MSP430F20xx- Tiny, Fast and Flexible

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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

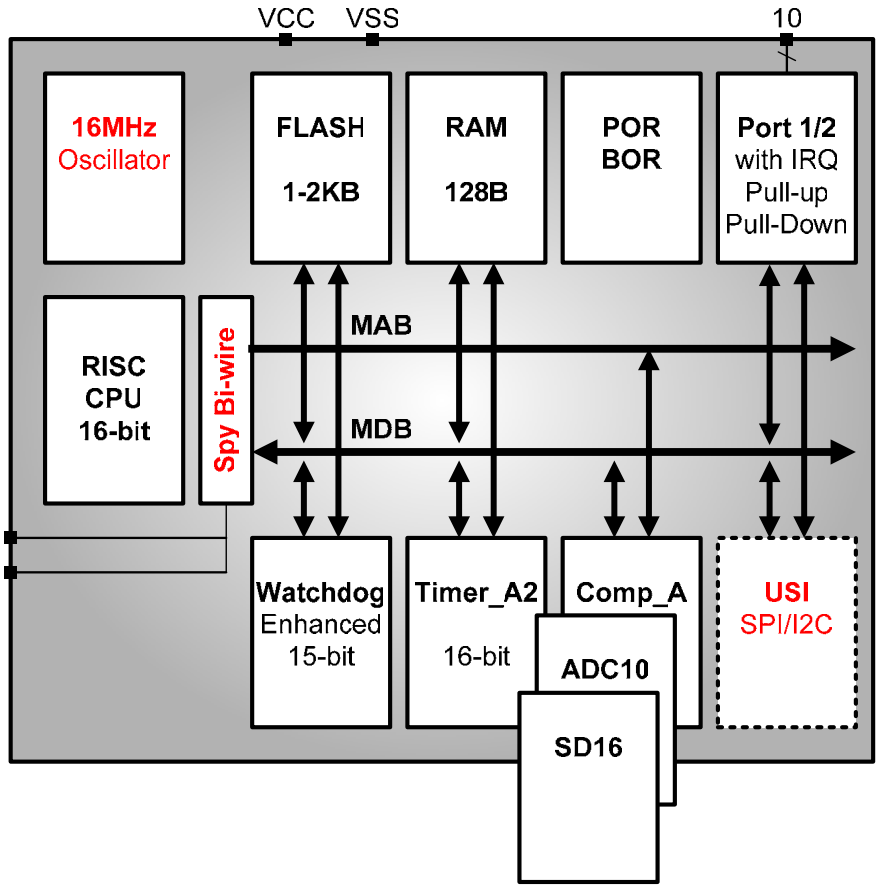
2X faster

1/2 power

Better

New MSP430F20xx

- **Tiny 14-pin packaging**
  QFN 4x4mm, TSSOP, PDIP
- **Fast 0-to-16 MIPS <1us**
- **Flexible**
  <<1uA RTC and 200uA/MIPS
  1.8 to 3.6V operation
  Zero-power BOR
  Failsafe OSC/WDT+
  ± 2.5% programmable DCO
  2.2V Flash ISP
  Pull-up/down port resistors
  128B RAM and 1/2kB ISP Flash
  Spy Bi-Wire emulation
  Universal Serial Interface (USI)
  Comparator/10-bit/16-bit ADC

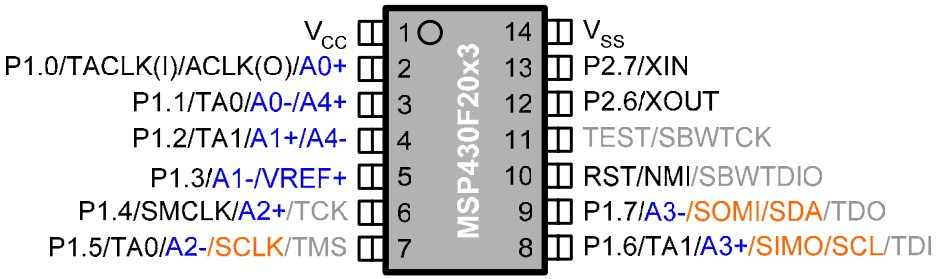


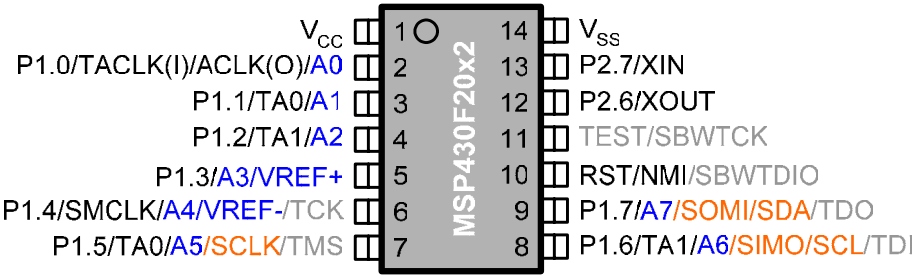
F20xx Family

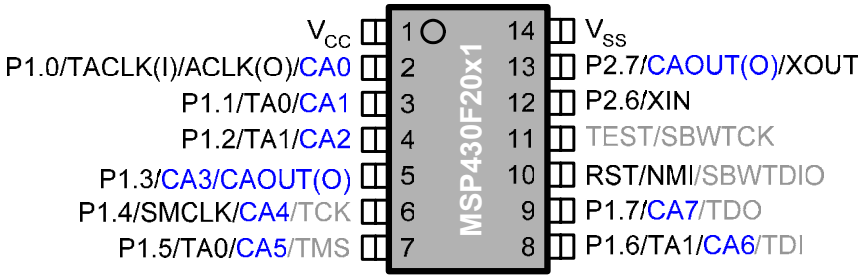
Device	Flash	RAM	Timer	Analog	USI	1ku Price
F2001	1KB	128B	WDT+/A2	Comp_A		$0.55
F2011	2KB	128B	WDT+/A2	Comp_A		0.70
F2002	1KB	128B	WDT+/A2	ADC10	✓	0.99
F2012	2KB	128B	WDT+/A2	ADC10	✓	1.15
F2003	1KB	128B	WDT+/A2	SD16_A	✓	1.49
F2013	2KB	128B	WDT+/A2	SD16_A	✓	1.65

- **Worlds lowest power MCU**
- **Tiny, fast and flexible**
- **Non-compromised architecture**

