SULIT

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN ELEKTRIK

PEPERIKSAAN AKHIR

SESI DISEMBER 2017

DEC5052 : EMBEDDED SYSTEM APPLICATIONS

TARIKH : 03 APRIL 2018
MASA : 8.30 PAGI - 10.30 PAGI (2 JAM)

Kertas ini mengandungi **ENAM BELAS (16)** halaman bercetak.

Bahagian A: Struktur (4 soalan)
Bahagian B: Esei (2 soalan)

Dokumen sokongan yang disertakan : Tiada

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 **FOUR (4)** structured questions. Answer **ALL** questions.

ARAHAN:

*Bahagian ini mengandungi **EMPAT (4)** soalan berstruktur. Jawab **SEMUA** soalan.*

QUESTION 1

SOALAN 1

CLO1
C1

(a) A microcontroller is a heart of embedded system. Describe this statement.
Sebuah mikropengawal adalah jantung bagi sistem terbenam. Jelaskan kenyataan ini.

[3 marks]
[*3 markah*]

CLO1
C3

(b) A programmer decides to use **TWO (2)** solenoid valve at pin RC6 and RC7, **ONE (1)** LED at pin RC5, **TWO (2)** digital sensor at pin RB0 and RB1 and **ONE (1)** digital switch at pin RA0 in his circuit. Complete the pins input and output instruction for the program using bit addressable format in C language.
*Seorang pengaturcara memutuskan untuk menggunakan **DUA (2)** injap solenoid pada pin RC6 dan RC7, **SATU (1)** LED pada pin RC5, **DUA (2)** penderia digital pada pin RB0 and RB1 dan **SATU (1)** suis digital pada pin RA0 dalam litar beliau. Lengkapkan arahan untuk pin masukan dan keluaran menggunakan format bit pengalamatan dalam Bahasa C.*

[6 marks]
[*6 markah*]

CLO2
C3

(c) Apply C language to perform operations below:
Aplikasikan bahasa C untuk melakukan operasi di bawah:

i. Set PORTB as output.
Setkan PORTB sebagai keluaran.

ii. Set PORTD as input.
Setkan PORTD sebagai masukan.

iii. Set pin RE0 as output.
Setkan pin RE0 sebagai keluaran.

iv. Set pin RC0 as input.
Setkan pin RC0 sebagai masukan.

v. Give 5V to pin RD4 to RD7 and 0V to pin RD3 to RD0.
Beri 5V kepada pin RD4 ke RD7 dan 0V kepada pin RD3 ke RD0.

[6 marks]
[*6 markah*]

QUESTION 2

SOALAN 2

CLO1
C2

(a) Describe the role of TMR0IF (TMR0 Overflow Interrupt Flag) bit in INTCON (Interrupt Control) Register.
Jelaskan peranan bit TMR0IF (TMR0 Overflow Interrupt Flag) dalam daftar INTCON (Interrupt Control).

[3 marks]
[*3 markah*]

CLO1
C3

(b) Timer0 in PIC18 is used to produce 3.072 seconds time delay. It uses XTAL = 10 MHz and prescale value of 1:256.
Timer0 dalam PIC18 digunakan untuk menjana lengah masa selama 3.072 saat. Ia menggunakan XTAL = 10 MHz dan nilai praskala 1:256.

i. Calculate the value for TMR0H and TMR0L.
Kira nilai untuk TMR0H dan TMR0L.

ii. Calculate the largest time delay that can be generated by this Timer0 using suitable TMR0H and TMR0L value.
Kira lengah masa terpanjang yang boleh dijana oleh Timer0 ini dengan menggunakan nilai TMR0H dan TMR0L yang sesuai.

[6 marks]
[*6 markah*]

CLO2
C3

(c) List in detail the operation of Timer0.
Senaraikan dengan terperinci operasi Timer0.

[6 marks]
[*6 markah*]

QUESTION 3

SOALAN 3

CLO1
C1

(a) List **THREE (3)** interrupt sources for PIC18 microcontroller.
*Senaraikan **TIGA (3)** punca sampukan untuk pengawalmikro PIC18.*

[3 marks]
[*3 markah*]

CLO1
C2

(b) Describe in detail the function of GIE (Global Interrupt Enable) bit in INTCON (Interrupt Control Register) register.
Terangkan dengan terperinci fungsi bit GIE (Global Interrupt Enable) di dalam daftar INTCON (Interrupt Control Register).

