NATIONAL UNIVERSITY OF SINGAPORE

CG1111 – ENGINEERING PRINCIPLES AND PRACTICE I

QUIZ #2

17 NOVEMBER 2018

INSTRUCTIONS:

1. This paper contains **15** multiple-choice questions (MCQs), with only a **SINGLE** correct answer each.
2. Answer **ALL** questions.
3. Use only **2B pencils** to shade the bubble sheet.
4. This is an **OPEN-BOOK** test.
5. There is no restriction on the use of programmable calculators.
6. There is **no penalty (i.e., no negative marks) for wrong answers**. Please attempt all questions.
7. You are **NOT ALLOWED** to use your **mobile phone, tablet** or **computer** during the test.
8. **DO NOT READ** the questions until you are told to do so.
9. Time allowed: **90 MINUTES**

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1. A permanent magnet DC motor is connected to a 12 V DC source. Under NO-LOAD condition, the motor's speed is 1000 RPM. At a load-torque of 1 Nm, the speed drops to 900 RPM. The armature resistance is

   (A) 0.138 Ω

   (B) 0.115 Ω

   (C) 0.014 Ω

   (D) 0.012 Ω

2. A permanent magnet DC motor is connected to a 24 V DC source. Under NO-LOAD condition, the motor's speed is 2000 RPM. At a load-torque of 1 Nm, the speed drops to 1800 RPM. Suppose we wish to operate the motor at a speed of 1600 RPM for the same load-torque of 1 Nm, using a PWM with an ON voltage of 24 V. The required duty cycle of the PWM is

   (A) 0.889

   (B) 0.900

   (C) 0.800

   (D) 0.750

3. A permanent magnet DC motor is powered by a 12 V DC supply. Under NO-LOAD condition, the motor's speed is 2500 RPM. If the shaft is clamped mechanically such that it doesn't spin, the current drawn by the motor is 0.5 A. When a particular load is attached to the shaft, its speed drops to 2000 RPM. The current drawn by the motor for this load-torque is

   (A) 2.4 A

   (B) 0.24 A

   (C) 0.4 A

   (D) 0.1 A

4. A full wave rectifier is connected to a resistive load of 40 Ω with a load voltage of 12 V. If the voltage ripple is 0.9 V, calculate the value of the filter capacitor connected in parallel to the resistive load. The AC frequency is 50 Hz. Assume the diodes are ideal with no voltage drop.

   (A) 333.33 μF

   (B) 666.67 μF

   (C) 3333.33 μF

   (D) 6666.67 μF

5. Calculate the primary voltage ($\boldsymbol{V_P}$) of a step-up transformer, if the secondary is connected to a load of 1500 W at 600 V RMS and the primary current is 12.5 A RMS. The number of turns in the primary winding is 500.

   (A) 30000 V RMS

   (B) 3000 V RMS

   (C) 1200 V RMS

   (D) 120 V RMS

6. What is the number of turns in the secondary winding of an ideal transformer, if the currents in the primary and secondary windings are of 4 A and 28 A, respectively. The number of turns in the primary windings is 100.

   (A) 700

   (B) 15

   (C) 4900

   (D) 25

7. Toothless is an audio recording artist whose current recording has been corrupted by the noise of the construction work near his recording studio. His recording is in the frequency range of 195 Hz to 395 Hz. He did an analysis of the noise and figured out that the noise is in the frequency range of 4000 Hz to 6000 Hz. Choose the correct combination of the resistor and capacitor values so that Toothless can design a filter that can reduce the construction work noise by at least 18 dB.

   (A) R = 314 kΩ, C = 0.01 μF

   (B) R = 314 kΩ, C = 0.001 μF

   (C) R = 209 kΩ, C = 0.001 μF

   (D) R = 209 kΩ, C = 0.01 μF

8. Determine the resistor values to design a band pass filter as shown in Figure 1 with cut-off frequencies of 600 Hz and 1600 Hz.