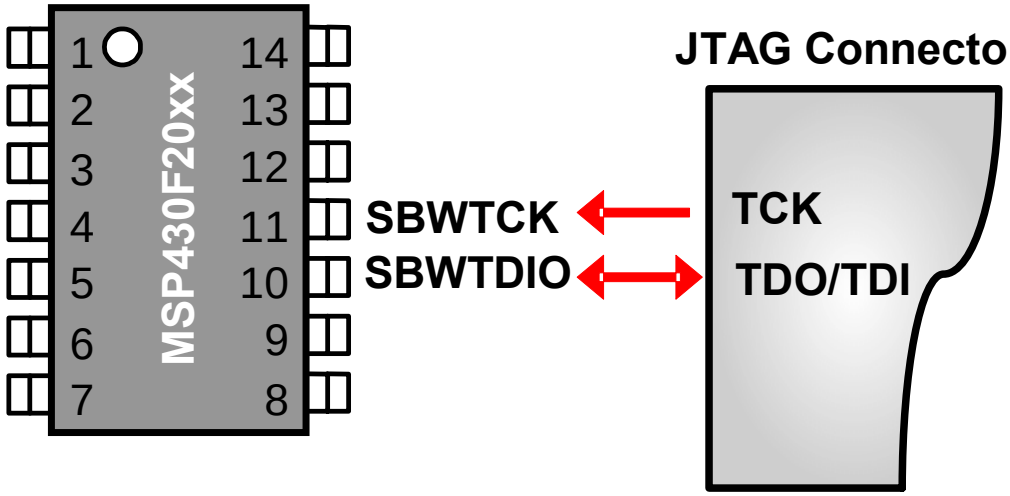
F20xx Family Compatibility





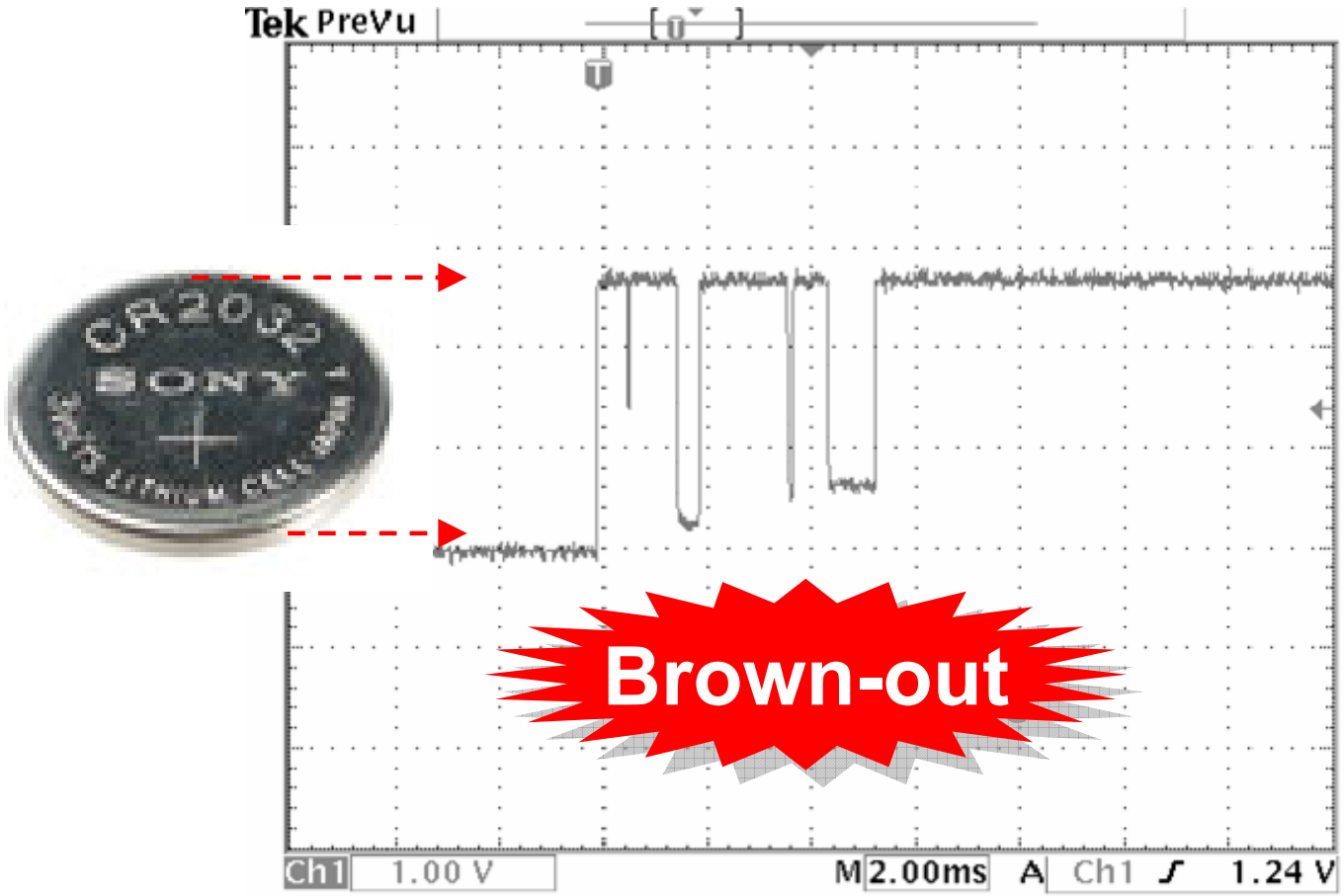


F20xx Easy In-System Emulation



- **Unobtrusive 2-wire Spy Bi-Wire Emulation**
  - Full-speed, single step
  - Hardware breakpoints
  - Clock control
- **Compatible with installed MSP430 IDEs**

All F2xx Have Zero Power BOR

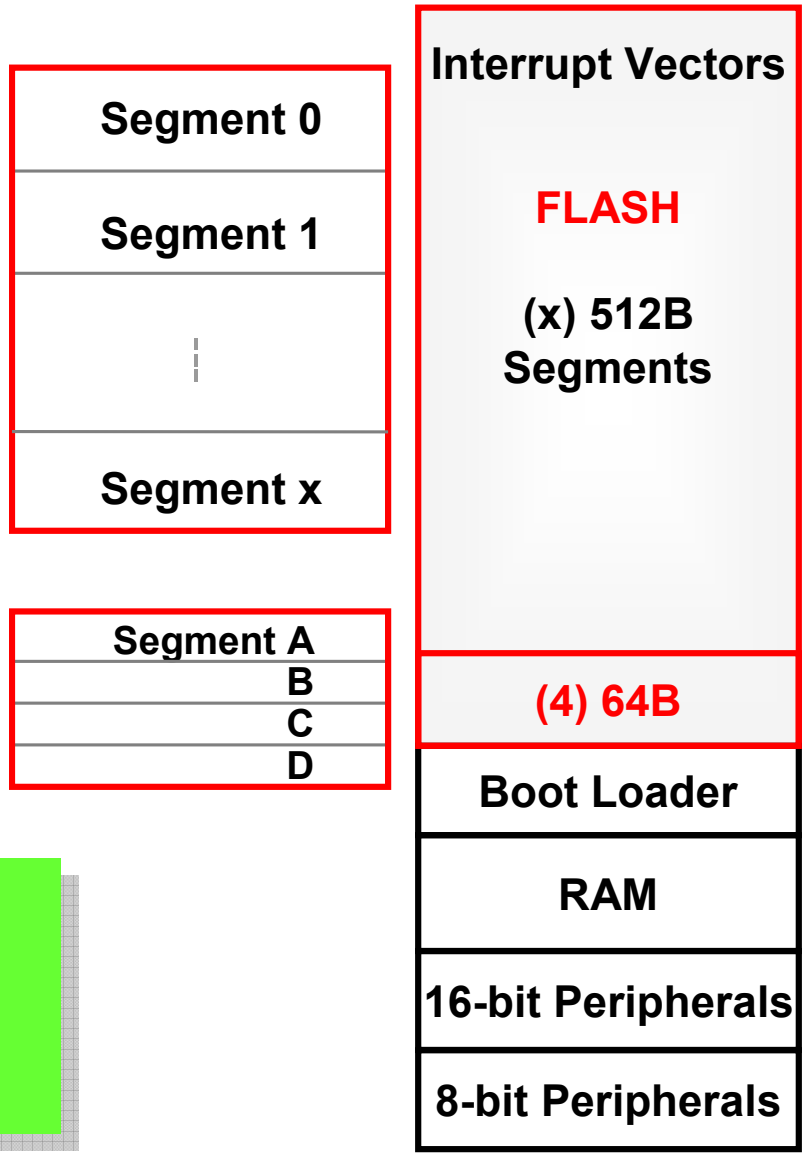


- **MSP430 BOR is always-on and zero-power**

F2xx: ISP Flash

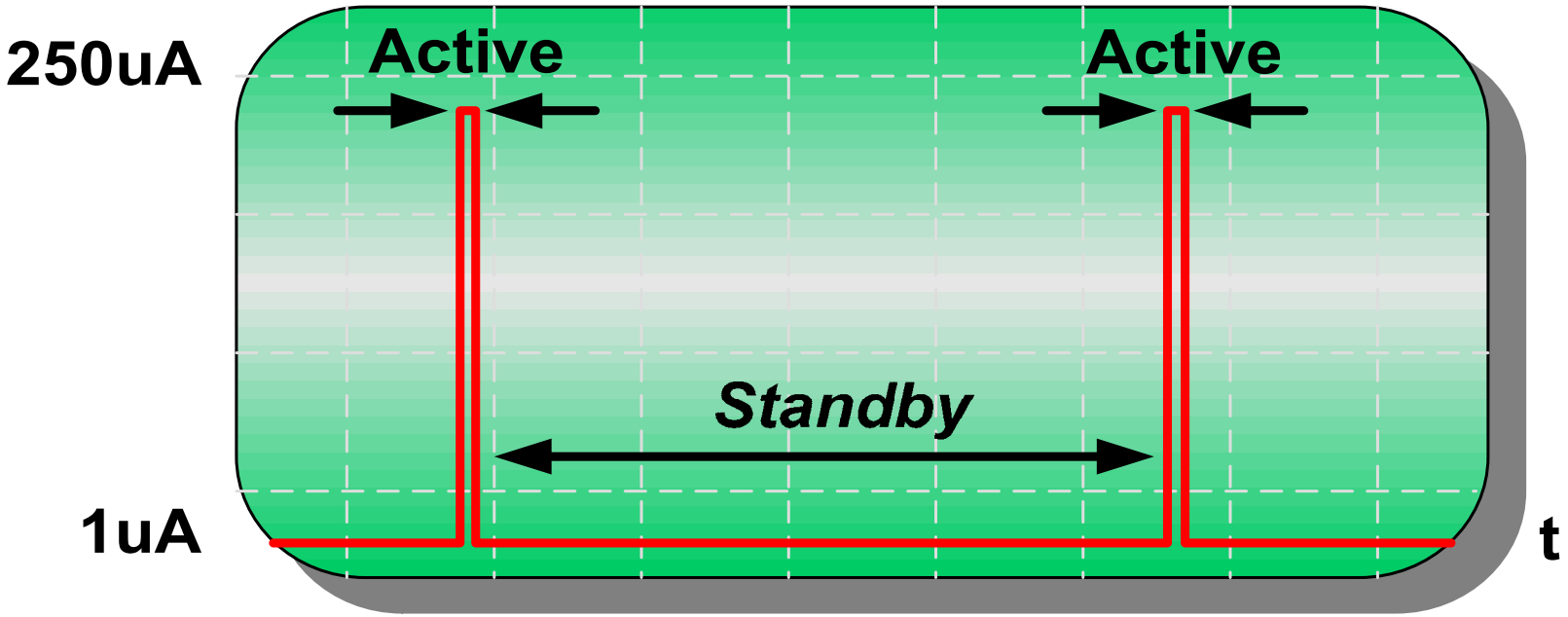
- Fast <20us /byte ISP
- Interruptible ISP/Erase
- Reduced size 64B info
- Lockable info
- Hackproof BSL
- Protection from BSL accidental prog/erase

F20xx has No BSL




```
// Flash In System Programming
FCTL3 = FWKEY;              // Unlock
FCTL1 = FWKEY | WRT;        // Enable
*(unsigned int *)0xFC00 = 0x1234;
```

