FNU FIJI NATIONAL UNIVERSITY

Supplementary Examination

College	Engineering, Science & Technollogy
School	Electrical & Electronics Engineering
Programme	Bachelor of Engineering (Electrical & Renewable) [Year 3]
Trimester	II
Year	2017
Unit Code	EEE766
Unit Title	Microcontroller Based System Design
Date of Examination	August 18
Time	9am to 12.10pm
Venue	TBA
Duration	3 Hours *(extra 10 mins allowed to read the paper)*
Maximum Marks	100

Instructions

1. There are five (5) questions in total with parts and subparts. Each question is worth 20 marks. Attempt all questions in the answer booklet.
2. Write your answers legibly in the answer booklet.
3. Write your student identification number on each page used.
4. A PIC16F877 assembly instruction set is provided on the last page.

Question 1 *(20 Marks)*

(a) Explain the difference between a microcontroller and a microprocessor? (2)

(b) List and briefly describe the three components of a microprocessor. (3)

(c) Explain the purpose of the following registers in a microprocessor

i. Program Counter (2)

ii. Status register (2)

iii. Accumulator or W register (1)

(d) With the aid of a block diagram compare the Harvard architecture and the von-Neumann architecture. Which architecture is used in mid-range PIC MCU family? (5)

(e) The midrange PIC CPU is a RISC processor. Explain what RISC means? (2)

(f) One of the most popular microcontroller bus communication is the I^2C communication. Explain what this communication protocol is and how it works. Give examples of applications where this communication protocol is used? (3)

Question 2 *(20 Marks)*

(a) Describe the instruction pipeline of the midrange PIC MCU family. (2)

(b) A PIC16F877 microcontroller is interfaced using a 4 MHz external clock signal. Compute the instruction cycle, T_{cy}, of the microcontroller. (4)

(c) The instruction set of PIC16F877 is divided into three categories. What are the three categories? (3)

(d) With the aid of diagrams describe the format of the instructions under each of the three categories that you listed for the previous question (3)

(e) Describe the purpose of the carry flag (C), digit-carry flag (DC) and zero flag (Z) of the status register. (3)

(f) Which bits of the status register are bank select bits? What should be the contents of these bits to select bank 2 of the data memory? (2)

(g) The program memory of PIC16F877 contains 8K x 14 words. Compute the address space required to address the 8K of flash program memory? (3)

Question 3 *(20 Marks)*

(a) How many bits microprocessor is the AVR CPU that is used in ATMega series microcontrollers? (1)

(b) What is the MIPS rating of the ATMega2560 microcontroller? What does this rating indicate? (2)

(c) What architecture is used in AVR CPU inside ATMega2560 microcontroller? Explain this architecture. (2)

(d) Explain the pipelining of the AVR architecture used in ATMega2560 microcontroller. (3)

(c) How many general purpose working registers does AVR CPU has? (1)

(f) State the size and type of program memory used in ATMega2560 microcontroller? Discuss the advantage of the type of memory used for program storage? (3)

(g) How many bits wide is the program counter (PC) of the ATMega2560 microcontroller? Explain why this is so? (2)

(h) The program memory of the ATMega2560 is divided into two sections. What are the two sections? (2)

(i) What is the size of data memory (RAM) in ATMega2560? (1)

(j) One of the features of ATMega2560 is Analog to Digital Converter. Give the resolution of the ADC in bits and explain what this feature is used for with an example. (3)

Question 4 *(20 Marks)*

In an electronic system, a PIC16F877 microcontroller was used to toggle on and off an LED when a push button switch is pressed. The circuit in Fig. 1 shows the schematic diagram of the LED and push button switch connection to the PIC16F877.

