SULIT

KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN ELEKTRIK

PEPERIKSAAN AKHIR

SESI I : 2024/2025

DEC40053: EMBEDDED SYSTEM APPLICATIONS

TARIKH : 08 DISEMBER 2024
MASA : 8.30 PAGI – 10.30 PAGI (2 JAM)

Kertas soalan ini mengandungi **SEMBILAN (9)** halaman bercetak.
Bahagian A: Subjektif (3 soalan)
Bahagian B: Esei (2 soalan)
Dokumen sokongan yang disertakan : *PIC18 Data Sheet*

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

SECTION A: 60 MARKS
BAHAGIAN A: 60 MARKAH

INSTRUCTION:
This section consists of **THREE (3)** subjective questions. Answer **ALL** questions.

ARAHAN:
*Bahagian ini mengandungi **TIGA (3)** soalan subjektif. Jawab **SEMUA** soalan.*

QUESTION 1
SOALAN 1

CLO1 (a) By using a suitable example, discuss the function of LATx register using bit addressability instruction in PIC18.

Dengan menggunakan contoh sesuai, bincangkan fungsi daftar LATx menggunakan arahan pengalamatan bit dalam PIC18.

[4 marks]
[4 *markah*]

CLO1 (b) One (1) temperature sensor, one (1) limit switch and two (2) infra-red (IR) sensors are connected to PIC18 at pin RA0, RB1, RC2 and RD3. Two (2) buzzers and two (2) solenoids are connected to pin RA4, RB5, RC6 and RD7. Using a bit addressability mode, write the instruction to initialize corresponding PIC18 pins as input output.

Satu (1) penderia suhu, satu (1) suis penghad dan dua (2) penderia infra-merah (IR) disambungkan ke PIC18 pada pin RA0, RB1, RC2 dan RD3. Dua (2) pembaz dan dua (2) solenoid disambungkan ke pin RA4, RB5, RC6 dan RD7. Menggunakan mod pengalamatan bit, tuliskan arahan untuk memulakan pin PIC18 berkaitan sebagai masukan keluaran.

[8 marks]
[8 *markah*]

CLO1

(c) Timer0 in PIC18 is used to produce 3.072 s time delay. It uses XTAL = 4 MHz and setting for T0CON = 0x07. From this information, calculate the value for register TMR0H and TMR0L. After that, change the value for TMR0H and TMR0L and calculate the largest time delay for this timer.

Timer0 dalam PIC18 digunakan untuk menghasilkan lengah masa 3.072 s. Ia menggunakan XTAL = 4 MHz dan tetapan untuk T0CON = 0x07. Dari maklumat ini, kira nilai daftar TMR0H dan TMR0L. Selepas itu, tukar nilai TMR0H dan TMR0L dan kira lengah masa terpanjang bagi pemasa ini.

[8 marks]
[8 *markah*]

QUESTION 2
SOALAN 2

CLO1

(a) Discuss the function of TMR0IF (TMR0 Overflow Interrupt Flag) bit in INTCON register for Timer0 8-bit and 16-bit operation.

Bincangkan fungsi bit TMR0IF (TMR0 Overflow Interrupt Flag) dalam daftar INTCON untuk operasi Timer0 8-bit dan 16-bit.

[4 marks]
[4 *markah*]

CLO1

(b) Write C instructions for PIC18 to initialize INT2 external hardware interrupt and its Interrupt Service Routine (ISR).

Tulis arahan C untuk PIC18 memulakan sampukan perkakasan luaran INT2 dan Interrupt Service Routine (ISR) miliknya.

[8 marks]
[8 *markah*]

CLO1 (c) Write C instructions for PIC18 to initialize Timer0 counter interrupt and its Interrupt Service Routine (ISR).

Tulis arahan C untuk PIC18 memulakan sampukan pembilang Timer0 dan Interrupt Service Routine (ISR) miliknya.

[8 marks]
[8 *markah*]

QUESTION 3
SOALAN 3

CLO1 (a) Based on Figure A3 (a), discuss the instructions to enable INT0 and INT1 external hardware interrupt in PIC18.

