Frequency response of R-L circuit
(Low-pass filter circuit)

Aim : - To observe the frequency response of an R – L circuit, which behaves as a low pass filter circuit and to find the upper 3-db (cut-off) frequency.

Apparatus : - Signal generator, AC milli – voltmeter, connecting terminals, carbon resistors and induction coils (inductors).

Formula :- The upper 3-db(cut-off) frequency $f = R / 2\pi L$ Hz.

Where R = Resistance in the circuit (Ω)

L = Inductance in the circuit (H)

Voltage gain $G = \frac{e_0}{e_i}$

e_o = Out put voltage (V)

e_i = In put voltage (V)

Description and theory :- This R-L filter circuit passes low frequency a.c. readily. The resistance of the resistor is independent of the applied AC frequency. But in case of inductor, as the frequency increases, the reactance ($X_L = \omega L = 2\pi fL$) of the inductor increases. At low frequencies, as the reactance is very low, the inductor acts as short circuit. So at this lower frequencies as $X_L << R$, the P.D. across the inductor is also low compared to that across the resistor, even though the current is high. The total in put voltage (e_i) is equal to the sum of voltages across the inductor and resistor in the R – L circuit. As the voltage across the inductor is so small, the total input (e_i) component appears at the out put(e_0) i.e. across the resistor.

As the frequency of the AC signal increases the reactance X_L of the inductor increases and the potential difference across the inductor also increases. The voltage across the resistor or the out put voltage (e_0) decreases. But at very high frequencies i.e. in M Hz, the reactance of the inductor is so high and the inductor virtually open - circuited and no current flows through the circuit or the resistor. So the voltage across the resistor falls to zero or the out put (e_0) is zero. Hence this circuit passes or sends the low frequency signals (voltages) from the in put to the out put and cut – off the high frequency signals in reaching the out put. So this circuit is called low pass circuit or low pass filter circuit.

Procedure : - First the signal generator is directly connected to the a.c.milli-voltmeter, keeping the frequency of S.G. at 1KHz and adjust the amplitude of the signal to 1 V. i.e. the in put voltage is 1V. This in put voltage 1V should be maintained through out the experiment. Now the a.c. milli - voltmeter is disconnected from the signal generator.

Now again connect the circuit as shown in the figure. In this circuit one end of the inductor L is connected to the resistor R and the other end is connected to the signal generator(S.G.). The second terminal of the resistor is connected to the other terminal of the signal generator. The out put (e_0) is measured across the resistor by a.c milli voltmeter.

Now vary the frequency of AC signal generator from 10 Hz and so on, up to MHz by taking at least 5 readings in each range and note down the values of out put voltage (e_0) using AC milli-voltmeter for each frequency f and calculate the gain ($G = e_0/ e_i$) for all values of frequencies and note down the gain ratio in the observation table. Also note the 'log f' values.

Note:- 1) The values of R and L are so selected such that the cut – off frequency lies in the range 1KHz to 20KHz.

2) To measure the out put voltage, digital multi-meter should not be used. Because at higher frequencies i.e. above 5 K Hz it shows less values instead of actual values.

Graph :- A graph is plotted between frequency f or log f and gain, by taking the frequency or log f on x – axis and gain on y – axis. This is called frequency response curve. The frequency and gain characteristics are as shown in the figure. The frequency corresponding to 0.707 times to the maximum gain ($0.707G_{max}$) is noted. It is the upper 3-db(cut-off) frequency. This is the frequency up to which the circuit can allow or pass voltage signal to reach the out put.

Precautions :- 1) The continuity of the connecting wires should be tested first.

2) The frequency of the signal generator should varied from the lowest value.

3) The in put must be maintained at constant value through out the experiment.

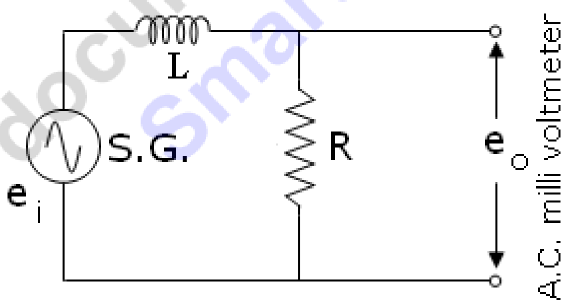
Result : - The frequency corresponding to 0.707 times to the max gain ($0.707G_{max}$) and the frequency from the formula $f = R / 2\pi L$ Hz. are equal. i.e. the upper 3-db frequency from graph and from formula are equal.

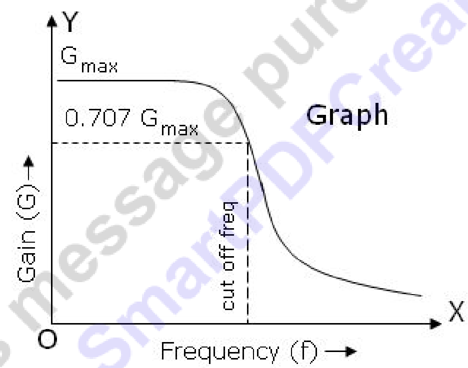
Table

The input voltage e_i = 1V

R = Ω L = H

S.No.	Frequency (Hz)	Out put voltage (e_0) (V)	Voltage gain $G = \frac{e_0}{e_i}$	$\log_{10} f$
1.				
20.				





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