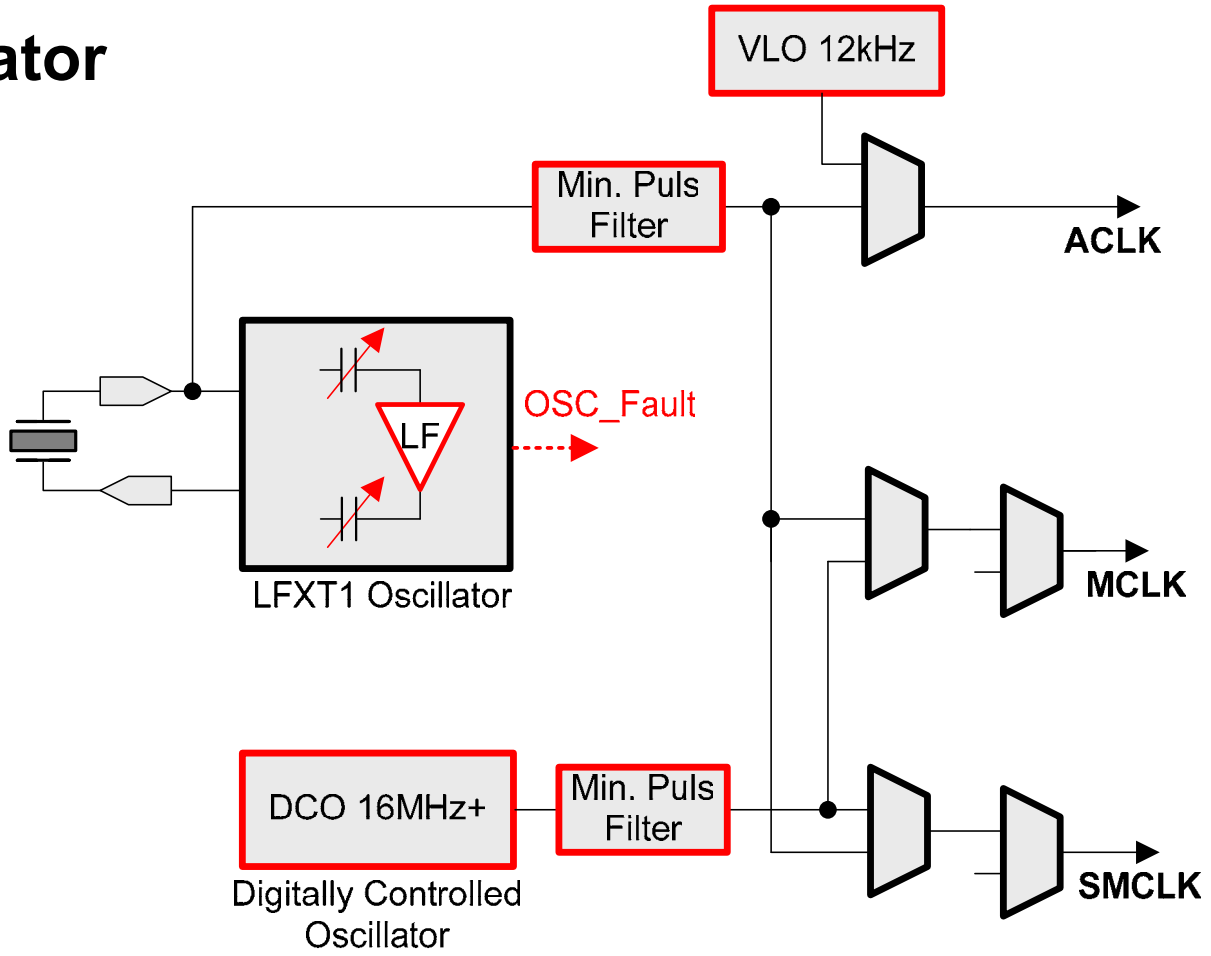
Achieving *Ultra-low Power*



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

F20xx Basic Clock+

- **LFXT1 XTAL Oscillator**
  - <1uA LPM3 standby mode
  - XTAL CAPs programmable
  - OSCfault LF/(XT)
  - New VLO
  - No XT mode
- **Improved DCO**
  - < 1us 0-to-16MHz
  - ± 2.5% DCO
  - Programmable frequency



Demo: LPM3 32kHz XTAL

```
void main(void)
{
  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)
}
```

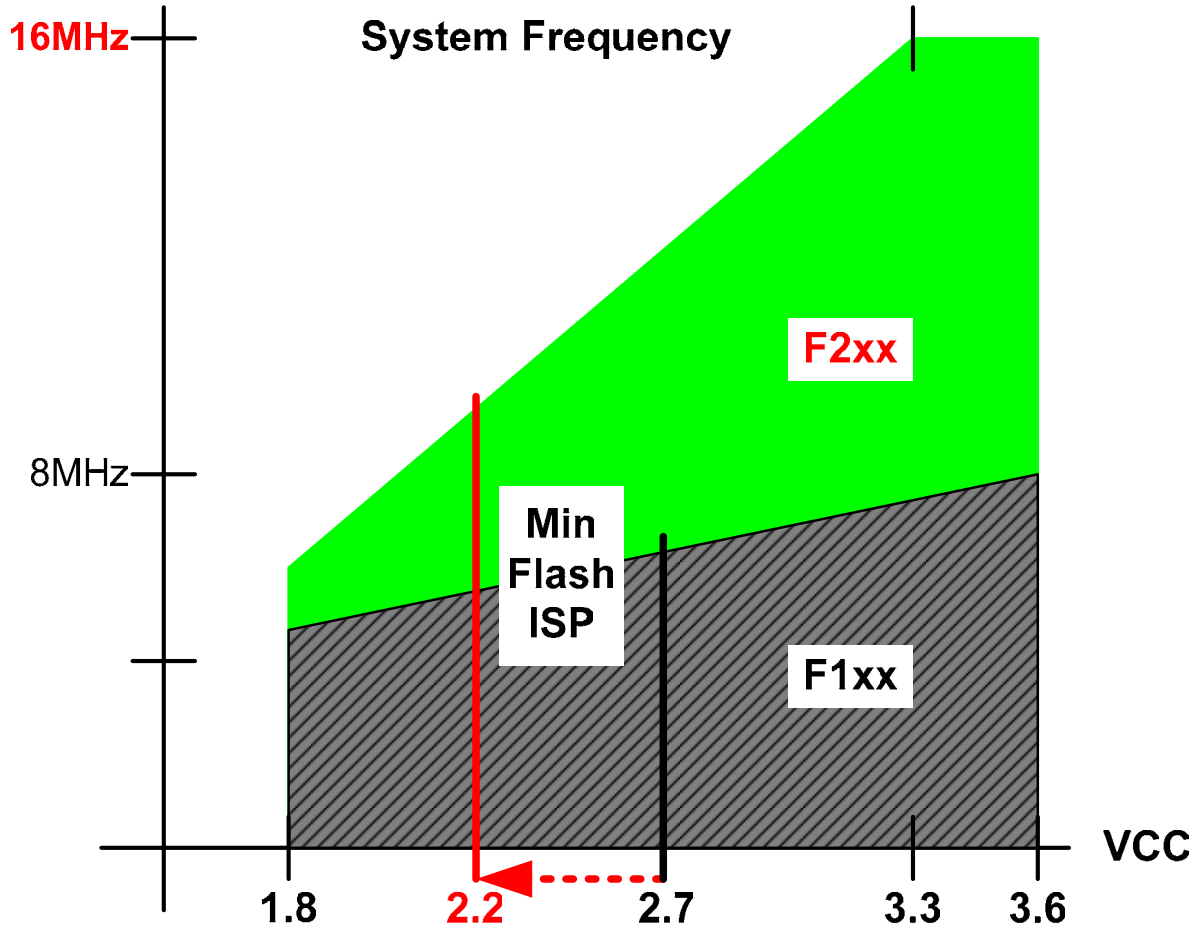
- **What is the measured current consumption?**

