Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2021/2022

COURSE NAME	:	SIGNALS AND INTERFACING SYSTEM
COURSE CODE	:	MET 11203
PROGRAMME CODE	:	MET
EXAMINATION DATE	:	JANUARY / FEBRUARY 2022
DURATION	:	3 HOURS 30 MINUTES
INSTRUCTION	:	1. ANSWER **ALL QUESTIONS** 2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK/CLOSE BOOK**

THIS QUESTION PAPER CONSIST OF **SIX (6)** PAGES

Q1 **(a)** A sensor produces data in a rectangular signal which is then amplitude modulated for transmission over the radio frequency. The envelope of the rectangular signal $x_e(t) = V_e \text{rect}\left(\frac{t}{\tau}\right)$ as in **Figure Q1(a),** and the carrier signal is given by $x_c(t) = A\cos(2\pi f_c t)$, where V_e is the amplitude of the rectangular signal, τ is the duration of the rectangular signal, and f_c is the frequency of the carrier signal respectively.

(i) If $y(t)$ is the output of the modulator, write the equation for $y(t)$.
(2 Marks)

(ii) Find the Fourier transform of $y(t)$, and sketch its magnitude spectrum. Let $\tau = 1$.
(6 Marks)

(iii) Evaluate the bandwidth required for data transmission.
(3 Marks)

(iv) Discuss the operation of subsystems needed to reduce the data signal bandwidth.
(3 Marks)

(v) Anticipate the receiver's requirement for reproducing the original data from the sensor.
(3 Marks)

(b) Given $x[n] = \sum_{n=-4}^{4} 2^n u[-n] + 0.5^n u[n]$.

(i) Sketch the plot $x[-n]$ and $x[n]$.
(3 Marks)

(ii) Determine the energy of the signal $x[n]$.
(2 Marks)

(iii) Find the discrete Fourier transform of $x[n]$.
(3 Marks)

Q2 **(a)** (i) The amplifier circuit in **Figure Q2(a)** was proposed by a senior advisor to design an IoT sensor system. The engineer is uncertain what will the amplifier output gain be. He proposed to set input resistance, R_i around 50Ω and R_f to nearly 1MΩ. Formulate what will the voltage gain for this proposed amplifier.
(5 Marks)

(ii) Using the formulate gain value in **Q2(a)(i)**, if the input voltage, V_{in} is 0.1 volts, what will you expect to obtain at the output, V_{out}?
(2 Marks)

(b) As an engineer for an instrumental company, you are instructed to design a dolphin detector by directly sampling the echolocation signal emitted by dolphins. The emitted ultrasound for dolphins are in the frequency range of 12kHz to 200kHz, which is detected by an ultrasound transducer that produces an AC signal in the range of ± 20mV with a 2.5V offset. However, your detector is designed to work up to only 100kHz since any signal above this frequency is rapidly absorbed in air. Your detector will first directly convert the raw dolphin signal from analogue to digital form using an A-to-D converter (ADC) with an accuracy of ± 0.(Last student digit number) %. The ADC operates in the voltage range of 0 to 5V.

(i) Choose the suitable sampling frequency for the ADC and justify your answer.

(2 Marks)

(ii) Justify the circuit would be connected to the ultrasound detector before the ADC.

(3 Marks)

(iii) Find the resolution of the ADC required in terms of the number of bits, and the resolution in volts.

(5 Marks)

(iv) The detector "converts" the digital dolphin signal from the ultrasound range of 12kHz to 200kHz to the audible frequency range. Describe in detail a method of approach for your instrument that will map the dolphin's ultrasound to the audible range of 120Hz to 20kHz.

(8 Marks)

Q3 A temperature monitoring system uses a M5StickC-Plus as a controller which has a built-in buzzer. A temperature sensor and limit switch are connected to the microcontroller, as given in **Figure Q3.** There are two software operation tasks as depicted in **Table Q3,** which priority of Task2 is higher than Task1.

(a) Predict the digital logic state at pin G0 if the limit switch is open.

(1 mark)

(b) Find the ADC digital data of the temperature sensor for 15 °C if the scale factor is 15mV/°C.

(4 marks)

(c) Analyze and do correction for the following configuration C-statement in the ***void setup()*** function:

```
begin()                          //M5 initialization
Mode(0, IN)                      //Switch as input
Mode(36, IN)                     //ADC pin as input
gpio_pulldown(GPIO_NUM_25)//Floating pin for GPIO25
gpio_pullup(GPIO_NUM_25)   //Floating pin for GPIO25
xTaskToCore(TaskA,"Temp") //Create TaskA
xTaskToCore(TaskB,"LS")    //Create TaskB
```

(8 marks)

(d) Based on **Q3(c)**, write a complete coding for TaskA and TaskB.

(12 marks)

Q4 **(a)** Two types of general purpose input-output (GPIO) chip can be selected for extending the GPIO peripheral: MCP23017 uses the inter-integrated circuit (I^2C) interface and MCP23S17 uses serial peripheral interface (SPI).

(i) Select and justify **ONE (1)** of the suitable chip, either MCP23017 or MCP23S17 to extend the microcontroller system's GPIO.

