Lab 4: Synchronous communication — the SPI

Goals:

The main goal of this lab is to become familiar with the SPI port, and with synchronous data communication. Also, to use the SPI to control a simple output device.

Synchronous communication — SPI

The SPI port is a common interface to peripheral devices. It uses a small number of pins, and can maintain a high data transfer rate. It is used with many devices, including flash memory devices (SD cards), ADCs, DACs, display controllers, RF (radio frequency) communication devices, etc.

Extending the SPI controller

In this lab, you will extend the SPI controller from class by creating a function to output an integer, rather than a single character, on the SPI port.

Test this function by connecting the output (the `MOSI`) pin) to the input (the `MISO` pin) and displaying the output on the LEDs.

Some devices do not support the SPI in hardware. Write a function which performs the same way in software, and test it as above.

Controlling a serial DAC

The Microchip MCP4921 12 bit digital to analog converter (DAC) is a typical peripheral device using the SPI as a controller. This device only receives input, so communication is in one direction. It is typically used to set an accurate fixed or slowly varying voltage level to control some other device, or to set a specific value for comparison.

Like many such devices, it uses serial input in order to reduce the total number of pins on the device, and consequently the cost of the device.

The output voltage is the 12 bit number input serially divided by 2^{12}, multiplied by the reference voltage, V_{ref}. Optionally, this voltage can be doubled.

It is a 12 bit device, but accepts a 16 bit input. The 12 low order bits are the relative value to be output. The 4 high order bits are control bits. See the data sheet to understand their use.

Configure the DAC with the reference voltage (pin 6) equal to the supply voltage, and connect the LDAC pin (pin 5) to ground, so the output is updated when the CS pin (SS on the SPI port) is set high after the data transfer.

Write a program loop to display all the possible outputs from the DAC on the oscilloscope, as done for the 4 bit DAC in an earlier lab.

Use the DAC to control the brightness of a LED. The LED should have a 220 ohm resistor in series with it, to limit the total current to about 10 ma. You can use the switches to set appropriate values, as done with the PWM controller.

DACs and PWMs are two common ways of digitally controlling external devices with high accuracy and controllability.

Optional:

Use this DAC to find the switching point (for both rising and falling voltages) as you did for an earlier lab. Comment on any difference you note.