SINGAPORE POLYTECHNIC ET1010

SAMPLE MID-SEMESTER TEST

Diploma in Aerospace Electronics (DASE)
Diploma in Computer Engineering (DCPE)
Diploma in Engineering with Business (DEB)
Diploma in Electrical & Electronic Engineering (DEEE)
Diploma in Mechatronics and Robotics (DMRO)

SAS code: **MST**

2nd Year Full-Time

MICROCONTROLLER APPLICATONS 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 - 12 Multiple Choice Questions, 3 marks each.

   Section B - 4 Questions, 16 marks each (total 64 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 12 pages (including 3 pages in the Appendix).
6. The question paper must be submitted together with the answer booklet at the end of this MST session.

SECTION A

MULTIPLE CHOICE QUESTIONS [3 marks each]

1. Please tick the correct answer in the boxes provided for each question onto the Multiple Choice Questions Answer Sheet.

2. No marks will be deducted for incorrect answers.

A1. A microcontroller _____

(a) is usually used in systems that require complex computation.
(b) has large RAM space.
(c) is a small computer with built in memory, timers, and I/O ports.
(d) usually comes with hard disk access.

A2. Consider the program piece below:

```
TRISBbits.TRISB1 = 0;
PORTBbits.RB1 = 0;
```

Which one of the following describes its' purpose?

(a) To reset PORTB bit1.
(b) To set PORTB bit 1 analog input.
(c) To set PORTB bit 1 output and place logic "0" as output.
(d) To set PORTB bit 1 analog output and place 0 volt as output.

A3. Which one of the following is a feature of PIC18F4550 microcontroller?

(a) 32 Mbyte flash memory
(b) 12 bit ADC
(c) Wireless communication
(d) USB for connectivity

A4. In microcontroller terminology, which of the following is correct for MIPS?

(a) Mega information per second
(b) Million instruction per second
(c) Maximum input per second
(d) It has no meaning.

A5. Using Vref+=5V and Vref-=0 V, the input signal amplitude present at the 10-bit analog input pin of PIC18 is 1.12 V. What value is ADC going to return for this signal?

(a) 228
(b) 230
(c) 229.15
(d) 229

A6. In the following motor interface circuit, what should be the output signal at RD0 in order to turn motor ON?

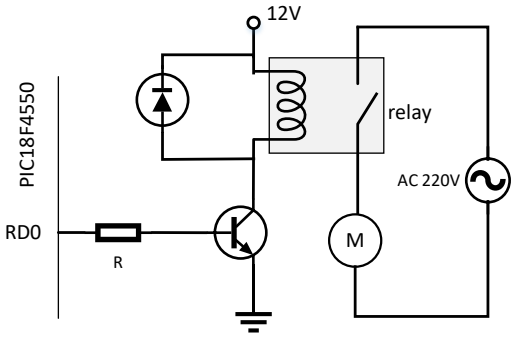


Figure A6.

(a) Logic 1
(b) Logic 0
(c) PWM
(d) A 50Hz square wave

A7. What is achieved with the following program lines?

```
...
unsigned char A=0b00010100;
A=A<<1;
...
```

(a) Value in A is cleared.
(b) Value in A is incremented by one.
(c) Value in A is decremented by one.
(d) Value in A is multiplied by 2.

A8. What is the purpose of a sample and hold circuit in analog to digital conversion process shown in Figure A8?

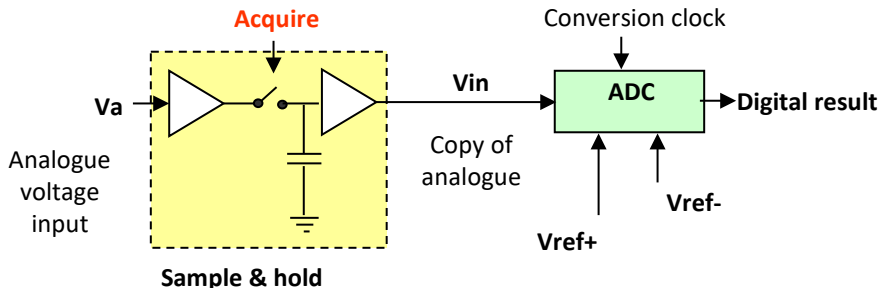


Figure A8.

