ECE 271 Microcomputer Architecture and Applications
Lab 9: Analog to Digital Converter (ADC)
Instructor: Prof. Yifeng Zhu
Spring 2015

Goals

1. Learn to use analog to digital converter to perform single or continuous conversion
2. Learn to use interrupts to read data between consecutive sampling

Pre-lab Assignment

1. Read Chapter 20 Analog to Digital Conversion (ADC)
2. Complete the pre-lab assignment

Lab Demo

1. Part 1. When the voltage input is higher than 2.0V, the LED is light up. When the voltage is lower than 1.0V, the LED is off. The input voltage can be controlled manually by using a potentiometer. Use a voltage meter to verify it.
2. Part 2. Infrared (IR) proximity sensor. When an object gets close to the IR sensor, light up the LED.
3. Something cool. The following gives a few examples.
    a. Use a timer to periodically trigger the ADC
    b. Use the potentiometer to control the brightness of a LED
    c. Show the measurement on the LCD
    d. Using the potentiometer to control the rotation speed of a stepper motor
    e. Count how many times your hands wave over the IR sensor
    f. Measure the distance of an object from the IR sensor
    g. Use the analog watchdog in the processor to trigger ADC when an object gets too close to the sensor
    h. Build a heartbeat rate sensor

Post-lab Assignment

1. Write your answer in Readme.md and submit it to the gitlab server.

Part 1. Measuring the Input Voltage Adjusted by a Potentiometer

A potentiometer (pot) is a three-terminal variable resistor. It uses a sliding contact and works as an adjustable voltage divider. When two outer terminals connected to Vcc and the ground respectively, the center terminal will generate a voltage that varies from 0 to Vcc depending on the position of the sliding contact.

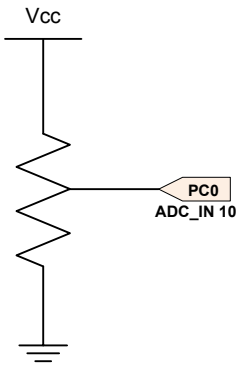

Figure 1. Measure the voltage from a potentiometer-based divider (Vcc = 3V)

Part 2. Infrared (IR) Proximity Sensor

PD 2 is to turn on or off the infrared emitter. When the output of PD 2 is high, the infrared emitter is turned on. The processor is to monitor via PB 15 the voltage across the phototransistor. When the phototransistor receives more infrared light reflected from an object, the phototransistor allows more current to flow through and thus the voltage of PB 15 gets smaller.

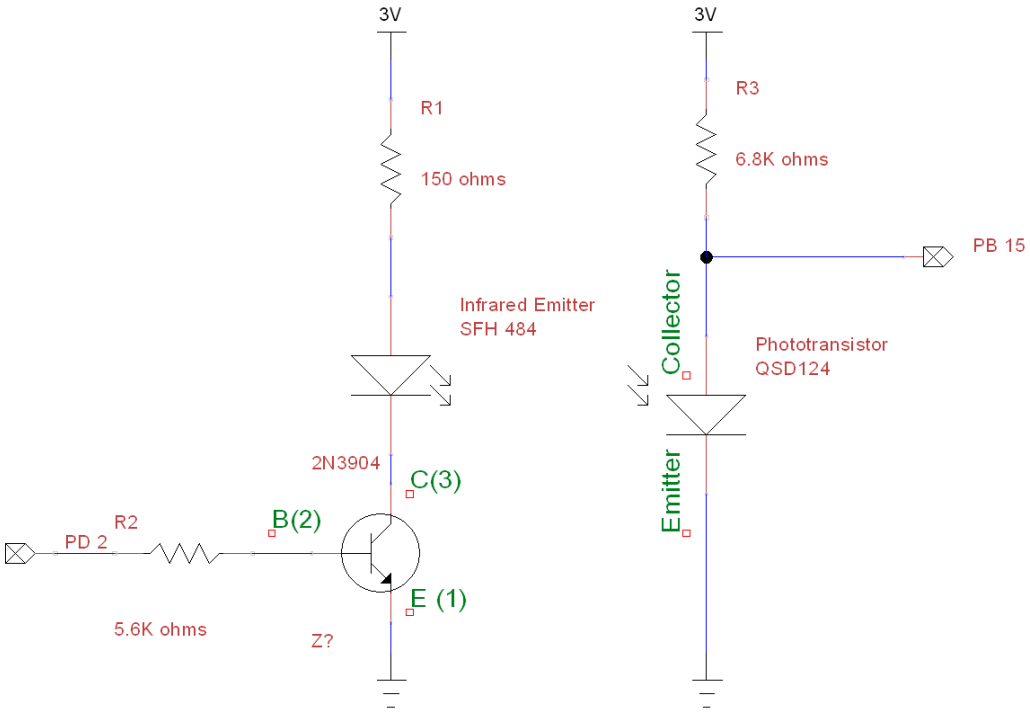

Figure 2. Schematic Diagram of IR emitter and phototransistor. (Vcc = 3V)

