New technology in MSP430

Charles Wu

Texas Instruments

Agenda

- MSP430 Roadmap
- High Resolution Timer in MSP430
- 0.9V Power Supply in MSP430
- Low cost in MSP430
- Q&A

TI is the leader in Embedded Processing

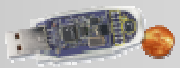
Microcontrollers | Arm-Based | DSP

16-bit MCU	32-bit Real-time	32-bit ARM	ARM+	ARM + DSP	DSP
MSP430	**C2000™**	**Stellaris Cortex™ M3**	**ARM9 Cortex A-8**	**C64x+ plus ARM9/Cortex A-8**	**C647x, C64x+, C55x**
Ultra-Low Power	Fixed & Floating Point	Industry Std Low Power	Industry-Std Core, High-Perf GPP	Industry-Std Core + DSP for Signal Proc.	Leadership DSP Performance
Up to 25MHz	Up to 150MHz	Up to 100MHz	Accelerators	4800 MMACs/ 1.07 DMIPS/MHz	24,000 MMACS
Flash 1KB to 256KB	Flash 32KB to 512KB	Flash 8KB to 256KB	MMU	MMU, Cache	Up to 3MB L2 Cache
Analog I/O, ADC LCD, USB, RF	PWM, ADC, CAN, SPI, I^2C	USB, ENET, ADC, PWM, HMI	USB, LCD, MMC, EMAC	VPSS, USB, EMAC, MMC	1G EMAC, SRIO, DDR2, PCI-66
Measurement, Sensing, General Purpose	Motor Control, Digital Power, Lighting	Host Control, general purpose, motor control	Linux/WinCE User Apps	Linux/Win + Video, Imaging, Multimedia	Comm, WiMAX, Industrial/ Medical Imaging
$0.25 to $9.00	$1.50 to $20.00	$2.00 to $8.00	$8.00 to $35.00	$12.00 to $65.00	$4.00 to $99.00+






Texas Instruments Developer Network




Software & Dev. Tools


Texas Instruments eXpressDSP

Texas Instruments

MSP430 - Overview

Ultra-low power & performance

- *Industry's Lowest Power*
- Standby <1uA; Active 160 µA/MIPS
- Includes RTC and BOR
- Fast wake-up <1 µs
- 4 programmable voltage levels
- Internal voltage regulator
- 8-25 MHz RISC CPU
- Industry leading code density
- Flexible clock system

Analog Integration

- 14 to 113 pin devices
- 1-256kB Flash/ROM
- 10-/12-/16-bit ADC
- 12-bit D/A, LCD Drivers, RTC, DMA
- Comparators and Op Amps
- Supply Voltage Supervisor & BOR
- 16-bit and 8-bit timers; WDT
- I2C, SPI, UART/LIN, IrDA

Roadmap

New

- Integrated RF on chip (CC430)
- Innovative nonvolatile memory (FRAM)
- Native sub-1 volt
- Higher memory roadmap
- 100 new devices through 4Q 2010

Ease of Use

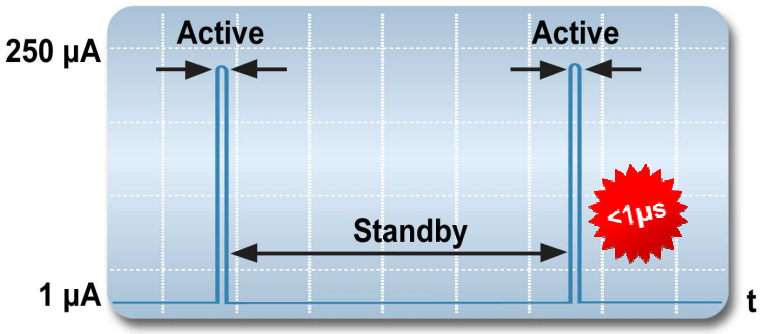
- Free/Low cost dev tools
- Workshops on demand
- Technical forums on community.ti.com
- Reference designs and code examples
- C friendly IDE and compiler
- Embedded emulation
- 430 teaching CD with labs

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

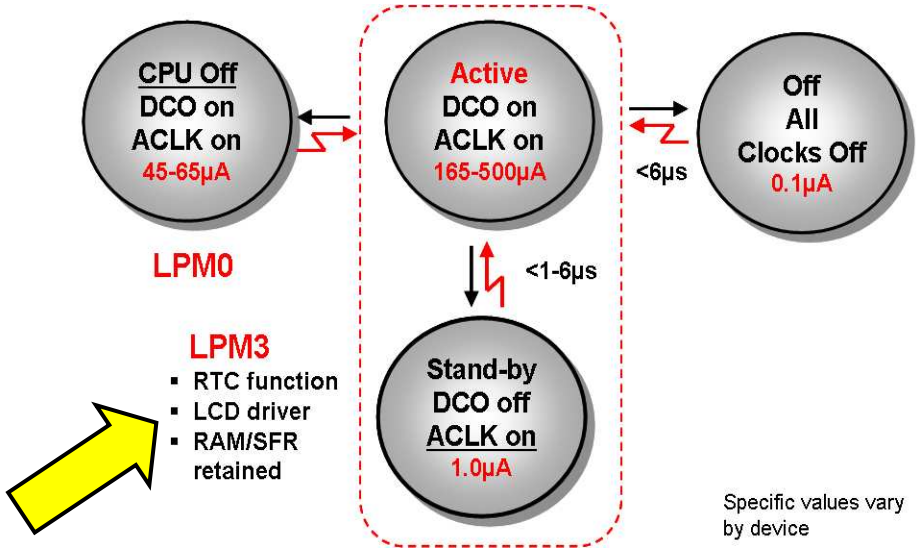
- ✓ Multiple operating modes
  - 0.1 µA power down; 0.3 µA standby; 165 µA / MIPS
- ✓ Instant-on stable high-speed clock
- ✓ 1.8 - 3.6V single-supply operation
- ✓ Zero-power BOR
- ✓ <50nA pin leakage
- ✓ CPU that minimizes cycles per task
- ✓ Low-power intelligent peripherals
  - ADC that automatically transfers data
  - Timers that consume negligible power
  - 100 nA analog comparators
- ✓ Performance over required operating conditions

