EXPERIMENT NO. 5

AIM → To obtain the resonant frequency and the resonance curves for the series and parallel resonant circuits.

APPARATUS → Experimental board on the study of resonance, CRO, AF generator.

THEORY → A resonant circuit is a combination of R, L and C elements. This combination could either be a series connection or a parallel connection.

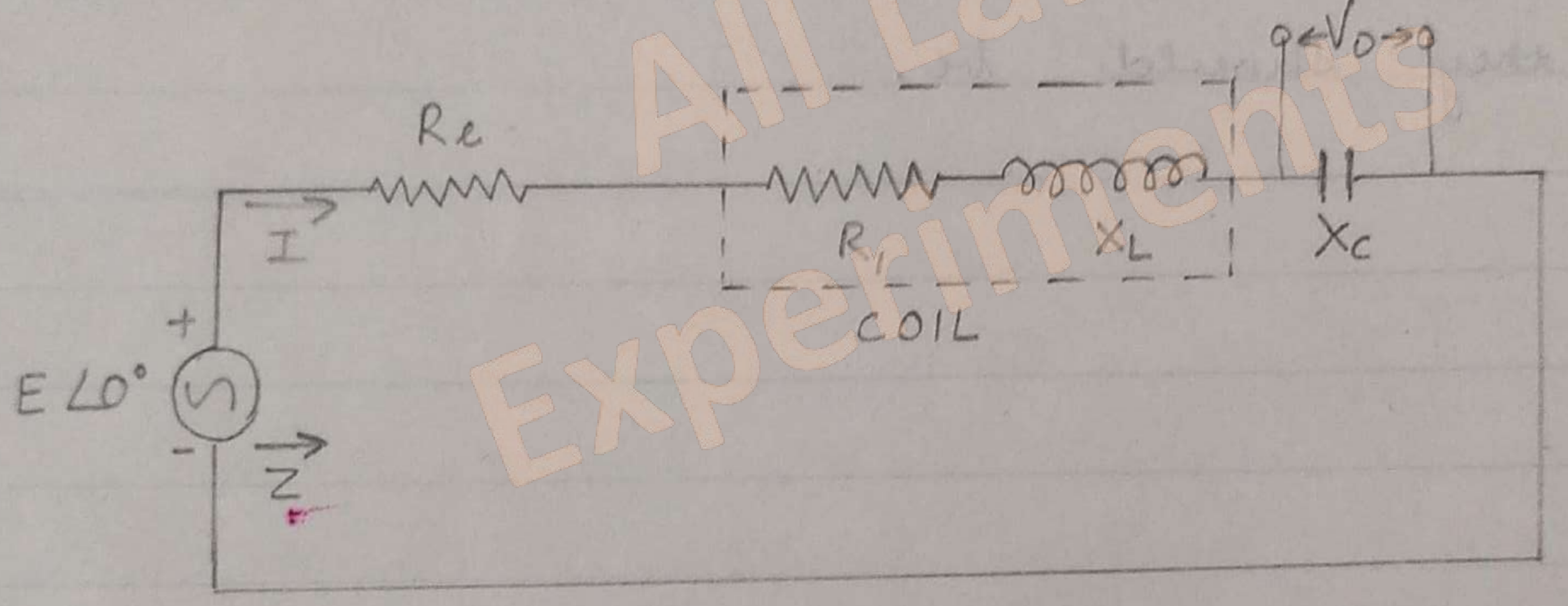
1. SERIES RESONANCE → Figure is shown on left. The total impedance of this network is given by

