MICROCONTROLLER APPLICATONS /

ENGINEERING DESIGN & BUSINESS PROJECT II

2019/2020 SEMESTER ONE MID-SEMESTER TEST

SAS code:

MST

ET1010
Diploma in Aerospace Electronics (DASE)
Diploma in Energy Systems and Management (DESM)
Diploma in Computer Engineering (DCPE)
Diploma in Electrical & Electronic Engineering (DEEE)
Diploma in Mechatronics and Robotics (DMRO)

ET1216
Diploma in Engineering with Business (DEB)

} 2nd Year Full-Time

Time Allowed: 1.5 Hours

Instructions to Candidates

1. The Singapore Polytechnic examination rules are to be complied with.
2. This paper consists of TWO sections:

   Section A - 10 Multiple Choice Questions, 3 marks each.

   Section B - 4 Questions, 18 marks each (except B3 which is 16 Marks).
3. ALL questions are COMPULSORY.
4. All questions are to be answered in the Answer Booklet. Start each question in Section B on a new page.
5. This paper consists of 10 pages (including 2 pages in the Appendix).

SECTION A

MULTIPLE CHOICE QUESTIONS [3 marks each]

- Please tick your answers in the MCQ box provided on the second page of the answer booklet.
- No marks will be deducted for wrong answers.

A1. Which one of the following is unlikely to be an integral part of a microcontroller?

(a) Digital input and output port.
(b) Analog input port.
(c) Registers and memory.
(d) Sensors and signal conditioning.

A2. What is the packaging type used for PIC18F4550 shown in Figure A2.?

(a) DIP
(b) TQFP
(c) QFN
(d) SOIC

Figure A2.

A3. For which application using a PIC18-based solution would be hard to realize?

(a) A coffee maker machine
(b) An automated online bitcoin trading system
(c) A beverage vending machine
(d) An intruder alarm system

A4. Using Vref+=5V and Vref-=0 V, a 10-bit analogue to digital converter returns 435 in decimal. What is the input signal amplitude presented to the analog input port?

(a) 1.2V
(b) 2.13V
(c) 3.31V
(d) 4.72V

A5. Consider the PIC controller setup mentioned in question A4. If a left justified AD conversion result shows **ADRESH**=00011001 and **ADRESL**=11000000. What is the voltage present at the analog input channel?

(a) 0.1V
(b) 0.2V
(c) 0.5V
(d) 1.2V

A6. Which one of the following is typically an output device?

(a) Relay
(b) Push button
(c) Proximity sensor
(d) Potentiometer

A7. The C statement line TRISB = 0b01010101 in a program:

(a) Sets Port B as output
(b) Sets Port B as input
(c) Sets even bits of Port B as output and odd bits as input
(d) Sets even bits of Port B as input odd bits as output

A8. Which one of the following statements decrements a variable from 10 to 0.

(a) while(i==0){i--;}
(b) for(i=10;i>0;i--)
(c) for(i=10;i<0;i--)
(d) for(i=10;i>=0;i--)

A9. If a user wants to connect a 4 x 4 matrix keypad to PIC controller directly without using any interfacing circuit, how many digital I/O pins will be needed?

(a) 8 output.
(b) 8 input.
(c) 4 output 4 input.
(d) 8 output 8 input.

A10. The ADCON1 register_____

(a) Turns on A/D module
(b) Configures voltage references
(c) Configures acquisition time
(d) Controls A/D clock source

SECTION B

SHORT QUESTIONS [18 marks each, except B3 which is 16 Marks]

B1. A servo motor is an actuator that allows precise control of angular position. Such servo motor is going to be controlled by using PIC18 microcontroller. In order to bring servo motor to different angular position, a periodic signal has to be provided as shown in Figure B1. For the chosen servo motor, a pulse width of 2ms followed with 18ms low period is provided continuously to maintain 180 degree position.