Demo: LPM3 Using VLO

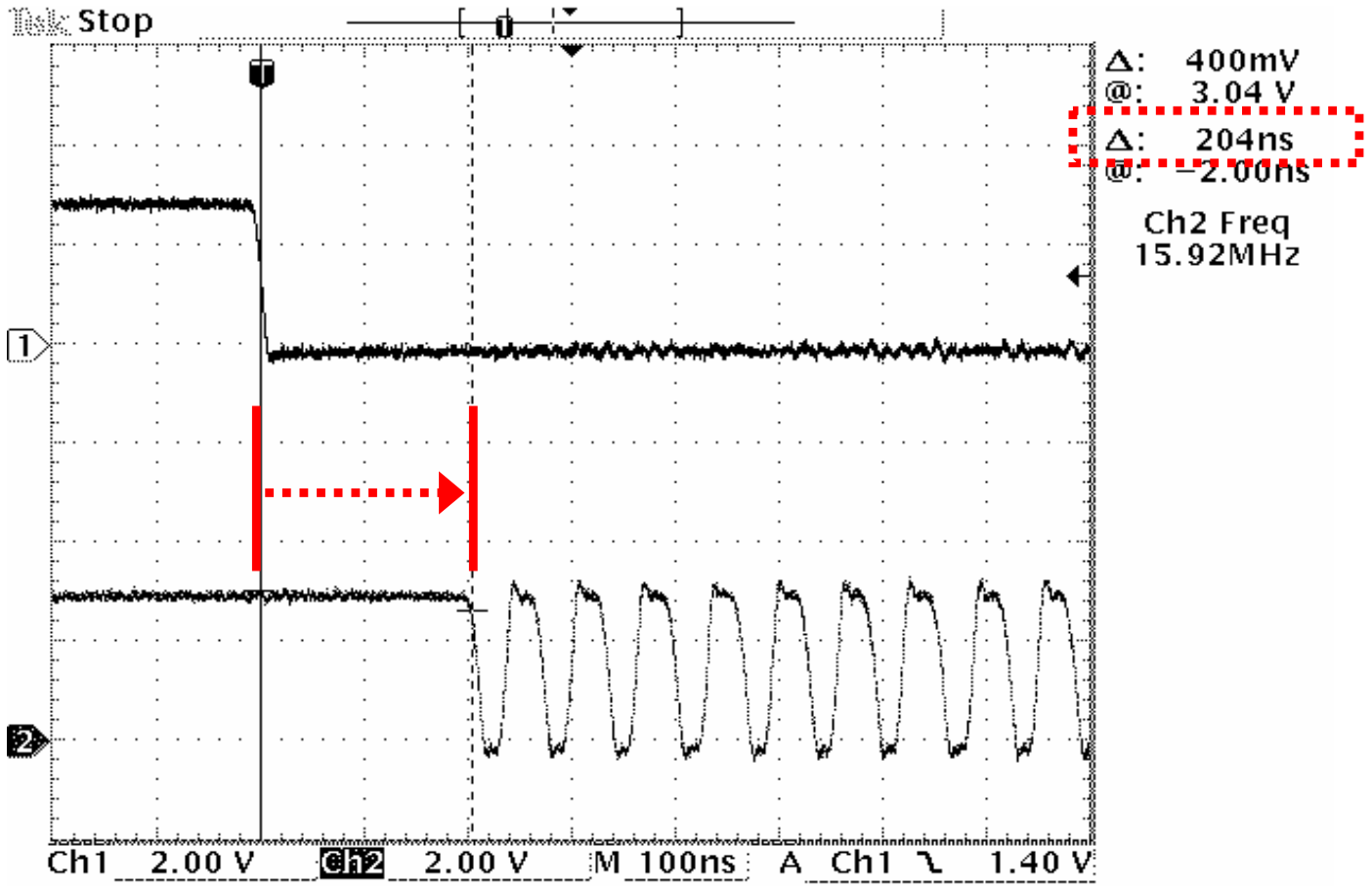
```
void main(void)
{
  BCSTL3 |= LFXT1S_2;                 // LFXT1 = VLO
  WDTCTL = WDT_ADLY_1000;
  IE1 |= WDTIE;
// Configure P1/P2
  for (;;){
    _BIS_SR(LPM3_bits + GIE);  // Enter LPM3
    P1OUT ^= 0x01;
  }
}
#pragma vector=WDT_VECTOR
__interrupt void watchdog_timer(void){
 _BIC_SR_IRQ(LPM3_bits);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

- **What is the measured current consumption?**

F2xx Expanded Operating Range



F2xx 16MIPS On-Demand



Interrupt

Oscillator

F2xx No XTAL Required – DCO+

PARAMETER	T_A	VCC	MIN	TYP	MAX	UNIT
1 MHz tolerance over V_{CC}	25°C	1.8 V – 3.6 V	−2.5	±2	+2.5	%
8 MHz tolerance over V_{CC}	25°C	1.8 V – 3.6 V	−2.5	±2	+2.5	%

PARAMETER	T_A	VCC	MIN	TYP	MAX	UNIT
1 MHz tolerance overall	−40°C – +85°C	1.8 V – 3.6 V	−5	±2	+5	%
8 MHz tolerance overall	−40°C – +85°C	1.8 V – 3.6 V	−5	±2	+5	%

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

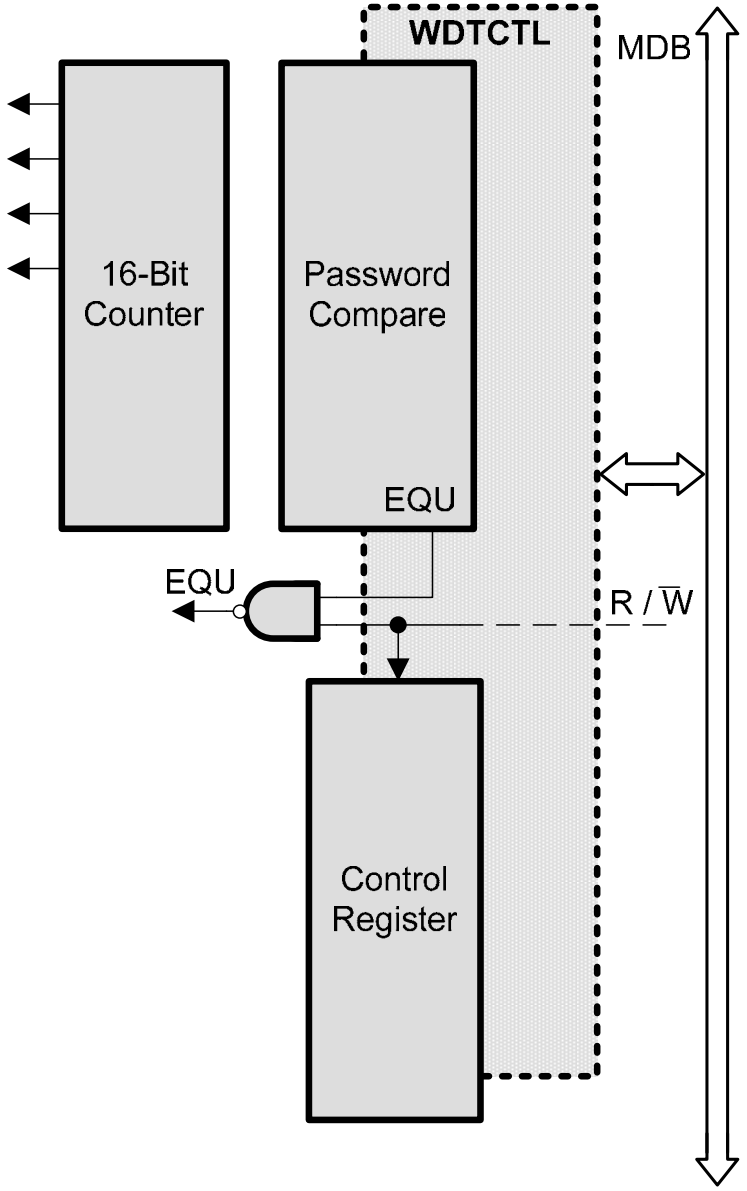
F2xx Loading DCO Calibration Data

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;
```

F2xx More Robust Watchdog+

- **Watchdog or interval timer**
- **Selectable intervals**
- **Password protected**
- Blank device > LPM4
- Invalid address reset
- Failsafe/protected clock



Demo: Watchdog+ Protected Clock

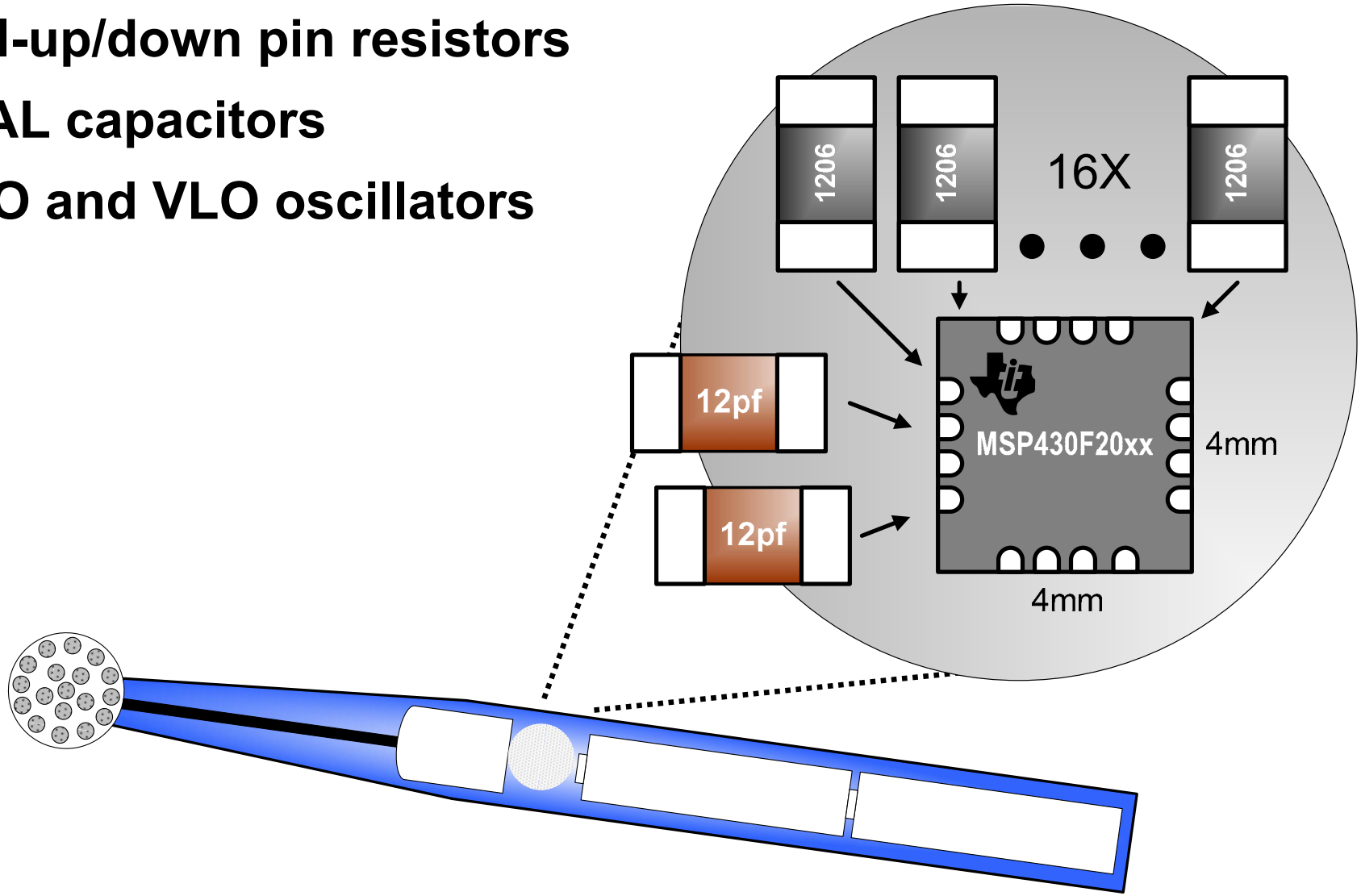
```
void main(void)
{
  P1DIR |= 0x01;
  P1OUT ^= 0x01;

_BIS_SR(LPM4_bits + GIE);  // Disable all clocks
}
```

- **What happens to the active WDT when S/W disables all clocks?**
  - MSP430x1xx
  - MSP430x2xx