$$Z = R + j(X_L - X_C)$$

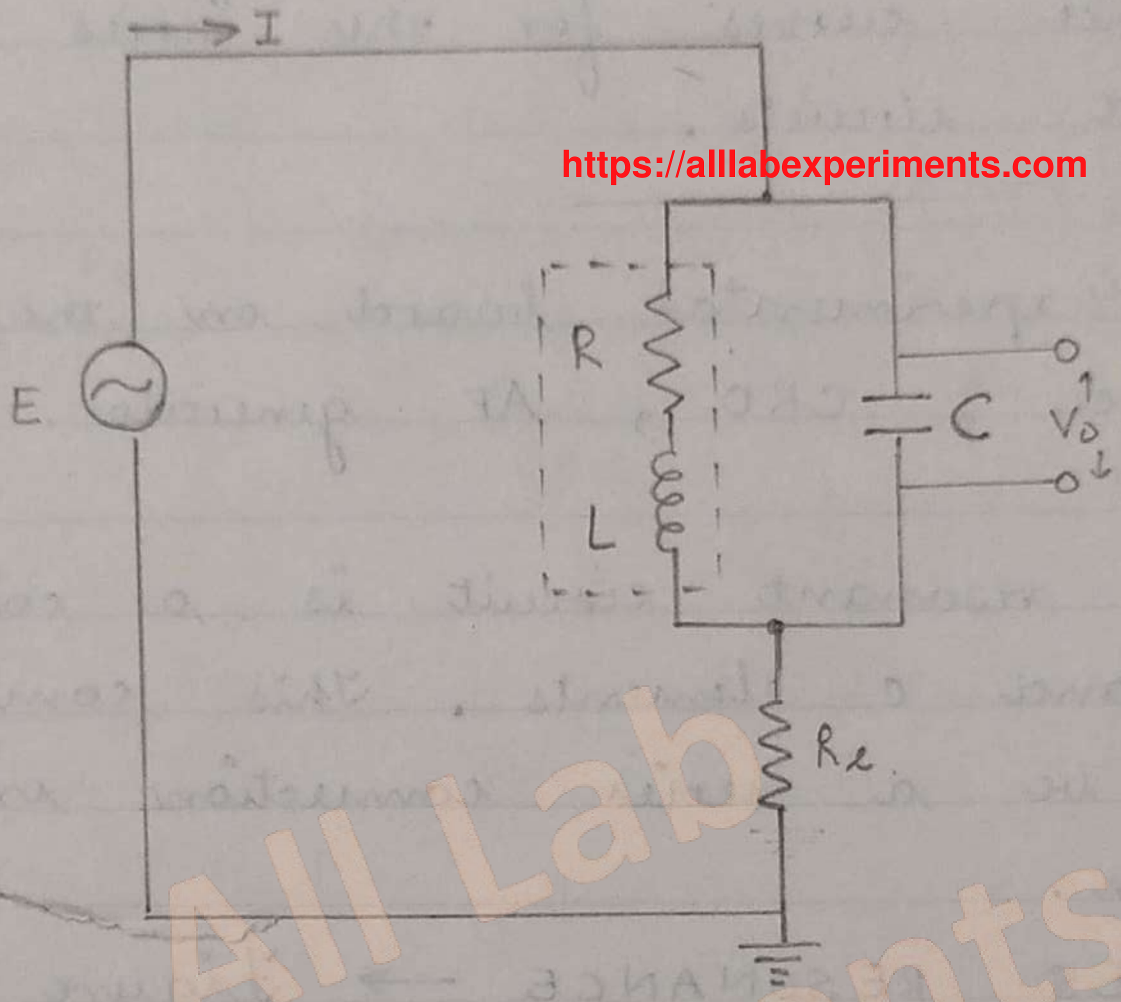
where $X_L = \omega L$ and $X_C = 1/\omega C$

X_L increases with frequency and X_C decreases. At low frequencies, the circuit is essentially capacitive and at higher frequencies it is inductive. In between these two extremes a balance pt. exists where $X_L = X_C$. At this pt., the net reactance is zero and the ckt. becomes purely resistive. The frequency at

SERIES RESONANT CIRCUIT.



PARALLEL RESONANT CIRCUIT.



which this happens is called the Resonant frequency. Thus at resonance,

$$X_L = X_C$$

$$\omega_0 L = \frac{1}{\omega_0 C}.$$

$$\omega_0^2 = \frac{1}{LC}.$$

$$\therefore, \quad f_0 = \frac{1}{2\pi\sqrt{LC}}$$

2. PARALLEL RESONANT CIRCUIT $\longrightarrow$ The parallel resonant circuit is also known as tank circuit due to storage of energy by inductor and capacitor. In the ideal case, at resonance the capacitor absorbs energy during one half of the power cycle at the same rate at which it is being released by the inductor. During the next half - cycle the reverse is true. The total power taken from source at this moment is zero. The process could continue indefinitely had their been no losses due to radiation or the presence of resistance in the circuit.

