University of Jordan
School of Engineering
Electrical Engineering Department

10/10

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EE 204
Electrical Engineering Lab

EXPERIMENT 7 REPORT & PRE-LAB
RESONANCE

Section # _____ **Group #** _____

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EXPERIMENT 7
RESONANCE

Note: Use MATLAB to quickly perform theoretical calculations by defining a vector of frequencies then using array arithmetic.

PROCEDURE A – SERIES RESONANCE

4. What is the equation for the resonant frequency of a series RLC circuit?

$f_r = \frac{1}{2\pi\sqrt{LC}}$

5. Use that above equation to find the resonant frequency in this experiment.

$f_r = 1591.5$ Hz

6. What is the equation for the quality factor Q, and bandwidth B of a series RLC circuit?

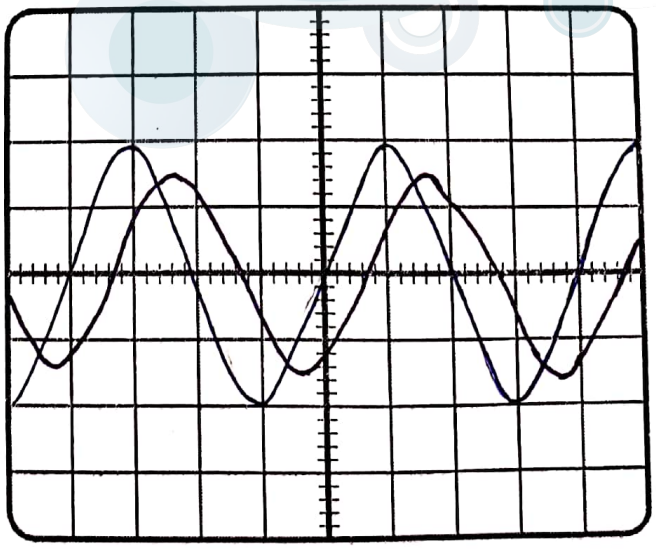
$B = \frac{R}{2\pi L}$ $Q = \frac{f_r}{B}$

7. Use the proper equations to find the frequencies f_1 and f_2, at which the current amplitude is approximately 0.707 times the resonant current (i.e., the half-power points).

$f_1 = \left(-\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}\right)/(2\pi)$

$f_2 = \left(\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}\right)/(2\pi)$

9. At the frequency of 6000 Hz, draw what you see on the oscilloscope screen.



$-V_S$

$-V_R$

11. Draw what you see on the oscilloscope screen at the resonant frequency.

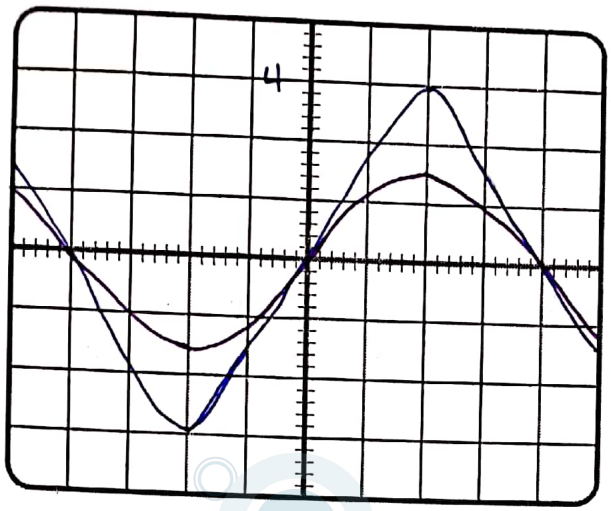


Table 1

AC Source Frequency (Hz)	$\lvert V_S\rvert$ (peak) (V)		V_S period T (μs)		$\lvert V_R\rvert$ (peak) (V)		$\measuredangle V_R$ with V_s (degrees)	
	Theory	Meas.	Theory	Meas.	Theory	Meas.	Theory	Meas.
6000	4	4.03	166.67	169.98	1.356	1.29	70.2°	63.5°
9000	4	4.09	111.11	110.4	2.253	2.11	55.7°	49°
14400	4	4	69.4	69.58	3.886	3.2	13.7°	15.7°
16800	4	4	59.52	59.41	3.966	3.4	-7.5°	-6.4°
30000	4	4	33.33	33.35	2.072	2.3	-58.8°	-50.6°
48000	4	4.09	20.83	20.99	1.169	1.44	-73°	-68.5°
f_r = 15915	4	4	62.83	63.37	4	3.35	0°	3°
f_1 = 10676	4	4.05	93.67	93.96	2.67	2.3	48.2°	45°
f_2 = 23727	4	4.05	42.21	42.33	2.15	2.3	-58.7°	-50°

