Tutorial 1 - Introduction to Microcontrollers

Q1.1 Which of the following best describes a microcontroller?

(a) A microcontroller is any device that can provide intelligent control in a system

(b) A microcontroller is small computer on a single integrated circuit consisting of a CPU, clock, timers, IO ports and memory.

(c) A microcontroller is an integrated circuit with a fixed program running in it.

(d) A microcontroller is a micro-processor.

Q1.2 Arrange the steps to program a PIC microcontroller.

Assuming

stands for Create a project

$ stands for Write a C-program

% stands for Compile the C-program to generate binary code in hex file

@ stands for Download the hex file into the PIC

(a) #, $, %, @

(b) $, #, %, @

(c) $, %, #, @

(d) %, %, @, #

Tutorial 2 - Microchip's PIC18F4550 – An Overview

Q2.1 Which of the following is an output device for a microcontroller-based system?

(a) An infra-red sensor.

(b) A servo motor.

(c) A Light Dependent Resistor (LDR).

(d) A push button.

Q2.2 The diagram below shows an "intelligent reading lamp".

If it is dark (Brightness Sensor, B == 0) and human is detected (Human Sensor, H == 1), the light will be switched on automatically (Light, L = 1).

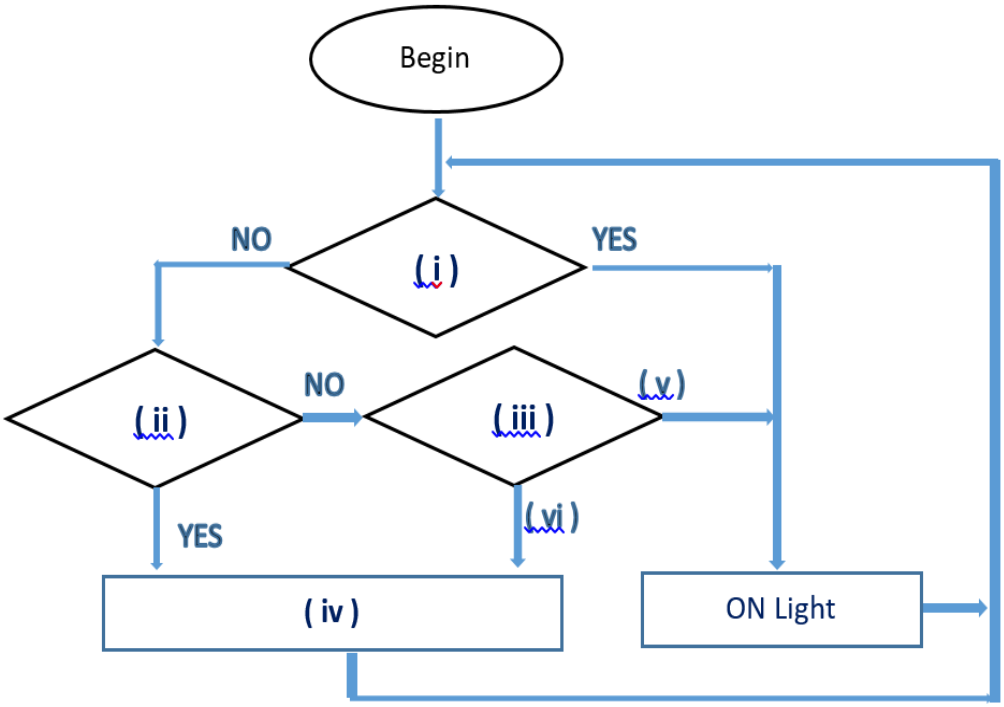
The light will be off if it is bright (B == 1) or human is not detected (H == 0).

A manual override Button, M, is provided so that if M == 1, the light will be on, regardless of the status of the Brightness Sensor or Human Sensor. In other words, the light will only depend on the sensors' status when M == 0.

A PIC18 microcontroller is used in the "intelligent reading lamp".

(a) Draw the block diagram to show how the Brightness Sensor B, the Human Sensor H, the Manual Override Button M and the Light L can be connected the PIC18 microcontroller.