Ultra-Low Power Activity Profile

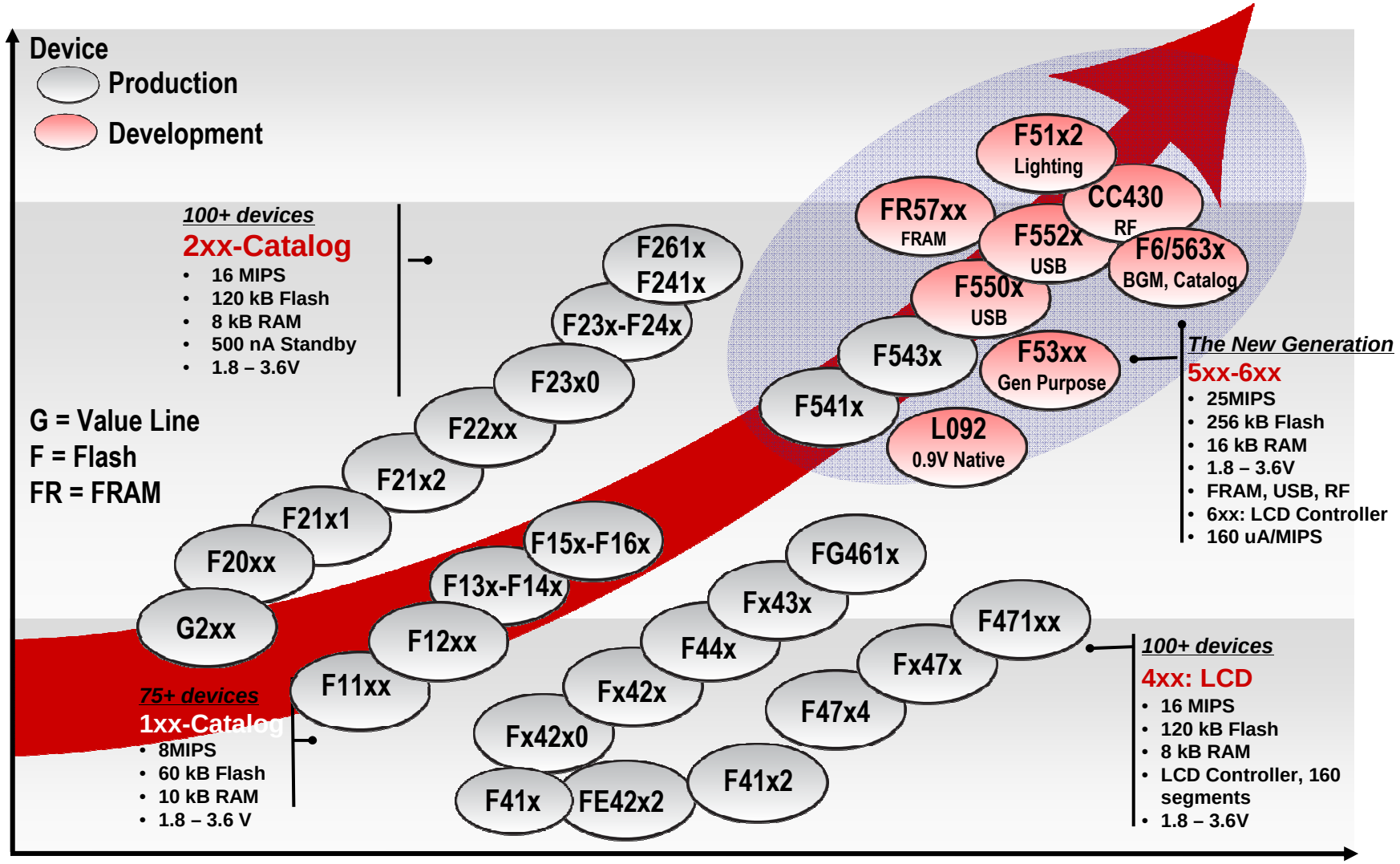


- Extended *Ultra-Low Power* standby mode
- Minimum active duty cycle
- Interrupt driven performance on-demand

MSP430 Low Power Modes



MSP430 Portfolio + Roadmap



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- High Resolution Timer in MSP430
- 0.9V Power Supply in MSP430
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High Resolution Timer Overview

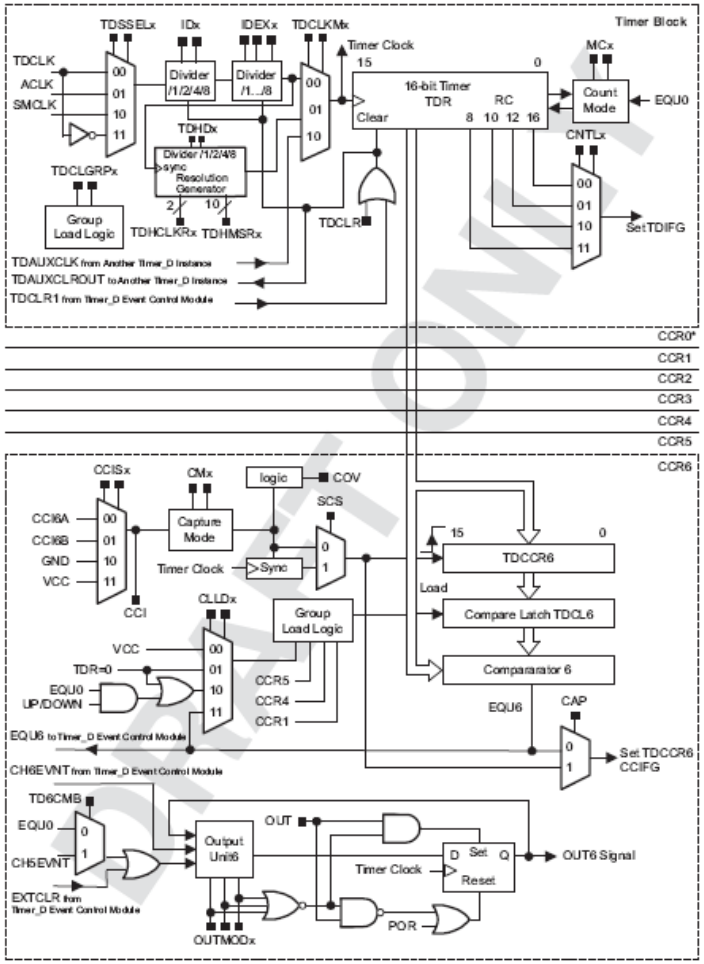
- 100% SW compatible to existing Timer_B
- Max 4ns resolution @ 16 MHz input clock
  Max 5 ns resolution @ 25 MHz input clock for PWM output and Capture input

- Low-power consumption: 40 µA/MHz resulting 500 µA @ 25 MHz input clock

- Scalable Architecture, from “TD1” to TD7
- Multiple Timer_D instances can be synchronized
- Fault and re-start inputs per channel
- Full PWM capability by combining 2 buffered CCR registers for one channel

New Target Applications:

LED lighting/dimming, Simple Motor Control, Power Factor Correction, Lamp Ballast



MSP430F51x2

Timer_D (High resolution PWM), 5V tolerant push/pull I/Os

Performance

- 16-bit RISC architecture, 40ns instruction cycle time
- Ultra-Low-Power, Integrated Intelligent Peripherals and Easy-to-Use