Table 2

AC Source Frequency (Hz)	$\lvert V_C\rvert$ (peak) (V)		$\measuredangle V_C$ with V_s (degrees)		$\lvert V_L\rvert$ (peak) (V)		$\measuredangle V_L$ with V_s (degrees)	
	Theory	Meas.	Theory	Meas.	Theory	Meas.	Theory	Meas.
6000	4.386	4.32	-19.8°	-21.17°	0.623	0.6	160.2°	155.4
9000	4.859	4.52	-34.3°	-37.7°	1.554	1.2	145.7°	143°
14400	5.237	4.41	-76.3°	-77.1°	4.288	3.4	103.7°	102.8°
16800	4.581	4.22	-97.5°	-92.3°	5.105	4.03	82.5°	84°
30000	1.34	1.45	-148.8°	-138.9°	4.762	4.68	31.2°	32°
48000	0.473	0.6	-163°	-171.8°	4.298	4.4	17°	18°
f_r = 15915	3.62	3.7	-90°	-90°	4.878	3.4	90°	91.2°
f_1 = 10676	5.07	2.48	-41.8°	-45°	2.09	1.8	138.2°	140°
f_2 = 23727	1.35	1.65	-148.7°	-142.6°	4.76	4.4	31.3°	35°

16. What is the relationship between the capacitor voltage V_C and inductor voltage V_L at resonant frequency?

Equal in magnitude and opposite in direction

17. Consider the capacitor voltage amplitude $|V_C|$. Which one is higher $|V_C|$ at resonant frequency or $|V_C|$ below resonant frequency?

|Vc| below the resonant frequency is higher

18. Consider the inductor voltage phase $\measuredangle V_L$. Which one is higher $\measuredangle V_L$ at resonant frequency or $\measuredangle V_L$ below resonant frequency? Note: In phase, consider the positive or negative signs.

∠VL below resonant frequency is higher

Table 3

AC Source Frequency (Hz)	$\|I\|$ (peak) (mA) $= V_R/R$		$\measuredangle I$ with V_s $(= \measuredangle V_R$ with $V_s)$		$\|Z\| = \|V_S\|/\|I\|$ (peak/peak) (kΩ)		$\measuredangle Z = \measuredangle V_S - \measuredangle I$ (degrees)	
	Theory	Meas.	Theory	Meas.	Theory	Meas.	Theory	Meas.
6000	1.654	1.573	70.2°	63.5°	2.418	2.562	−70.2	−63.5°
9000	2.748	2.573	55.7°	49°	1.456	1.589	−55.7°	−49°
14400	4.739	3.902	13.7°	15.7°	0.844	1.025	−13.7°	−15.7°
16800	4.837	4.146	−7.5°	−6.4°	0.827	0.965	7.5°	6.4°
30000	2.527	2.805	−58.8°	−50.6°	1.583	1.426	58.8°	50.6°
48000	1.426	1.756	−73°	−68.5°	2.805	3.329	73°	68.5
$f_r =$ 15915	4.878	4.085	0	3°	0.82	0.979	0	−3°
$f_1 =$ 10676	3.256	3.221	48.2°	45°	1.228	1.444	−48.2°	−45°
$f_2 =$ 23727	2.622	3.003	−58.7°	−50°	1.526	1.444	58.7°	50°

20. Using the measured values in Table 3, plot (by hand) the following figures using the graph paper attached at the end of the report: (1) $|Z|$ versus source frequency; (2) $\measuredangle Z$ versus source frequency; (3) I versus source frequency.

21. For the above plots, state your conclusions under the plot? Also identify the resonant frequency and bandwidth in each plot.

PROCEDURE B –PARALLEL RESONANCE

4. What is the equation for the resonant frequency of a parallel RLC circuit?

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

5. Use that above equation to find the resonant frequency in this experiment.

159155 Hz

6. What is the equation for the quality factor Q, and bandwidth B of a parallel RLC circuit?

$Q = \omega_r RC$ $\quad B = \frac{1}{2\pi RC}$

7. Use the proper equations to find the frequencies f_1 and f_2, at which the current amplitude is approximately 1.414 = 1/0.707 times the resonant current (i.e., the bandwidth limits).

$$f_1 = \left(-\frac{1}{2RC} + \sqrt{\left(\frac{1}{2RC}\right)^2 + \frac{1}{LC}}\right) / (2\pi)$$

$$f_2 = \left(\frac{1}{2RC} + \sqrt{\left(\frac{1}{2RC}\right)^2 + \frac{1}{LC}}\right) / (2\pi)$$

Table 4

AC Source Frequency (Hz)	V_S (peak) (V)		V_S period T (μs)		$V_{R'}$ (peak) (V)		$\angle V_{R'}$ with V_s (degrees)	
	Theory	Meas.	Theory	Meas.	Theory	Meas.	Theory	Meas.
6000	4	4.05	166.67	166.67	0.102	0.115	−60.5°	−63.8
9000	4	4.04	111.11	111.9	0.068	0.07	-43.9°	-42.7
14400	4	4.04	69.4	69.93	0.049	0.052	-9.2°	-12.2°
16800	4	4.03	59.52	59.4	0.048	0.062	5°	15°
30000	4	4.03	33.33	33.48	0.072	0.078	47.2°	42.4°
48000	4	4	20.83	20.81	0.116	0.124	64°	63°
f_r = 15915	4	4.03	62.83	64.3	0.048	0.062	0°	2°
f_1 = 8936.3	4	4	111.9	111.82	0.067	0.07	-40.2°	-38°
f_2 = 28345.4	4	4.03	35.28	35.33	0.07	0.075	47.1°	42.8°

12. What is the relationship between the capacitor current I_C and inductor current I_L at resonant frequency?

They are equal

13. Consider the capacitor current phase $\angle I_C$. Which one is higher $\angle I_C$ at resonant frequency or $\angle I_C$ above resonant frequency? Note: In phase, consider the positive or negative signs.