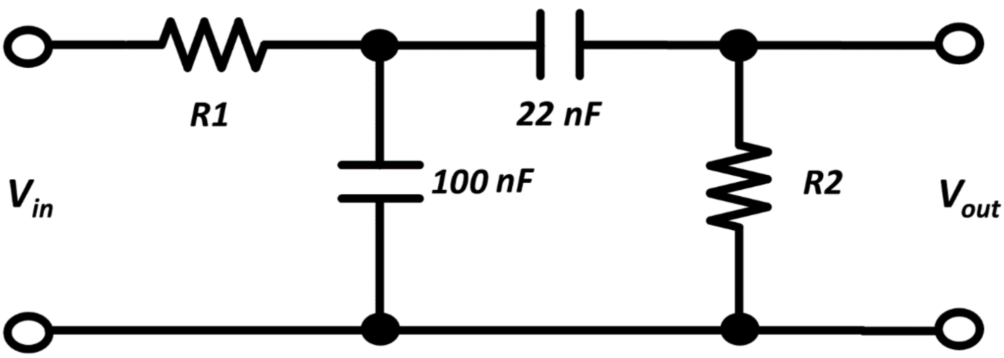

Figure 1

   (A) R1= 995 Ω, R2 = 12060 Ω

   (B) R1= 12060 Ω, R2 = 995 Ω

   (C) R1= 2652 Ω, R2 = 4522 Ω

   (D) R1= 4522 Ω, R2 = 2652 Ω

9. Calculate the value of I_{OUT} in Figure 2. The op-amp is supplied with a dual power supply of ± 5 V.

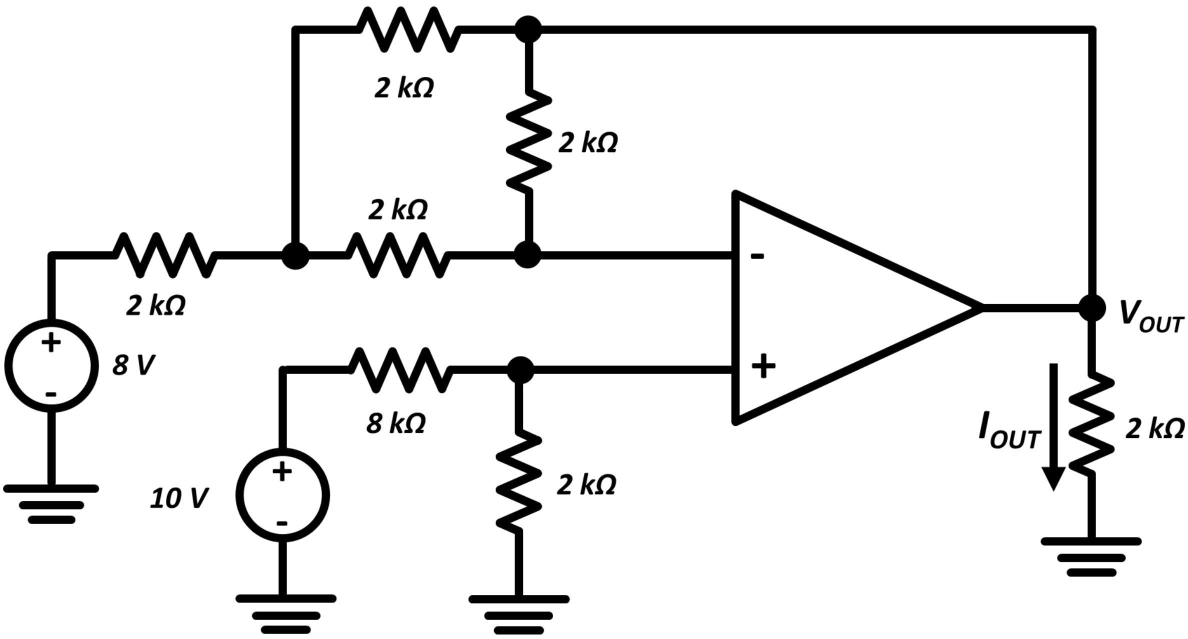

Figure 2

(A) 0.5 A

(B) 0.5 mA

(C) 2.5 mA

(D) 0.25 mA

10. Calculate the value of V_{OUT} in Figure 3. Both the op-amps are supplied with a dual power supply of ± 8 V.

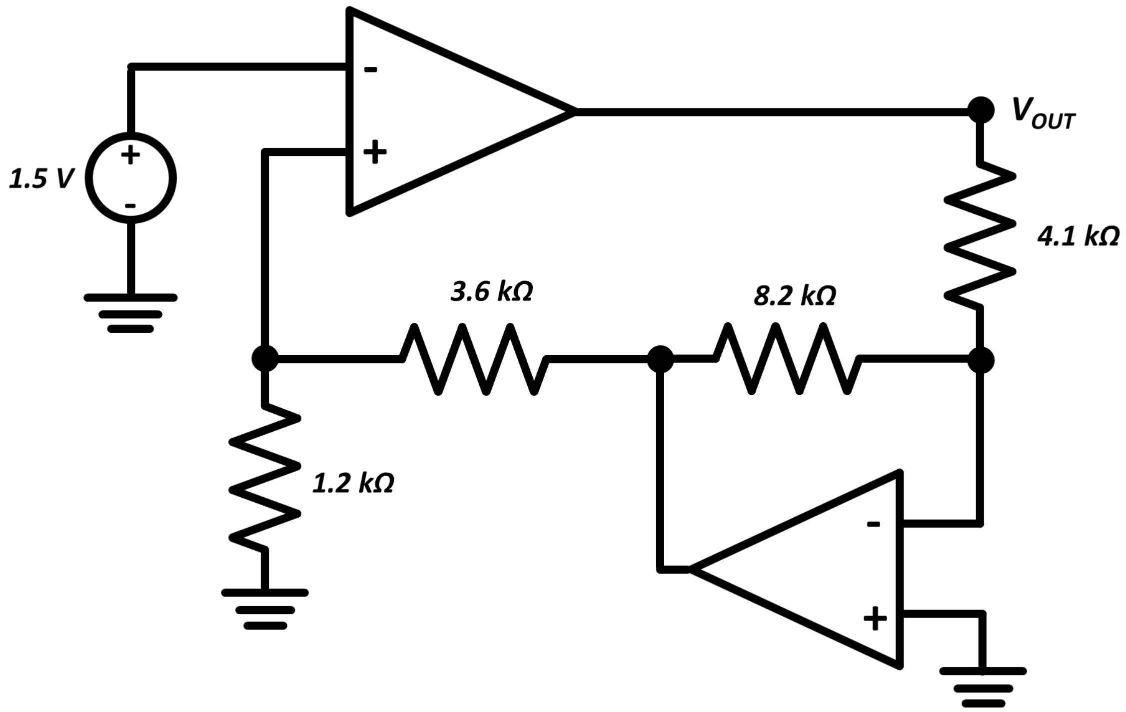

Figure 3

(A) 1.5 V

(B) –1.5 V

(C) –3 V

(D) 3 V

11. Calculate the value of V_{OUT} in Figure 4. The op-amp is supplied with a dual power supply of $\pm$ 8 V.

V_{IN} = 1.5 cos(100t) + 2.2 V

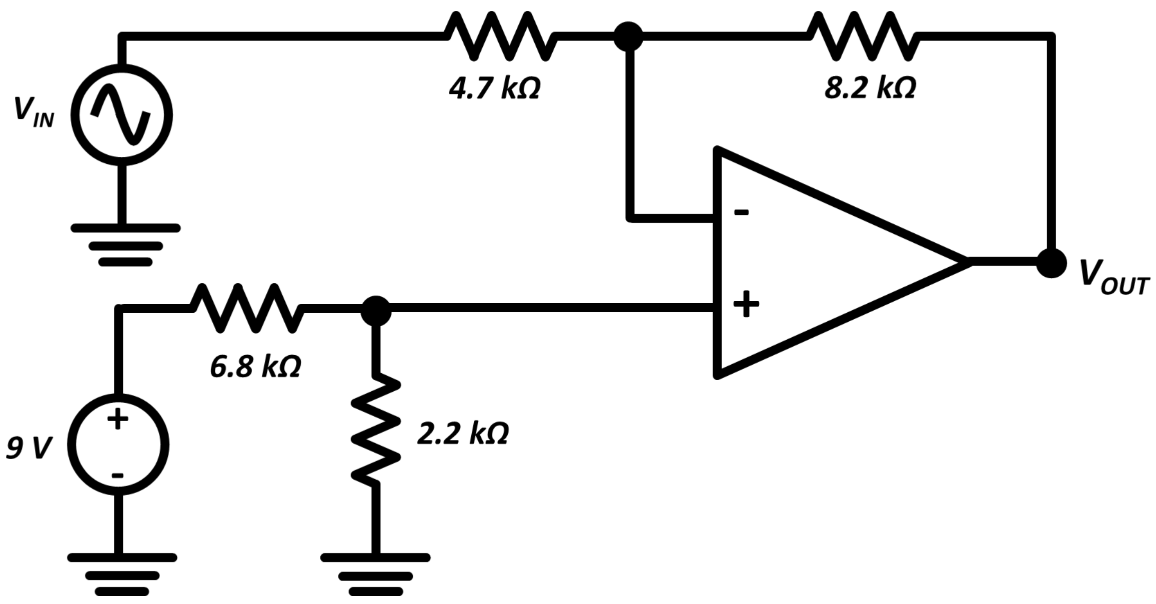

Figure 4