(a) It is a low pass filter and it eliminates noise in the signal.
(b) It shortens the capturing process so that time is not wasted during conversion.
(c) It keeps the sampled signal at the input of ADC so that it has enough time to convert.
(d) None of the above.

A9. What is the configuration achieved with the following program line?

```
…
ADCON1=0b00001110;
…
```

(a) Vref+=5V,Vref-=0V, pin AN0 is configured as analog pin.
(b) Vref+=0V,Vref-=5V, pin AN0 is configured as analog pin.
(c) Vref+=5V,Vref-=0V, pin AN1 is configured as analog pin.
(d) Vref+=0V,Vref-=5V, pin AN1 is configured as analog pin.

A10. A new generation microcontroller has 12-bits ADC unit and uses reference voltages V_{ref+}= 3.3V and V_{ref-}= 0V. If the ADC conversion result is 0x01FF what is the input signal amplitude?

(a) -0.455V
(b) 0.411 V
(c) -0.73 V
(d) 0.655 V

A11. Based on the following program piece and circuit connections, which LEDs are going to be lit up?

```
unsigned char val, num;
TRISD=0x00;
…
val=0b00010100;
num=val>>2;
PORTD=num;
```

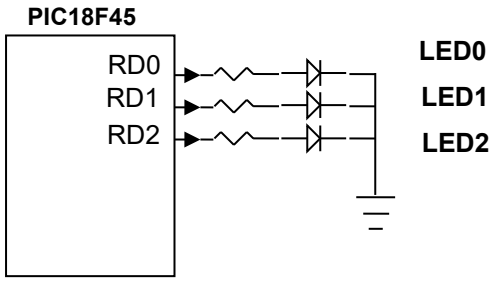


Figure A11.

(a) LED 0 and LED1
(b) LED 0 and LED2
(c) LED 1 and LED2
(d) LED 1 only

A12. Refer to circuit given at Figure A11 and the following program piece. What is the outcome of if-else statement?

```
unsigned char num;
TRISD=0x00;
…
num=0b00010100;
…
if (~num > 0x0F)PORTD=0x00;
else PORTD=0x07;
```

(a) All the LEDs are turned ON.
(b) All the LEDs are turned OFF.
(c) Program will stuck in if-else statement.
(d) Only LED1 will be ON.

SECTION B

SHORT QUESTIONS [Total 64 marks, 16 marks each]

B1. A seven segment display module designed for a PIC18 microcontroller is shown in Figure B1a.

