EEE3096S: Prac 4: RPI-3B SPI and Interrupt

Nick Anderson - ANDNIC019, Devin Stickells - STCDEV001

September 18, 2018

1 Introduction

The purpose of this report is to develop code for a simple environment monitor system. The system will monitor temperature, light and voltage using a temperature sensor (MCP9700A), a LDR and a potentiometer, while using timing on the RPi as a real time reference to the readings.

2 Questions

2a. SPI Communication

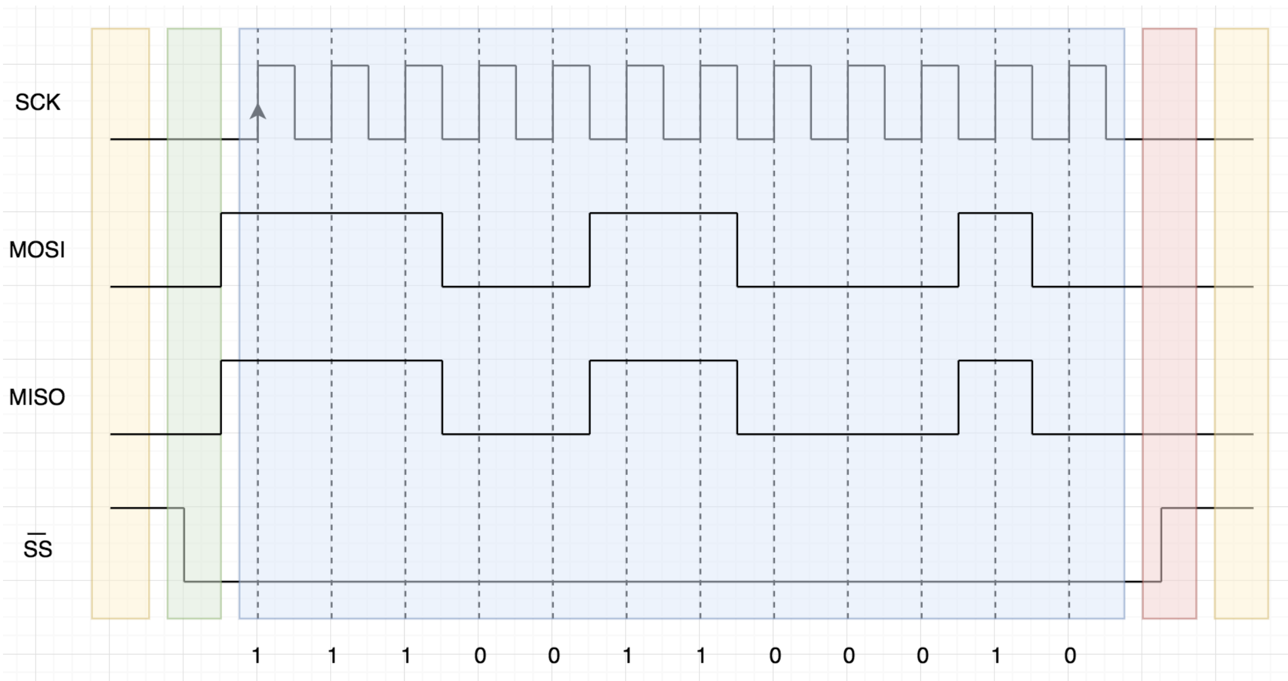

Figure 1: SPI timing diagram

The different phases of the SPI communication protocol are distinguished in Figure 1 above as different colours. Yellow represents the idle state - this is characterised by the Slave Select line being held high, while the Clock Signal Line (SCK) does not transition. The start command (green) is given by the SS line going low in order to enable the slave. Once this has taken place, data can begin to be transferred, and is sampled on every rising edge of the clock signal. The raising of the slave select line signals the stop bit, and the end of data transfer (red), and finally the system returns to idle, with no clock transition and SS high.

2b. Interrupt and Threaded Call-Back

Formally, an interrupt (as in an Interrupt Service Routine, ISR) is a function that is separate from an application and runs in supervisor mode. It is typically able to supersede the normal program execution sequence.

A threaded call-back runs on a separate thread (IO Master) to the application thread. When certain IO conditions are met, a call is made from the IO Master thread to the application thread to execute the relevant callback function.

2c. Potentiometer ADC Function

The ADC readings of a 10 bit ADC will range between `0000000000` and `1111111111` (0 and 1023). Thus, the following equation will convert a 10-bit ADC reading from the potentiometer to a 3.3V limited output:

$$V_{ADC} = \frac{ADC_{reading}}{1023} \times 3.3V$$

where V_{ADC} is the convert voltage limited to $3.3V$ and $ADC_{reading}$ is the 10 bit value read by the ADC.

