INTI
International College Penang

FINAL
Examination Paper

(COVER PAGE)

Session	:	**August 2019**			
Programme	:	Diploma in Electrical and Electronic Engineering			
Course	:	**EEE 2114: Introduction to Embedded Systems**			
Date of Examination	:	10 December 2019 (Tuesday)			
Time	:	11:00am – 1:00pm	Reading Time	:	Nil
Duration	:	2 Hours			
Special Instructions	:				

This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

IMPORTANT NOTE : THIS PAPER SHOULD NOT BE TAKEN OUT OF THE EXAMINATION HALL

Materials permitted :

Non-Programmable Scientific Calculator

Materials provided :

Appendix A, Appendix B & Appendix C

Examiner(s) : **Mr. Steven Khoo Boo Tap**

Moderator : Dr. Ooi Beng Lee

*This paper consists of **12** printed pages, including the cover page.*

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
EEE2114: INTRODUCTION TO EMBEDDED SYSTEMS
FINAL EXAMINATION: AUGUST 2019 SESSION

Instructions: This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Question 1

(a) Differentiate between PIC16F628A microcontroller and PIC16F877A microcontroller by completing Table 1a as shown below.

Table 1a Comparison between PIC16F628A and PIC16F877A microcontroller

Description	PIC16F628A	PIC16F877A
Ports (Number of Bits) E.g. Port A(2), Port B(5),...		
Number of Analog Pins		
Total I/O Pins		
Data Memory (Bytes)		
Program Flash (Words)		
Program Flash (Bytes)		
Data EEPROM (Bytes)		
ADC-bit (Channel)		
CCP (PWM)		
Number of Interrupt Sources		

(10 marks)

(b) Given the Special Function Registers and File Registers for PIC16F877A microcontroller as follows:

Table 1(b)(i) Special Function Registers

Update	Address	Symbol Name	Value
		WREG	0x23
	003	STATUS	0x1F
	004	FSR	0x70
	006	PORTB	0X00
	086	TRISB	0xFF

Table 1(b)(ii) File Registers

Address	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
000	00	00	00	1F	70	00	00	--	--	--	16	77	70	--	08	00
010	10	20	00	--	--	00	55	33	60	00	00	--	--	--	--	00
020	61	12	10	56	34	18	52	AA	11	33	22	44	50	60	78	80
030	14	24	34	45	54	64	74	84	94	A4	B4	C4	D4	E4	F4	04
040	21	31	41	51	62	71	81	91	01	02	03	04	05	06	07	08
050	09	0A	0B	0C	0D	E0	0E	0F	F0	35	36	37	38	39	40	42
060	42	46	47	48	49	56	85	57	58	59	5A	5B	5C	5D	5E	5F
070	63	65	66	67	68	69	6A	6B	6C	6D	6E	6F	72	73	74	75
080	00	FF	00	1F	70	FF	00	--	--	--	16	77	70	--	08	--
090	--	11	FF	00	00	--	--	--	02	79	--	--	0C	00	--	6E
0A0	82	83	84	85	86	87	88	89	8A	8B	8C	8D	8E	8F	92	93
0B0	94	95	96	97	98	99	9A	9B	9C	9D	9F	9E	A0	B0	C0	D0
0C0	E0	F0	A1	A2	A3	A4	A5	A6	A7	A8	A9	AA	AB	AC	AD	AE
0D0	30	05	06	07	35	08	09	0A	0B	0C	0D	0E	0F	19	90	70

(All data of File Register are hexadecimal)

Perform the following short programs. Elaborate the result of the affected register(s) and Status (Z, DC and C) as shown in Table 1(b)(iii) using **Before** and **After** the execution of each instruction. The questions are independent of each other but the instructions are linked within the question.

