2016/2017 SEMESTER 1 EXAMINATION

Diploma in Aerospace Electronics (DASE)
Diploma in Energy Systems Management (DESM)
Diploma in Computer Engineering (DCPE)
Diploma in Electrical & Electronic Engineering (DEEE)
Common Engineering Programme (DCEP)
Diploma in Engineering with Business (DEB)
1st Year and 2nd Year FT

PRINCIPLES OF ELECTRICAL & ELECTRONIC ENGINEERING II

Time Allowed: 2 Hours

Instructions to Candidates

1. The examination rules set out on the last page of the answer booklet are to be complied with.

2. This paper consists of **TWO** sections:
   Section A - 10 Multiple Choice Questions, 2 marks each.
   Section B - 8 Short Questions, 10 marks each.

3. **ALL** questions are **COMPULSORY**.

4. **All questions are to be answered in the answer booklet**.

5. **Start** each question in Section B on a **new page**.

6. Fill in the Question Numbers, in the order that they were answered, in the boxes found on the front cover of the answer booklet under the column "Questions Answered".

7. This paper contains **12** pages, inclusive of formulae sheets.

SECTION A

MULTIPLE CHOICE QUESTIONS (20 marks)

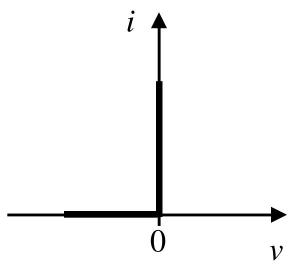
1. Please **tick** your answers in the **MCQ box** on the inside of the front cover of the answer booklet.

2. No marks will be deducted for incorrect answers.

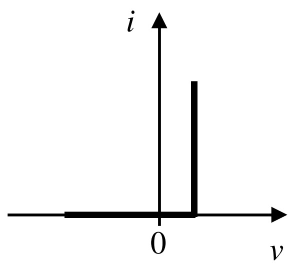
A1. Materials can be classified broadly into conductor, semiconductor and insulator base on the size of the energy gap between

(a) the valence band and the conduction band.
(b) the valence band and the nucleus.
(c) the valence shell and the nucleus.
(d) the conduction band and the nucleus.

A2. Which one of the following curves shows the characteristics of the practical diode model?



(a)



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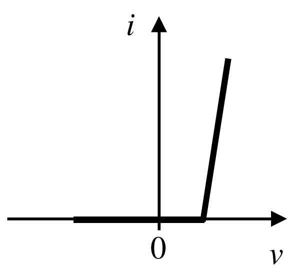

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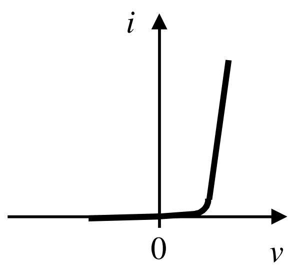


(d)

A3. D_1 in Figure A3 is a silicon diode. V_o = ?

(a) 0 V
(b) 2.15 V
(c) 2.5 V
(d) 4.3 V

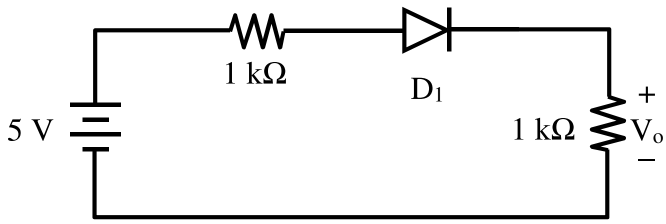
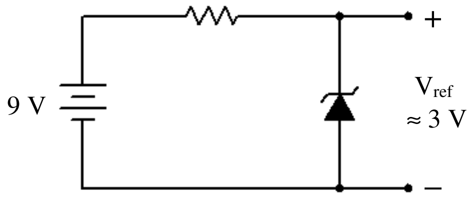
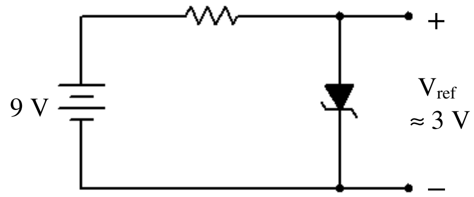


Figure A3

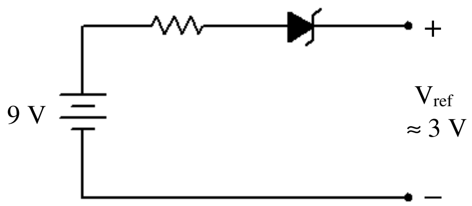
A4. A 3-V Zener diode is used to produce an approximately constant reference voltage. Which one of the following circuits biases the Zener diode properly?



