

MSP430 Advanced Technical Conference 2006



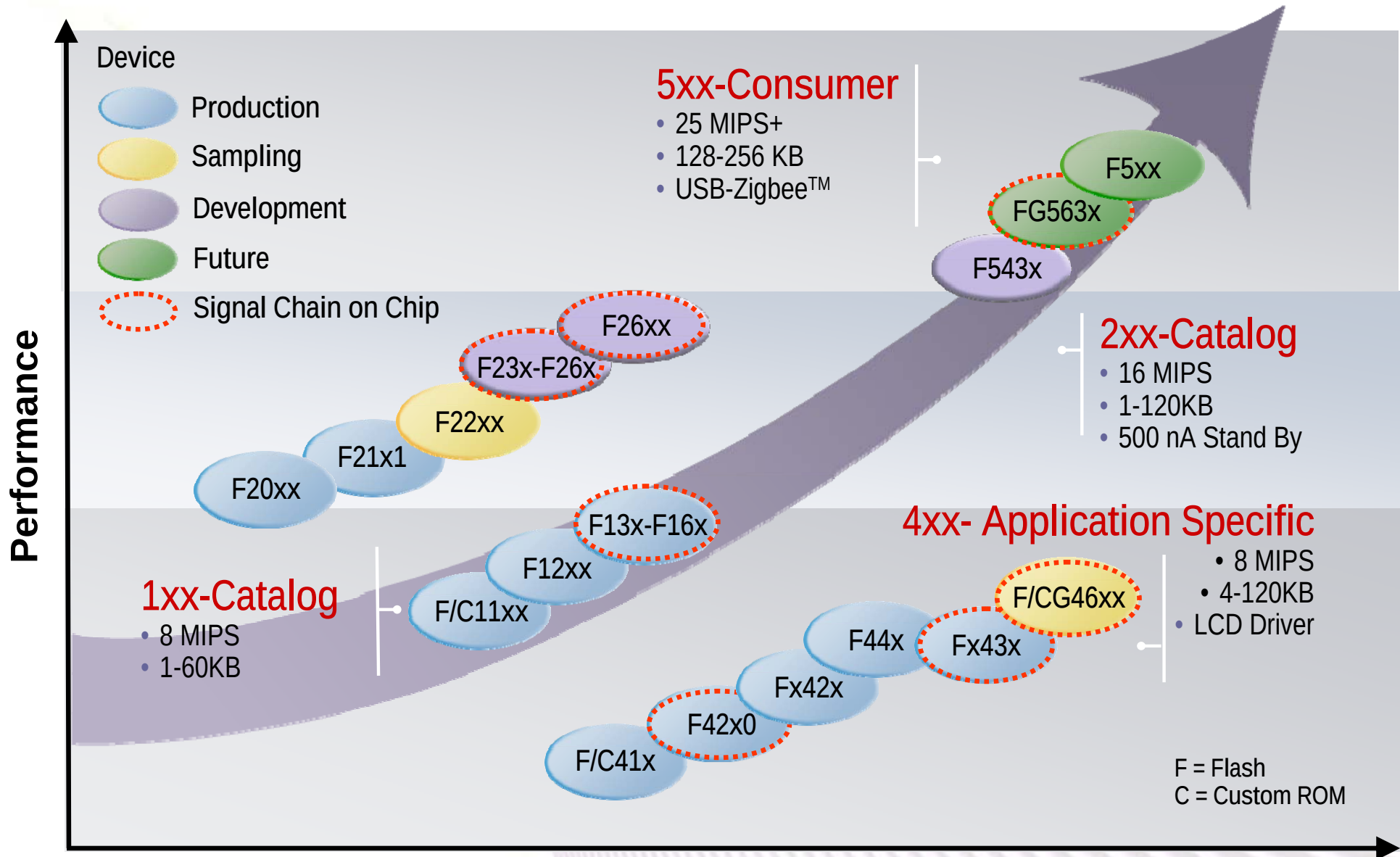
MSP430F2xx Family Enhancements and Features

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Texas Instruments

Agenda

- Enhancements
- Application Examples
- Devices & Summary

MSP430 Products



MSP430F2xx – What's Different

- *Faster*
- *Lower power*
- *New peripherals*
- **Compatible migration path with the '1xx**
- **Great starting point for new applications**
- **Complete family of new devices planned**

MSP430F1xx Versus MSP430F2xx

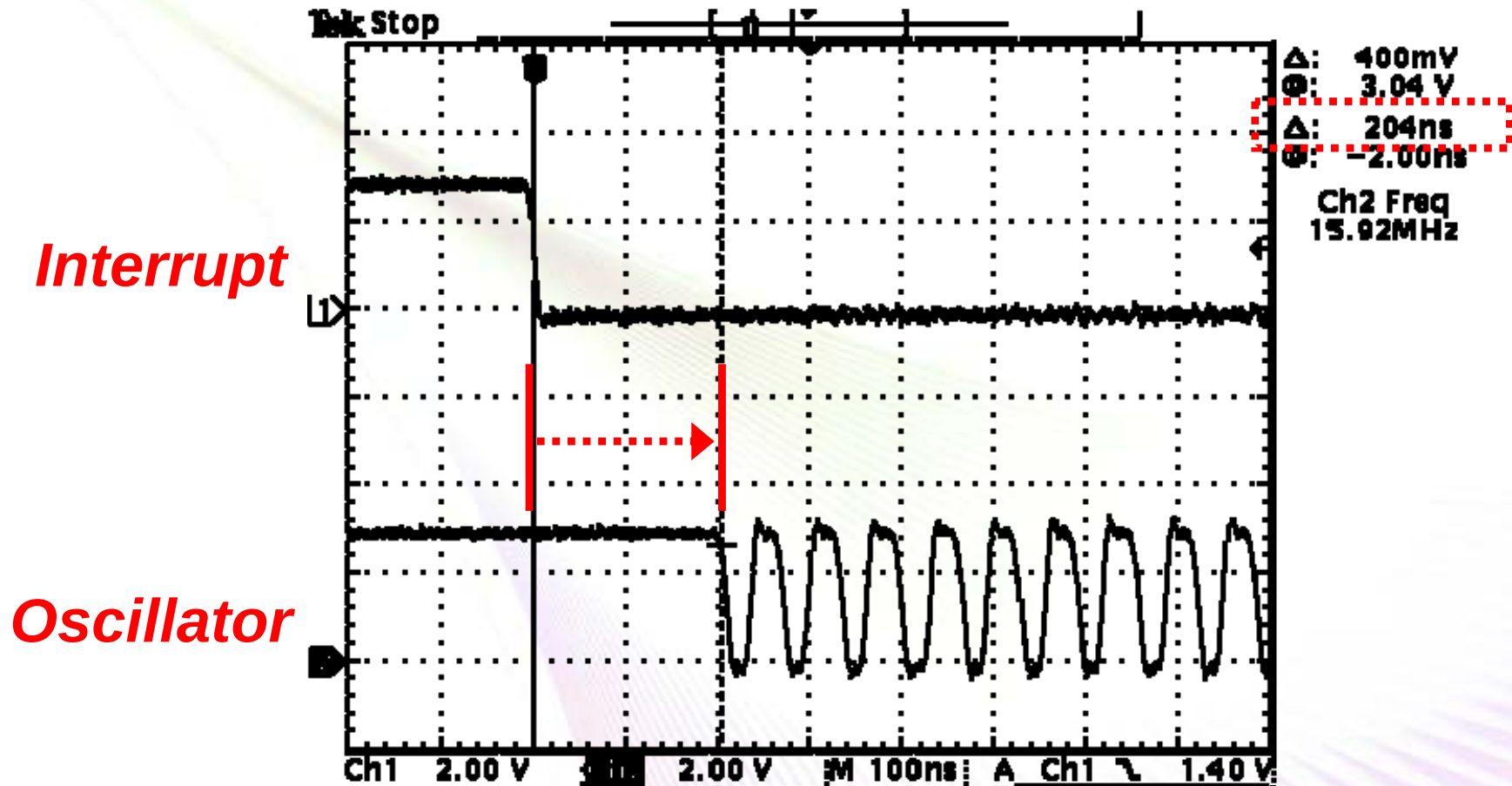
	1xx	2xx
CPU Clock	8MHz	16MHz
Wakeup	6us	1us
Stand-by	<2uA	<1uA
BOR	Some	ALL
Flash ISP	2.7V	2.2V
P1/2	-	Pull-up / Down
Oscillator	±20%	±2.5%
OscFault	HF	HF/LF
Watchdog	SW	SW Invalid Address Clock Fault
BSL	2 ²⁵⁶	Hackproof