F2xx Every Little Bit Counts

- Pull-up/down pin resistors
- XTAL capacitors
- DCO and VLO oscillators



F2xx Selecting Port Pull-Up/Down

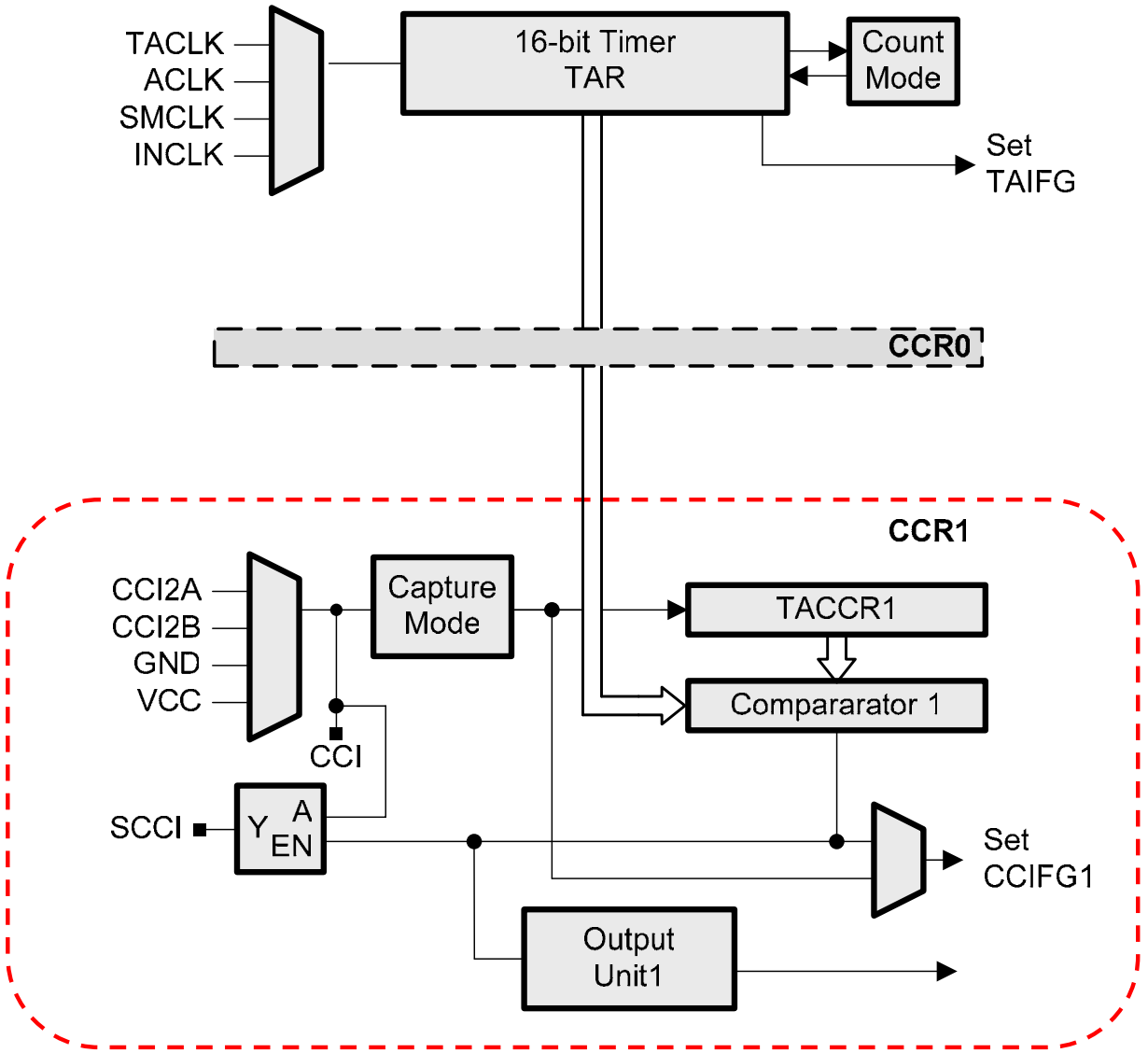
Port P1	Port P1 resistor enable	P1REN	027h
	Port P1 selection	P1SEL	026h
	Port P1 interrupt enable	P1IE	025h
	Port P1 interrupt edge select	P1IES	024h
	Port P1 interrupt flag	P1IFG	023h
	Port P1 direction	P1DIR	022h
	Port P1 output	P1OUT	021h
	Port P1 input	P1IN	020h

- **PxREN enables pull−up/down resistor, corresponding PxOUT bit selects;**
  - Bit = 0: The pin is pulled down
  - Bit = 1: The pin is pulled up

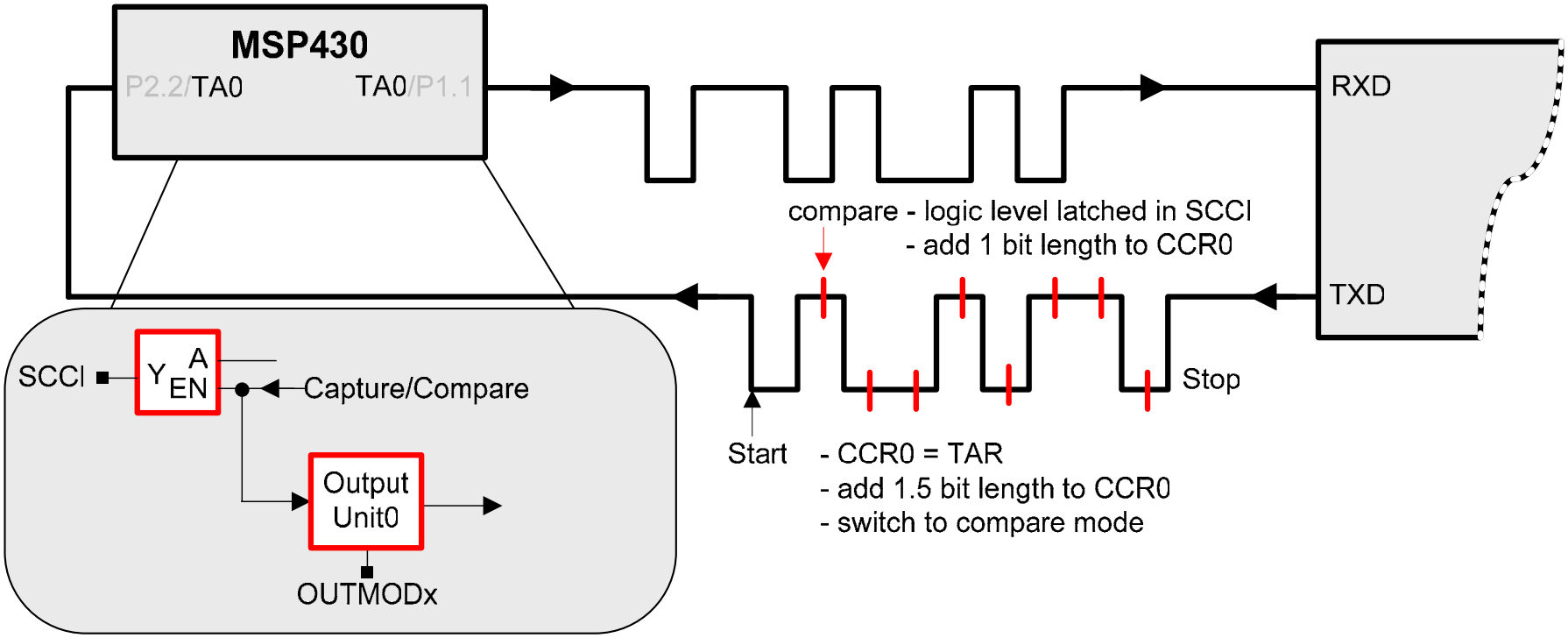
```
P1DIR &= ~0x10;                         // P1.4 input
P1OUT |= 0x10;                          // P1.4 set
P1REN |= 0x10;                          // P1.4 pull-up
```

F20xx Timer_A2

- Asynchronous timer/counter
- Continuous up-down up
- Asynch input latch
- Interrupt vector register for fast decoding
- Only 2 CCRx



