



University of British Columbia  
Electrical and Computer Engineering  
ELEC291/ELEC292

## Module 3 – SPI and Data Logging using Matlab

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### Introduction

Embedded systems are often designed to perform simple or repetitive tasks while connected to larger computers. Examples of such systems are found in many of today's computers: the mouse, keyboard, memory sticks, hard drive controllers, etc. For this module you will build one of such devices: an embedded digital thermometer using the AT89LP52 microcontroller system. The digital thermometer will serially transmit the temperature to a personal computer using the serial port. You will program the personal computer using either Matlab or Python to receive the temperature and conveniently present it in real time using a strip chart plot.

### References

A51 user manual included with the latest version of CrossIDE.

AT89LP52 user manual and MCP3008 data sheet.

Matlab reference manual. Available online.

### Pre-laboratory

- 1) Find the datasheet of the MCP3008 10-bit 8-channel ADC. Draw in your notebook its pin out and describe the function of each pin.
- 2) Find the datasheet of the LM335 integrated circuit. Draw in your notebook its pin out and explain why and how it is used. What is the temperature range of operation of the LM335?
- 3) What is the difference between a regular plot and a 'strip chart' plot in Matlab/Python?

### Laboratory

- 1) **Testing the Serial Port of the AT89LP52 Microcontroller.** Available in course web page you'll find the program 'hello.asm'. This program prints "Hello, world!" in PuTTY running in a personal computers throughout the serial port of the AT89LP52 microcontroller. Compile, load, and test this program using the AT89LP52 microcontroller and verify that you can receive the message through the serial port of a computer using PUTTY.

PUTTY is a free Telnet/SSH/Serial terminal that can be downloaded from <http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html>. It is possible to launch PUTTY directly from CrossIDE by pressing <Control>+T. Configure PUTTY to

115200 baud, 8 bits, parity none, 1 stop bits, and Flow Control 'none'. Also make sure the 'Complete path of PuTTY.exe' field points to a valid location.

- 2) **SPI communication.** Attach an MCP3008 ADC to the AT89LP52 microcontroller. You'll need to communicate the ADC and the microcontroller using the Serial Peripheral Interface (SPI) standard. In order to do so, you'll need an assembly subroutine to perform SPI communication. Bellow is a subroutine that implements SPI in software (bit-bang SPI).

```
; These 'EQU' must match the wiring between the microcontroller and ADC
CE_ADC      EQU    P2.0
MY_MOSI     EQU    P2.1
MY_MISO     EQU    P2.2
MY_SCLK     EQU    P2.3

INIT_SPI:
    setb MY_MISO      ; Make MISO an input pin
    clr MY_SCLK       ; For mode (0,0) SCLK is zero
    ret

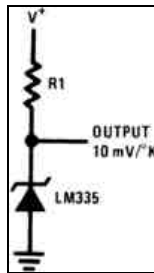
DO_SPI_G:
    push acc
    mov R1, #0        ; Received byte stored in R1
    mov R2, #8        ; Loop counter (8-bits)
DO_SPI_G_LOOP:
    mov a, R0          ; Byte to write is in R0
    rlc a              ; Carry flag has bit to write
    mov R0, a
    mov MY_MOSI, c
    setb MY_SCLK       ; Transmit
    mov c, MY_MISO     ; Read received bit
    mov a, R1          ; Save received bit in R1
    rlc a
    mov R1, a
    clr MY_SCLK
    djnz R2, DO_SPI_G_LOOP
    pop acc
    ret
```

Modify the 'hello.asm' program from the previous point so that it continuously prints the voltage from channel 0 of the MCP3008 ADC into PuTTY. In order to read a voltage from the ADC using SPI you may find useful figure 6-1 in the MCP3008 data sheet.

- 3) **Using Matlab to communicate with the AT89LP52 Microcontroller.** The Matlab script shown below opens the serial port in the host computer, constantly reads and prints a received value, and finally closes the serial port when CTRL+C is pressed in Matlab's command console. Attach an LM335 temperature sensor to channel zero of the MCP3008. Modify the program you wrote for the previous point so it converts the acquired value to temperature and transmits it through the serial port every second. To convert the voltage acquired from the LM335 sensor to temperature, a library of 32-bit arithmetic functions ('math32.asm') and an example file ('mathtest.asm') are available in the course web page for you to use.

```
try
    fclose(instrfind);
end;
s1 = serial('COM1', ... % Change as needed!
            'BaudRate', 115200, ...
            'Parity', 'none', ...
            'DataBits', 8, ...
            'StopBits', 1, ...
            'FlowControl', 'none');
fopen(s1);
try
    fprintf('Press CTRL+C to finish\n');
    while (1)
        val=fscanf(s1);
        result = sscanf(val, '%f');
        fprintf('T=%5.2fC\n', result);
    end
end
fclose(s1);
```

The script above assumes you are using COM1. For other serial ports, adjust accordingly. Also, Matlab expects a new line escape sequence ('\n') for each received value from the microcontroller. Connect the LM335 as shown in the figure below. Make  $V^+=5V$  and  $R1=2.2k\Omega$ . To observe different temperature readings, you can **carefully** heat up the LM335 using the solder iron.



- 4) Temperature strip-chart using Matlab.** The script available from the link below includes strip-chart functions for Matlab.

<http://www.mathworks.com/matlabcentral/fileexchange/3356-strip-chart>

These strip-chart functions can be used to plot the temperature transmitted from the AT89LP52 microcontroller to Matlab in real time. Instructions on how to create a basic strip-chart plot are provided as comments inside the file 'StripChart.m'.

Demo the temperature strip-chart (in °C) to you lab TA. Once again, you can use the solder iron to carefully heat the LM335 up! Copy into your notebook the assembly and Matlab programs; hint: the programs should be short! Also, save and print a copy of a good strip chart plot and attach it to your laboratory notebook. Don't forget to add extra functionality and/or features for bonus marks!