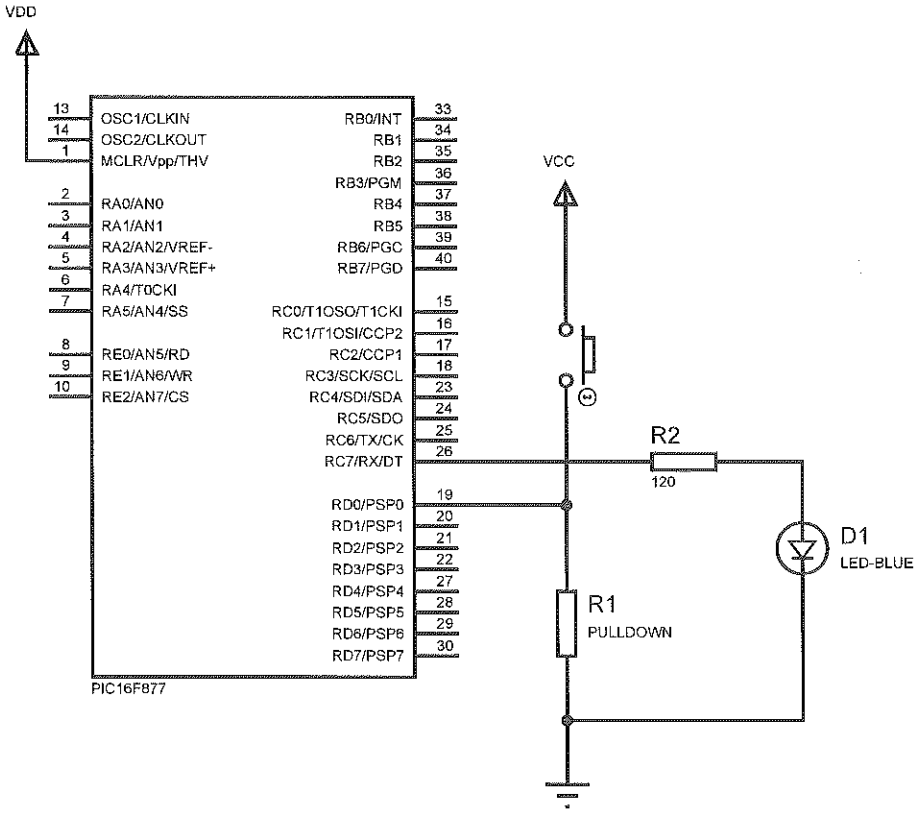

Figure 1: LED and push button connection to PIC16F877

(a) Write a complete program in assembly language using PIC16F877 instruction set to achieve the objective of the circuit. (10)

(b) Often when a push button switch is interfaced to a microcontroller, a problem known as the switch contact bounce occurs. Explain what this problem is and how it can be overcome? (4)

(c) Write a complete program in C for the Arduino compiler to blink an LED connected to pin 13 of the Arduino Mega board. (6)

Question 5 (*20 Marks*)

In a microcontroller based temperature control system, an Atmel ATmega2560 microcontroller on the popular Arduino Mega board was used to read temperature from an analog temperature sensor and control LED's. The circuit diagram in Fig. 2 shows the connection from the Arduino Mega to the LED's and the temperature sensor input. Note that the variable resistor is used instead of a temperature sensor.