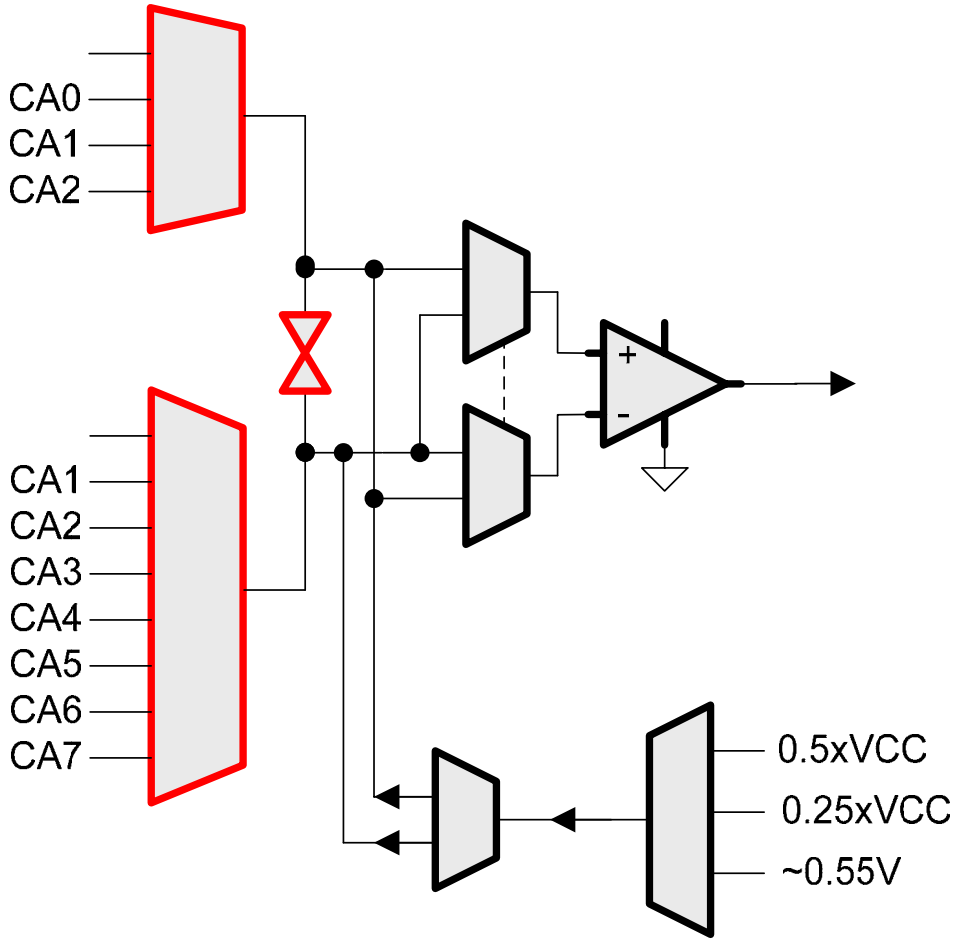
Timer_Ax UART Function



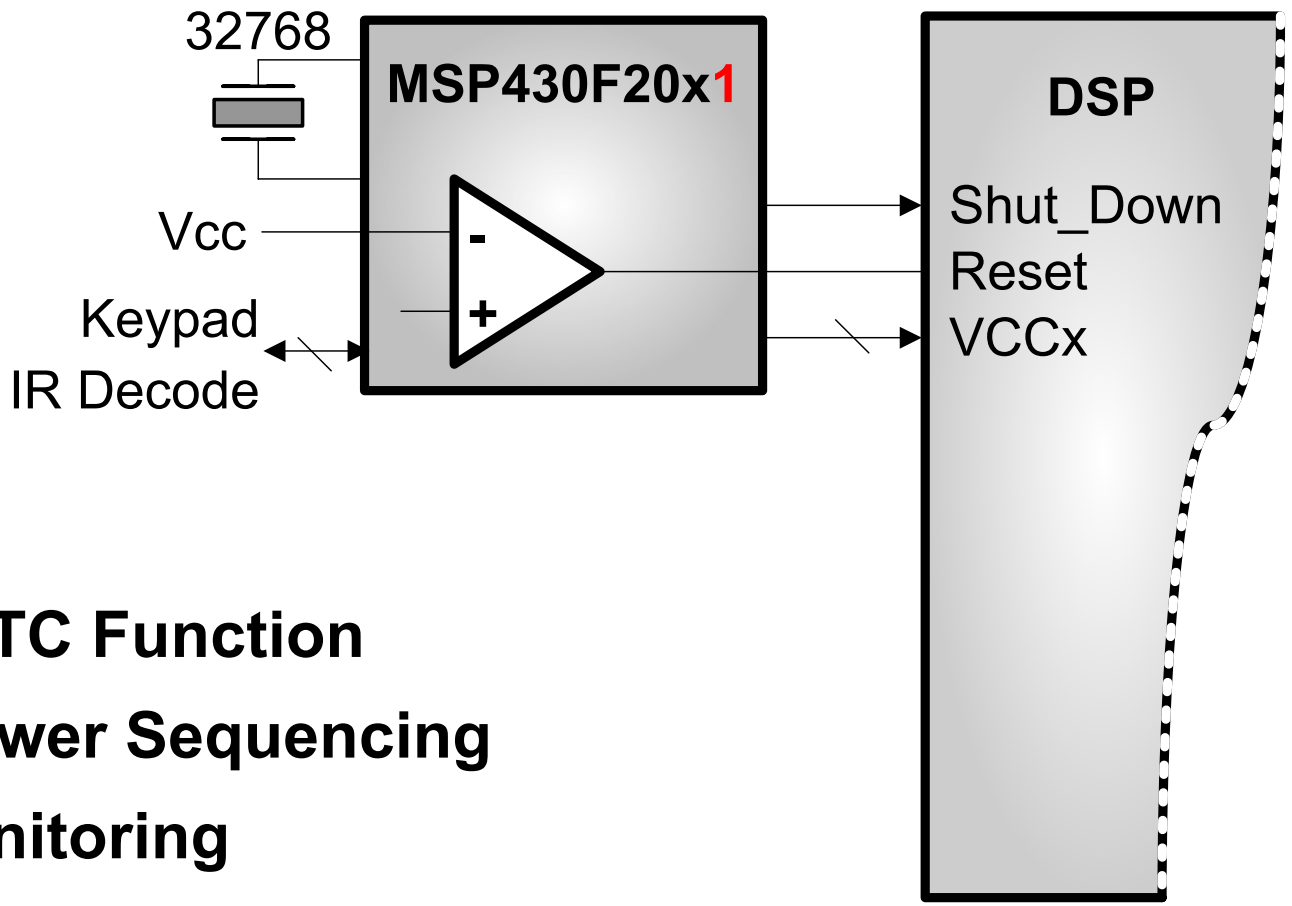
- **100% hardware bit latching and output**
- **Full speed from LPM3 and LPM4**
- **App Note SLAA078**

F20x1 Comparator A+

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

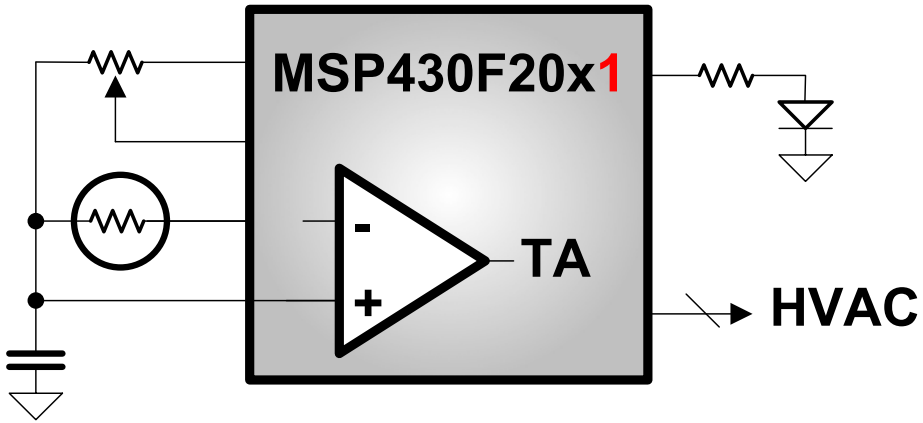


F20x1 Tiny Power Saver



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

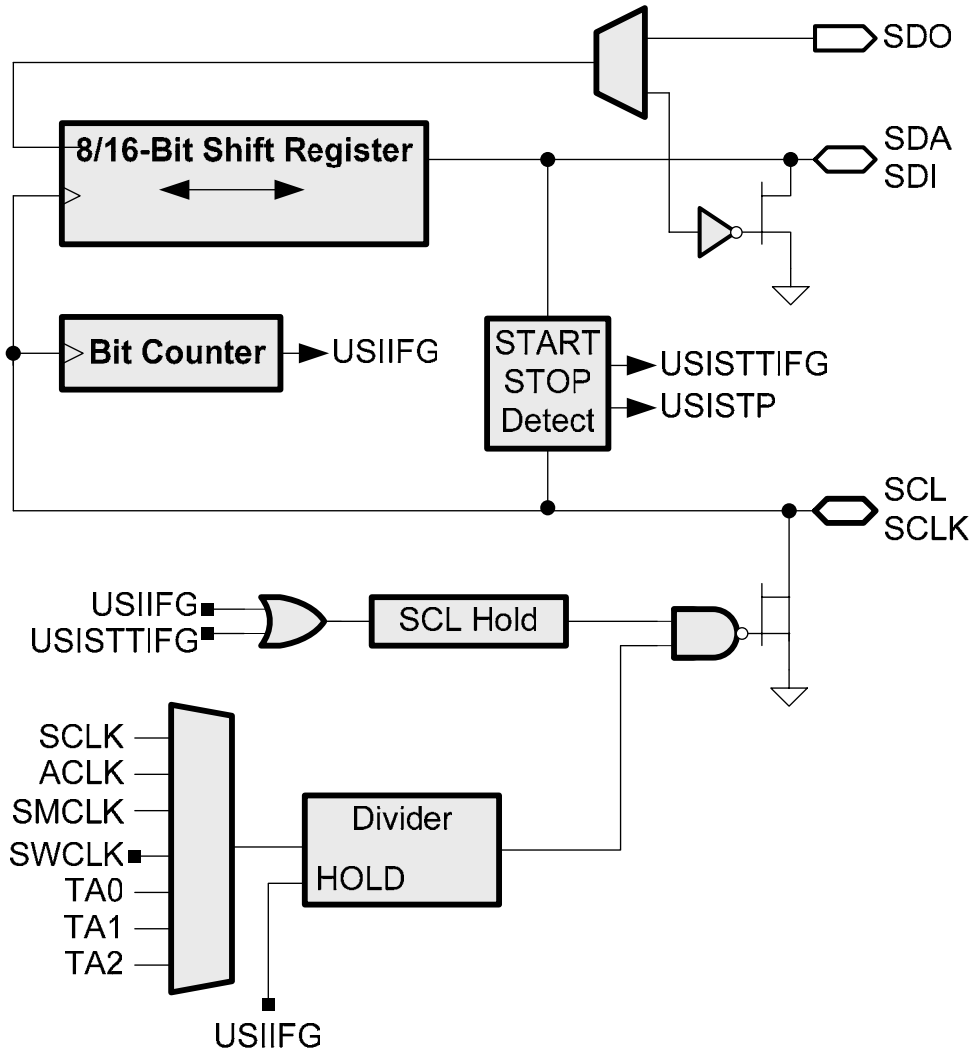
F20x1 Residential Thermostat



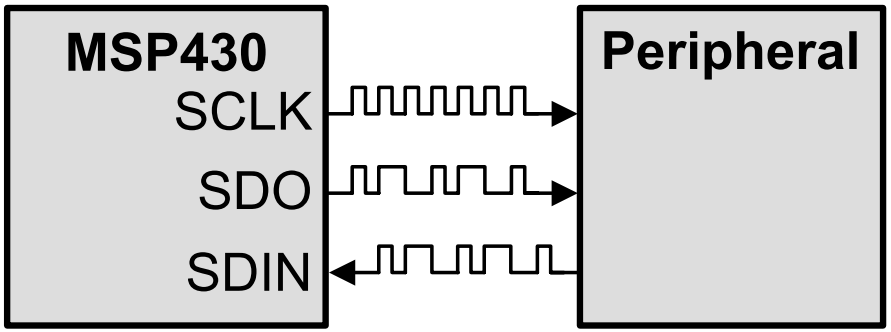
- <1uA total system power
- 10-bit slope ADC
- ± 1C/F
- No XTAL needed
- Very low cost

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**



USI Reduces CPU Load



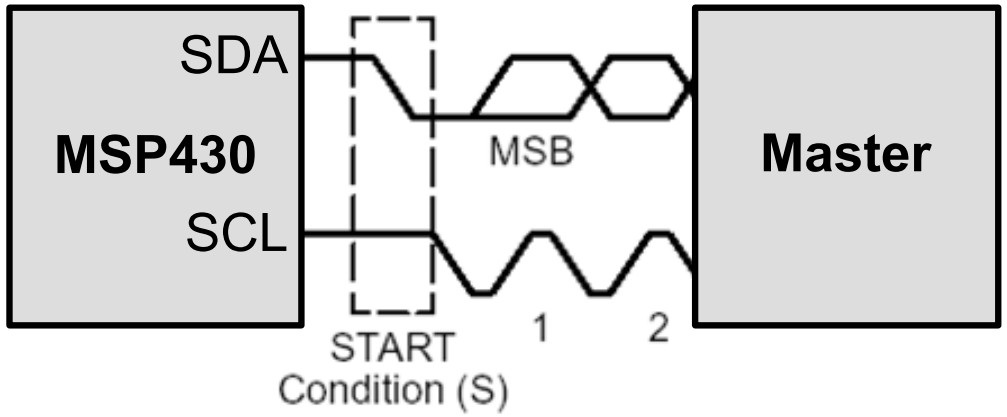

```
//Shift16_inout_Software
SR = DATA;
for (CNT=0x10;CNT>0;CNT--)
{
  P2OUT &= ~SDO;
  if (SR & 0x8000)
   P2OUT |= SDO;
  SR = SR << 1;
  if (P2IN & SDIN)
    SR |= 0x01;
  P2OUT |= SCLK;
  P2OUT &= ~SCLK;
}
```

