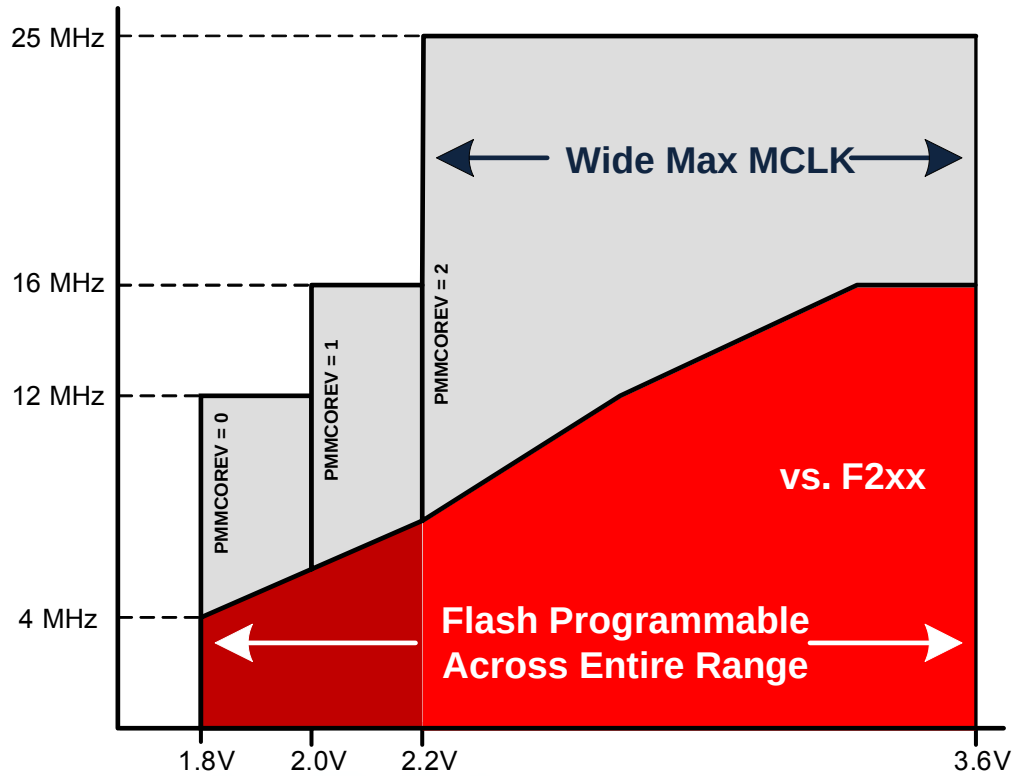
Benefits

- Ultra-Low Power functionality
- Best balance of performance and low power
- Enables flexible and capable Low Power Modes
- Instant on with fast oscillator wakeup



MSP430F5xx Speed and Flexible Operation

- 25MHz peak performance
- More performance across V_{CC} range
  - Flash ISP @ 1.8V
  - 12MHz @ 1.8V
  - 25MHz @ 2.4V-3.6V



MSP430 is Integrated

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Performance Through Integration

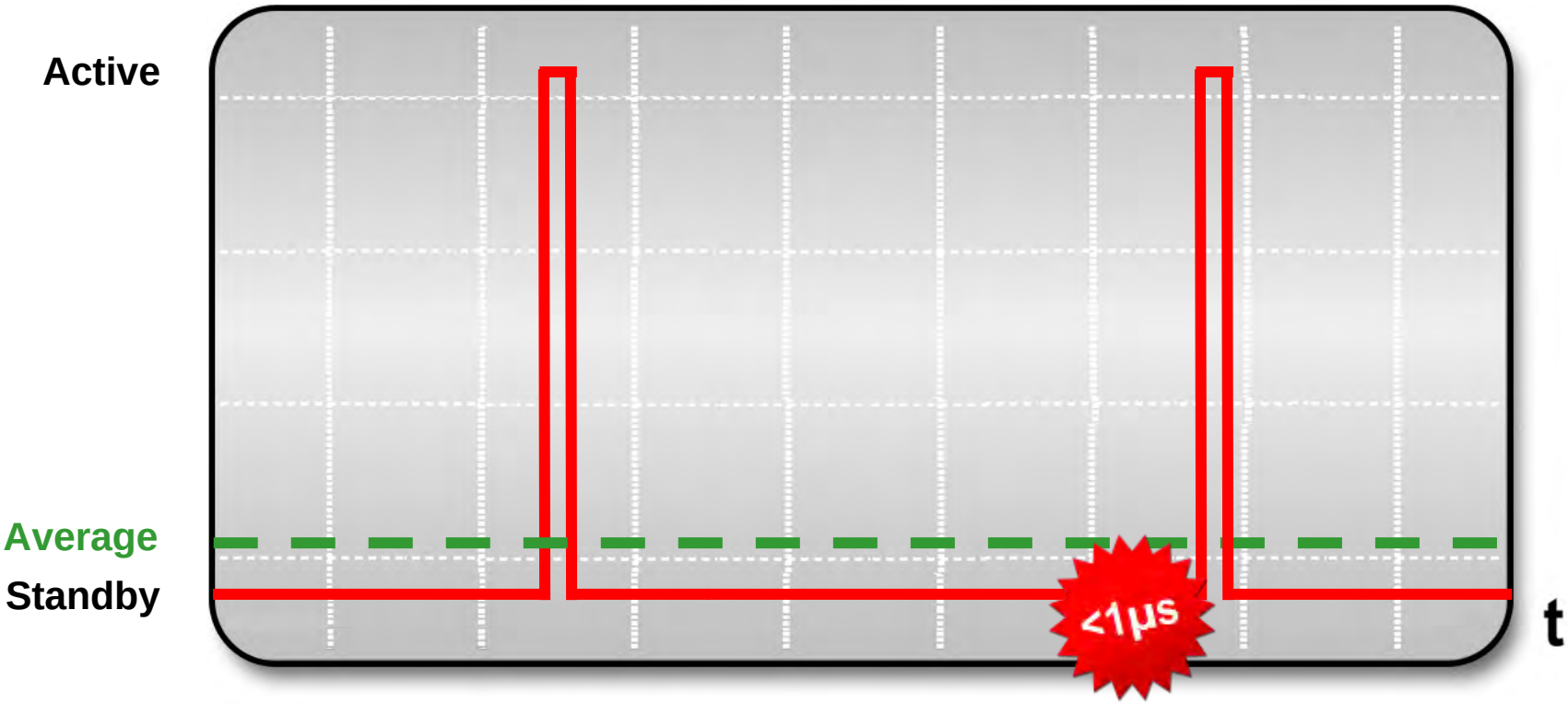
- The 200+ MSP430 devices offer high-performance integration

Snapshot of Integrated Peripherals

• ADC10, ADC12	• WDT	• AES
• SD16	• Basic Timer	• USB
• Comparator	• RTC	• SPI
• DAC12	• PMM	• I²C
• DMA	• BOR	• LIN/IrDA
• Multiplier	• SVS	• SCAN_IF
• OpAmp	• EDI	• ESP430
• Timer	• RF Front End	• LCD

- Various levels of integration allows designers to find the right MSP430
- Integration enables smaller physical footprints and minimizes system costs

Intelligent Peripherals → Ultra-Low Power



Even at Low Power Modes, intelligent peripherals allow many activities *without* the CPU

- Sampling the ADC
- Transfer data between entire memory range
- Generate PWM signals
- BOR is always enabled
- Use Hardware multiplier
- Includes Full RAM retention (LPM0, 1, 2, 3, 4)
- More…

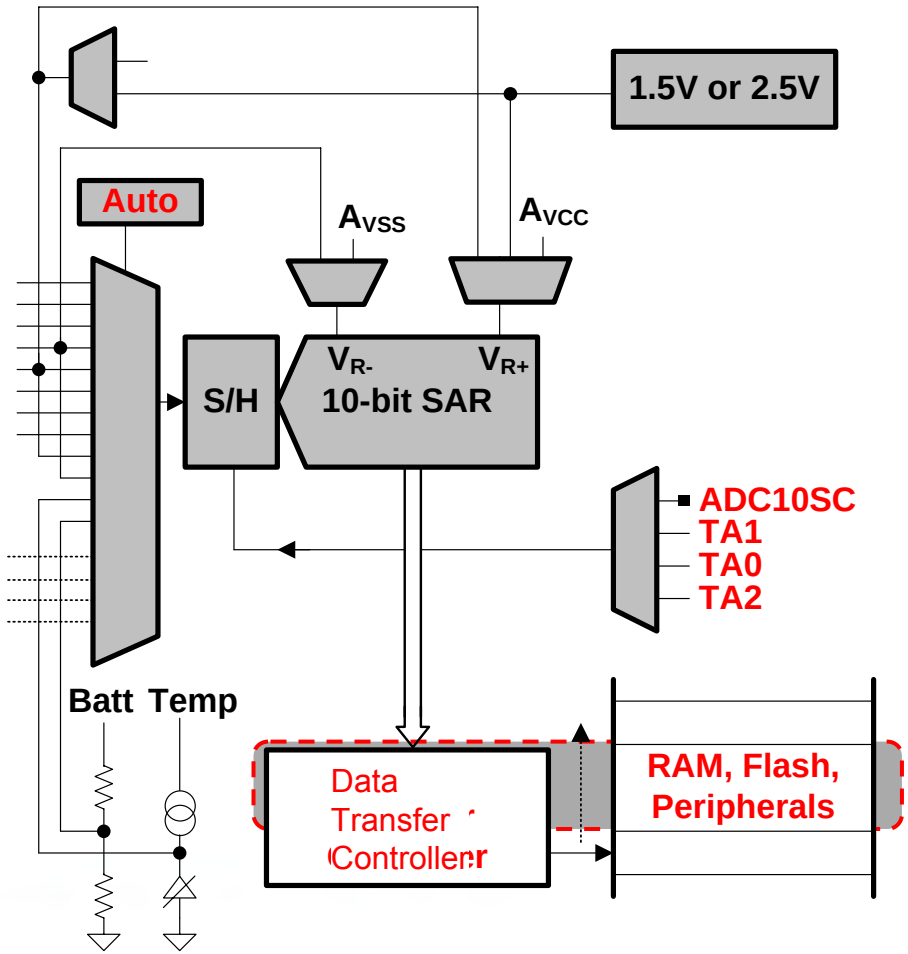
Fast Flexible 10- and 12-Bit ADCs

Features

- 10-bit & 12-bit ADCs
- 200ksps+
- Autoscan
- Single
  Sequence
  Repeat-single
  Repeat-sequence
- Int/ext ref
- TA SOC triggers
- Data Transfer Controller (DTC)
- DMA Enabled

Benefits

- Fast sample/conversions for greater accuracy
- Sample data autonomously, lowering CPU load
- Stay in Low Power Modes, minimizing current consumption



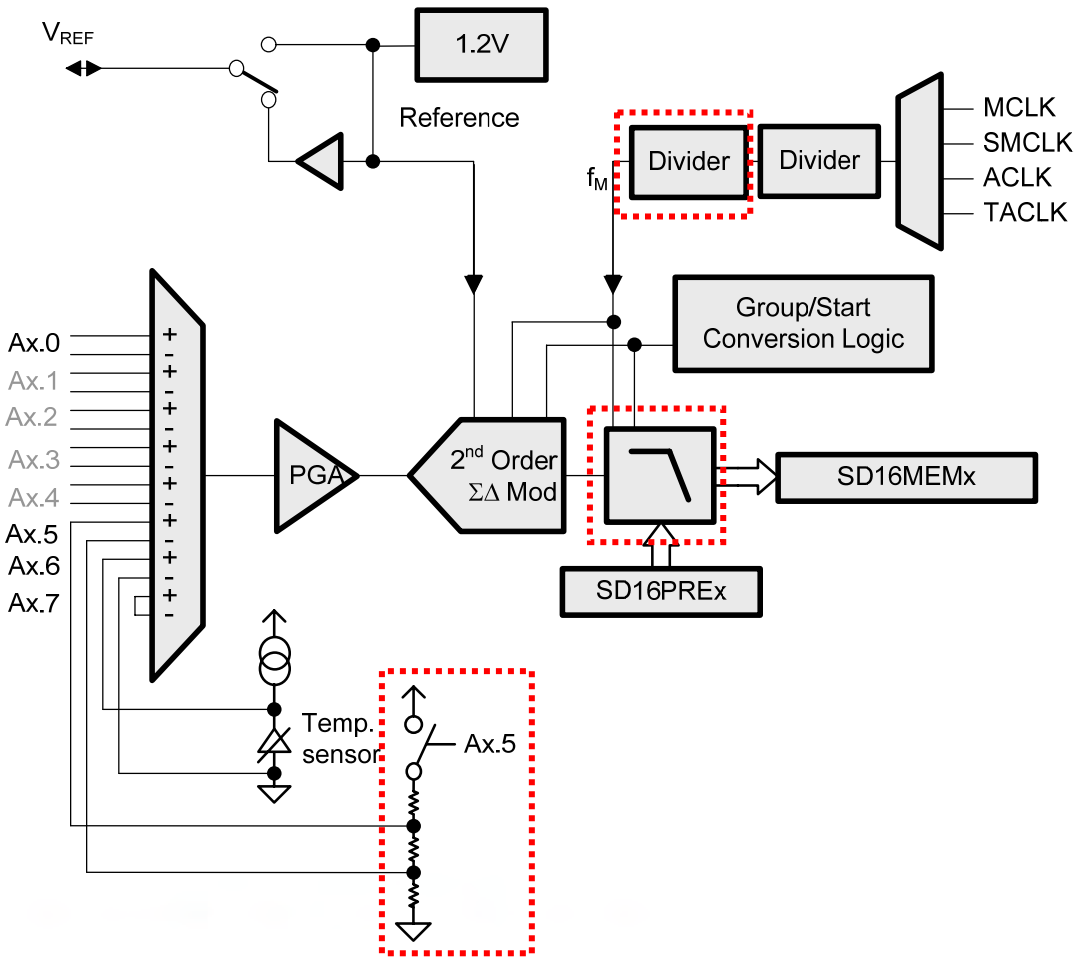
SD16_A Overview

Features

- 2nd order 16-bit sigma-delta architecture
- Multiple channels
- 30kHz to 1.1MHz modulation frequency
- Modulation frequency divider
- Up to 1024 OSR
- Temperature sensor
- AVCC measure
- Up to 4096 samples/sec
- Gain amplifier to support wide range of current measurements
- SW selectable internal/external reference

Benefits

- Achieves <0.1% accuracy for precise measurements with a 2400:1 dynamic range.
- Multiple SD16s can be used for anti-tampering needs in applications such as utility metering.
- More robust performance and software development with simultaneous sampling



