UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: January 2022

Module Number: ME4210 **Module Name: Analog and Digital Electronics**

[Three Hours]

[Answer **all questions**, each question carries **12** marks]

This paper contains **5 questions** in **4 pages**.
Clearly state any assumptions that you may make.
In order to get **full marks**, make sure to use standard notations and correct SI units.

Q1. (a) Explain the difference between analog and digital signals.

[2.0 Marks]

(b) Briefly describe the necessity of signal conditioning, and list **two** types of signal conditioning methods.

[2.0 Marks]

(c) List **two** advantages of processing signals in the digital domain rather than in the analog domain.

[2.0 Marks]

(d) Describe the necessity of Analog to Digital Conversion (ADC) when interfacing analog sensors with microcontrollers.

[2.0 Marks]

(e) In the analog to digital signal conversion process, the sampling stage plays a significant role. Explain briefly the importance of following the "Nyquist Sampling Theorem" in order to improve the quality of the output.

[2.0 Marks]

(f) Calculate the resolution of a 3 bit Analog to Digital Converter (ADC) which has a 10 V Full Scale Range (FSR) value.

[2.0 Marks]

Q2. (a) List **four** different types of operations that an op-amp can perform.

[2.0 Marks]

(b) Suppose you have been asked to design an audio mixer for adding together individual waveforms or sounds from **three** different source channels (vocal, drum, and guitar) before sending them to an audio amplifier.

i. Sketch the circuit diagram that you are going to purpose for the above requirement using a summing amplifier.

Q2 continues to the next page

ii. Briefly explain, how you can adjust the strength of input waveforms using the circuit that you purposed in Q2 (b) i.

[5.0 Marks]

(c) Multiplexing is a technique used to combine and send multiple data streams over a single medium. Using a sketch, briefly explain the operation of a 4-to-1 multiplexer.

[3.0 Marks]

(d) Briefly describe the importance of including Voltage to Current Converters in control systems.

[2.0 Marks]

Q3. (a) Filters can be divided into two distinct types such as active filters and passive filters. State the main difference between the two types of filters.

[2.0 Marks]

(b) Briefly explain different types of analog filters, which can be classified based on the range of frequencies passed by the filter.

[2.0 Marks]

(c) Assume you have been assigned to design a non-inverting active low pass filter circuit to filter out frequency bands above 159 Hz from a sensor signal. The filter should have a gain of 10 at low frequencies, and an input impedance of 10 kΩ.

i. Sketch the circuit diagram of the filter.

ii. Calculate the values of the resistor and the capacitor of the filter.

iii. Draw the frequency response curve of the filter.

iv. If there are changes in the external impedance connected to the input of the filter circuit, it can affect the cut-off frequency (fc) of the filter. Modify the filter circuit to minimize such effects.

[8.0 Marks]

Q4. You have been tasked with designing a traffic light system using any D, JK, or T flip-flops in order to fulfill the below given operational sequence. However, you are restricted to use only one type of flip-flops. The system is given a binary input named 'x' and additionally, each flip-flop needs a clock signal to operate.

Operational sequence (as long as the input 'x' is high, the system changes the states in this order):

- State A: Connect power to the red signal
- State B: Connect power to the yellow signal
- State C: Connect power to the green signal
- State D: Connect power to the yellow signal
- Goto State A

Q4 continues to the next page

Note: The system has only one power line. If the input 'x' is low, the system will stay in the current state.

(a) Sketch a D-type flip-flop with clearly named input and output pins.

[1.0 Mark]

(b) Sketch a JK-type flip-flop with clearly named input and output pins.

[1.0 Mark]

(c) Sketch a T-type flip-flop with clearly named input and output pins.

[1.0 Mark]

(d) i. Write down the characteristic equations of the D, JK and T flip-flops separately.

ii. Construct the state diagram for the traffic light system.

iii. Explain whether the state reduction is possible or not for this system. If the answer is possible, construct the state diagram with the state reduction.

iv. Conduct the state assignment and construct the state table using any one of the flip-flops mentioned above.