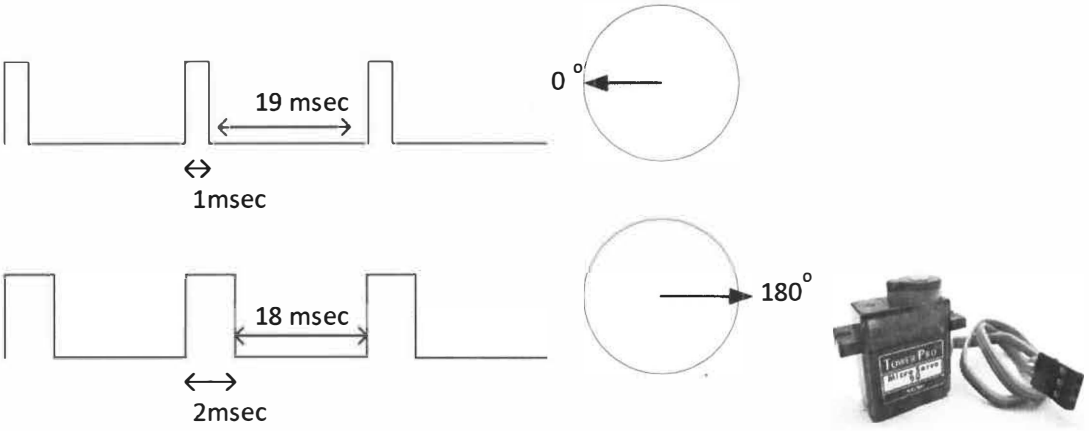


Figure B1.

Assume that **RD0** will be used to generate the signal.

(a) Write the C code to make **RD0** an output pin. (4 marks)

(b) Write the C code to produce 2ms pulse followed with 18ms low period at **RD0**. (6 marks)

(c) Complete the C code below, such that servo can maintain 180 degree position for 2 seconds and 0 degree position for 3 seconds, repeatedly. (8 marks)

```
int i;
_____________________________ // configure the pins
while (1) {
   for(i=_________){      //    repeat ? times for 2 sec.
     _____________;       //    set RD0 high
     _____________;       //    delay 2 ms
     _____________;       //    set RD0 LOW
     _____________;       //    delay 18ms
   }
   for(i=_________){      //    repeat ? times for 3 sec.
     _____________;       //    set RD0 high
     _____________;       //    delay 1 ms
     _____________;       //    set RD0 LOW
     _____________;       //    delay 19ms
   }
}
```

B2. You are to design a safety system for a hydraulic press machine used in heavy industry. A push button is used to start the machine. However, once the start button is pressed, machine will start operating after 8 seconds of delay. While counting 8 seconds of delay, you need to display the count of the up counter and turn on a buzzer to indicate machine is about to operate. To complete the task, you are given one push button, one buzzer and one seven segment display (common anode), and a PIC 18 Controller as shown in Figure B2(a).

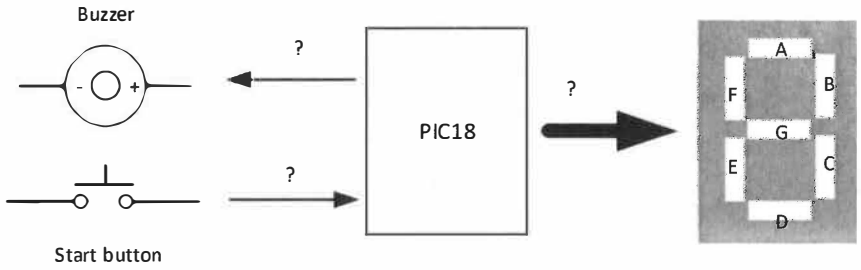


Figure B2 (a).

(a) Choose port D for outputs and port B for input to connect these devices and draw the circuit diagram of the system clearly (Hint: you need to consider using proper resistors for the buzzer, push button and seven segment display).

(6 Marks)

(b) Write the C statements to configure input and output ports.

(2 marks)

(c) The flowchart of the program is shown in Figure B2(b). Complete flow chart by finding the correct place for each statement in the given flow chart.

(10 marks)

Display count	?	Start buzzer	
Stop buzzer		Start	
Set i/O pins		Increment counter	
counter=0		Is button pressed?	
Is count ==8?		Delay 1 sec	

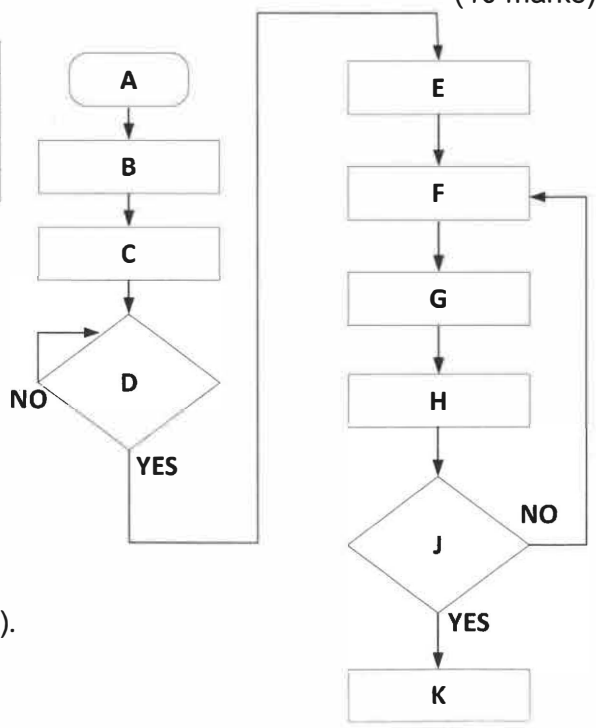


Figure B2 (b).