Table 1(b)(iii) Before and After

Instruction	Before						After					
CLRW	W 23	FSR 70	70H 63	Z 1	DC 1	C 1	W	FSR	70H	Z	DC	C
COMF FSR,0												

(i)
```
CLRW
COMF      FSR,0
ANDWF     INDF,F
IORWF     b'101010',1
DECF      0X42,0
```

(5 marks)

(ii)
```
MOVLW     .32
RLF       FSR,W
XORWF     FSR,1
SWAPF     0X43,F
INCF      INDF,0
```

(5 marks)

(iii)
```
MOVF      o'76',W
SUBWF     INDF,F
RRF       FSR,F
ADDWF     INDF,W
SWAPF     0x41,1
```

(5 marks)

Question 2

(a) Table 2(a) assembly program will be built using MPLAB X IDE with MPASMWIN assembler. Study and analyze the Assembly Language Codes given below written using PIC16F877A microcontroller and answer the following questions.

Table 2(a) PIC16F877A Assembly Coding

```
Line 1   INCLUDE <P16F877A.inc>
Line 2   __CONFIG 3F3AH
Line 3   C EQU 0x0
Line 4   ORG 0
Line 5          movf     52H,W
Line 6          addwf    62,0
Line 7          btfss    3,C
Line 8          goto     NC
Line 9          clf      0x71,1
Line 10         incf     71H,F
Line 11         movwf    .114
Line 12         movf     b'1010001',0
Line 13         addwf    h'61',W
Line 14         addwf    71h,1
Line 15         goto     A
Line 16  NC     movwf    o'162',0
Line 17         movf     51H,0
Line 18         addwf    0x61,W
Line 19         movwf    d'113'
Line 20  A      goto     A
Line 21  END
```

(i) Identify significant **ERROR(S)** in the instructions of Table 2(a) that will caused the assembler to output "BUILD FAILED" when build all. Explain why it is incorrect and write the correct codes according to the Assembly Language format. Indicate the Line number of the error code as well.

(3 marks)

(ii) Based on the assumption that all lines of codes are corrected, describe the function of the program and also provide a sample final result of Table 2(a) program after correction.

(4 marks)

(iii) Modify the program in Table 2(a) to less than 13 lines of coding but still perform the same outcome as the original function of the coding. Hint: The improved full program should be less than 13 lines of coding instead of 21 lines.

(8 marks)

(b) Table 2(b) shows the Port B Functions of PIC16F877A microcontroller. Pin RB4:RB7 of PIC16F877A microcontroller are normally used in keypad interfacing, explain why? Sketch the circuit diagram connection of Port B of PIC16F877A microcontroller and the 4 × 4 matrix keypad. Explain how the scanning method can be used to detect which keypad being pressed.

(10 marks)

Table 2(b) Function of Port B.

Name	Bit#	Buffer	Function
RB0/INT	bit 0	TTL/ST(1)	Input/output pin or external interrupt input. Internal software programmable weak pull-up.
RB1	bit 1	TTL	Input/output pin. Internal software programmable weak pull-up.
RB2	bit 2	TTL	Input/output pin. Internal software programmable weak pull-up.
RB3/PGM(3)	bit 3	TTL	Input/output pin or programming pin in LVP mode. Internal software programmable weak pull-up.
RB4	bit 4	TTL	Input/output pin (with interrupt-on-change). Internal software programmable weak pull-up.
RB5	bit 5	TTL	Input/output pin (with interrupt-on-change). Internal software programmable weak pull-up.
RB6/PGC	bit 6	TTL/ST(2)	Input/output pin (with interrupt-on-change) or in-circuit debugger pin. Internal software programmable weak pull-up. Serial programming clock.
RB7/PGD	bit 7	TTL/ST(2)	Input/output pin (with interrupt-on-change) or in-circuit debugger pin. Internal software programmable weak pull-up. Serial programming data.

Legend: TTL = TTL input, ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.

2: This buffer is a Schmitt Trigger input when used in Serial Programming mode or in-circuit debugger.