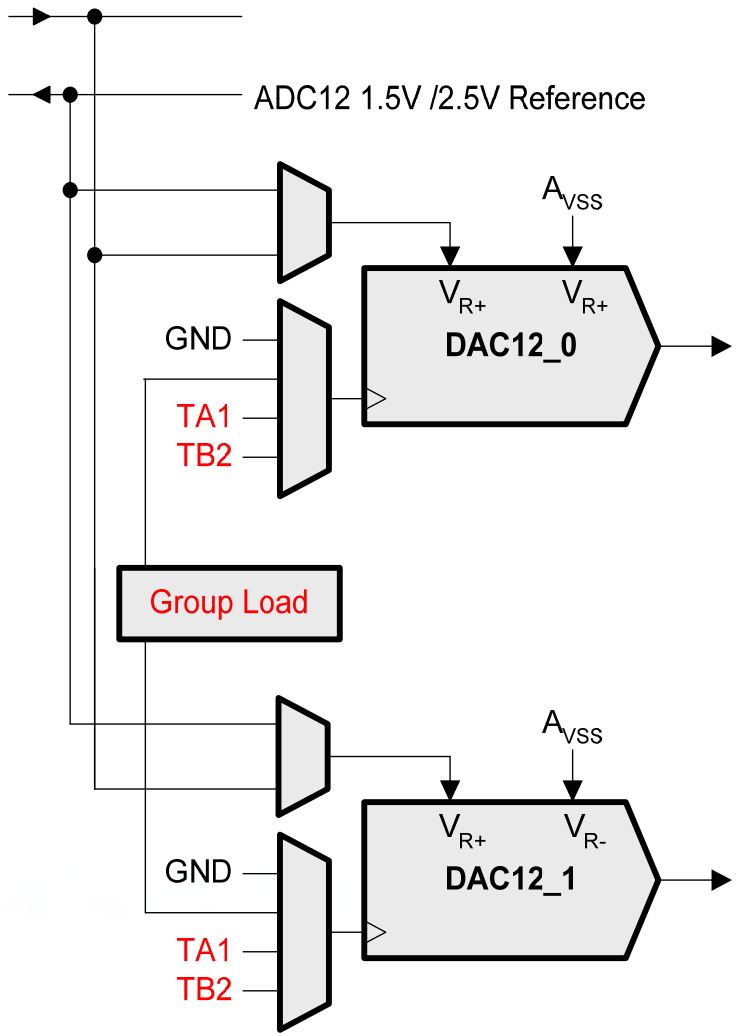
DAC12

Features

- 12-bit monotonic
- 8/12-bit voltage output
- Programmable settling time versus power
- Int/ext reference
- Binary or 2's compliment
- Self-calibration
- Group sync load
- DMA enabled

Benefits

- Configurable balance between performance and power
- Allows synchronous update operations when multiple modules are available



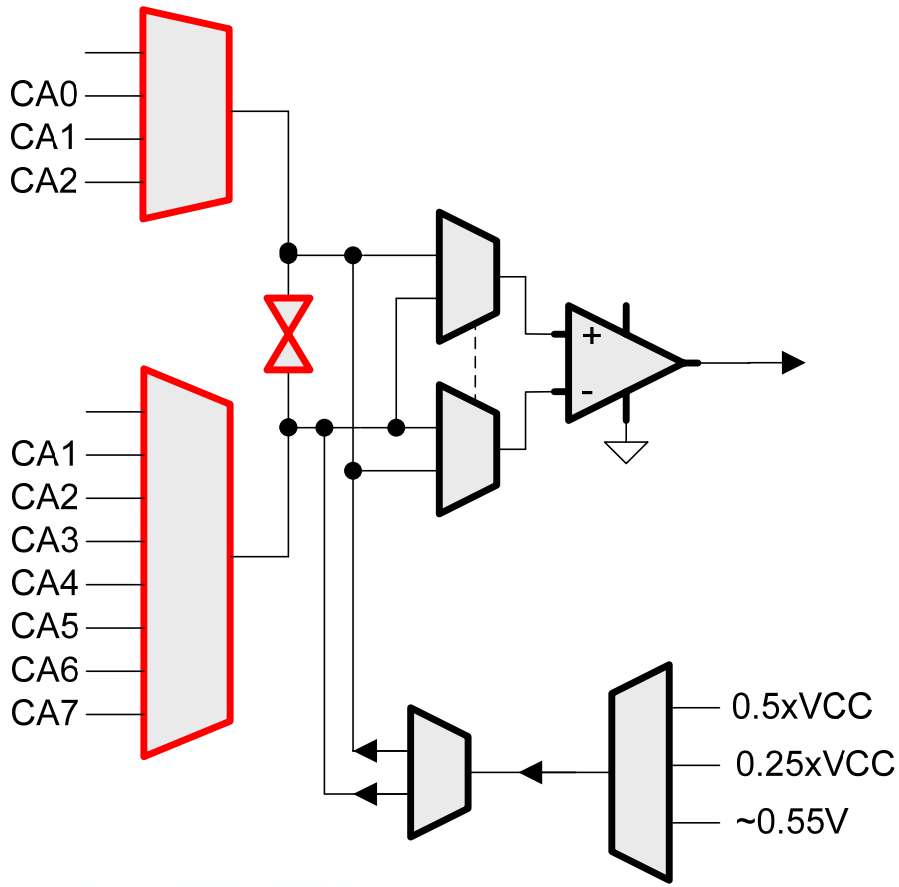
Analog Comparators

Features

- ~100nA operation (Comp_B)
- Hysteresis generator (B)
- Input multiplexer
- Reference generator
- Low-pass filter
- Battery detect
- Interrupt source
- Timer_A capture
- Multiplexer short for sample-and-hold

Benefits

- Ultra-Low Power
- Enables monitoring of external analog signals
- Supports precision slope Analog to Digital Conversions



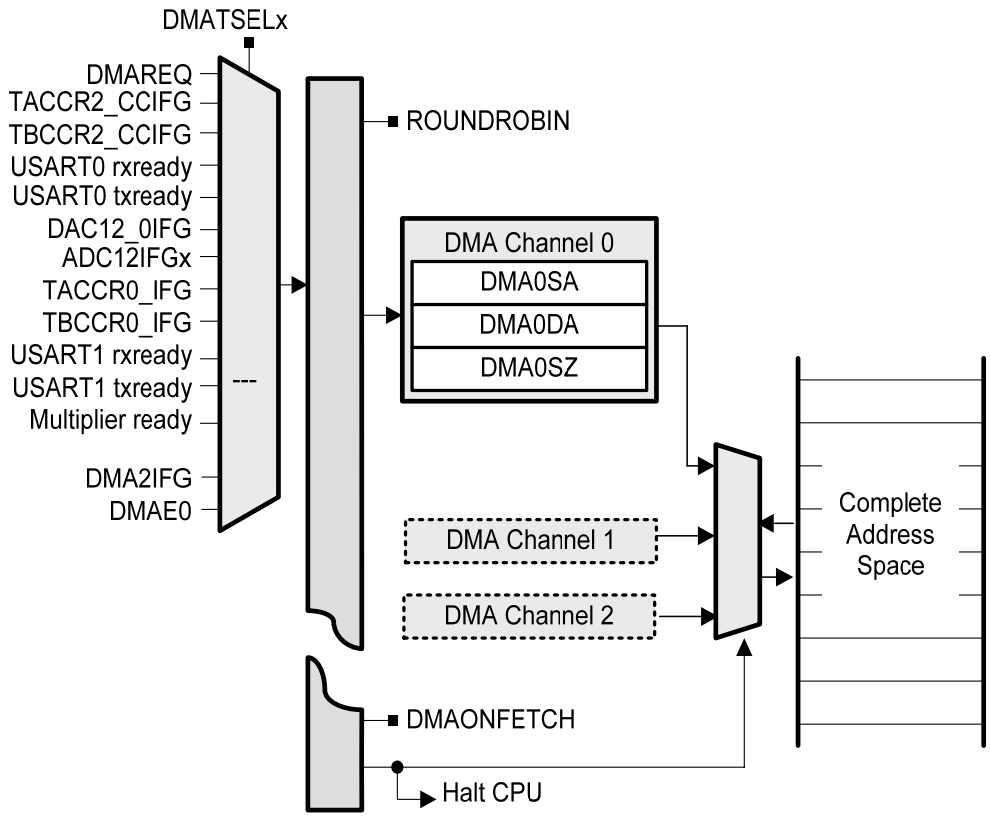
Direct Memory Access (DMA)

Features

- Edge/level triggers
- Single Block
- Burst-block
- Byte/word or mixed transfer
- Requires just two MCLK cycles

Benefits

- Allows data to be transferred throughout ENTIRE address range.
- Transfer data from ADC conversions to RAM without CPU
- Maximize CPU offloading for lower power and max MIPS throughput



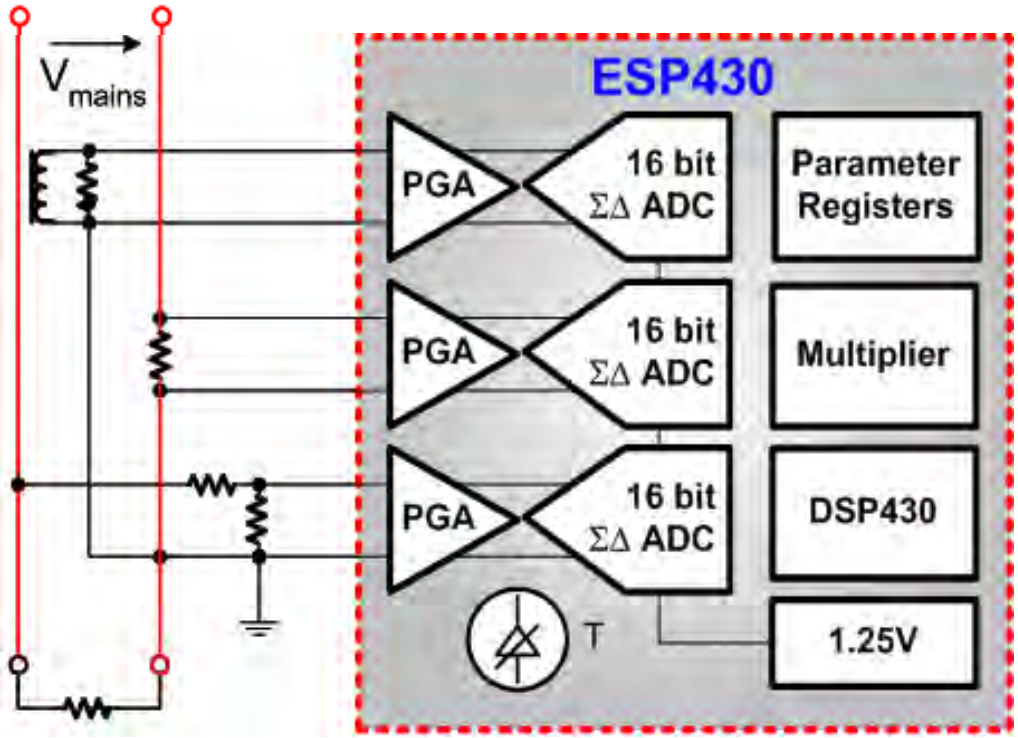
ESP: Single-Chip E-Meter

Features

- Dedicated function
- An embedded SoC
- User programmable
- Measures 2 or 3 wire, single phase energy and automatically calculates energy, power factor, etc.

Benefits

- Minimize system size with true SoC functionality
- Reduce total system chip count by 80%
- Maximize CPU offload with true encapsulated single phase e-meter module



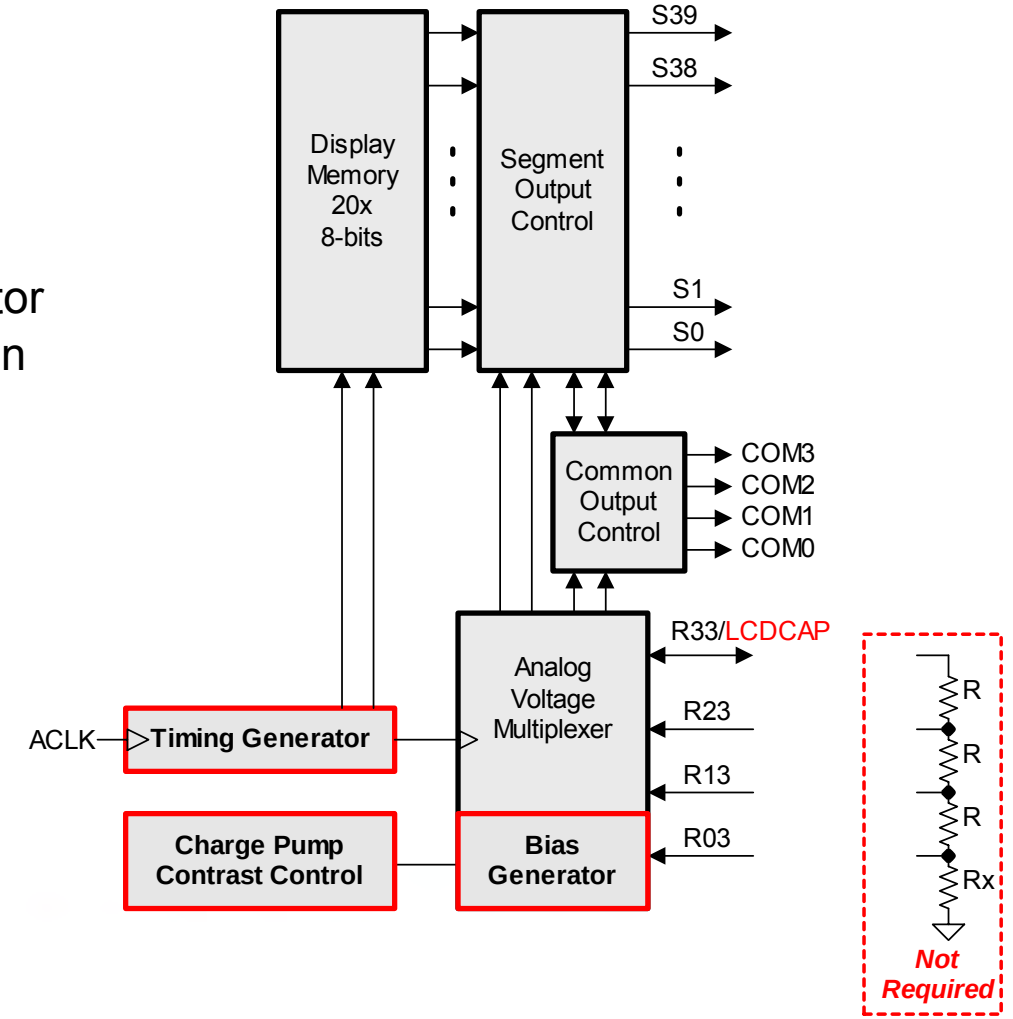
LCD Controllers

Features

- Fully automatic
- 4/3/2/1 mux
- Up to 160-bit display
- Internal regulated voltage generator
- Internal or external bias generation
- Contrast control
- 1/2 bias for 3 or 4 mux
- Internal clock generation
- Auto segment blinking

Benefits

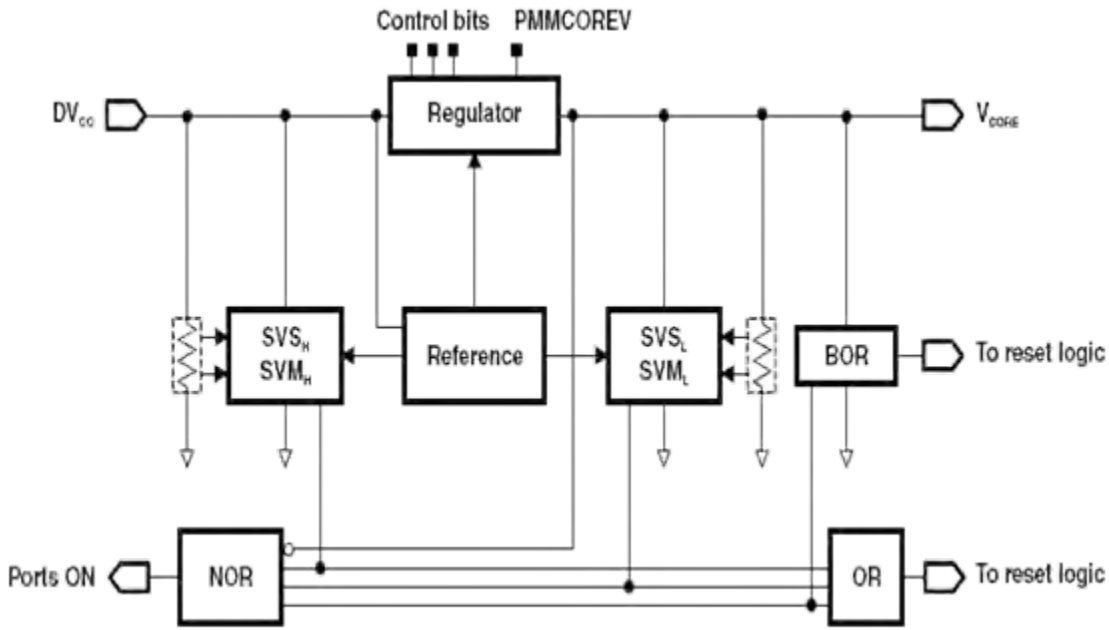
- Ultra-Low Power functionality
- Easy integration
- Flexible LCD support