425 Cycles

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

10 Cycles

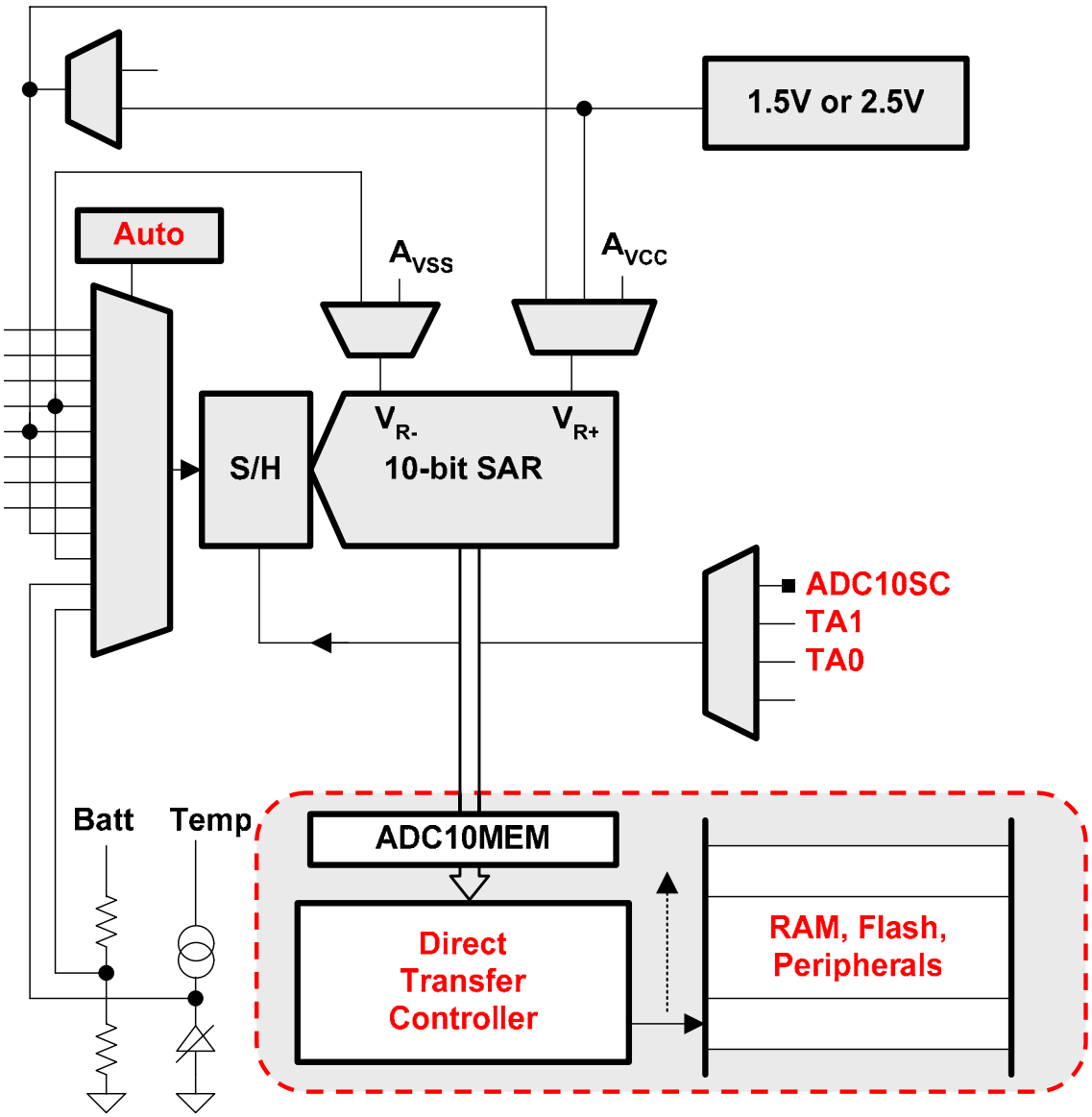
F20xx USI Enables Practical I2C



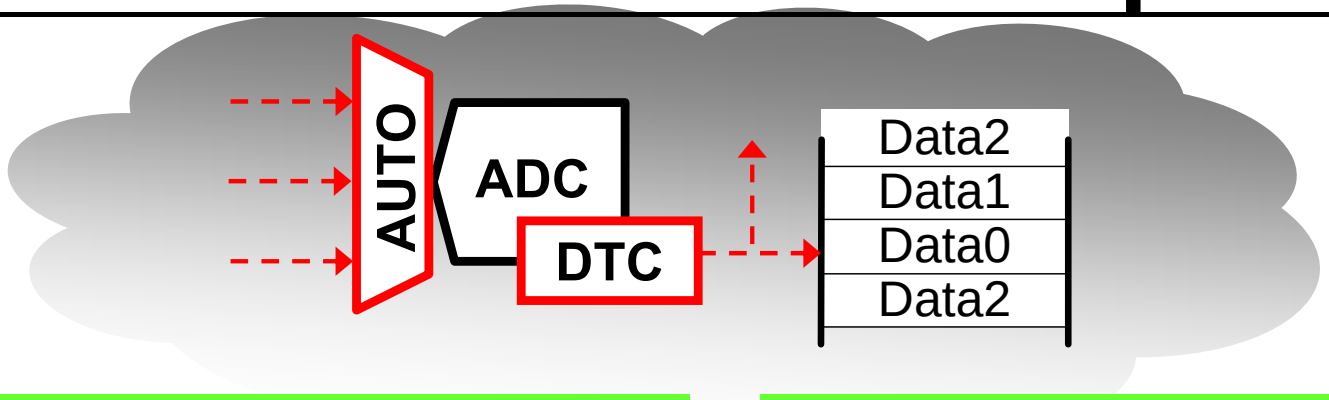
- I2C Slave has as little as 4us from clock edge to data
- Software only solution allows little else
- USI hardware enables practical and compliant I2C

F20x2 ADC10

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



Why Is Autoscan + DTC Important?



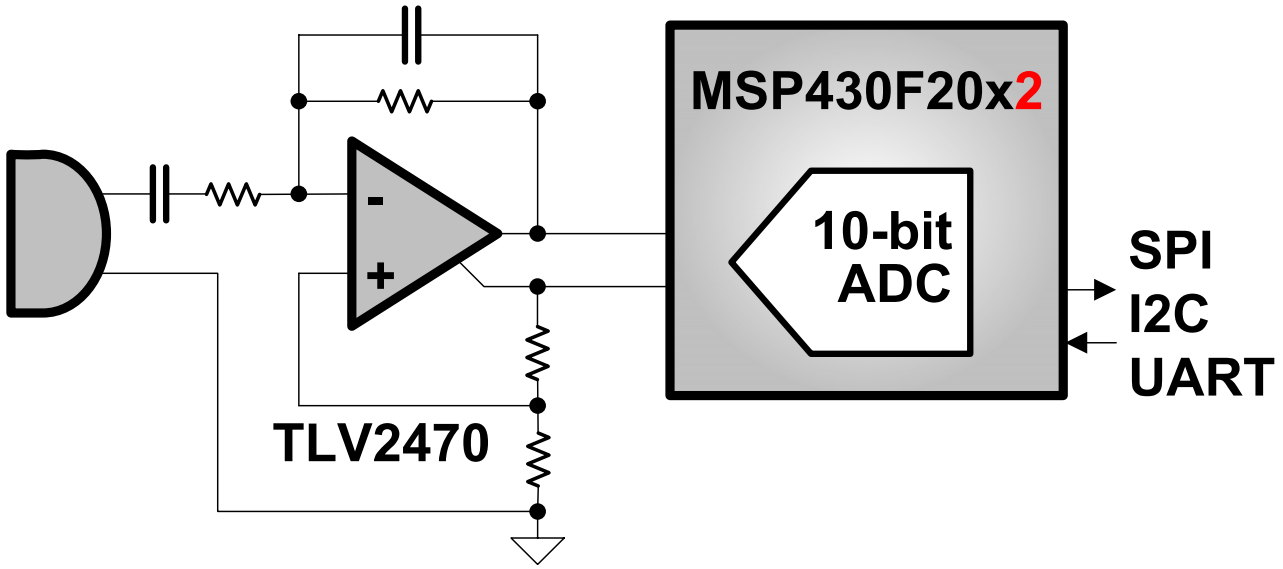

```
// Software
Res[pRes++] = ADC10MEM;
ADC10CTL0 &= ~ENC;
if (pRes < NR_CONV)
 {
 CurrINCH++;
 if (CurrINCH == 3)
   CurrINCH = 0;
 ADC10CTL1 &= ~INCH_3;
 ADC10CTL1 |= CurrINCH;
 ADC10CTL0 |= ENC+ADC10SC;
 }
```

```
// Autoscan + DTC
 _BIS_SR(CPUOFF);
```

