MICROCONTROLLER APPLICATONS /

ENGINEERING DESIGN & BUSINESS PROJECT II

2018/2019 SEMESTER TWO 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 - 5 Questions, 14 marks each.
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. What is a microcontroller?

(a) A microcontroller is any device that can provide intelligent control in a system.
(b) A microcontroller is an integrated circuit with a fixed program running in it.
(c) A microcontroller is small computer on a single integrated circuit.
(d) A microcontroller is a microprocessor.

A2. Which of the following is NOT true of PIC18F4550 ADC?

(a) The conversion result can be left-justified or right-justified.
(b) More than one analogue input channel can be converted at the same time.
(c) The reference voltages can be selected.
(d) The acquisition time is selectable.

A3. Which of the following packages would you choose to prototype a PIC18-based circuit on a breadboard?

(a) SPDIP (Skinny Plastic Dual-In-Line).
(b) TQFP (Thin Quad Flat Pack).
(c) QFN (Quad Flat No-lead).
(d) SO (Small Outline).

A4. What is a transducer?

(a) A transducer converts an analogue voltage into a binary bit pattern.
(b) A transducer samples and holds an input voltage for conversion.
(c) A transducer converts a physical quantity into an electrical quantity.
(d) A transducer is a digital to analogue converter.

A5. Using 5V & ground as the reference voltages, a 10-bit analogue to digital converter would convert a 3V input to

(a) $(1 / 5) \times (2^{10} - 1)$
(b) $(2 / 5) \times (2^{10} - 1)$
(c) $(5 / 3) \times (2^{10} - 1)$
(d) $(3 / 5) \times (2^{10} - 1)$

A6. An active low push button switch _____.

(a) gives a logic '0' when released
(b) gives a logic '1' when pressed
(c) can be connected as an input to a microcontroller
(d) can be connected as an output to a microcontroller

A7. To indicate the water level in a drain, which one of the following devices is suitable?

(a) A buzzer
(b) An LED bar
(c) An LED
(d) A solenoid

A8. Referring to the PIC18F4550 microcontroller pin diagram in the Appendix, at which pins should a crystal oscillator be connected, in order to supply a clock signal to the microcontroller?

(a) Pins 1 and 21
(b) Pins 13 and 14
(c) Pins 11 and 32
(d) Pins 23 and 24

A9. A compiler _____

(a) converts a high level language e.g. C-language program into machine code.
(b) converts an assembly language program into machine code.
(c) allows a program to be simulated on a PC before it is run on a microcontroller.
(d) converts machine code into a high level language e.g. C-language program.

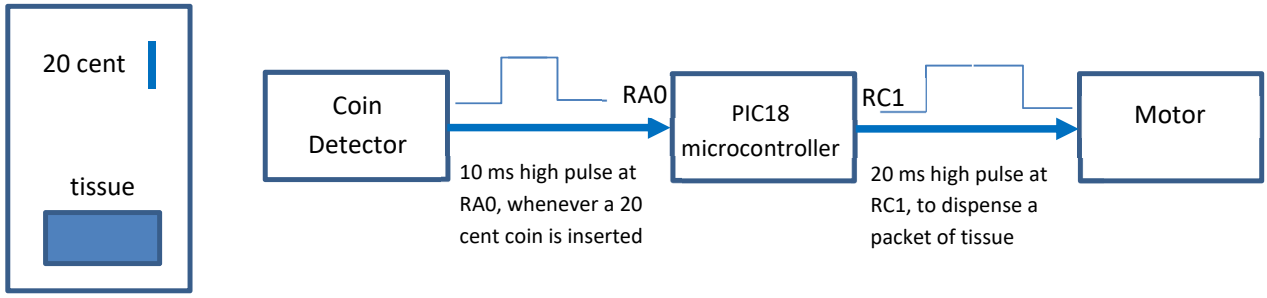
A10. Which line of code below can be used to write a logic 1 to RB5 (Port B, Bit 5), without affecting other bits of Port B?

(a) PORTB = 0xFF;
(b) PORTBbits.RB5 = 0;
(c) PORTB = 0b00100000;
(d) PORTB = PORTB | 0b00100000;

SECTION B

SHORT QUESTIONS [14 marks each]

B1. A tissue vending machine inside a public washroom charges 20 cent for a packet of tissue. It only accepts 20 cent coin and cannot give change.



The "coin detector" in the machine produces a 10ms high pulse at RA0 pin of the PIC18 microcontroller whenever a 20 cent coin is inserted. To dispense a packet of tissue, the PIC18 microcontroller has to produce a 20ms high pulse at its RC1 pin, which is connected to a motor.

