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 II : 2022/2023

DEC40053: EMBEDDED SYSTEM APPLICATIONS

TARIKH : 12 JUN 2023
MASA : 8.30 PG – 10.30 PG (2 JAM)

Kertas ini mengandungi **TUJUH (7)** halaman bercetak.
Bahagian A: Struktur (3 soalan)
Bahagian B: Esei (2 soalan)
Dokumen sokongan yang disertakan : Lampiran

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)** structured questions. Answer **ALL** questions.

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

QUESTION 1
SOALAN 1

CLO1 (a) Explain the function of TRISx register in I/O with an example of C language program using bit addressable.

Terangkan fungsi pendaftar TRISx di dalam I/O berserta contoh aturcara Bahasa C menggunakan format pengalamatan bit.

[4 marks]
[*4 markah*]

CLO1 (b) Figure A1 (b) shows the connection between input devices and output devices with PIC microcontroller. Write the C language to configure the input/output port using bit addressable and byte addressable.

Rajah A1(b) menunjukkan sambungan peranti masukan dan peranti keluaran dengan pengawal mikro PIC. Tulis aturcara Bahasa C untuk mengkonfigurasikan pin masukan/keluaran menggunakan format pengalamatan bit dan byte.

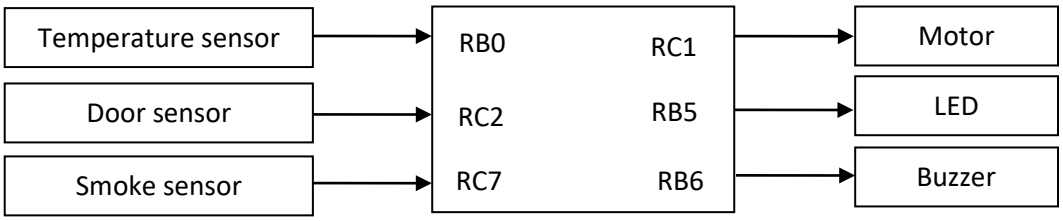

Figure A1(b) / *Rajah A1(b)*

[8 marks]
[*8 markah*]

CLO1 (c) Given that the crystal oscillator frequency = 20MHz and the value of TMR0H:TMR0L = CF27 H. Referring to Appendix 1, calculate the amount of time generated by Timer0 if T0CON register is set to 0x04.

Diberi frekuensi pengayun = 20MHz dan nilai TMR0H:TMR0L =CF27H. Merujuk kepada Lampiran 1, kirakan masa lengah yang dijana oleh Timer0 jika pendaftar T0CON disetkan kepada 0x04.

[8 marks]
[*8 markah*]

QUESTION 2
SOALAN 2

CLO1 (a) Explain the function of prescaler to generate a large time delay.

Terangkan fungsi prescaler untuk menghasilkan lengah masa yang besar.

[4 marks]
[*4 markah*]

CLO1 (b) Construct a single instruction to enable and disable the Timer 0 and Timer 1 interrupt, enable external hardware interrupt at RB0 (INT0), RB1 (INT1), RB2 (INT2) and lastly disable all the interrupt.

Bina arahan yang diperlukan untuk membenarkan dan tidak membenarkan gangguan Pemasa 0 dan Pemasa 1, membenarkan 'external hardware interrupt' berlaku pada RB0 (INT0), RB1 (INT1), RB2 (INT2) dan akhir sekali. tidak membenarkan semua gangguan berlaku.

[8 marks]
[*8 markah*]

CLO1 (c) A postman has put a letter in the mailbox. If the letter falls, the buzzer will notify the owner that he/she has received a letter. An LDR sensor is attached at RB0 at the microcontroller and a buzzer is connected at RA6.Write a source code that shows only instruction from interrupt vector table until interrupt service routine for the process.

Seorang posmen telah memasukkan sepucuk surat ke dalam peti surat. Jika surat itu jatuh, buzzer akan berbunyi untuk memberitahu pemilik bahawa dia telah menerima surat. Penderia LDR dipasang pada RB0 pada mikropengawal dan penggera disambungkan pada RA6. Tuliskan aturcara yang hanya menunjukkan arahan daripada 'interupt vector table' sehingga 'interrupt service routine' untuk proses tersebut.