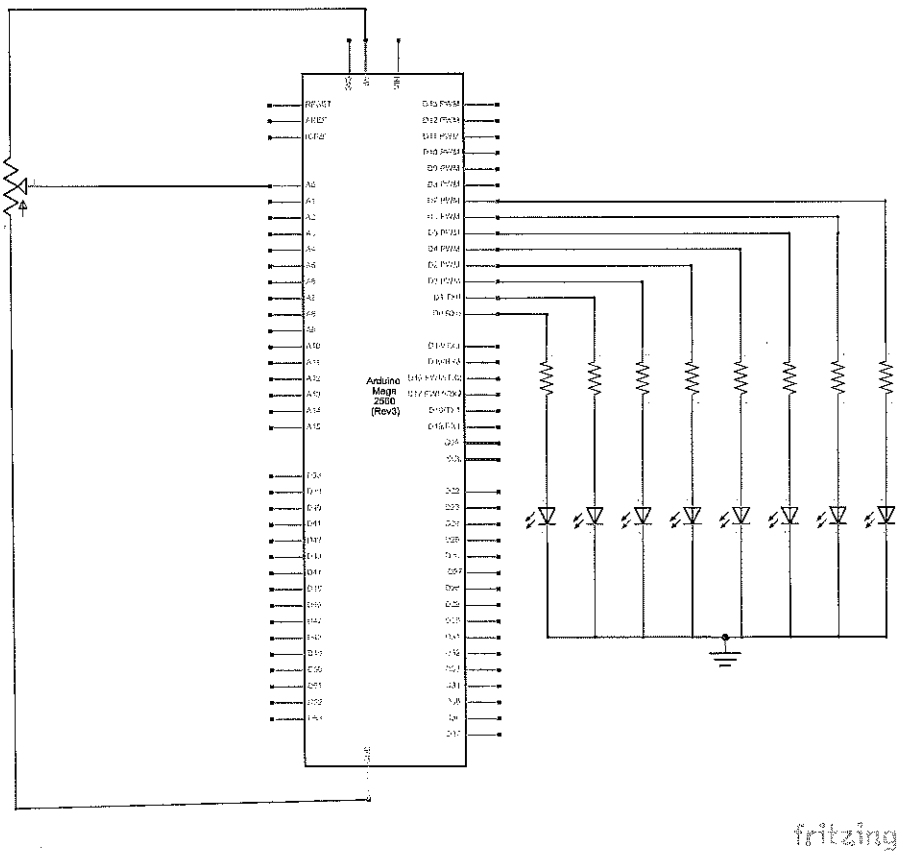

Figure 2: Schematic showing LED and analog input connection (source: Fritzing)

The following program was written to read analog voltage on analog pin 0, and write the

converted digital value as an integer to the USB serial port. The read value can be seen on the Serial Monitor. The program is written in C language for the Arduino compiler.

```
1 int analogPin = 0;
2
3 int val = 0;
4
5 void setup()
6 {
7   Serial.begin(9600);
8 }
9
10 void loop()
11 {
12   val = analogRead(analogPin);
13   Serial.println(val);
14 }
```

(a) Write an equation to convert the digital value into voltage value. (3)

(b) Using the equation, calculate the value of the voltage on analog pin 0 if the serial monitor displays a digital value of 44. (3)

(c) Rewrite the program given above to display the voltage value on analog pin 0 on the serial monitor screen. (5)

(d) Assume that the potentiometer is replaced with an analog temperature sensor (LM35). Rewrite the program to display the temperature value instead of the voltage value. Assume that the temperature is in degrees Celsius and that the temperature change is 10 mV/°C. (4)

(e) Write a program that will control the LED's connected to the digital I/O pins (0 - 7) of the Arduino as shown in Figure 2. At a temperature of 25°C, only one LED must be high, that is LED connected to output pin 0. As the temperature increases in steps of 5°C, then the rest of the LED's must become high in a sequence. That is at 30°C, LED's 0 and 1 must be high; at 35°C, LED's 0, 1 and 2 must be high, and so on. As the temperature drops then the LED's should also indicate this as well. Therefore, the LED's act as a visual display of the temperature from 25°C in steps of 5°C. (5)

