UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: March 2021

Module Number: ME3211 **Module Name: Principles and Applications of Microcontrollers**

[Three Hours]

[Answer **all questions**, each question carries **10 marks,** provide neat sketches where necessary, clearly state all assumptions that you may make, answer Part 1 and Part 2 in separate booklets]

Part 1

Q1. i) A microcontroller is an electronic component assembly that is manufactured as a single unit.
Briefly describe the operation of the following components inside a microcontroller.

(a) Central Processing Unit (CPU)

(b) I/O Ports (I/O – Input/Output)

(c) Bus

(d) Timers/ Counters

[4.0 Marks]

ii) When choosing a microcontroller for an application, we should pay close attention to its' internal memory capacities.

(a) Explain briefly why it is essential to consider the amount of memory in the microcontroller when selecting it for a specific application.

(b) List and briefly describe three (03) major memory types present in a microcontroller.

[2.5 Marks]

iii) The architecture of a microcontroller refers to how the CPU is arranged in reference to its memories.

Differentiate between the Von Neumann and the Harvard Architecture.

[1.0 Mark]

Q1 continuous to the next page

3/3

iv) List three(03) advantages and two(02) disadvantages of microcontrollers with compared to the microprocessors.

[2.5 Marks]

Q2. i) Assume you need to adjust an LED's brightness, based on the amount of light in the background using a microcontroller. Briefly describe the role of PWM and how to use PWM to adjust the brightness of the LED.

[3.0 Marks]

ii) Interrupts available in a microcontroller are categorised into two main categories as hardware interrupts and software interrupts. Explain the function of above two interrupt types.

[2.0 Marks]

iii) (a) Sketch a typical two resistor voltage divider circuit and explain how it can be used to scale down the input voltage to a desired lower value.

(b) Suppose you are going to use a 16×2 LCD module with a microcontroller and the required voltage and current for the module are 4.5 V and 20 mA, respectively.
Design a voltage controlling circuit to supply a constant 4.5 V to the LCD module from a 10 V DC power source.
(Note: You may assume the voltage and current values for the Zener diode)

[5.0 Marks]

Part 2

Note:

- Use the given information (figures .1-4 and tables 1-3) in the Annex when answering part 2.
- No need to mention the resistor values for fixed resistors in the constructed circuit diagrams.
- Use appropriate resistor values for potentiometers.

Q3. i) Write a C programme to achieve the operation shown in the flow chart Figure Q3 (i).