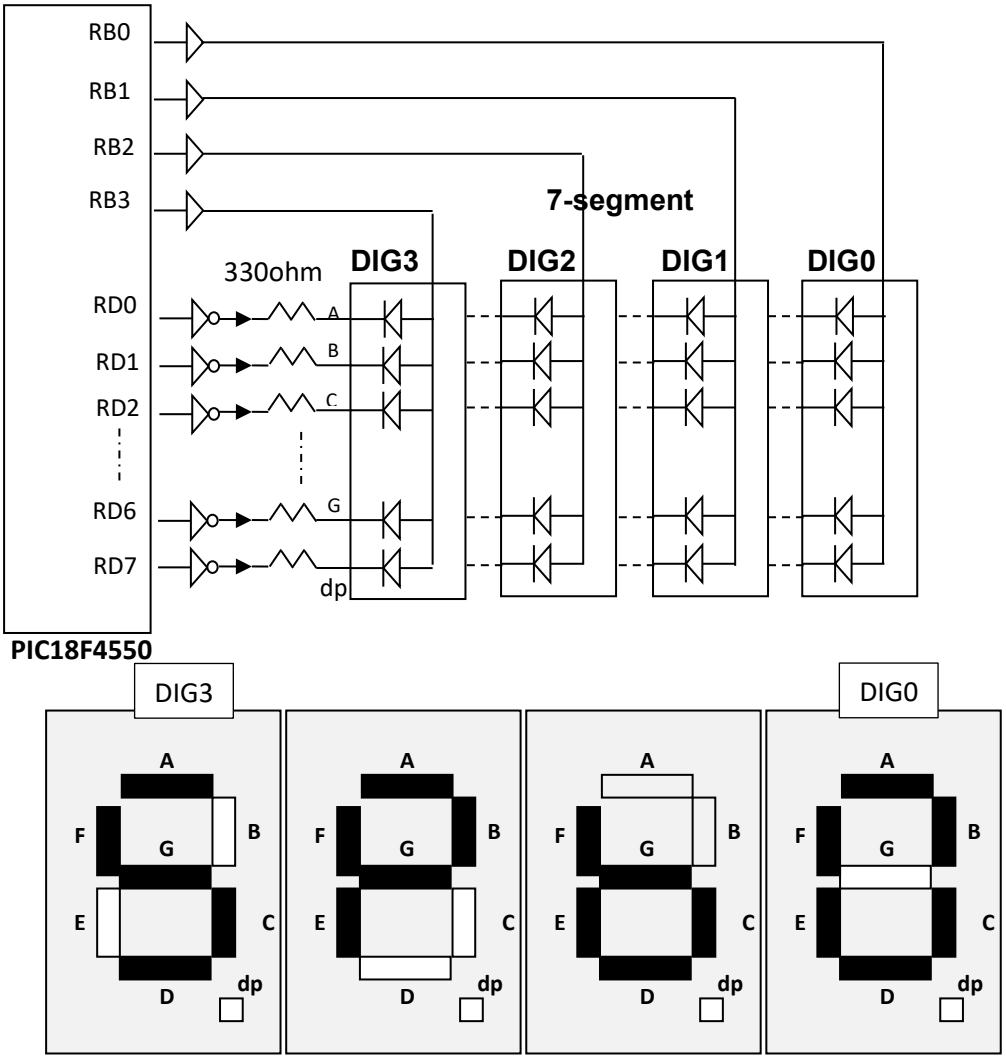


Figure B1a

(a) Assuming voltage drop across an LED is 1.8V, estimate the maximum possible current that may be demanded for the LEDs at any given time considering the circuit diagram show in Figure B1a. (4 marks)

(b) Complete the program shown in Figure B1b in order to display SP60 on seven-segment displays. (12 marks)

```
#include <xc.h>
#include "delays.h"
void main(void)
{
 _____________     //Configure PORTB RB3 to RB0 as output      2 marks

 _____________     // Configure PORTD RD0 to RD7 as output      2 marks

 while(1)          //repeat
 {
  _____________    //enable DIG0
  _____________    //display 0                                 2 marks
  delay_ms(10);    //delay for a while

  _____________    //enable DIG1
  _____________    //display 6                                 2 marks
  delay_ms(10);    //delay for a while

  _____________    //enable DIG2
  _____________    //display p                                 2 marks
  delay_ms(10);    //delay for a while

  _____________    //enable DIG3
  _____________    //display S                                 2 marks
  delay_ms(10);    //delay for a while
 }
}
```

Figure B1b.

B2. A new LCD module is to be used with PIC18 microcontroller. LCD Manufacturers' technical datasheet provides time diagram and necessary signal handshakes for LCD to accept a control command from microcontroller as shown in Figure B2. Manufacturers define critical time periods as t_a=150μsec, t_b=70μsec, t_c=100μsec and t_d as minimum 140μsec for a correct operation. Answer the following questions accordingly.