Power Management Module

Features

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

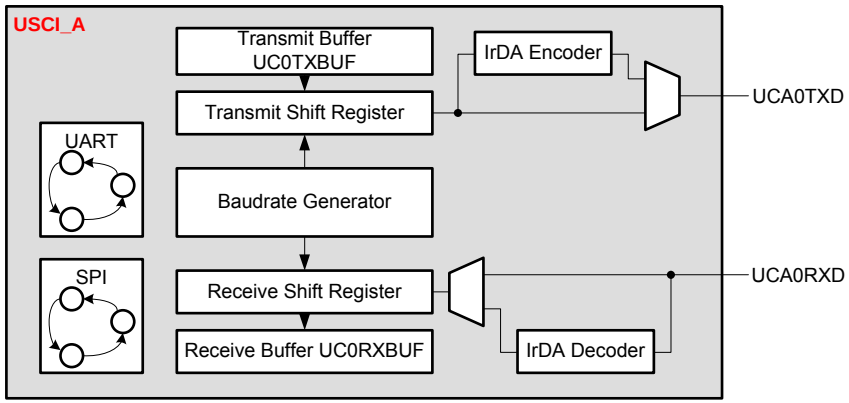


Benefits

- Ultra-Low Power Functionality
- Ensure proper operation in power on and off sequences

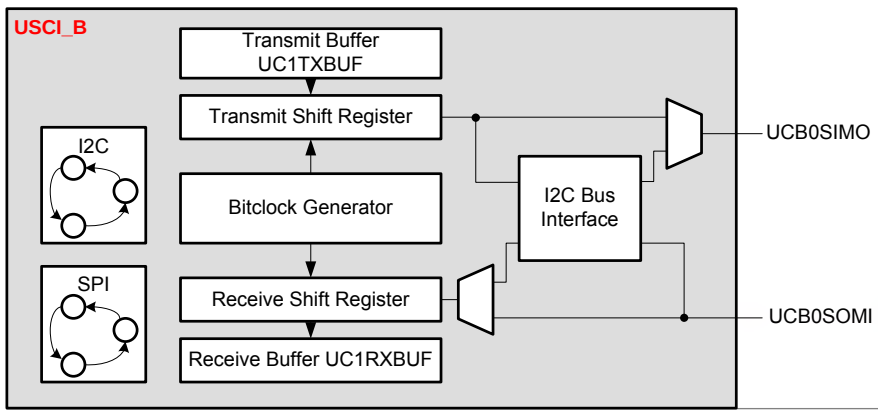
USCI: Serial Communication I/F

USCI_A



- UART with IrDA/LIN support or SPI
- Baud-rate generator with auto-baud rate detect
- *Double buffered TX/RX*

USCI_B



- I2C master/slave up to 400kHz or SPI
- Bit clock generator
- *Double buffered TX/RXs*

Integrated 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 pins (5 volt tolerant)

Analog and peripheral integration reduces system cost

- Multiple analog options with 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

Added features within MSPF663x / F563x devices

- Integrated 160 segmented LCD driver
- Higher flash memory options up to 256KB
- Battery back-up switch and Enhanced Data Integrity (EDI) feature for added reliability

44 New MSP430 USB devices within next 7 months

- Wide range of memory configurations and package options
- Diverse peripheral mix
- Competitive pricing as low a $0.96 (F550x) in volume

Benefits of MSP430 USB

USB is integrated into our on-chip bootstrap loader (BSL)
- Enables end user to update firmware in the field
- Customizable Windows GUI project you can provide to end users
- Just distribute GUI to end users; nothing else required
- Also can be used in factory programming

High flexibility
- Fully-configurable 2K data buffers that can be used as system RAM when USB module is disabled
- Unused USB interface pins can function as high-current I/O pins

USB power supply system
- Integrated LDO for use with 5V USB bus power
- Can power entire system, saving the battery
- Provides 3.3V/1.8V supporting USB PHY, PLL, and logic
- Separate from 5xx Power Management Module (PMM)

Uses low-cost crystal for USB clock, with flexible, integrated PLL
- Same crystal can source non-USB system clocks

Speedy USB Development

USB Bootstrap Loader (USB)
- Supporting device programming
- Field Firmware updates

USB Descriptor Tool
- Configures stack functions

Free USB stacks available:
- Communication Device Class (CDC)
- Human Interface Device (HID)
- Mass Storage Class (MSC)

Additional stacks available from third parties

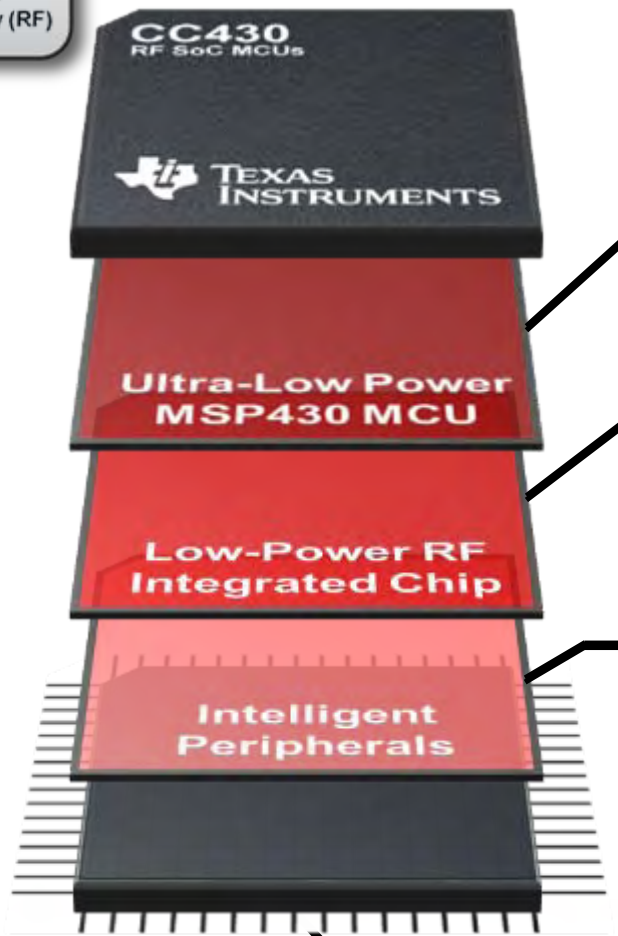
MSP430F5529 Sample Kit

VID
Request for embedded USB products

FREE
Vendor ID/ Product ID sharing program

Radio Frequency (RF)

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 RF Transceiver SoC
- 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

48QFN Pin Package
- 7.15 mm x 7.15 mm area

Radio Frequency (RF)

Broad range of applications benefit from low power networking

Consumer / personal networking

- Watch/shoe combination for monitoring of miles and calories
- Enough processing for wireless networking and batteries that 10+ years

Industrial remote monitoring

- Low power sensor networks for innovative applications like remote monitoring for stress cracks
- Harvest energy from motion, vibration and heat

Shipment monitoring

- Information transmitted wirelessly is protected via encryption for more secure systems
- Location, tamper detection and temperature monitoring

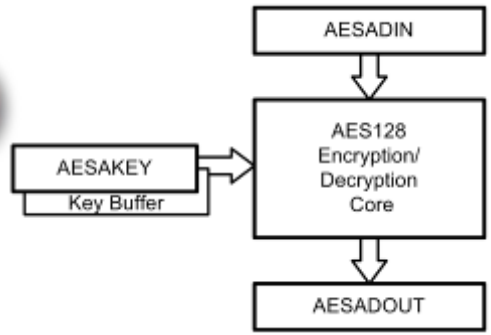
Radio Frequency (RF)

CC430: Innovative Peripherals

LCD_B

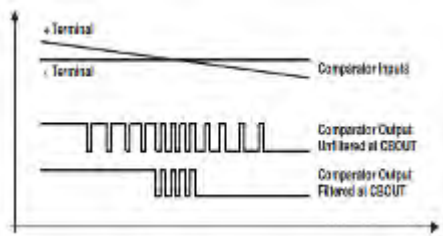
- Blinking of individual segments, Programmable frame frequency, Software-driven contrast control
- Regulated charge pump
- Integrated drivers

AEC 128



- Encryption and decryption according to AES FIPS PUB 197 with 128-bit keys
- Key expansion for en- and decryption
- Off-line key generation for decryption

Comparator_B



- Flexible - Selectable ref. voltage & voltage hysteresis generator
- High-speed, normal, and ultra-low power 100nA modes
- Internal output to Timer A capture
- Selectable RC filter for comparator output

Strong, Vibrant Ecosystem & Solutions

Radio Frequency (RF)

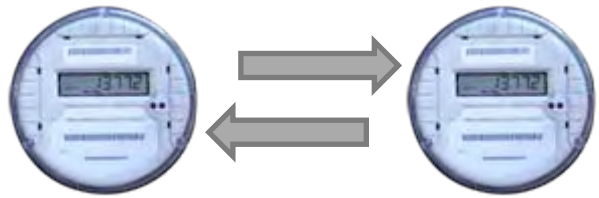
sensinode • 6LoWPAN

- IPv6 over low-power wireless area networks
- Highly efficient use of code and memory
- Direct end-to-end Internet integration
  - Multiple topology options


Home automation & Lighting Control

AMBER WIRELESS • Wireless M-BUS

- Meter-to- meter communication
- Enables a simple star network topology that fits very well to the applications' requirements.
- Sub 1 GHz band (868 MHz)
  - Quality and low power consumption of the transmission critical



Meter-to-Meter communication

DASH7 ALLIANCE • DASH7

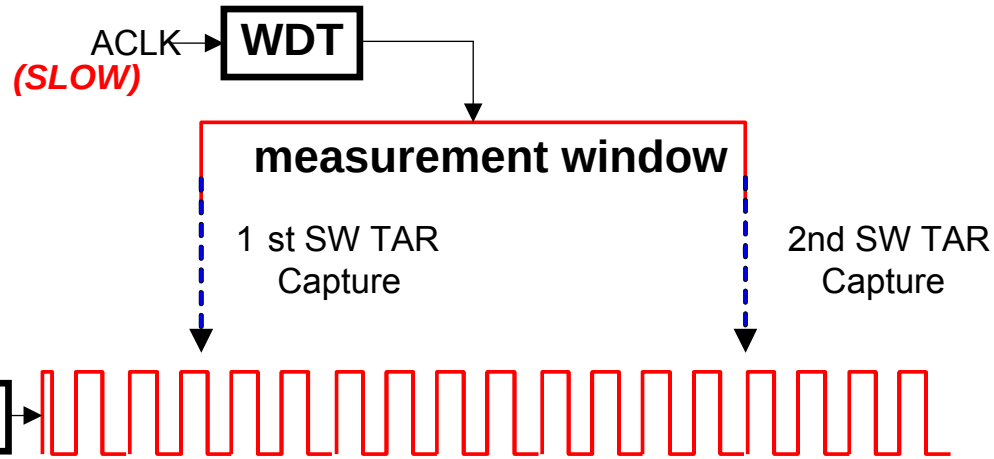
the future of low power wireless data

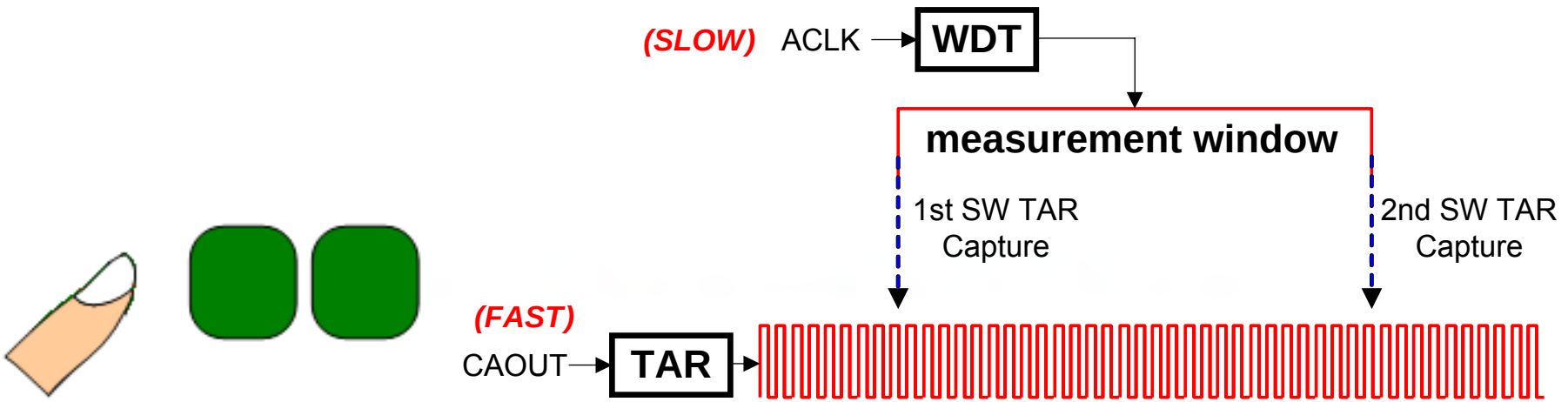
- Ultra-Low Power, Low Bandwidth space
  - Range is scalable, 10 - 2000 m (1.2 mi)
  - 433 MHz, 28 kbps
- Mandated by U.S. Department of Defense, allied militaries
- Asset Tracking, Tire pressure monitoring → sensors, security

Asset Tracking & Tire Pressure Monitor

Cap Touch – RO Method

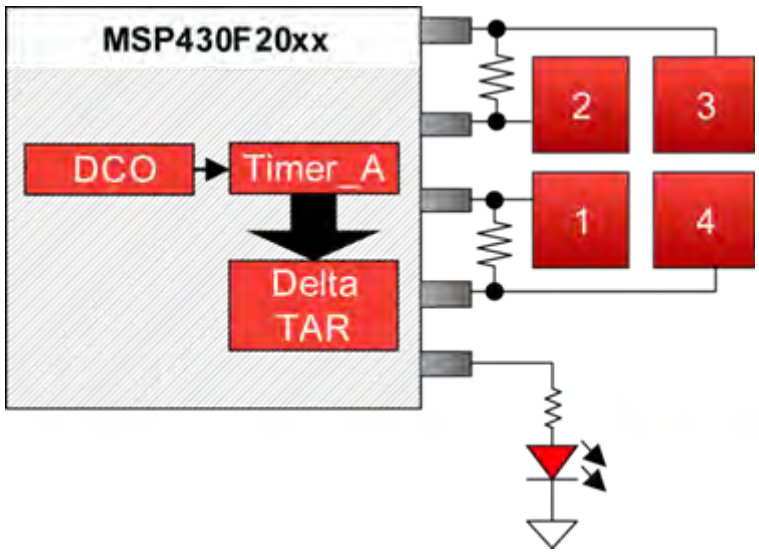
- No external switches/analog required
- Contact is determined by the frequency during the measurement window