$\angle I_C$ at resonant frequency is higher: ($\angle I_C$ & $\angle I_S$)

14. Consider the inductor current amplitude $|I_L|$. Which one is higher $|I_L|$ at resonant frequency or $|I_L|$ above resonant frequency?

$|I_L|$ at resonant frequency is higher

$f\uparrow, |X_L|\uparrow, V_{constant}, |I_L|\downarrow$

Table 5

AC Source Frequency (Hz)	I (peak) (mA) $= V_{R'}/R'$		$\angle I$ with V_s $(= \angle V_{R'}$ with $V_s)$		$\lvert Y\rvert = \lvert I\rvert/\lvert V_S\rvert$ (peak/peak) (mS)		$\angle Y = \angle I - \angle V_S$ (degrees)	
	Theory	Meas.	Theory	Meas.	Theory	Meas.	Theory	Meas.
6000	10.2	11.5	−60.5°	−63.8°	2.55	2.88	−60.5°	−63.8°
9000	6.8	7	−43.9°	−42.7°	1.7	1.75	−43.9°	−42.7°
14400	4.9	5.2	−9.2°	−12.2°	1.23	1.3	−9.2°	−12.2°
16800	4.8	5	5°	15°	1.2	1.27	5°	15°
30000	7.2	7.8	47.2°	42.4°	1.8	1.95	47.2°	42.4°
48000	11.6	12.4	64°	63°	2.9	3.1	64°	63°
f_r = 15915	4.8	4.7	0°	2°	1.2	1.25	0°	2°
f_1 = 8936.3	6.7	7	−45.2°	−48°	1.67	1.75	−45.2°	−48°
f_2 = 28345.4	7	7.5	47.1°	42.8°	1.75	1.88	47.1°	42.8°

16. Using the *measured* values in Table 5, plot (by hand) the following figures using the graph paper attached at the end of the report: (1) $|Y|$ versus source frequency; (2) $\angle Y$ versus source frequency; (3) I versus source frequency.

17. For the above plots, state your conclusions under the plot? Also identify the resonant frequency and bandwidth in each plot.

Table 6

AC Source Frequency (Hz)	$\lvert S\rvert$ (mVA)	$\angle S$ (degrees)	P (mW)	Q (mVAR)	PF value	PF lead or lag
	Measured	Measured	Measured	Measured	Measured	Measured
6000	23	−63.8°	10.155	−20.637	0.442	lead
9000	14	−42.7°	10.289	−9.494	0.735	lead
14400	10.4	−12.2°	10.165	−2.198	0.977	lead
16800	12.4	15°	11.977	3.209	0.966	lag
30000	15.6	42.4°	11.52	10.519	0.738	lag
48000	24.8	63°	11.259	22.097	0.454	lag
f_r = 15915	12.4	2°	12.392	0.433	0.999	lag
f_1 = 8936.3	14	−38°	11.326	−8.619	0.809	lead
f_2 = 28345.4	15	42.8°	11.006	10.192	0.734	lag

19. Using the values in Table 6, plot (by hand) the following figure using the graph paper attached at the end of the report: P and Q on the same plot versus source frequency.

20. For the above plot, state your conclusions under the plot?

21. At what frequency the real power P is minimum? Why?

At 6000 Hz due to small power factor.