3: Low-Voltage ICSP Programming (LVP) is enabled by default which disables the RB3 I/O function. LVP must be disabled to enable RB3 as an I/O pin and allow maximum compatibility to the other 28-pin and 40-pin mid-range devices.

Question 3

(a) "An embedded system can be a very simple piece of electronic circuitry that performs a specific function within a larger system". Describe how a computer scanner can be an example of embedded systems applications.

(5 marks)

(b) Describe the serial communications used in PIC microcontroller shown in Figure 3(b). Provide TWO (2) comparisons between SPI mode and I^2C mode as shown as Table 3(b).

(8 marks)

Table 3(b) Comparison between SPI and I^2C.

Description	SPI (Serial Peripheral Interface)	I^2C (Inter-Integrated Circuit)
Data Rate		
Number of Masters		

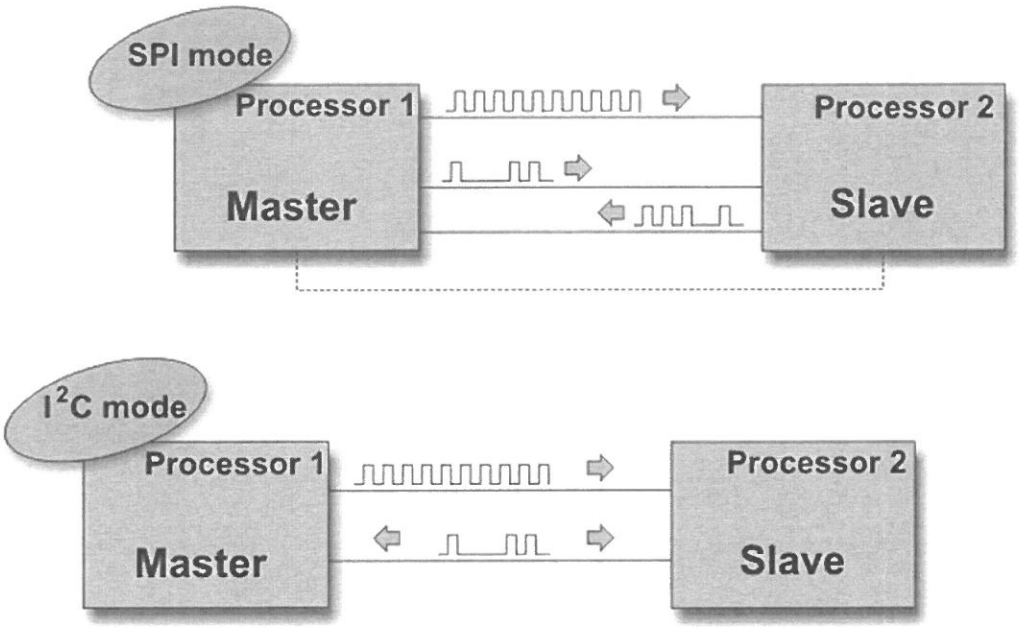

Figure 3(b) Serial communication.

(c) The TXTSA Register and RCSTA Register of a PIC16F877A microcontroller is set as shown in Table 3(c-1) and Table 3(c-2) respectively. Table 3(c-3) indicates the setting requires for configuring the 4800 baud rate 4 MHz oscillator at high speed operating in asynchronous mode using 8-bit data. Assume that there is no error and awaiting for the data being to be transmitted.

Table 3(c-1) TXTSA register.

TXTSA	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Register	0	0	1	0	0	0	0	0

Table 3(c-2) RCSTA register.

RCSTA	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Register	1	0	0	0	0	0	0	0

Table 3(c-3) SPBRG register.

SPBRG	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Register	?	?	?	?	?	?	?	?

Table 3(c-4) Baud rate formula.

SYNC	**BRGH = 0 (Low Speed)**	**BRGH = 1 (High Speed)**
0	(Asynchronous) Baud Rate = $F_{osc}/(64(X + 1))$	Baud Rate = $F_{osc}/(16(X + 1))$
1	(Synchronous) Baud Rate = $F_{osc}/(4(X + 1))$	N/A

Legend: X = value in SPBRG (0 to 255)

[Refer to Appendix]

(i) Describe in details the setting used for TXSTA register.