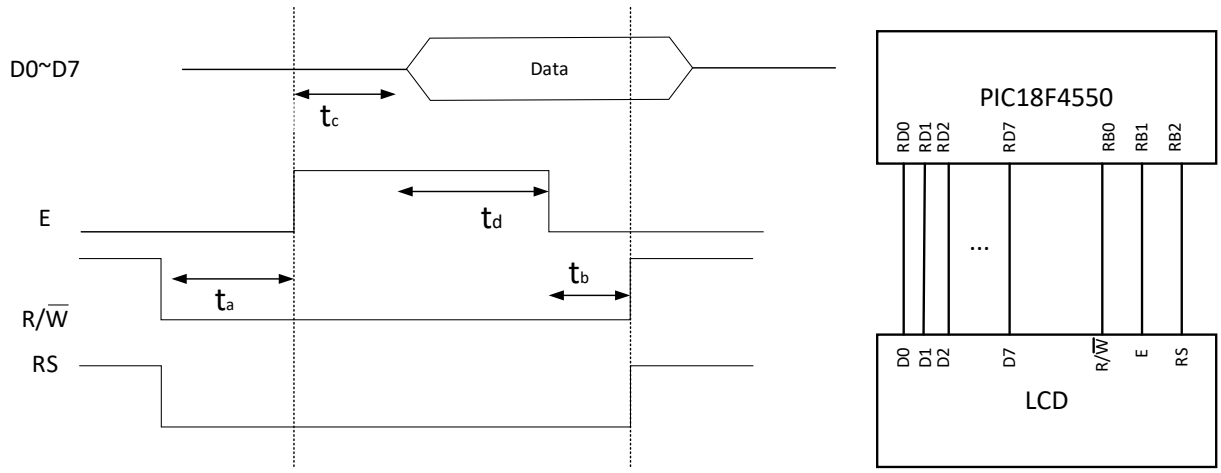


Figure B2.

(a) For PIC18F4550 PORTD and RB0—RB2 in the circuit diagram shown in Figure B2, list down the input pin(s) and output pin(s). (3 marks)

(b) Microcontroller and LCD interfacing circuit uses eight I/O pins for data communication. Discuss what are the advantages and disadvantages of such arrangement. (3 marks)

(c) A function that receives a char value as argument and sends it to LCD is given below. Complete the missing program lines based on the comments on the right.

Code	**Comments**	
void LCD_command (char A) {		
TRISB = _____ ;	// Configure PORTB	(1 mark)
TRISD = _____ ;	// Configure PORTD	(1 mark)
…		
_____ ;	// Make RS LOW	(1 mark)
_____ ;	// Make R/W LOW	(1 mark)
delay_us(_____) ;	// Wait for duration **ta**	(1 mark)
_____ ;	// Make E HIGH	(1 mark)
delay_us(_____) ;	// Wait for duration **tc**	(1 mark)
_____ ;	// write command to PORTD	(2 marks)
delay_us(_____) ;	// Wait for duration **td**	(1 mark)
…		
}		

B3. An automated paint machine is to be designed to achieve uniform spray painting of manufactured parts. A block diagram of the desired system is shown in Figure B3. Paint nozzle makes linear motions with the help of left and right motors. Motor L moves nozzle to the left and Motor R moves nozzle to the right. Spray paint is controlled by turning solenoid valve ON and OFF. Painting should start with nozzle at far left. Nozzle should travel back and forth 3 times before completing the operations.