[5 marks]
[*5 markah*]

CLO1
C3

(c) Interpret the functions of Interrupt Enable (IE), Interrupt Flag (IF) and Interrupt Priority (IP) bits for PIC18 interrupt operation.
Interpritasikan fungsi bit Interrupt Enable (IE), Interrupt Flag (IF) dan Interrupt Priority (IP) untuk operasi sampukan PIC18.

[7 marks]
[*7 markah*]

QUESTION 4

SOALAN 4

CLO1
C2

(a) Identify the most suitable internal features of PIC18 microcontroller that need to be used to handle input **x** and output **y** which are connected to it as illustrated in **Figure Q4(a)** with justification.

*Terangkan ciri-ciri dalaman pengawal mikro PIC18 yang paling sesuai digunakan untuk mengawal peranti input **x** dan output **y** yang bersambung kepadanya seperti yang di tunjukkan dalam **Rajah Q4 (a)** berserta justifikasi.*

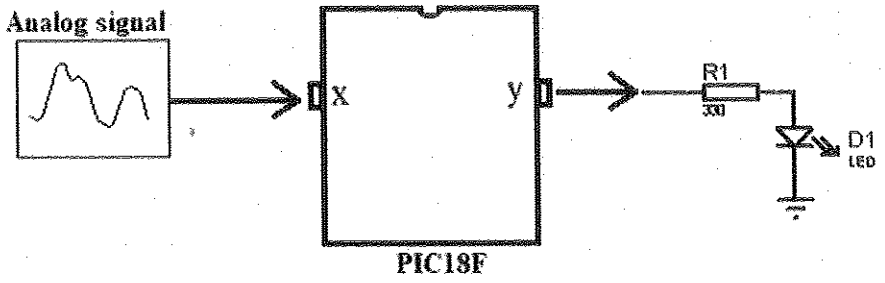

Figure Q4 (a) / *Rajah Q4 (a)*

[3 marks]

[*3 markah*]

CLO1
C3

(b) An embedded system that uses digital door sensor to detect the door when it opens, while a buzzer is used to alert the user. This system applies PIC18F microcontroller to monitor the door sensor and when it opens, the buzzer will make sound. Use C language to write a program for this system. An input and output circuit of this system is shown in **Figure Q4 (b).**

*Sebuah sistem terbenam menggunakan penderia pintu automatik bagi mengesan pintu yang terbuka, manakala "buzzer" digunakan untuk makluman pengguna. Sistem ini menggunakan pengawal mikro PIC18F untuk mengawal sekiranya pintu terbuka maka "buzzer" akan terbunyi. Gunakan bahasa C untuk menulis aturcara sistem ini. Gambarajah litar masukan dan keluaran bagi sistem ini ditunjukkan dalam **Rajah Q4 (b).***

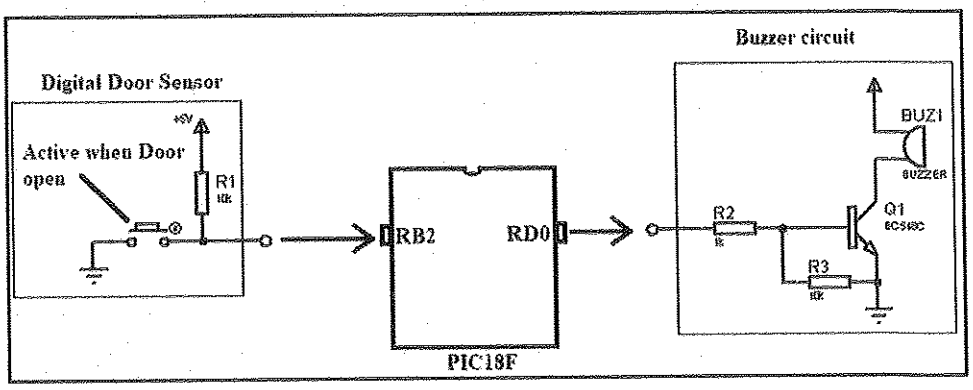

Figure Q4 (b) / *Rajah Q4 (b)*

[6 marks]

[*6 markah*]