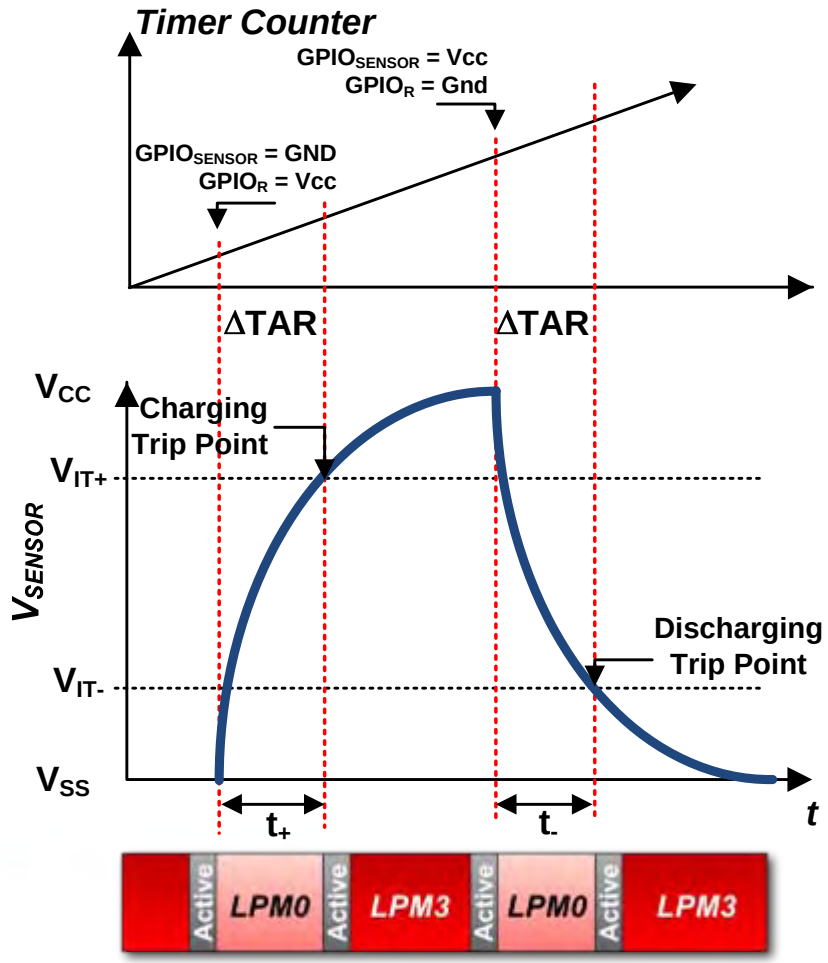




Cap Touch – RC Method

- No external switches or analog required
- Port pin used to charge sensor capacitance
- RC discharge time measured
- App Note: SLAA363





Coming soon

FRAM: The next generation Non-Volatile memory

- Why?
  - Address 21st century macro trends – Wireless, Low Power, Security
  - Drive new applications in our highly networked world
  - Improve time to market & lower total cost of ownership - enable unprecedented flexibility and efficiency in embedded product development & management
- What? To meet Emerging *and* Existing needs for embedded non-volatile memory, support
  - Lower power consumption
  - Faster Access speeds
  - Higher Write Endurance
  - Higher inherent security
  - Lower total solution cost

FRAM – Meets the needs of today & tomorrow

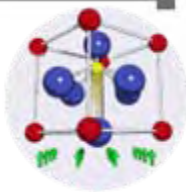
Photo: forums.wow-europe.com

RAMTRON
Automotive F-RAM Memory

Today's embedded controller applications are limited partly by the embedded memory tech of today.

- **Meet FRAM (Ferro-electric Random Access Memory)**
- **Proven & Mature technology** Used for years in many applications including battery-backed SRAM alternatives in automotive industry.
- **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** FRAM 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
- Very High write endurance **>100 Trillion** read/write cycles

What is FRAM Technology?



FRAM - Non-volatile embedded memory technology

- Similar DRAM (1T-1C) **except data stored in crystal state, not charge**
  - Capable of read/write access and cycle times similar to DRAM, but is lower power
- Is a Random Access Memory - **Each bit read/written individually**
- Single step write process – **no separate erase then write cycle (unlike Flash)**
- FRAM has been in products for over 15 years**, primarily automotive space**
- TI has been involved with FRAM for 9 years, **ensuring it's manufacturable, reliable, and cost effective. Focus: FRAM an embedded memory solution**
- **FRAM implementations are not ideal for high speed single cycle memory access speeds of 25MHz, Flash is currently better.**
- **Also, we are using a 2T-2C architecture to improve initial reliability for this new embedded implementation of FRAM. Flash is currently better on a die size/memory density standpoint. FRAM holds the advantage for up to 128kB**

FRAM Operation

- FRAM is intrinsically simpler & faster than current EEPROM technologies, which utilizes a complex charge storage mechanism

- This simplicity means faster operation for reads & writes
  – This also directly leads to lower power consumption

FRAM: Proven, Reliable, Better

Endurance
- Proven data retention to 10 years @ 85°C
- 100 Hrs @150°C
- 1K Hrs @125°C
- 10 Yrs @85°C

Secure
- Fast access times
- No perceptible difference in read/write processes

Radiation Resistance
- Terrestrial Soft Error Rate is below detection limits

Immune to Magnetic Fields
- FRAM does not contain iron

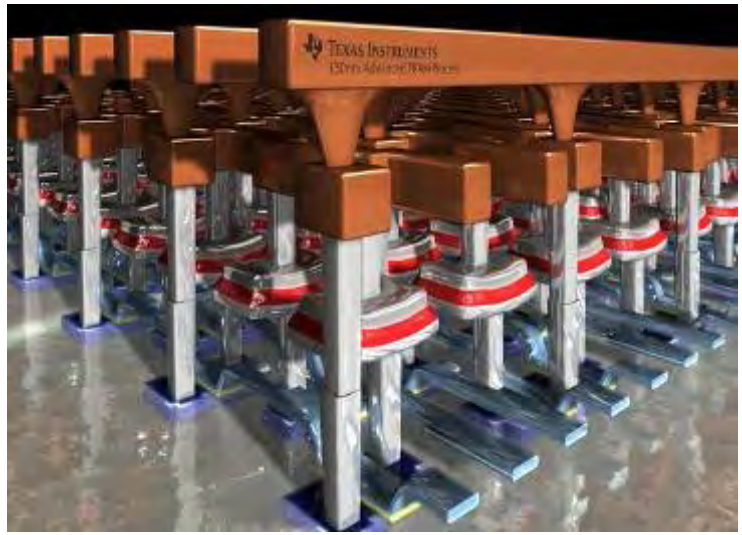


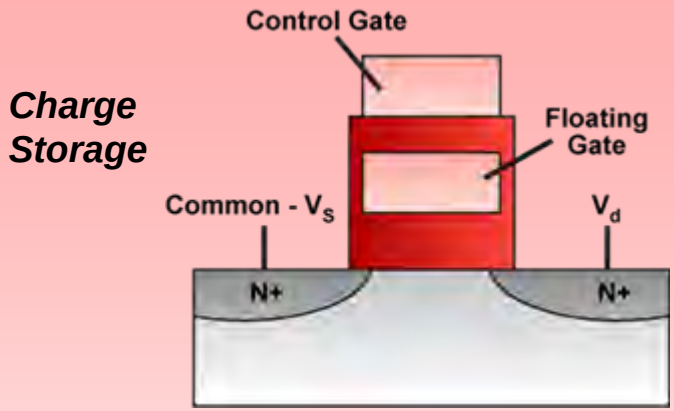
Photo: Ramtron Corporation

www.ti.com/fram

For more info on
TI's FRAM technology

Next Gen Technology Comparison

Floating Gate



- Floating gate memories need high voltages to write (>10 V)
- Exhibit slow writes/erase cycles
- Subject to added cost, increased power consumption

MRAM

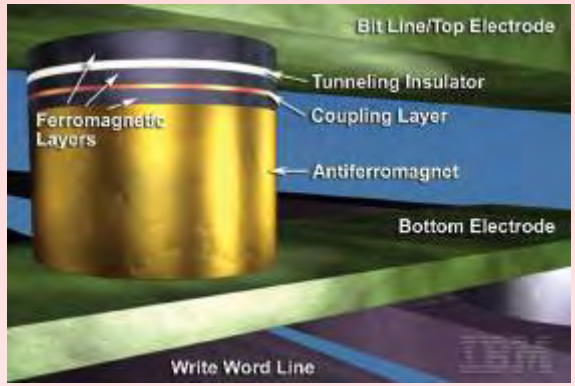


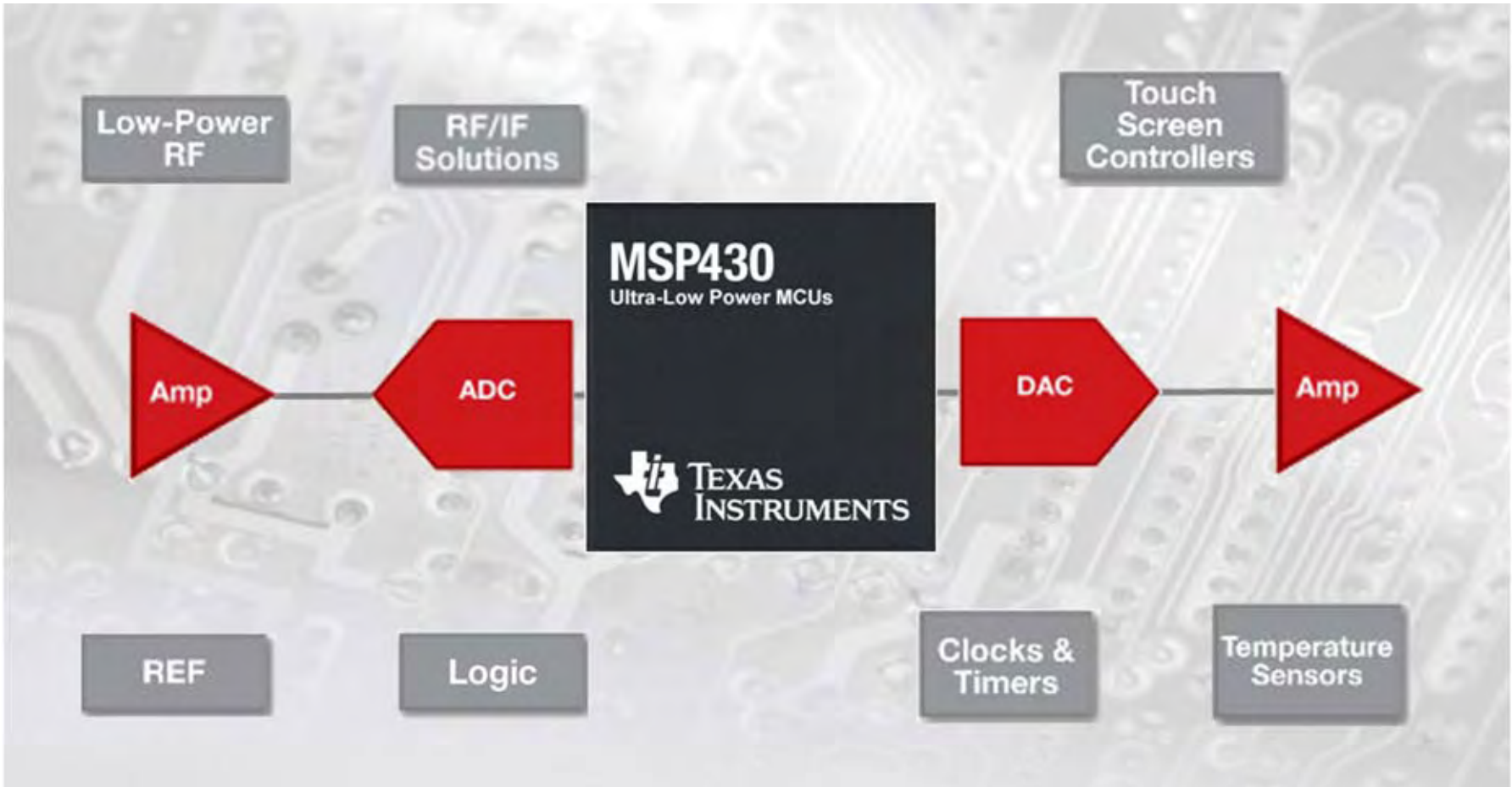
Photo: www.eetimes.com

- Access speeds comparable to DRAM
- Low Power supported in some implementations
- Bit cell size comparable to FRAM
- Read/Write currents higher than FRAM (~mA)

FRAM Current Gen Technology Performance Comparison

	FRAM	EEPROM	Flash
Time to write 64 bytes to memory	1.6 µs	2,200 µs	6,400 µs
Time to read 64 bytes from memory	1.6 µs	4.5 µs	4.5 µs
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: it's what's on the inside that counts.

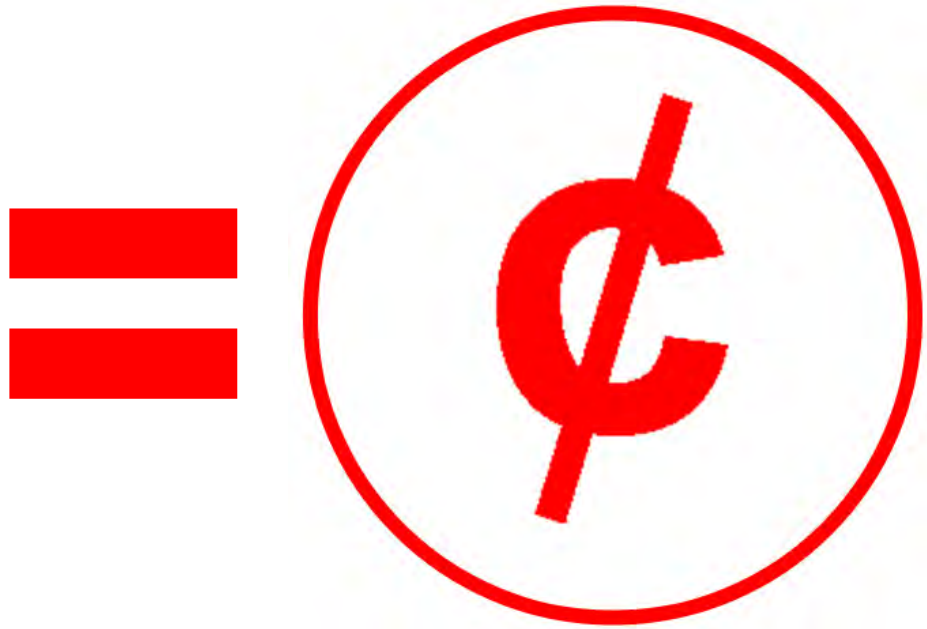


…most of the time

Need more _____ ?

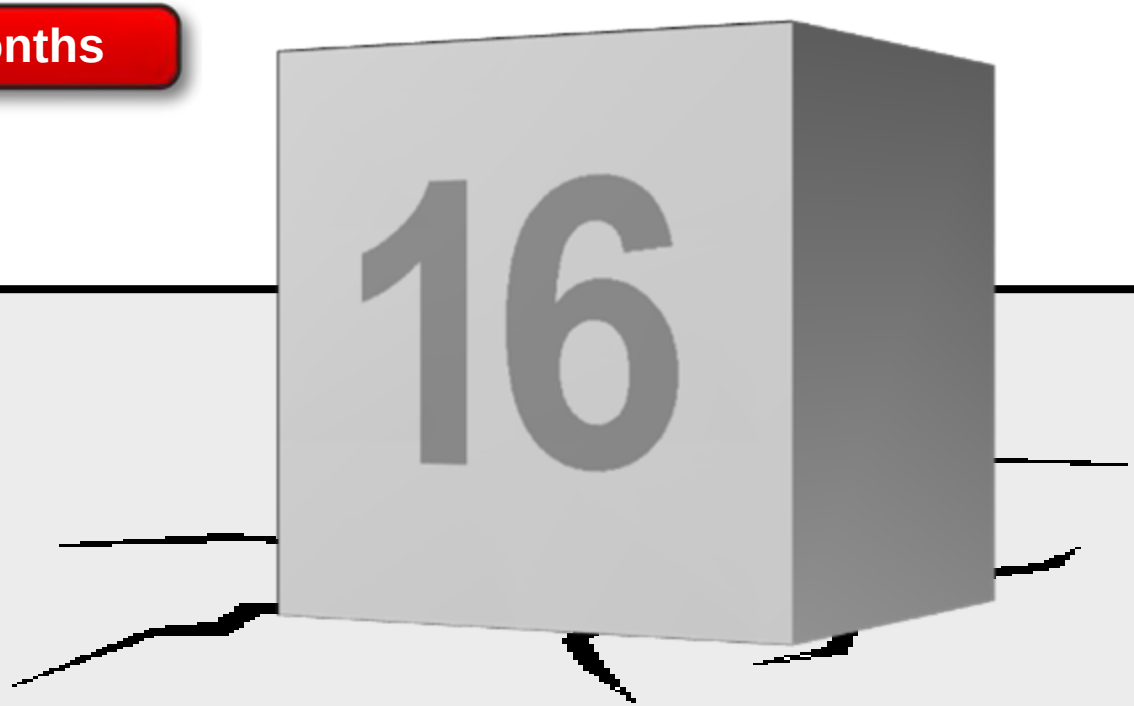
- Functionality, Precision, Power Management, Interface….
  - Sometimes you just need more, and the TI analog portfolio offers it.
- We make it easy for you to find more "____":
- www.ti.com/mcu4analog
  - Summary of complementary analog and mcu components, sorted by End Equipments and Specific Analog Function.
- www.ti.com/processorpower
  - Reference designs for your power needs.
- www.ti.com/plus1
  - Season your design with "salt and pepper" logic.