(4 marks)

(ii) Describe in details the setting used for RCSTA register.

(4 marks)

(iii) Determine the setting used for SPBRG register. Show the calculation working clearly.

(4 marks)

Question 4

(a) Describe the following types of embedded systems as shown in Figure 4a.

(i) Standalone embedded systems.

(3 marks)

(ii) Networked embedded systems.

(3 marks)

(iii) Mobile embedded systems.

(3 marks)

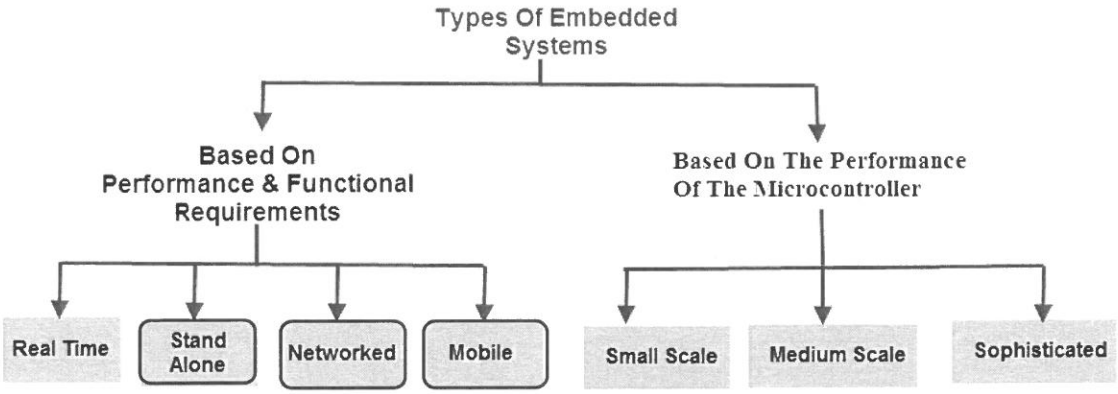

Figure 4(a) Types of Embedded System.

(b) Figure 4(b-1) shows the serial communication settings between the transmitter and receiver. Both of the PIC16F877A transmitter and receiver's settings are identical. The transmission uses asynchronous serial data communication (UART) with **LSB** being transmitted first to transmit a passkey to the receiver. Figure 4(b-2) shows the incoming data received at the receiver's side.

(7 marks)

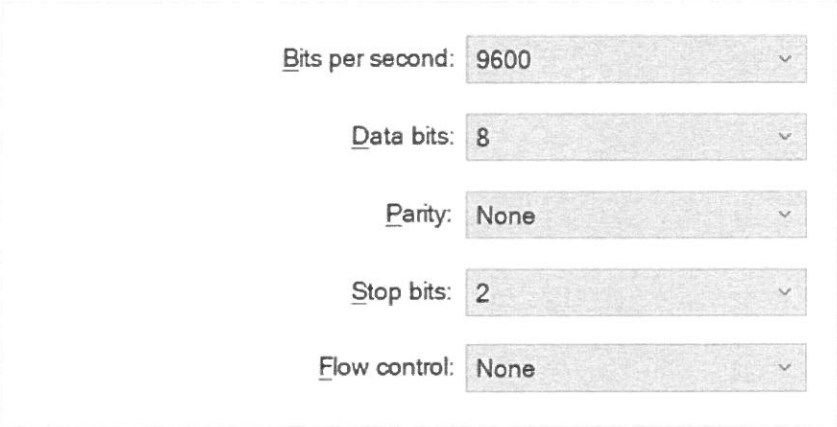

Figure 4(b-1) Serial communication setting.

Referring to ASCII codes in Table 4(b), deduce the following serial data received in continuous ASCII characters message.