Berdasarkan Rajah A3 (a), bincangkan arahan untuk membenarkan sampukan perkakasan luaran INT0 dan INT1 dalam PIC18.

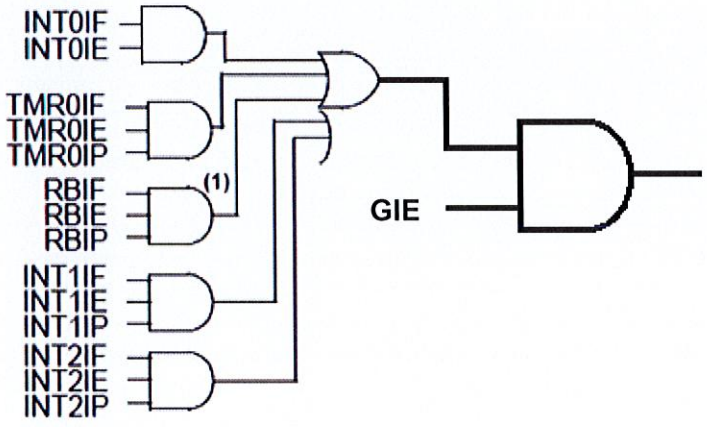

Figure A3 (a) / *Rajah A3 (a)*

[5 marks]
[5 *markah*]

CLO1

(b) Based on Figure A3 (b), discuss the steps to switch on LED for both active high and active low connection to PIC18 GPIO.

Berdasarkan Rajah A3 (b), bincangkan langkah untuk mensuis hidupkan LED pada kedua-dua sambungan aktif tinggi dan aktif rendah pada GPIO PIC18.

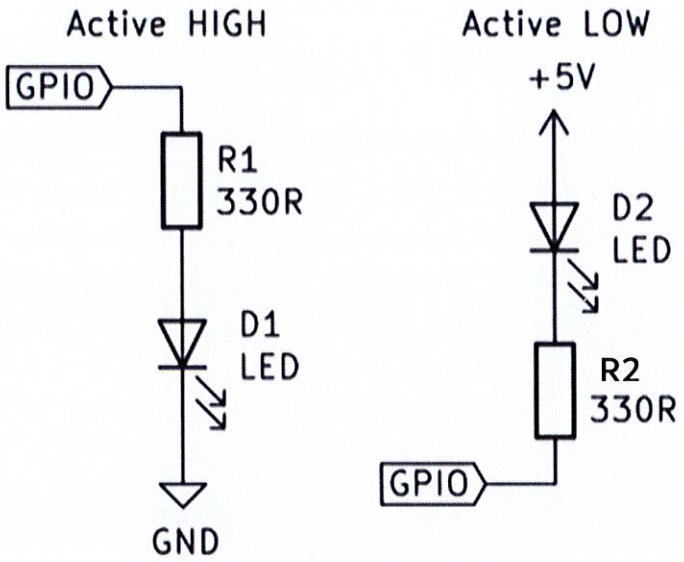

Figure A3 (b) / *Rajah A3 (b)*

[5 marks]

[5 *markah*]

CLO1

(c) LM35 shown in Figure A3 (c) is used as analog input for ADC in PIC18. This 12-bit ADC is used with settings of Vref- = 0 V and Vref+ = 4.096 V. Based on the information given, calculate ADC output, Dout if output from LM35 is 15°C and 45°C.

LM35 ditunjukkan dalam Rajah A3 (c) digunakan sebagai masukan analog untuk PIC18. ADC 12-bit ini digunakan dengan Vref- = 0 V dan Vref+ = 4.096 V. Berdasarkan maklumat yang diberi, kira keluaran ADC, Dout jika keluaran dari LM35 ialah 15°C and 45°C.