Features

- Power
  - Low Supply Voltage Range 1.8 V to 3.6 V
  - Ultra-low Power Consumption
    - Active Mode: 165 **(TBD)** µA / MHz
    - Standby Mode (LPM3 RTC Mode): 1.5 **(TBD)** µA
    - Off Mode (LPM4 RAM Retention) 1.0 **(TBD)** µA
    - Shutdown Mode (LPM5): 0.1 **(TBD)** µA
  - Ultrafast Wake-Up from Standby Mode in < 5 µs
- Package
  - 38-pin DA (TSSOP); 40-pin RHA (QFN) (6mm x 6mm)

Benefits

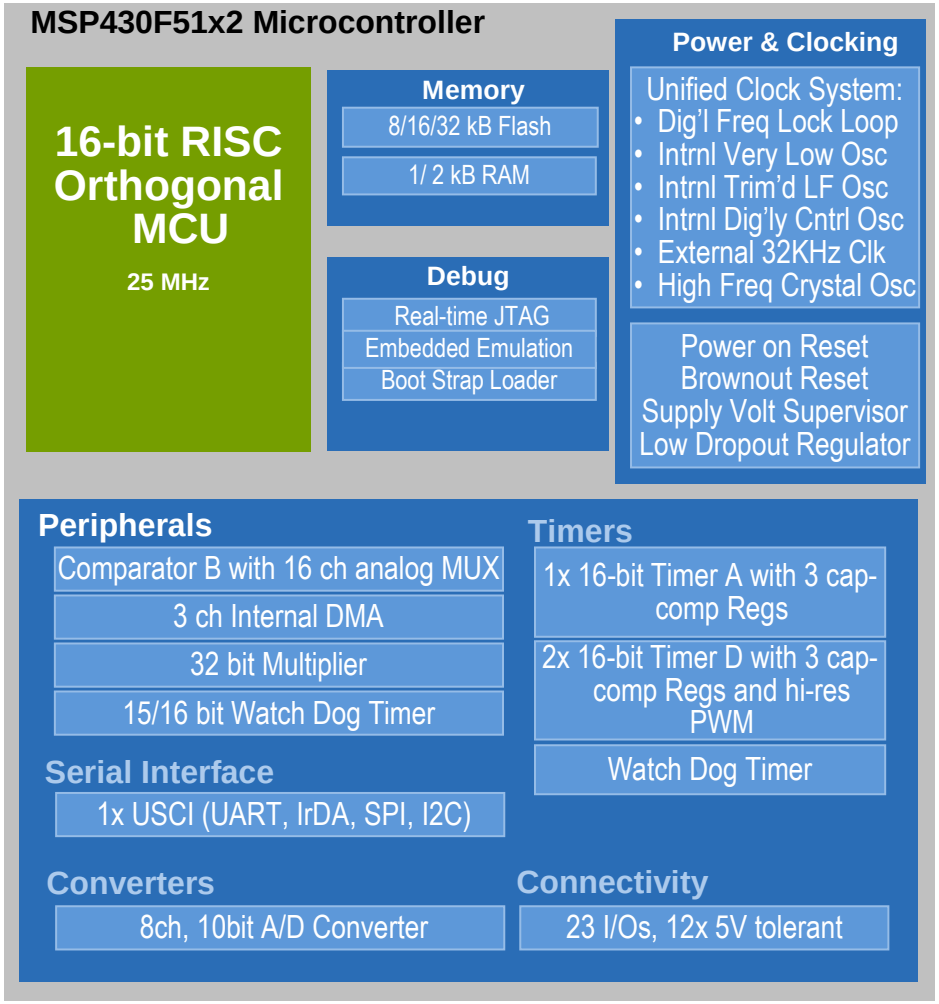
- High resolution PWM of 4ns for precise motor and LED lighting control
- Cap sense enabled by optimized comparator with 16 input analog MUX
- 5V tolerant push/pull IOs with up to 20 mA drive strength for interfacing to 5V IC, driving logic level MOSFETs or white LEDs

Development Board and Programmer

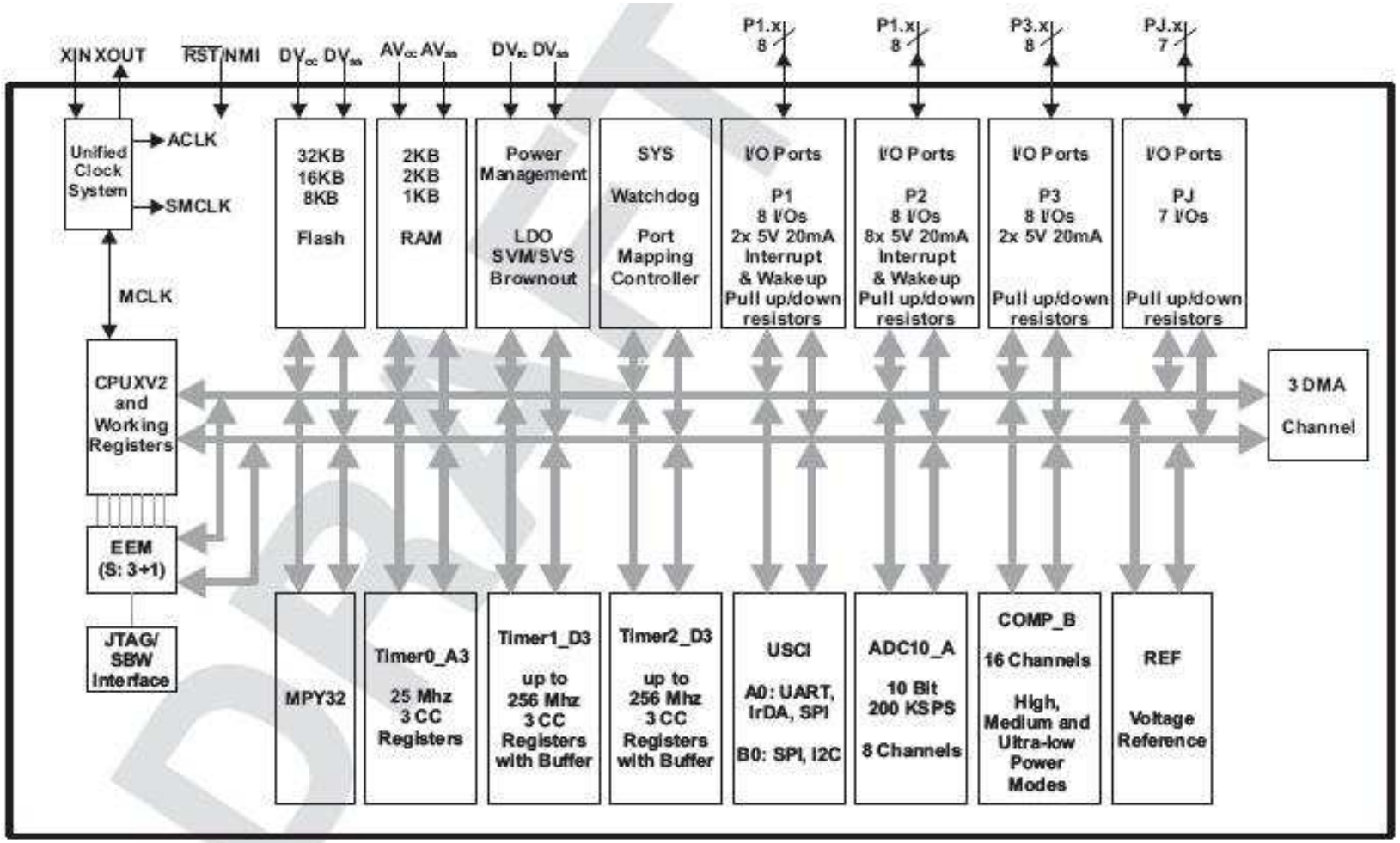
- TBD

Applications include:

- LED backlights and incandescent replacements
- Cap Sense
- Motor Control
- UPS and Battery Chargers
- Voice synthesis

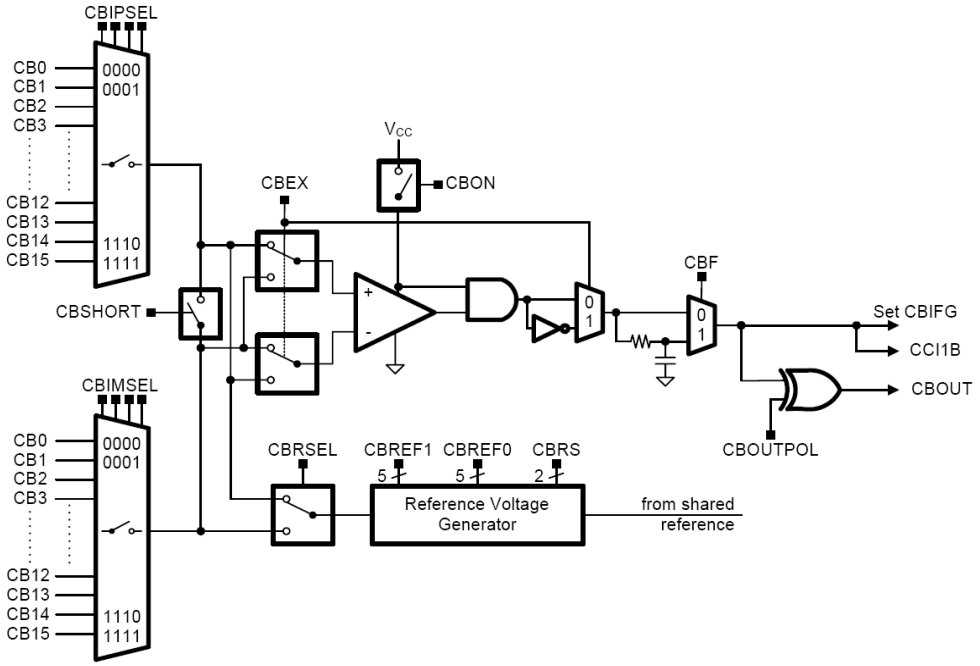


F51x2 Block Diagram

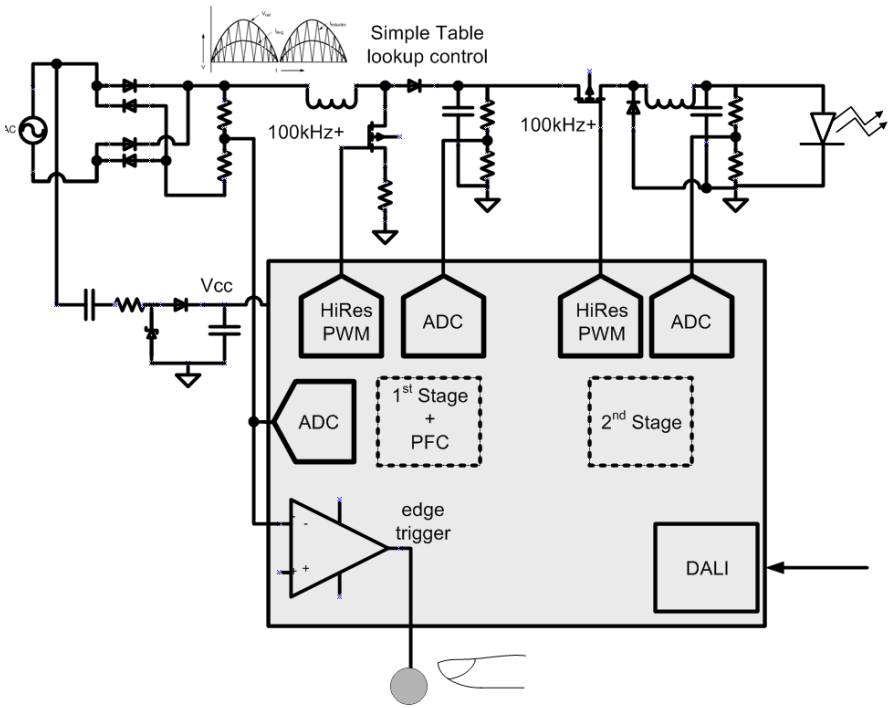


Comp_B Overview

- 16 input analog comparator
- Programmable hysteresis
- Optimized for relaxation oscillator cap sense



MSP430F51x2 Application: Lighting



LED Lighting block diagram

- **Attributes**
- HI-Res PWM with 4ns resolution cycle
- 5V tolerant push-pull I/Os with 20mA drive strength

- **Benefits**
- Precise digital control for motor control, lighting, etc.
- Interface to legacy electronics
- Drives white LEDs
- Gate driver for logic-level MOSFETs

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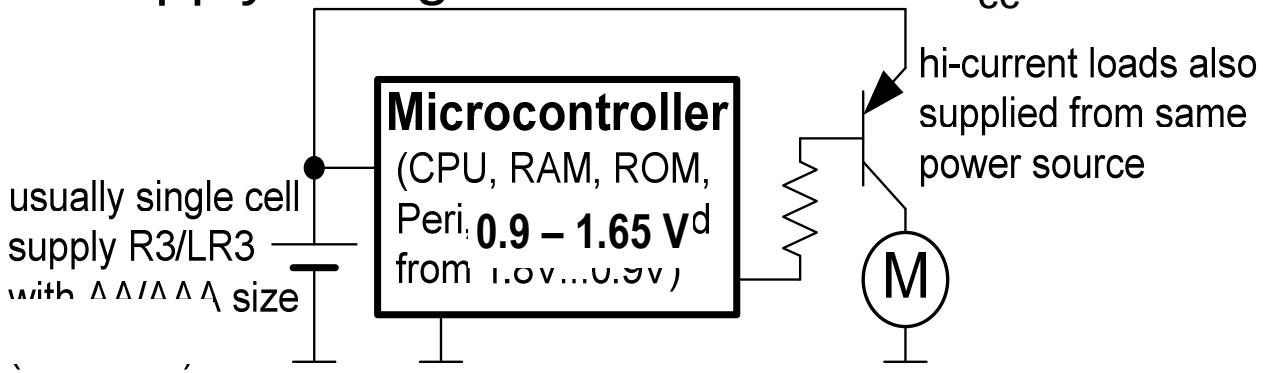
0.9V Power Supply

