NATIONAL UNIVERSITY OF SINGAPORE

CG1111A – ENGINEERING PRINCIPLES AND PRACTICE I

QUIZ #2

21 OCTOBER 2023

INSTRUCTIONS:

1. Shade your Student Number carefully in the MCQ form. Your Student Number is the one on your student card that starts with the letter '**A**'. We will **subtract 3 MARKS** if your Student Number is not properly shaded in the MCQ form.

2. This paper contains **12** multiple-choice questions (MCQs), with only a **SINGLE** correct answer each.

3. Answer **ALL** questions.

4. Use only **2B pencils** to shade the bubble sheet.

5. This is an **OPEN-BOOK** test.

6. There is no restriction on the use of programmable calculators.

7. There is **no penalty (i.e., no negative marks) for wrong answers**. Please attempt all questions.

8. You are **NOT ALLOWED** to use your **mobile phone, tablet** or **computer** during the test.

9. **DO NOT READ** the questions until you are told to do so.

10. Time allowed: **75 MINUTES**

11. After the quiz, please **remain seated** while we tally the number of submitted scripts.

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1. Calculate the primary current (I_P) and number of turns in the primary (N_P) of a transformer, if the power at the secondary of the transformer is **40 kW,** primary voltage is at **5 kV** RMS and the secondary current is **0.8 A** RMS. The number of turns in the secondary winding is **8400**. Assume an ideal transformer.

   (A) I_P = 8 A RMS, N_P = 840

   (B) I_P = 80 A RMS, N_P = 840

   (C) I_P = 8 A RMS, N_P = 84000

   (D) I_P = 80 A RMS, N_P = 84000

2. Bindi is a device engineer and needs to design a full wave rectifier with a voltage ripple of **0.9 V** for her new IoT product: Banana Bread. The required load voltage is **12 V** and the rectifier is connected to a resistive load of **48 Ω**. You can help her by calculating the value of the filter capacitor connected in parallel to the resistive load. The AC frequency is **100π** rad/s. Assume the diodes are ideal with no voltage drop.

   (A) 442 µF

   (B) 884 µF

   (C) 2778 µF

   (D) 5556 µF

3. The primary voltage of a transformer is given as $\mathbf{380\angle 70^\circ\ V}$. A series RLC load is connected to the secondary side, with voltage magnitudes $\mathbf{|V_R| = 15\ V}$, $\mathbf{|V_L| = 75\ V}$ and $\mathbf{|V_C| = 110\ V}$. Calculate the primary rms current if the secondary current is **1 A** RMS.

   (A) 0.1 A RMS

   (B) 0.54 A RMS

   (C) 1.85 A RMS

   (D) 10 A RMS

4. The following are known about a particular PMDC motor:

   - It is controlled using PWM, powered by a 12 V DC supply
   - At 80% duty cycle, and a load-torque of 20 mNm, the speed is 3000 RPM
   - At 60% duty cycle, and a load-torque of 30 mNm, the speed is 2000 RPM

   If it is now connected to a load torque of 35 mNm, what is the PWM duty cycle required for the motor to operate at 2000 RPM?

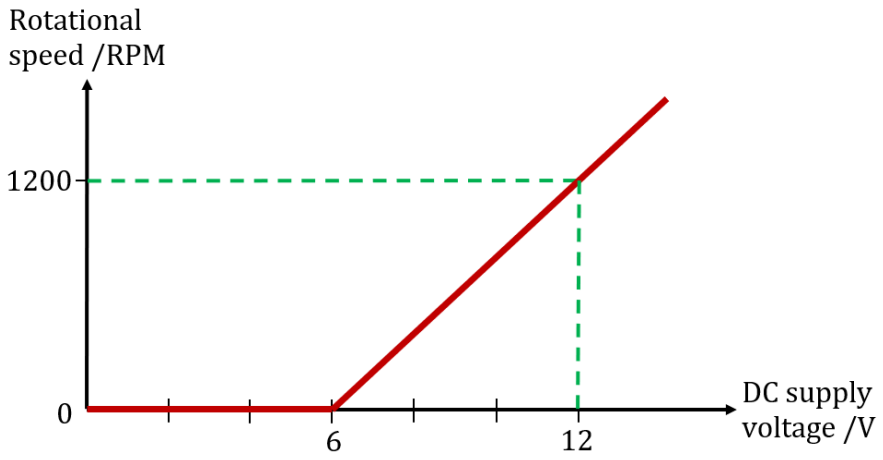
   (A) 62%

   (B) 64%

   (C) 66%

   (D) 68%

5. The figure below plots the rotational speed vs. DC supply voltage for a particular PMDC motor when it is connected to a particular load-torque.