(a) Write the C code to make RA0 an input pin. (2 marks)

(b) Write the C code to make RC1 an output pin. (2 marks)

(c) Write the C code to check if RA0 is high. (2 marks)

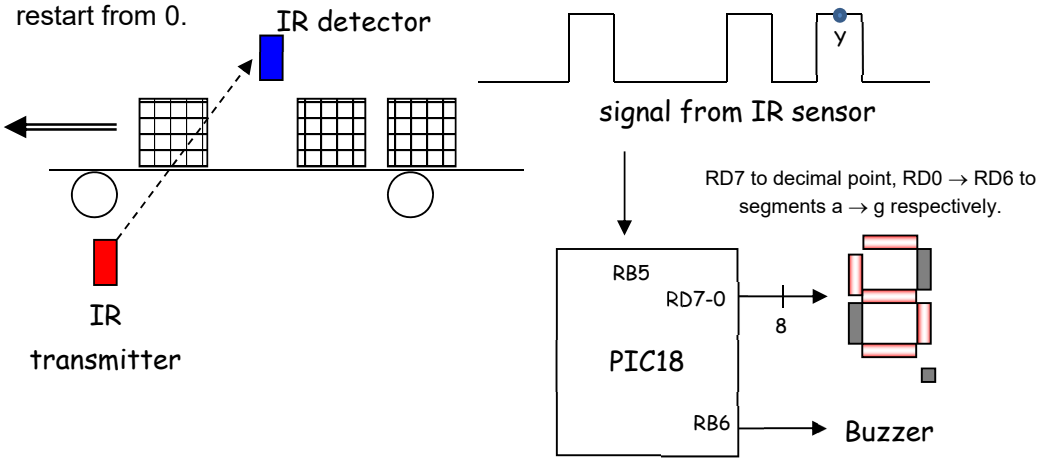
(d) Given that delay_ms(k) where 0 < k < 255 produces a delay of k millisecond, write the lines of C code to produce a 20ms high pulse at RC1. (4 marks)

(e) Using the answers to parts (a) to (e), write the C code for the tissue vending machine, such that a packet of tissue is dispensed whenever a 20 cent coin is inserted. You can use the following outline. (4 marks)

```
// configure the pins
__ ?? __
__ ?? __

while (1) {
  if ( ___ ?? ___ ) {  // if 20 cent coin is inserted
     __ ?? __          //   turn on the motor
     __ ?? __          //   delay for 20 ms
     __ ?? __          //   turn off the motor
  } // if
} // while
```

B2. In a factory, the boxes moving on a conveyor belt are detected using an Infra-Red sensor and counted by a PIC18 microcontroller. The count (0-5) is displayed on a 7-segment display. Whenever the count reaches 5, a buzzer will beep and the count will restart from 0.

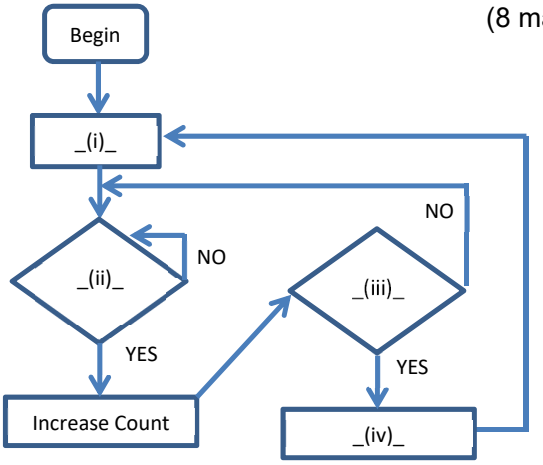


(a) Assuming common cathode 7-segment display is used (i.e. '1' = ON), what is the code that will display the number '3' (with the decimal point turned off)?

PORTD = 0b_____ ; (2 marks)

(b) A number of 470-ohm resistors are often used with the 7-segment display. Give a reason for using these resistors. (2 marks)

(c) The flowchart for programming the PIC18 is given below. Complete it using these words: Beep Buzzer Box detected? Count = 0 Count=5? Indicate your answers in the answer booklet as (i) your answer… (8 marks)

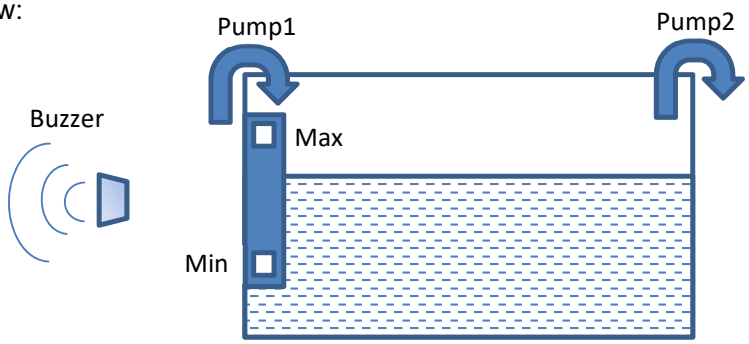


(d) An engineer has written the code to detect & count the boxes as:

```
while(PORTBbits.RB5==0); // wait for IR signal to go high
while(PORTBbits.RB5==1); // wait for IR signal to go low
Count++; // increment count
```