70 cycles/Sample

Fully Automatic

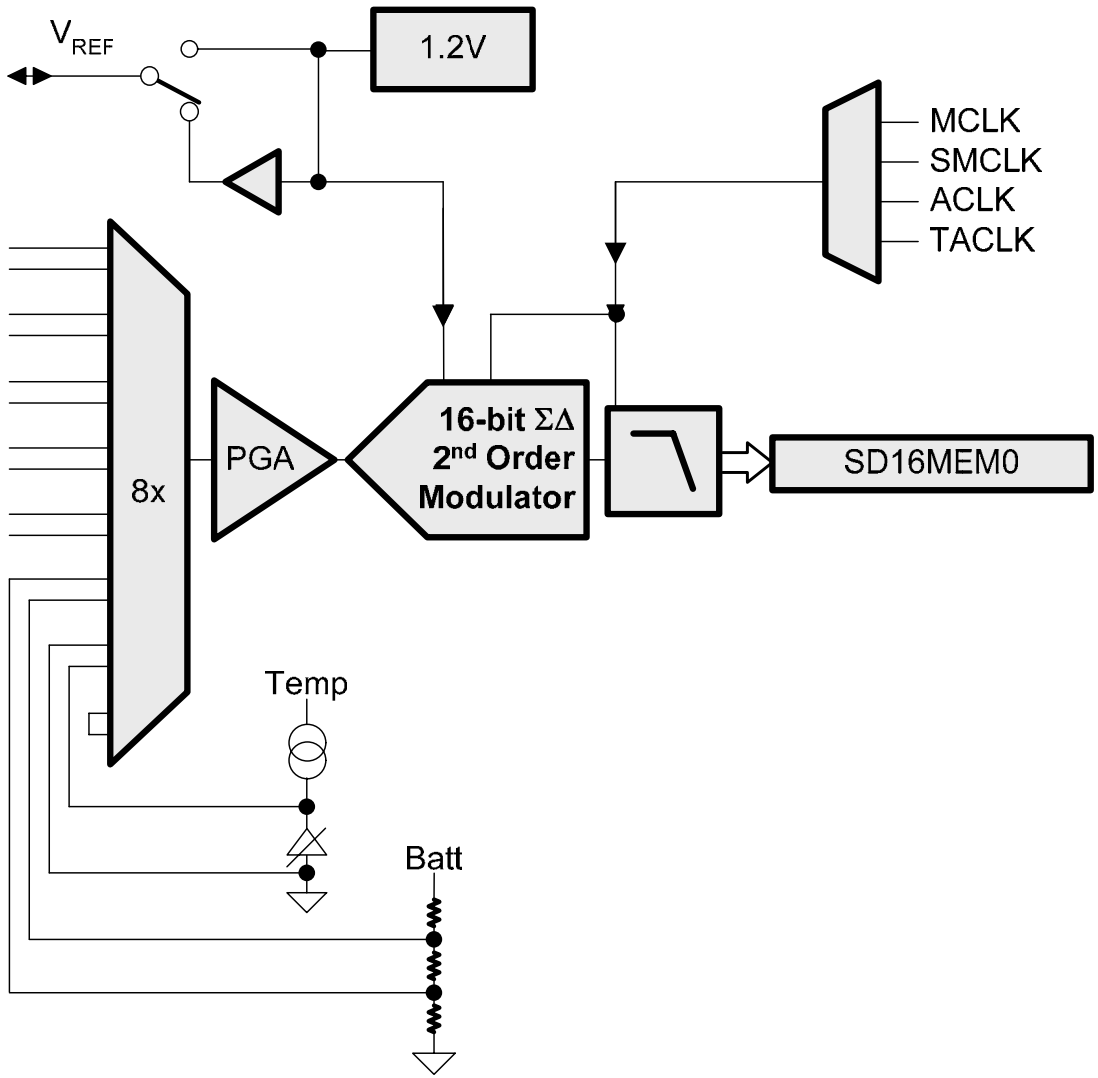
F20x2 Glass Break Detector



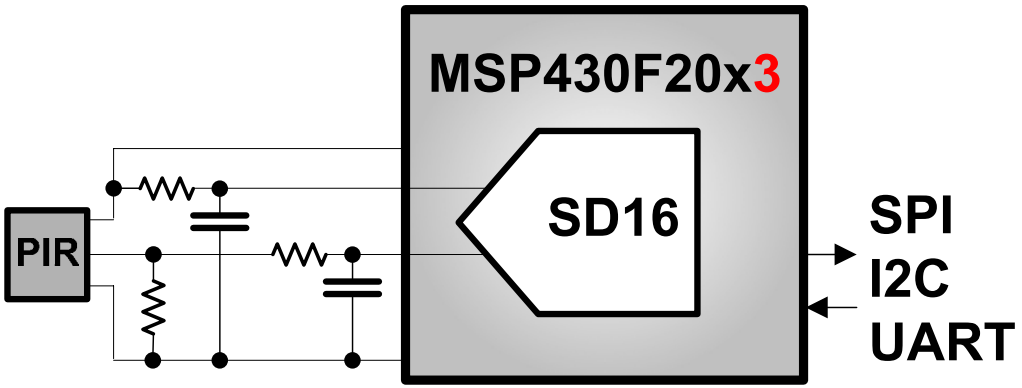
- Extremely low power
- Real-time signal analysis
- Fully programmable

F20x3 SD16_A

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



Demo: 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

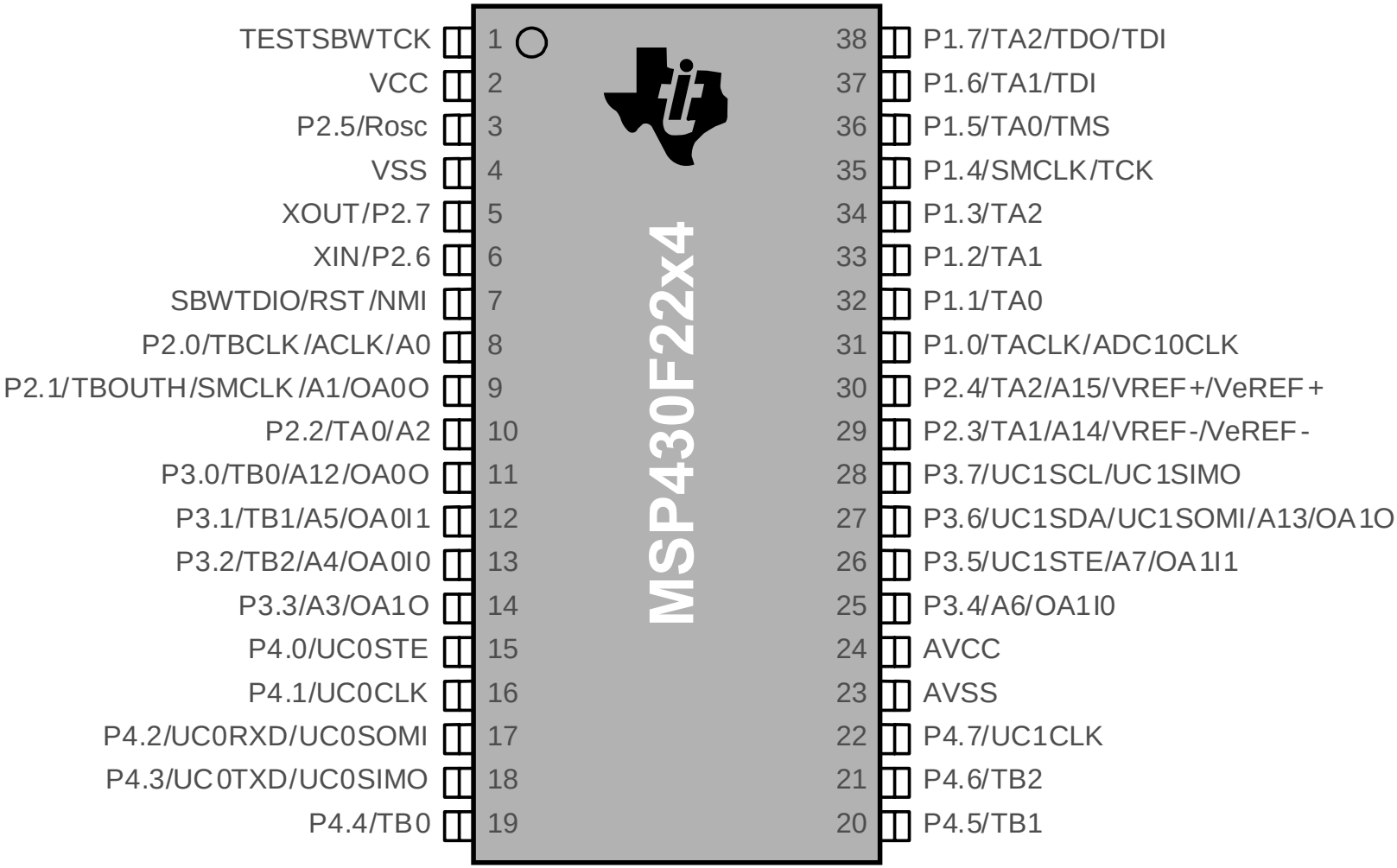
  VLO – no XTAL required

- **Lower cost**

Planned MSP430F2xx Rollout

Device	Pins	Max Flash	Max RAM	Timer	Features
MSP430F20x1	**14**	**2KB**	**128B**	**A**	**Comp_A+**
MSP430F20x2	**14**	**2KB**	**128B**	**A**	**ADC10,USI**
MSP430F20x3	**14**	**2KB**	**128B**	**A**	**SD16_A,USI**
MSP430F21x1	**20**	**8KB**	**256B**	**A**	**Comp_A+**
MSP430F22x4	*38*	*32KB*	*1kB*	*A,B*	*ADC10,USCI,(2)OPA*
MSP430F23x	*64*	*32KB*	*1KB*	*A,B*	*ADC12,USCI*
MSP430F24x	*64*	*60KB*	*2KB*	*A,B*	*ADC12,MPY,USCI,USART*
MSP430F26xx	*80*	*120KB*	*8KB*	*A,B,C*	*ADC12,DAC12,DMA,MPY, USCI,USART*

What's Next With the 2xx



F20xx: 1000 And 1 Uses

- Tiny: as small as 4x4mm
- Full- feature 16MHz MSP430 core with usable RAM
- Reuse existing MSP430 libraries
- 14-pin & more functionality at same or lower price compared to competitive 8-pin devices
- Real emulation capability
- Comparator, 10-bit 200ksps or 16-bit sigma-delta ADC
- Robust BOR, failsafe clock & enhanced watchdog all at zero power
- 500nA standby mode!