MSP430 is Affordable and Scalable



MSP430 Value Line

- 16-bit performance, 8-bit price
- Starting at $0.25 USD
- 100+ New Devices in 15 months



MSP430 Value Line

Starting @ $0.25 USD!

¢

Deliver increased features and functionality with optimized 16-bit MSP430 architecture

- 10X more MIPS throughput
- Reduced cycles/task
- 50% greater code density

Design products with up to 20 years of battery life through leading ultra-low power consumption

- 10X lower power
- Smart ADC
- Sub 1µs wakeup

Accelerate time to market with easy-to-use tools, free software & extensive third party support

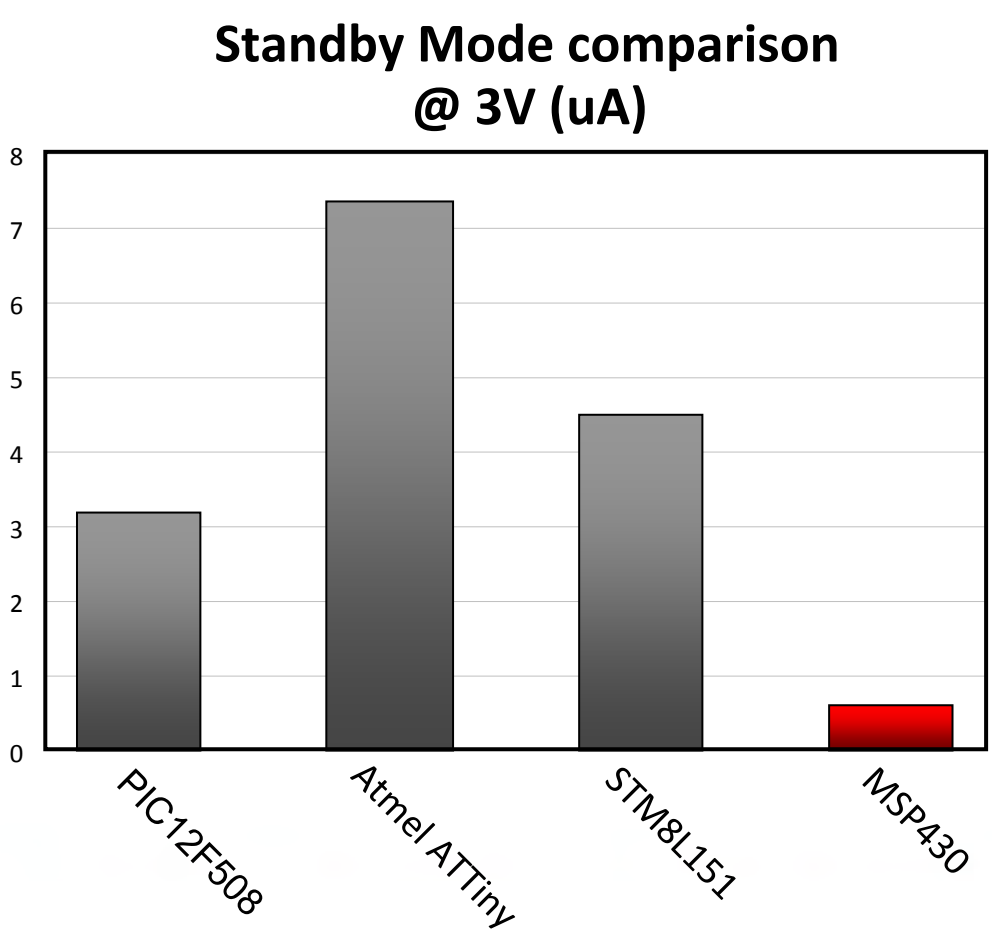
- 100 new MCUs as low as $0.25
- Full compatibility across entire MSP430 platform

What do I get for 25 cents?

	PIC10F200	MSP430G2001
Flash	512B Ext 12V	512B In System
RAM	25B	128B
Timers	8-bit counter	16-bit multifunction
Emulation	0	2-pin In System
GPIO/ Interrupts	6 0	10 22
MIPS	1x 8-bit	16x 16-bit
Power Modes	2	5
Price	$0.25	$0.25

- Flexible
- Agile
- More Functionality
- Faster Development
- No Compromise
- Hi-Performance
- MSP430 is lower power in all modes of operation

MSP430 Value Line Competitive Snapshot ¢



Typical battery powered applications spend 99 – 99.9% of their time in standby mode

MSP430 power consumption is lower than competing 8-bit MCUs; as low as (values @ 2.2V)

- 0.1 µA RAM retention
- 0.4 µA Standby mode (VLO)
- 0.7 µA real-time clock mode
- Ultra-Fast Wake-Up From Standby Mode in <1 µs

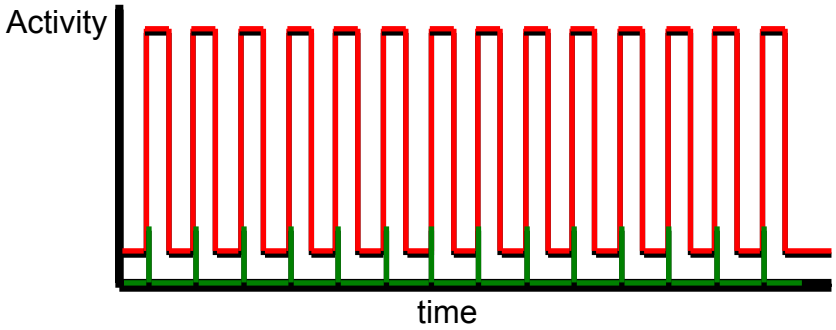
***10*X lower power**

ADC + Data Transfer Controller

ADC Sample
CPU Activity

PIC12F508: ADC

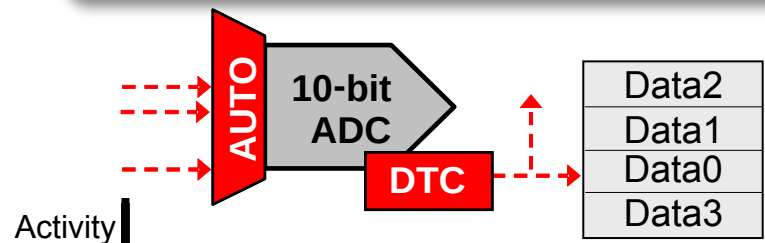
The competition requires the CPU to be active for each ADC conversion and loaded data transfer.

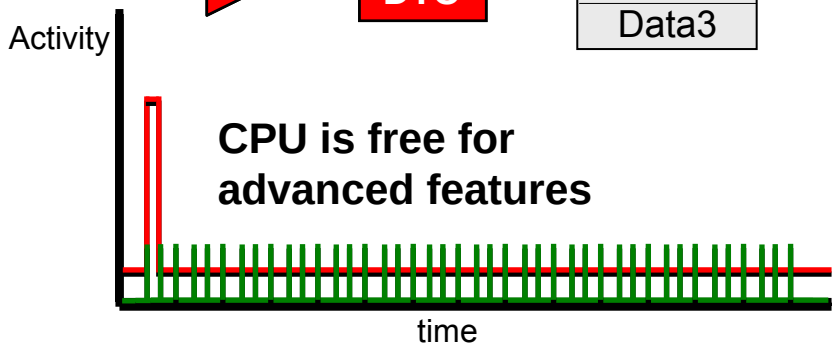



```
Competitor A
                movlw       0x2
                movwf       FS
                movlw       0x
                movwf       Ch
Main            movf        Cha
                movwf       ADCON0
                decf        Channel
                btfss       STATUS Z
                mov         0x03
Wait            bsf         ADCON0, GO
                btfss       ADCON0, GO
                goto        Wait
                movf        ADCRESH, W
                movwf       INDF
                incf        FSR, F
                bcf         STATUS, 0x20
                movwf       INDF
                incf        FSR, F
                btfss       STATUS, Z
                goto        main
```

Limited to 10,638 samples/s @ 100% CPU load

MSP430G2xx: ADC + DTC





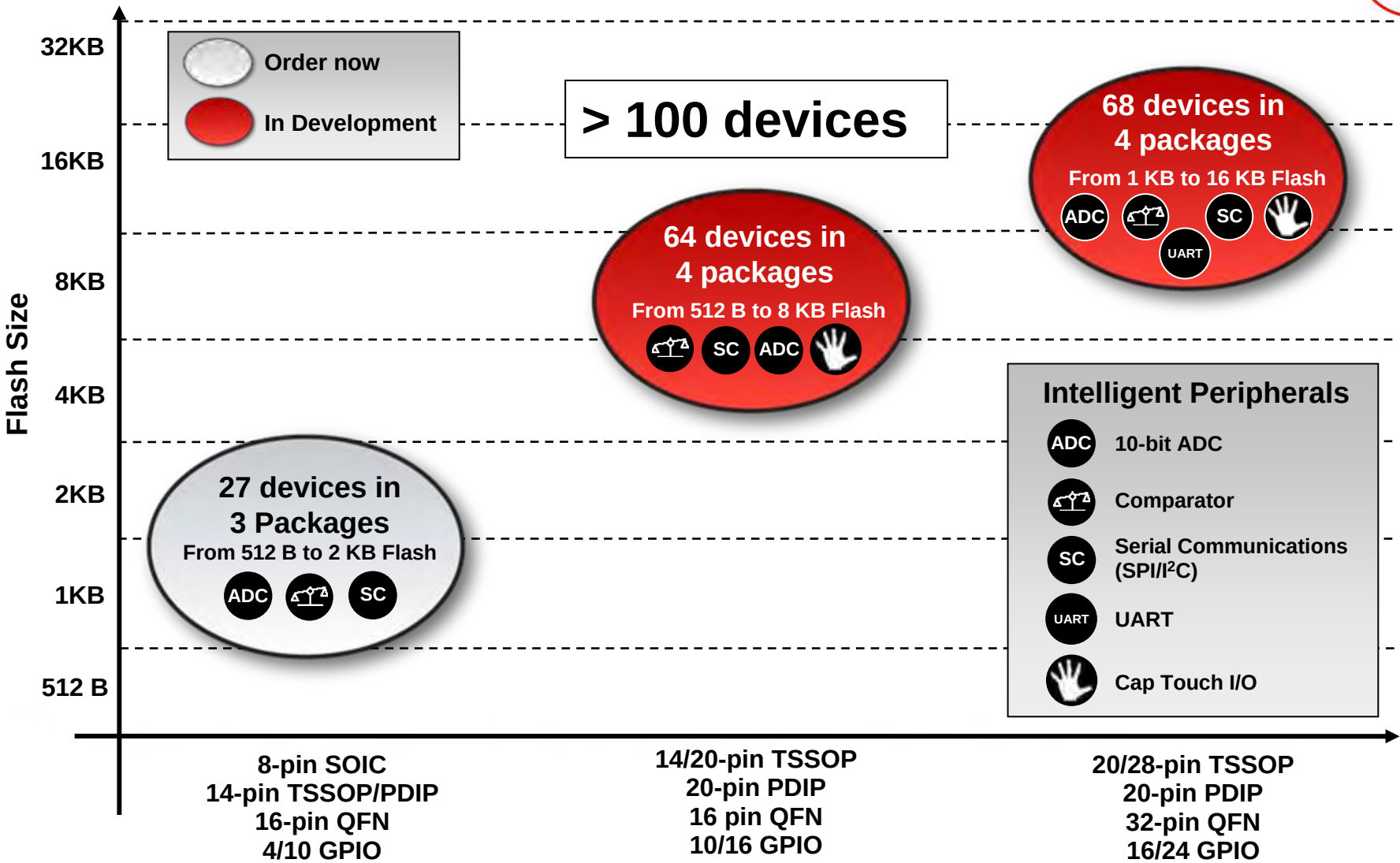

```
MSP430 + DTC
 bis.w  #CPUOFF,SR
```

Up to 200,000 samples/s @ 0.6% CPU load

MSP430's ADC10 with Data Transfer Controller (DTC) can manage ADC samples throughout entire memory range – All without CPU overhead!

- Less time in Active Mode saves power
- CPU available for other more advanced tasks
- Intelligent autonomous sampling
- Deterministic behavior

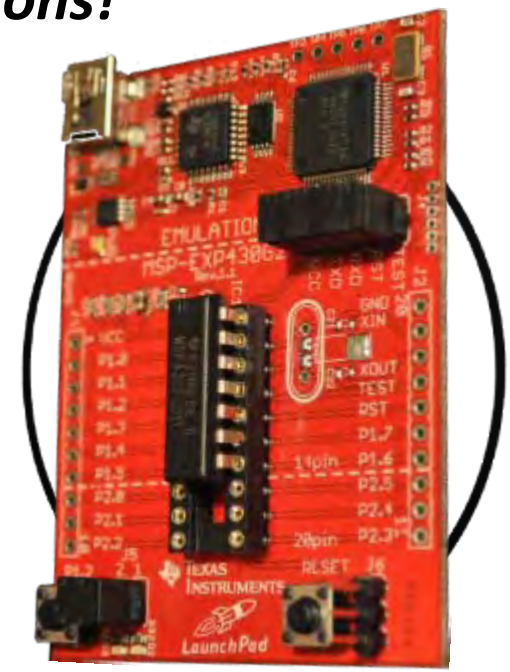
100 devices over the next 15 months



Meet the new MSP430 *LaunchPad*

Everything you need to Launch your applications!