- 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}



MSP430[C/L]09x

Native 0.9V MSP430

Performance

- 16-bit RISC Architecture, up to 4MHz system clock
- Ultra-Low-Power, Integrated Intelligent Peripherals and Easy-to-Use

Features

- Power
  - Low Supply Voltage Range 0.9V to 1.65 V
  - Ultra-low Power Consumption
    - Active Mode: 500 **(TBD)** µA @ 1MHz (1.2V)
    - Standby Mode (LPM3 WDT Mode): <10 **(TBD)** µA
    - Off Mode (LPM4) 3-9 **(TBD)** µA
  - Ultrafast Wake-Up from Standby Mode in < 5 µs
- Package
  - 14-pin PW (TSSOP) 5.1mm x 6.6mm

Benefits

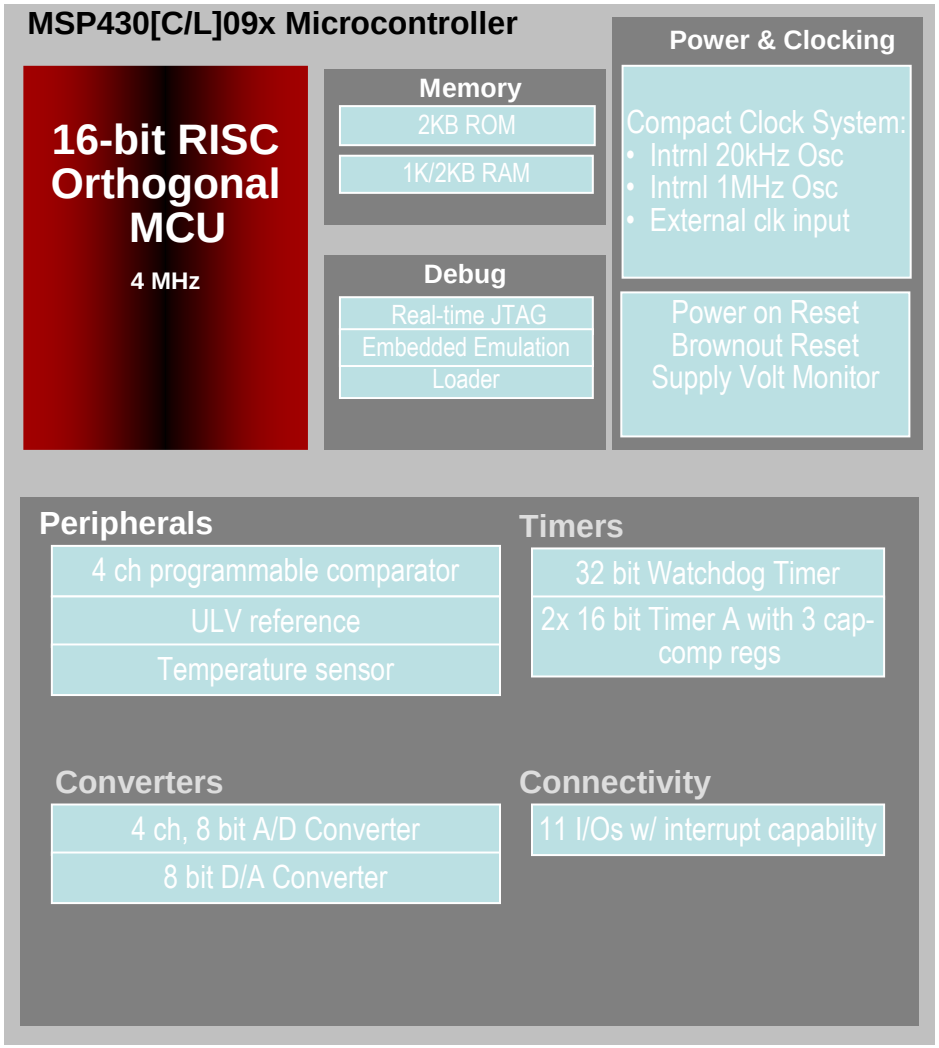
- Market's first 16 bit sub 1V microcontroller
  - 16-bit processing power at low voltage/cost
- Operates off of single alkaline battery for:
  - Longer battery life
  - Lower operating and system cost
  - Smaller end equipment and lower weight
- Operates down to 0.9V (EOL of standard alkaline batteries)
- Code reuse
  - MSP430 core is 100% compatible with previous MSP430 devices