ECE 271 pre-Lab Assignment
Lab 9: Analog to Digital Converter (ADC)

Student Name: _____
TA: _____
Time & Date: _____

1. Setting of ADC Control Registers

Register	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ADC_SR	Reserved																						JCNR	RCNR	Reserved	ADONS	OVR	STRT	JSTRT	JEOC	EOC	AWD
Value																																
ADC_CR1	Reserved					OVRIE	RES[1:0]		AWDEN	JAWDEN	Reserved				PDI	PDD	DISC NUM [2:0]			JDISCEN	DISCEN	JAUTO	AWD SGL	SCAN	JEOCIE	AWDIE	EOCIE	AWDCH[4:0]				
Value																																
ADC_CR2	Reserved	SWSTART	EXTEN[1:0]		EXTSEL [3:0]				Reserved	JSWSTART	JEXTEN[1:0]		JEXTSEL [3:0]				Reserved				ALIGN	EOCS	DDS	DMA	Reserved	DELS[2:0]			Reserved	ADC_CFG	CONT	ADON
Value																																
ADC_SMPR1	Sample time bits SMPx_x																															
Value																																
ADC_SMPR2	Sample time bits SMPx_x																															
Value																																
ADC_SMPR3	Sample time bits SMPx_x																															
Value																																
ADC_JOFR1	Reserved																				JOFFSET1[11:0]											
Value																																
ADC_JOFR2	Reserved																				JOFFSET2[11:0]											
Value																																
ADC_JOFR3	Reserved																				JOFFSET3[11:0]											
Value																																
ADC_JOFR4	Reserved																				JOFFSET4[11:0]											
Value																																
ADC_HTR	Reserved																				HT[11:0]											
Value																																
ADC_LTR	Reserved																				LT[11:0]											
Value																																

Register	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ADC_SQR1	Reserved							L[4:0]					Regular channel sequence SQx_x bits																			
Value																																
ADC_SQR2	Reserved		Regular channel sequence SQx_x bits																													
Value																																
ADC_SQR3	Reserved		Regular channel sequence SQx_x bits																													
Value																																
ADC_SQR4	Reserved		Regular channel sequence SQx_x bits																													
Value																																
ADC_SQR5	Reserved		Regular channel sequence SQx_x bits																													
Value																																
ADC_JSQR	Reserved										JL[1:0]		Injected channel sequence JSQx_x bits																			
Value																																
ADC_JDR1	Reserved																JDATA[15:0]															
Value																																
ADC_JDR2	Reserved																JDATA[15:0]															
Value																																
ADC_JDR3	Reserved																JDATA[15:0]															
Value																																
ADC_JDR4	Reserved																JDATA[15:0]															
Value																																
ADC_DR	Reserved																Regular DATA[15:0]															
Value																																
ADC_SMPR0	Sample time bits SMPx_x																															
Value																																
ADC_CSR	Reserved																									ADONS	OVR	STRT	JSTRT	JEOC	EOC	AWD
Value																										ADC1						
ADC_CCR	Reserved								TSVREFE	Reserved							ADCPRE		Reserved													
Value																																

ECE 271 Lab Demo
Lab 9: Analog to Digital Converter (ADC)

Demo Part 1, Part 2, and something cool to TA.

ECE 271 post-Lab Assignment
Lab 9: Analog to Digital Converter (ADC)

Write your answer to the following questions in Readme.md and submit it to the gitlab server.

1. For 12-bit ADC, we know that

$$ADC\ Result = \ floor\left(2^{12} \times \frac{V}{V_{REF}} + \frac{1}{2}\right)$$

   Design an experiment to find out V_{REF}

2. When the voltage output from the potentiometer-based voltage divider is lower than 1.0V, the LED is turned off. What constant value should the ADC DR register be compared with?

3. When the voltage output from the potentiometer-based voltage divider is higher than 2.0V, the LED is light up. What constant value should the ADC DR register be compared with?

4. What is the maximum distance at which your sensor can reliably detect your hand?