CLO2
C3

(c) A water level monitoring system has **THREE (3)** sensors S1, S2 and S3 that detect the Low, Intermediate, and Full water level respectively in the tank. The sensors produce 5V when detect a water. Otherwise, the sensor produces 0V when no water detected. It is required **THREE (3)** LED colors which is red LED, yellow LED and green LED to display the low, intermediate and full water level respectively. Moreover, the buzzer will be activated if the tank is empty. This system used PIC18F microcontroller to monitor the water level and thus display water level on the LEDs. If the tank is empty, then activate the buzzer. Use a C language to write a program for this process. The overview of this system is shown in **Figure Q4 (c).**

*Sebuah sistem pemantauan paras air dilengkapi dengan **TIGA (3)** penderia iaitu S1, S2 dan S3 yang digunakan untuk mengesan paras air rendah, perantaraan dan penuh di dalam tangki. Sensor ini menghasilkan 5V apabila mengesan air. Sebaliknya, menghasilkan 0V apabila tiada air dikesan. Sistem memerlukan **TIGA (3)** warna LED iaitu LED merah, LED kuning dan LED hijau masing-masing untuk memaparkan tahap air rendah, pertengahan dan penuh. Selain itu, "buzzer" akan diaktifkan jika tiada air dikesan. Sistem ini menggunakan pengawal mikro PIC18F untuk memantau tahap air dan seterusnya memaparkan paras air pada LED. Sekiranya tiada air dikesan, maka aktifkan "buzzer" tersebut. Gunakan bahasa C untuk menulis proses ini. Gambaran keseluruhan sistem ini ditunjukkan dalam **Rajah Q4 (c).***

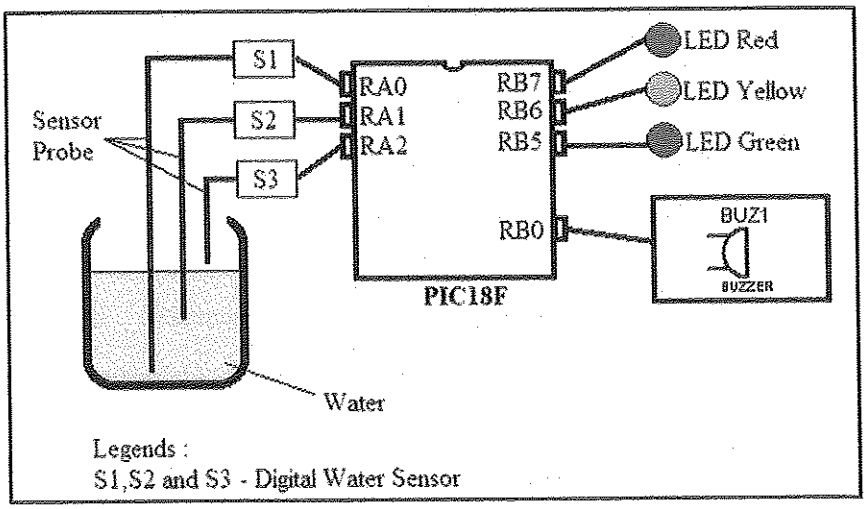

Figure Q4 (c) / *Rajah Q4 (c)*

[6 marks]

[*6 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

CLO2
C3

An automation company has been assigned by a ball manufacturing plant to design and install a packaging system for ball based on PIC18 microcontroller. This system used a motor to move a conveyer belt that carry and drop balls into a box. A counter sensor will count the amount of balls that fall into the box. After **TWO HUNDRED (200)** balls has fallen, motor will stop moving and buzzer will be switched on. Sensor is ACTIVE LOW. Buzzer and motor are ACTIVE HIGH. As a designer of the company, you are required to design the packaging system. Using Timer0 Interrupt as a counter, use a C language to write program to perform the operation. Use any pins as output. Ignore any time delay functions.
Use **Figure B1 (a)** to **B1 (b)** as reference.

