TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering and Technology

Department of Electrical and Electronic Engineering

UNIVERSITY EXAMINATION FOR:

Bachelor of Science in Medical Engineering

EEE 4431: Microcontrollers

END OF SEMESTER EXAMINATION

SERIES: NOVEMBER 2024

TIME: 2 HOURS

DATE: Pick DateSelect MonthPick Year

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **five** Questions; Question ONE is compulsory. In addition, attempt any Other TWO Questions.

Do not write on the question paper.

Question ONE (Compulsory 30 marks)

a) Sketch the pin diagram of the PIC16F84A [8 marks]

b) Describe the operation of the following code snippet, and explain what the program accomplishes.

```
DATUML      equ     h'30'
DATUMH      equ     h'31'
STATUS      equ     3
C           equ     0
; --------------------------------------------------
            clrf    DATUMH
            movf    DATUML,w
            addwf   DATUML,f
            btfsc   STATUS,C
            incf    DATUMH,f
NEXT    ---     ------
```

[10 marks]

c) Write an assembly language program to subtract the literal h'30' to the contents of File h'64' and store the result in File h'45'. State the highest difference from this routine that can be accomplished. [6 marks]

d) Explain the difference between a ***goto*** instruction and a ***call*** instruction. [2 marks]

e) Briefly detail the disadvantages of a modular approach to writing software, using subroutines to illustrate your answer. [4 marks]

Question TWO

a) Write a PIC MCU assembly-level program to check that the byte content of File h'30' (to be named NUMBER1) and the byte content of File h'31' (to be called NUMBER2) are the same, and if they are, the contents of File h'40' (to be named EQUAL) are to be made h'FF' otherwise the contents of File h'40' are to be h'00'. [12marks]

b) Without writing code, explain how could you extend your approach to (a) to determine if NUMBER2 is higher than or lower than NUMBER1. [4marks]

c) State any FOUR factors to configure when choosing a microcontroller for use in an application. [4 marks]

Question THREE

a) The Harvard memory structure gives some clear advantages over conventional von Neumann structure. With the help of a diagram, state any FOUR disadvantages of Harvard memory architecture. [6 marks]

b) With the aid of a diagram show how you would set Port A pin RA0 as an output and all other Port A and Port B pins as inputs [9 marks]

c) List FIVE features of the Microcontroller-Based Embedded Systems [5 marks]

Question FOUR

a) Describe the function and implementation of the watchdog timer in the PIC microcontroller. [6 marks]

b) Using appropriate equate statements, write a commented section of PIC16F84 assembly code to set 1 pin of PortB to be an output and the other 7 pins to be inputs. Your code must make use of bank switching. You may NOT use the TRIS instruction. [8 marks]

c) Using the register file map diagram included as appendix to this paper, explain the key functions of the registers located in data memory locations:

i) 0x01
ii) 0x85
iii) 0x10 [6 marks]

Question FIVE

a) Identify (in both binary and hexadecimal) the resulting values in the working register for each of the following:

i) MOVLW B'00011001'
SUBLW B'01001001'

ii) MOVLW B'10110011'
XORLW B'10001010'

iii) MOVLW B'11010010'
ANDLW B'00011011' [6 marks]

b) A student project involves the detection and display of wind direction; namely north, east, south or west. It is suggested that a disc, having black and white markings as shown in Fig. Q5b, be connected to a weather vane and that two reflected opto-switches, A and B, detect the position the disc is turned to. Each sensor outputs a logic 1 when light is reflected and logic 0 otherwise. Four LEDs are to be used to indicate the wind direction.

i) List the four patterns for the various directions and draw a flow chart showing a process of systematically testing the two signals A and B, with one of four outcomes being indicated for the various possibilities.

ii) Show how the two opto-switches and four LEDs could be interfaced to a PIC16F84 MCU.

iii) Write a program to:

I) Set up the port(s) as appropriate to (ii) above.

II) Implement your four tests to light the appropriate LED for each pattern.

[6 Marks]

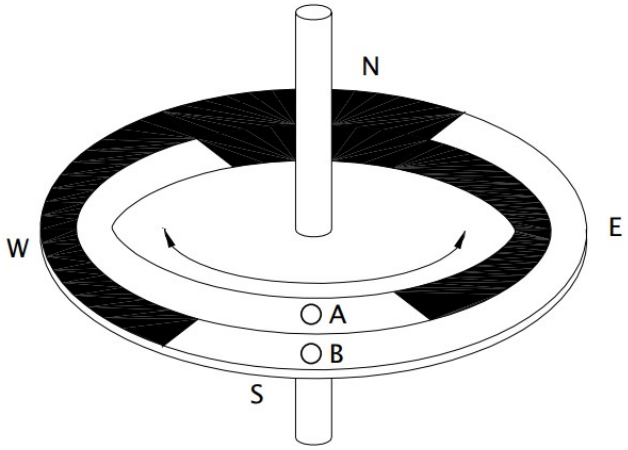

FIG. Q5b

c) An embedded system has a PIC 16F84 microcontroller with a crystal frequency of 4.0 MHz.

