OPTI 380B Intermediate Optics Laboratory

Lab 9

Microcontroller / Data Acquisition Project I

Objectives: This lab is an introduction to the world of microcontrollers. In particular, we will explore the world of digital input-output "I/O" using a BASIC Stamp microcontroller. This tiny computer, made by Parallax, Inc., has become world-famous for its low-cost ability to control hardware in large variety of applications.

In particular, we will:

- Learn how to program the Stamp, using its built-in "PBASIC" language.
- Write a program to detect logic changes in one of the input pins, to measure switch bounce.
- Write a program to flash an LED at a controlled rate and duty cycle.
- Write a program to control the logic level of the output pins. Coupled with a simple LED circuit, this program will input a decimal number and visually display its binary equivalent.
- Write a program to control the logic level of the output pins. Coupled with the 7-segment LED circuit used last week, this program will input a decimal number and visually display its value on the LED display equivalent.

Reading Assignment:

Selected readings (below) from the "BASIC Stamp Syntax and Reference Manual": (NOTE: The model of board that we have is the BS2px. In the manual, ignore information relating to the older BS1 model, but pay attention to the information relating to any of the BS2 models. These sections are labeled "All 2" or "2px" in the little "chip" icons. Ignore the sections with the chip icon labeled "1".)

OPTI 380b WEB SITE

(NOTE: page numbers refer to pages in the manual, not the pdf file)
- pages 7, 9, 11, 23, 25, 29-34, 35-39, 51-52, 81-91, 103
- Specific commands: COUNT, DEBUG, DEBUGIN, END HIGH, LOW, PAUSE

PRELAB QUESTIONS

(PL1) Explain what the circuit (on page 215) does when the program (on page 216) is run.

(PL2) Re-write this program to produce a pulse of light that has a frequency of 1 Hz, with a duty cycle (on-time) of 20%.

Three points before we begin:

► Do NOT unplug the BS2px24 CPU chip from its socket, for any reason.

► Always turn the power to the board OFF (slide switch set to "0") when wiring up a circuit on the breadboard. Make any connections to the power supply ("V_{dd}" +5VDC), ground ("V_{ss}") and the I/O pins ("P0-P15") BEFORE turning on the power (slide switch set to "1").

► Do NOT connect an "output" pin directly to ground, or +5V. This will, most likely, destroy the CPU.

THE LABORATORY EXERCISE

A. DIGITAL INPUT "I/O" – SWITCH BOUNCE

- Wire up the "active-low" switch circuit on page 139. Connect to I/O Pin 0.
- Load the program "Switch Bounce.txt" (found on our webpage) into the Stamp Editor.
- Modify the program to run for 2 seconds, instead of 1 second.
- Run the program and test 1 (and more) switch closures.

- **[1]** What do you conclude about switch bounce?

B. DIGITAL OUTPUT ("I/O") – LED FLASHER

- Wire up the circuit on page 215.
- Load the program "LED Blinker.txt" (found on our webpage) into the Stamp Editor.
- Run the program.

- **[2]** What is the frequency of the flash?
- **[3]** What is the duty cycle?
- **[4]** Can you see the flash of light?

- Modify the program to match what your answer for Pre-Lab question (PL2).
- **[5]** Can you see the flash of light?

- Vary the duty cycle until you can just (barely) see the flash of light.
- **[6]** What is the duty cycle at your threshold of seeing the flash?

C. DIGITAL OUTPUT – BINARY NUMBER

- Load the program "Dec to Bin.txt" (found on our webpage) into the Stamp Editor.

- Wire up LED's with series current-limiting resistors to pins P0-P7. The circuit will essentially be what you just used for the LED flasher, replicated at each of the 8 pins P0-P7.

NOTE: Use a 1kohm resistor in place of the 470Ω resistor to limit the current to ≤5mA. According to page 14 of our Manual:

"General-purpose I/O pins: each can sink 25mA and source 20mA. However, the total of all pins should not exceed 50mA (sink) and 40mA (source) if using the internal 5-volt regulator."

- **[7]** If you set an output pin HIGH, is the pin sinking or sourcing current? If you input the decimal number 255, what is the total current that will flow? Will you burn up the CPU if you input 255?

- Run the program. Debug your program until it works properly!!

- **[8]** For the following 5 decimal numbers, what is the pattern of bits that you observe as the binary equivalent?

(HB)……..(LB)

0 = _ _ _ _ _ _ _ _

6 = _ _ _ _ _ _ _ _

17 = _ _ _ _ _ _ _ _

141 = _ _ _ _ _ _ _ _

255 = _ _ _ _ _ _ _ _

D. BINARY CLOCK

- Load the program "Binary Clock.txt" (found on our webpage) into the Stamp Editor.
- Use the same circuit that you just used for part C.
- Run the program and explain what you observe!

E. DIGITAL OUTPUT – 7-SEGMENT LED DISPLAY

- Re-load the program "Dec to Bin.txt" into the Stamp Editor.
- Make connections for +5VDC and ground from the Stamp board to the breadboard containing the 74LS47 and 7-segment LED circuit.
- Wire up pins P0-P3 to control the "ABCD" input pins on the 74LS47 7-segment driver chip used in last week's lab.

- Modify the program to count from 0 to 9. Update the display every second.