*Sebuah syarikat aotomasi telah ditugaskan oleh sebuah kilang pengeluaran bola untuk mereka dan memasang sistem pembungkusan bola menggunakan mikropengawal PIC18. Sistem ini menggunakan sebuah motor untuk menggerakkan tali sawat penyampai yang membawa dan menjatuhkan bola ke dalam kotak. Sebuah penderia pengira akan mengira jumlah bola yang telah jatuh ke dalam kotak. Setelah **DUA RATUS (200)** bola telah jatuh, motor akan berhenti bergerak dan "buzzer" akan dihidupkan. Penderia adalah AKTIF RENDAH. "Buzzer" dan motor adalah AKTIF TINGGI. Sebagai perekabentuk syarikat, anda diperlukan untuk merekabentuk sistem pembungkusan tersebut. Dengan menggunakan pengira Sampukan Timer0, gunakan bahasa C untuk menulis program untuk melakukan operasi tersebut. Gunakan sebarang pin untuk output. Abaikan sebarang fungsi lengah masa. Gunakan **Rajah B1 (a)** hingga **B1 (b)** sebagai rujukan.*

[20 marks]
[20 *markah*]

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 high priority 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
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

Figure B1 (a) ***/Rajah B1 (a)*** *Interrupt control register.*

TMR0ON	T08BIT	T0CS	T0SE	PSA	T0PS2	T0PS1	T0PS0

TMR0ON D7 Timer0 ON and OFF control bit
1 = Enable (start) Timer0
0 = Stop Timer0

T08BIT D6 Timer0 8-bit/16-bit selector bit
1 = Timer0 is configured as an 8-bit timer/counter.
0 = Timer0 is configured as a 16-bit timer/counter.

T0CS D5 Timer0 clock source select bit
1 = External clock from RA4/T0CKI pin
0 = Internal clock (Fosc/4 from XTAL oscillator)

T0SE D4 Timer0 source edge select bit
1 = Increment on H-to-L transition on T0CKI pin
0 = Increment on L-to-H transition on T0CKI pin

PSA D3 Timer0 prescaler assignment bit
1 = Timer0 clock input bypasses prescaler.
0 = Timer0 clock input comes from prescaler output.

T0PS2:T0PS0 D2 D1 D0 Timer0 prescaler selector

0 0 0 = 1:2	Prescale value (Fosc / 4 / 2)
0 0 1 = 1:4	Prescale value (Fosc / 4 / 4)
0 1 0 = 1:8	Prescale value (Fosc / 4 / 8)
0 1 1 = 1:16	Prescale value (Fosc / 4 / 16)
1 0 0 = 1:32	Prescale value (Fosc / 4 / 32)
1 0 1 = 1:64	Prescale value (Fosc / 4 / 64)
1 1 0 = 1:128	Prescale value (Fosc / 4 / 128)
1 1 1 = 1:256	Prescale value (Fosc / 4 / 256)

Figure B1 (b) */Rajah B1 (b) Timer0 Control.*

QUESTION 2

SOALAN 2

CLO2
C5

Design an embedded system for controlling the fluid in a storage tank using PIC Microcontroller. The purpose of this system is to maintain an appropriate level of fluid by controlling the inlet and outlet valve. Also, the embedded system must control the temperature of the fluid within a certain range. To maintain the temperature, an analog temperature sensor is used to read the fluid temperature, output specification of this sensor is 10 mV/ ° C. The embedded system produces a HIGH to turn on a heating element when too-cold condition is indicated; otherwise, the heating element is turned off. When a too-hot condition is indicated, an alarm is activated. When the low-level sensor produces a HIGH output (indicating that it is immersed) and when the temperature of fluid is greater than temperature too-cold (indicating a correct temperature), the system opens the outlet valve. If the low-level sensors output goes LOW or if either temperature less then too-cold, the system closes the outlet valve. **Figure B2 (a)** shows the tank control system. The system input and outputs are summarized in **Table B2**. Use **Figure B2 (b)** to **B2 (e)** as reference.

Rekabentukkan sistem terbenam untuk mengawal bendalir di dalam tangki simpanan menggunakan PIC Microcontroller. Tujuan sistem ini adalah untuk mengekalkan tahap yang sesuai bendalir dengan mengawal bahagian masuk dan keluar injap. Selain itu, sistem ini perlu mengawal suhu bendalir dalam julat tertentu. Untuk mengekalkan suhu penderia suhu jenis analog digunakan untuk membaca suhu bendalir, spesifikasi output penderia ini adalah 10 mV/ ° C. *Sistem ini menghasilkan HIGH untuk menghidupkan elemen pemanas apabila keadaan terlalu sejuk dikesan; jika tidak, elemen pemanasan dimatikan. Apabila keadaan terlalu panas dikesan, penggera diaktifkan. Apabila sensor tahap rendah menghasilkan output HIGH (menunjukkan bahawa ia tenggelam) dan apabila suhu bendalir adalah lebih besar suhu terlalu sejuk (yang menunjukkan suhu yang betul), sistem yang membuka injap outlet. Jika penderia peringkat rendah menghasilkan LOW atau jika suhu kurang dari suhu terlalu sejuk, sistem menutup injap saluran keluar.* ***Rajah B2 (a)*** *menunjukkan sistem kawalan tangki. Input sistem dan output diringkaskan dalam* ***Jadual B2.*** *Gunakan* ***Rajah B2 (c)*** *ke* ***B2 (e)*** *sebagai rujukan.*