Incoming data:

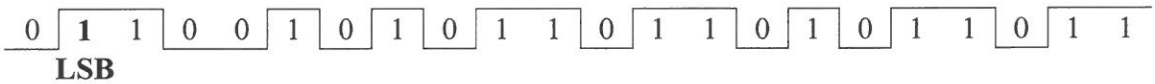

Figure 4(b-2) Data received at PIC16F877A receiver's side.

Table 4(b) ASCII Codes in Hexadecimal.

00: null	20: spa	40: @	60: `
01: ☺	21: !	41: A	61: a
02: ☻	22: "	42: B	62: b
03: ♥	23: #	43: C	63: c
04: ♦	24: $	44: D	64: d
05: ♣	25: %	45: E	65: e
06: ♠	26: &	46: F	66: f
07: beep	27: '	47: G	67: g
08: back	28: (	48: H	68: h
09: tab	29:)	49: I	69: i
0A: newl	2A: *	4A: J	6A: j
0B: ♂	2B: +	4B: K	6B: k
0C: ♀	2C: ,	4C: L	6C: l
0D: cret	2D: -	4D: M	6D: m
0E: ♫	2E: .	4E: N	6E: n
0F: ☼	2F: /	4F: O	6F: o
10: ►	30: 0	50: P	70: p
11: ◄	31: 1	51: Q	71: q
12: ↕	32: 2	52: R	72: r
13: ‼	33: 3	53: S	73: s
14: ¶	34: 4	54: T	74: t
15: §	35: 5	55: U	75: u
16: ▬	36: 6	56: V	76: v
17: ↨	37: 7	57: W	77: w
18: ↑	38: 8	58: X	78: x
19: ↓	39: 9	59: Y	79: y
1A: →	3A: :	5A: Z	7A: z
1B: ←	3B: ;	5B: [	7B: {
1C: ∟	3C: <	5C: \	7C: ¦
1D: ↔	3D: =	5D:]	7D: }
1E: ▲	3E: >	5E: ^	7E: ~
1F: ▼	3F: ?	5F: _	7F: ⌂

(c) A PIC16F628A microcontroller was setup to read some digital signals from PORTA as shown in Table 4(c-1) but it did not work. However, the program work after changing to Table 4(c-2). Explain why it does not work in the first place but work after the changes. Describe the function of the program in Table 4(c-2).

(9 marks)

Table 4(c-1) Initial Program.

Instruction	
CLRF	PORTA
BCF	STATUS, RP1
BSF	STATUS, RP0
MOVLW	0xFF
MOVWF	TRISA

Table 4(c-2) Changed Program.

Instruction	
CLRF	PORTA
MOVLW	0x07
MOVWF	CMCON
BCF	STATUS, RP1
BSF	STATUS, RP0
MOVLW	0x1F
MOVWF	TRISA

Question 5

(a) A Timer 2 block diagram is shown in Figure 5(a). Timer 2 is used to generate a delay of 30μs.

(i) Determine the value of the PR2 if the TMR2 is 0, the prescaler and postscaler of 1:1 are selected. Assume that the crystal clock is running at the frequency of 8MHz. Ignore the overhead due to instructions in the calculation.

(5 marks)

(ii) Explain how the microcontroller knows the delay of 30μs has reached.

(3 marks)

