M.Sc. Sem III

MPHYCC - 12

electronics II

OP-amp

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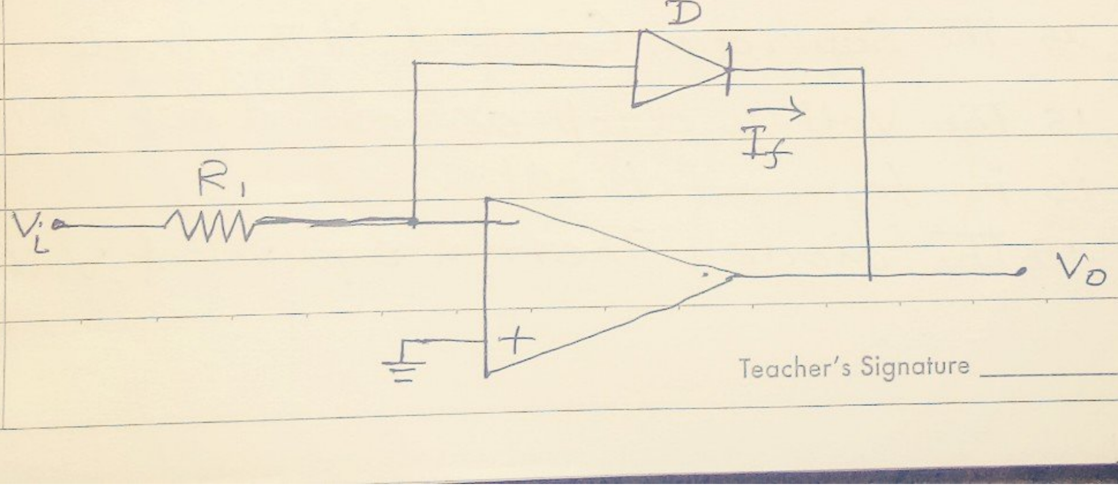
Logarithmic and exponential Amplifiers :-

The electronic Circuits which Perform The mathematical operations such as logarithmic and exponential with an amplification are Called as Logarithmic amplifier and exponential amplifier respectively.

Logarithmic Amplifier :-

A logarithmic amplifier, or a log amplifier, is an electronic Circuit That produces an output That is Proportional to The logarithm of The applied input. This section discusses about The OP-amp based logarithmic amplifier in detail.

An op-amp based logarithmic amplifier Produces a voltage at the output, which is Proportional to The logarithm of The voltage applied to the resistor Connected to its inverting terminal. The Circuit diagram of an op-amp based logarithmic amplifier is shown in The following figure.



In The above Circuit, The non-inverting input terminal of The op-amp is connected to ground. That means Zero Volts is applied at The non-inverting input terminal of the op-amp.

According to the Virtual Short Concept, The Voltage at The inverting input terminal of an op-amp will be equal to the Voltage at its non-inverting input terminal. So, the Voltage at The inverting input terminal will be Zero Volts.

The nodal equation at the inverting input terminal's node is —

$$\frac{0 - V_i}{R_1} + I_f = 0$$

$$\Rightarrow I_f = \frac{V_i}{R_1} \quad \text{—— (1)}$$

The following is The eqn for Current flowing Through a diode, when it is in forward bias —

$$I_f = I_s e^{\left(\frac{V_f}{n V_T}\right)} \quad \text{—— (2)}$$

where,

I_s, is The Saturation Current of The diode.

V_f, is The Voltage drop across diode, when it is in forward bias.

V_T, is The diode's Thermal equivalent Voltage.

The KVL equation around the feed-back loop of the OP-amp will be

$$0 - V_f - V_o = 0$$

$$\Rightarrow V_f = -V_o$$

Substituting the value of V_f in eqn ②, we get,

$$I_f = I_s e^{\left(\frac{-V_o}{nV_T}\right)} \quad \text{---} \quad (3)$$

observe that the left hand side terms of both eqn ① and ③ are same. Hence, equate the right hand side term of those two equations as shown below —

$$\frac{V_i}{R_1} = I_s e^{\left(\frac{-V_o}{nV_T}\right)}$$

$$\frac{V_i}{R_1 I_s} = e^{\left(\frac{-V_o}{nV_T}\right)}$$

Applying natural logarithm on both sides, we get —

$$\ln\left(\frac{V_i}{R_1 I_s}\right) = \frac{-V_o}{nV_T}$$

$$V_o = -nV_T \ln\left(\frac{V_i}{R_1 I_s}\right)$$

Note that in the above eqn, the parameters n, V_T and I_S are constants. So, the output voltage V_0 will be proportional to the natural logarithm of the input voltage V_i, for a fixed value of resistance R_1.

Therefore, the op-amp based logarithmic amplifier circuit discussed above will produce an output, which is proportional to the natural logarithm of the input voltage

V_T, when $R_1 I_S = 1V$.

Observe that the output voltage V_0 has a negative sign, which indicates that there exists a 180° phase difference between the input and the output.