(b) Complete the flowchart for the intelligent control of the Light. The flowchart should include the following words: M==1? B==1? H==0? OFF light YES NO



(c) Which of the following can be used for the brightness sensor: An LDR, a thermistor or a limit switch?

(d) Why is the brightness sensor mounted above the lamp shade?

Tutorial 3 - PIC18F4550's I/O Ports & Device Interfacing (Part 1)

Q3-1.1 When the code TRISB = 0b00001111; appears in a program, we know that for PORTB,

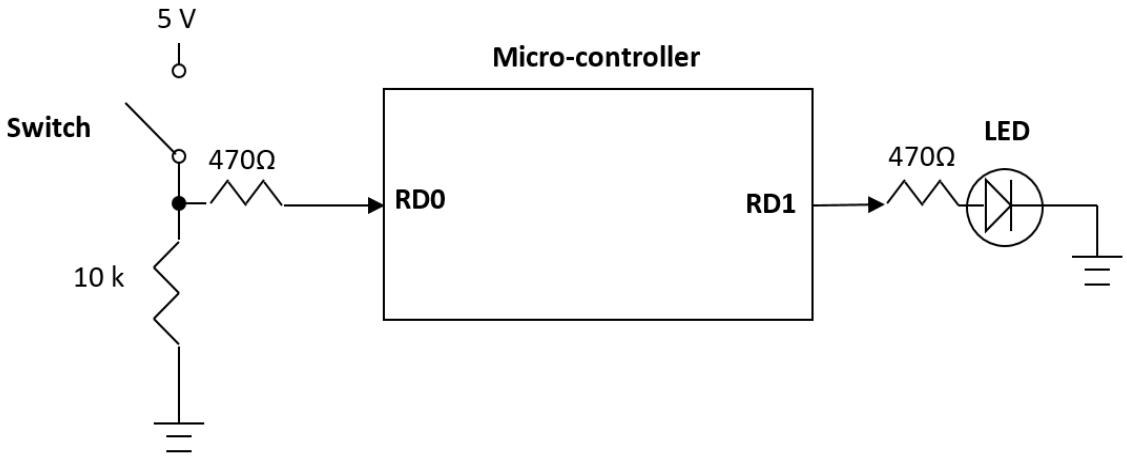
(a) bits 7-4 are inputs, while bits 3-0 are outputs.

(b) bits 7-4 have been set to 0, while bits 3-0 have been set to 1.

(c) bits 7-4 are outputs, while bits 3-0 are inputs.

(d) bits 7-4 have been set to 1, while bits 3-0 have been set to 0.

Q3-1.2



For the circuit diagram above,

(a) When the switch is closed (connected), RD0 is ____ (high / low). The switch is an active ____ (high / low) ____ (input / output) device.

(b) When RD1 is high, the LED will be ___ (on / off). The LED is an active ____ (high / low) _____ (input / output) device.

(c) Design a program so that when the switch is closed, the LED will be on; else the LED will be off.

1	main () {
2	__(i) _____ // code to configure RD0 as input & RD1 as output
3	___(ii)_____ { // loop forever
4	if (PORTDbits.RD0==1) _(iii)_____ // on the LED
5	else __(iv) _____ // off the LED
6	} // end of while
7	} // end of main

Tutorial 3 - PIC18F4550's I/O Ports & Device Interfacing (Part 2)

Q3-2.1 A common cathode 7-segment display device is connected to PORTD (segment "a" to RD0, segment "b" to RD1... decimal point to RD7). Which command displays a 7?