   Suppose the load-torque is now doubled, what will be its rotational speed when the DC supply voltage is 24 V?

   (A) 1800 RPM

   (B) 2400 RPM

   (C) 3000 RPM

   (D) 3600 RPM

6. Determine the resistor values to design a band pass filter as shown in Figure Q6 with cut-off frequencies of **100 Hz** and **1600 Hz**.

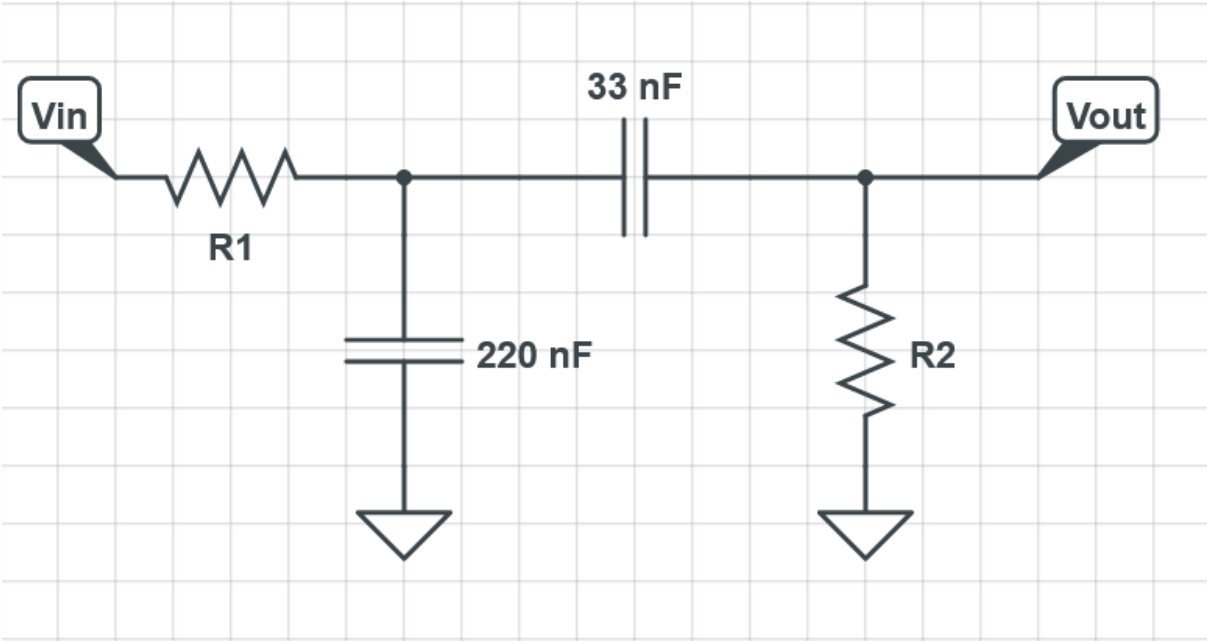


Figure Q6

(A) R2 = 452 Ω, R1 = 48229 Ω

(B) R2 = 3014 Ω, R1 = 7234 Ω

(C) R2 = 7234 Ω, R1 = 3014 Ω

(D) R2 = 48229 Ω, R1 = 452 Ω

7. Dixy is a music producer whose recordings are in the frequency range of **100** to **1600 Hz**. One day he notices a colony of rabbits outside his basement recording studio and suspects that rabbit chatter may be corrupting his recordings. On analyzing the recordings, he found the chatter to be between the frequencies of **14200 Hz** and **17450 Hz**. Choose the closest correct combination of resistor and capacitor so that Dixy can design a filter that can reduce these chatter noise by at least **13 dB**.

(A) R = 433.05 kΩ, C = 0.001 µF

(B) R = 48.79 kΩ, C = 0.001 µF

(C) R = 39.71 kΩ, C = 0.001 µF

(D) R = 2.57 kΩ, C = 0.001 µF

8. Determine the **Vout** of the op-amp configuration given in Figure Q8-Q9 if **V1 = 1 V,** and **V2 = 3 V**. Assume ideal op-amps.