22. At what frequency the magnitude of the reactive power $|Q|$ is maximum? Why?

At 48000 Hz due to small power factor

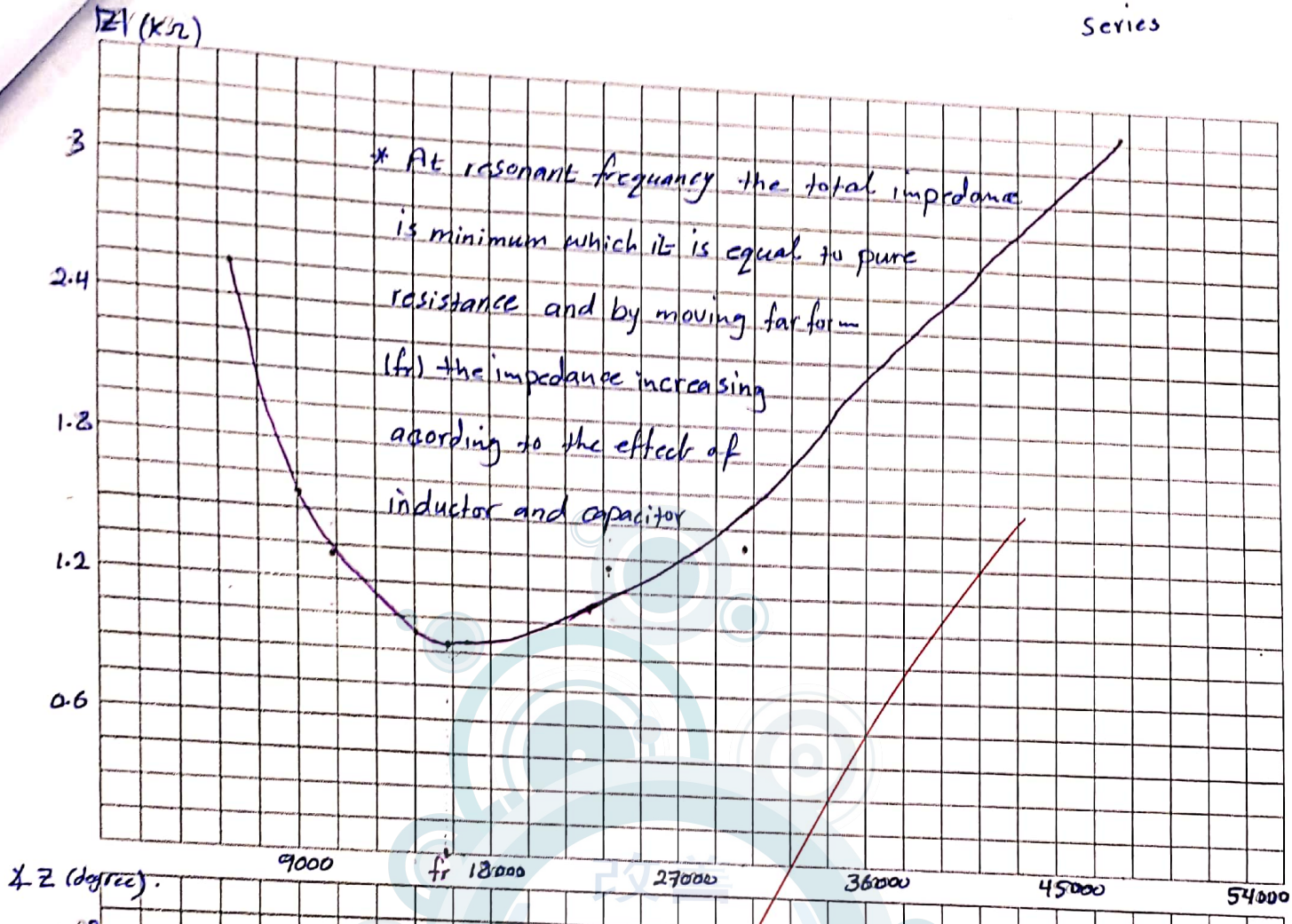
CONCLUSIONS

Summarize in clear but concise format what you learned from this experiment:

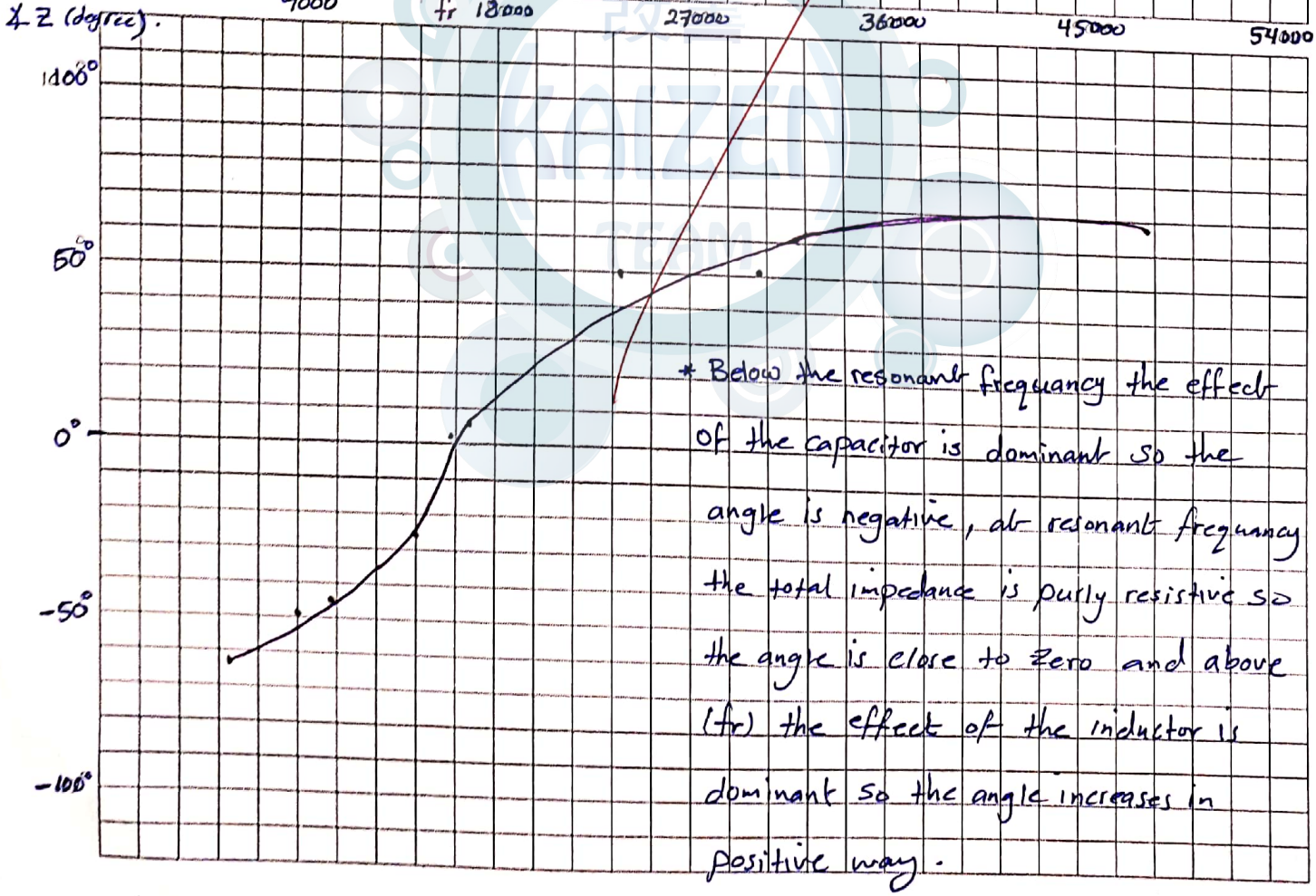
This experiment describe the resonant circuit in both configrations: seriers and Parallel, how to ~~connect~~ choose resonant frequancy according to the values of resistors, capacitor, Inductor and then the relation between changing the frequancy and its effect on different values in the circuit such that: voltage, current, total impedance, total admitance, phase shift, real power and reactive power in Parallel and series configrations