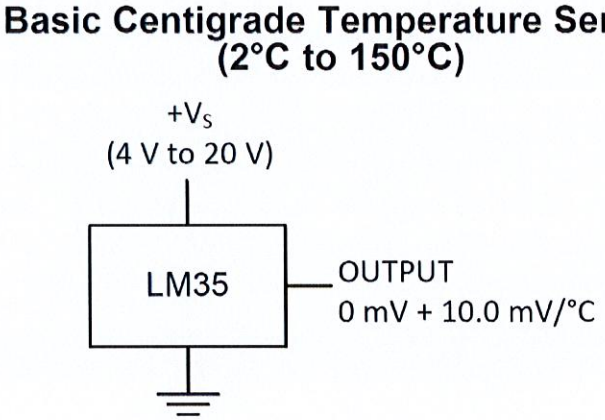

Figure A3 (c) / *Rajah A3 (c)*

[10 marks]

[10 *markah*]

SECTION B: 40 MARKS
BAHAGIAN B: 40 MARKAH

INSTRUCTION:
This section consists of **TWO (2)** essay questions. Answer **ALL** questions.

ARAHAN:
*Bahagian ini mengandungi **DUA (2)** soalan esei. Jawab **SEMUA** soalan.*

QUESTION 1
SOALAN 1

CLO1

Figure B1 illustrates a lamp system controlled by PIC18. Two (2) infra-red (IR) sensors (NPN output) are connected to PIC18 at pin RA0 and RB0 respectively. Two (2) lamps are connected to two (2) relays. These relays are connected to PIC18 using pin RD6 and RD7. Relay will be switched on and off based on the output of IR sensors as shown in Table B1. Lamp will be switched on every time the relay is on.

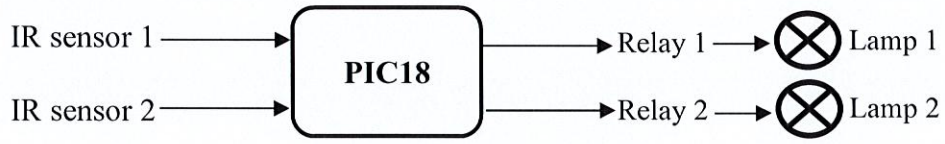

Figure B1 / *Rajah B1*

Table B1 / Jadual *B1*

IR sensor output		Relay state	
Sensor 2	Sensor 1	Relay1	Relay2
Low	Low	Off	Off
Low	High	Off	On
High	Low	On	Off
High	High	Off	Off

Based on the given information, determine the input and output for PIC18 and illustrate the schematic diagram for this system. Then, figure out how PIC18 can perform the task by using truth table and C program.

Rajah B1 menunjukkan sebuah sistem lampu yang dikawal PIC18. Dua (2) penderia infra-merah (IR) (keluaran NPN) disambung ke PIC18 masing-masing pada pin RA0

and RB0. Dua (2) lampu disambungkan kepada dua (2) geganti. Geganti-geganti ini disambungkan kepada PIC18 menggunakan pin RD6 dan RD7. Geganti akan disuis hidup dan mati berdasarkan keluaran penderia IR seperti ditunjukkan dalam Jadual B1. Lampu akan disuis hidup setiap kali geganti dihidupkan. Berdasarkan maklumat yang diberi, tentukan masukan dan keluaran untuk PIC18 dan lakarkan litar system ini. Kemudian, fikirkan bagaimana PIC18 boleh melakukan tugas tersebut dengan menggunakan jadual kebenaran dan program C.

[20 marks]

[20 *markah*]

QUESTION 2
SOALAN 2

CLO2

A PIC18 microcontroller is used to produce Pulse Width Modulation (PWM) signal. A switch is connected to PIC18 and used to select PWM duty cycle coming from CCP pin of the PIC18. The operation of the PIC18 is shown in Table B2.

Table B2 / *Jadual B2*

Switch state / *Keadaan suis*	PWM Duty Cycle / *Kitar Tugas PWM*
Closed / *Tutup*	60%
Opened / *Buka*	20%

PIC18 used 8 MHz crystal and PWM frequency of 1 KHz. Based on Table B2, produce C program for PIC18 to perform the operation. Ignore any time delay functions. Your design must consist of a schematic diagram and C program.

