

# Low Power Case Study #2: Longer Battery Life



**Objective:** Compare the battery life between PIC24F and MSP430 for a portable measurement system example with low duty cycle.

## Design Requirements

- Portable measurement system example
- Application runs only 0.1% of the time, sleeps 99.9% of the time
- CR2032 coin cell battery with 225 mAh capacity and ~1% battery self discharge per year
- Requires BOR and WDT for safe battery operation

## Comparing Sleep Modes

PIC24 has Sleep mode and Deep Sleep mode. Sleep mode is best when applications require RAM retention and super fast wake-up times. Deep Sleep mode is lower power and works best for applications that sleep most of the time, need accurate timekeeping, and operate in environments with extreme temperatures. Both BOR and WDT are available in this mode.

MSP430 has LPM3, LPM4 and LPM5. The lowest power mode with BOR and WDT is LPM3. This mode allows the clock to be running for the timer.

The chart below shows the various Sleep modes for the PIC® MCU and MSP430 and how they are different. For this case study, we need to compare the PIC XLP MCU with Deep Sleep to the MSP430 LPM3 since both BOR and WDT are needed.

Operating Mode	Active Clocks	Active Peripherals	Wake-up Sources	Typical Current	Typical Usage
Deep Sleep <sup>(1)</sup>	• Timer1/SOSC • INTRC/LPRC	• RTCC • DSWDT • DSBOR • INT0	• RTCC • DSWDT • DSBOR • INT0 • MCLR	< 50 nA	• Long life, battery-based applications • Applications with increased Sleep times <sup>(3)</sup>
Sleep	• Timer1/SOSC • INTRC/LPRC • A/D RC	• RTCC • WDT • ADC • Comparators • CVREF • INTx • Timer1 • HLVD • BOR	All device wake-up sources (see device data sheet)	50-100 nA	Most low-power applications
Idle	• Timer1/SOSC • INTRC/LPRC • A/D RC	All Peripherals	All device wake-up sources (see device data sheet)	25% of Run Current	Any time the device is waiting for an event to occur (e.g., external or peripheral interrupts)
Doze <sup>(2)</sup>	All Clocks	All Peripherals	Software or interrupt wake-up	35-75% of Run Current	Applications with high-speed peripherals, but requiring low CPU use
Run	All Clocks	All Peripherals	N/A	See device data sheet	Normal operation

**Note 1:** Available on PIC18 and PIC24 devices with nanoWatt XLP Technology only.

**Note 2:** Available on PIC24, dsPIC and PIC32 devices only.

**Note 3:** Refer to "Deciding Between Sleep and Deep Sleep" for guidance on when to use Sleep or Deep Sleep modes.

	Sleep Mode	BOR	WDT	RAM	Timer/ RTC	I/O State Maintained	Wake-up Time
MSP430	LPM3	Yes	Yes	Yes	Yes	Yes	Fast
	LPM4	Yes	No	Yes	No	Yes	Fast
	LPM5	No	No	No	No	No	Extended
PIC MCU w/XLP	Sleep	Yes	Yes	Yes	Yes	Yes	Fast
	Deep Sleep	Yes	Yes	No	Yes	Yes	Extended

# Low Power Case Study #2: Longer Battery Life (continued)



## Battery Life Comparison

Details of Battery Life Calculations:

- Average Current = Standby \* 99.9% + Active \* 0.1%
- Battery Life in Years = 225 mAh / Average Power / 24 / 365
- All numbers are at 3V, 25°C, typical
- Active numbers are at 1 MHz
- Sleep numbers include BOR and WDT
- 3.3V datasheet numbers are multiplied by 0.8 to get 3V estimates
- Annual battery discharge of ~1% (or 250 nA) is assumed

	Sleep Current with BOR & WDT (μA)			Active Current (μA)			Avg. Current (μA)	With Yearly Discharge (μA)		Battery Life (Years)
MSP43020XX	0.600	99.90%	+	300	0.10%	=	0.899	1.149	→	22.3
MSP430F26XX	0.600	99.90%	+	515	0.10%	=	1.114	1.364	→	18.8
PIC24F16KA Sleep	0.856	99.90%	+	292	0.10%	=	1.147	1.397	→	18.4
PIC24F16KA Deep Sleep	0.476	99.89%	+	292	0.11%	=	0.797	1.047	→	24.5

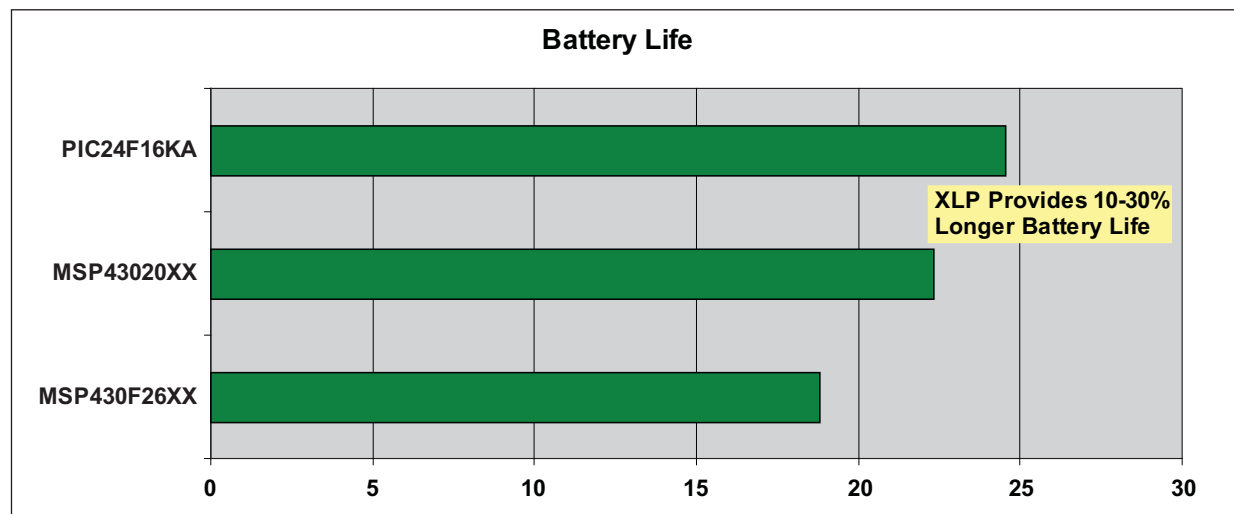
**Note:** PIC24F16KA Sleep numbers include RAM retention.

For Deep Sleep, time spent in "Active" is adjusted to 0.11% to account for application state recovery.

## Conclusions

- ✓ XLP provides greater than 20 years battery life
- ✓ PIC24 in Deep Sleep provides at least 10% longer battery life compared to MSP430
  - Over 18 years battery life with RAM retention
  - Over 24 years battery life with lowest power mode

**PIC® MCU with XLP = Battery Friendly**



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