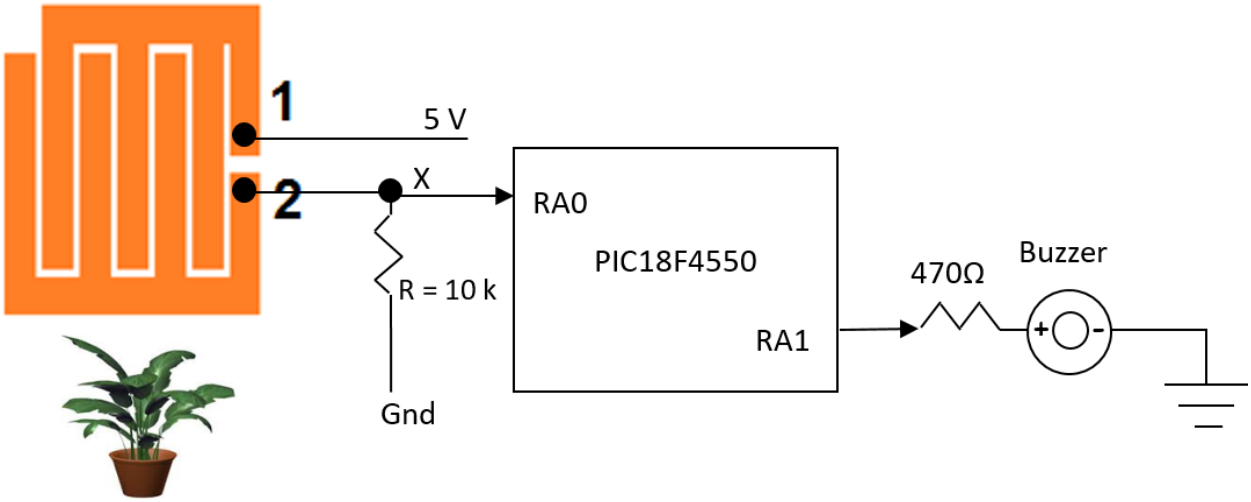
(a) PORTD = 0b11100000;

(b) PORTD = 0b00011111;

(c) PORTD = 0b11111000;

(d) PORTD = 0b00000111;

Q3-2.2 To monitor a potted plant soil, a moisture sensor (on the left) and a buzzer (on the right) are connected to a PIC18 microcontroller as shown below:



When the soil is moist, points 1 & 2 of the moisture sensor will be shorted. When the soil is dry, points 1 & 2 will not be connected.

(a) If the soil is dry, what logic value will the PIC18 microcontroller read at its RD0 pin?

(b) What must the PIC18 microcontroller produce at its RD1 pin, to allow turn on the buzzer?

(c) Write a C programme for the PIC18 microcontroller to turn on the buzzer when the soil is dry.

1	main () {
2	_(i)_____ // code to configure RA0 and RA1 as digital PIN
3	_(ii)_____ // code to configure RA0 as input & RA1 as output
4	_(iii)_____ { // loop forever
5	if (PORTDbits.RA0==1) __(iv)_____ // off the buzzer
6	else { __(v) _____ // on the buzzer
7	// …Delay for 5 seconds here…
8	PORTDbits.RA1 = 0; // off the buzzer after 5 sec
9	} // end of else
10	// …Delay for 30 minutes here… don't check the soil too often
11	} // end of while
12	__(vi)___ // end of main

Tutorial 4 - PIC18F4550's Analogue to Digital Conversion

Q4.1 In a 10-bit ADC, the reference voltages are 5 V and 0 V. Estimate the digital result if Vin (the analogue input voltage) is 2 V. [Hint: Result = Vin x 1023 / 5]

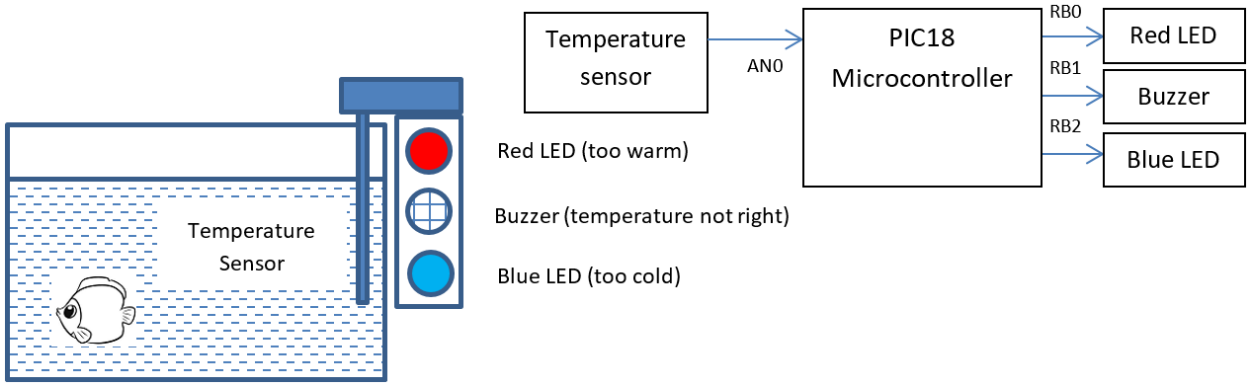
(a) 450_{10}

(b) 415_{10}

(c) 409_{10}

(d) 400_{10}

Q4.2. A sensor is used to monitor the water temperature in a fish tank, as follows:



The temperature value (analogue) is converted into 10 bits (digital) by the PIC18's ADC (analog to digital converter), right-justified and then used to turn on / off the LEDs and Buzzer, according to the table below:

ADRESH bit1 bit0	Condition	Action to be taken	C Code
0 0	Too cold	On Buzzer & Blue LED	PORTB = 0b00000110;
0 1	OK	**Off** Buzzer & LED's	PORTB = 0b00000000;
1 0	Too warm	On Buzzer & Red LED	PORTB = 0b00000011;
1 1	Too warm	On Buzzer & Red LED	PORTB = 0b00000011;

The program running in the microcontroller is as follows:

```
……
main (void) { // … other lines not shown
    // configure A/D converter module & switch it on
    ADCON0 = 0 b 0 0 ? ? ? ? 0 1;       // select AN0 for conversion
    ADCON1 = 0 b 0 0 ? ? 1 1 1 0;       // use Vss (0V) as Vref-, and Vdd (5V) as Vref+
    ADCON2 = 0 b ? 0 0 1 0 1 1 0;       // right justify 10 bit result
    while (1) {
      __?__                                  // starts A/D conversion
      while (ADCON0bits.GO == 1);     // wait here for A/D completion
      _?_                    //  turn on LED & Buzzer, if temperature value not acceptable
    }
}
```

(a) What binary bit pattern should be put into bits 5 to 2 of ADCON0 in order to use AN0 as the analogue input channel? You may need to refer to the Appendix.

(b) What binary bit pattern should be put into bits 5 to 4 of ADCON1 in order to use Vss (i.e. 0 volt) as Vref- and Vdd (i.e. 5 volts) as Vref+?

(c) What value (0 or 1) should be put into bit 7 of ADCON2 in order to right-justify the 10 bit conversion result?

(d) Write the C code to start the A to D conversion.

(e) Write the C code to turn on / off the LEDs & Buzzer, depending on the temperature.

Tutorial 5 - A Brief Revision on C Language

Q5.1 Which of the following command waits for an "active low" button connected to RB0 (Port B Pin 0) to be pressed?

(a) while (PORTBbits.RB0 == 0);

(b) while (PORTBbits.RB0 = 0);

(c) while (PORTBbits.RB0 = 1);

(d) while (PORTBbits.RB0 == 1);

Q5.2 Give the C-code to shift "count" (an unsigned char variable) right by 2 bits:

(a) count = count + 2;

(b) count = count * 2;

(c) count = count << 2;

(d) count = count >> 2;

Tutorial 6 - PIC18F4550's Programmable Timers / Counters

Q6.1 Which one of the following applications certainly does not require a microcontroller with timer?

(a) Blinking an LED
(b) A real time clock
(c) A mechanical safe box
(d) Medicine dispenser

Q6.2 In the following program line, what is the Timer0 pre-scaler value chosen?

```
T0CON = 0b10000110;
```

(a) 1/256
(b) 1/128
(c) 1/64
(d) 1/32

Q6.3 Assuming crystal oscillator with Fosc = 48 MHz is used as clock source and pre-scaler is not used, how long does it take for Timer0 (used as 16-bit timer) to count from 0x4000 to 0xFFFF & roll over?

Q6.4 Assuming crystal oscillator with Fosc = 48 MHz is used as clock source and pre-scaler of 32 is used, what is the starting count value in order that exactly 0.1 sec has elapsed when timer overflows?

Q6.5 A duration of a pulse signal that inputs to RB0 is to be measured using Timer0. The input signal and the program used are shown below. Based on the Timer0 configuration used in the program, what should be the values recorded to variables TempLow and TempHigh?