What is the value of the variable Count at point y in the timing waveform above, assuming initial value of 0 for Count? (2 marks)

B3. A PIC18 microcontroller-based "water level monitoring" system is used in a fish tank, as shown below:



When the water level is too high (i.e. Max == 1), Pump2 is turned on (Pump2 = 1) to pump away the excess water. When the water level is too low (i.e. Min == 0), Pump1 is turned on (Pump1 = 1) to add water to the tank. Whenever Pump1 or Pump2 is turned on, the buzzer will also be activated, to alert the owner.

The microcontroller pins used for connecting to the I/O devices are shown below:

Max (sensor)	RA3	Active high
Min (sensor)	RA4	Active high
Pump1	RD1	Active high
Pump2	RD2	Active high
Buzzer	RD0	Active high

The water level sensors (Max & Min) can be created from 2 metal strips placed very close to one another, so that the presence of water will short the strips, resulting in a closed circuit between points 1 and 2.

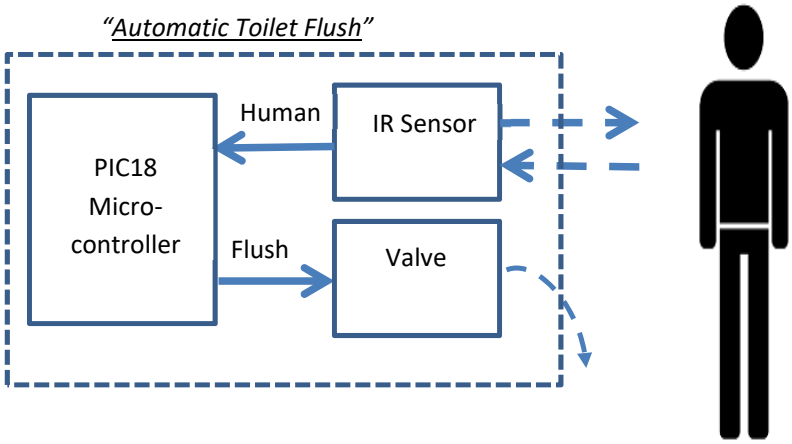
(a) Draw the circuit diagram of a water level sensor. Include Vcc, Ground and a 10k resistor in your circuit. (4 marks)

(b) Write the codes to configure Port A bits 3 and 4 as inputs, and Port D bits 0, 1 and 2 as outputs. (4 marks)

(c) Write the codes (in your answer booklet) to check the water level and to switch the pumps and buzzer on/off (as appropriate), for the "water level monitoring" described above. (6 marks)

```
while(1) { // loop forever
                        // if water level too high
                        //   on Pump2, off Pump1, on Buzzer
                        // else if water level too low
                        //   …
                        // else
                        // …
}
```

B4. An "automatic toilet flush" is used in a hotel washroom. When a person approaches the urinal (Human==1), the PIC18 microcontroller will set Flush=1 (so that the valve will open) for 2 seconds. This is called "pre-flush". When the person leaves (Human==0), the controller will again set Flush =1, this time for 5 seconds. The C-program used is shown in outline form below.



line	code	comments
1	void main () {	
2	…	// ….. set pins as input/output here
3	while(1) {	
4	while (Human==0);	// Human defined as PORTAbits.RA0
5	Flush = 1;	// Flush defined as PORTAbits.RA1
6	Delay2sec ( );	// a delay function
7	Flush = 0;	
8	while (Human==1);	
9	Flush = 1;	
10	Delay5sec ( );	// another delay function
11	Flush = 0;	
12	}	
13	}	

(a) What is the purpose of line 3? (2 marks)

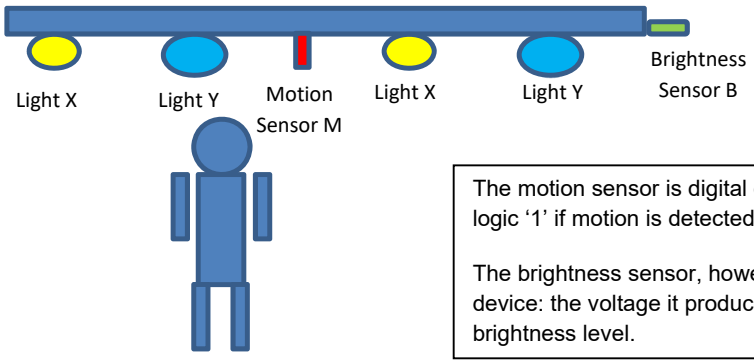
(b) Which 3 lines are "pre-flush"? (2 marks)

(c) What is the purpose of line 8? (2 marks)

(d) Given that delay_ms(100); will give a delay of 0.1 sec, write the "for loop" to produce a delay of 2 second for the Delay2sec function. (4 marks)

(e) There is some complaint that the pre-flush is a waste of water, while the "post-flush" of 5 seconds is longer than necessary. Suggest the changes to be made to the code, to save some flushing water. (4 marks)

B5. In a covered activity area, 2 sets of lights, X and Y, are installed.