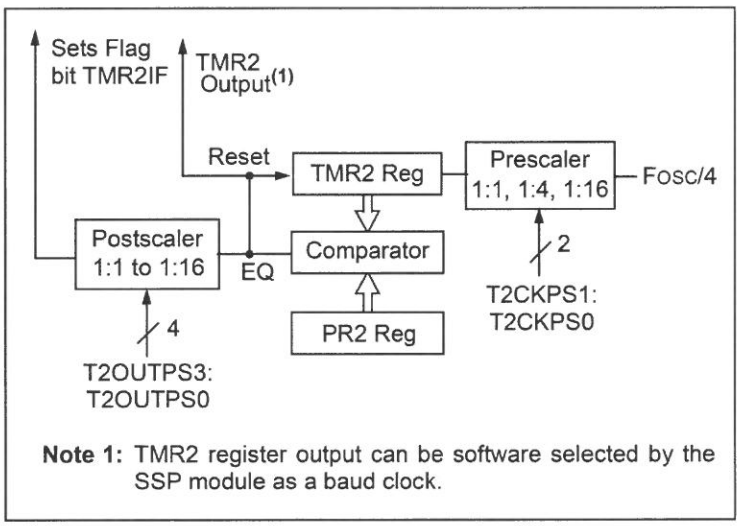

Figure 5(a)

(b) Explain THREE (3) types of memories available in the Peripheral Interface Controller (PIC) microcontroller and how each of them are being used by the programmer as shown in Figure 5(b-1). The description should include the size in bytes or words and the range (Hexadecimal) of each memory explained. State the possible type of microcontroller used for Figure 5(b-1). Appropriate diagram can be used to aid your explanation. Also, explain the amount of memory usage left in Data memory and Program memory of Figure 5(b-2).

(9 marks)

Flash Program Memory (14-bit words)
Data Memory (bytes)
EEPROM Data Memory (bytes)

Figure 5(b-1) Memories

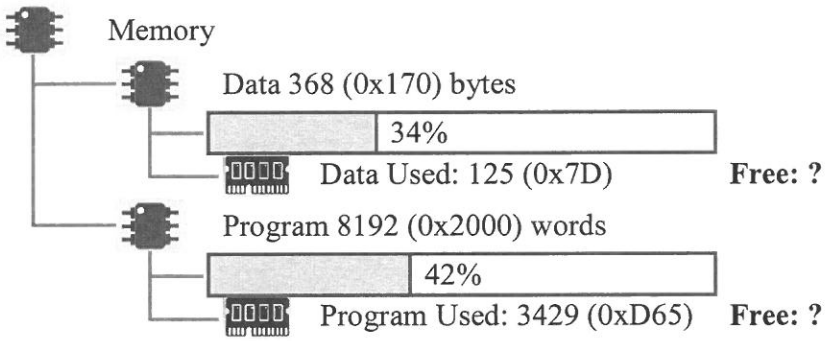

Figure 5(b-2) Memory Usage

(c) The block diagram of the PIC16F877A analogue to digital converter (ADC) is shown in Figure 5(c)(i). The ADCON0 and ADCON1 registers are shown in Figure 5(c)(ii) and Figure 5(c)(iii) respectively. In this design, an internal voltage reference is selected, input channel 3 is selected, and the ADC is switched on but not running. Assume that channel 0, channel 1, channel 2 and channel 4 are configured as analogue input only. Also, assume that the conversion clock used is Fosc/4 with left justification on the result.

[Refer to Appendix]

(i) Determine the setting for the ADCON0 register.

(2 marks)

(ii) Determine the setting for the ADCON1 register.

(2 marks)

(iii) Explain in details with the aid of diagram the meaning of 8-channel 10-bit ADC used in PIC16F877A microcontroller.

(4 marks)

Question 6

(a) The INTCON Register of a PIC16F628A microcontroller is set as shown in Table 6(a-1).

Table 6(a-1) Initial INTCON register.

INTCON Register	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
	1	0	0	0	1	0	0	0

(i) Determine which interrupts are enabled.

(ii) An interrupt occurs and the INTCON register is found to have changed to the setting shown in Table 6(a-2). Which interrupt source has called?

Table 6(a-2) After interrupt occurred.

INTCON Register	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
	1	0	0	0	1	0	0	1

[Refer to Appendix]

(5 marks)

(b) Compare the operation of Harvard architecture and von Neumann architecture with the aid of diagram.

(4 marks)

(c) Name and describe the function of the following labels as shown in Figure 6(c).