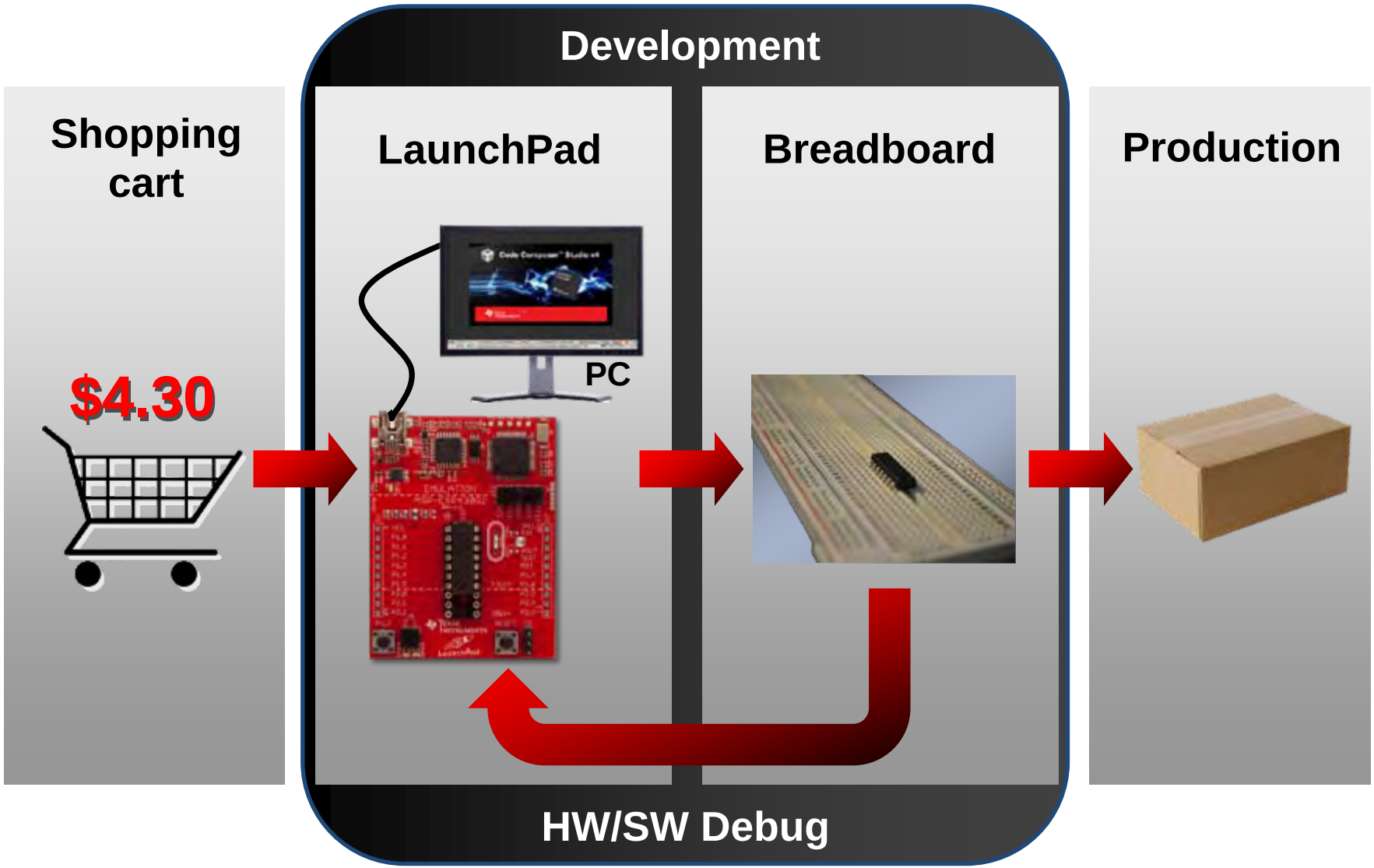
- + ***Embedded emulation***
  Includes mini USB Cable
- + ***14 and 20-pin DIP Socket***
  Supports all MSP430 Value Line devices
- + ***Includes 2x MSP430 Devices***
  MSP430G2231 & MSP430G2211
- + ***2 Pushbuttons***
- + ***2 LEDs***
- + ***FREE software Compiler/Debugger***
  Code Composer Studio Ver 4
  IAR Embedded Workbench



MSP430 **LaunchPad**

$4.30 ***& for a limited time only***
FREE SHIPPING!

Accelerate time to market with LaunchPad



Other Value Line Tools

eZ430-F2013: $20 Development System

- Real-time, in-system emulation
- Removable target with full pin access

Free, code-limited software IDEs

- Code Composer Studio™ v4
- IAR Embedded Workbench

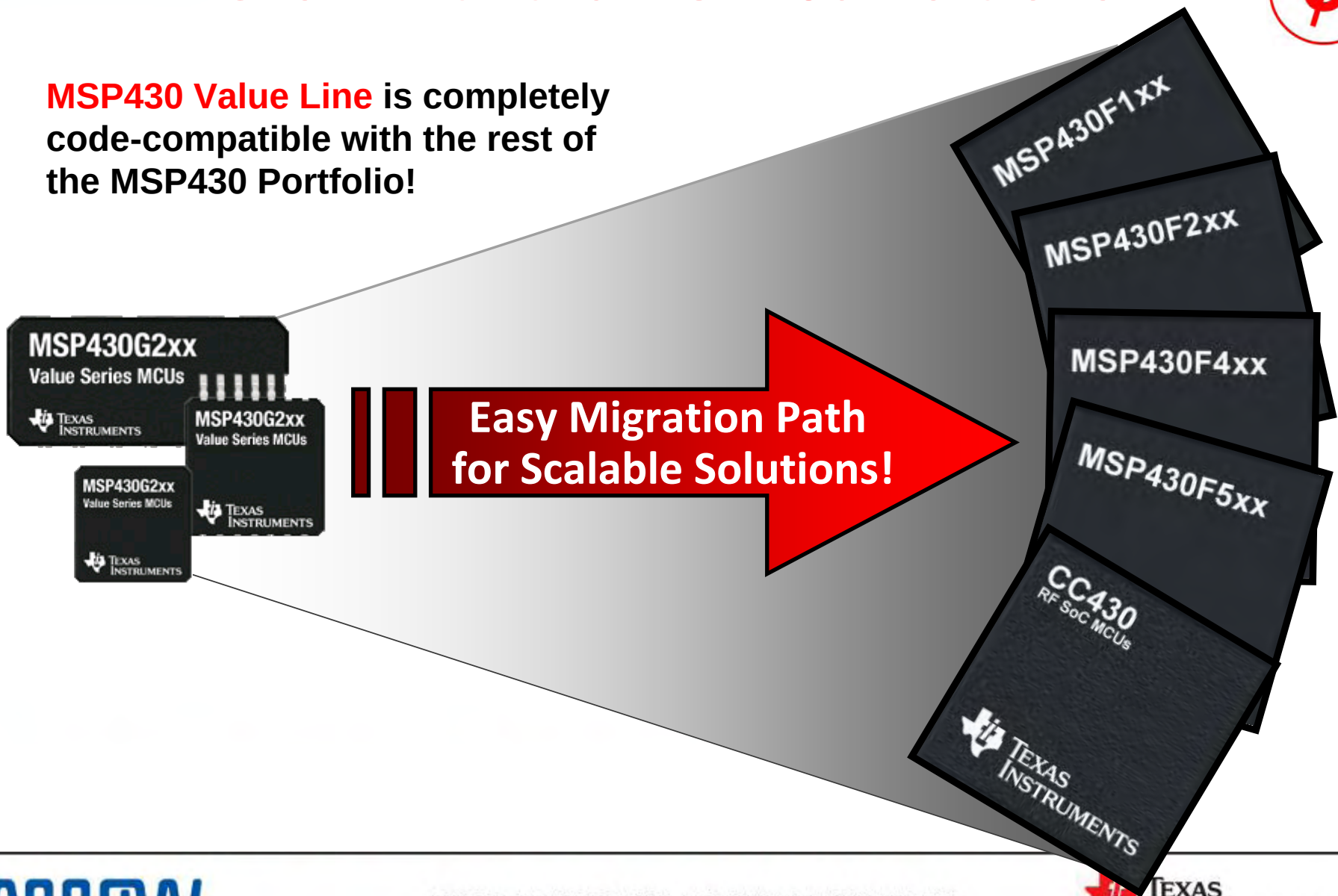
Flash Emulation Tools

- Compatible with all MSP430 devices
- Socketed target boards available

Complete Development – starting @ $4.30

Grow with the MSP430 Portfolio

MSP430 Value Line is completely code-compatible with the rest of the MSP430 Portfolio!



MSP430 Scalable Portfolio | 200+ Devices

Ultra-Low Power Performance — Analog Integration — Easy-to-Use

MSP430
16-bit RISC CPU

All devices feature:
- 16-bit timers
- Watchdog Timer
- Internal Digitally Controlled Oscillator
- Ext 32-kHz crystal support
- <50 nA pin leakage
- <6 µs wakeup

F1xx
Speed 8Mhz
Flash 1-60kB
RAM to 10kB
GPIO 14-48

BOR
ADC10.12
Comp_A
DAC12
DMA
MPY
SVS
USART

$0.25

G2xx
Speed 16Mhz
Flash 0.5-2kB
RAM 120kB
GPIO 10

BOR
ADC10
Comp_A+
Temp
USI

F2xx
Speed 16Mhz
Flash 1-120kB
RAM to 8kB
GPIO 10-64

BOR
ADC10,12
SD16_A
Comp_A+
DAC12
DMA
MPY
OpAmp
SVS
USCI
USI

F4xx
Speed 8/16Mhz
Flash 4-120kB
RAM to 8k
GPIO 14-80

BOR
LCD
ADC10,12
SD16(_A)
Comp_A
DAC12
DMA
MPY
OpAmp
SVS
USART
USCI
ESP430
SIF
Basic Timer
WDT+
RTC_C

F5xx
Speed 25Mhz
Flash 8-256kB
RAM to 16kB
GPIO 32-83

PMM
BOR
SVS
SVM
LDO
MPY
USCI
DMA
EDI
USB
ADC10,12 (A)
Comp_B
RTC_A/B

CC430
Speed 20Mhz
Flash 8-16kB
RAM to 4kB
GPIO 40

PMM
BOR
SVS
SVM
LDO
MPY
USCI
DMA
Sub 1GHz RF
AES
ADC12 (A)
Comp_B
RTC_A/B
LCD

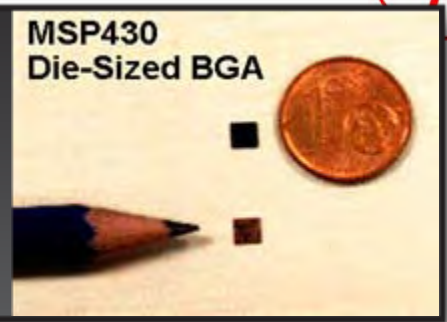
All Devices | Some Devices

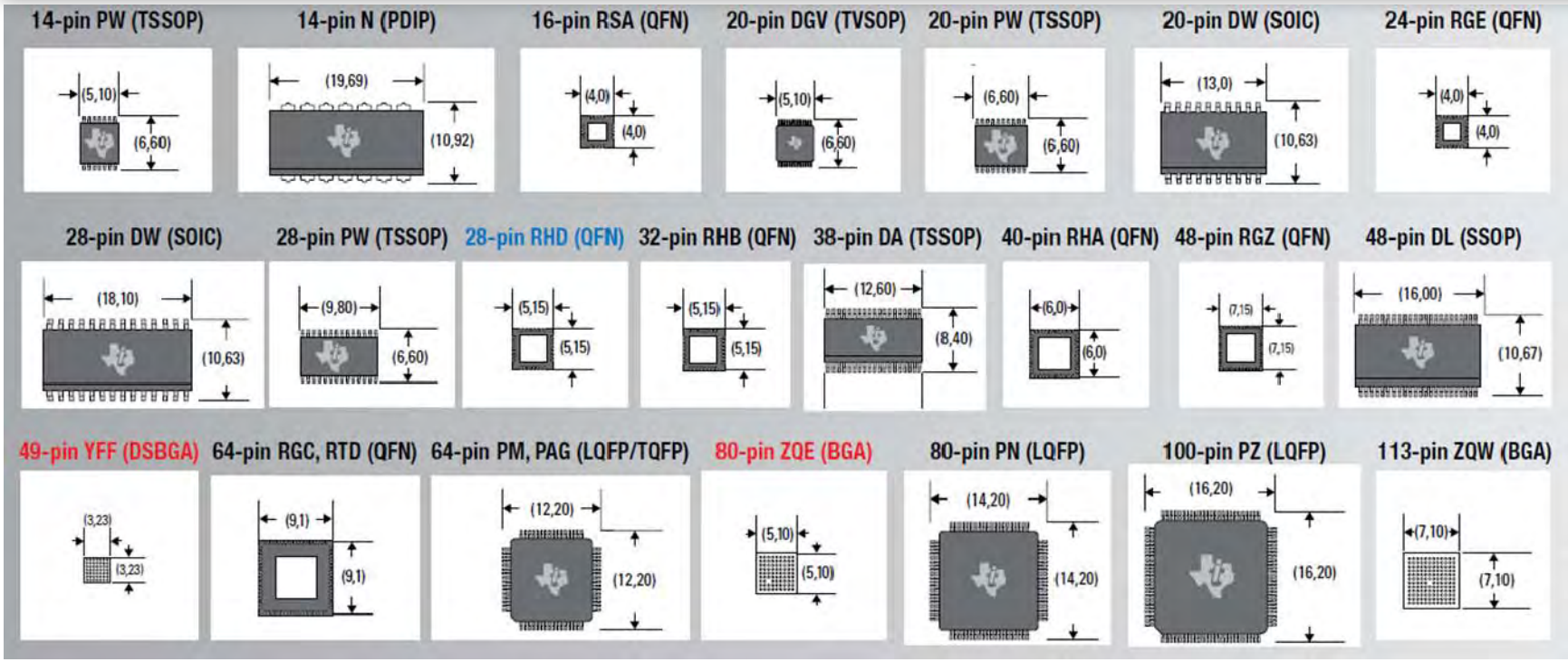
MSP430 Package Options

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

20+ packages!

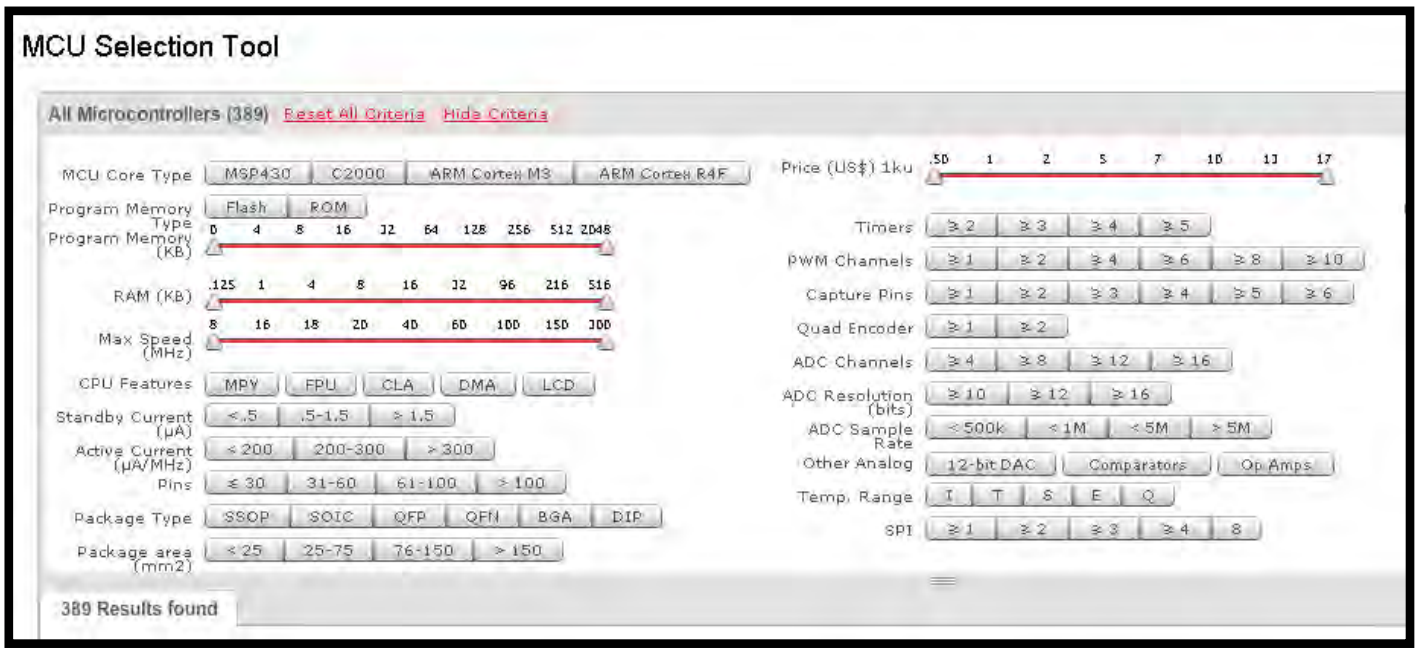




Red: New **Blue: Preview**

MCU Selection Tool

- Find the right MCU for your application
- Browse the 200+ MSP430 devices and explore the rest of TI's MCU offerings