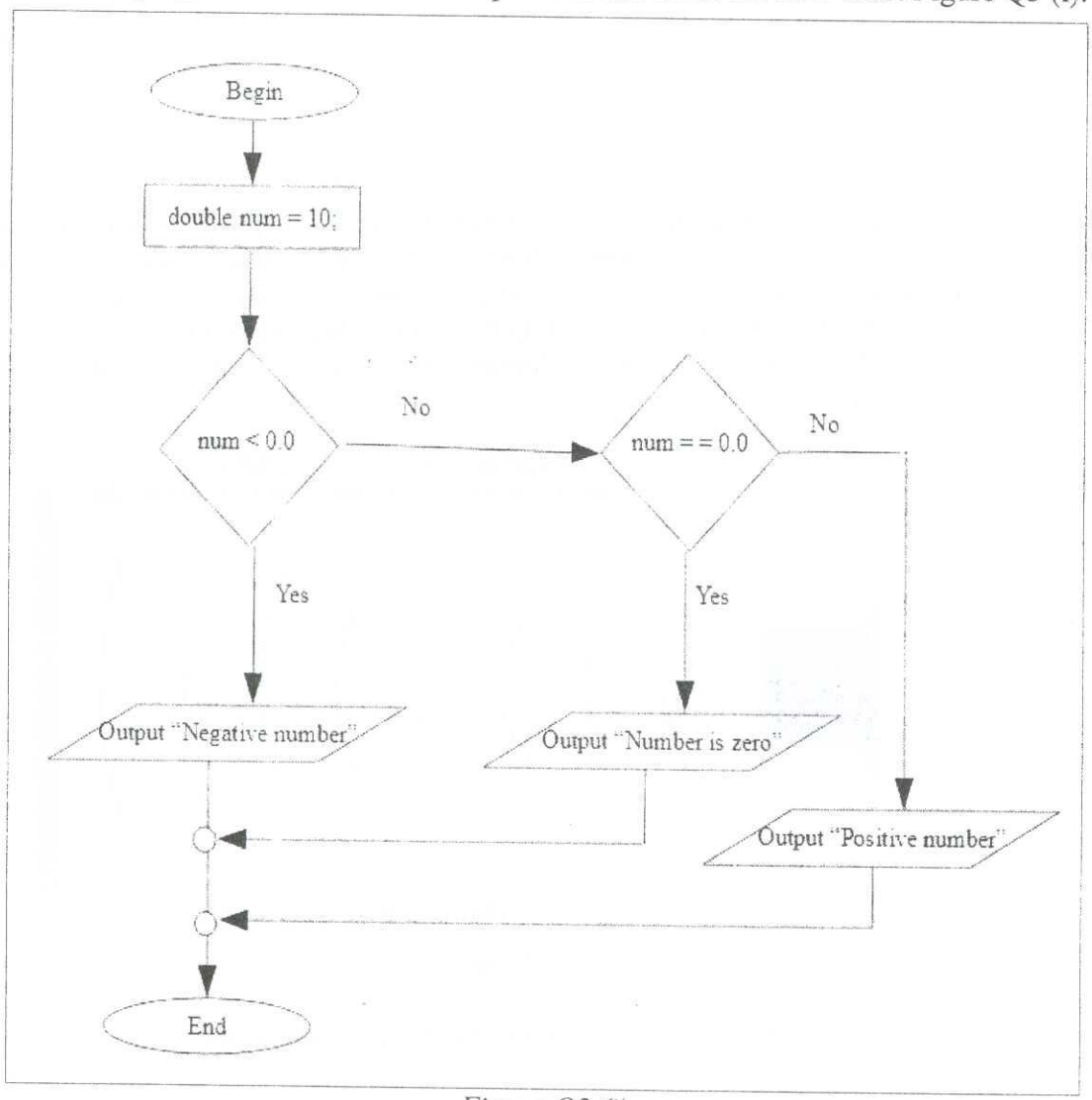


Figure Q3 (i)

[5.0 Marks]

ii) State the three communication peripherals/protocols available in the ATmega328P microcontroller based Arduino UNO board (see the Figure 1 in the Annex.).

[1.5 Marks]

Q3 continuous to the next page

iii) Two microcontroller boards can be connected to communicate with each other when one board is connected to a computer through the USB port for debugging the code.

(a) Propose a suitable communication protocol to achieve communication between two microcontroller boards.

(b) Sketch the wiring diagram to achieve the communication between microcontroller boards mentioned above. Include any additional components as needed and clearly label each connection.

[3.5 Marks]

Q4. An ultrasonic sensor is to be used to measure the distance from the sensor to a stationary object (Figure Q4 (i)). Two 7-segment displays are to be used to display the distance results. Distance between and including 5 cm and 20 cm is considered valid and to be displayed. If the distance is out of the range, all 14 LEDs of two 7-Segments must be turned off and only numbers must be displayed if valid distance detected. An Arduino UNO microcontroller board will be used as the controller.