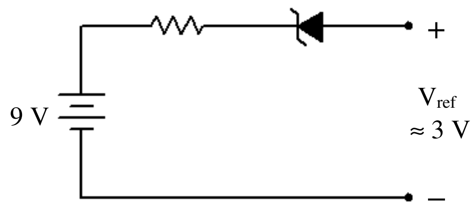
(a)



(b)



(c)



(d)

A5. A Zener diode is designed for operation in the

(a) p-type semiconductor only.
(b) cut off region.
(c) reverse breakdown region.
(d) avalanche breakdown region.

A6. An electric kettle consists of a coil with winding resistance. It consumes 3 kW of true power P. If an apparent power S of 3.06 kVA is measured, the power factor is

(a) 0.98 leading
(b) 1.02 leading
(c) 0.98 lagging
(d) 1.02 lagging

A7. Identify two circuits which can generate the voltage waveform shown in Figure A7.

(a) Half-wave rectifier and waveform limiter
(b) Half-wave rectifier and Full-wave bridge rectifier
(c) Half-wave rectifier and full-wave centre-tapped transformer rectifier
(d) Full-wave bridge rectifier and full-wave centre-tapped transformer rectifier

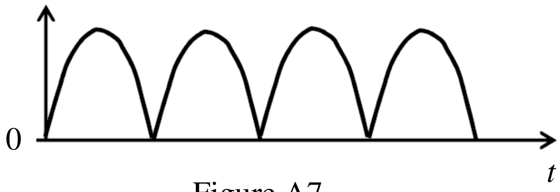


Figure A7

A8. A rectifier produces a 60 V dc supply which has a small ripple superimposed on it. The ripple factor is 0.5%. The rms voltage of the ripple is

(a) 0.1 V
(b) 0.3 V
(c) 0.42 V
(d) 3 V

A9. A voltage regulator has a 12 V output when there is no load (load current = 0). When the full-load current of 1 A is supplied by the regulator, the output voltage drops to 11.4 V. The voltage regulation is equal to

(a) 5.26%
(b) 7.44%
(c) 10.5%
(d) 95%

A10. Figure A10 shows a single digit LED display unit. Including the full stop on the display, the unit contains how many light-emitting diode(s) in total?

(a) 1
(b) 2
(c) 7
(d) 8

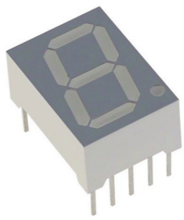


Figure A10

SECTION B

SHORT QUESTIONS (80 marks)

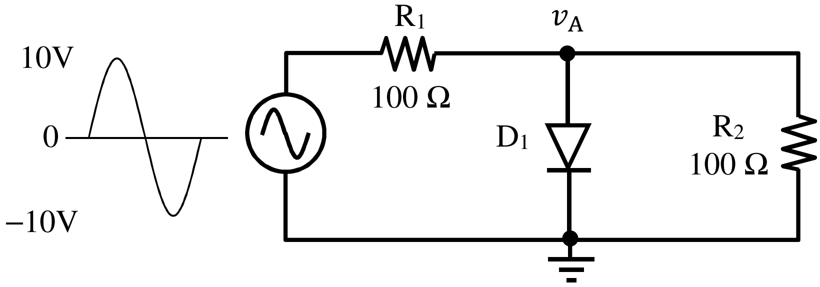
B1. (a) What type of dopants (pentavalent or trivalent) is used to produce n-type silicon? What are the majority carriers in n-type silicon? Explain how they are produced by the dopant. (5 marks)

(b) For the silicon diode circuit shown in Figure B1, the forward voltage drop of the diode D_1 is 0.7 V. Determine:

(i) The maximum voltage of v_A during the positive half cycle. (2 marks)