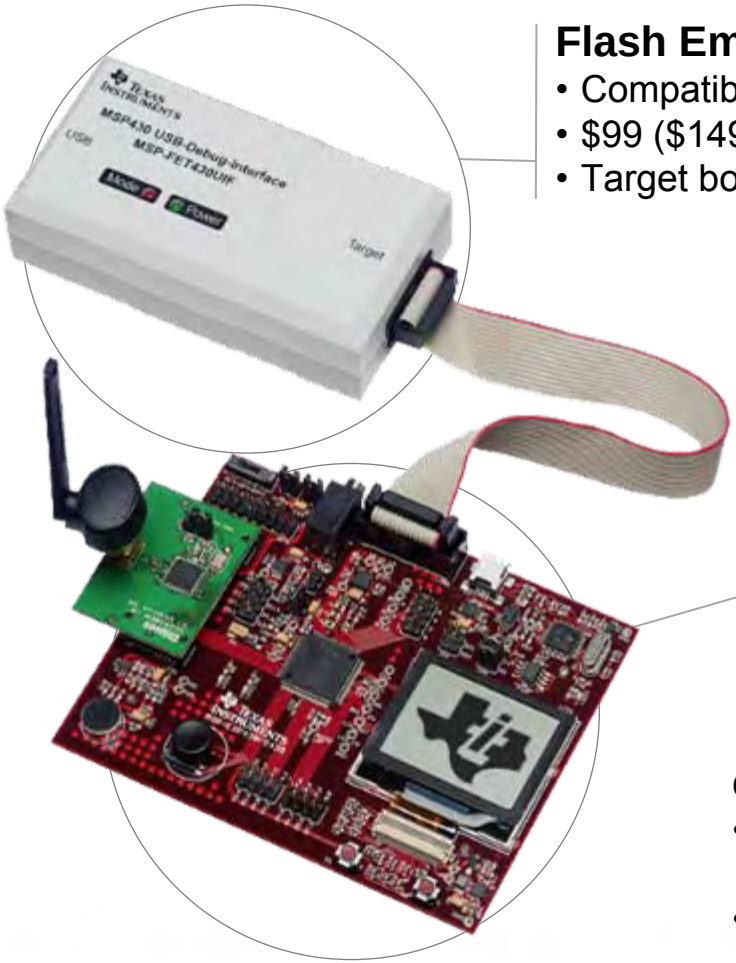


MSP430 is Easy to Get Started

=

eZ

Easy To Use, Innovative Tools



Flash Emulation Tools

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

Free Software IDEs Available

- CCSv4 MCU Edition
- IAR Embedded Workbench

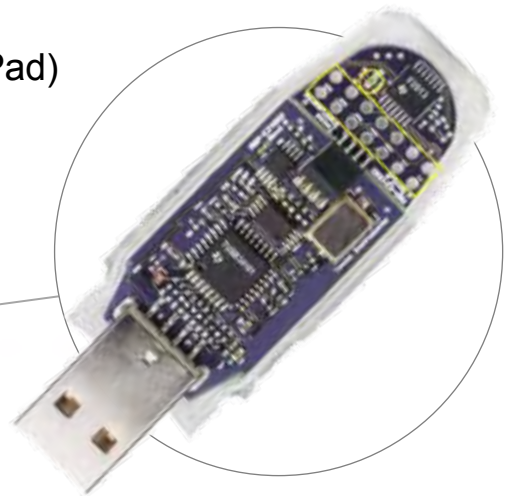
IAR SYSTEMS

MSP430 Experimenter Boards

- Fully features prototyping system
- Available for FG4618 & F5438
- Starting at $99 ($4.30 for LaunchPad)

eZ430 Tools

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



Embedded Emulation

- Real-time, in-system debug
  - No application resources used
  - Full speed execution
  - H/W breakpoints
  - Single stepping
  - Complex triggering
  - Trace capability
- Powerful, easy to use tools
- Spy Bi-Wire
  - 2-wire debug interface
  - No pin function impact
- Only 1 tool required for *all* devices

Chronos | Advanced Features at Your Disposal

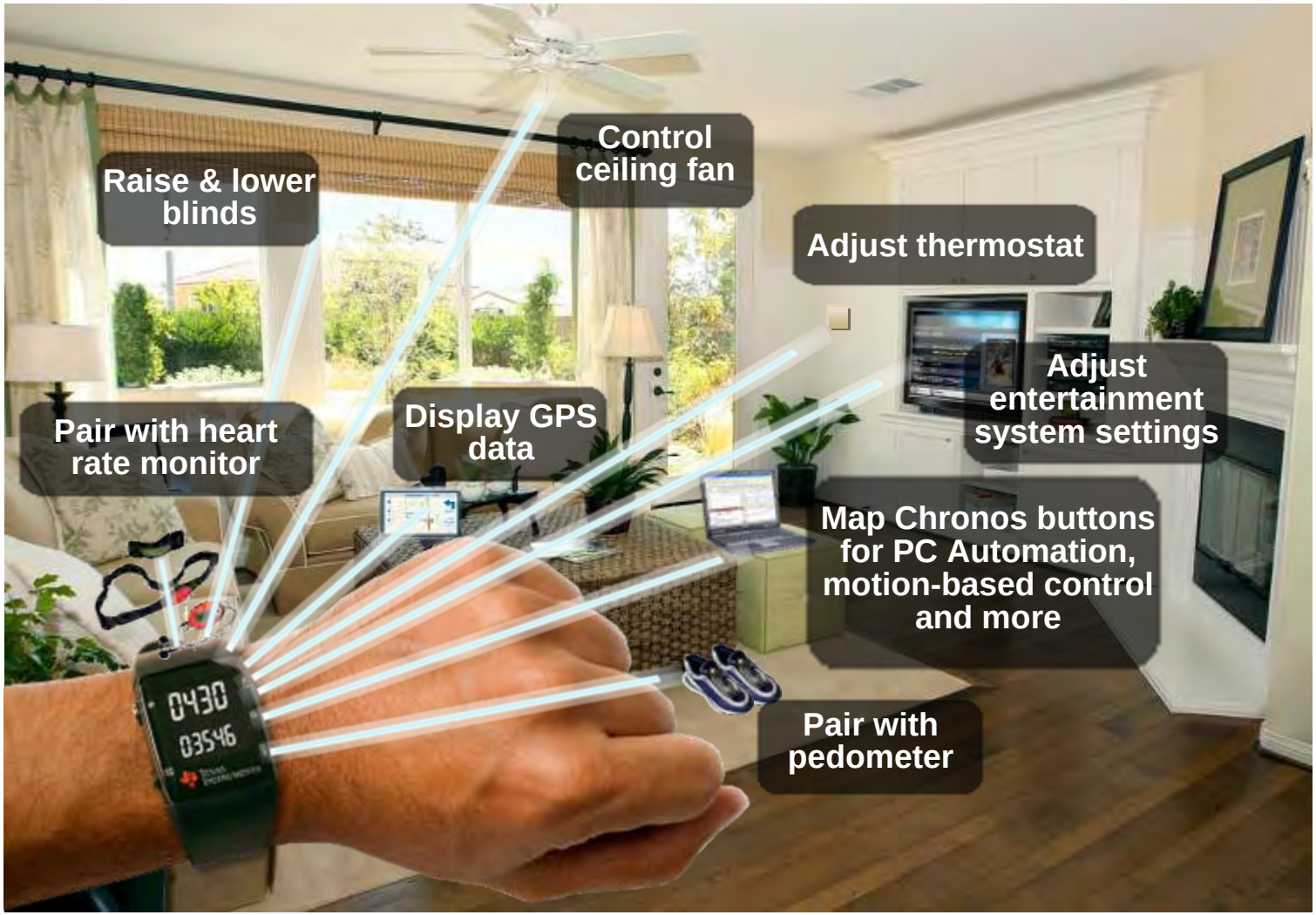
- CC430F6137 MCU
- <1GHz RF
  - 433, 868 & 915 MHz
- 2-Wire JTAG Access
- 96 segment LCD
- Buzzer
- 3-Axis Accelerometer
- Pressure & Altitude Sensor
- Temperature Sensor
- Voltage & Battery Sensor
- CR2032 Battery

eZ430 Programmer

RF Access Point

Chronos Disassembly Tool

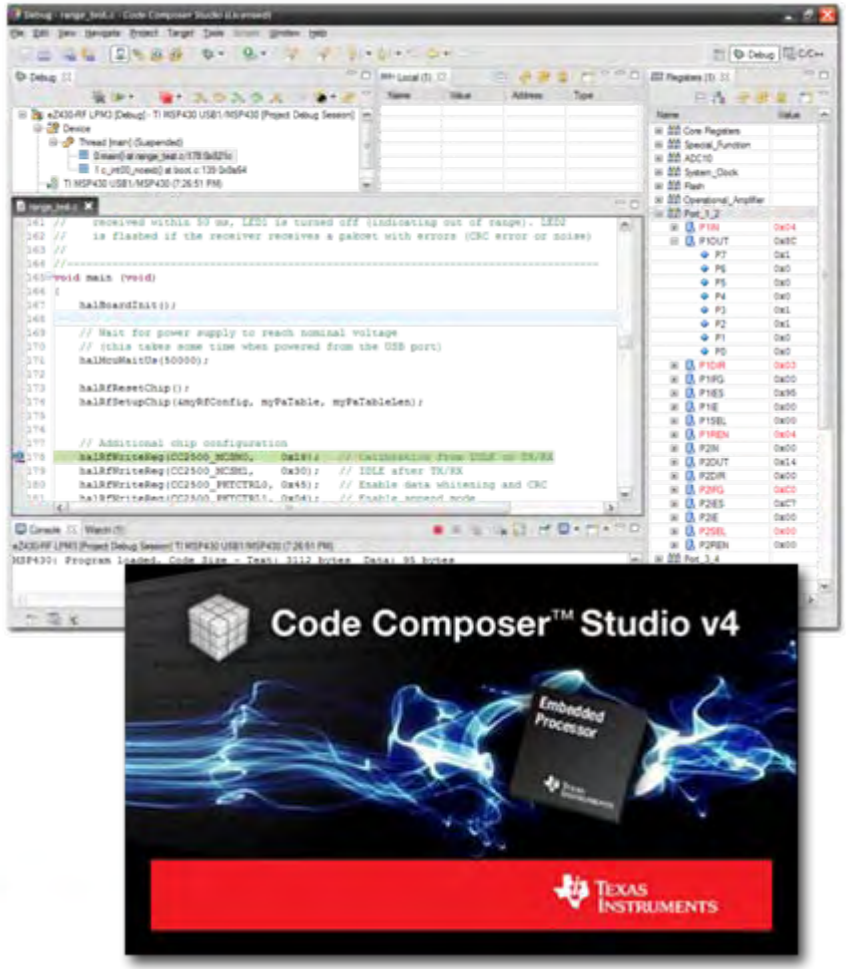
Endless possibilities: Chronos serves as a central hub for nearby wireless sensors



Enabling Customer Innovation

Code Composer Studio v4

- Code Composer Studio v4:
  A single development platform for all TI processors
- CCE users will feel at home
- Enhancements since CCE:
  - Speed
  - Code size improvements
  - Auto-updating
  - License manager
  - Support for all TI MCUs
- Only $495 for MCU Edition
  - $249 for MCU Day attendees
- FREE 16KB-limited edition



http://tiexpressdsp.com/wiki/index.php?title=Category:Code_Composer_Studio_v4

TI and IAR Systems: Deep and Evolving Partnership

1990's	2005	2006	2009
TI and IAR Systems partners on MSP430	TI and IAR partners on ARM MCU's	TI acquires Chipcon, partner to IAR Systems	TI acquires Luminary Micro, partner to IAR Systems

TI and IAR Systems Product Integration and Support

IAR Embedded Workbench
C/C++ compiler and debugger tool set

IAR PowerPac
RTOS
File System
USB Device Stack
TCP/IP stack

IAR visualSTATE
design, test and verification tools using state machines

IAR KickStart Kits
Completely integrated kits

TI MSP430 microcontrollers

TI Stellaris microcontrollers

RF/IF and ZigBee Solutions

IAR SYSTEMS

Third Party Development Resources

Rowley CrossWorks

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

www.rowley.co.uk

Elprotronic

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

RTOS Options

- µC/OS-II™
- CMX-Tiny+™
- embOS
- FreeRTOS™
- IAR PowerPac
- QP™
- Salvo™
- TinyOS

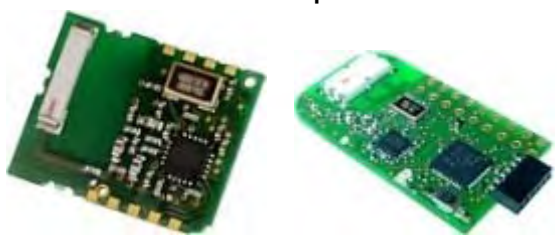
MSPGCC Tool Chain

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

http://mspgcc.sourceforge.net

Amber Wireless

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



USB Stacks

- IAR
- HCC

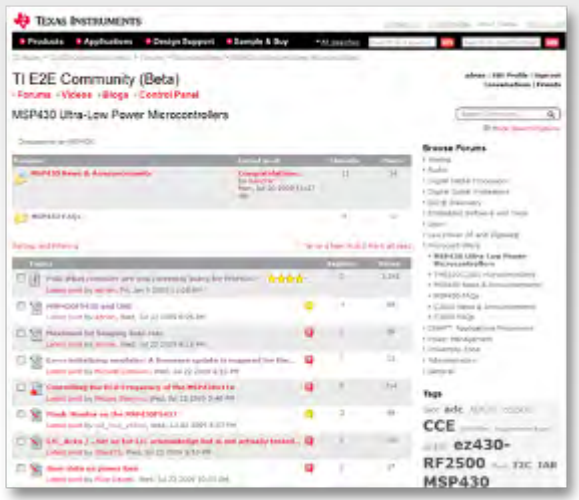
www.ti.com/msp430

- User's Guides
- Datasheets
- TI Community Forum
- 100+ Application Reports
- 1000+ Code Examples
- Product Brochure
- MCU Selection Tool
- Latest Tool Software
- 3rd Party Listing
- Silicon Errata

Extensive Community Support

E2E Community

- Videos, Blogs, Forums
- Extensive community support and idea exchange
- Global customer support
- http://e2e.ti.com