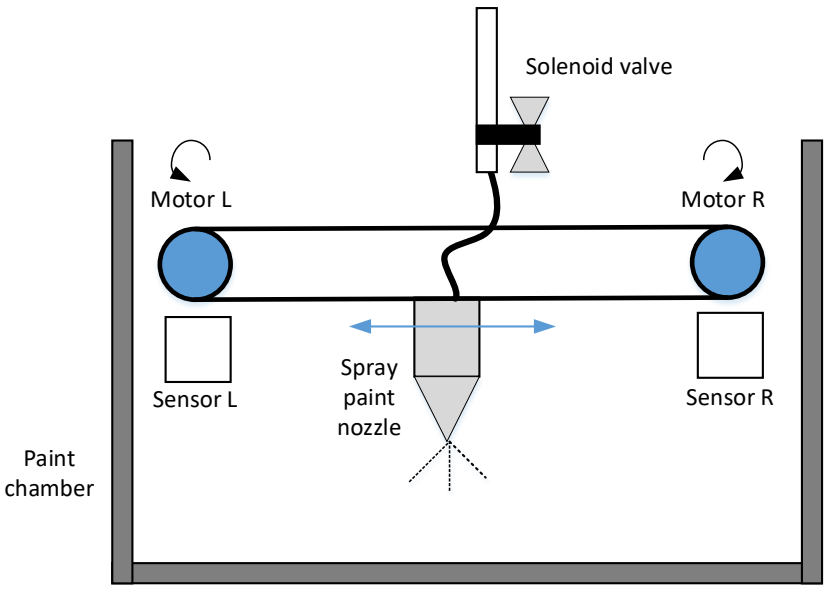


Figure B3.

(a) In order to detect nozzle position on both sides, you are given two sensor options: an optical sensor or a mechanical limit switch. Which one would you chose for this system and why? (2 marks)

Limit switch

optical sensor

(b) What is the number of input/output pins required from microcontroller to interface all the components of the system? (2 marks)

(c) What are the potential failures to the system and what hardware/software precautions would you take to prevent them? Give two examples. (4 marks)

(d) Draw the flow chart of operations to control this system as described. (8 marks)

B4. Block diagram of an industrial pressure tank is shown in Figure B4a. In this system, a pressure sensor shows the inner pressure of the tank. The output of the sensor is analog signal and it is proportional to the pressure as shown in Figure B4a. Pressure tank also contains a relief valve which can be activated to reduce the high pressure accumulating inside the tank if it is at the critical level of 115 psi. Answer the following questions accordingly.

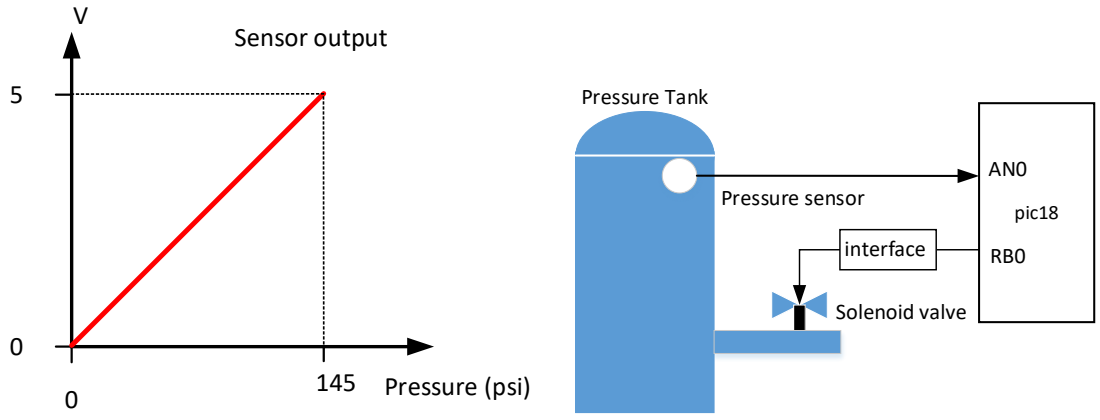


Figure B4a.