** End **

Series

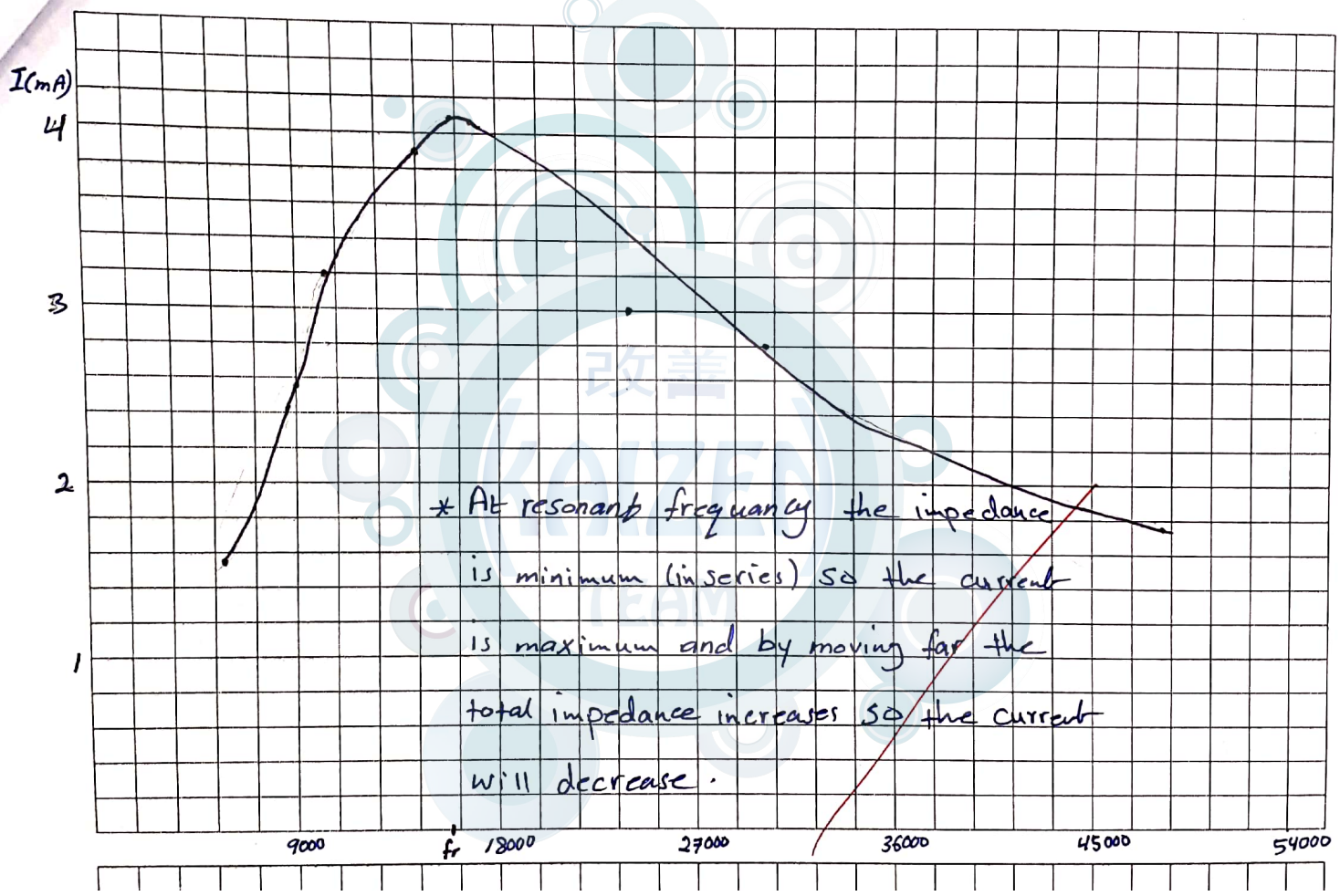


* At resonant frequancy the total impedance is minimum which it is equal to pure resistance and by moving far form (fr) the impedance increasing according to the effect of inductor and capacitor