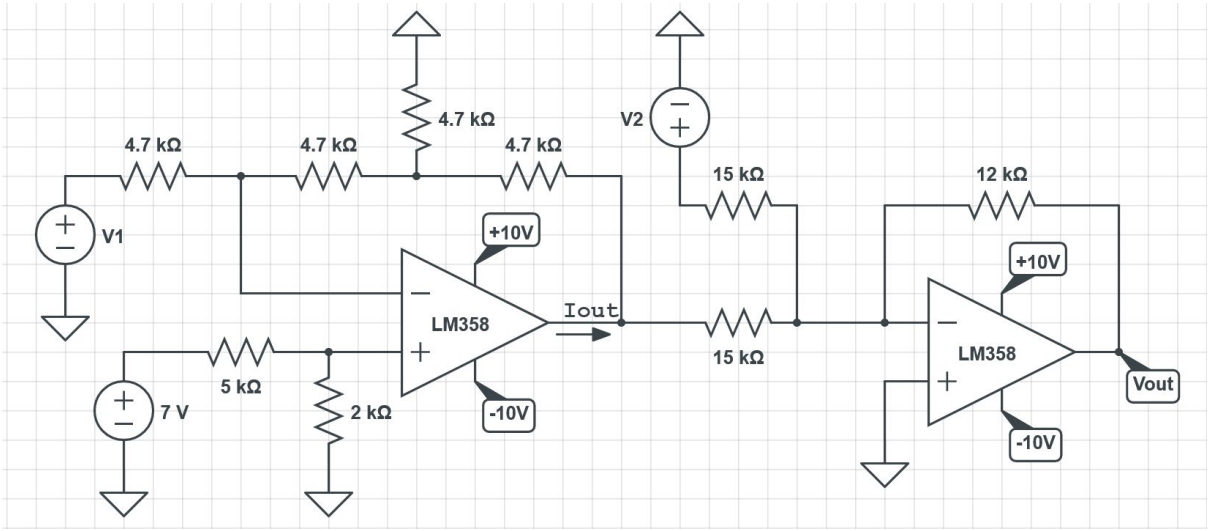


Figure Q8-Q9

(A) −3.2 V

(B) −8 V

(C) −10 V

(D) −12.5 V

9. What is the value of **Iout** in Figure Q8-Q9?

(A) 0 A

(B) −0.384 mA

(C) 1.318 mA

(D) Cannot be determined with the given data.

10. Determine which of the following statements are true for the op-amp configuration in Figure Q10. Assume ideal op-amps.