2X faster

1/2 power

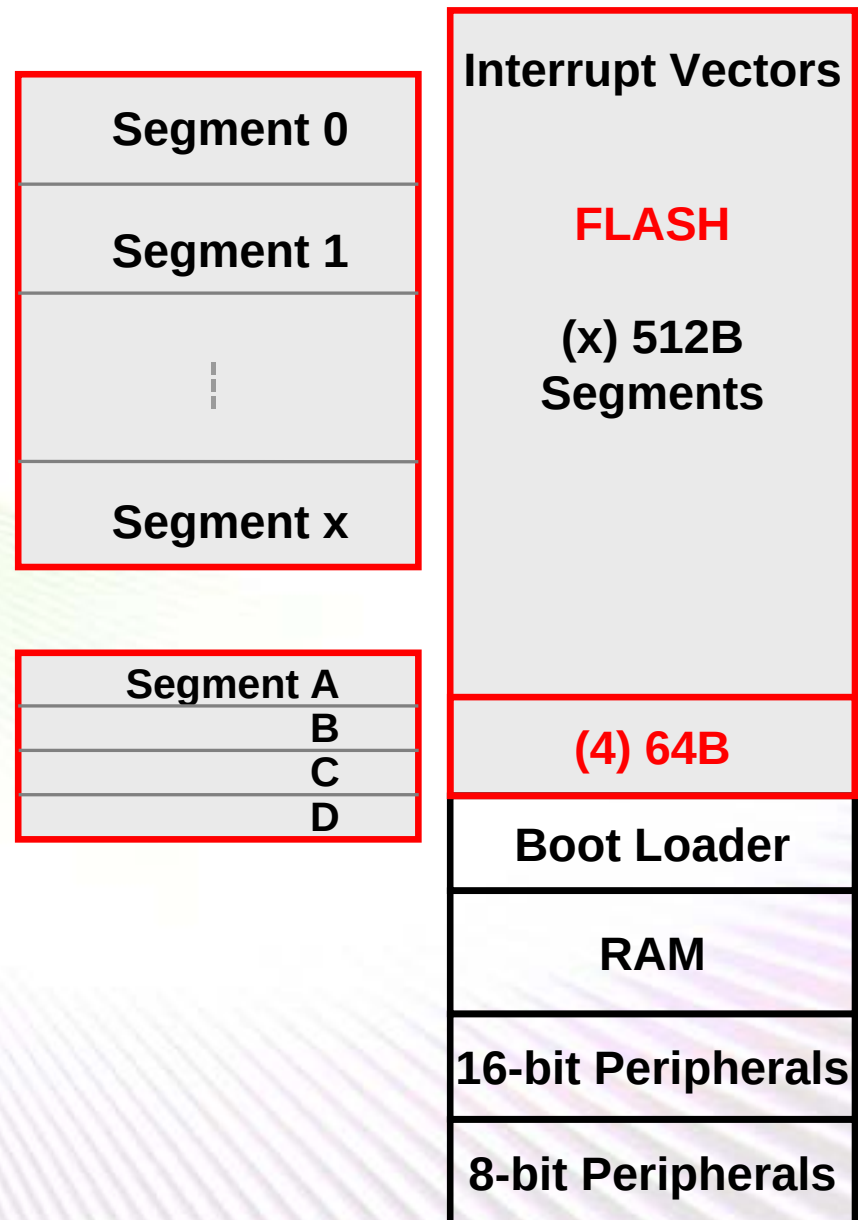
Improved

F2xx 16MIPS On-Demand

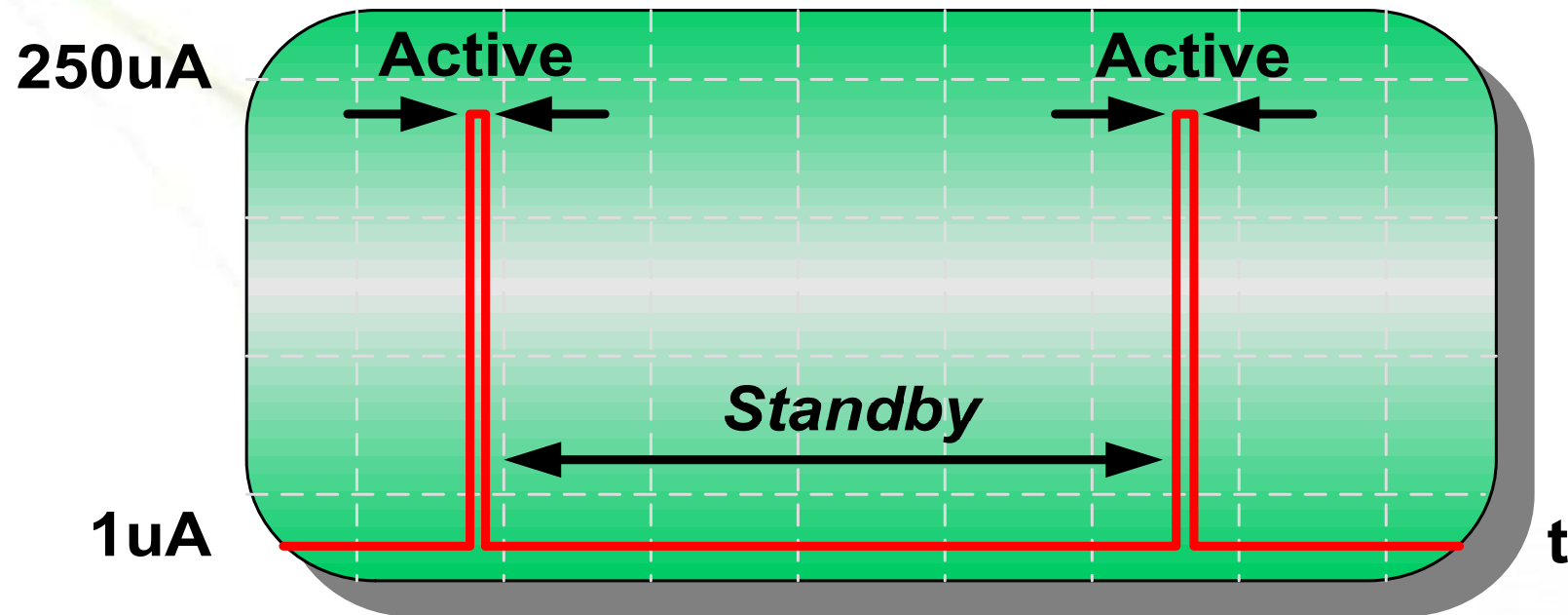


F2xx Flash

- Fast <20us /byte ISP
- ISP down to 2.2V
- Interruptible ISP/Erase
- Reduced size 64B info memory segments
- Lock(able) info segment A
- Improved BSL security
- Protection against program/erase from accidental BSL entry



Achieving *Ultra-low Power*



- Max time in Ultra-low Power *LPM3* standby mode
- *Active* Performance on-demand
- Minimum active duty cycle

F2xx Basic Clock+

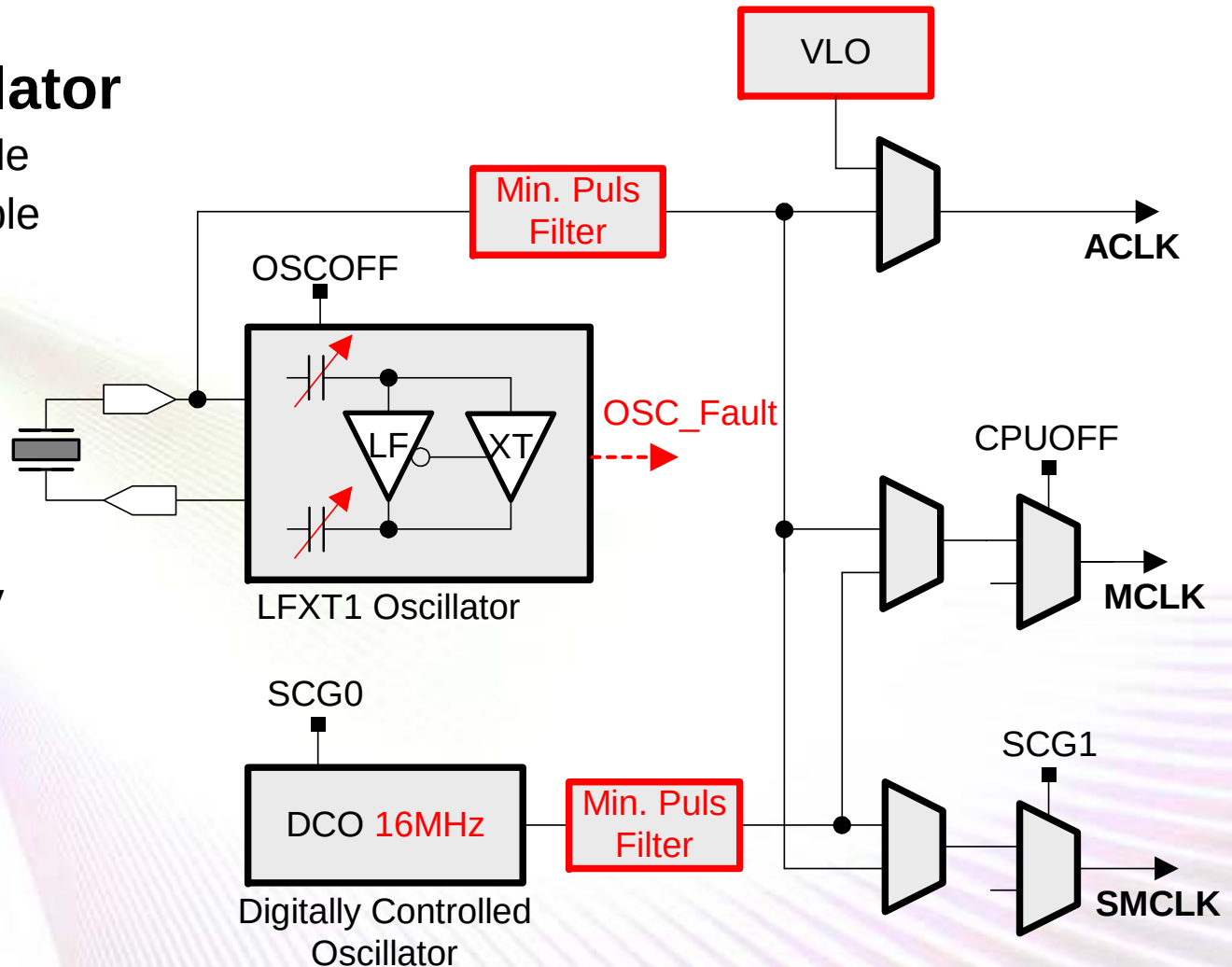
- **LFXT1 XTAL Oscillator**

- <1uA LPM3 standby mode
- XTAL CAPs programmable
- OSCfault LF/(XT)
- **New VLO**

- **Improved DCO**

- < 1us 0-to-16MHz
- $\pm 2.5\%$ DCO
- Programmable frequency

- **VLO not in '21x1**



F2xx: No XTAL Required – DCO+

calibrated DCO frequencies – tolerance at calibration

PARAMETER	TEST CONDITIONS	T _A	V _{CC}	MIN	TYP	MAX	UNIT
Frequency tolerance at calibration		25°C	3 V	-1	±0.2	+1	%

calibrated DCO frequencies – tolerance over temperature 0°C – +85°C

PARAMETER	TEST CONDITIONS	T _A	V _{CC}	MIN	TYP	MAX	UNIT
1 MHz tolerance over temperature		0–85°C	3.0 V	-2.5	±0.5	+2.5	%
8 MHz tolerance over temperature		0–85°C	3.0 V	-2.5	±1.0	+2.5	%
12 MHz tolerance over temperature		0–85°C	3.0 V	-2.5	±1.0	+2.5	%
16 MHz tolerance over temperature		0–85°C	3.0 V	-3.0	±2.0	+3.0	%

calibrated DCO frequencies – tolerance over supply voltage V_{CC}

PARAMETER	TEST CONDITIONS	T _A	V _{CC}	MIN	TYP	MAX	UNIT
1 MHz tolerance over V _{CC}		25°C	1.8 V – 3.6 V	-3	±2	+3	%
8 MHz tolerance over V _{CC}		25°C	1.8 V – 3.6 V	-3	±2	+3	%
12 MHz tolerance over V _{CC}		25°C	2.2 V – 3.6 V	-3	±2	+3	%
16 MHz tolerance over V _{CC}		25°C	3.0 V – 3.6 V	-3	±2	+3	%

calibrated DCO frequencies – overall tolerance

PARAMETER	TEST CONDITIONS	T _A	V _{CC}	MIN	TYP	MAX	UNIT
1 MHz tolerance overall		I: -40–85°C T: -40–105°C	1.8 V – 3.6 V	-5	±2	+5	%
8 MHz tolerance overall		I: -40–85°C T: -40–105°C	1.8 V – 3.6 V	-5	±2	+5	%
12 MHz tolerance overall		I: -40–85°C T: -40–105°C	2.2 V – 3.6 V	-5	±2	+5	%
16 MHz tolerance overall		I: -40–85°C T: -40–105°C	3.0 V – 3.6 V	-6	±3	+6	%

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Loading DCO Calibration Data

DCO Calibration Data (provided from factory in flash info memory segment A)			
DCO Frequency	Calibration Register	Size	Address
1 MHz	CALBC1_1MHz	byte	010FFh
	CALDCO_1MHz	byte	010FEh
8 MHz	CALBC1_8MHz	byte	010FDh
	CALDCO_8MHz	byte	010FCh
12 MHz	CALBC1_12MHz	byte	010FBh
	CALDCO_12MHz	byte	010FAh
16 MHz	CALBC1_16MHz	byte	010F9h
	CALDCO_16MHz	byte	010F8h

```
BCSCTL1 = CALBC1_16MHZ;           // DCO = 16MHz
DCOCTL = CALDCO_16MHZ;
```

VLO Specs

internal very low power, low frequency oscillator (VLO)

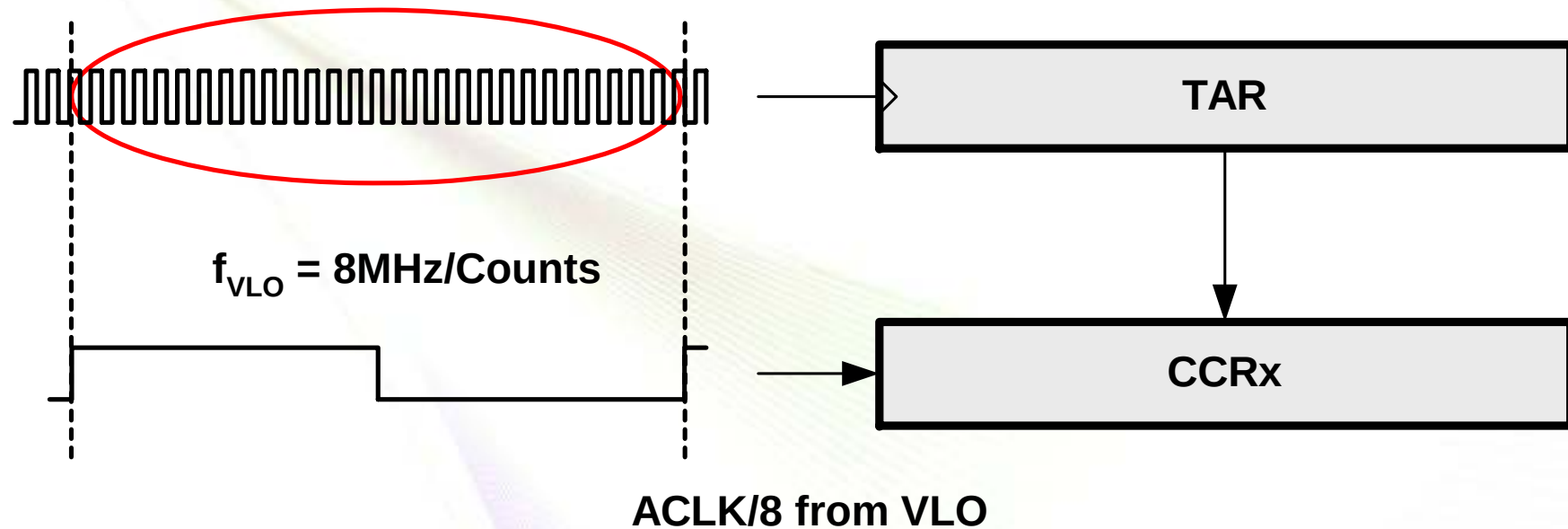
PARAMETER	TEST CONDITIONS	T _A	V _{CC}	MIN	TYP	MAX	UNIT
f _{VLO} VLO frequency		-40–85°C	2.2 V/3 V	4	12	20	kHz
		105°C	2.2 V/3 V			22	
df _{VLO} /dT VLO frequency temperature drift	(see Note 1)	I: -40–85°C T: -40–105°C	2.2 V/3 V		0.5		%/°C
df _{VLO} /dV _{CC} VLO frequency supply voltage drift	(see Note 2)	25°C	1.8V – 3.6V		4		%/V