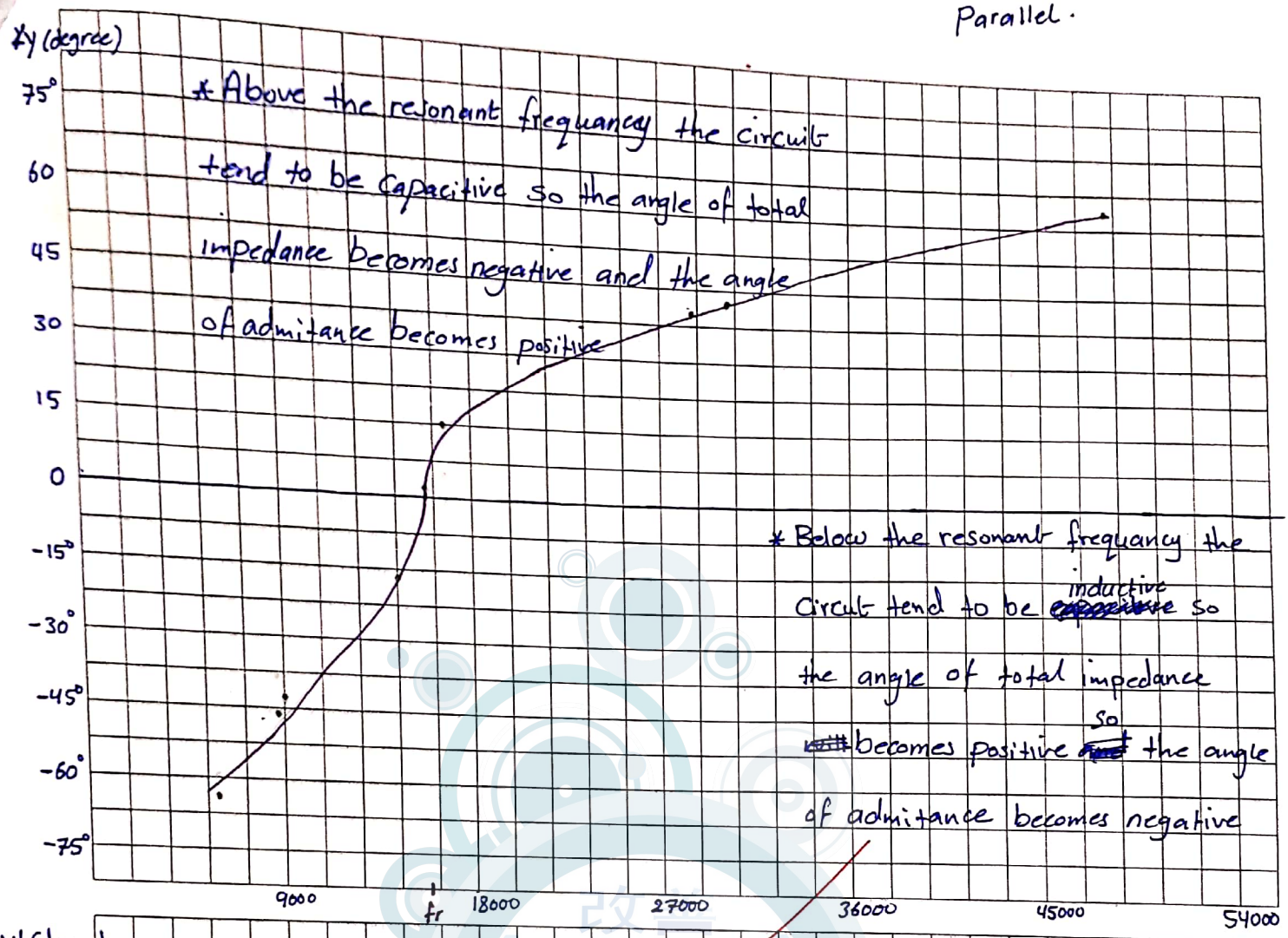
* Below the resonant frequancy the effect of the capacitor is dominant so the angle is negative, at resonant frequancy the total impedance is purly resistive so the angle is close to Zero and above (fr) the effect of the inductor is dominant so the angle increases in positive way.