Sebuah PIC18F digunakan untuk menghasilkan isyarat PWM. Sebuah suis disambungkan ke PIC18 dan digunakan untuk memilih kitar tugas PWM yang datang dari pin CCP PIC18. Operasi PIC18 ditunjukkan dalam Jadual B2.
PIC18 menggunakan kristal 8 MHz dan frekuensi PWM 1 KHz. Berdasarkan Jadual B2, terbitkan program C untuk PIC18 melakukan operasi tersebut. Abaikan sebarang fungsi lengah masa. Rekabentuk anda mesti mengandungi rajah skematik dan program C.

[20 marks]
[*20 markah*]

SOALAN TAMAT

REGISTER 11-1: T0CON: TIMER0 CONTROL REGISTER

R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1
TMR0ON	T08BIT	T0CS	T0SE	PSA	T0PS<2:0>		
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 **TMR0ON:** Timer0 On/Off Control bit
1 = Enables Timer0
0 = Stops Timer0

bit 6 **T08BIT:** Timer0 8-bit/16-bit Control bit
1 = Timer0 is configured as an 8-bit timer/counter
0 = Timer0 is configured as a 16-bit timer/counter

bit 5 **T0CS:** Timer0 Clock Source Select bit
1 = Transition on T0CKI pin
0 = Internal instruction cycle clock (CLKOUT)

bit 4 **T0SE:** Timer0 Source Edge Select bit
1 = Increment on high-to-low transition on T0CKI pin
0 = Increment on low-to-high transition on T0CKI pin

bit 3 **PSA:** Timer0 Prescaler Assignment bit
1 = TImer0 prescaler is NOT assigned. Timer0 clock input bypasses prescaler.
0 = Timer0 prescaler is assigned. Timer0 clock input comes from prescaler output.

bit 2-0 **T0PS<2:0>:** Timer0 Prescaler Select bits
111 = 1:256 prescale value
110 = 1:128 prescale value
101 = 1:64 prescale value
100 = 1:32 prescale value
011 = 1:16 prescale value
010 = 1:8 prescale value
001 = 1:4 prescale value
000 = 1:2 prescale value

REGISTER 13-1: T2CON: TIMER2 CONTROL REGISTER

U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	T2OUTPS3	T2OUTPS2	T2OUTPS1	T2OUTPS0	TMR2ON	T2CKPS1	T2CKPS0
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 **Unimplemented:** Read as '0'

bit 6-3 **T2OUTPS3:T2OUTPS0:** Timer2 Output Postscale Select bits
0000 = 1:1 Postscale
0001 = 1:2 Postscale
•
•
•
1111 = 1:16 Postscale

bit 2 **TMR2ON:** Timer2 On bit
1 = Timer2 is on
0 = Timer2 is off

bit 1-0 **T2CKPS1:T2CKPS0:** Timer2 Clock Prescale Select bits
00 = Prescaler is 1
01 = Prescaler is 4
1x = Prescaler is 16

REGISTER 9-1: INTCON: INTERRUPT CONTROL REGISTER

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-x
GIE/GIEH	PEIE/GIEL	TMR0IE	INT0IE	RBIE	TMR0IF	INT0IF	RBIF(1)
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 **GIE/GIEH:** Global Interrupt Enable bit

When IPEN = 0:
1 = Enables all unmasked interrupts
0 = Disables all interrupts

When IPEN = 1:
1 = Enables all high-priority interrupts
0 = Disables all interrupts

bit 6 **PEIE/GIEL:** Peripheral Interrupt Enable bit

When IPEN = 0:
1 = Enables all unmasked peripheral interrupts
0 = Disables all peripheral interrupts

