**NATIONAL UNIVERSITY OF SINGAPORE**

**CG1111 – ENGINEERING PRINCIPLES AND PRACTICE I**

**QUIZ #2**

**16 NOVEMBER 2019**

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**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: **75 MINUTES**

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

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1. Consider a PWM controlled PMDC motor powered by a 12 V supply. The torque constant of this motor is 30 mNm/A. The motor drives a torque load at the speed of 2000 RPM with 90% duty cycle. If the duty cycle is now reduced to 60%, while the load remains the same, what will be the speed?

   (A) 1333 RPM

   (B) 472 RPM

   (C) 854 RPM

   (D) 2292 RPM

2. A PMDC motor is powered by a 24 V DC supply. When the motor current is 0.4 A, the motor spins at 3000 RPM. When the motor current is 0.8 A, the motor spins at 1200 RPM. What is the torque constant of the motor?

   (A) 30.2 mNm/A

   (B) 47.7 mNm/A

   (C) 60.4 mNm/A

   (D) 23.9 mNm/A

3. A PMDC motor is powered by a 24 V DC supply. Its rotor coil's resistance is 2.5 Ω. What is the current drawn by the motor when it is providing maximum mechanical power?

   (A) 4.8 A

   (B) 9.6 A

   (C) 2.4 A

   (D) 1.2 A

4. What is the number of turns in the secondary winding of an ideal transformer, if the currents in the primary and secondary windings are 14 A and 2 A, respectively? The number of turns in the primary winding is 120.

   (A) 3360

   (B) 840

   (C) 18

   (D) 2

5. A full wave rectifier is connected to a resistive load of 20 Ω with a load voltage of 8 V. If the voltage ripple is 0.4 V peak-to-peak, calculate the value of the filter capacitor connected in parallel to the resistive load. Assume that the AC frequency is 60 Hz, and the diodes are ideal with no voltage drop.

   (A) 20000 μF

   (B) 10000 μF

   (C) 16666.67 μF

   (D) 8333.33 μF

6. Calculate the secondary voltage ($\boldsymbol{V}_S$) of a transformer, if the input power at the primary of the transformer is 1200 W at 200 V RMS, and the secondary current is 1.5 A RMS. The number of turns in the primary winding is 50.

   (A) 800 V RMS

   (B) 50 V RMS

   (C) 200 V RMS

   (D) 12.5 V RMS

7. Determine the resistor values to design a band pass filter as shown in Figure 1 below, with cut-off frequencies of 1200 Hz and 4500 Hz.

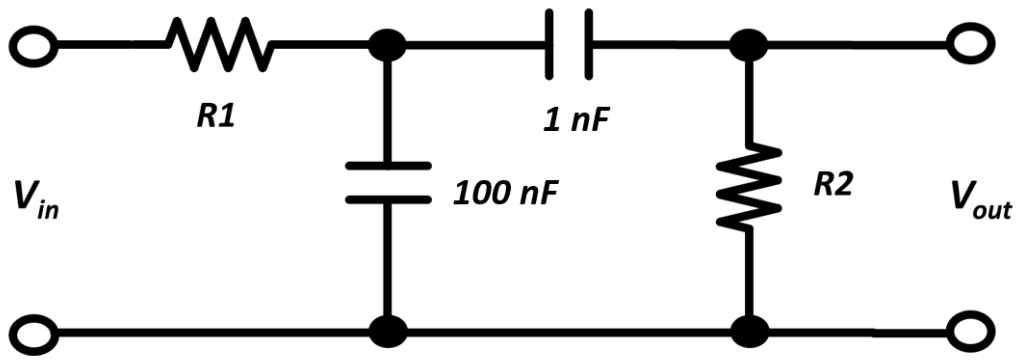



Figure 1

(A) R1= 132629 Ω, R2 = 354 Ω

(B) R1= 354 Ω, R2 = 132629 Ω

(C) R1= 265258 Ω, R2 = 707 Ω

(D) R1= 707 Ω, R2 = 265258 Ω

8. Momo is a music producer whose recordings are corrupted by the airplanes taking off and landing at the airport near his recording studio. His recordings are in the frequency range of 195 Hz to 540 Hz. He did an analysis of the noise and figured out that the noise is in the frequency range of 8000-13000 Hz. Choose the closest correct combination of resistor and capacitor so that Momo can design a low pass filter that can reduce the airport noise by at least 15 dB.