[9.0 Marks]

Q5. (a) Briefly explain why Programmable Logic Controllers (PLCs) are preferred over microcontrollers when it comes to industrial applications.

[2.0 Marks]

(b) State the main steps of the operating cycle of a PLC.

[1.0 Marks]

(c) List **four** advantages of PLCs compared to conventional relay control systems.

[2.0 Marks]

(d) To maintain health guidelines during the COVID 19 pandemic, an automated hand sanitizing process has been purposed at the entrance of a laboratory in order to automatically disinfect hands and to issue a token to each person entering the laboratory after this disinfection process. The layout of the machine is shown in **Figure Q5(d),** and it is supposed to perform the following functions.

- When the presence of a person is identified by the "sensor", "gate" closes and remains closed for 10 s. In the meantime, activate the "spray nozzle" for 4 s to sanitize the hands.
- Following spray nozzle operation, a token needs to be printed by the "printer".
- Finally, the "gate" opens, allowing the person to enter the laboratory.
- A "liquid level sensor" is used to continuously monitor the sanitizer liquid level in the tank and & if the level gets lower than a pre-set value, "alarm" will get activated as an alert to the supervisor and the "gate" will remain closed until the liquid level becomes back to normal.

Q5 continues to the next page

- The fully automated system is to be activated using a master switch.

Draw the "Input/ output mapping table" and develop a ladder logic program for the above application.

[7.0 Marks]

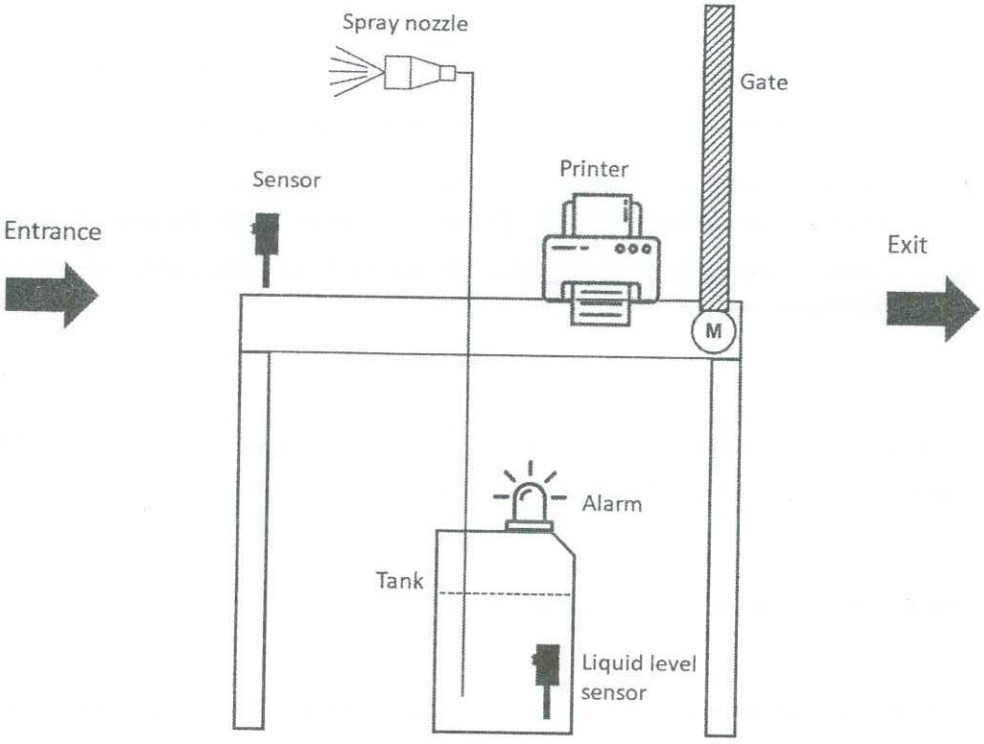

Figure Q5(d) – Layout of the automated hand sanitizing machine