When IPEN = 1:
1 = Enables all low-priority peripheral interrupts (if GIE/GIEH = 1)
0 = Disables all low-priority peripheral interrupts

bit 5 **TMR0IE:** TMR0 Overflow Interrupt Enable bit
1 = Enables the TMR0 overflow interrupt
0 = Disables the TMR0 overflow interrupt

bit 4 **INT0IE:** INT0 External Interrupt Enable bit
1 = Enables the INT0 external interrupt
0 = Disables the INT0 external interrupt

bit 3 **RBIE:** RB Port Change Interrupt Enable bit
1 = Enables the RB port change interrupt
0 = Disables the RB port change interrupt

bit 2 **TMR0IF:** TMR0 Overflow Interrupt Flag bit
1 = TMR0 register has overflowed (must be cleared in software)
0 = TMR0 register did not overflow

bit 1 **INT0IF:** INT0 External Interrupt Flag bit
1 = The INT0 external interrupt occurred (must be cleared in software)
0 = The INT0 external interrupt did not occur

bit 0 **RBIF:** RB Port Change Interrupt Flag bit(1)
1 = At least one of the RB7:RB4 pins changed state (must be cleared in software)
0 = None of the RB7:RB4 pins have changed state

REGISTER 9-2: INTCON2: INTERRUPT CONTROL 2 REGISTER

R/W-1	R/W-1	R/W-1	R/W-1	U-0	R/W-1	U-0	R/W-1
$\overline{\text{RBPU}}$	INTEDG0	INTEDG1	INTEDG2	—	TMR0IP	—	RBIP
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 **$\overline{\text{RBPU}}$:** PORTB Pull-up Enable bit
1 = All PORTB pull-ups are disabled
0 = PORTB pull-ups are enabled provided that the pin is an input and the corresponding WPUB bit is set.

bit 6 **INTEDG0:** External Interrupt 0 Edge Select bit
1 = Interrupt on rising edge
0 = Interrupt on falling edge

bit 5 **INTEDG1:** External Interrupt 1 Edge Select bit
1 = Interrupt on rising edge
0 = Interrupt on falling edge

bit 4 **INTEDG2:** External Interrupt 2 Edge Select bit
1 = Interrupt on rising edge
0 = Interrupt on falling edge

bit 3 **Unimplemented:** Read as '0'

bit 2 **TMR0IP:** TMR0 Overflow Interrupt Priority bit
1 = High priority
0 = Low priority

bit 1 **Unimplemented:** Read as '0'

bit 0 **RBIP:** RB Port Change Interrupt Priority bit
1 = High priority
0 = Low priority

REGISTER 9-3: INTCON3: INTERRUPT CONTROL REGISTER 3

R/W-1	R/W-1	U-0	R/W-0	R/W-0	U-0	R/W-0	R/W-0
INT2IP	INT1IP	—	INT2IE	INT1IE	—	INT2IF	INT1IF
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 **INT2IP:** INT2 External Interrupt Priority bit
1 = High priority
0 = Low priority

bit 6 **INT1IP:** INT1 External Interrupt Priority bit
1 = High priority
0 = Low priority

bit 5 **Unimplemented:** Read as '0'

bit 4 **INT2IE:** INT2 External Interrupt Enable bit
1 = Enables the INT2 external interrupt
0 = Disables the INT2 external interrupt

bit 3 **INT1IE:** INT1 External Interrupt Enable bit
1 = Enables the INT1 external interrupt
0 = Disables the INT1 external interrupt

bit 2 **Unimplemented:** Read as '0'

bit 1 **INT2IF:** INT2 External Interrupt Flag bit
1 = The INT2 external interrupt occurred (must be cleared in software)
0 = The INT2 external interrupt did not occur

bit 0 **INT1IF:** INT1 External Interrupt Flag bit
1 = The INT1 external interrupt occurred (must be cleared in software)
0 = The INT1 external interrupt did not occur