Series



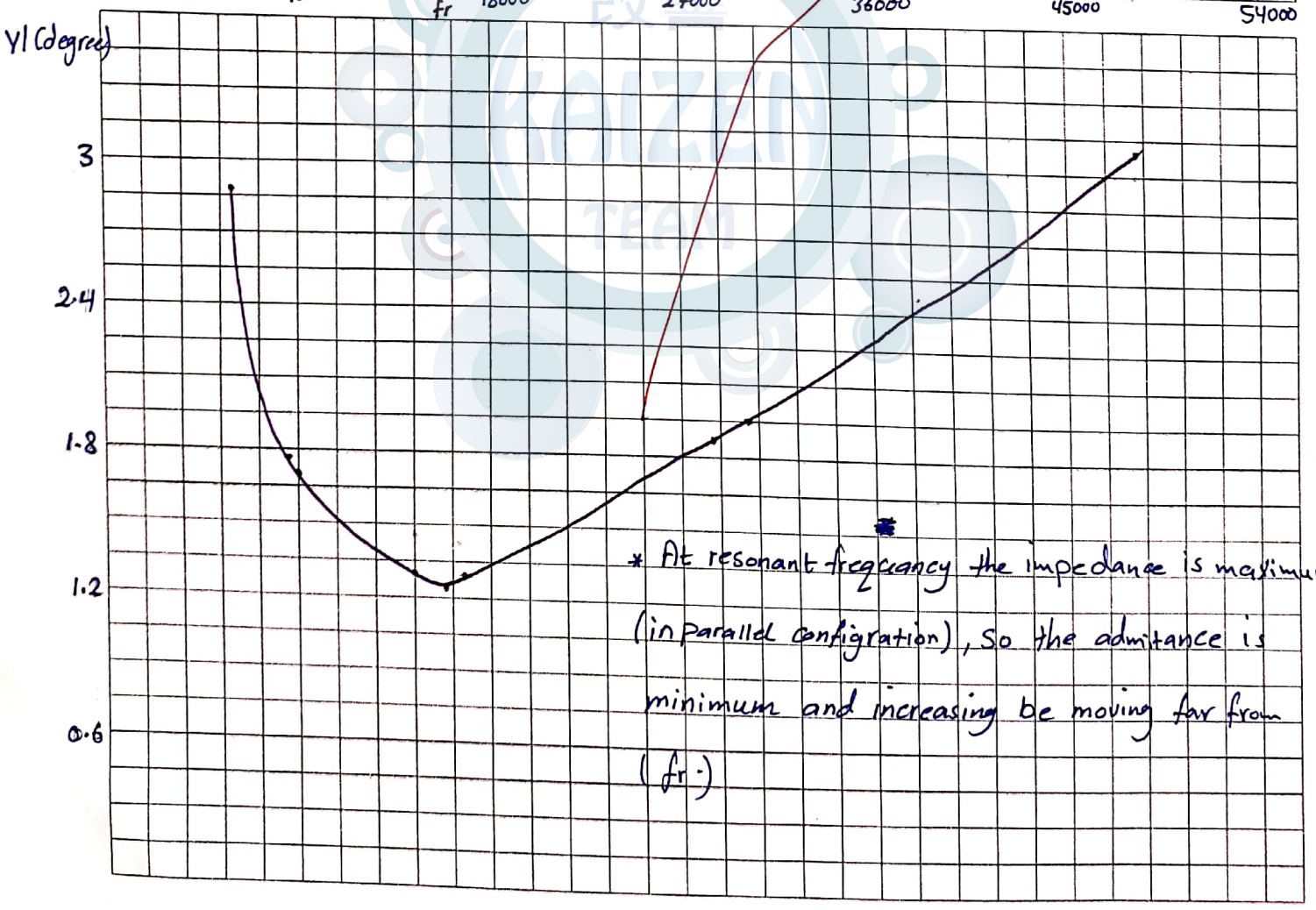
* At resonant frequancy the impedance is minimum (in series) so the current is maximum and by moving far the total impedance increases so the current will decrease.

Parallel.



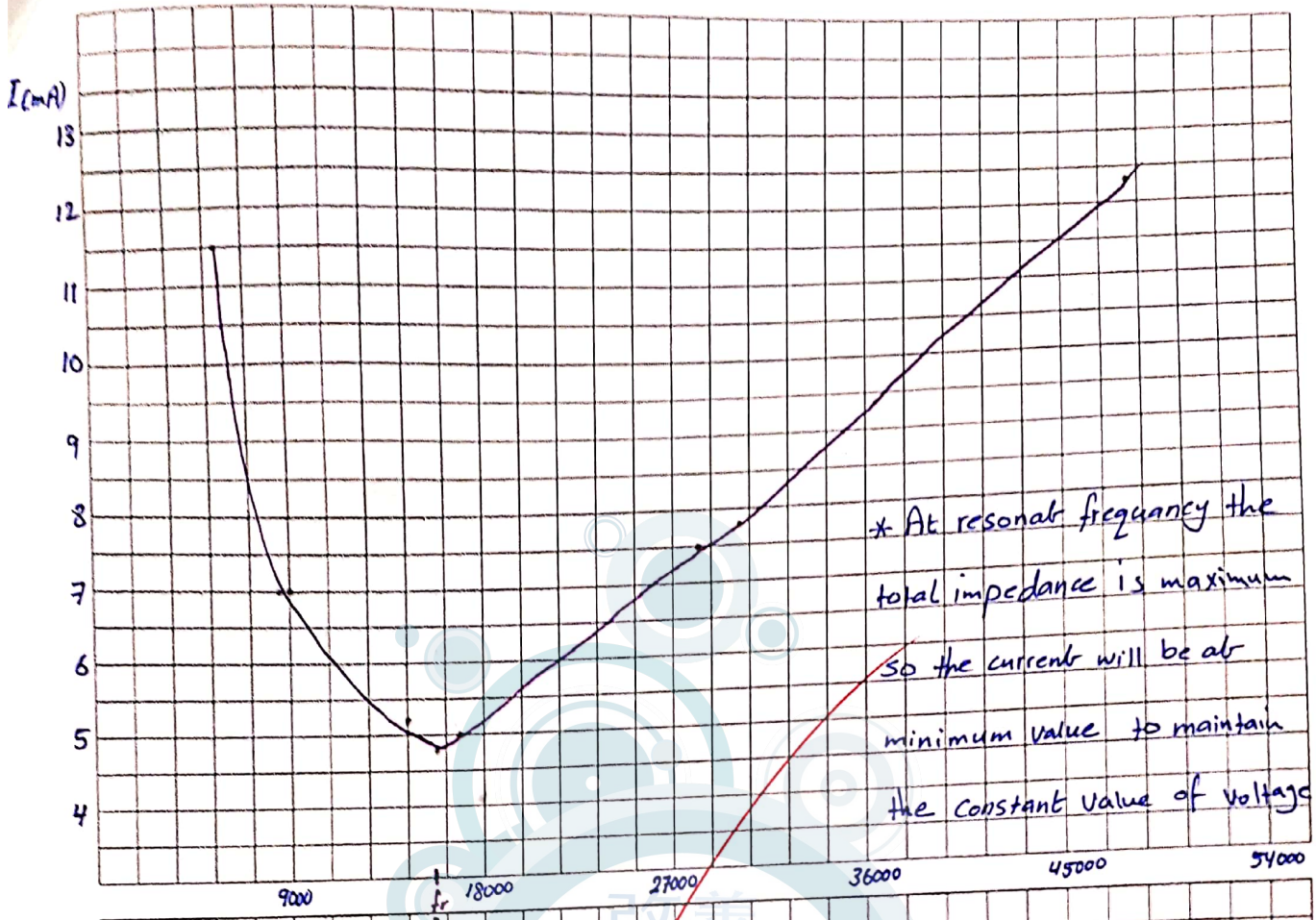
* Above the resonant frequancy the circuit tend to be capacitive so the angle of total impedance becomes negative and the angle of admitance becomes positive