The total admittance Y of the circuit will be given by,

$$Y = \frac{1}{R + jX_L} + j\frac{1}{X_C}.$$

$$= \frac{R - jX_L}{R^2 + X_L^2} + j\frac{1}{X_C}$$

$$= \frac{R}{R^2 + X_L^2} + j\left(\frac{1}{X_C} - \frac{X_L}{R^2 + X_L^2}\right)$$

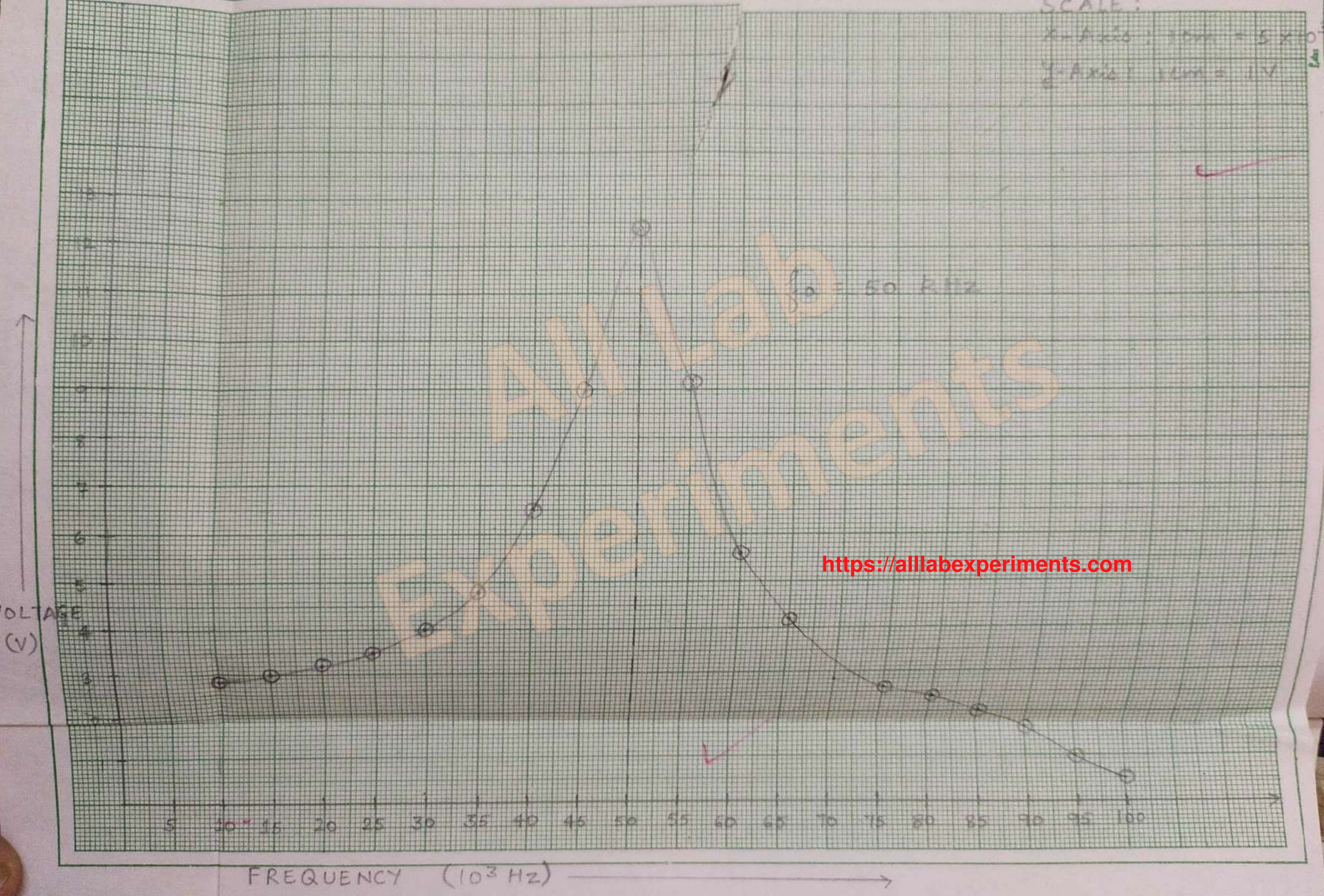
At resonance the circuit has to be purely resistive. Equating the imaginary part to zero,