The motion sensor is digital device which gives a logic '1' if motion is detected and '0' otherwise.

The brightness sensor, however, is an analogue device: the voltage it produces increases with the brightness level.

A motion sensor, M, and a brightness sensor, B, are used with a PIC18 microcontroller to add intelligence to the lighting system. The PIC18 program is given in outline form below. Study the program and answer the questions which follow.

```
main (void)
{
  TRISD = 0x00;
  TRISA = 0xFF;
  ADCON0 = 0 b 0 0 0 0 0 0 0 1;
  ADCON1 = 0 b 0 0 0 0 1 1 1 0;
  ADCON2 = 0 b 1 0 0 1 0 1 1 0;
  while (1)
    {
    ADCON0bits.GO = 1;
    while (ADCON0bits.GO == 1);
    if (ADRESH < 0b00000010) { // it is dark
      if (PORTAbits.RA1==1) // and motion is detected
        PORTD = 0xFF; // on all lights i.e. sets X & Y
      else
        PORTD = 0x0F; // on set X lights only
      }
    else
      PORTD = 0x00; // off all lights i.e. sets X & Y
    }
}
```

(a) Which AD channel (AN0 to AN12) is used for the brightness sensor B? (2 marks)

(b) What are the reference voltages used for the ADC i.e. Vref- = __, Vref+ = __? (2 marks)

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

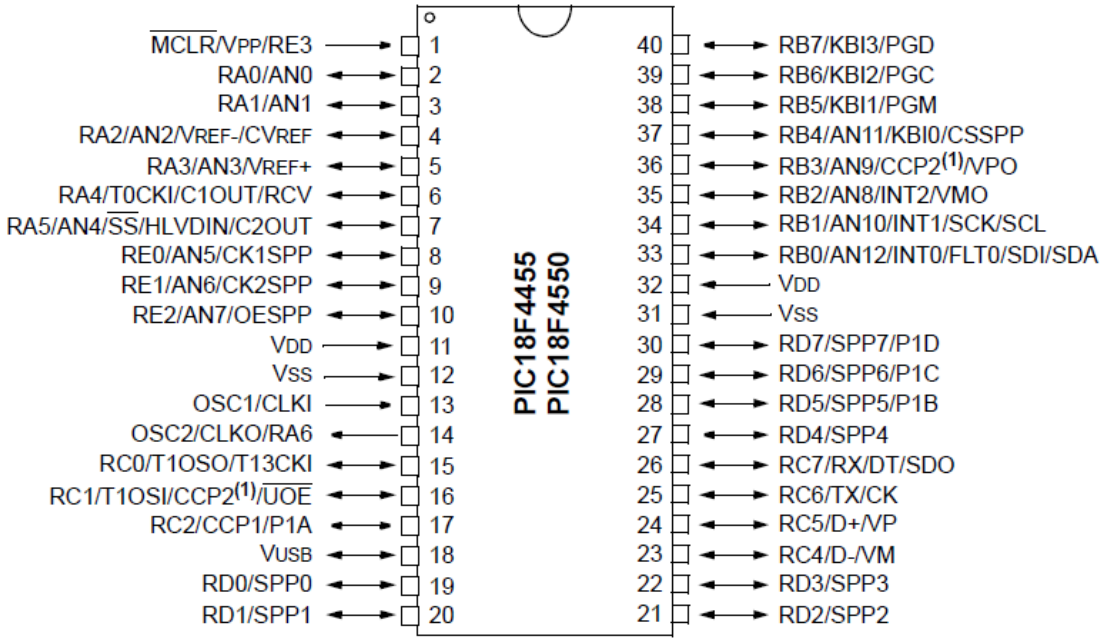
(d) What is the purpose of the statement below? (2 marks)

while (ADCON0bits.GO == 1);

(e) Based on the ADCON0 to ADCON2 settings, if the brightness sensor B gives a voltage of 1 volt, what will be the value in ADRESH once conversion is finished? (4 marks)

(f) Which set of lights will be turned on if it is bright and motion is detected? (2 marks)

APPENDIX - PIC18F4550 – 40-pin PDIP – pin diagram



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 -