(A) 2.62 cos(100t + 180°) + 2.20 V

(B) 2.62 cos(100t + 180°) + 3.83 V

(C) 2.62 cos(100t + 0°) V

(D) 2.62 cos(100t + 180°) V

12. Jack is a music producer and wants to hire a sound engineer for his up and coming band "Shed Ereen". Jack has a music sample that has been recorded for vocals in the frequency range of 200 Hz to 400 Hz. The sound engineer needs to set up the music editing software that requires him to enter the "Nyquist Rate" of the recording. What should the sound engineer enter as the "Nyquist Rate" of the recording?

    (A) 100 Hz

    (B) 200 Hz

    (C) 400 Hz

    (D) 800 Hz

13. The rotary encoder of an electric car operates in the frequency range of 15 Hz to 120 Hz. It is used to measure the frequency of wheel rotations of the car. The optimal fuel consumption occurs when the wheel rotations are in the frequency range of 30 Hz to 60 Hz. The rotary encoder data is sampled by the Artificial Intelligence of the car to identify the non-optimal frequencies and to correct it to the optimal frequency range. What is the "Nyquist Frequency" of the rotary encoder signal?

    (A) 240 Hz

    (B) 120 Hz

    (C) 60 Hz

    (D) 30 Hz

14. A young engineer tested a new IR sensor for proximity sensing using the indirect incidence setup. He obtained the graph as shown in Figure 5. He built a proximity sensor circuit as shown in Figure 6. By using two op-amp comparators, he wanted his circuit to light up one LED when an opaque object is less than 4 cm from the sensor, and another LED when it is more than 4 cm. Help him complete his circuit design.