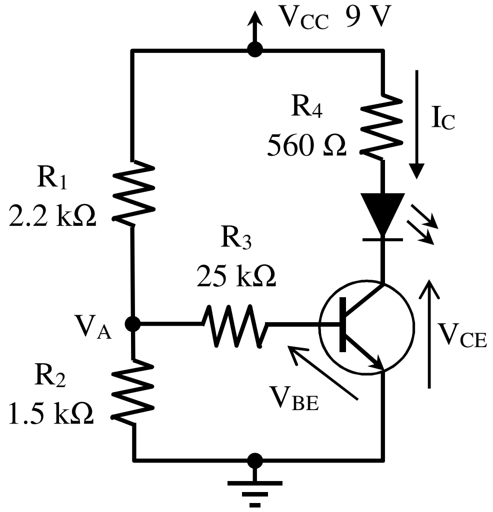
(ii) The peak inverse voltage (PIV) of diode D_1. (3 marks)

Figure B1



B2. The transistor in Figure B2 is biased in the saturation region to light up the LED. Given that the forward voltage of the LED, V_{LED} = 2.0 V, V_{BE} = 0.7 V when forward biased; and $V_{CE(sat)}$ = 0.2 V in saturation mode.

Figure B2



(a) Determine V_{CE} and hence calculate I_C. (4 marks)

(b) Assume that $V_A = \frac{R_2}{R_1+R_2} \times V_{CC}$. Calculate V_A and the current in R_3.

(4 marks)

(c) Is the transistor a PNP or an NPN type? (2 marks)

B3. Figure B3 shows a moisture sensor circuit. When the sensor gets wet, the transistor operates in saturation mode and the LED lights up. The following values are given for this question:

Moisture sensor:

Resistance value when wet, $R_{M(wet)} = 0\ \Omega$ (close-circuited)

Resistance value when dry, $R_{M(dry)} = \infty\ \Omega$ (open-circuited)

LED:

LED forward voltage, $V_{LED} = 1.8$ V

Transistor:

$V_{BE} = 0.7$ V when transistor is conducting, $\beta = 150$, $V_{CE(sat)} = 0.2$ V

Assume that all leakage currents in the circuit are zero.

(a) What are I_B and I_C when the moisture sensor is dry? (2 marks)

(b) When the moisture sensor is wet:

(i) Determine V_{BE} and V_{CE}. (2 marks)

(ii) Calculate I_B and I_C. (4 marks)

(iii) What is the function of the resistor R_C? (2 marks)

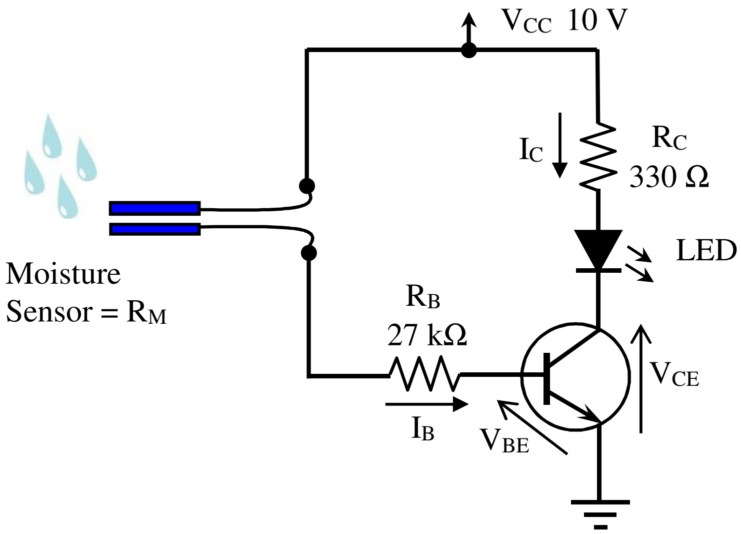


Figure B3

B4. Two 500 Hz sinusoidal ac voltage sources are connected in series as shown in Figure B4. The expressions for the two sources are respectively:

$v_{S1}(t) = 36 \sin(\omega t + 60^o)$ V

$v_{S2}(t) = 48 \sin(\omega t - 30^o)$ V

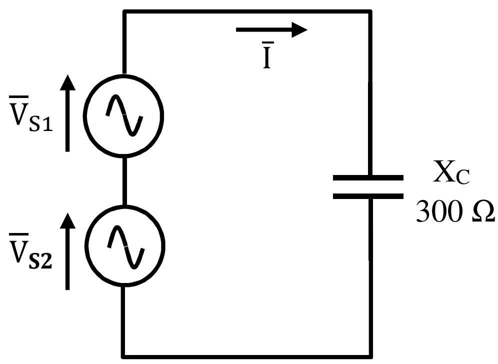


Figure B4

(a) Express $\bar{V}_{S1}$ and $\bar{V}_{S2}$ as phasors in polar form, with the voltage magnitudes expressed in their rms values. (2 marks)