- Wide initial tolerance
- Temperature drift
- Voltage drift

 **Calibratable, just like 1xx DCO!**

Calibrating the VLO

Calibrated 1 MHz DCO



- Clock Timer_A from calibrated 1MHz DCO
- Capture with rising edge of ACLK/8 from VLO
- VLO = 8MHz/counts

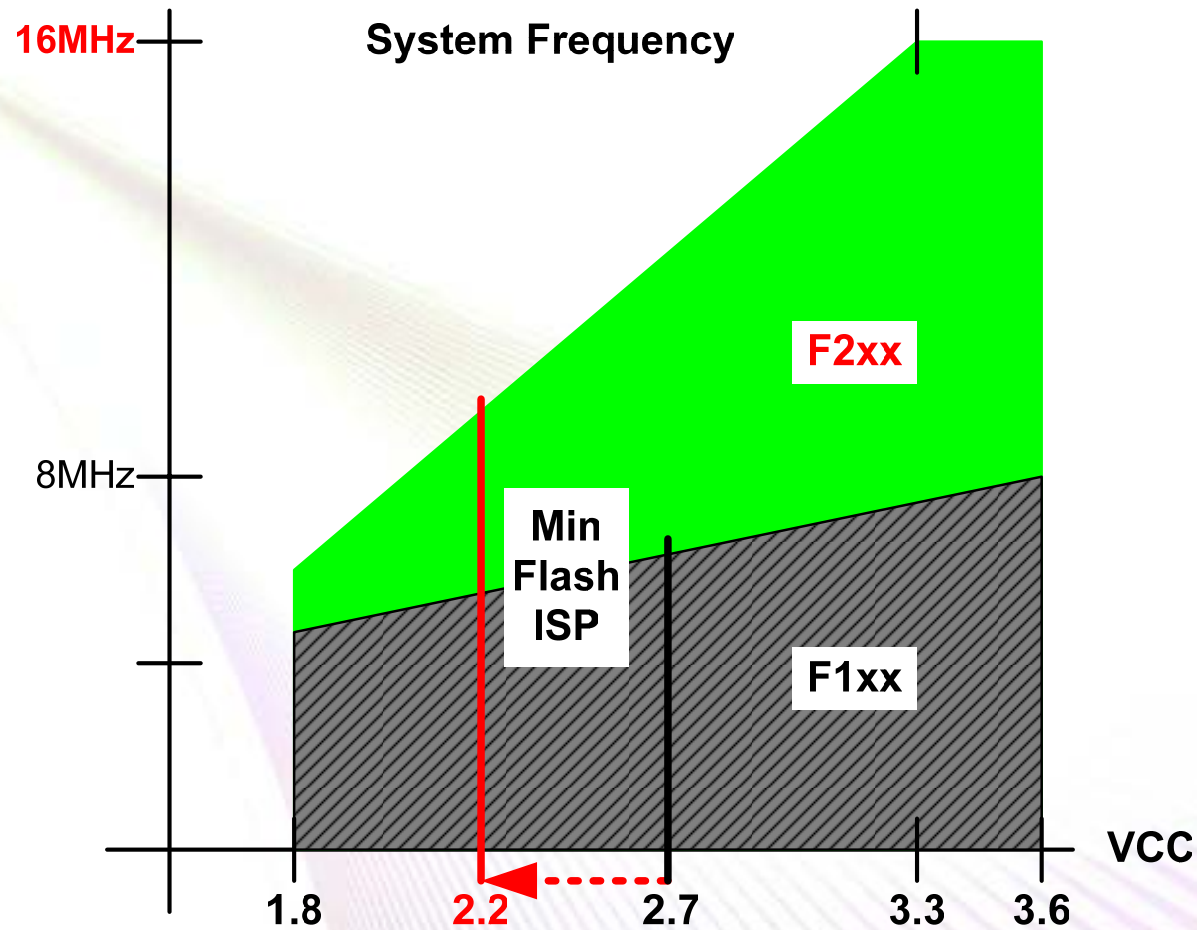
 **Library coming soon!**

Demo: LPM3 Using VLO

```
void main(void)
{
    BCSTL3 |= LFXT1S_2;           // LFXT1 = VLO
    WDTCTL = WDT_ADLY_1000;
    IE1 |= WDTIE;
    // Configure P1/P2
    for (;;) {
        _BIS_SR(LPM3_bits + GIE); // Enter LPM3
        P1OUT ^= 0x01;
    }
}
#pragma vector=WDT_VECTOR
__interrupt void watchdog_timer(void) {
    _BIC_SR_IRQ(LPM3_bits);       // Clear LPM3 bits 0(SR)
}
```

- What is the measured current consumption?

F2xx Expanded Operating Range



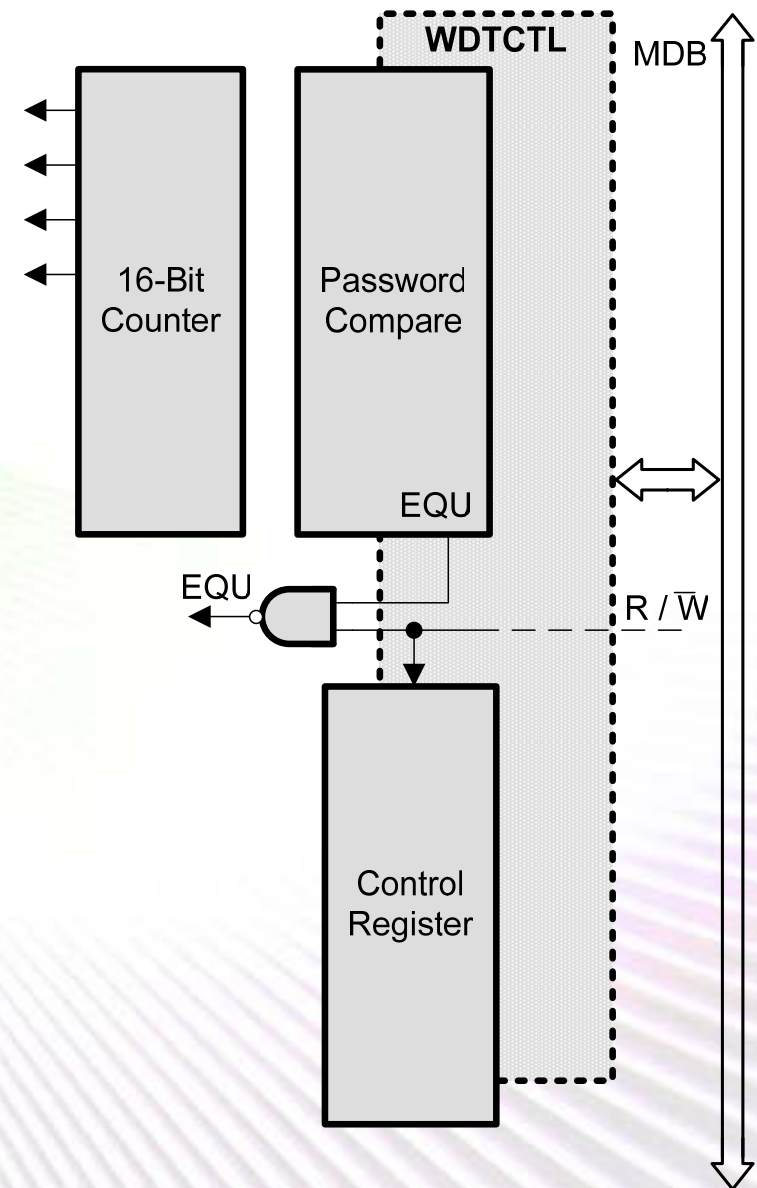
F2xx: More Robust

WDT+:

- Watchdog or interval timer
- Selectable intervals
- Password protected
- **Failsafe/protected clock**

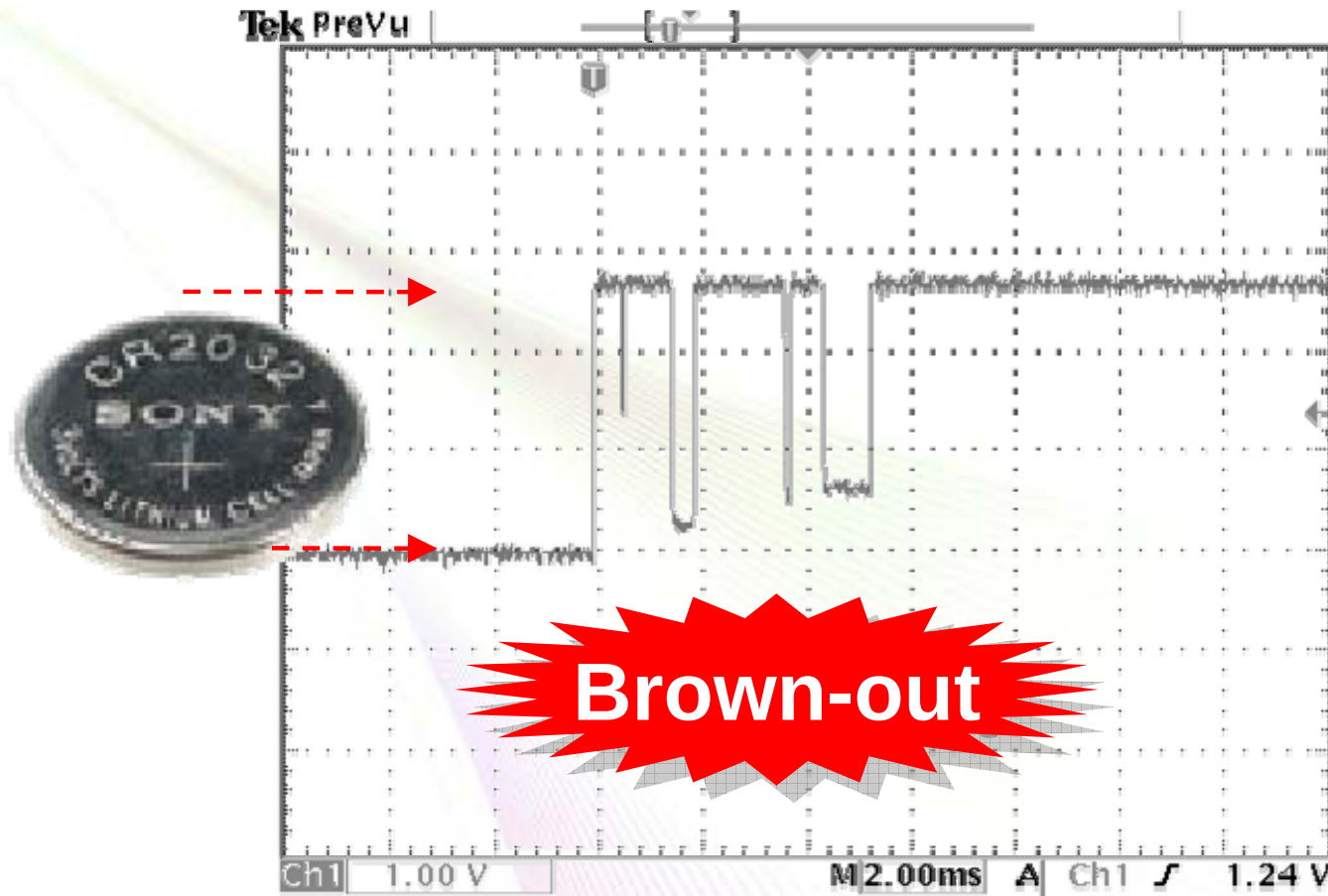
System Enhancements:

- **Blank device > LPM4**
- **Invalid address reset**
- **BOR on every 2xx**



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All F2xx Have Zero Power BOR

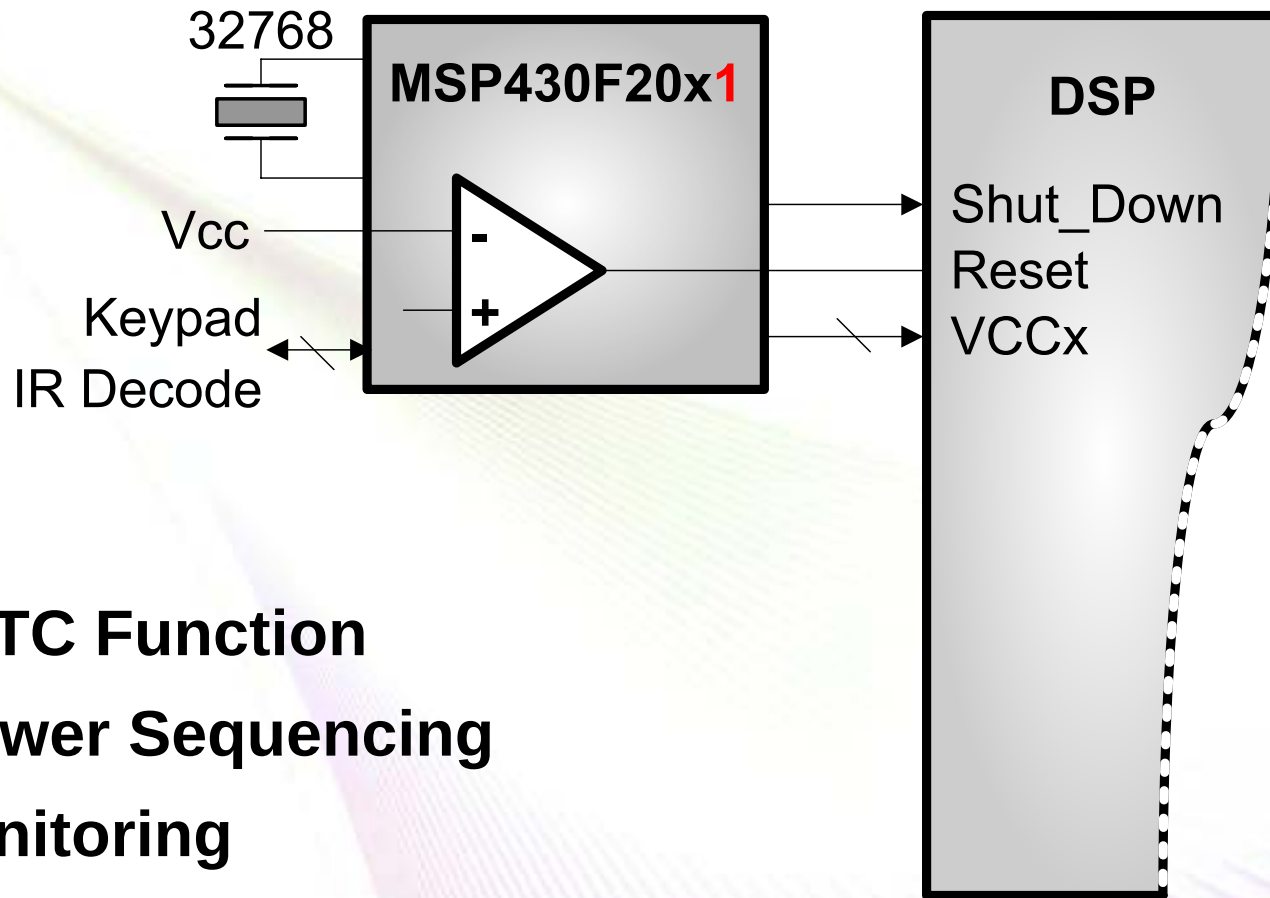


- MSP430 BOR is always-on and zero-power

Agenda

- Enhancements
- Application Examples
- Devices & Summary

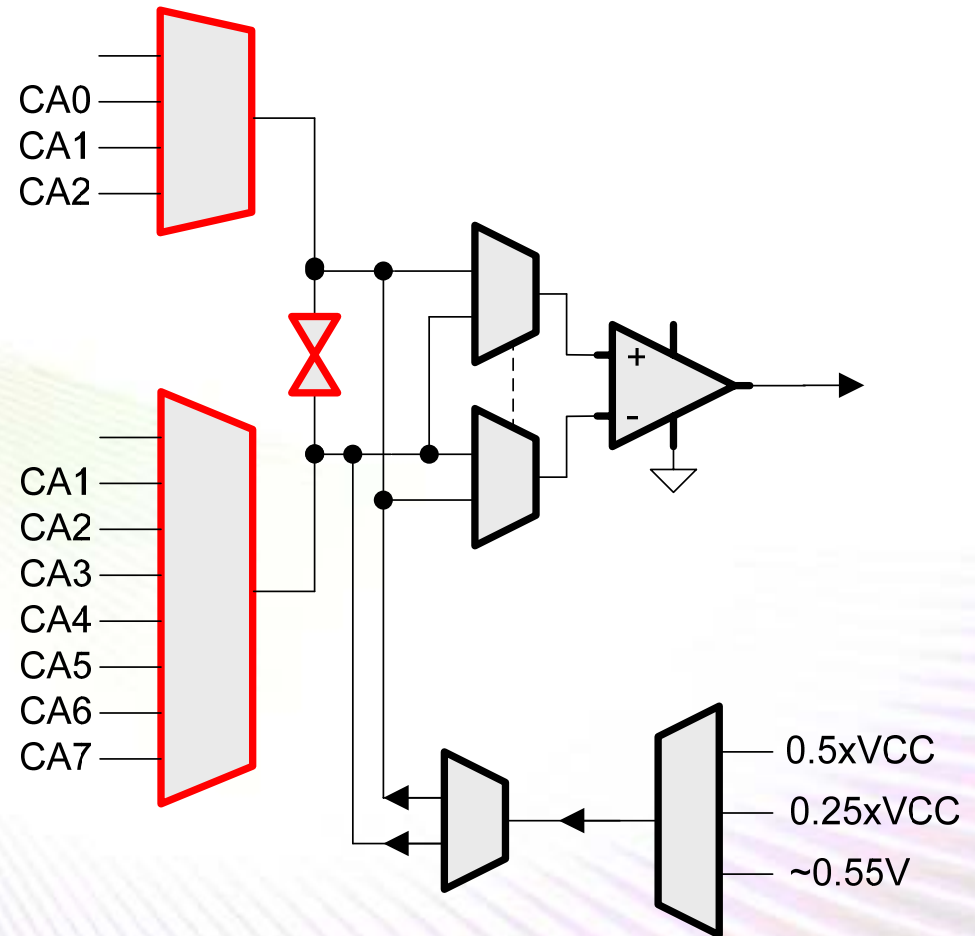
F20x1 Tiny Power Saver



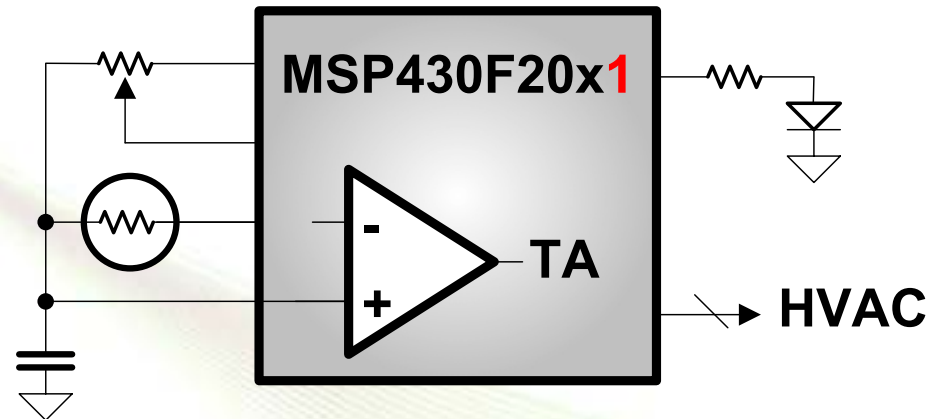
- <1uA RTC Function
- DSP Power Sequencing
- Vcc Monitoring
- User Interface
- Tiny 4x4mm Footprint

F2xx Comparator A+

- Slope ADC
- Battery detect
- Reference generator
- Interrupt source
- Timer_A capture
- **Expanded input multiplexer**
- **Multiplexer short for sample-and-hold**



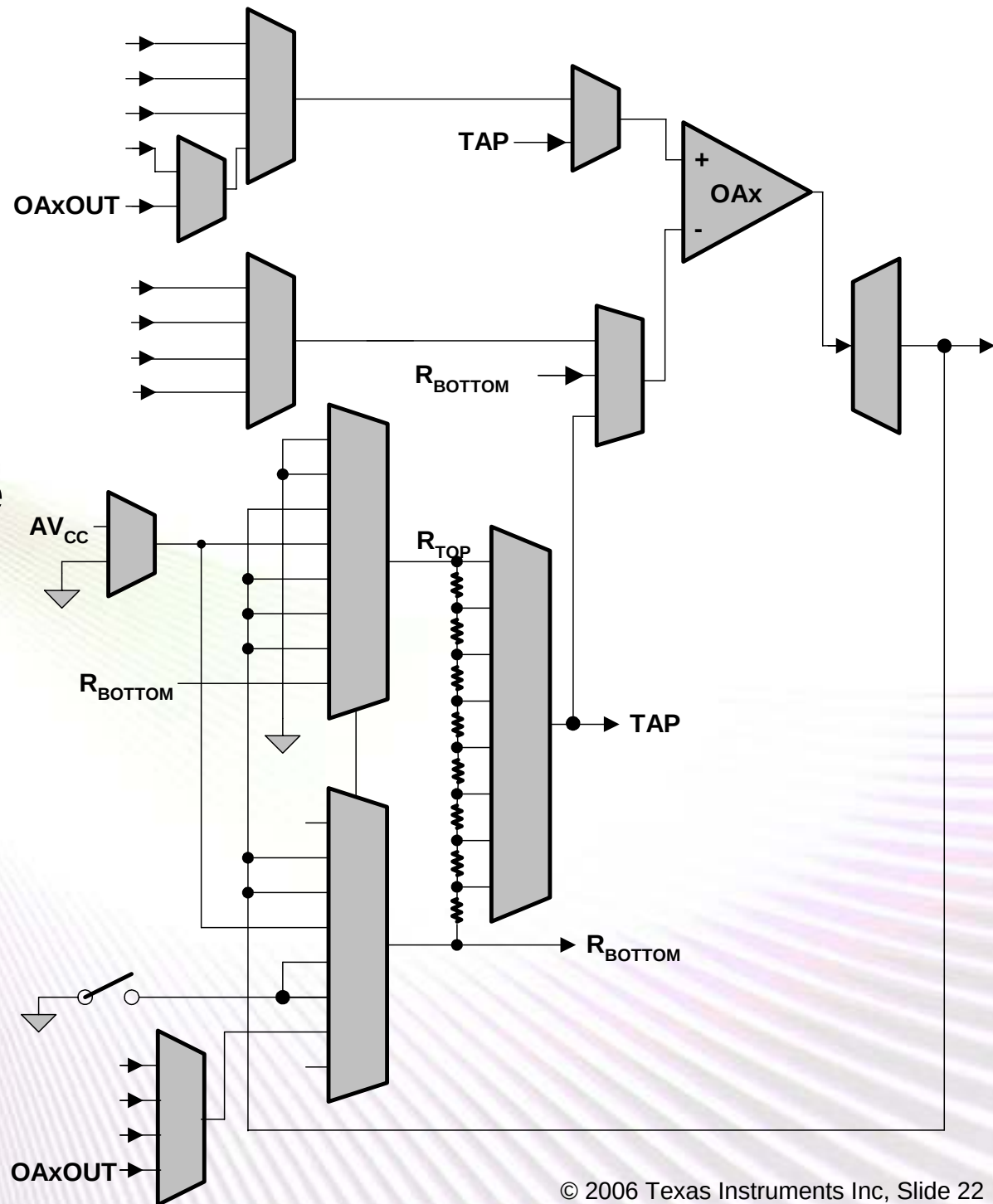
F20x1 Residential Thermostat



- <1uA total system power
- 10-bit slope ADC
- $\pm 1\text{C}/\text{F}$
- No XTAL needed
- Very low cost

