



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: February 2023

Module Number: ME 3211 Module Name: Principles and Applications of Microcontrollers

[Three Hours]

[Answer all questions; each question carries 10 marks; provide neat sketches where necessary, and clearly state all assumptions you may make. Use the given information in figures Q3-Q5 and tables 1-3 when answering questions. No need to mention the resistor values for fixed resistors in the constructed circuit diagrams.]

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- Q1 a) Briefly describe the operation of the below components inside a microcontroller.
- i. Central Processing Unit (CPU) [1.0 Mark]
 - ii. I/O Ports (I/O - Input/Output) [1.0 Mark]
 - iii. Watchdog timer [1.0 Mark]
 - iv. System bus [1.0 Mark]
 - v. Program Memory [1.0 Mark]
- b) i. Briefly describe the interrupt function found in microcontrollers. [1.0 Mark]
- ii. List down the two ways that an interrupt could be triggered. [2.0 Marks]
- iii. Draw an interrupt signal and label the positions on the signal that corresponds to the ways listed above (ii). [2.0 Marks]
- Q2 a) i. List down and briefly describe three main operations carried by an Arithmetic Logic Unit (ALU). [4.0 Marks]
- ii. Briefly describe the Control Unit (CU) found in microcontrollers. [1.0 Mark]
- b) Briefly describe the difference between Volatile Memory and Non - volatile Memory. [1.0 Mark]
- c) What is Pulse Width Modulation (PWM)? How do you specify it? Explain how a DC motor speed can be controlled using a PWM signal using an appropriate circuit diagram. [4.0 Marks]

- Q3 a) A flow chart for a C programme is given in figure Q3(a). Construct the C programme following the logic. [5.0 Marks]
- b) You are asked to use an On/Off switch as an input and an LED as an output with the microcontroller development board given in figure Q3(b). The switch should be connected to the microcontroller with a pull down resistor. Construct a basic circuit diagram for this task. [5.0 Marks]
- Q4 a) You are asked to design a low-cost consumer device to measure the temperature and transmit the measurement to another low-cost consumer device. The main device is connected with a TMP36 temperature sensor (Figure Q4(a)) to measure the temperature. TMP36 output is an analog voltage output depends on the temperature. Red colour LED should be used with the other device to indicate temperatures larger than 50°C. Both devices contain the same microcontroller development board (Figure Q3(b)). The UART communication should be used to communicate between two devices and indicate whether the measured temperature is higher than 50°C or not (No need to communicate the temperature value).
- Construct a circuit diagram for both devices, showing the connected communication lines and clearly labelling all the pins. [2.5 Marks]
 - Construct two C programmes to two devices given above. Indicate the purpose of each section of the code of the program as comments (begin by //). [2.5 Marks]
- b) You are asked to use the devices in section (a) for temperature monitoring in a medical sector environment. Explain what changes to the devices should be done for reliable operation. You can use any number of microcontroller development boards, any type of communication methods and any number of TMP36 sensors and LEDs. [5.0 Marks]
- Q5 a) You are asked to design a low-cost consumer fan with a speed control function using a microcontroller development board shown in figure Q3(b). A DC motor for the fan and two switches for increasing decreasing motor speed should be used. Speed levels are '0', '1', '2', '3'.
- '0' is for zero speed.
 - '3' is for maximum speed.
 - Choose appropriate speed values for '1' and '2'.
- A seven segment display (figure Q5(a)) should also be connected to the circuit to show the current speed level (show the corresponding number) which the motor is operating. Use the given motor driver shown in figure Q5(b) and seven segment display driver shown in figure Q5(c). Use pull-up resistors with the switches.
- Construct the circuit diagram for the device above, clearly labelling all the used pins. [2.5 Marks]

Q5 continuous to the next page

ii. Construct the C programme for the device above indicating the purpose of each section of the code of the program as comments (begin by //).

[2.5 Marks]

b) You are asked to use the device in section (a) for multi-speed blood pumping machine in medical sector. The above DC motor should be connected to the blood pump. Explain what problems can occur due to hardware malfunctions and how to change the device to minimize those problems.