(b) Calculate the resultant rms source voltage $\bar{V}_T$ in polar form. (2 marks)

(c) Draw the phasor diagram for $\bar{V}_{S1}$, $\bar{V}_{S2}$ and $\bar{V}_T$. Indicate their magnitudes and phase angles in your diagram. (3 marks)

(d) Write down the time-domain sinusoidal expression for the circuit current. (3 marks)

B5. The circuit current, $\bar{I}_T$, is to be used as the reference phasor in analysing the series RLC circuit shown in Figure B5.

(a) Calculate the total impedance, $\bar{Z}_T$. (4 marks)

(b) Calculate the supply voltage, $\bar{V}_S$, in polar form. (2 marks)

(c) What is the power factor of the circuit? Is it leading or lagging? (2 marks)

(d) Calculate the real power P delivered to the circuit. (2 marks)

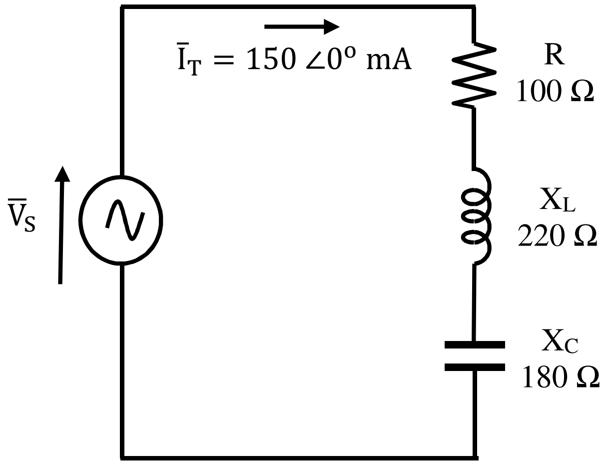


Figure B5

B6. (a) For the circuit in Figure B6, find the total admittance $\overline{Y}_T$, the total current $\overline{I}_T$, and the branch currents $\overline{I}_R$ and $\overline{I}_C$. Express all answers in polar form. (6 marks)

(b) Sketch the phasor diagram of the currents $\overline{I}_T$, $\overline{I}_R$ and $\overline{I}_C$ obtained in part (a). Use the supply voltage $\overline{V}_S$ as reference phasor. (4 marks)

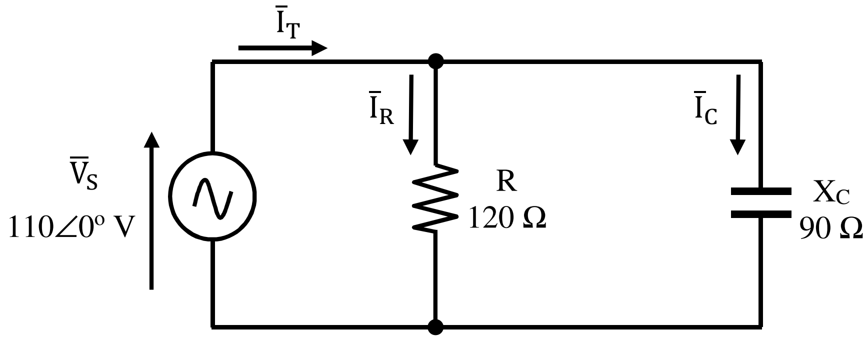


Figure B6

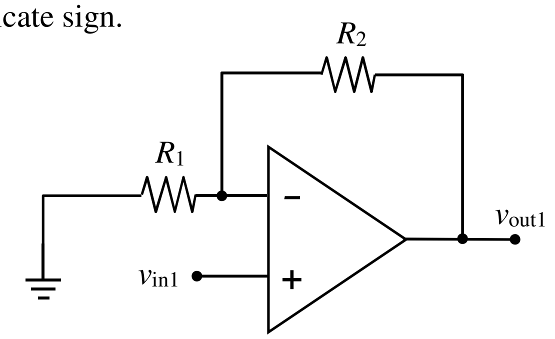
B7. (a) Give two advantages of having the negative feedback loop in a non-inverting operational amplifier circuit. (4 marks)