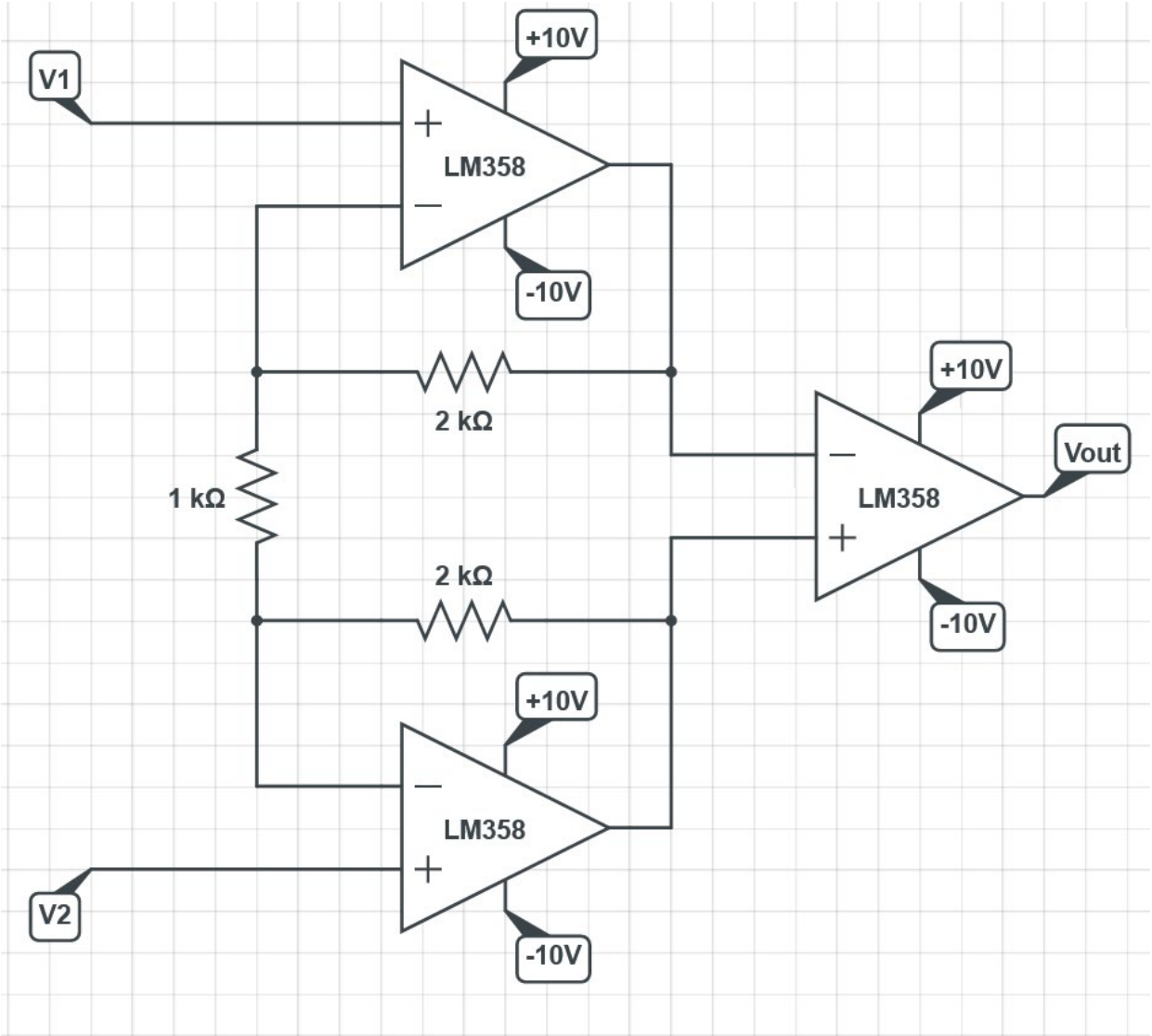


Figure Q10

(A) If V1 is greater than V2 then Vout = +10V

(B) If V2 is greater than V1 then Vout = −10V

(C) If V1 is greater than V2 then Vout = −10V

(D) Insufficient information to conclude whether any of the above statements is true.

11. As his laptop gets hot after prolonged use, Wynn decided to build a "smart" environmentally friendly laptop cooling pad that only turns on when necessary. He used a TMP36 temperature sensor to detect excessive heat buildup at his laptop's exhaust vents. He mounted a few identical miniature fans underneath an old book stand to enhance air ventilation. The TMP36 temperature sensor outputs 0.5 V at 0°C and increases by 10 mV per degree Celsius, while each fan requires a minimum of 3 V to operate. Assuming that he has taken care of the current requirements of the fans, help him design the non-inverting amplifier needed to turn on the fans automatically when the temperature at the laptop's exhaust vents is above 40°C.

    (A) R_f = 9.1 kΩ, R_i = 2.7 kΩ

    (B) R_f = 7.5 kΩ, R_i = 1 kΩ

    (C) R_f = 7.2 kΩ, R_i = 1.1 kΩ

    (D) R_f = 5.6 kΩ, R_i = 2.4 kΩ

12. Figure 12a depicts an IR sensor's characteristic output voltage versus distance in an indirect incidence setup for proximity sensing. Olivia wants to incorporate it in her EPP project and she found a potential circuit diagram online, as shown in Figure 12b.

    She needs LED2 to be lit when an opaque object is more than 3 cm from the sensor and LED1 to be lit otherwise. In your opinion, the circuit shown in Figure 12b _____.