[5.0 Marks]

ANNEX

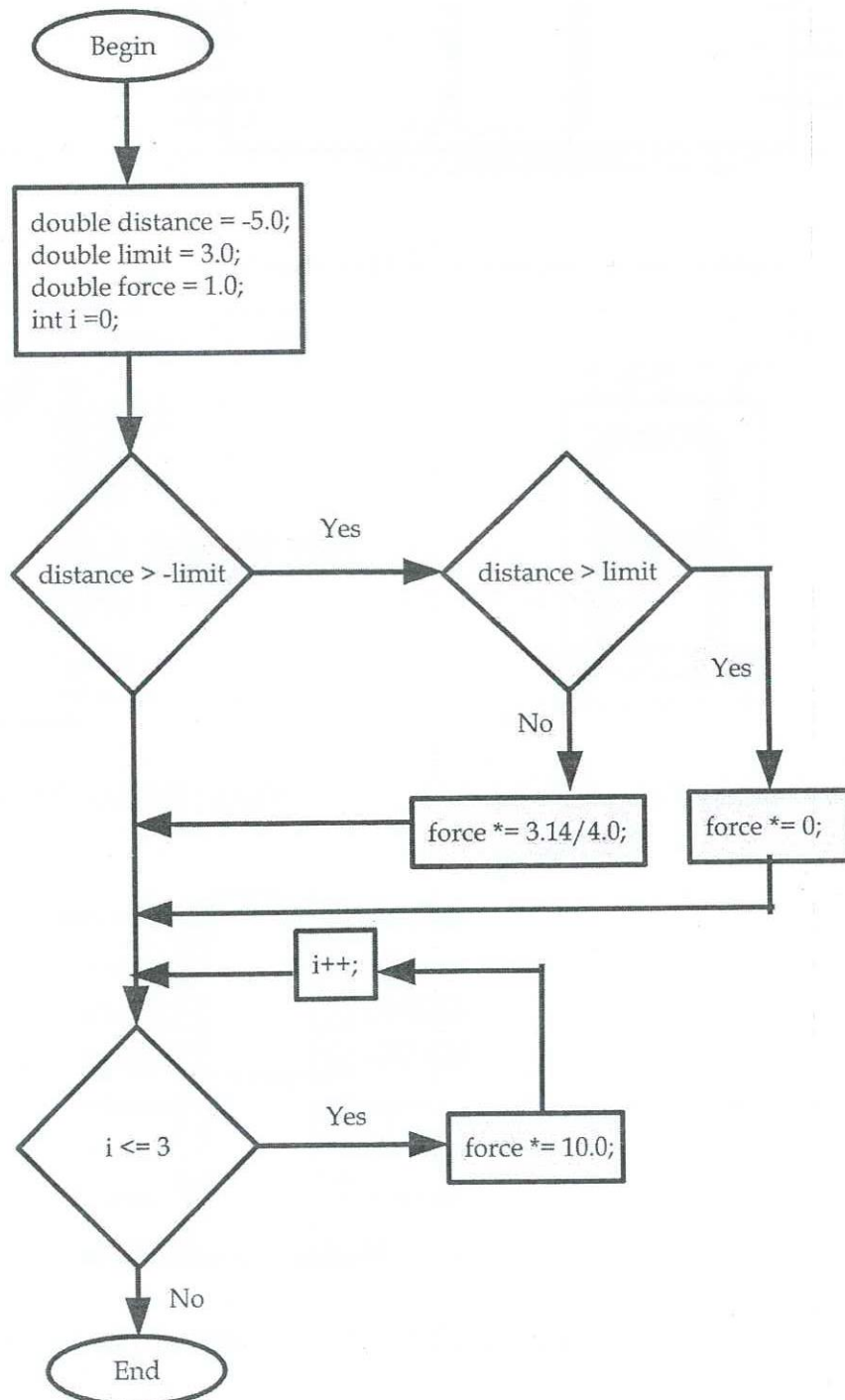


Figure Q3(a): Flow Chart

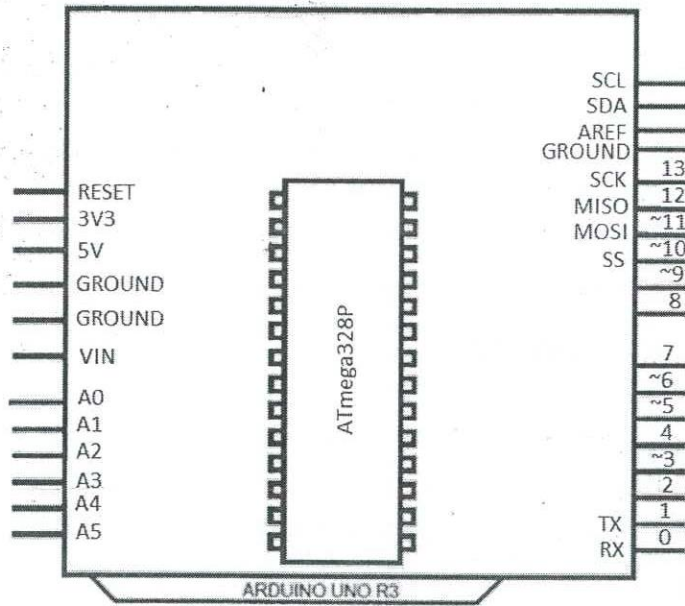


Figure Q3(b): Arduino UNO pin diagram

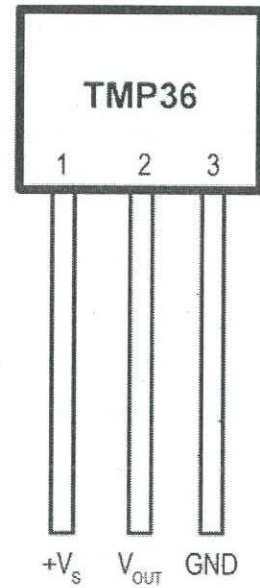


Figure Q4(a): TMP36

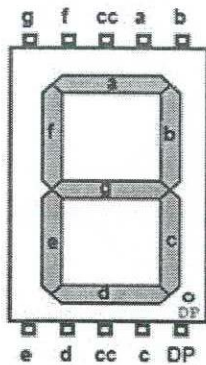


Figure Q5(a): 7-segment display

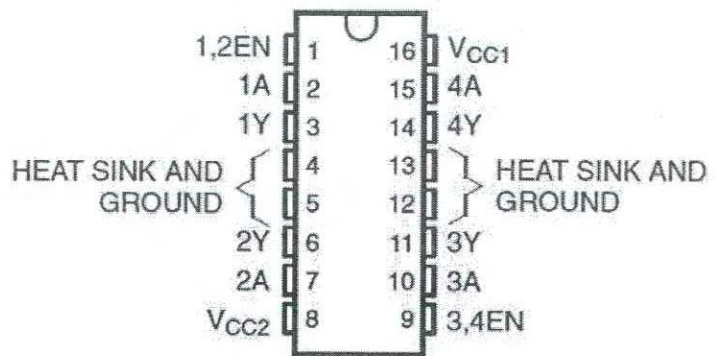


Figure Q5(b): L293/L293D motor driver

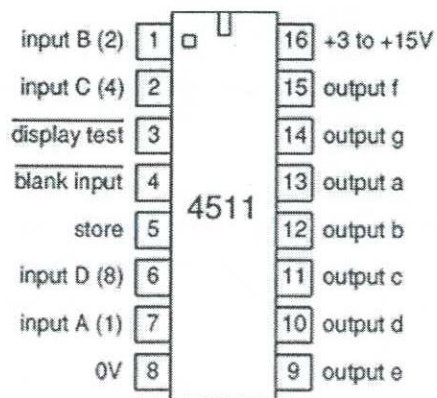


Figure Q5(c): CD4511 7-segment display driver

Table 1: Useful C commands

Programme code	Explanation
For Arduino UNO board	
pinMode(pin_number, OUTPUT);	Define an output
digitalWrite(pin_number, LOW);	Write a digital value to an output (value = LOW)
delayMicroseconds(x);	Pause x number of micro seconds
analogWrite(pin_number, i);	Get a PWM output from a digital pin. i is a number from 0 to 255
analogRead(pin_number) *0.0049;	Get the input voltage of an analog input to the microcontroller
(sensor_voltage - 0.5) * 100;	Read the temperature in Celsius from the input voltage of the TPM36 to the microcontroller
For UART communication in Arduino UNO board	
Serial.available()	Get the number of bytes (characters) available for reading from the serial port. Can used as 'True' if there are bytes to read.
Serial.write('0')	Writes binary data '0' to the serial port.
Serial.read()	Reads incoming serial data.

Table 2: 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	V _{cc2}	Connected to voltage pin for supplying 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	V _{cc1}	Connected to 5V to enable the IC function.

Table 3: Pin functions of CD4511

Pin No.	Pin Name	Description
1, 2, 6, 7	A, B, C, D	4 BDC inputs.
3	\sim display test	Lamp test input is used to test the display.
4	\sim 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.