i) Determine the function of the following set of instructions;

ii) Write a 100 msec delay subroutine

iii) The hardware counter/timer (TMR0) of the microcontroller can be used to generate a repetitive interrupts. Explain that and calculate the minimum and maximum interrupt frequency

[8 marks]

Instruction	Mnemonic	Operation	Flags	
			Z	C
Arithmetic				
Add W and File	addwf f,d	(d) <- W + (f)	√	√
Add Literal and W	addlw L	W <- #L + W	√	√
Bit Clear File bit n	bcf f,n	f_n <- 0	•	•
Bit Set File bit n	bsf f,n	f_n <- 1	•	•
Clear File	clrf f	(f) <- 00	√	•
Increment File	incf f,d	(d) <- (f) + 1	√	•
Decrement File	decf f,d	(d) <- (f) - 1	√	•
Subtract W from File	subwf f,d	(d) <- (f) - W	√	√
Movement				
Move File	movf f,d	(d) <- (f)	√	•
Move W to File	movwf f	W <- (f)	•	•
Move Literal to W	movlw L	W <- #L	•	•
Logic				
AND W and File	andwf f,d	(d) <- W · (f)	√	•
AND Literal and W	andlw L	W <- #L · W	√	•
Complement File	comf f	(f) <- $(\overline{f})$	√	•
Inclusive OR W and File	iorwf f,d	(d) <- W + (f)	√	•
Inclusive OR Literal and W	iorlw L	W <- #L + W	√	•
Skip and Jump				
Bit Test File, Skip if Clear	btfsc f,b	b == 0 ? PC++ : PC	•	•
Bit Test File, Skip if Set	btfss f,b	b == 1 ? PC++ : PC	•	•
Call (jump to) subroutine	call aaa	(TOS) <- pc, pc <- aaa	•	•
Go to address	goto aaa	pc <- aaa	•	•
Return from subroutine	return	pc <- (TOS)	•	•

√	: Flag operates normally	•	: Flag not affected
aaa	: Address of instruction	b	: Bit b (0–7) in file
C	: Carry or $\overline{\text{B}}$orrow, bit 0 in F3	Z	: Zero, bit 2 in F3
d	: Destination; 0 = W, 1 = file	W	: Working register
L	: 8-bit Literal	==	: Equivalent to
++	: Increment	( )	: Contents of
A?S1:S2	: IF A is True THEN DO S1 ELSE DO S2	TOS	: Top Of Stack
f	: File	d	: File or W
pc	: Program Counter		

PIC16F83/84 Special-Purpose Register file summary											
File address	Name	7	6	5	4	3	2	1	0	Power-on Reset	All other Resets
Bank 0											
00*h*	INDF	Uses contents of this to address Data memory (not a physical register)									
01*h*	TMR0	8-bit real-time clock/counter								XXXX XXXX	UUUU UUUU
02*h*	PCL[1]	Lower-order 8 bits of the Program Counter								0000 00000	0000 0000
03*h*	STATUS[1]	IRP	RP1	RP0	$\overline{TO}$	$\overline{PD}$	Z	DC	C	0001 1XXX	000? ?UUU
04*h*	FSR	Indirect Data memory address pointer 0								XXXX XXXX	UUUU UUUU
05*h*	PORTA	—	—	—	RA4	RA3	RA2	RA1	RA0	---X XXXX	---U UUUU
06*h*	PORTB	RB7	RB6	RB5	RB4	RB3	RB2	RB1	RB0	XXXX XXXX	UUUU UUUU
08*h*	EEDATA	Data EEPROM Data register								XXXX XXXX	UUUU UUUU
09*h*	EEADR	Data EEPROM Address register								XXXX XXXX	UUUU UUUU
0A*h*	PCLATH	—	—	—	Write buffer for top 5 PC bits					---0 0000	---0 0000
0B*h*	INTCON	GIE	EEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000X	0000 000U
Bank 1											
80*h*	INDF	Uses contents of this to address Data memory (not a physical register)									
81*h*	OPTION	$\overline{RBPU}$	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	1111 1111
82*h*	PCL[1]	Lower-order 8 bits of the Program Counter								0000 00000	0000 0000
83*h*	STATUS[1]	IRP	RP1	RP0	$\overline{TO}$	$\overline{PD}$	Z	DC	C	0001 1XXX	000? ?UUU
84*h*	FSR	Indirect Data memory address pointer 0								XXXX XXXX	UUUU UUUU
85*h*	TRISA	—	—	—	Port A Direction Register					---1 1111	---1 1111
86*h*	TRISB	Port B Data Direction Register								1111 1111	1111 1111
88*h*	EECON1	Data EEPROM Data register								XXXX XXXX	UUUU UUUU
89*h*	EECON2	EEPROM Control register (not a physical register)									
8A*h*	PCLATH	—	—	—	Write buffer for top 5 PC bits					---0 0000	---0 0000
8B*h*	INTCON	GIE	EEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000X	0000 000U

X Not known

U Unchanged

? Value depends on whether a Watchdog Reset and if in Sleep mode before Reset.

— Unimplemented; reads as 0.

Note 1: Next instruction address if PIC in Sleep mode.

REGISTER FILE MAP