B3. A PIC18 based system will be used to monitor water pH level. Saltwater fish prefer an alkaline pH of 8.0 or above. The pH sensor used for the system has an analog output of 0-5V that corresponds to a pH level between 5-10. A diagram illustrating the water pH monitoring system is shown in Figure B3. It is expected that when the pH level drops below 8, the LED for "below normal" value is turned on to alert the user. Similarly, when pH level is above 9, pH is "above normal" LED indicator is turned on.

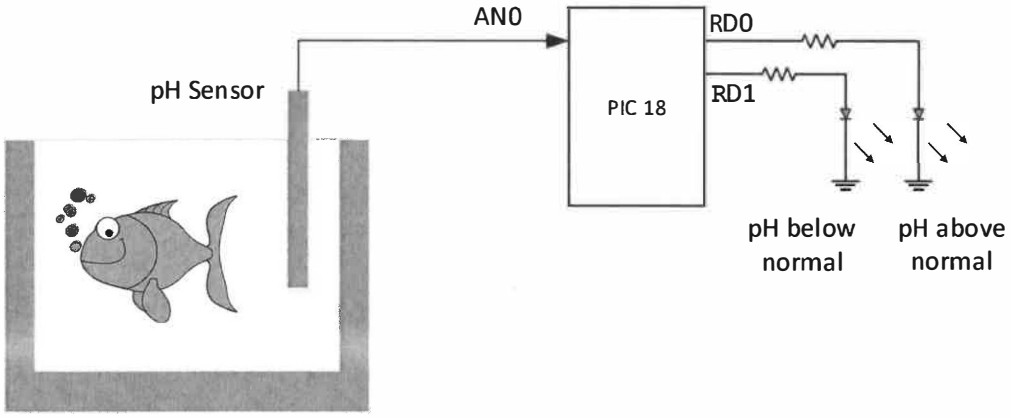


Figure B3.

(a) If the analog output from pH Sensor is 2.78 V, what is the corresponding pH value of the water? (4 marks)

(b) What are the minimum and maximum numbers that can be received from A/D converter (2 marks)

(c) What is the binary equivalent that will be acquired from analog input channel for pH levels 8 and 9? (6 marks)

(d) Part of the program written by an engineer is shown below. What is the purpose of line 9? (2 marks)

(e) Is the result of the A to D conversion left-justified or right-justified? (2 marks)

line	code	comments
1	void main () {	
2	TRISD = 0x00;	//..... Configure output port
3	ADCON0 = 0 b 0 0 0 0 0 0 0 1;	//.... Configure AD channel
4	ADCON1 = 0 b 0 0 0 0 1 1 1 0;	
5	ADCON2 = 0 b 0 0 0 1 0 1 1 0;	
	....	
	....	
7	while(1) {	
8	ADCON0bits.GO = 1;	
9	while (ADCON0bits.GO == 1);	
10	Value1 = ADRESH;	
11	Value0 = ADRESL;	
	...	
	...	
12	}	
13	}	

B4. A chemical mixer system is to be controlled using PIC 18. When user presses the SW1, a DC motor is activated to start mixing after 2 seconds delay. Motor will remain ON as long as user presses the SW1, otherwise motor is turned OFF.