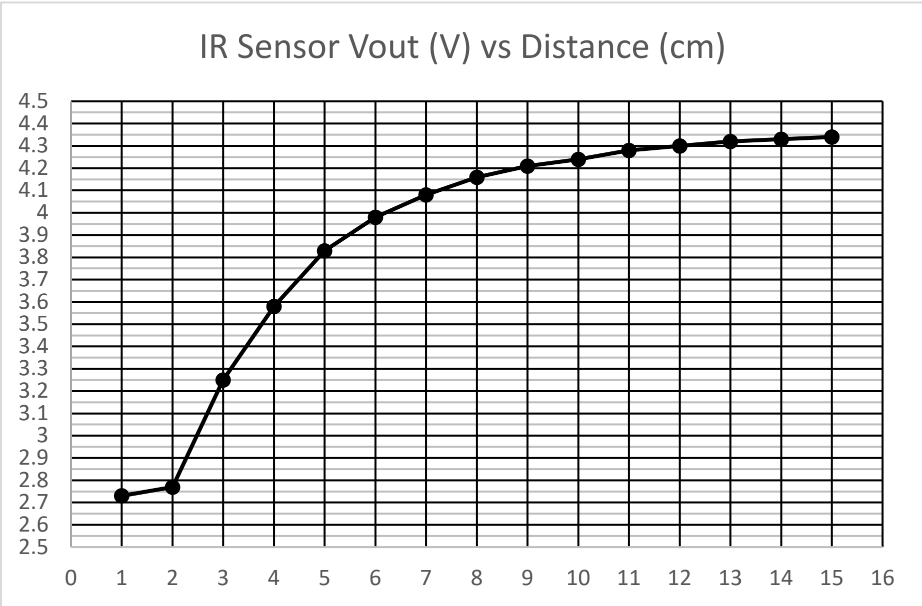

Figure 5: IR Sensor V_{OUT} vs Distance.

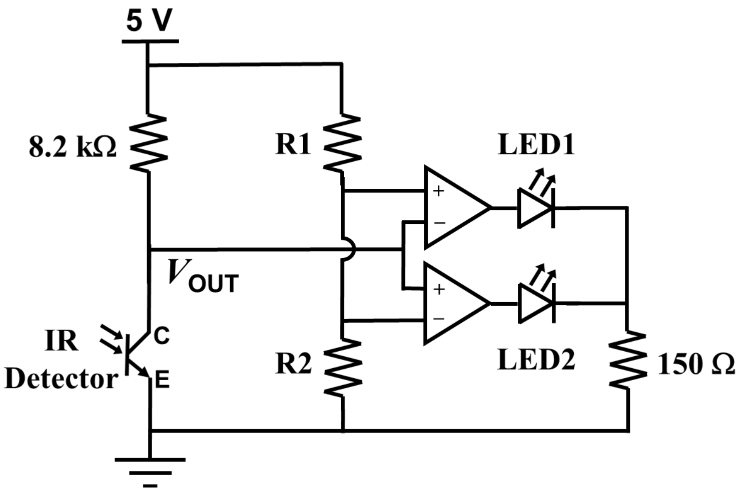

Figure 6: IR Proximity Sensor Circuit.

(A) R1 = 6.8 kΩ, R2 = 2.7 kΩ, only LED1 lights up when object is < 4 cm, and LED2 otherwise.

(B) R1 = 2.7 kΩ, R2 = 6.8 kΩ, only LED1 lights up when object is < 4 cm, and LED2 otherwise.

(C) R1 = 6.8 kΩ, R2 = 2.7 kΩ, only LED2 lights up when object is < 4 cm, and LED1 otherwise.

(D) R1 = 2.7 kΩ, R2 = 6.8 kΩ, only LED2 lights up when object is < 4 cm, and LED1 otherwise.

15. The Humirel HS 1101 is a commonly used 5 V (V_{cc}) humidity sensor that operates according to the following relationship:

$$V_{out} = V_{cc} \times (0.00474 \times \%RH + 0.2354),$$

where $\%RH$ is the relative humidity in percentage (note: $0 \leq \%RH \leq 100$).

If its V_{out} is to be amplified by a non-inverting amplifier before being sampled by an Arduino, which one of the following amplifier designs optimizes both the sensor operating range, and the Arduino ADC range of 0 to 5 V?

(A) R_f = 3.1 kΩ, R_i = 2.2 kΩ

(B) R_f = 1.1 kΩ, R_i = 2.7 kΩ

(C) R_f = 8.2 kΩ, R_i = 3.9 kΩ

(D) R_f = 1.8 kΩ, R_i = 2 kΩ

END OF PAPER