F2xx OA

- Single-supply
- Low-current
- Rail-Rail output
- Selectable settling time vs. current consumption
- Integrated R-ladder for PGA function
- 5 modes
 - GP
 - Unity buffer
 - Comparator
 - NI PGA
 - Inverting PGA

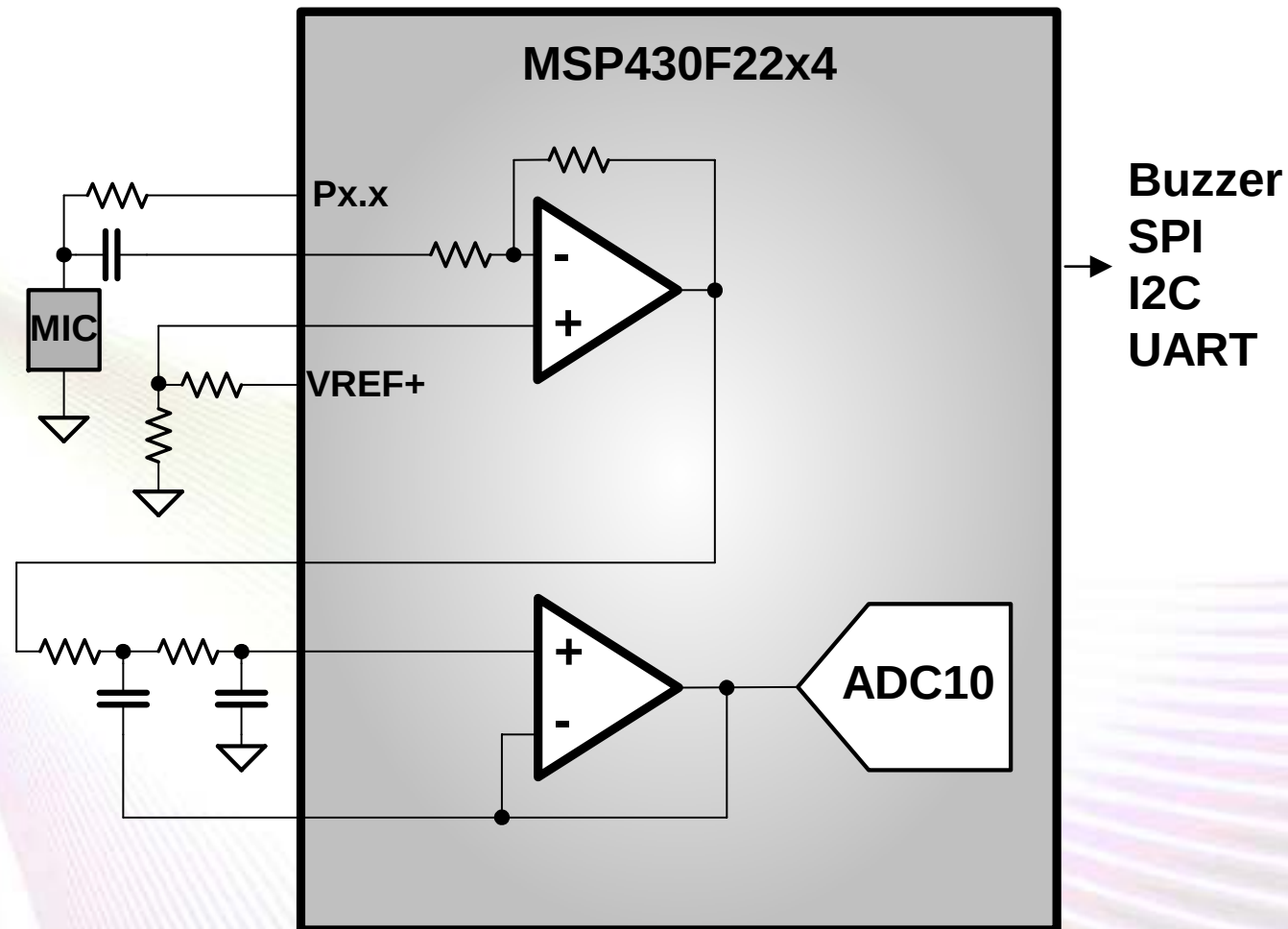


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 **MSP430F22x4**

F22x4 Glass Break Detector

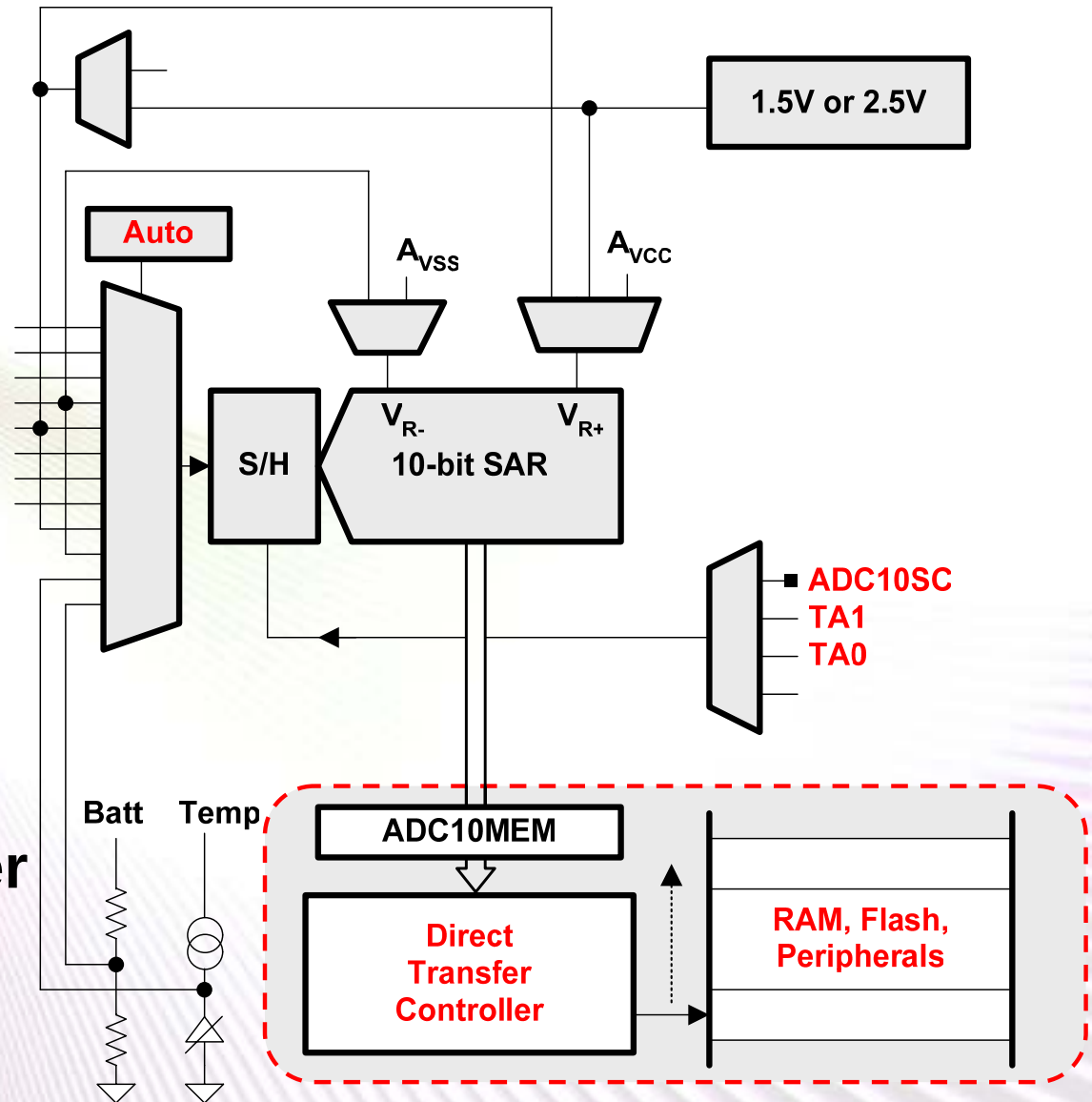
- Integrated Solution
- 2ms sample interval
- VLO – no crystal required
- 50uA average current
- Real-time signal analysis



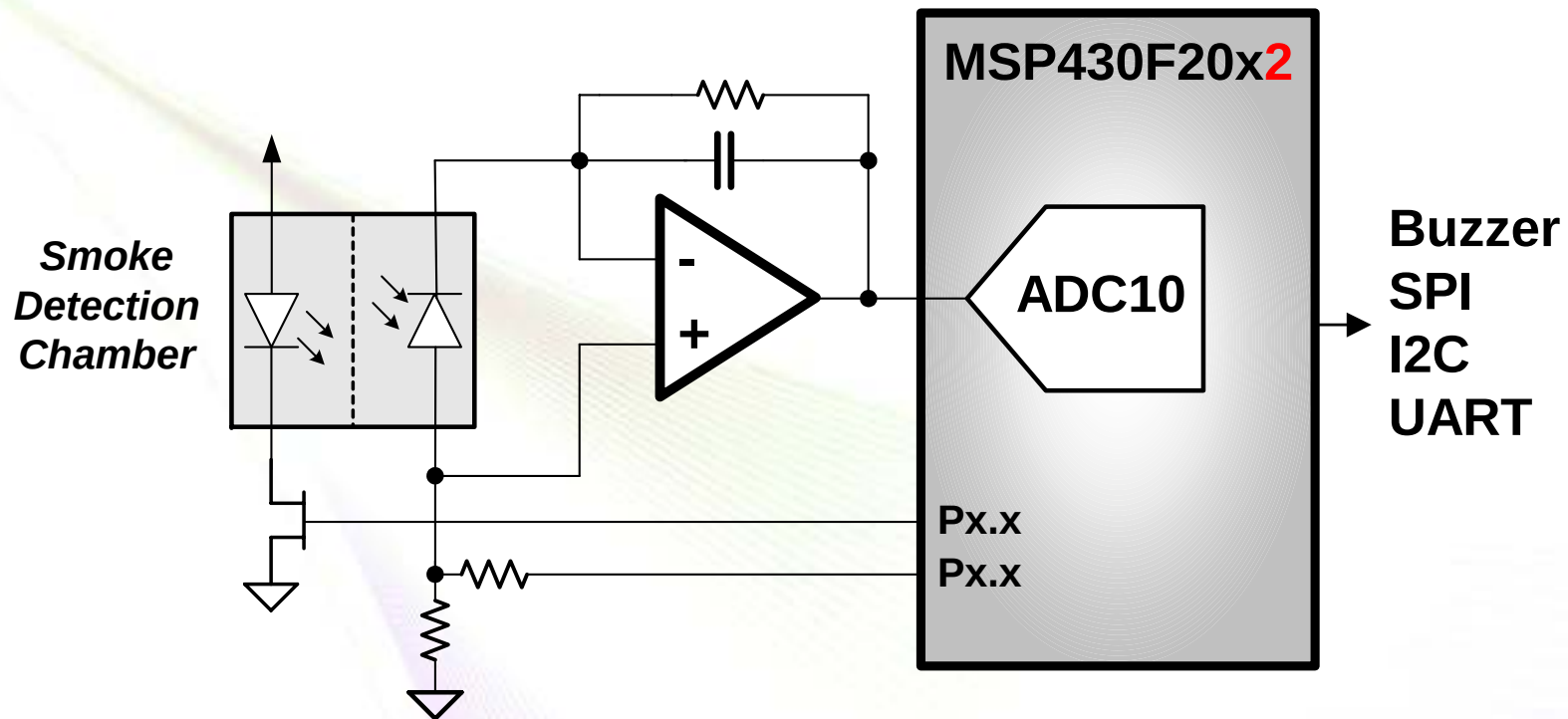
ADC10

- 10-bit ADC
- 200ksps+
- Autoscan
- Single Sequence Repeat-single Repeat-sequence
- Int/ext ref
- TA SOC triggers
- Data transfer controller