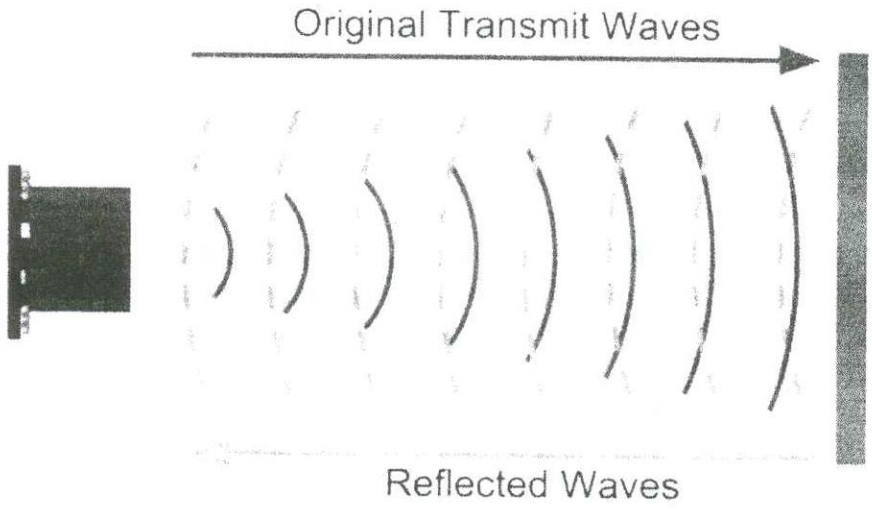


Figure Q4(i)

i) Sketch a suitable circuit diagram for the design, clearly labelling all the used pins.

[5.0 Marks]

ii) Write a C programme taking the air temperature as 25 ^{0}C. The conversion equation is included in the annex.

[5.0 Marks]

Q5. Most hotels have different sizes of water fountains for decorative proposes. You have given the task to manually change the water flow rate of such a water fountain using a microcontroller based controller. A DC motor is to used to achieve the water flow and a potentiometer is used to give the input signal to microcontroller. Arduino UNO microcontroller board based on the ATmega328P microcontroller is to be used as the controller.

ii) Draw a suitable circuit diagram for the system, clearly labelling all the used pins. Use a separate power supply for the motor.

[5.0 Marks]

ii) Design a flow chart for the above function.

[2.0 Marks]

iii) Write a C programme to achieve the operation in (ii) above. Include comments to describe major parts of the program.

[3.0 Marks]

The annex starts from the next page

Annex

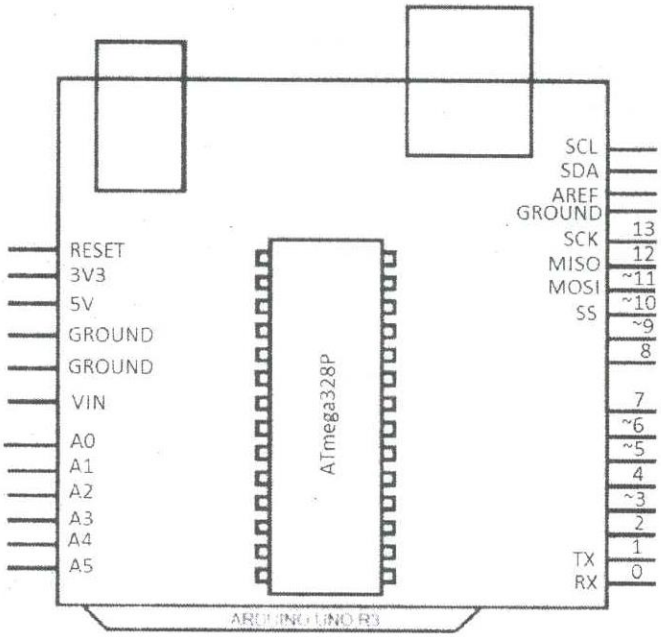
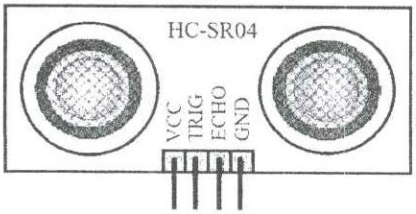


Figure 1: Arduino UNO pin diagram



Distance (cm) = Speed of sound (cm/µs) × Time (µs) / 2

$$V\ (m/s) = 331.3 + (0.606 \times T)$$

V = Speed of sound (m/s)
T = Air Temperature (°C)