[8 marks]
[*8 markah*]

QUESTION 3

SOALAN 3

CLO1 (a) Explain the interrupt and polling methods in a PIC18f4550 microcontroller.

Terangkan kaedah sampukan dan tinjauan dalam mikropengawal PIC18F4550.

[5 marks]

[*5 markah*]

CLO1 (b) ADC (analog-to-digital converter) and PWM (pulse-width modulation) are both methods of controlling and manipulating analog signals using digital devices, but they differ in their approach and application. Compare the differences between ADC and PWM.

ADC (penukar analog-ke-digital) dan PWM (modulasi lebar denyut) ialah kedua-dua kaedah mengawal dan memanipulasi isyarat analog menggunakan peranti digital, tetapi ia berbeza dalam pendekatan dan aplikasinya. Bandingkan perbezaan antara ADC dan PWM.

[5 marks]

[*5 markah*]

CLO1 (c) PIC18f4550 has a 10-bit 13 channel Analog Digital Converter (ADC). If the reference voltage, V_{ref} = 3V, calculate the digital output value, D0-D9 for an analog input, V_{in} = 1V and 1.4V.

PIC18f4550 mempunyai 10-bit dengan 13 saluran Penukar Analog ke Digital (ADV). Jika voltan rujukan, V_{ref}=3V, kirakan nilai keluaran digital, D0-D9 bagi masukan analog, V_{in}= 1V dan 1.4V.

[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

A mobile robot uses an infrared sensor to detect an obstacle created. A sensor is placed in front of it. The mobile robot is designed to perform the following task.

- When the sensor detects an obstacle, the led and buzzer will be switched 'ON' at the same time.
- When the sensor not detects any obstacle, the led and buzzer will be switched 'OFF' at the same time.

The infrared sensor is connected at PORT C as an input while the led and buzzer at PORT D as an output. Illustrate the schematic circuit for the mobile robot system. Then, write the program in C language by using PIC 18.

Robot mudah alih menggunakan penderia inframerah untuk mengesan halangan dicipta. Sensor ini diletakkan di hadapannya.

- *Apabila sensor mengesan halangan, led dan buzzer akan berfungsi serentak pada masa yang sama.*
- *Apabila sensor tidak mengesan sebarang halangan, led dan buzzer akan tidak berfungsi serentak pada masa yang sama.*

Sensor inframerah disambungkan pada PORT C sebagai masukan manakala led dan buzzer pada PORT D sebagai keluaran. Gambarkan gambarajah skematik bagi sistem robot mudah alih. Gambarkan litar skematik untuk robot mudah alih. Kemudian, tuliskan atur cara dalam bahasa C dengan menggunakan PIC 18.

[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
Closed / *Tutup*	70%
Opened / *Buka*	30%

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

Sebuah pengawalmikro PIC18 digunakan untuk menghasilkan isyarat Pulse Width Modulation (PWM). Sebuah suis disambungkan ke PIC18 dan digunakan untuk memilih duty cycle 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. Suis adalah aktif rendah. Abaikan sebarang fungsi lengah masa. Rekabentuk anda mesti mengandungi rajah block 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	TOPS<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 VREF+ connected to internal signal, AVDD
01 = A/D VREF+ connected to external pin, VREF+
10 = A/D VREF+ connected to internal signal, FVR BUF2
11 = Reserved (by default, A/D VREF+ connected to internal signal, AVDD)

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

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/$\overline{\text{DONE}}$ bit is set until conversions begins.
000 = 0(1)
001 = 2 TAD
010 = 4 TAD
011 = 6 TAD
100 = 8 TAD
101 = 12 TAD
110 = 16 TAD
111 = 20 TAD

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

Note 1: When the A/D clock source is selected as FRC then the start of conversion is delayed by one instruction cycle after the GO/$\overline{\text{DONE}}$ 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