$$\frac{R^2 + X_L^2}{X_L} = X_C$$

$$\therefore \quad f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

ROCEDURE ⟶ I. SERIES RESONANT CIRCUIT

1. Assemble the series circuit using R_1, L_1 and C_1
2. connect an AF generator at the input terminals.
3. Connect a CRO across C_1.
4. Set the frequency to 500 Hz and measure voltage V_C across it. Record its in the table.
5. Repeat V_C measurement at regular intervals of frequency and find the resonant frequency.
6. Plot the voltage vs. frequency on a linear graph paper and find the resonant frequency f_0 from this.
7. Find the value of L_1 and also calculate the Q factor.

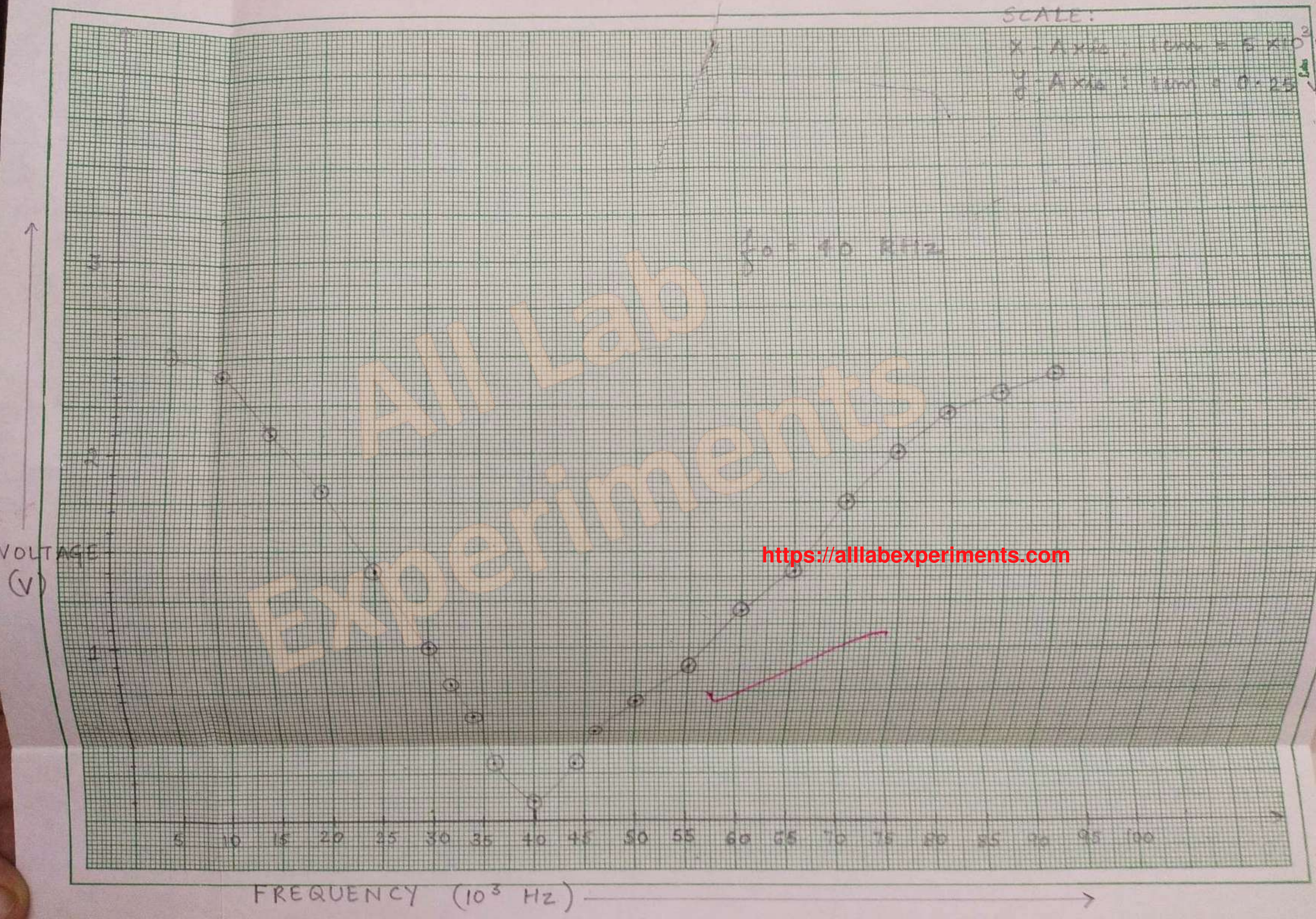

SCALE:
Y-Axis: 1cm = 1V
f0 = 50 KHz
VOLTAGE (V)
FREQUENCY (10³ Hz)
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

II. Parallel Resonant Ckt.

1. Assemble the circuit as shown in the figure.
2. Connect an AF generator at the input terminal and a CRO across the resistor R_e with the ground of CRO and AF generator common.
3. Set the frequency to some value and record V_c. Now repeat the frequency adjustments at regular intervals of time and note the corresponding V_c.
4. Calculate f_o, the resonant frequency, L, and the Quality factor Q.

OBSERVATION TABLE → 1. Series LCR ~~&~~ Circuit. V_{in} = ?

Frequency f (Hz)	Voltage (V)	Freq. (f) Hz	Voltage (V)
200	2.8	40000	6.5
400	2.8	45000	9.0
500	2.8	50000	12.4
⋮ 10000	2.8	55000	9.2
15000	3.0	60000	5.6