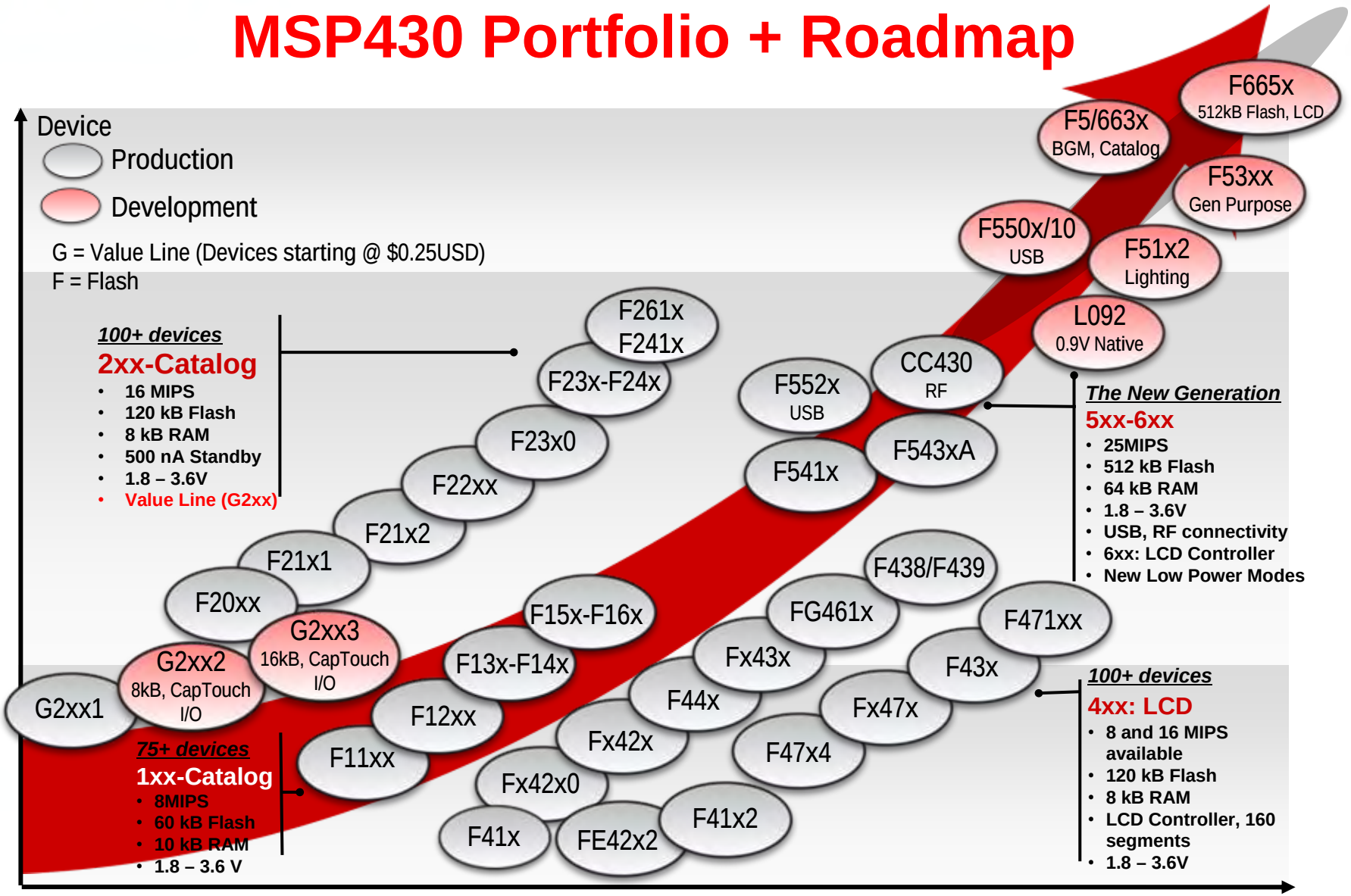


Processor Wiki

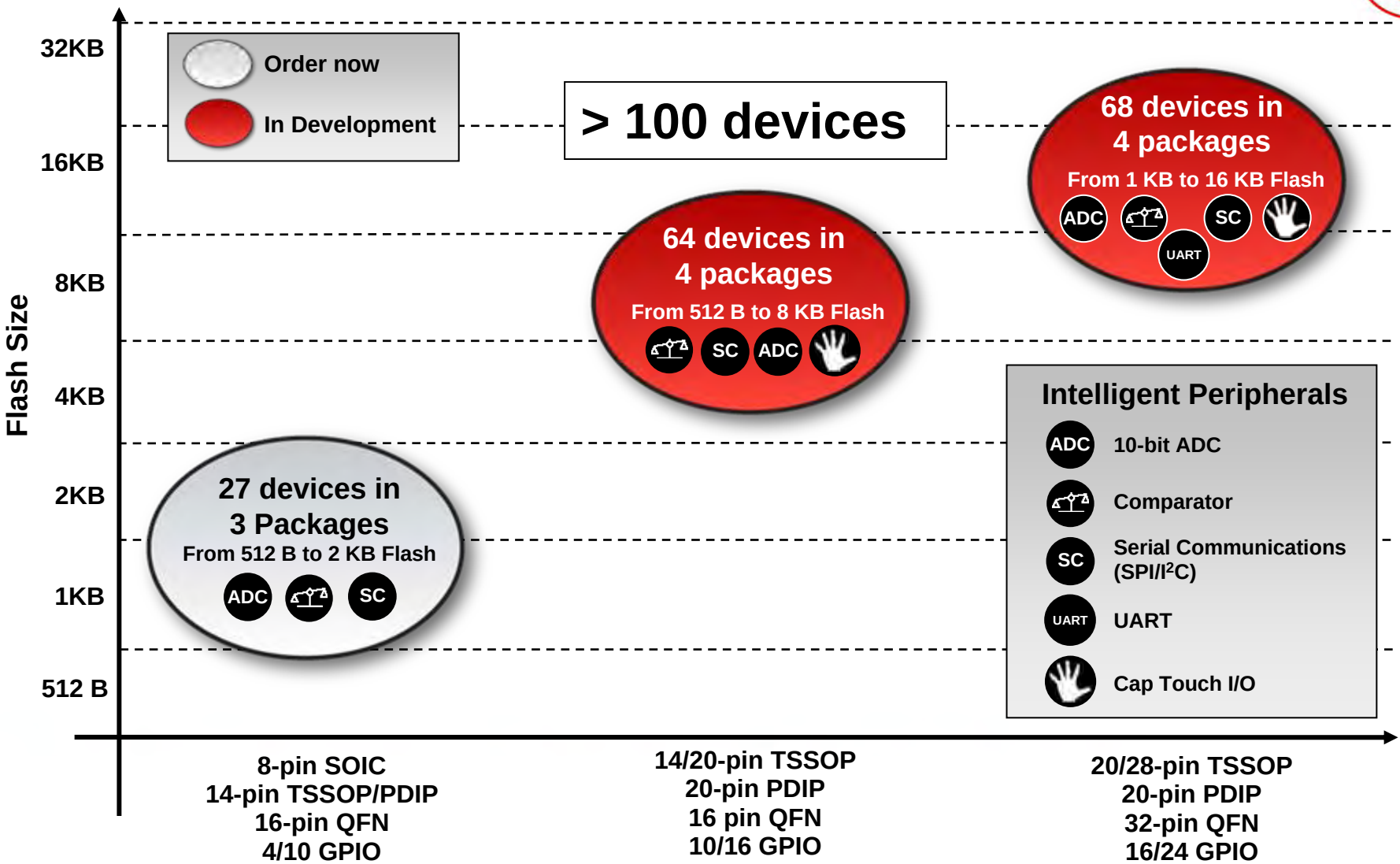
- Growing collection of technical wiki articles
- Tips & tricks, common pitfalls, and design ideas
- http://wiki.msp430.com

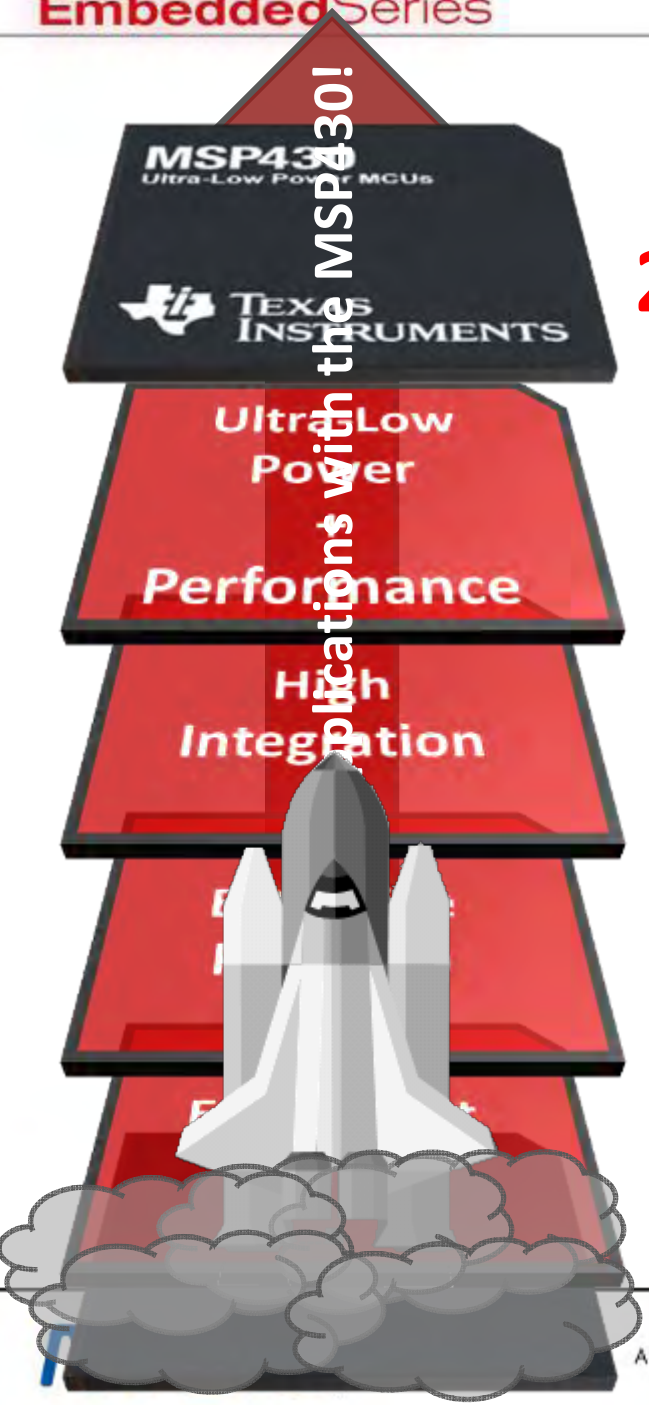
Roadmap

MSP430 Portfolio + Roadmap



MSP430 Value Line Roadmap





MSP430 Summary

200+ Ultra-Low Power Devices | **25¢** Starting Price | **$4.30** LaunchPad Tool

Ultra-Low Power + Performance

- Six Low-Power Modes
- <1 µs wakeup time
- Zero-Power BOR
- 25MHz speed
- Leading Code Density
- Do more without CPU

High Integration

- Intelligent Analog & Digital Peripherals
- 16-bit ADC, 12-bit DAC, LCD Controllers, DMA
- Communication Interfaces include RF & USB

Extensive Portfolio with Low Cost Options

- MSP430 Value Line starting @ $0.25
- 200+ Devices, various levels of integration/performance
- Roadmap with new technology

Easy to Get Started

- One programming tool for all devices
- Free Software IDEs
- Upcoming MSP430 LaunchPad!
- Code compatibility throughout MSP430 platform

TI has a complete portfolio of Analog and Embedded Processing Solutions…

Embedded processing portfolio

TI Embedded Processors

Microcontrollers (MCUs)

16-bit ultra-low power MCUs	32-bit real-time MCUs	32-bit ARM Cortex™-M3 MCUs
MSP430™	**C2000™ Delfino™ Piccolo™**	**Stellaris®** ARM® Cortex™-M3
Up to 25 MHz	40MHz to 300 MHz	Up to 100 MHz
Flash 1 KB to 256 KB	Flash, RAM 16 KB to 512 KB	Flash 8 KB to 256 KB
Analog I/O, ADC LCD, USB, RF	PWM, ADC, CAN, SPI, I^2C	USB, ENET MAC+PHY CAN, ADC, PWM, SPI
Measurement, Sensing, General Purpose	Motor Control, Digital Power, Lighting, Ren. Enrgy	Connectivity, Security, Motion Control, HMI, Industrial Automation
$0.25 to $9.00	$1.50 to $20.00	$1.00 to $8.00

ARM®-Based Processors

ARM Cortex-A8 MPUs	DSP DSP+ARM
Sitara™ ARM® Cortex™-A8 & ARM9	**C6000™ DaVinci™** video processors **OMAP™**
300MHz to >1Ghz	300MHz to >1Ghz +Accelerator
Cache, RAM, ROM	Cache RAM, ROM
USB, CAN, PCIe, EMAC	USB, ENET, PCIe, SATA, SPI
Industrial computing, POS & portable data terminals	Floating/Fixed Point Video, Audio, Voice, Security, Conferencing
$5.00 to $20.00	$5.00 to $200.00

Digital Signal Processors (DSPs)

Multi-core DSP	Ultra Low power DSP
C6000™	**C5000™**
24.000 MMACS	Up to 300 MHz +Accelerator
Cache RAM, ROM	Up to 320KB RAM Up to 128KB ROM
SRIO, EMAC DMA, PCIe	USB, ADC McBSP, SPI, I^2C
Telecom test & meas., media gateways, base stations	Audio, Voice Medical, Biometrics
$40 to $200.00	$3.00 to $10.00

Software & Dev. Tools

Texas Instruments Developer Network

Texas Instruments eXpressDSP™

MPUs – Microprocessors

Helpful Links

- MSP430 homepage – www.ti.com/msp430
- Complete list of MSP430 tools – www.ti.com/msp430tools
- Complete list of MSP430 code examples – www.ti.com/msp430codeexamples
- Chronos wiki - www.ti.com/chronoswiki
- LaunchPad wiki – www.ti.com/launchpadwiki
- Rock ‘em Sock ‘em demo - http://processors.wiki.ti.com/index.php/Electronic_Rock-Em_Sock-Em_Robots
- Cool Chronos demos from Co-op design challenge - http://processors.wiki.ti.com/index.php/Co-Op_Design_Challenge

Exclusive MSP430 Day Discounts
50% off Select MSP430 Tools!

Visit the TI eStore at http://www.ti-estore.com/ and take advantage of these limited time discounts!

- **Experimenter Board for MSP430 New Generation 5xx**
  - Regular price: $149. MSP430 Day Price: $75
  - Part number: MSP-EXP430F5438
  - Code: 430day1
- **eZ430-Chronos Wireless Watch Development Tool (915 MHz)**
  - Regular price: $49. MSP430 Day Price: $25
  - Part number: EZ430-CHRONOS
  - Code: 430day2
- **eZ430-RF2500 2.4GHz Wireless Development Tool**
  - Regular price: $49. MSP430 Day Price: $25
  - Part number: eZ430-RF2500
  - Code: 430day3
- **MSP430 Debugging Interface**
  - Regular price: $99. MSP430 Day Price: $50
  - Part number: MSP-FET430UIF
  - Code: 430day4
- **Code Composer Studio™ MCU Edition** - (Full support of MSP430™, Stellaris®, C2000™ and TMS570 MCUs)
  - Regular price: $495. MSP430 Day Price: $250
  - Part number: TMDSCCS-MCUN01
  - Code: 430day5

Discount Terms:

- Each customer can order up to one of each of the 5 tools at a 50% discount.
- You can enter multiple discount codes in one order.
- Codes are valid through October 15, 2010.
- You do need to have a my.TI account to place an order, however, if you do not have one signing up will only require you to enter a user name and password. This will allow you to review, track and reorder at a later date
- If you do not want to enter a user name and password, you call also call the Product Info Center and order the tools with your discount codes at (972) 644-5580
- For questions or help please email TI_Store@ti.com

Thank you.

Lunch time!

BACKUP

Low Power Mode Overview

Operating Mode	Description	CPU (MCLK)	SMCLK	AMCLK	RAM Retention	BOR	Self Wakeup	Interrupt Sources
Active	CPU, all clocks and peripherals available.	●	●	●	●	●		Timers, ADC, DMA, USART, WDT, I/O, comparator, USI, Ext. Interrupt, USCI, RTC, other peripherals
LPM0	CPU is shutdown, peripheral clocks available.		●	●	●	●	●	Timers, ADC, DMA, USART, WDT, I/O, comparator, USI, Ext. Interrupt, USCI, RTC, other peripherals
LPM1	CPU is shutdown, peripheral clocks available. DCO is disabled and the DC generator can be disabled.		●	●	●	●	●	Timers, ADC, DMA, USART, WDT, I/O, comparator, USI, Ext. Interrupt, USCI, RTC, other peripherals
LPM2	CPU is shutdown, only one peripheral clock available. DC generator is enabled.			●	●	●	●	Timers, ADC, DMA, USART, WDT, I/O, comparator, USI, Ext. Interrupt, USCI, RTC, other peripherals
LPM3	CPU is shutdown, only one peripheral clock available. DC generator is disabled.			●	●	●	●	Timers, ADC, DMA, USART, WDT, I/O, comparator, USI, Ext. Interrupt, USCI, RTC, other peripherals
LPM3.5	No RAM retention, RTC can be enabled. (MSP430F5xx generation only)					●	●	Ext. Interrupt, RTC
LPM4	CPU is shutdown and all clocks disabled.				●	●		Ext. Interrupt
LPM4.5	No RAM retention, RTC disabled. (MSP430F5xx generation only)					●		Ext. Interrupt

BACK