Lab Assignment #1

Overview

Be sure to read the entire assignment before beginning so that you will know what to collect for the report.

Provided below is a simple program for the LPC1769 LPCXpresso board that blinks the built-in LED. This assignment will help familiarize you with the lab equipment and MCUXpresso software by having you compile and run several versions of this program, while collecting timing data with the oscilloscope, to ultimately achieve an LED blinking at 2 Hz and 30% duty cycle.

```
#define FIO0DIR (*(volatile unsigned int *)0x2009c000)
#define FIO0PIN (*(volatile unsigned int *)0x2009c014)

// Waste time by counting from 0 to ticks
void wait_ticks(int ticks)
{
    volatile int count;
    for (count=0; count<ticks; count++) {
        // do nothing
    }
}

int main(void) {
    FIO0DIR |= (1<<22); // configure port 0 bit 22 as output
    while(1) {
        FIO0PIN |= (1<<22); // make port 0 bit 22 go high
        wait_ticks(30);
        FIO0PIN &= ~(1<<22); // make port 0 bit 22 go low
        wait_ticks(30);
    }
    return 0 ;
}
```

Procedure

Start a new C project in MCUXpresso for the LPC1769 and replace the default main program with the program above. Build the project, start a debug session, and click the Resume button in the toolbar so that the program runs at full speed.

1. Assuming you made no errors while entering the program, the LED should be blinking, but is blinking far too fast for a human to notice. Connect an oscilloscope probe to port 0 bit 22 (this is the microcontroller signal controlling the built-in LED) and adjust the oscilloscope so that you can see a stable square wave. Use the oscilloscope cursor controls to measure the high-time (positive pulse width) of the square wave.
2. The oscilloscope can automatically perform many measurements and do so with more accuracy than available with the cursor controls. Turn off the cursor controls and have the oscilloscope automatically measure the high-time in this and all following steps.

3. Click the Terminate button in the toolbar to terminate the debug session. Edit the program so that the wait_ticks() function is passed a parameter of 3000 instead of 30. Rebuild the program and start it running in a new debug session
4. Note the new high-time measurement. The timing of wait_ticks() can be modeled as the equation of a line in slope-intercept form, $y = mx+b$, where y is in units of time and x is the parameter passed to the wait_ticks() function. Use your collected measurements to compute m and b.
5. Terminate the debug session. Use your equation from step 4 to edit the parameters to the wait_ticks() function so that the high-time will be 150 ms and the low-time will be 350 ms. Rebuild the program and start it running in a new debug session.
6. Measure the high-time and low-time and verify that they are within 0.5% of their targets. You should be able to see that the LED is blinking quickly (2 Hz). If the high-time or low-time is off by more than 0.5%, revise your equation and go back to step 6 again. (You can use linear regression to find the best fit for a line to more than 2 data points; use an X-Y graph of the data in Excel, select insert linear trendline and show equation.)
7. Using what you have learned, write a function named wait_ms that takes an integer parameter specifying the number of milliseconds to wait, and waits that amount of time. Rewrite the main function to call your new wait_ms function instead of wait_ticks. Rebuild the program and start it running in a new debug session. Verify that the timing is still correct on the oscilloscope.

Hints

Look at the last page of the LPCXpresso board's schematic to see the pin-out for the board as a whole to find port 0 bit 22 as well as a ground connection for the oscilloscope probe.

The easiest way to obtain a snapshot from the oscilloscope is to insert a USB flash device into the front of the scope and then press the button with the printer icon. This will save a graphic file onto the flash device that you can then either print or embed into your report.

Note that the LPCXpresso boards default to a nominal, but not necessarily exact, clock rate of 4 MHz. Thus the final values needed to accurately achieve the specified timing may not be the same for everyone.

Since the point of the assignment is really just to become familiar with how to use our fundamental lab tools (the oscilloscope and the MCUXpresso software) and it should not take very long to complete the in-lab work, every member of the team should practice using both the oscilloscope and the MCUXpresso software, even if that might mean some steps are repeated redundantly. Time spent learning now will cut down on time spent later in the more difficult assignments.

What to demo

Show that the LED is blinking at 2 Hz with a 150 ms high time and 350 ms low time on the oscilloscope, all with less than 0.5% relative error.

What to put in the lab report

1. The objectives of the lab assignment (Do not simply copy the overview section from the assignment; instead, describe this in your own words)
2. The design of your solution
   a) Show the data that you collected
   b) Derive the equation that relates the wait_ticks() function parameter to the high time

c) Show how this led you to the proper constants for the parameters to the two calls of the wait_ticks() function in step 5
d) Derive the new equation needed by the wait_ms function in step 7

3. Details of your final solution (the final version of the software source code, and if this were an assignment involving hardware design, the hardware schematic)
4. Oscilloscope snapshots of port 0 bit 22 to document your measurements after steps 1, 2, 3, 5, 6 (after step 6 is only needed if you had to revise your computations), and step 7. This should be at an appropriate time scale with the waveform's timing measurements visible (either with the oscilloscope's automatic measurement tools or manually with the cursor controls, as appropriate). Using your phone to take a picture of the oscilloscope screen leads to an unprofessional result and will receive reduced credit.
5. Describe the individual contributions of each team member in this assignment and note their major (Electrical Engineering, Computer Engineering, or other)
6. Any additional comments (optional). Point out any incomplete objectives, extra features, etc

Due date

Friday January 26