Fig. Q6.5

```
…
T0CON = 0b10000100;          // Timer 0 on, 16-bit, Fosc/4, pre-scaler 32

while (PORTBbits.RB0 == 0);  // wait for signal at RB0 to go high

TMR0H = 0x00;
TMR0L = 0x00;

while (PORTBbits.RB0 == 1);  // wait for signal at RB0 to go low

T0CONbits.TMR0ON = 0;       // stop Timer 0

TempLow = TMR0L;
TempHigh = TMR0H;
…
```

Q6.6 A PWM signal is shown below. Calculate the duty cycle of the signal. (Please note that the figure is not drawn to the scale.)

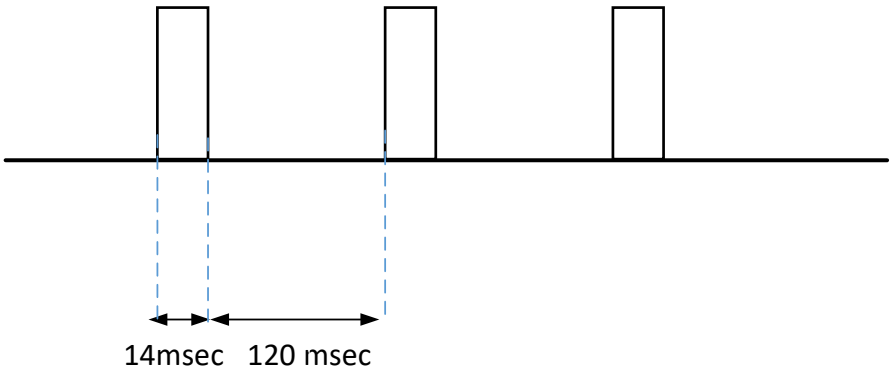


Fig. Q6.6

Q6.7 Observe the program given below. If a PWM signal is used for controlling a DC motor speed, what is achieved with following program? Fill out the missing comments.

```
……
TRISCbits.TRISC2 = 0;        //……?…….
CCP1CON = 0b00001100;  // ……?……
TMR2 = 0;                    // ……?……

T2CON = 0b00000110;     //……?……..
PR2 = 149;                  //……?……...


while (1)
{
        CCPR1L = 74;        //……?……
        delay_ms(500);
        CCPR1L = 25;        //……?…….
        delay_ms(500);
 }
…..
```

Tutorial 7 - PIC18F4550's Interrupt

Q7.1 Which one of the following applications requires use of interrupts for a reliable operation?

(a) Obstacle avoiding robot
(b) Auto-plant watering device
(c) Room temperature control
(d) Medicine dispenser

Q7.2 INTEDG0 bit of INTCON2 register _____.

(a) selects internal or external interrupt
(b) selects interrupt priority
(c) selects interrupt to occur at falling or raising edge
(d) none of these

Q7.3 Which one of the following is not an interrupt source in PIC18F4550?

(a) All the timers
(b) Any change in PORTB pins
(c) When RAM memory is full
(d) ADC

Q7.4 Observe the following program lines and fill out the missing comments.

```
INTCONbits.GIEH = 1;      //……?……

INTCONbits.TMR0IE = 1;  //……?……
```

Q7.5 A Timer0 interrupt is to be implemented.

Write the appropriate C statements for the task, with following Timer0 setting:

(i) Timer0 in 16 bit operation, pre-scale value of 1:8
(ii) initialise Timer0 with value 0x4F28
(iii) enable Global Interrupt and Timer0 interrupt
(iv) clear Timer0 overflow flag

Q7.6 For a PIC18F4550 to have pin RB0 as an interrupt-input, write instructions for the following operations, referring to the comments.