The End

TABLE 13-2: PIC16F87X INSTRUCTION SET

Mnemonic, Operands		Description	Cycles	14-Bit Opcode MSb			LSb	Status Affected	Notes
BYTE-ORIENTED FILE REGISTER OPERATIONS									
ADDWF	f, d	Add W and f	1	00	0111	dfff	ffff	C,DC,Z	1,2
ANDWF	f, d	AND W with f	1	00	0101	dfff	ffff	Z	1,2
CLRF	f	Clear f	1	00	0001	lfff	ffff	Z	2
CLRW	-	Clear W	1	00	0001	0xxx	xxxx	Z	
COMF	f, d	Complement f	1	00	1001	dfff	ffff	Z	1,2
DECF	f, d	Decrement f	1	00	0011	dfff	ffff	Z	1,2
DECFSZ	f, d	Decrement f, Skip if 0	1(2)	00	1011	dfff	ffff		1,2,3
INCF	f, d	Increment f	1	00	1010	dfff	ffff	Z	1,2
INCFSZ	f, d	Increment f, Skip if 0	1(2)	00	1111	dfff	ffff		1,2,3
IORWF	f, d	Inclusive OR W with f	1	00	0100	dfff	ffff	Z	1,2
MOVF	f, d	Move f	1	00	1000	dfff	ffff	Z	1,2
MOVWF	f	Move W to f	1	00	0000	lfff	ffff		
NOP	-	No Operation	1	00	0000	0xx0	0000		
RLF	f, d	Rotate Left f through Carry	1	00	1101	dfff	ffff	C	1,2
RRF	f, d	Rotate Right f through Carry	1	00	1100	dfff	ffff	C	1,2
SUBWF	f, d	Subtract W from f	1	00	0010	dfff	ffff	C,DC,Z	1,2
SWAPF	f, d	Swap nibbles in f	1	00	1110	dfff	ffff		1,2
XORWF	f, d	Exclusive OR W with f	1	00	0110	dfff	ffff	Z	1,2
BIT-ORIENTED FILE REGISTER OPERATIONS									
BCF	f, b	Bit Clear f	1	01	00bb	bfff	ffff		1,2
BSF	f, b	Bit Set f	1	01	01bb	bfff	ffff		1,2
BTFSC	f, b	Bit Test f, Skip if Clear	1 (2)	01	10bb	bfff	ffff		3
BTFSS	f, b	Bit Test f, Skip if Set	1 (2)	01	11bb	bfff	ffff		3
LITERAL AND CONTROL OPERATIONS									
ADDLW	k	Add literal and W	1	11	111x	kkkk	kkkk	C,DC,Z	
ANDLW	k	AND literal with W	1	11	1001	kkkk	kkkk	Z	
CALL	k	Call subroutine	2	10	0kkk	kkkk	kkkk		
CLRWDT	-	Clear Watchdog Timer	1	00	0000	0110	0100	TO,PD	
GOTO	k	Go to address	2	10	1kkk	kkkk	kkkk		
IORLW	k	Inclusive OR literal with W	1	11	1000	kkkk	kkkk	Z	
MOVLW	k	Move literal to W	1	11	00xx	kkkk	kkkk		
RETFIE	-	Return from interrupt	2	00	0000	0000	1001		
RETLW	k	Return with literal in W	2	11	01xx	kkkk	kkkk		
RETURN	-	Return from Subroutine	2	00	0000	0000	1000		
SLEEP	-	Go into standby mode	1	00	0000	0110	0011	TO,PD	
SUBLW	k	Subtract W from literal	1	11	110x	kkkk	kkkk	C,DC,Z	
XORLW	k	Exclusive OR literal with W	1	11	1010	kkkk	kkkk	Z	

Note 1: When an I/O register is modified as a function of itself (e.g., `MOVF PORTB, 1`), the value used will be that value present on the pins themselves. For example, if the data latch is '1' for a pin configured as input and is driven low by an external device, the data will be written back with a '0'.

2: If this instruction is executed on the TMR0 register (and, where applicable, d = 1), the prescaler will be cleared if assigned to the Timer0 module.

3: If Program Counter (PC) is modified, or a conditional test is true, the instruction requires two cycles. The second cycle is executed as a NOP.

Note: Additional information on the mid-range instruction set is available in the PICmicro™ Mid-Range MCU Family Reference Manual (DS33023).