Development Board and Programmer

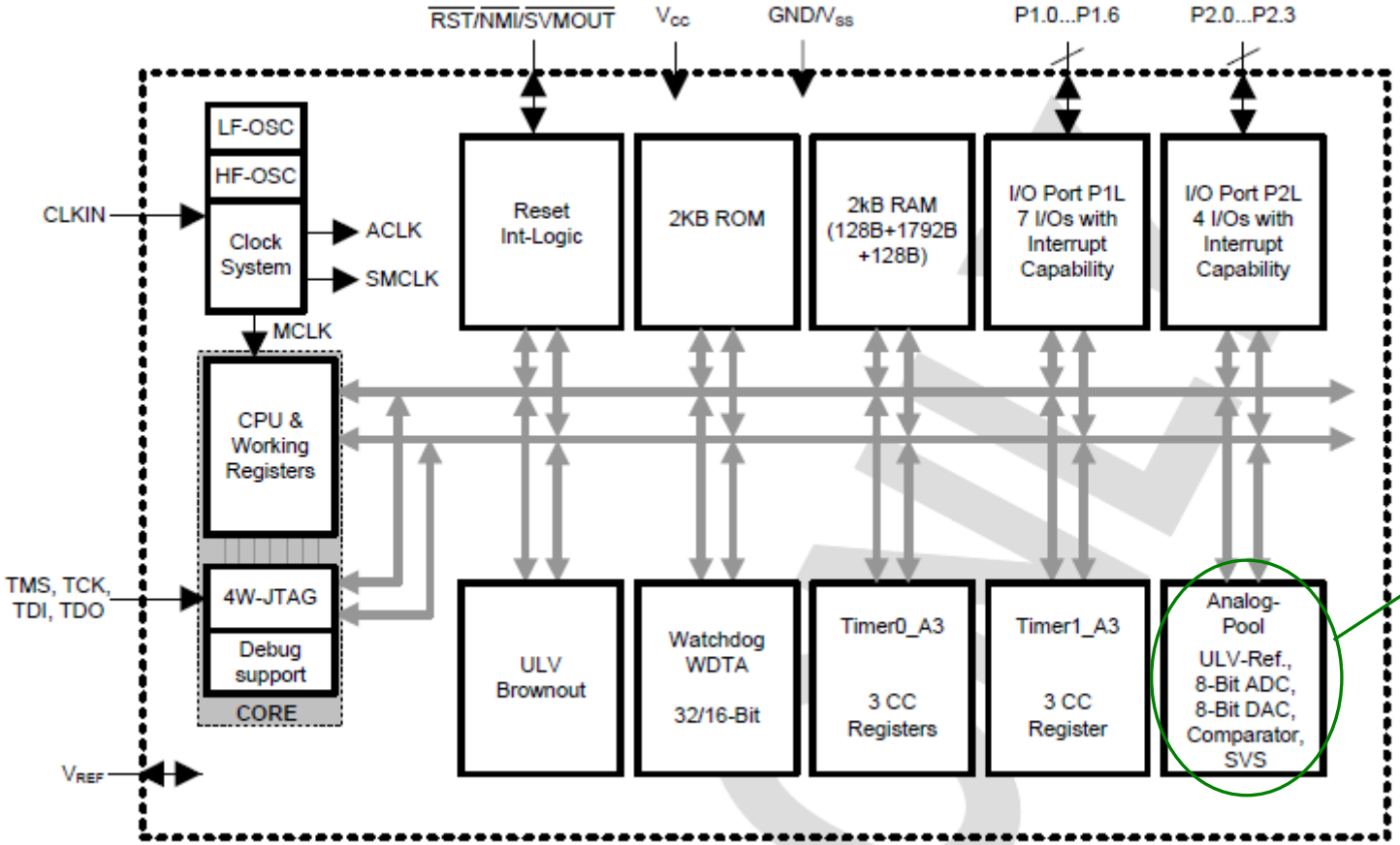
- TBD

Applications include:

- Security devices (door sensors, PIR)
- Electric tooth brush, shavers etc.
- Sports applications
- Sensors (motion, pressure)



MSP430L092 Block Diagram



NEW to MSP430

Initial Target Applications List

- 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)

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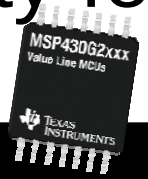
8-bit developers no longer need to sacrifice performance, power efficiency or scalability for price



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

Texas Instruments

16-bit performance for enhanced accuracy and headroom for differentiation

Safety & Security

Lighting

Touch pads

Consumer Electronics

Personal Health & Fitness

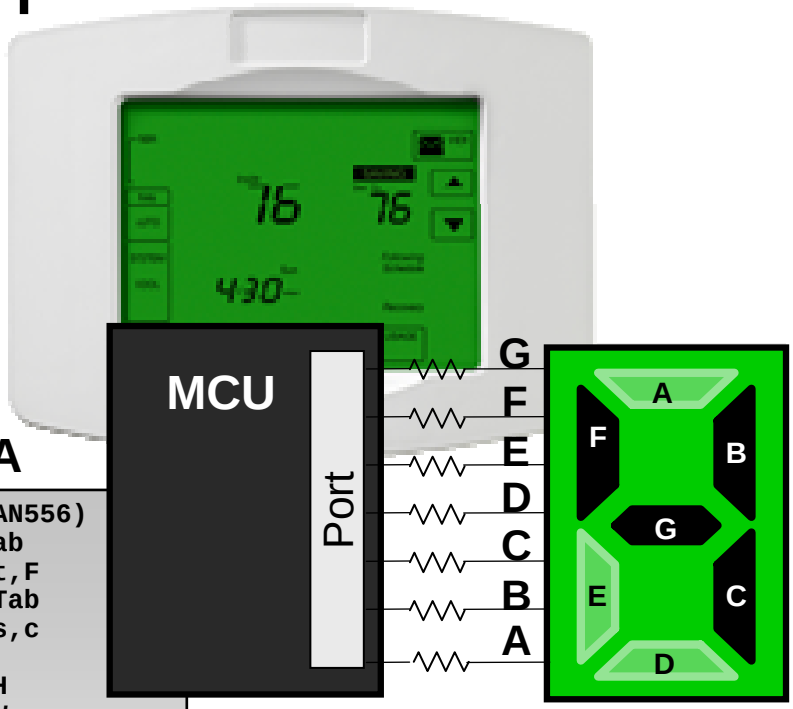
Intelligent Sensors

- Lower maintenance cost and longer product life
- Headroom and intelligence for new functionality
- More precise settings and faster response time

What do I get for 25 cents?

	Competitor	MSP430G20	
Flash	512B Ext 12V	512B In System	Flexible
RAM	25B	128B	Agile
Timers	8-bit counter	16-bit multifunctio	More Functionality
Emulation	0	2-pin In System	Faster Development
GPIO/ Interrupts	6 0	10 22	No Compromise
MIPS	1x 8-bit	16x 16-bit	Hi-Performance
Power	2	5	MSP430 is lower power in all modes of operation
Price	$0.25	$0.25	