 **14-pin MSP430F2012**



F20x2 Low-Cost Smoke Detector

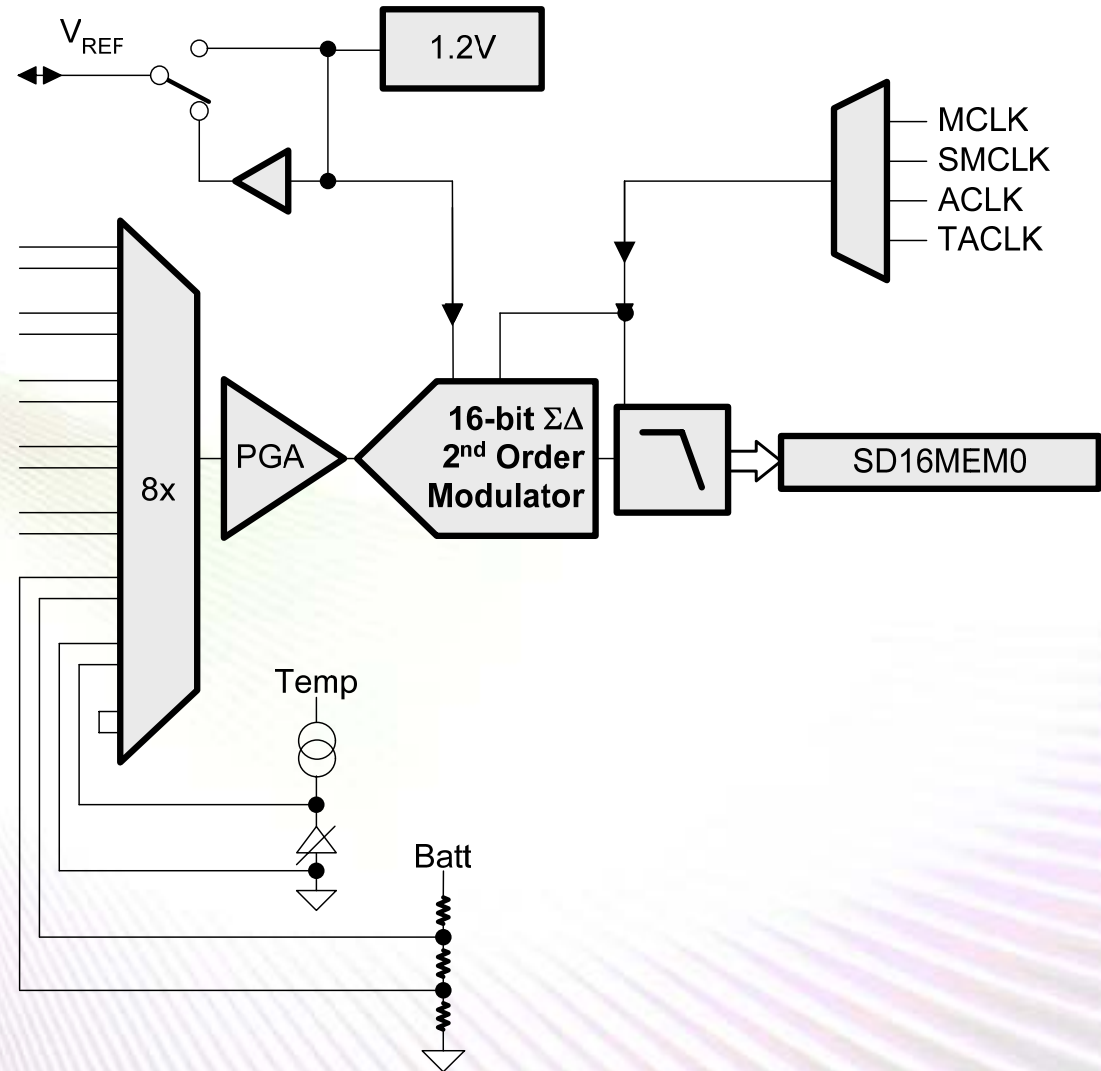


- 8s sample interval
- 2uA average system power
- VLO – no crystal required

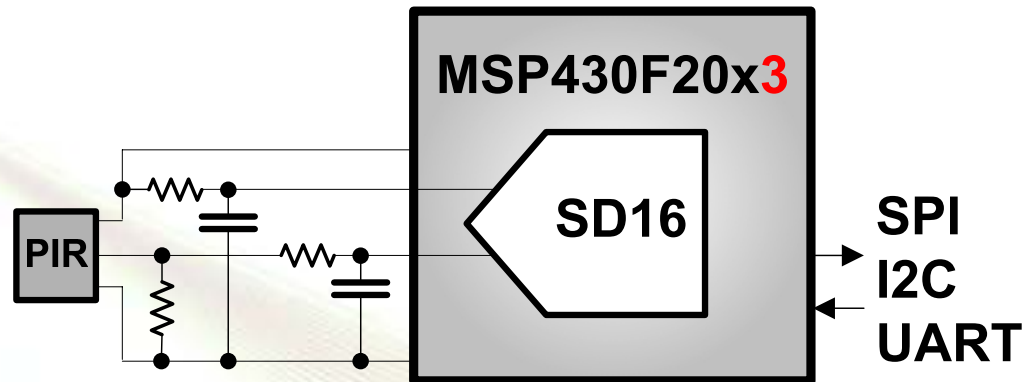
SD16 A

- 16-bit $\Sigma\Delta$ ADC
- 4.096 ksps
- Differential inputs
- 85db SINAD
- 32x PGA
- 18ppm 1.2V ref
- Temp sensor

 **14-pin MSP430F2013**



F20x3 PIR Motion Detector



< 7uA total system power

- ~5uA PIR
- ~1uA Measurement
- ~0.5uA MSP430 LPM3

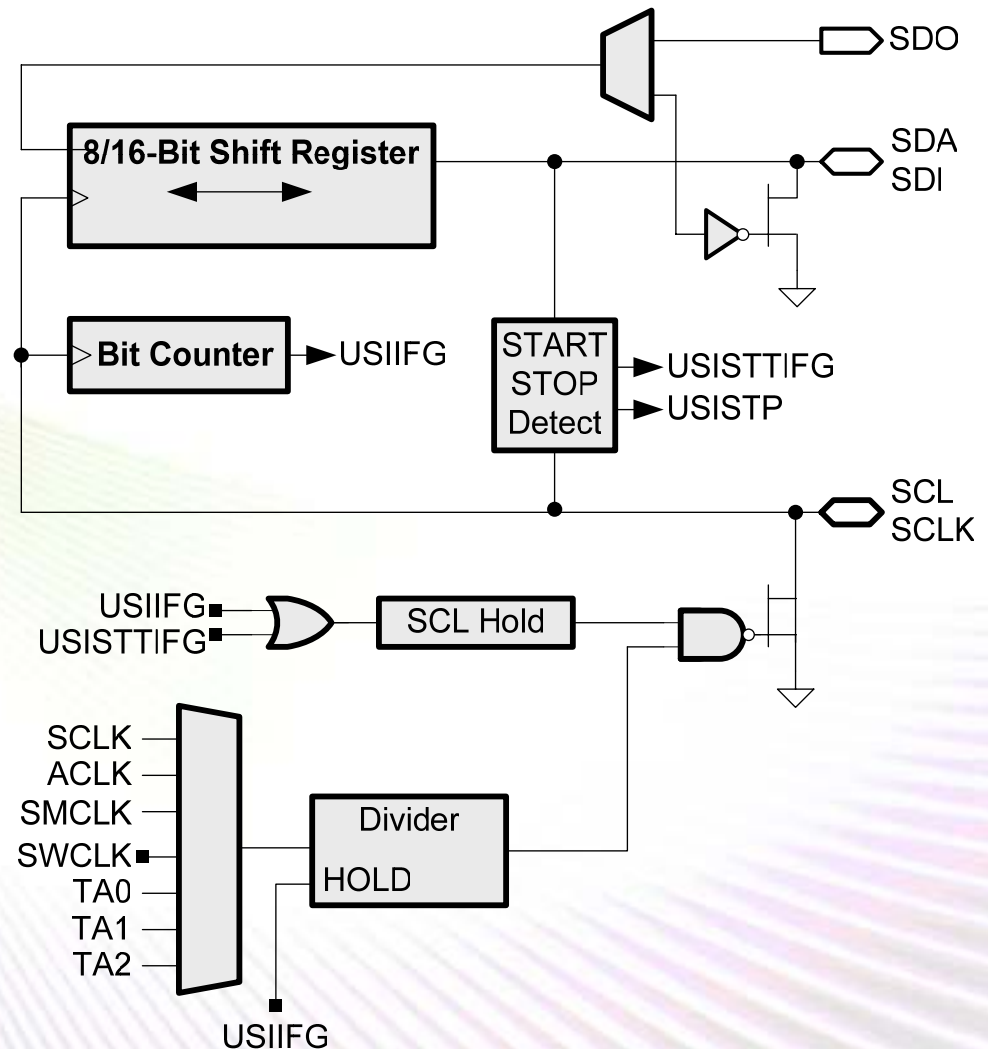
• Fully programmable

- Single-chip solution
- Direct interface to SD16
- VLO – no XTAL required

• Lower cost

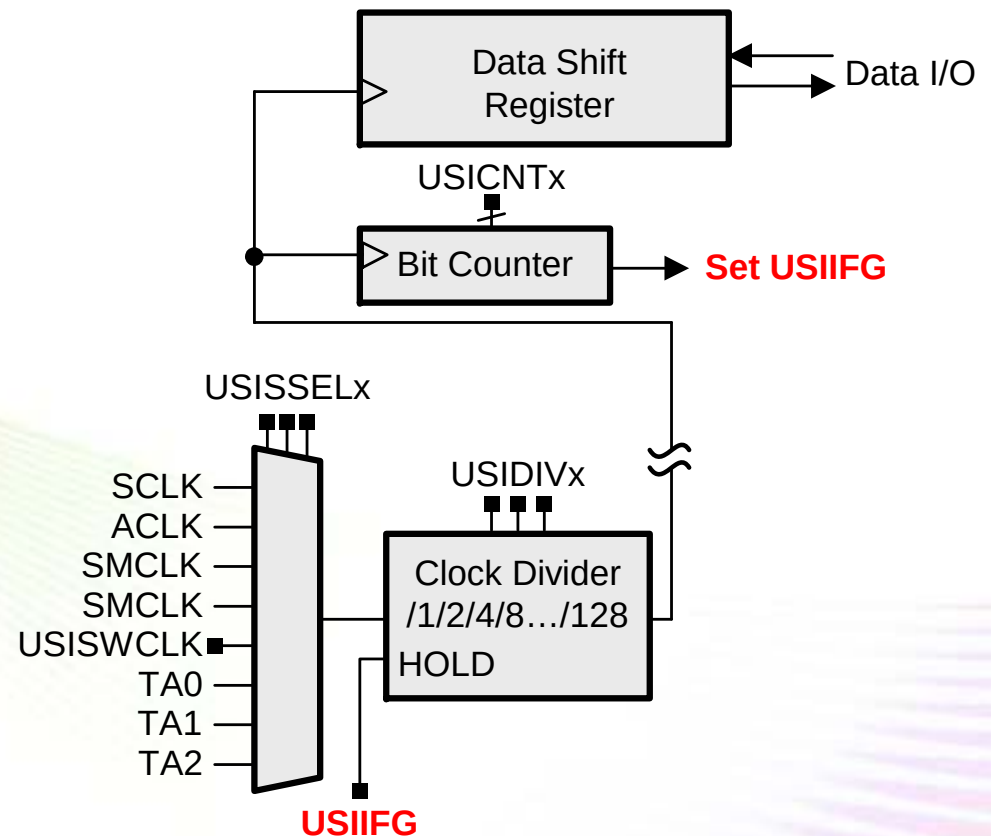
F20x2/3 Universal Serial Interface

- Reduces CPU load
- SPI Mode
 - 8/16-bit Shift Register
 - MSB/LSB first
- I²C Mode Support
 - START/STOP detection
 - SCL held after START
 - SCL held after counter overflow
 - Arbitration lost detection
- Fully Static Design
- Interrupt Driven