(A) R = 11 kΩ, C = 0.001 µF

(B) R = 6.78 kΩ, C = 0.01 µF

(C) R = 11 kΩ, C = 0.01 µF

(D) R = 6.78 kΩ, C = 0.001 µF

9. Calculate the value of $V_{out}$ in Figure 2. Both the op-amps are supplied with a dual power supply of $\pm$ 5 V.

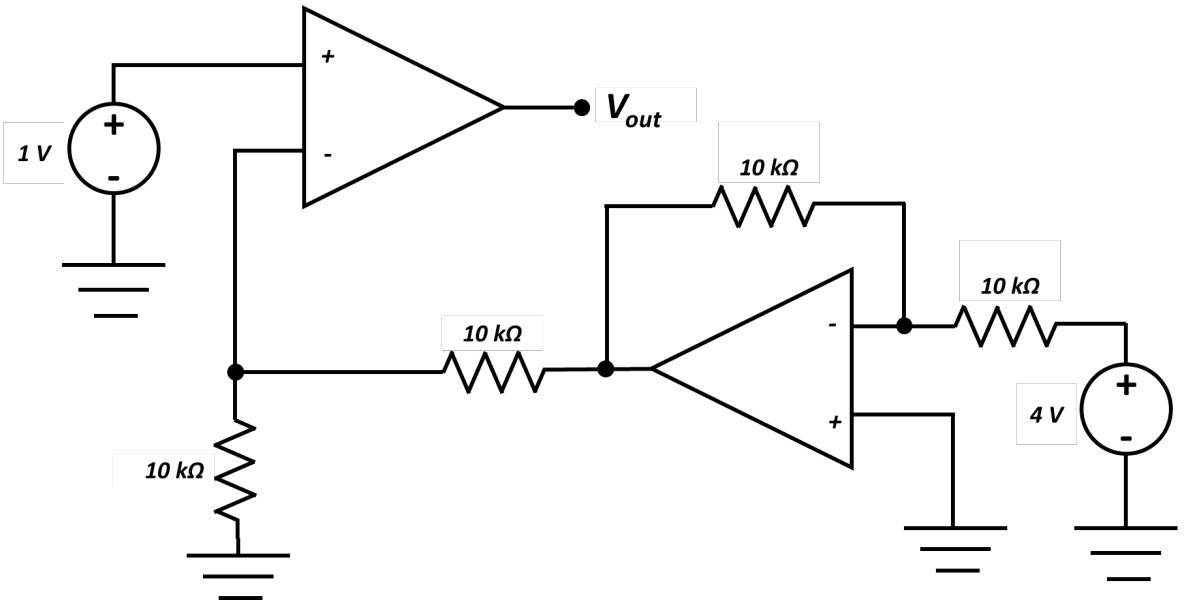



Figure 2

(A) +5 V

(B) −5 V

(C) +3 V

(D) Cannot be determined

10. Calculate the value of $I_{out}$ in Figure 3. The op-amp is supplied with a dual power supply of ± 10 V.

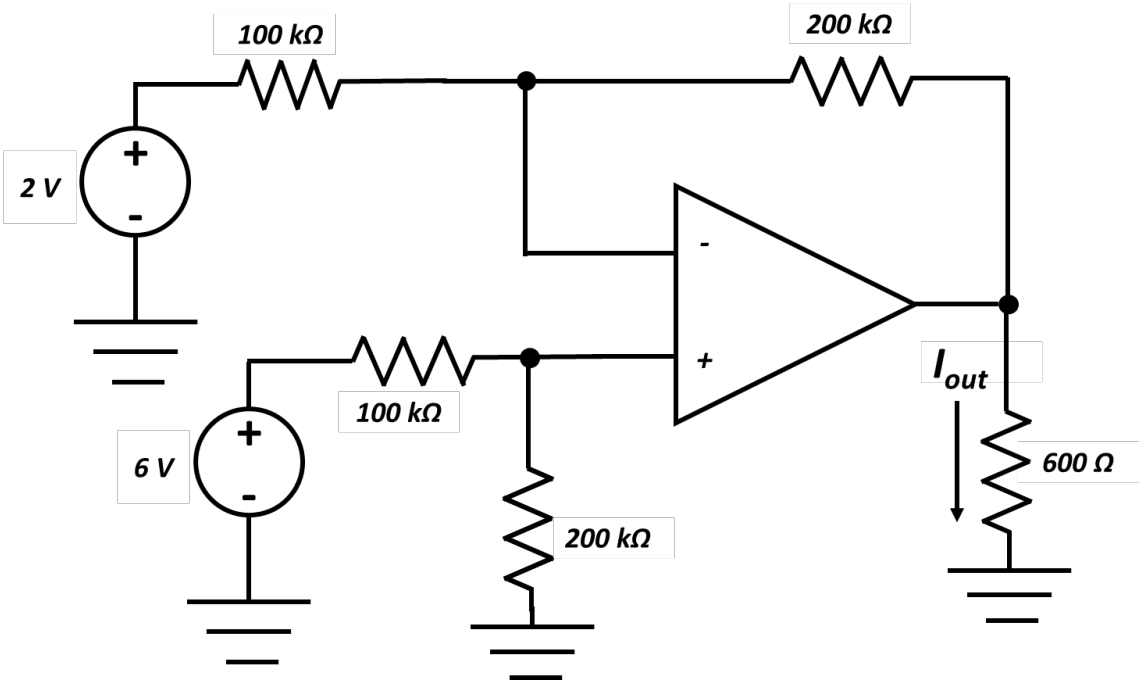



Figure 3

(A) +6.667 mA

(B) −6.667 mA

(C) −13.33 mA

(D) +13.33 mA

11. Christoph is a sound engineer for a new band “MnMs”. He recorded a music sample that has been recorded for vocals in the frequency range of 600 Hz to 1000 Hz. Christoph needs to set up the music editing software that requires him to enter the “Nyquist Rate” of the recording. What should he enter as the “Nyquist Rate” of the recording?

    (A) 600 Hz

    (B) 1200 Hz

    (C) 2000 Hz

    (D) 1000 Hz

12. A deep-sea microphone has a maximum sampling frequency of 150 kHz. The microphone is used to record dolphin sounds and the data is used to study the social communication amongst dolphins. The optimal social signals occur in the frequency range of 3 Hz to 40 kHz. The deep-sea microphone data is sampled by the Artificial Intelligence of the recorder to isolate the optimal social signal ranges and further studied. What is the “Nyquist Frequency” of the deep-sea microphone recorder?