(a) At the critical pressure level of 115 psi, what will be the analog voltage at the AN0 input? (2 marks)

(b) What will be the 10-bit conversion result from ADC unit of PIC18 for the critical pressure? (2 marks

(c) Draw the circuit diagram of the interface circuit between RB0 and solenoid valve. (4 marks)

(d) Draw the flow chart of the pressure control operation. (6 marks)

(e) The pressure sensor in Figure B4a is replaced with a new one and its characteristic is as shown in Figure B4b. What are the potential problems we may face? How can we tackle them? (2 marks)

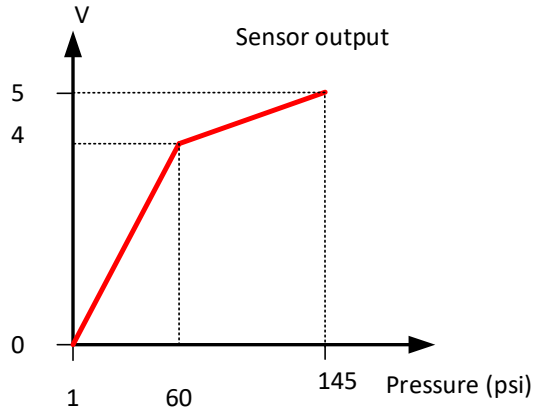
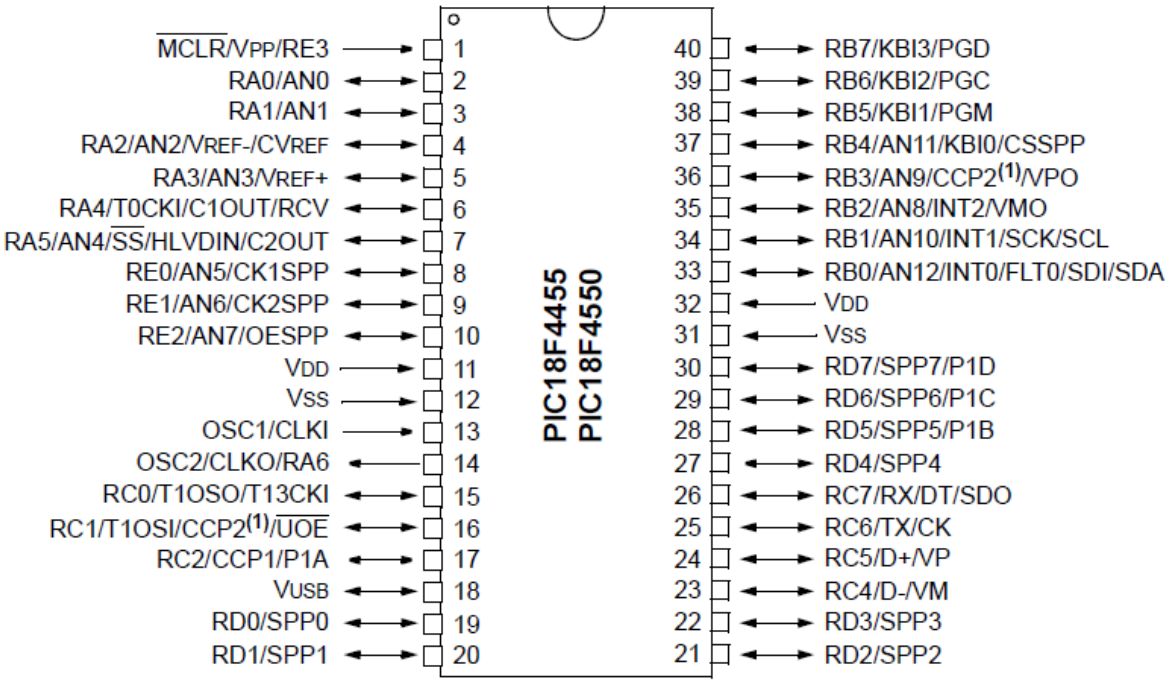


Figure B4b.

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

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

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 (V_{REF-} source)
1 = V_{REF-} (AN2)
0 = V_{SS}

bit 4 **VCFG0:** Voltage Reference Configuration bit (V_{REF+} source)
1 = V_{REF+} (AN3)
0 = V_{DD}

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

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 -