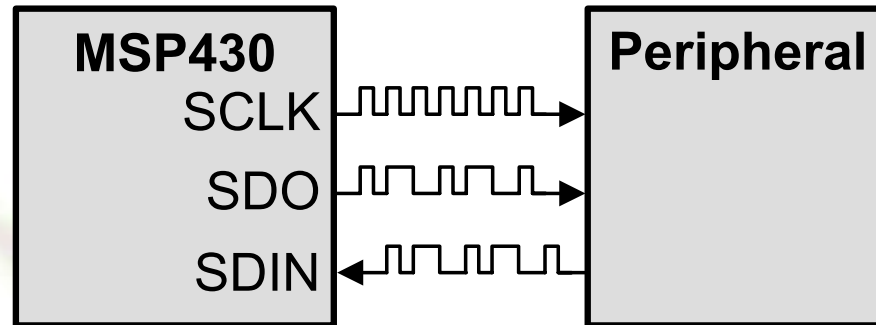


Data I/O

- Data shift register: up to 16 bits supported
- Number of bits TX'd & RX'd controlled by bit counter
- TX & RX is simultaneous
- Data I/O is user-defined: MSB or LSB first
- Bit counter automatically stops clocking after last bit & sets flag
- **No data buffering!**



USI Reduces CPU Load for SPI



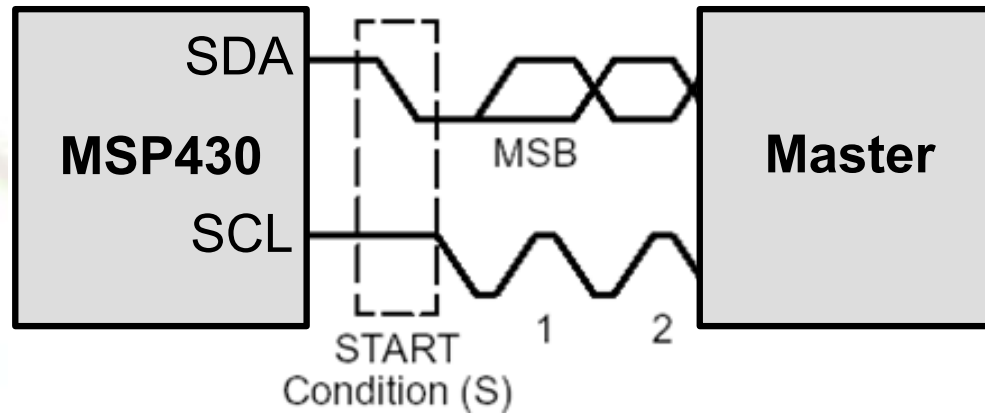
```
//Shift16_inout_Software
SR = DATA;
for (CNT=0x10;CNT>0;CNT--)
{
    P2OUT &= ~SD0;
    if (SR & 0x8000)
        P2OUT |= SD0;
    SR = SR << 1;
    if (P2IN & SDIN)
        SR |= 0x01;
    P2OUT |= SCLK;
    P2OUT &= ~SCLK;
}
```

425 Cycles

```
// Shift16_inout_USI
USISR |= DATA;
USICNT |= 0x10;
```

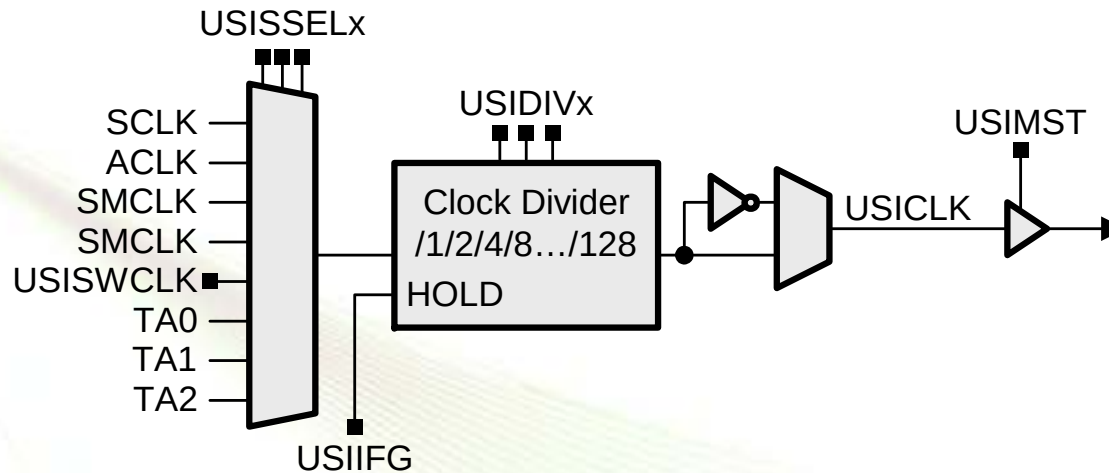
10 Cycles

F20x2/3 USI Enables Practical I2C



- I2C Slave has as little as **4us** from clock edge to data
- **Traditional software**-only solution allows for little else
- USI **hardware** enables practical and compliant I2C
- Code examples on the web

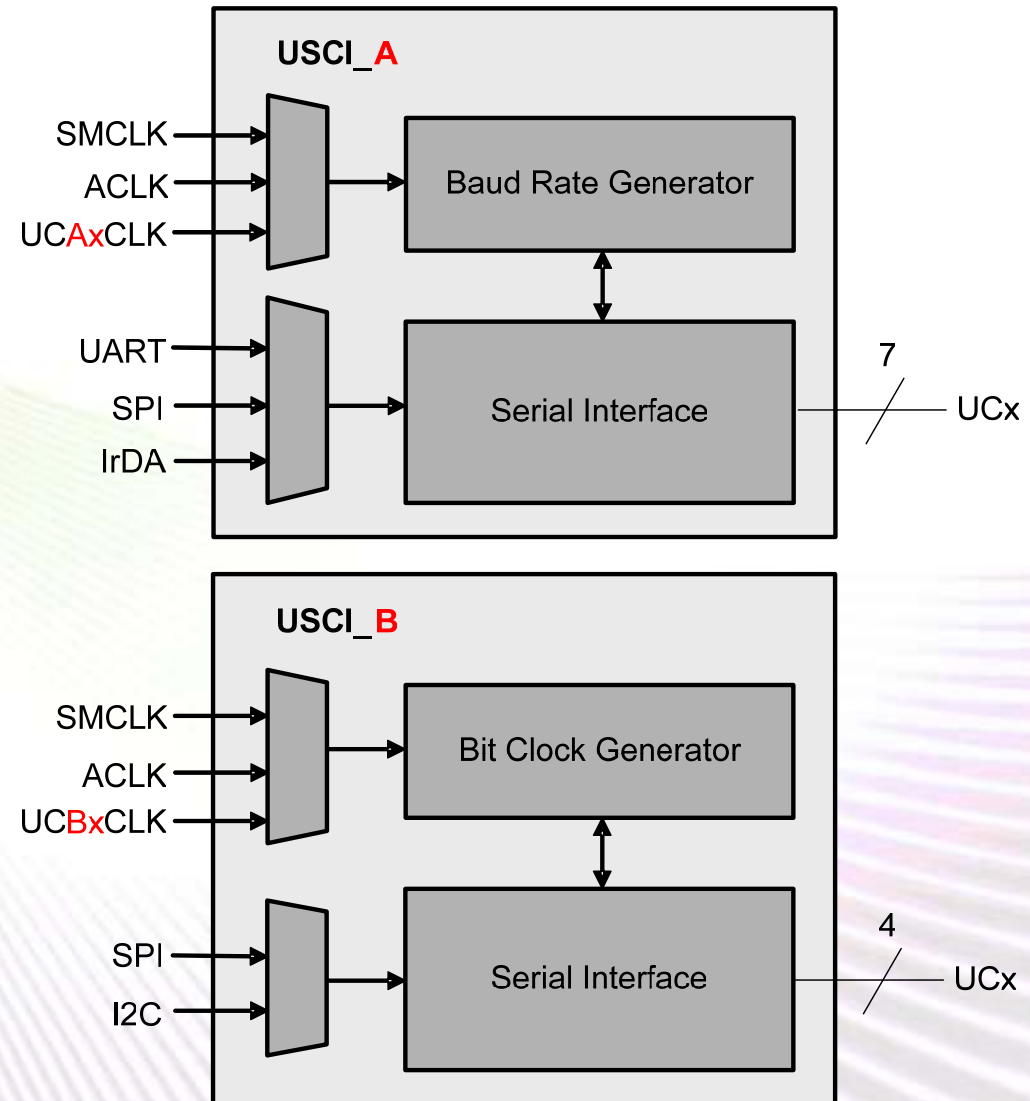
USI Clock Control



- Multiplexed input from up to 8 int/ext sources
- Configurable divider
- Auto-stop on interrupt: USIIFG
- Selectable phase and polarity
- Software clock: USISWCLK clock input bit

Universal Serial Communication I/F

- **Ultra-low power**
 - LPMx operation
- **2 individual blocks**
- **Double buffered TX/RX**
- **RX glitch suppression**
- **Baud rate generator**
 - Flexible clock source
 - Automatic detection
 - Generation
- **DMA enabled**
- **Interrupt driven**