(b) With reference to Figure B7-A:

(i) Is this an inverting or a non-inverting amplifier? (1 mark)

(ii) Given that R_1 = 1.5 kΩ and R_2 = 12 kΩ, calculate the closed loop gain of the amplifier. Indicate sign. (2 marks)

Figure B7-A

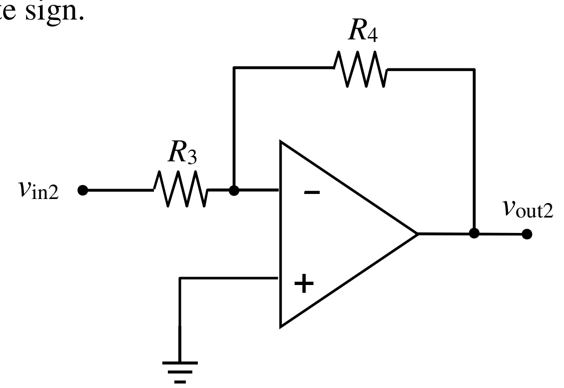


(c) With reference to Figure B7-B:

(i) Is this an inverting or a non-inverting amplifier? (1 mark)

(ii) Given that R_3 = 12 kΩ and R_4 = 1.2 kΩ, calculate the gain of the amplifier. Indicate sign. (2 marks)

Figure B7-B



B8. Figure B8 shows the configuration of an op-amp circuit which has three input terminals v_{in1}, v_{in2} and v_{in3}; and an output terminal v_{out}.

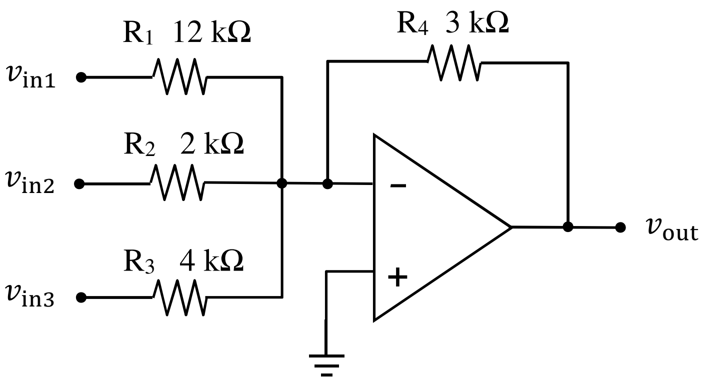


Figure B8

(a) Express the output voltage v_{out} in terms of the input voltages v_{in1}, v_{in2} and v_{in3}. Indicate sign. (5 marks)

(b) If $v_{\text{in1}} = 3$ V, $v_{\text{in2}} = 6$ V, and $v_{\text{in3}} = -12$ V, determine v_{out}. Indicate sign. (2 marks)

(c) By keeping the value of R4 to be 3 kΩ, redesign the circuit in Figure B8 such that the output voltage v_{out} satisfies the expression:

$$v_{\text{out}} = -\{\, v_{\text{in1}} + v_{\text{in2}} + v_{\text{in3}}\}$$

Draw your circuit in the answer booklet. Label all the resistance values of the resistors.

(3 marks)

- End of Paper -

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Formulae List

Number of electrons in a shell (band) = $2N^2$

6.25×10^{18} electrons ➔ 1C of negative charge

Ohm's Law for ac:

$\overline{V} = \overline{I}\overline{Z}$ $\quad\quad$ $\overline{I} = \dfrac{\overline{V}}{\overline{Z}} = \overline{V}\overline{Y}$ $\quad\quad$ $\overline{Z} = \dfrac{\overline{V}}{\overline{I}}$

Capacitors:

Capacitive reactance, $X_C = \dfrac{1}{2\pi f C}$ in ohms

Inductors:

Inductive reactance, $X_L = 2\pi f L$ in ohms

AC Voltages and Currents:

$I_{rms} = I_p / \sqrt{2} = 0.7071\ I_p$	$I_{p\text{-}p} = 2I_p$	$I_{av} = 2I_p / \pi = 0.637 I_p$
$V_{rms} = V_p / \sqrt{2} = 0.7071\ V_p$	$V_{p\text{-}p} = 2V_p$	$V_{av} = 2V_p / \pi = 0.637 V_p$