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

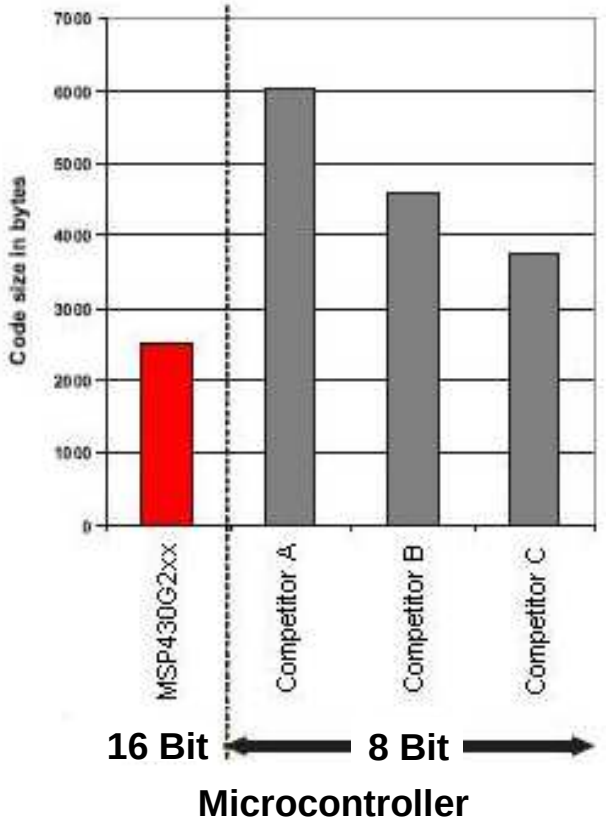
MSP430

8X reduction in Cycles/Task

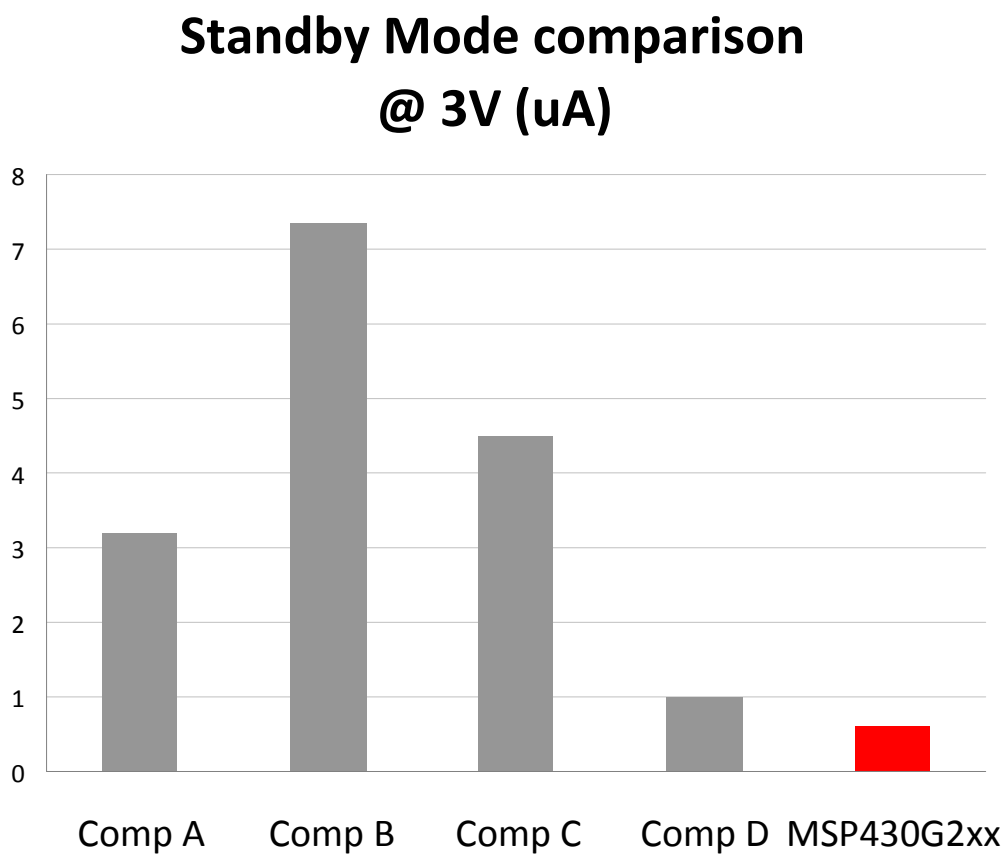
```
;   MSP430
;   mov.b Tab(Data),P1OUT
Tab DW    0063Fh
    DW    04F5Bh
    DW    06E66h
    DW    0077Ch
    DW    0677Fh
```

128 bits / 6 cycles

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



Leading ultra-low power consumption drives longer battery life



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

G2xx power consumption is lower than typical 8-bit MCUs; as low as (@2.2V):

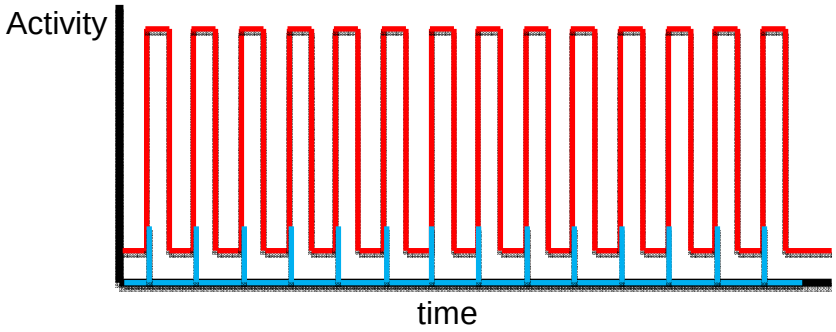
- 0.1 μA RAM retention
- 0.4 μA Standby mode (VLO)
- 0.7 μA real-time clock mode
- Ultra-Fast Wake-Up From Standby Mode in <1 μs

10X lower power

Intelligent Peripherals

Competitor A: ADC

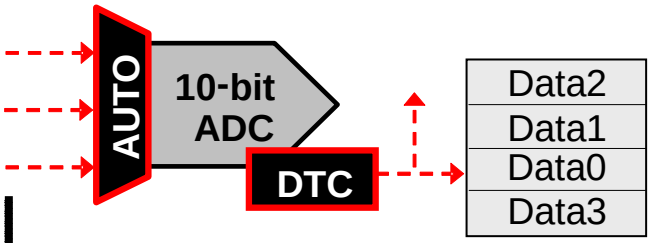
The competition requires the CPU to be active for each ADC conversion and loaded data transfer.