2d. Temperature Sensor ADC Function

As for the potentiometer ADC converter, the ADC reading from the temperature sensor can be converted to a 3.3V limited output as follows:

$$V_{ADC} = \frac{ADC_{reading}}{1023} \times 3.3V$$

According to the datasheet of MCP9700A, the relationship between the temperature and the output voltage are as follows:

$$V_{out} = T_C \times T_A + V_{0^\circ C}$$

where $T_C = 10mV$ and $V_{0^\circ C} = 500mV$ as given on the datasheet, and T_A is the ambient temperature. Thus, solving for T_A

$$T_A = \frac{V_{out} - V_{0^\circ C}}{T_C}$$

but in the case of this system, $V_{out} = V_{ADC}$, thus the temperature is calculated as follows:

$$T_A = \frac{\frac{ADC_{reading}}{1023} \times 3.3V - 500mV}{10mV}$$

2e. LDR ADC Function

In order to calculate the percentage light received by the LDR, a reference light value must be established. In the case of this system, the reference was found by shining a flash light directly on the LDR. This reference will be denoted as $ADC_{reading(flashlight)}$. Using this as the 100% value, the percentage light can be calculated as follows:

$$light_{\%} = \frac{ADC_{reading}}{ADC_{reading(flashlight)}} \times 100$$

2f. Flow Chart of System

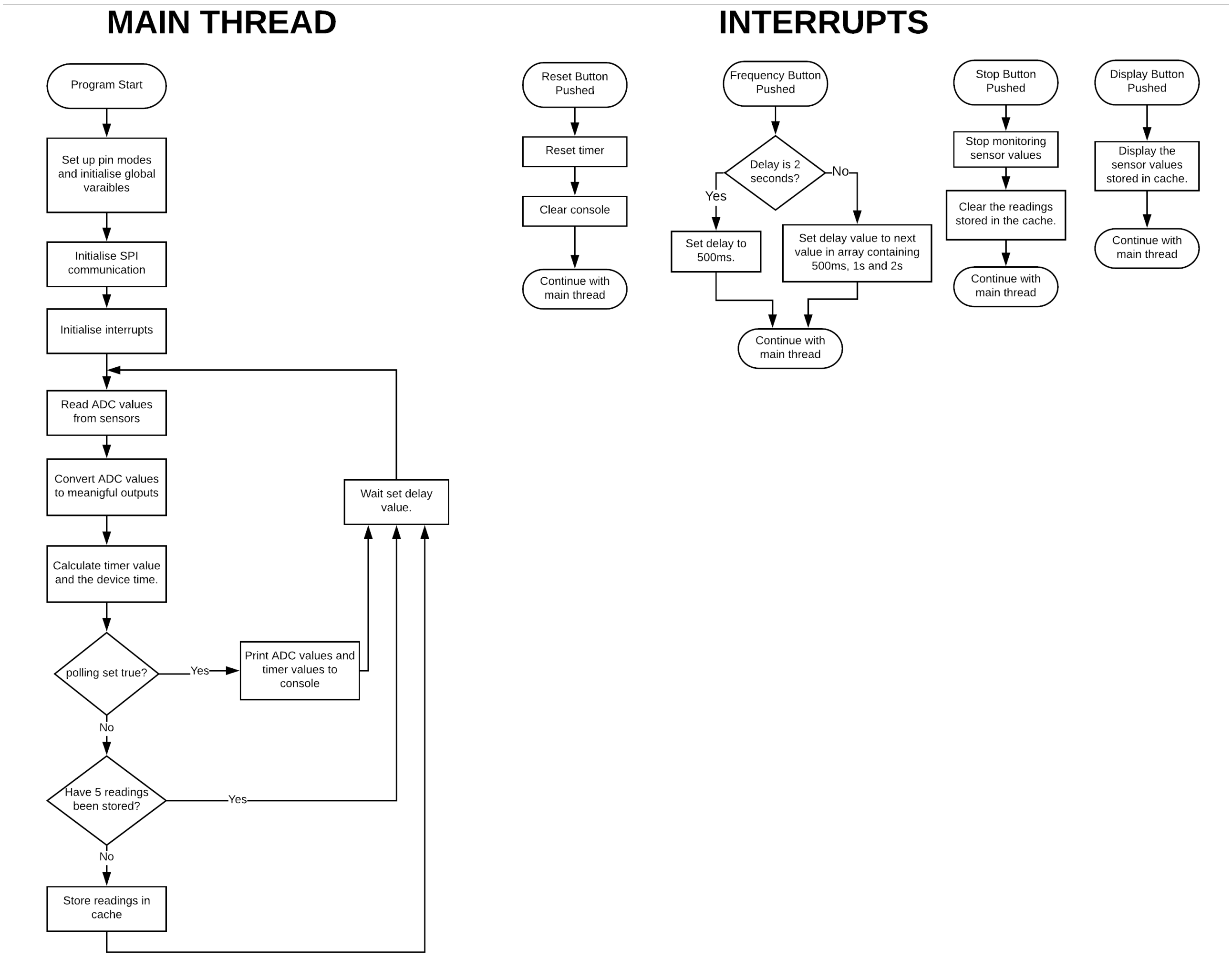

Figure 2: Flow chart of monitoring system showing multiple threads as a result of multiple interrupts.