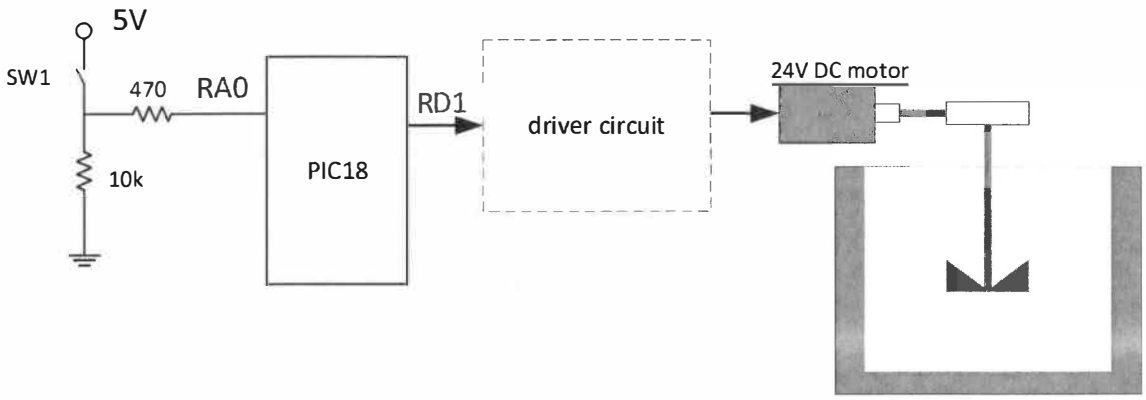


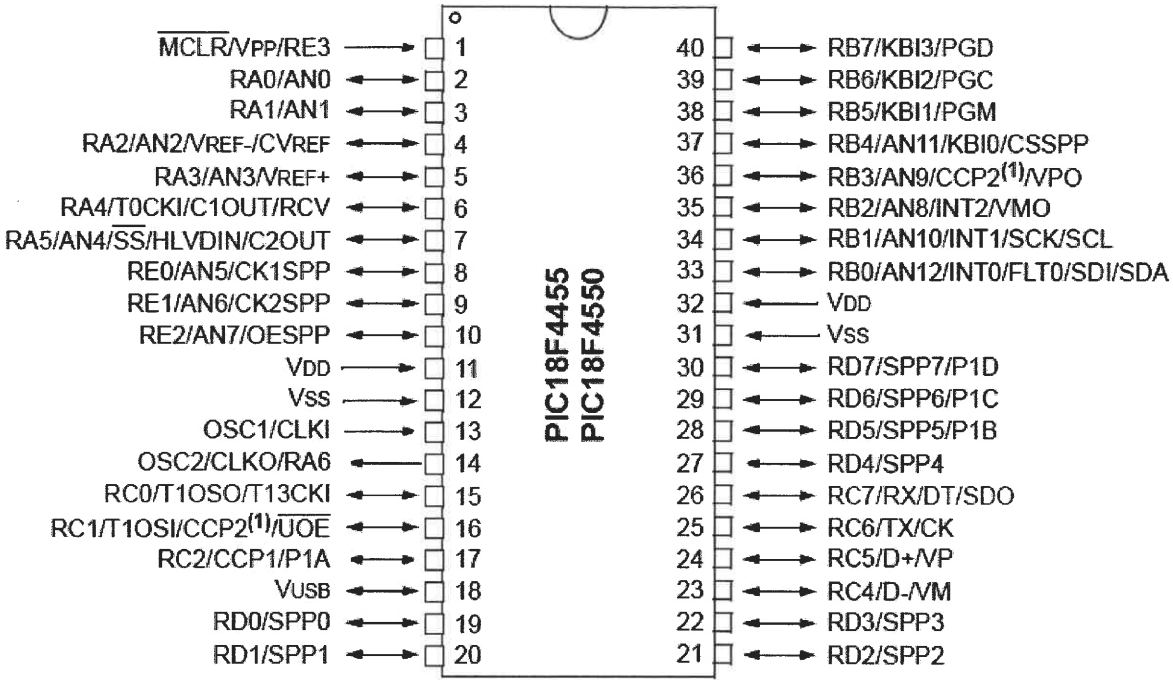
Figure B4.

(a) PIC18 cannot provide the high current and voltage required for the DC motor shown in Figure B4. A separate power source for 24V and a driver circuit is to be used to isolate high power device. Draw the driver circuitry that goes between the output pin from PIC18 to DC motor. (8 marks)

(b) Write the program that can accomplish the task above (10 marks)

```
// configure the pins initialize variables etc.
.....
.....
.....
while (1) {  // check SW1 and generate output to control motor
.....
.....
.....
.....
.....
} // while
```

APPENDIX - PIC18F4550 – 40-pin PDIP – pin diagram



☐ The table below shows which pins can be used as general purpose I/O pins and whether they are, by default (i.e. after power on reset), analogue or digital, input or output.

☐

Port	Available pins	Not available as general purpose I/O (- reasons)	After power on reset
A	RA6-0	RA6 (– oscillator)	RA5, 3-0: Analogue inputs (*). RA4: Digital input.
B	RB7-0	RB4 (– "Boot" button)	RB4-0: Digital / Analogue inputs (#). RB7-5: Digital inputs.
C	RC7-4, 2-0	RC5-4 (– USB connector)	RC7-4, 2-0: Digital inputs.
D	RD7-0		RD7-0: Digital inputs
E	RE3-0	RE3 (– "Reset" button)	RE2-0: Analogue inputs (*). RE3: Digital input.