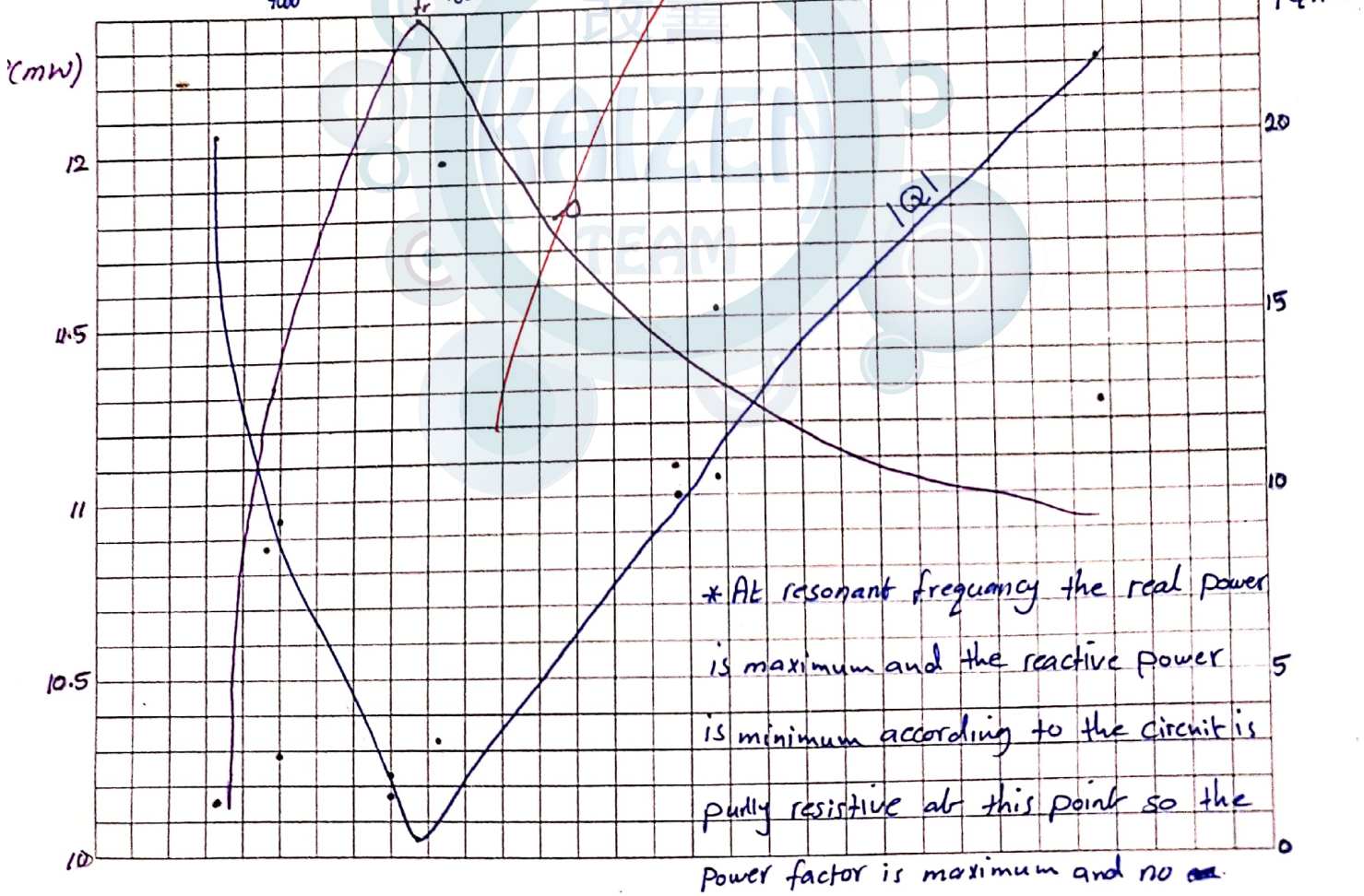
* Below the resonant frequancy the circuit tend to be ~~capacitive~~ inductive so the angle of total impedance ~~and~~ so becomes positive ~~and~~ the angle of admitance becomes negative



* At resonant frequancy the impedance is maximum (in parallel configration), so the admitance is minimum and increasing be moving far from (fr.)

Parallel





2-12