18000	3.1	65000	4.2
20000	3.2	70000	3.6
24000	3.5	80000	2.4
25000	3.5	85000	2
30000	4.2	90 K.	1.6
35000	5.2	100 K.	1.0


SCALE:
X-Axis: 1cm = 5×10³
Y-Axis: 1cm = 0·25 V
f0 = 40 KHz
VOLTAGE (V)
FREQUENCY (10³ Hz)
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
1 2 3

2. ~~PARARRE~~ PARALLEL LCR ckt. $V_{in} = ?$

Frequency (Hz)	Voltage (V)	Frequency (Hz)	Voltage (V)
500	2.5	55000	0.9
⋮ 5000	2.5	60000	1.2
10000	2.4	65000	1.4
15000	2.1	70000	1.7
20000	1.8	75000	2.0
25000	1.4	80000	2.2
30000	1.0	85000	2.3
35000	0.6	90000	2.3
40000	0.1	95000	2.4
45000	0.6	100K.	2.4
50000	0.7		

CALCULATIONS → FOR SERIES RESONANT CIRCUIT

$f_0 = 50$ kHz $\quad C = 6.87\ \mu F \quad L = ?$

From $f_0 = \dfrac{1}{2\pi\sqrt{LC}}$ $\quad L = \dfrac{1}{4\pi^2 f_0^2 C}$

$$L = \frac{1}{4 \times (3.14)^2 \times (50 \times 10^3)^2 \times 6.87 \times 10^{-6}} = 1.476\ \mu H.$$

FOR PARALLEL RESONANT CIRCUIT

$f_0 = 40$ kHz $\quad C = 6.87\ \mu F \quad L = ?$

$$\therefore L = \frac{1}{4 \times (3.14)^2 \times (40 \times 10^3)^2 \times 6.87 \times 10^{-6}} = 2.306\ \mu H$$

RESULT → The graph when plotted i.e.. when frequency is plotted vz voltage, we get the shapes as expected. The resonant frequency for the series ckt is 50 KHz and for the Parallel ckt is 40 KHz.

DISCUSSION → Since the value of inductor is not provided, so we cannot compare the calculated value of inductor for parallel and series circuit with the theoretical value.