AC Impedance/Admittance:

Series circuit,

$\overline{Z}_R = R$ $\quad\quad$ $\overline{Z}_C = -jX_C = -j\dfrac{1}{\omega C} = \dfrac{1}{\omega C}\angle -90^o$ $\quad$ $\overline{Z}_L = jX_L = j\omega L = \omega L \angle 90^o$ $\quad$ $\omega = 2\pi f$

$\overline{Z} = \overline{Z}_1 + \overline{Z}_2 + \overline{Z}_3 + ...$ $\quad\quad$ $\phi = \angle\overline{Z} = \angle\overline{I} = \tan^{-1}\dfrac{X_{tot}}{R_{tot}}$

Parallel circuit,

$\overline{Y}_R = G$ $\quad$ $\overline{Y}_C = jB_C = j\omega C = \omega C \angle 90^o$ $\quad\quad$ $\overline{Y}_L = -jB_L = -j\dfrac{1}{\omega L} = \dfrac{1}{\omega L}\angle -90^o$ $\quad$ $\omega = 2\pi f$

$\overline{Y} = \overline{Y}_1 + \overline{Y}_2 + \overline{Y}_3 + ...$ $\quad\quad$ $\phi = \angle\overline{Y} = \angle\overline{V}_S = \tan^{-1}\dfrac{B_{tot}}{G_{tot}}$

AC Power:

$S = V_S I = I^2 Z$ $\quad\quad$ $P = V_S I\cos\phi$ $\quad\quad$ $Q = V_S I\sin\phi$ $\quad\quad$ $\cos\phi = \dfrac{P}{S}$

Diodes:
Forward voltage drop is 0.7 V for silicon diode and 0.3 V for germanium diode

Zener impedance $Z_Z = \dfrac{\Delta V_Z}{\Delta I_Z}$

Half-Wave Rectifier:

$V_{p(out)} = V_{p(\sec)} - 0.7\,V \quad V_{AVG} = \dfrac{V_{p(out)}}{\pi} \quad PIV = V_{p(\sec)}$

Centre-Tapped Full-Wave Rectifier:

$V_{p(out)} = \dfrac{V_{p(\sec)}}{2} - 0.7\,V \quad V_{AVG} = \dfrac{2V_{p(out)}}{\pi} \quad PIV = 2V_{p(out)} + 0.7\,V$

Bridge Full-Wave Rectifier:

$V_{p(out)} = V_{p(\sec)} - 1.4\,V \quad V_{AVG} = \dfrac{2V_{P(out)}}{\pi} \quad PIV = V_{p(out)} + 0.7\,V$

Ripple Factor:

$r = \dfrac{V_{r(rms)}}{V_{DC}}$ where $V_{r(rms)} = \dfrac{V_{r(p-p)}}{2\sqrt{3}}$

Line Regulation = $\left(\dfrac{\Delta V_{OUT}}{\Delta V_{IN}}\right)100\,\%$ **Load Regulation =** $\left(\dfrac{V_{NL} - V_{FL}}{V_{FL}}\right)100\,\%$

Transistors:

$I_E = I_C + I_B \quad \beta_{DC} = \dfrac{I_C}{I_B} \quad \alpha_{DC} = \dfrac{I_C}{I_E} \quad \beta_{DC} = \dfrac{\alpha_{DC}}{1-\alpha_{DC}}$

$V_{BE} = 0.7V \quad V_{BB} = V_{BE} + I_B R_B \quad V_{CE} = V_{CB} + V_{BE}$

Operational Amplifiers

Voltage Gain of Inverting Amplifier: $-\dfrac{R_f}{R_i}$

Voltage Gain of Non-inverting Amplifier: $1 + \dfrac{R_f}{R_i}$

Output voltage of summing amplifier:

$V_O = -\left(\dfrac{R_f}{R_1}V_1 + \dfrac{R_f}{R_2}V_2 + \dfrac{R_f}{R_3}V_3 + ... + \dfrac{R_f}{R_n}V_n\right)$ for “n” inputs

Threshold Voltages for comparator with positive feedback:

Upper Trigger Point (UTP) = $\dfrac{R_2}{R_1 + R_2}(+V_{O[max]})$

Lower Trigger Point (LTP) = $\dfrac{R_2}{R_1 + R_2}(-V_{O[max]})$