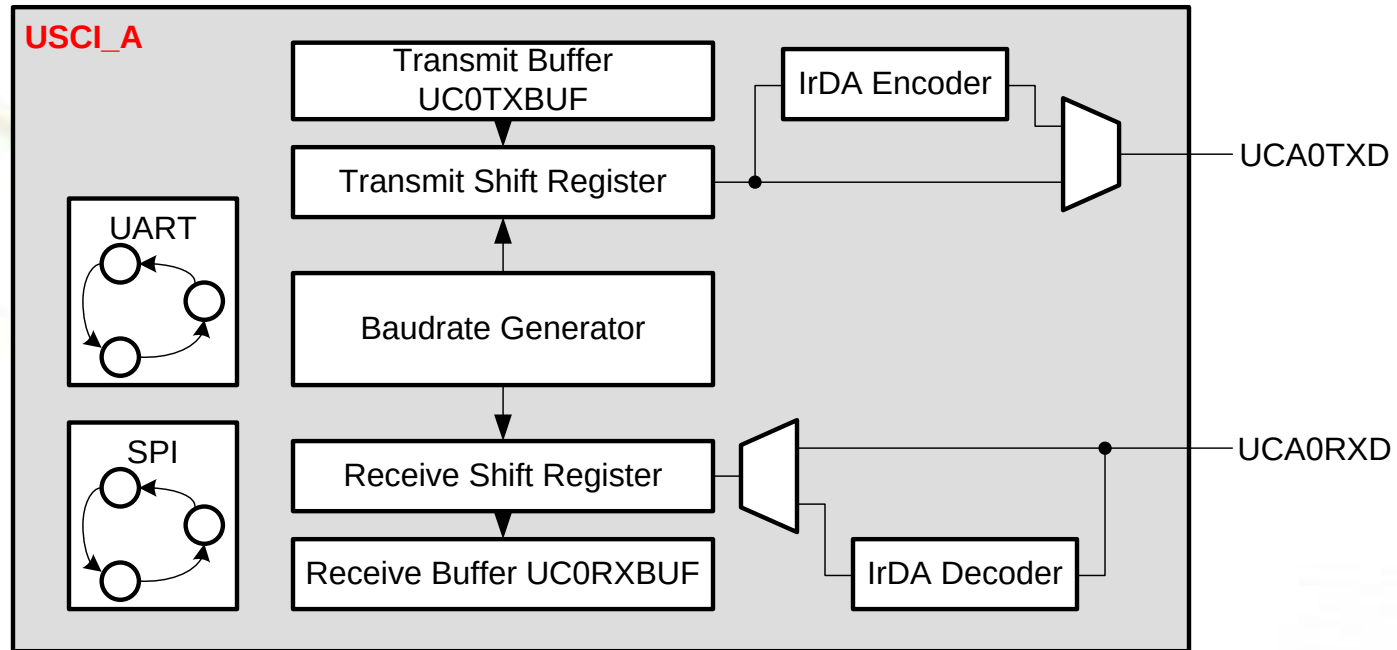


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USCI Enhanced Features

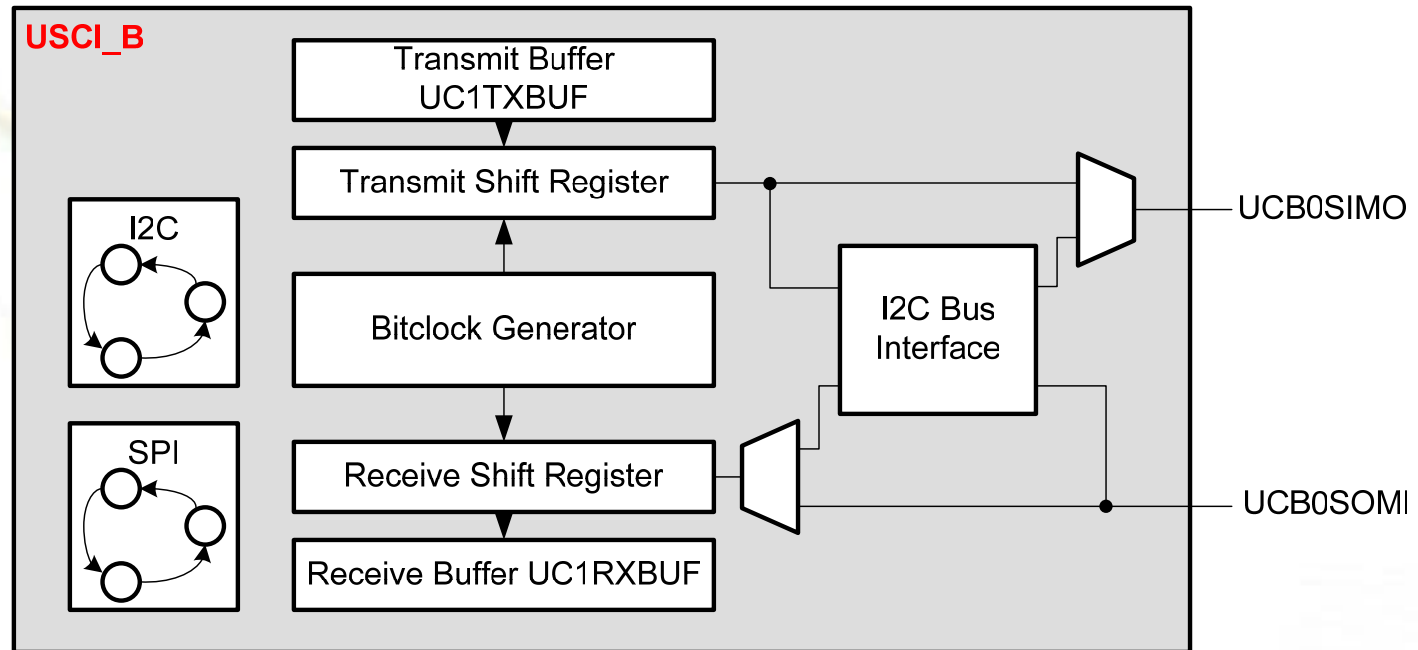
- **New standard MSP430 serial interface**
- **Auto clock start from any LPMx**
- **Two independent communication blocks**
- **Asynchronous communication modes**
 - UART standard and multiprocessor protocols
 - UART with automatic Baud rate detection (LIN support)
 - Two modulators support n/16 bit timing
 - IrDA bit shaping encoder and decoder
- **Synchronous communication modes**
 - SPI (Master & Slave modes, 3 & 4 wire)
 - I2C (Master & Slave modes)

USCI_A



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

USCI_B

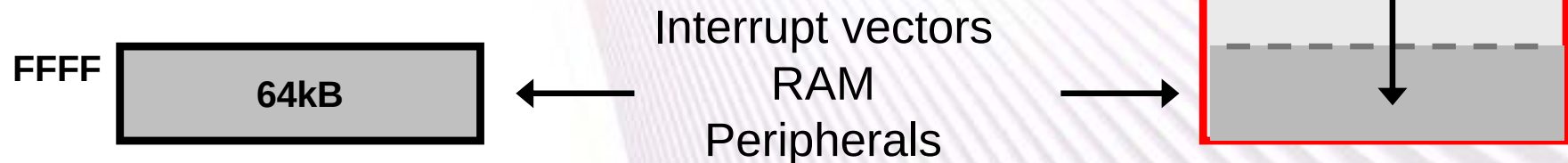


- I2C master/slave up to 400kHz or SPI
- Bit clock generator
- Double buffered TX/RX

New MSP430X CPU

- Architecture upgrade
- 100% code compatible
- 1MB unified memory map
- **Extended addressing modes**
 - Page-free 20-bit reach
 - Improved code density
 - Faster execution

 **MSP430F241x/261x**



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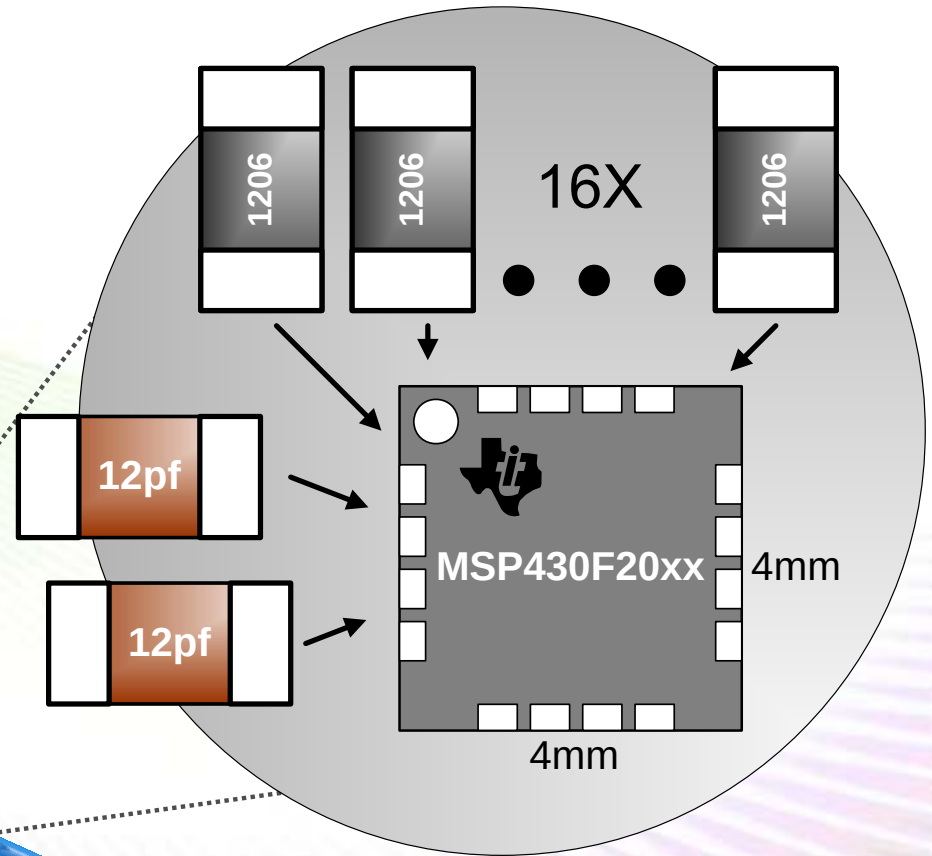
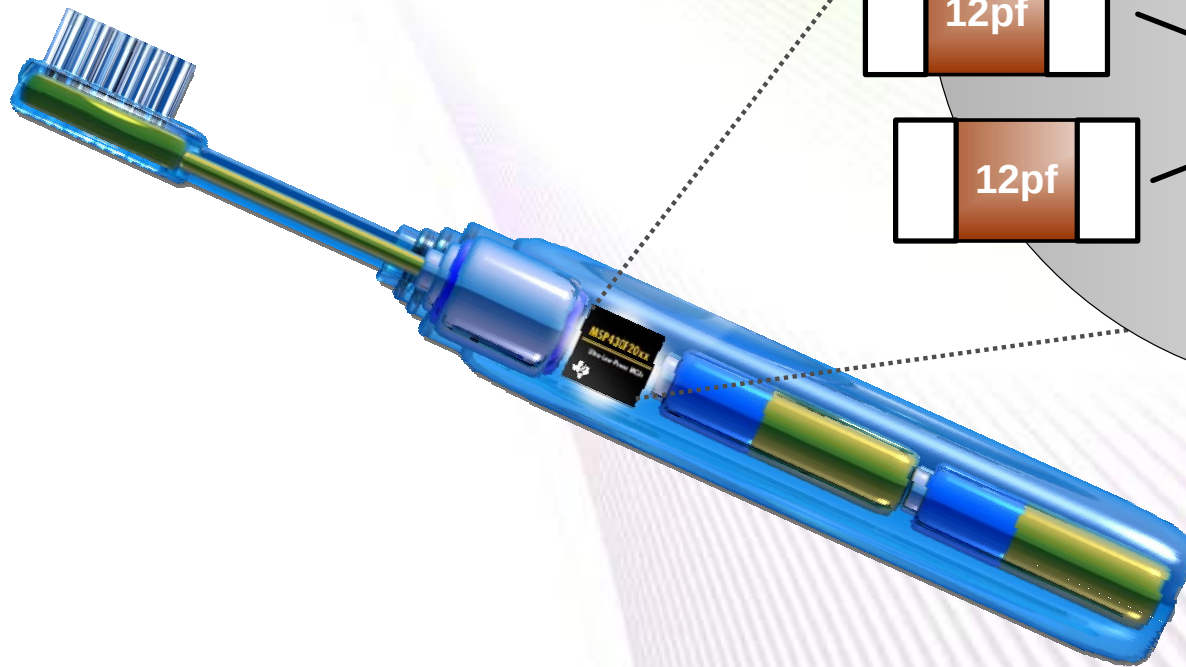
F2xx: Every Little Bit Counts

- Pull-up/down pin resistors

MIN	TYP	MAX
20	35	50
K Ω		

- XTAL capacitors

- DCO and VLO oscillators



Agenda

- Enhancements
- Application Examples
- Devices & Summary

New F2xx Multi-Purpose Devices

Device	Pins	Flash/RAM	Features	Samples
F20x1	14	2KB / 128B	TA2, Comp_A	Now
F20x2	14	2KB / 128B	TA2, USI, AC10	Now
F20x3	14	2KB / 128B	TA2, USI, SD16	Now
F21x1	20	8KB / 256B	TA3, Comp_A	Now
F22x2*	38/40	32KB / 1KB	TA3, TB3, USCI, ADC10	Now
F22x4*	38/40	32KB / 1KB	TA3, TB3, USCI, ADC10, (2)OPA	Now
F23x0*	40	32KB / 2KB	TA3, TB3, USCI, Comp_A, MPY	1Q07
F23x*	64	16KB/512B	TA3, TB3, USCI, ADC12	2Q07
F24x*	64	60KB/2KB	TA3, TB7, (2)USCI, ADC12	2Q07
F241x*	64/80	120KB / 8KB	TA3, TB7, (2)USCI, ADC12,MPY	1Q07
F261x*	64/80	120KB / 8KB	TA3, TB7, (2)USCI,ADC12, MPY, (2)DAC12, (3)DMA	1Q07
All devices include enhanced watchdog timer (WDT+) and enhanced basic clock system (BCS+)				
* Planned Future device, in development				

Summary

- **Pin-compatible drop-ins**
- **Lower Power**
- **Faster**
- **Many upgraded peripherals**
- **Many new devices**

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