(i) Label (A)

(3 marks)

(ii) Label (B)

(3 marks)

(iii) Label (C)

(3 marks)

(iv) Label (D)

(3 marks)

(v) Label (E)

(3 marks)

State the possible type of microcontroller for Figure 6(c) internal architecture.

(1 mark)

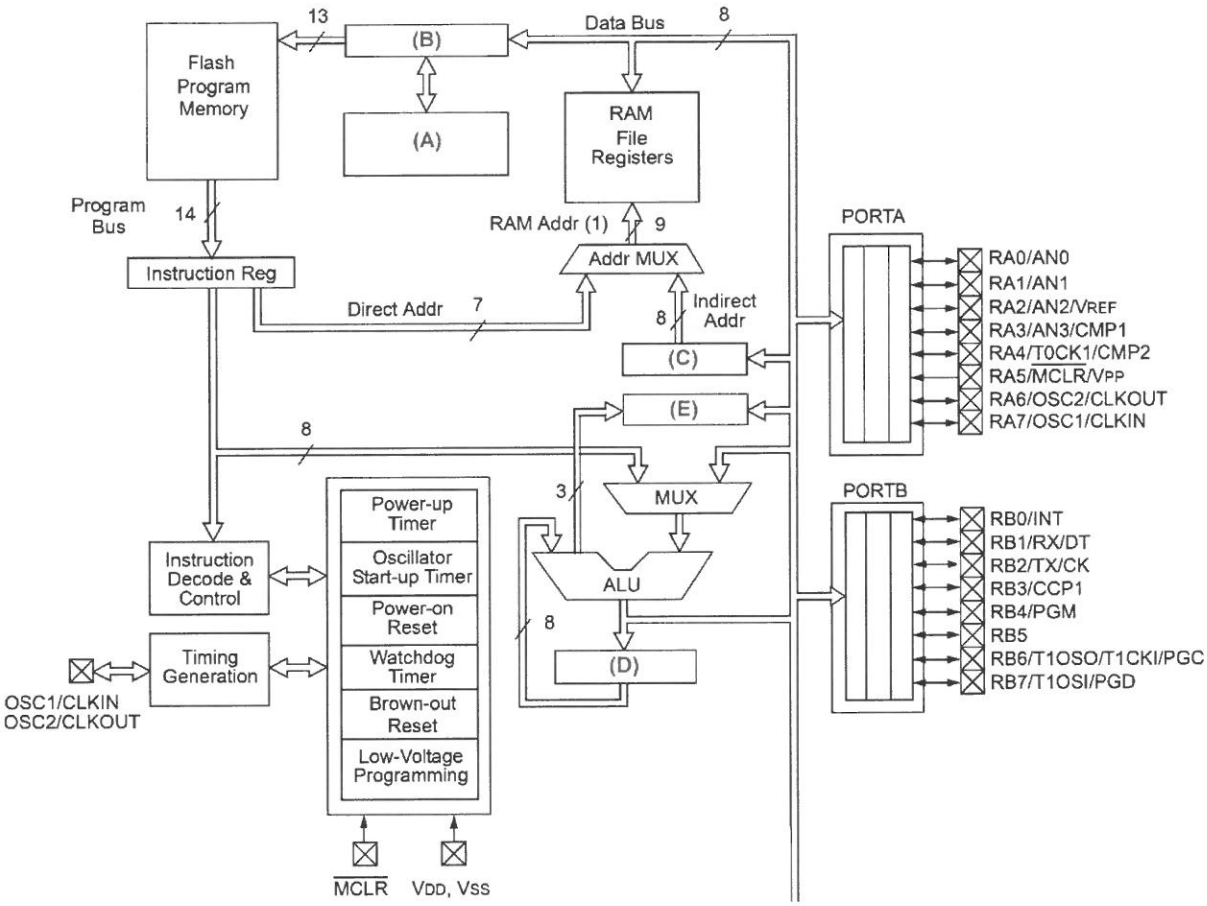

Figure 6(c) Internal architecture.

– THE END –

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