Low Power Operation

Objective:

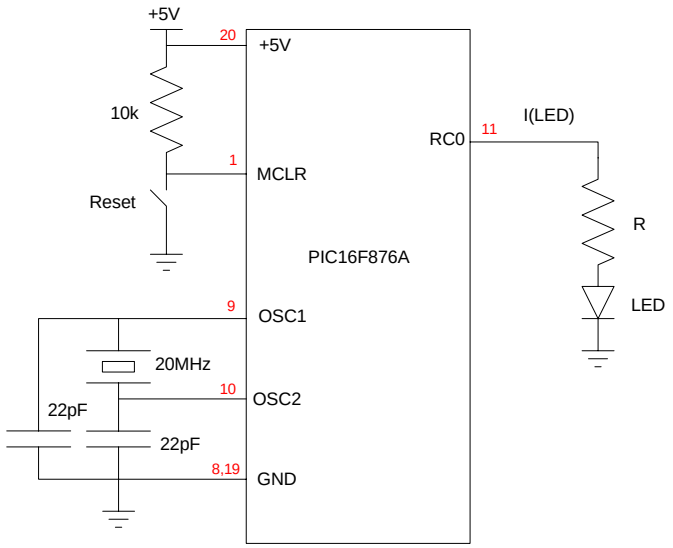
Reduce the power consumption of a PIC-based system.

Why?

Battery operated devices last longer if you minimize the current consumption.

Methods:

Suppose you want to build a device which turns on an LED to indicate it's working. A simple circuit with a PIC would be as follows:



Lets assume

- The PIC runs off of four AA batteries, which have a life of 1000 mAh
- The LED should output 1000 mcd.
- The PIC runs at 20MHz (and from Lab #1 uses 5mA)
- The LED draws 20mA (1000mcd @ 20mA - size R to give you this)

This results in:

- The total current consumption for this device is 25mA
- The battery's life is 1000 mAh / 25mA = 40 hours.

You'll need to replace the batteries every two days.

To extend the battery life, some trick you can play:

Use an ultra-bright LED that outputs 130,000 mcd @ 20mA. This lets you reduce the current to

- LED : 153.8uA
- PIC: 5mA
- Total = 5.138mA = 194 hour battery life.

Blink the LED. Turn it on for 10ms every second. The LED is only on 1% of the time, so the effective current consumed is 1% of the previous value:

- LED : 1.538uA
- PIC: 5mA
- Total = 5.00138mA = 199.9 hour battery life.

Reduce the clock on the PIC from 20MHz to 1MHz. From lab #1, this should reduce the current consumed by the PIC down to 0.6mA

- LED : 1.538uA
- PIC: 600uA
- Total = 601uA = 1663 hour battery life.

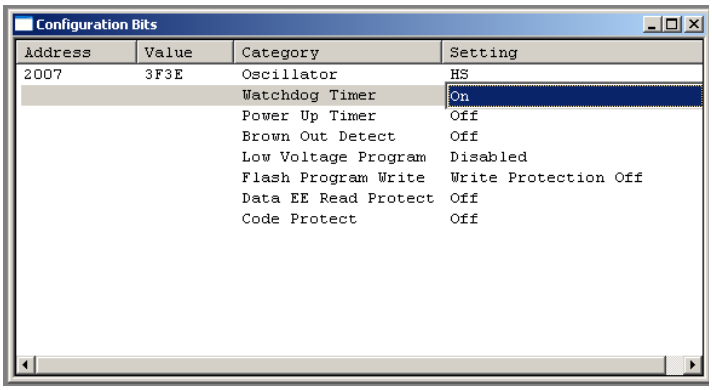
Reduce the operating voltage of the PIC from 5V down to 3V. From lab #1, this reduces the current consumed to 0.4mA.

- LED : 1.538uA
- PIC: 400uA
- Total = 401uA = 2493 hour battery life.

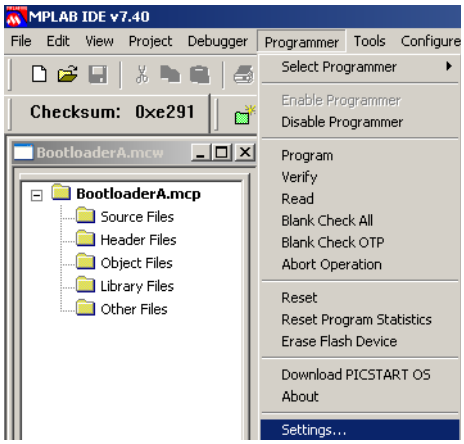
Place the PIC in sleep mode. Sleep mode is a low-power state for the PIC. All I/O pins go to high impedance and the current consumption drops to 0.6uA (!). You can come out of sleep mode with an interrupt (RB0 goes high when INT interrupts are turned on, etc.) If you turn on the watchdog timer when programming the PIC with PICSTART PLUS, you can also get the PIC to wake up every 3 seconds.

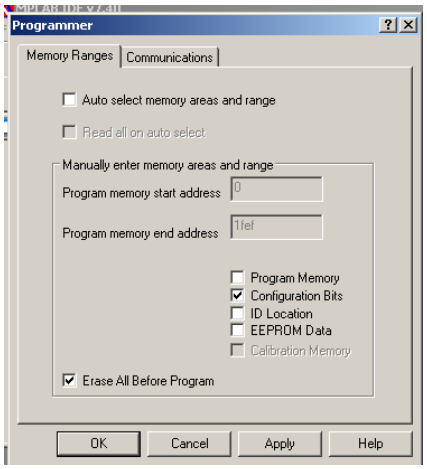
Step 1: Turn on the Watchdog timer on your PIC. Find a working copy of PICSTART-Plus. Connect it to your PC and start up MPLAB. Select Programmer - PICSTART-Plus.

Select the configuration bits and turn on the watchdog timer.



Select that you only want to program the configuration bits:





Click 'Program - Program'.

The Watchdog timer should be turned on. This causes the watchdog timer to kick in every 3 seconds or so.

Step 2: In your main loop, add the following code:

```
#asm("sleep");
```

This adds the assembler command 'sleep' to your code. When your program hits this line of code, it goes to sleep for 3 seconds (about) and current drops to 6uA. When it wakes up (about 3 seconds later), it continues the program at the next instruction. For longer sleep cycles, place several sleep commands in series.

Now the total power consumption is

- LED : 1.538uA
- PIC: 400uA (for 10ms)
- PIC: 6uA (for 2.99 seconds)
- Total = 7.5uA (average) = 133,014 hour battery life = 15 years.

Actually, the shelf life of a battery is only about 10 years. This can be modeled as the battery having a leakage current of 11u - in addition to your demand. Adding this leakage current gives a better estimate of battery life:

- LED : 1.538uA
- PIC: 400uA (for 10ms)
- PIC: 6uA (for 2.99 seconds)
- Battery: 11uA (leakage current)
- Total = 18.5uA (average) = 54,054 hour battery life. (6.18 years)

With these tricks, you've taken a device which drains its batteries every two days and made it one where the batteries should last 6 years.