REGISTER 17-1: ADCON0: A/D CONTROL REGISTER 0

U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	CHS<4:0>					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 **Unimplemented:** Read as '0'

bit 6-2 **CHS<4:0>: Analog Channel Select bits**
00000 = AN0
00001 = AN1
00010 = AN2
00011 = AN3
00100 = AN4
00101 = AN5(1)
00110 = AN6(1)
00111 = AN7(1)
01000 = AN8
01001 = AN9
01010 = AN10
01011 = AN11
01100 = AN12
01101 = AN13
01110 = AN14
01111 = AN15
10000 = AN16
10001 = AN17
10010 = AN18
10011 = AN19
10100 = AN20(1)
10101 = AN21(1)
10110 = AN22(1)
10111 = AN23(1)
11000 = AN24(1)
11001 = AN25(1)
11010 = AN26(1)
11011 = AN27(1)
11100 = Reserved
11101 = CTMU
11110 = DAC
11111 = FVR BUF2 (1.024V/2.048V/2.096V Volt Fixed Voltage Reference)(2)

bit 1 **GO/$\overline{\text{DONE}}$:** A/D Conversion Status bit
1 = A/D conversion cycle in progress. Setting this bit starts an A/D conversion cycle.
This bit is automatically cleared by hardware when the A/D conversion has completed.
0 = A/D conversion completed/not in progress

bit 0 **ADON:** ADC Enable bit
1 = ADC is enabled
0 = ADC is disabled and consumes no operating current

Note 1: Available on PIC18(L)F4XK22 devices only.
2: Allow greater than 15 µs acquisition time when measuring the Fixed Voltage Reference.

REGISTER 17-2: ADCON1: A/D CONTROL REGISTER 1

R/W-0	U-0	U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
TRIGSEL	—	—	—	PVCFG<1:0>		NVCFG<1:0>	
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 **TRIGSEL**: Special Trigger Select bit
1 = Selects the special trigger from CTMU
0 = Selects the special trigger from CCP5

bit 6-4 **Unimplemented**: Read as '0'

bit 3-2 **PVCFG<1:0>**: Positive Voltage Reference Configuration bits
00 = A/D V_{REF+} connected to internal signal, AV_{DD}
01 = A/D V_{REF+} connected to external pin, V_{REF+}
10 = A/D V_{REF+} connected to internal signal, FVR BUF2
11 = Reserved (by default, A/D V_{REF+} connected to internal signal, AV_{DD})

bit 1-0 **NVCFG<1:0>**: Negative Voltage Reference Configuration bits
00 = A/D V_{REF-} connected to internal signal, AV_{SS}
01 = A/D V_{REF-} connected to external pin, V_{REF-}
10 = Reserved (by default, A/D V_{REF-} connected to internal signal, AV_{SS})
11 = Reserved (by default, A/D V_{REF-} connected to internal signal, AV_{SS})

REGISTER 17-3: ADCON2: A/D CONTROL REGISTER 2

R/W-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
ADFM	—	ACQT<2:0>			ADCS<2:0>		
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 Conversion Result Format Select bit
1 = Right justified
0 = Left justified

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

bit 5-3 **ACQT<2:0>**: A/D Acquisition time select bits. Acquisition time is the duration that the A/D charge holding capacitor remains connected to A/D channel from the instant the GO/$\overline{DONE}$ bit is set until conversions begins.
000 = 0(1)
001 = 2 T_{AD}
010 = 4 T_{AD}
011 = 6 T_{AD}
100 = 8 T_{AD}
101 = 12 T_{AD}
110 = 16 T_{AD}
111 = 20 T_{AD}

bit 2-0 **ADCS<2:0>**: A/D Conversion Clock Select bits
000 = F_{OSC}/2
001 = F_{OSC}/8
010 = F_{OSC}/32
011 = F_{RC}(1) (clock derived from a dedicated internal oscillator = 600 kHz nominal)
100 = F_{OSC}/4
101 = F_{OSC}/16
110 = F_{OSC}/64
111 = F_{RC}(1) (clock derived from a dedicated internal oscillator = 600 kHz nominal)

Note 1: When the A/D clock source is selected as F_{RC} then the start of conversion is delayed by one instruction cycle after the GO/$\overline{DONE}$ bit is set to allow the SLEEP instruction to be executed.