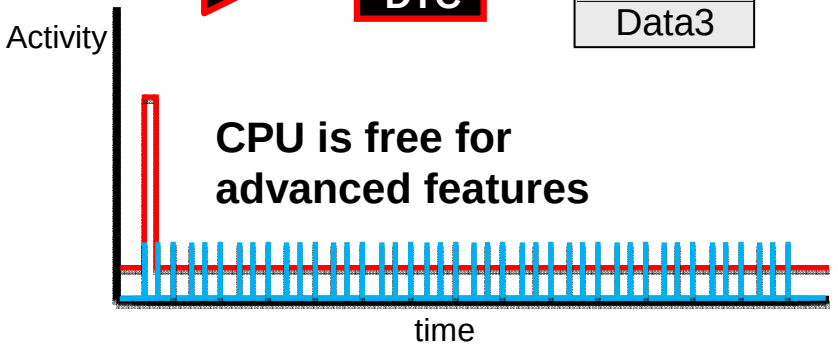



```
Competitor A
                movlw           0x20
                movwf           FSR
                movlw           0x03
                movwf           STATUS
Main            movf            INDF, W
                movwf           ADCRESH
                decf            FSR, F
                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

MSP430: 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

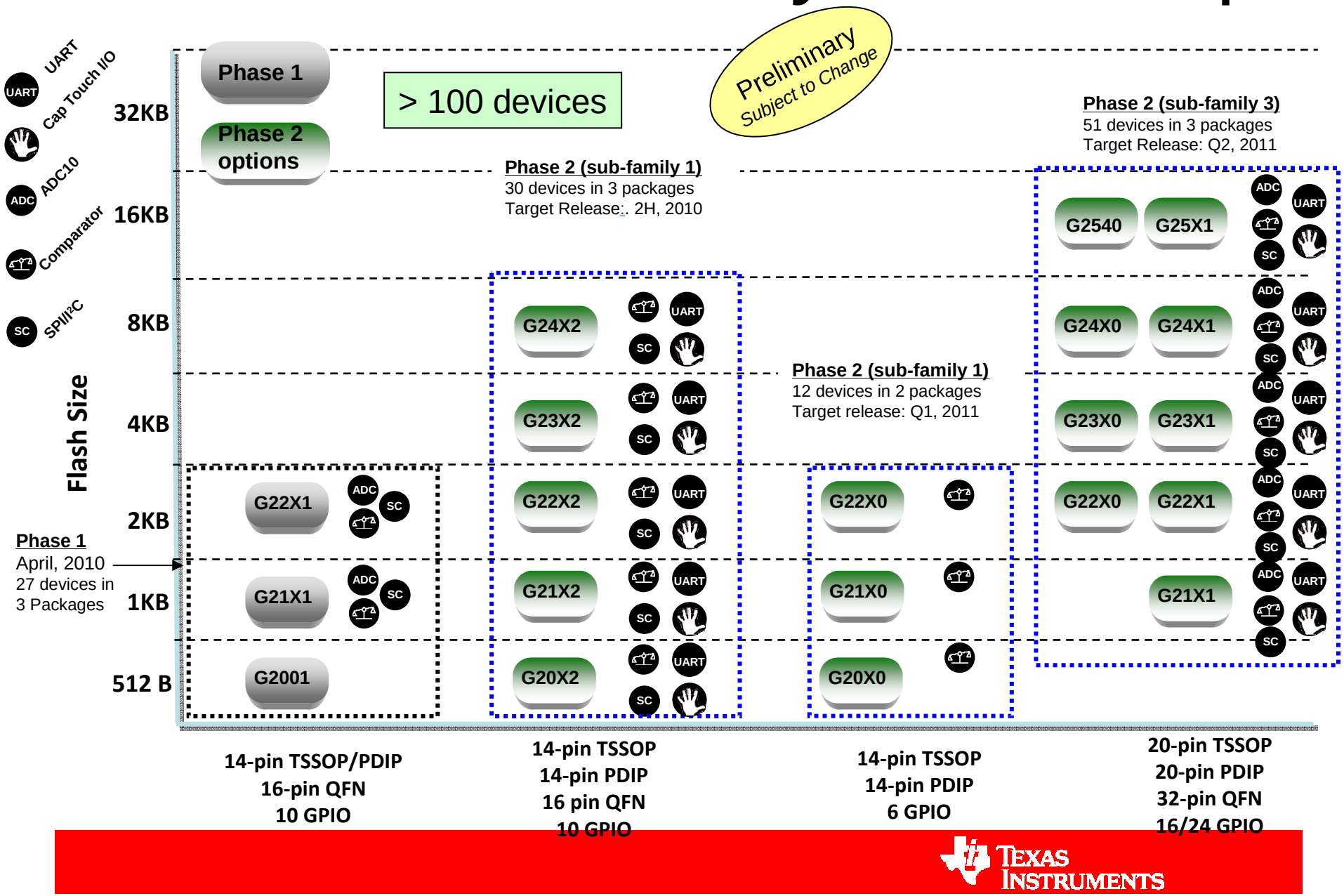
Portfolio – Phase 1 (April 2010)

Flash-Based MSP430G2xx Value Series (V_{CC} 1.8 to 3.6V) (*See www.ti.com/430value for additional information*)

					16-Bit Timers								
Value Line Product	Closest MSP430F2xx	Program (KB)	SRAM (B)	I/O	Total	# CCR	Watchdog	BOR	USI:I²C/SPI	Comp_A+	Temp Sensor	ADC Ch/Res	Packages
MSP430G2001		0.512	128	10	1	2	✓	✓	-	-	-	-	PW14, N14, RSA16
MSP430G2101		1	128	10	1	2	✓	✓	-	-	-	-	PW14, N14, RSA16
MSP430G2121		1	128	10	1	2	✓	✓	✓	-	-	-	PW14, N14, RSA17
MSP430G2201		2	128	10	1	2	✓	✓	-	-	-	-	PW14, N14, RSA16
MSP430G2221		2	128	10	1	2	✓	✓	✓	-	-	-	PW14, N14, RSA16
MSP430G2111	MSP430F2001	1	128	10	1	2	✓	✓	-	✓	-	-	PW14, N14, RSA16
MSP430G2211	MSP430F2011	2	128	10	1	2	✓	✓	-	✓	-	-	PW14, N14, RSA16
MSP430G2131	MSP430F2002	1	128	10	1	2	✓	✓	✓	-	✓	8ch ADC10	PW14, N14, RSA16
MSP430G2231	MSP430F2012	2	128	10	1	2	✓	✓	✓	-	✓	8ch ADC10	PW14, N14, RSA16

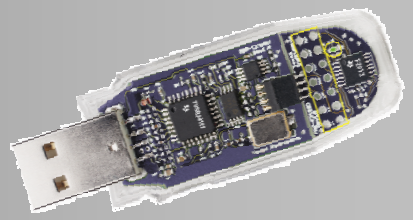
Note: Add I + Package + pincount ('Packages' column) to 'Value Line Product' column to get complete part number e.g. MSP430G2001IPW14

The Value Line Family - Roadmap



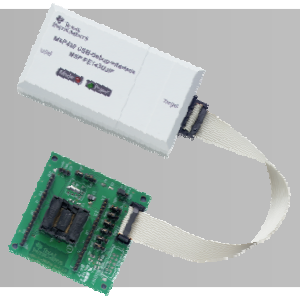
Powerful, low cost development tools

eZ430-F2013: $20 Development System
- Real-time, in-system emulation
- Removable target with full pin access



Free, unrestricted software IDEs
- Code Composer Studio™ v4
- IAR Embedded Workbench

Flash Emulation Tools
- Compatible with all MSP430 devices
- Socketed target boards available



Your development – only $20

Texas Instruments

Full compatibility across MSP430 platform allows developers to easily scale product lines

Scalable performance options

- 8MHz - 25MHz CPU speed
- 16-bit Sigma Delta ADCs 12-bit DACs, 32x32 Multipliers, Op Amps, LCD Drivers, DMAs, and other high-performance peripherals are available throughout the MSP430 portfolio.

Flexible memory options

- MSP430 offers between ½ kB to 256kB Flash
- 128B to 16kB RAM

Pin counts

- MSP430 offers 22 different package options, scaling from 14 pins to 113 pins

$20 EVM and free software

- The ez430 development kits, starting at just $20, offer everything you need to start developing for the MSP430
- Free, downloadable Code Composer Studio™ and IAR IDE

Same architecture and same software from lowest-end to highest end MSP430

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