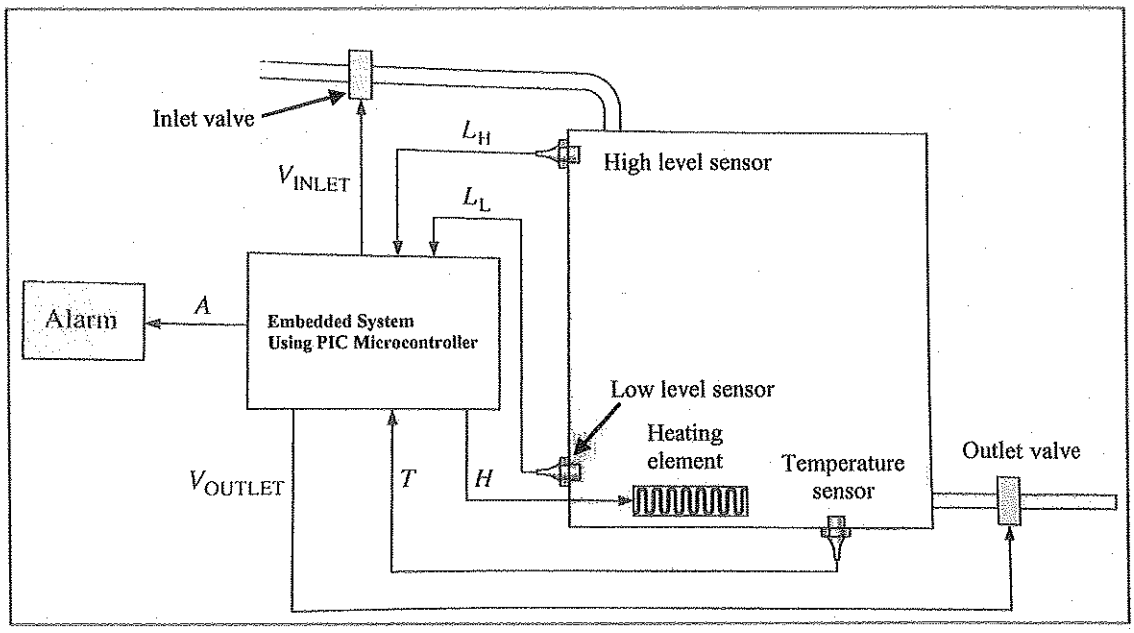

Figure B2 (a) / ***Rajah B2 (a)***

Table B2 / *Jadual B2*

INPUT TO EMBEDDED SYSTEM			
Variable	**Description**	**Active level**	**Comments**
L_H	High-level sensor	HIGH (1)	Sensor is immersed
L_L	Low-level sensor	HIGH (1)	Sensor is immersed
T	Temperature of fluid	$T > 70°C$ $T < 35°C$	Temperature too hot Temperature too cold
OUTPUT FROM EMBEDDED SYSTEM			
V_{INLET}	Inlet valve	HIGH (1)	Valve open
V_{OUTLET}	Outlet valve	HIGH (1)	Valve open
H	Heating element	HIGH (1)	Heat on
A	Alarm	HIGH (1)	Too-hot condition

[20 marks]

[*20 markah*]

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

Figure B2 (b) / *Rajah B2 (b)* *ANSELA-PORTA Analog select register.*

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/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

Figure B2 (c) / *Rajah B2 (c)* *ADCON0: A/D Control register 0.*

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})

Figure B2 (d) / *Rajah B2 (d)* *ADCON1: A/D Control register 1.*

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)

Figure B2 (e) / *Rajah B2 (e)* *ADCON2: A/D Control register 2.*

SOALAN TAMAT