    (A) 20 kHz

    (B) 80 kHz

    (C) 300 kHz

    (D) 75 kHz

13. Calculate the value of $V_{out}$ in Figure 4. The op-amp is supplied with a dual power supply of $\pm$ 15 V.

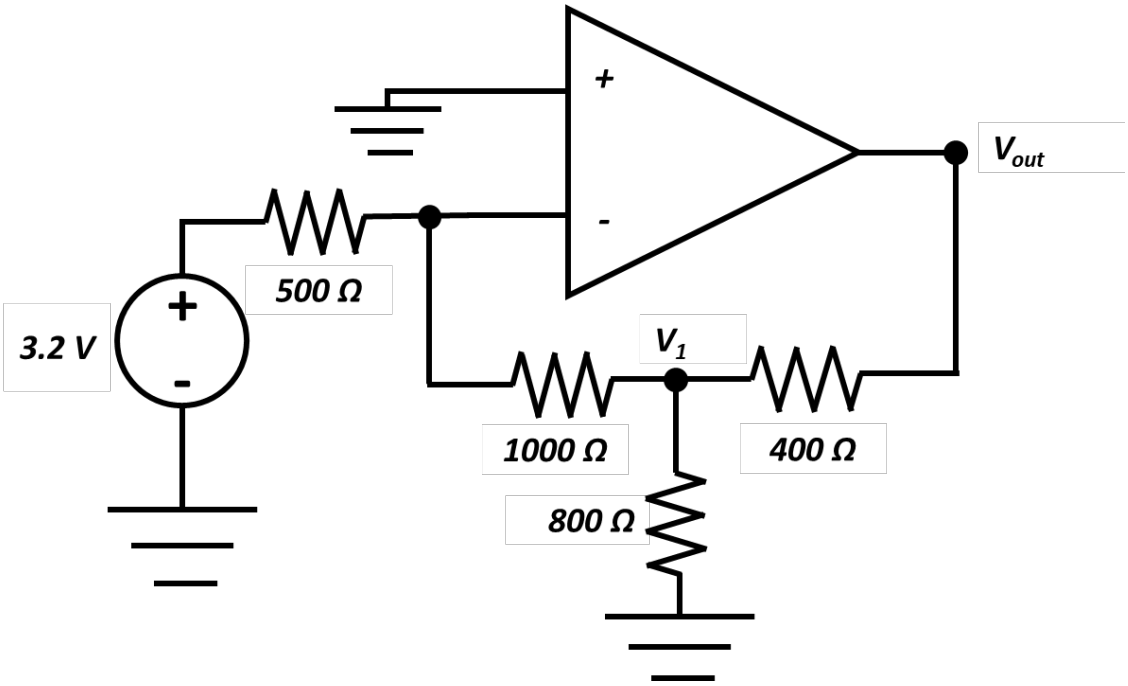



Figure 4

(A) 12.16 V

(B) −12.16 V

(C) −5.76 V

(D) 5.76 V

14. Katy is interested in building a low-cost kettle. She attaches an LM35 temperature sensor at the pitcher spout and intends to cut off the power supply to the heating element in the pitcher when the water boils. However, the output of LM35 only increases by 10 mV per degree Centigrade. She needs the cut-off signal voltage to be around 3.3 V. Help her design a non-inverting amplifier to complete her task. You may assume that the output of LM35 at 0°C is 0 V.

(A) $R_f$ = 2.7 kΩ, $R_i$ = 6.2 kΩ

(B) $R_f$ = 4.3 kΩ, $R_i$ = 1.3 kΩ

(C) $R_f$ = 3 kΩ, $R_i$ = 1.3 kΩ

(D) $R_f$ = 2 kΩ, $R_i$ = 1.5 kΩ

15. Figure 5 depicts the characteristic output voltage versus distance of an IR sensor in indirect incidence setup for proximity sensing. A young hobbyist wants to incorporate it into his project – he needs LED2 to be lit when an opaque object is more than 5 cm from the sensor, and LED1 to be lit otherwise. He found three potential circuit diagrams online (namely, Circuit A, Circuit B, and Circuit C, as shown in Figure 6 on next page), but he is uncertain about them meeting his requirement. Help him out by selecting the correct option below.