(2 Marks)

(ii) Based on the **Q4(a)(i)** selection, sketch a schematic diagram between the GPIO expander chip and the microcontroller system.

(4 Marks)

(b) An additional security device for an existing alarm system will be developed using M5StickC-Plus which consist of a master and a slave. The slave controller will send the status of door (open/close) to the master through bluetooth. If a door is open, the master will turn on a relay from normally open (NO) to normally close (NC). The existing alarm system will detect this event to trigger the alarm.

(i) Design a circuit and write a complete coding for the master device. The operating voltage for the relay is +5VDC. Tips: Use the example of BLE server for a master device as a coding template.

(12 Marks)

(ii) Write a complete coding for the slave device. The magnetic sensor (similar as in https://electropeak.com/learn/interfacing-mc-38-magnetic-reed-switch-with-arduino) is connected to pin G26. Tips: Use the example of BLE client for a slave device as a coding template.

(7 Marks)

-END OF QUESTIONS-

FINAL EXAMINATION

SEMESTER/SESSION	:	SEMESTER I 2021/2022	PROGRAMME CODE	:	MET
COURSE NAME	:	SIGNALS AND INTERFACING SYSTEM	COURSE CODE	:	MET 11203

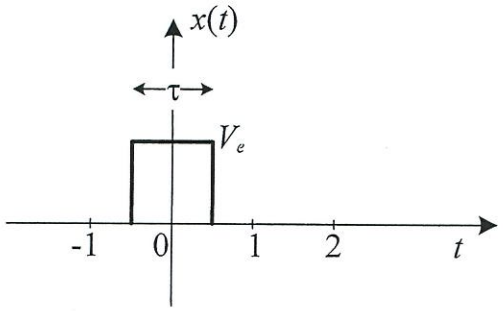

Figure Q1(a): Rectangular signal

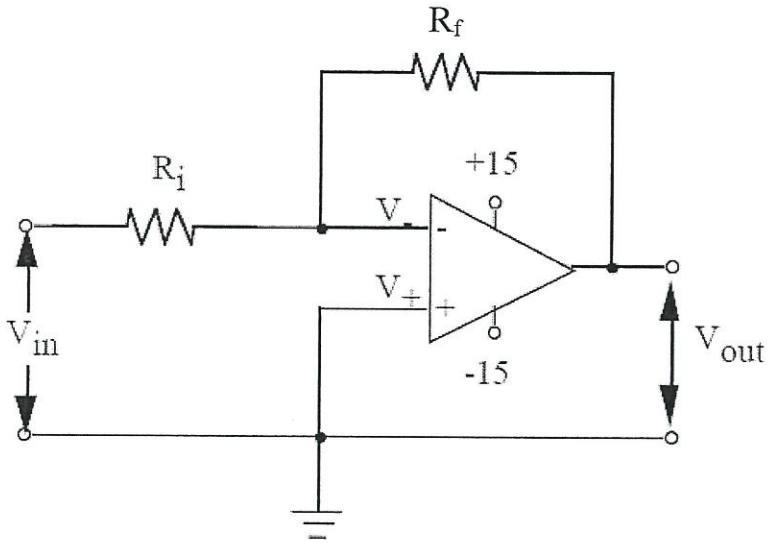

Figure Q2(a): Amplifier circuit

FINAL EXAMINATION

SEMESTER/SESSION	:	SEMESTER I 2021/2022	PROGRAMME CODE	:	MET
COURSE NAME	:	SIGNALS AND INTERFACING SYSTEM	COURSE CODE	:	MET 11203

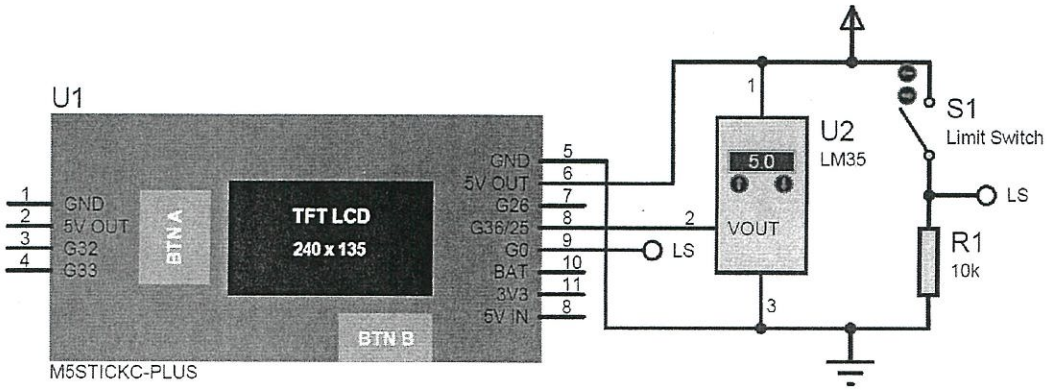

Figure Q3: Temperature Monitoring Ciruit

Table Q3: Task information

Task	Stack Size	Period	Description
A	256 B	150ms	Generate a buzzer tone at 5kHz if the temperature over than 15 °C otherwise buzzer is mute.
B	128 B	500ms	Generate a buzzer tone at 2kHz if the limit switch is open otherwise buzzer is mute.