REGISTER 21-1: VREFCON0: FIXED VOLTAGE REFERENCE CONTROL REGISTER

R/W-0	R/W-0	R/W-0	R/W-1	U-0	U-0	U-0	U-0
FVREN	FVRST	FVRS<1:0>		—	—	—	—
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
'1' = Bit is set	'0' = Bit is cleared	

bit 7 **FVREN:** Fixed Voltage Reference Enable bit
0 = Fixed Voltage Reference is disabled
1 = Fixed Voltage Reference is enabled

bit 6 **FVRST:** Fixed Voltage Reference Ready Flag bit
0 = Fixed Voltage Reference output is not ready or not enabled
1 = Fixed Voltage Reference output is ready for use

bit 5-4 **FVRS<1:0>:** Fixed Voltage Reference Selection bits
00 = Fixed Voltage Reference Peripheral output is off
01 = Fixed Voltage Reference Peripheral output is 1x (1.024V)
10 = Fixed Voltage Reference Peripheral output is 2x (2.048V)(1)
11 = Fixed Voltage Reference Peripheral output is 4x (4.096V)(1)

bit 3-2 **Reserved:** Read as '0'. Maintain these bits clear.

bit 1-0 **Unimplemented:** Read as '0'.

Note 1: Fixed Voltage Reference output cannot exceed VDD.

REGISTER 10-3: ANSELA – PORTA ANALOG SELECT REGISTER

U-0	U-0	R/W-1	U-0	R/W-1	R/W-1	R/W-1	R/W-1
—	—	ANSA5	—	ANSA3	ANSA2	ANSA1	ANSA0
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 **ANSA5:** RA5 Analog Select bit
1 = Digital input buffer disabled
0 = Digital input buffer enabled

bit 4 **Unimplemented:** Read as '0'

bit 3-0 **ANSA<3:0>:** RA<3:0> Analog Select bit
1 = Digital input buffer disabled
0 = Digital input buffer enabled

REGISTER 14-1: CCPxCON: STANDARD CCPx CONTROL REGISTER

U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	DCxB<1:0>		CCPxM<3:0>			
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Reset
'1' = Bit is set	'0' = Bit is cleared	

bit 7-6 **Unused**

bit 5-4 **DCxB<1:0>:** PWM Duty Cycle Least Significant bits

Capture mode:
Unused

Compare mode:
Unused

PWM mode:
These bits are the two LSbs of the PWM duty cycle. The eight MSbs are found in CCPRxL.

bit 3-0 **CCPxM<3:0>:** ECCPx Mode Select bits

0000 = Capture/Compare/PWM off (resets the module)
0001 = Reserved
0010 = Compare mode: toggle output on match
0011 = Reserved

0100 = Capture mode: every falling edge
0101 = Capture mode: every rising edge
0110 = Capture mode: every 4th rising edge
0111 = Capture mode: every 16th rising edge

1000 = Compare mode: set output on compare match (CCPx pin is set, CCPxIF is set)
1001 = Compare mode: clear output on compare match (CCPx pin is cleared, CCPxIF is set)
1010 = Compare mode: generate software interrupt on compare match (CCPx pin is unaffected, CCPxIF is set)
1011 = Compare mode: Special Event Trigger (CCPx pin is unaffected, CCPxIF is set)
TimerX (selected by CxTSEL bits) is reset
ADON is set, starting A/D conversion if A/D module is enabled(1)
11xx =: PWM mode

Note 1: This feature is available on CCP5 only.

$$PR2 = \frac{\text{PWM period}}{\text{TMR2PS}^{*}4^{*}T_{OSC}} - 1$$

EQUATION 14-3: DUTY CYCLE RATIO

$$Duty\ Cycle\ Ratio = \frac{(CCPRxL:CCPxCON<5:4>)}{4(PRx+1)}$$

$$Pulse\ Width = (CCPRxL{:}CCPxCON<5:4>) \bullet T_{OSC} \bullet (TMRx\ Prescale\ Value)$$

Pulse width = Duty cycle x Tpwm

$$1Tcy = \frac{1}{Fosc \div 4 \div Prescaler}$$