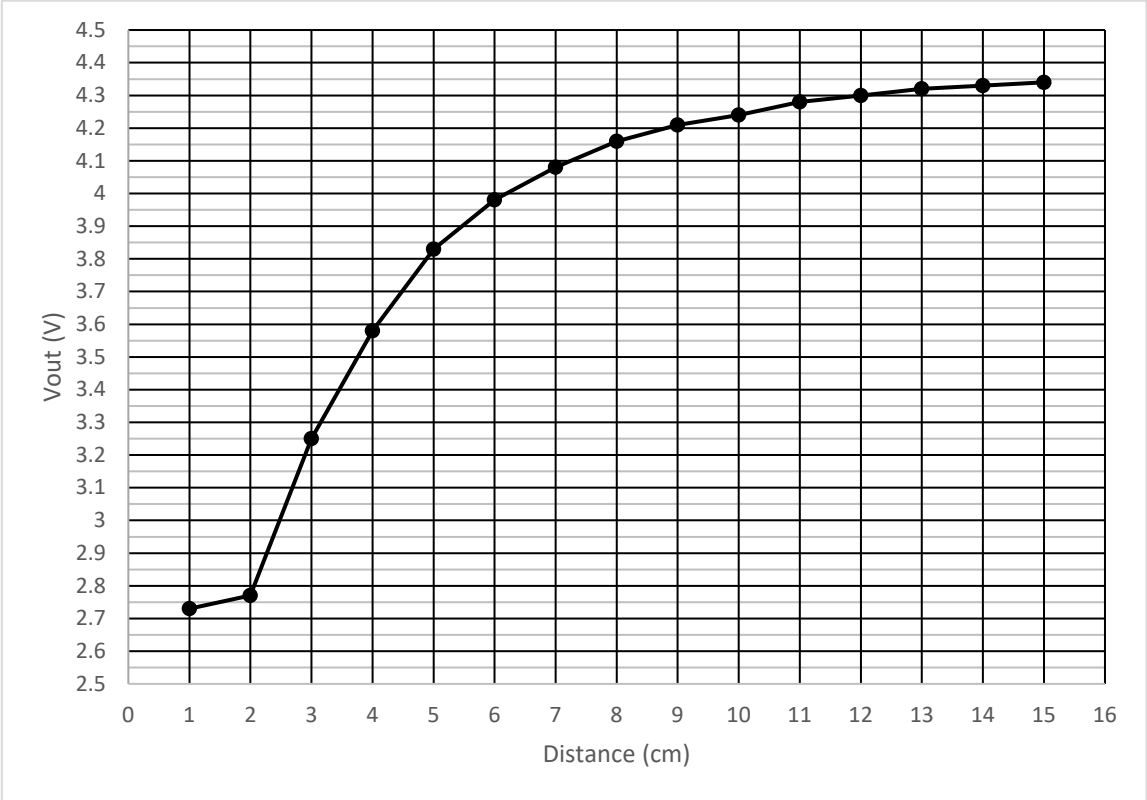


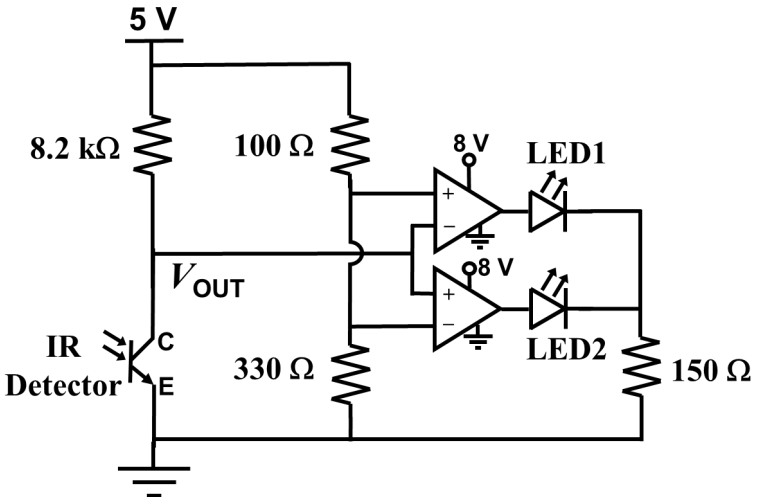

Figure 5: IR Sensor's $V_{OUT}$ vs. Distance.

(A) Circuit A only.

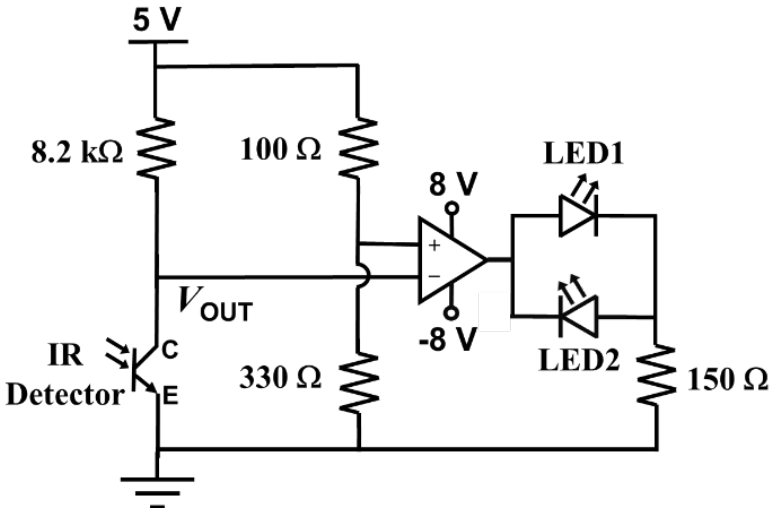
(B) Circuits A and B only.

(C) Circuits A and C only.

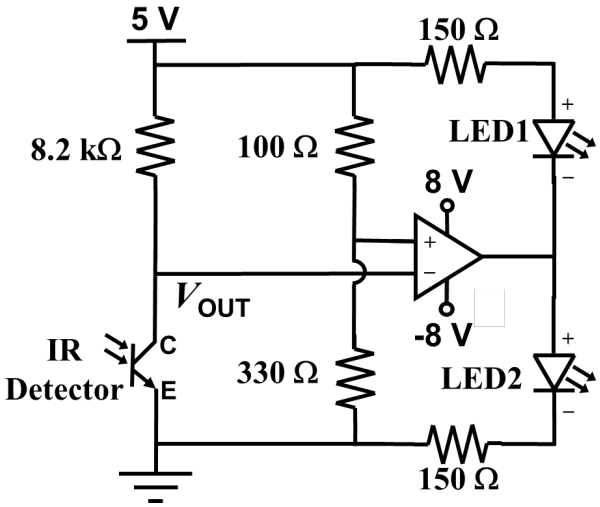
(D) Circuits B and C only.




Circuit A




Circuit B




Circuit C

Figure 6: The three circuit diagrams he'd found online.

**END OF PAPER**