PIC18F4550 – Analogue to Digital Converter

ADCON1 - The ADCON1 register configures the **voltage references** and the **functions of the port pins**.

U-0	U-0	R/W-0	R/W-0	R/W-0(1)	R/W(1)	R/W(1)	R/W(1)
—	—	VCFG1	VCFG0	PCFG3	PCFG2	PCFG1	PCFG0
bit 7							bit 0

Legend:
R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'
-n = Value at POR '1' = Bit is set '0' = Bit is cleared x = Bit is unknown

bit 7-6 **Unimplemented:** Read as '0'

bit 5 **VCFG1:** Voltage Reference Configuration bit (VREF- source)
1 = VREF- (AN2)
0 = VSS

bit 4 **VCFG0:** Voltage Reference Configuration bit (VREF+ source)
1 = VREF+ (AN3)
0 = VDD

bit 3-0 **PCFG3:PCFG0:** A/D Port Configuration Control bits:

PCFG3: PCFG0	AN12	AN11	AN10	AN9	AN8	AN7(2)	AN6(2)	AN5(2)	AN4	AN3	AN2	AN1	AN0
0000(1)	A	A	A	A	A	A	A	A	A	A	A	A	A
0001	A	A	A	A	A	A	A	A	A	A	A	A	A
0010	A	A	A	A	A	A	A	A	A	A	A	A	A
0011	D	A	A	A	A	A	A	A	A	A	A	A	A
0100	D	D	A	A	A	A	A	A	A	A	A	A	A
0101	D	D	D	A	A	A	A	A	A	A	A	A	A
0110	D	D	D	D	A	A	A	A	A	A	A	A	A
0111(1)	D	D	D	D	D	A	A	A	A	A	A	A	A
1000	D	D	D	D	D	D	A	A	A	A	A	A	A
1001	D	D	D	D	D	D	D	A	A	A	A	A	A
1010	D	D	D	D	D	D	D	D	A	A	A	A	A
1011	D	D	D	D	D	D	D	D	D	A	A	A	A
1100	D	D	D	D	D	D	D	D	D	D	A	A	A
1101	D	D	D	D	D	D	D	D	D	D	D	A	A
1110	D	D	D	D	D	D	D	D	D	D	D	D	A
1111	D	D	D	D	D	D	D	D	D	D	D	D	D

A = Analog input D = Digital I/O

ADCON0 - The ADCON0 register controls the **operation of the A/D module**.

U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	CHS3	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	ADON
bit 7							bit 0

Legend:
R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'
-n = Value at POR '1' = Bit is set '0' = Bit is cleared x = Bit is unknown

bit 7-6 **Unimplemented:** Read as '0'

bit 5-2 **CHS3:CHS0:** Analog Channel Select bits
0000 = Channel 0 (AN0)
0001 = Channel 1 (AN1)
0010 = Channel 2 (AN2)
0011 = Channel 3 (AN3)
0100 = Channel 4 (AN4)
0101 = Channel 5 (AN5)
0110 = Channel 6 (AN6)
0111 = Channel 7 (AN7)
1000 = Channel 8 (AN8)
1001 = Channel 9 (AN9)
1010 = Channel 10 (AN10)
1011 = Channel 11 (AN11)
1100 = Channel 12 (AN12)

bit 1 **GO/$\overline{\text{DONE}}$:** A/D Conversion Status bit
When ADON = 1:
1 = A/D conversion in progress
0 = A/D Idle

bit 0 **ADON:** A/D On bit
1 = A/D converter module is enabled
0 = A/D converter module is disabled

ADCON2 - The ADCON2 register configures the **A/D clock source**, **programmed acquisition time** and **justification**.

R/W-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
ADFM	—	ACQT2	ACQT1	ACQT0	ADCS2	ADCS1	ADCS0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7 **ADFM:** A/D Result Format Select bit
1 = Right justified
0 = Left justified

bit 6 **Unimplemented:** Read as '0'

bit 5-3 **ACQT2:ACQT0:** A/D Acquisition Time Select bits
111 = 20 TAD
110 = 16 TAD
101 = 12 TAD
100 = 8 TAD
011 = 6 TAD
010 = 4 TAD
001 = 2 TAD
000 = 0 TAD

bit 2-0 **ADCS2:ADCS0:** A/D Conversion Clock Select bits
111 = FRC (clock derived from A/D RC oscillator)
110 = FOSC/64
101 = FOSC/16
100 = FOSC/4
011 = FRC (clock derived from A/D RC oscillator)
010 = FOSC/32
001 = FOSC/8
000 = FOSC/2

- End of Paper -