Figure 2: HC-SR04 pin diagram and operating equation

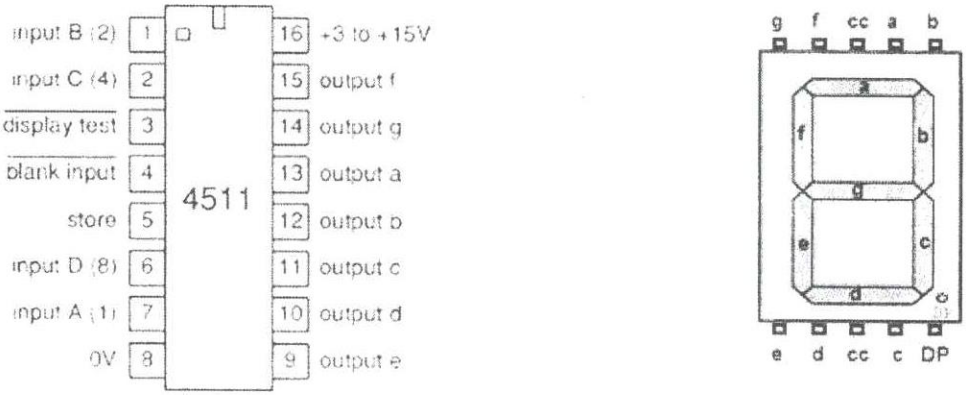


Figure 3: Pin diagrams of CD4511 and 7-segment display

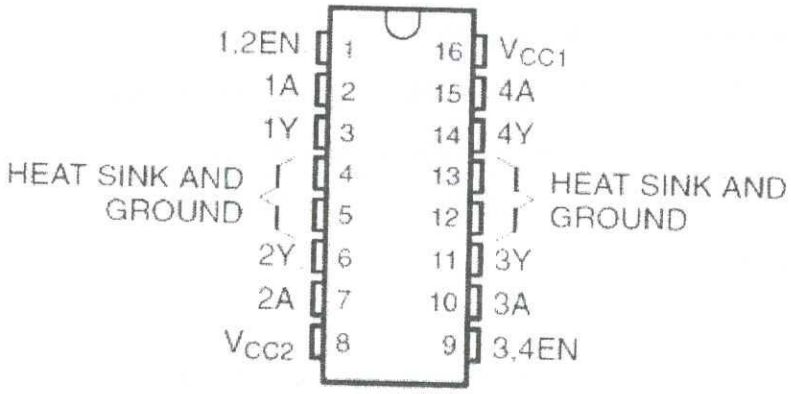


Figure 4: Pin diagram of the L293/L293D motor driver

Table 1: Pin functions of CD4511

Pin No.	**Pin Name**	**Description**
1, 2, 6, 7	A, B, C, D	4 BDC inputs.
3	display test	Lamp test input is used to test the display.
4	blank input	Blanking input is used to turn-off or pulse modulate the brightness.
5	store	Latch Enable or Strobe input is used for storing BCD code.
8	Vss	Ground segment output.
9, 10, 11, 12, 13, 14, 15	a, b, c, d, e, f, g	Seven segment outputs.
16	Vdd	Positive power supply.

Table 2: Useful C commands

Programme code	**Explanation**
printf("Include here the required text output");	Give outputs from C language
For Arduino UNO board	
pinMode(trigPin, OUTPUT);	Define an output
digitalWrite(trigPin, LOW);	Write a digital value to an output (value = LOW)
duration = pulseIn(pin number, HIGH);	returns the duration of a pulse (length of the pulse) in microseconds
delayMicroseconds(x);	Waite x number of micro seconds
analogWrite(pin number, i);	Get a PWM output. i is a number from 0 to 255
analogRead(pin number) *0.0049	Get the input voltage of an analog input

Table 3: Pin functions of L293/L293D

Pin number	Pin name	Description
1	1, 2EN	This pin enables the input pins 1A and 2A.
2	1A	Directly controls the output pin 1Y.
3	1Y	Connected to one end of motor 1.
4	GROUND	
5	GROUND	
6	2Y	Connected to other end of motor 1.
7	2A	Directly controls the output pin 2Y.
8	Vcc_2	Connected to voltage pin for running motors. (4.5 V to 36 V)
9	3, 4EN	This pin enables the input pins 3A and 4A.
10	3A	Directly controls the output pin 3Y.
11	3Y	Connected to one end of motor 2.
12	GROUND	
13	GROUND	
14	4Y	Connected to other end of motor 2.
15	4A	Directly controls the output pin 4Y.
16	Vcc_1	Connected to 5V to enable IC function.