_____; // (i) Configure RB0 as input

_____; // (ii) Interrupt on rising edge of signal at RB0

_____; // (iii) Enable Global Interrupt

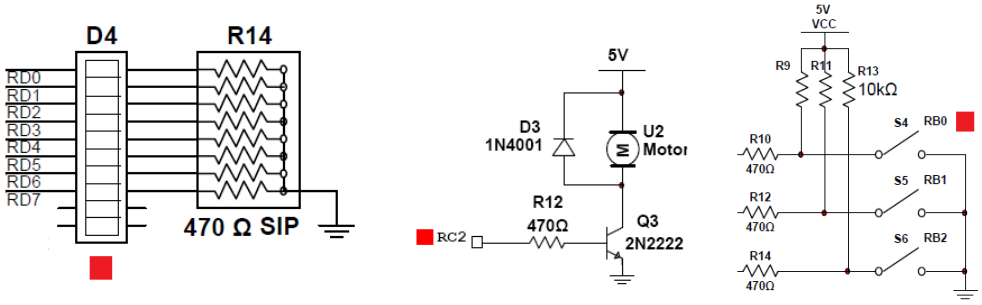
_____; // (iv) Enable INT0 external interrupt

_____; // (v) Enable priority levels on interrupts

_____; // (vi) Clearing interrupt flag

Q7.7 The following circuit diagram shows interface circuits and connections made to a PIC18F4550 microcontroller. A program written by an application engineer is also given below. The program is developed using polling technique.

(i) Analyse the program given below and describe what the application engineer is trying to achieve?
(ii) What are the problems with this program piece?
(iii) Rewrite this program using interrupts.




```
#include <xc.h>
#include "delays.h"

unsigned char press;

void main(void)
{
   unsigned char TL;
   unsigned char TH;
   TRISC=0x00;
   TRISD=0x00;
   TRISB=0x0F;
   T0CON = 0b10000100; // configure timer0
   T2CON=0b00000111;   // configure timer2
   CCP1CON=0b00001100;
   PR2 = 149;
   CCPR1L = 75;              // 50% duty cycle by default
   press==0;
```

```
    while(1)
    {
      if(PORTBbits.RB0==0){
            press++;
            if (press==1){
               CCPR1L = 37;
            } else if (press==2){
               CCPR1L = 120;
               press=0;
            }
      }
      while (PORTBbits.RB1 == 1);
      TMR0H = 0x00;
      TMR0L = 0x00;
      T0CONbits.TMR0ON = 1;
      while (PORTBbits.RB1 == 0);
      T0CONbits.TMR0ON = 0;
      TL = TMR0L;                  // read TMR0L first
      TH = TMR0H;
      if (TH>0x20) {
              PORTD=TH;     // display TMR0H content
              delay_ms(500);
              PORTD=0x00;
       }
    }
}
```

Tutorial 8 - PIC18F4550's Serial Port

Q8.1 Which of the following is used to receive a byte of data serially in PIC18F4550?

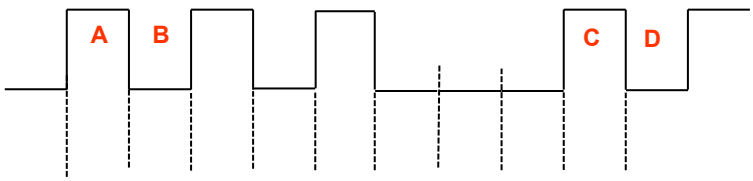
(a) data_in = TXREG;
(b) data_in = RCREG;
(c) SPBRG = 77;
(d) PIR1bits.RCIF == 1;

Q8.2 For a PIC18F4550 microcontroller with an oscillator frequency of 48 MHz, calculate the value for SPRBG register in order to communicate at a baud rate of 19200.

Q8.3 The following program piece is taken from a program which is written to send numerical values through serial communication port of PIC18F4550 to an external device. Explain the purposes of program lines (1), (2) and (3).

```
……
unsigned char data;
 …
 data = D2+0x30;                 // Line (1)
 while (PIR1bits.TXIF == 0); // Line (2)
 TXREG = data;                  // Line (3)
 delay_ms(100);
 …
```

Q8.4 Refer to the serial communication signal captured on an oscilloscope screen. What would be the descriptions for A, B, C and D? What is the data being sent?



Q8.5 Fill out the missing program lines in the following program segment order to communicate with a sensor connected to PIC18 via serial communication.

```
while(1) {

…… // send command 0x50 to smart sensor

…… // wait for receive flag to be set

…… // receive sensor data and keep in variable temp

….
```