    (A) works exactly the way she needed

    (B) will meet her requirements if she makes just one simple change to it

    (C) requires two or more changes to it in order to meet her requirements

    (D) is wrong for her application and she should use another op-amp configuration

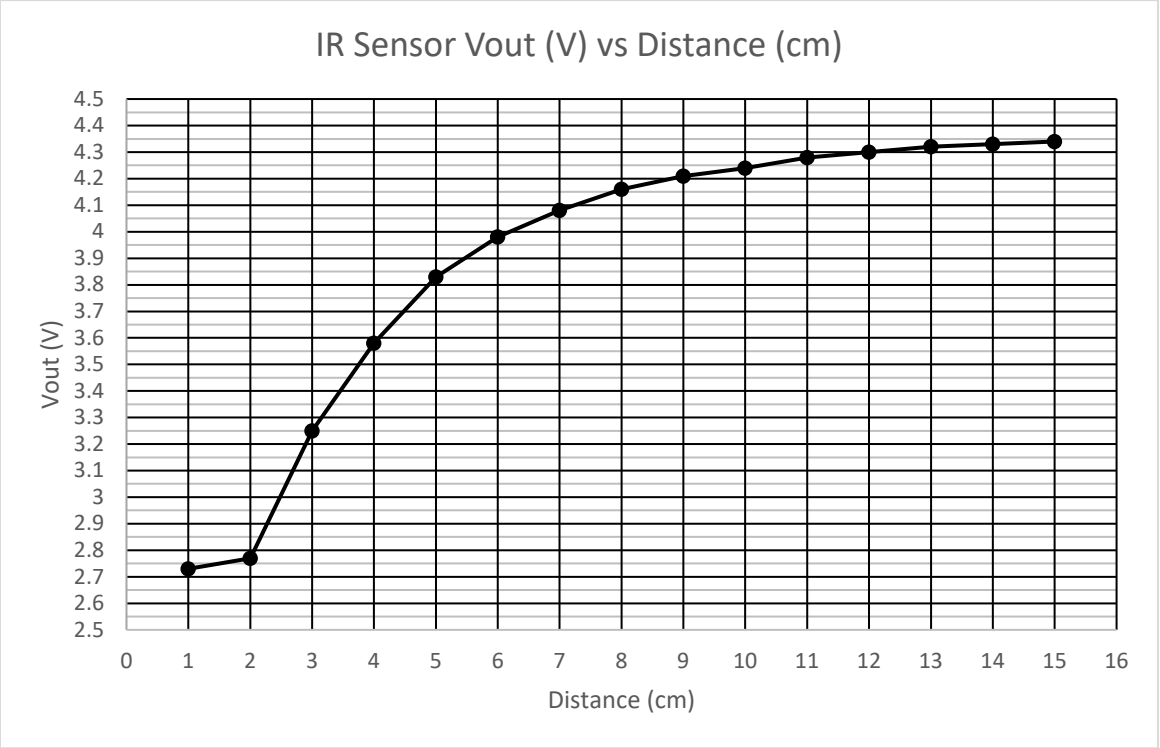


Figure 12a. IR Sensor V_{OUT} vs Distance.

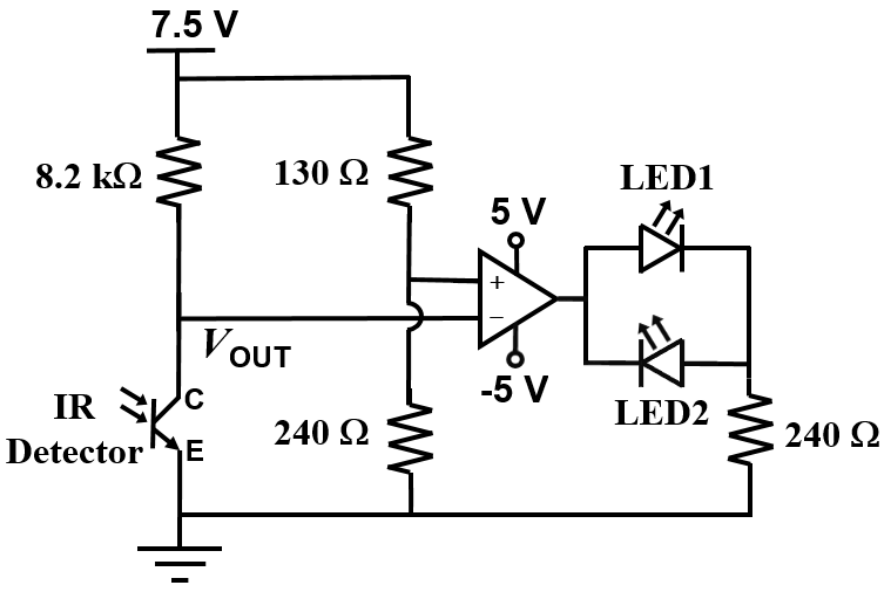


Figure 12b. A circuit diagram she found online.

END OF PAPER

ANSWERS:

1. A
2. C
3. A
4. A
5. B
6. D
7. B
8. B
9. C
10. C
11. D
12. B