University of Jordan
School of Engineering
Electrical Engineering Department

10/10

EE 204
Electrical Engineering Lab

EXPERIMENT 5 REPORT & PRE-LAB
CAPACITIVE REACTANCE

Section # _____ Group # _____

Student Name	ID
1. Lamees Mahmoud Salahat	0154007
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EXPERIMENT 5
CAPACITIVE REACTANCE

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

PROCEDURE A – AC-EXCITED SERIES RC CIRCUIT

Table 1

AC Source Frequency (Hz)	V_S (peak) (V)		V_S period T (ms)		V_C (peak) (V)		$\measuredangle V_C$ with V_s (Lag = negative)	
	Theory	Meas.	Theory	Meas.	Theory	Meas.	Theory	Meas.
50	5	5.1	20	20.8	4.999	4.95	−0.94°	0
100	5	5	10	9.3	4.997	4.95	−1.89°	0
200	5	5.1	5	4.6	4.988	4.95	−3.78°	0
300	5	5.1	3.33	3.2	4.98	4.92	−5.65°	−4.5°
500	5	5.2	2	2	4.93	4.9	−9.37°	−9°
700	5	5.3	1.48	1.5	4.876	4.8	−13°	−12°
1100	5	5	0.909	0.92	4.7	4.7	−19.95°	−18°
2000	5	5.2	0.5	0.47	4.176	4.2	−33.42°	−30°

Table 2

AC Source Frequency (Hz)	V_R (peak) (V)		$\measuredangle V_R$ with V_s (Lead = positive)		V_R period T (ms)		I and $\measuredangle I$ (mA) $= V_R/R$	
	Theory	Meas.	Theory	Meas.	Theory	Meas.	Theory	Meas.
50	0.082	0.05	89.05°	90°	20	18.9	0.025	0.015
100	0.165	0.2	88.12°	90°	10	9.6	0.05	0.061
200	0.329	0.3	86.22°	85°	5	4.8	0.1	0.091
300	0.493	0.5	84.35°	85°	3.33	3.25	0.149	0.151
500	0.814	0.8	80.63°	81°	2	1.97	0.247	0.242
700	1.125	1.2	76.99°	76.5°	1.429	1.4	0.341	0.364
1100	1.706	1.5	70.05°	72°	0.909	0.89	0.517	0.455
2000	2.75	2.75	56.58°	55°	0.5	0.495	0.833	0.833

6. Can we just subtract the magnitudes of $|V_S| - |V_C|$ to obtain the magnitude $|V_R|$? Why or why not?

No, because they are vectors (we should take the angle in consider)

7. What is the relationship between the periods T of the two signals V_S and V_R?

The signals are equal in length but shifted in phase by θ°
because they are rotating with same angular speed

Table 3

AC Source Frequency (Hz)	$X_C = \|V_C\|/\|I\|$ (peak/peak) (kΩ)		$\|Z\| = \|V_S\|/\|I\|$ (peak/peak) (kΩ)		$\angle Z = \angle V_S - \angle I$ (degrees)	
	Theory	Meas.	Theory	Meas.	Theory	Meas.
50	199.96	330	200	340	−89.05°	−90°
100	99.94	81.15	100	81.96	−88.12°	−90°
200	49.88	54.39	50	56.04	−86.22°	−85°
300	33.42	32.58	33.56	33.77	−84.35°	−85°
500	19.96	20.25	20.24	21.49	−80.63°	−81°
700	14.28	13.19	14.66	14.56	−76.99°	−76.5°
1100	9.09	10.33	9.67	10.99	−70.05°	−72°
2000	5	5.04	6	6.24	−56.58°	−55°

10. 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) X_C and $|Z|$ on the same plot versus source frequency; (2) $\angle Z$ versus source frequency; (3) V_C and V_R on the same plot versus source frequency.

11. For the above plots, state your conclusions under the plot?

Table 4

AC Source Frequency (Hz)	$\|S\|$ (mVA)	$\angle S$ (degrees)	P (mW)	Q (mVAR)	PF value	PF lead or lag
	Measured	Measured	Measured	Measured	Measured	Measured
50	0.0383	−90°	0	−0.0383	0	lead
100	0.1525	−90°	0	−0.1525	0	lead
200	0.232	−85°	0.0202	−0.2311	0.087	lead
300	0.385	−85°	0.0336	−0.3835	0.087	lead
500	0.6292	−81°	0.0984	−0.6214	0.156	lead
700	0.965	−76.5°	0.2253	−0.9383	0.233	lead
1100	1.1375	−72°	0.3515	−1.0818	0.309	lead
2000	2.166	−55°	1.2424	−1.7743	0.574	lead

13. Using the values in Table 4, 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.

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

15. At what frequency the real power P is maximum? Why?

At 2000 Hz because the ckt is in series configration and changing the frequancy will affect all the voltages & currents value (the total impedance will decrease so current will increase so P ↑).

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

At 2000 Hz (f↑, Z↓, I_c↑, Q↑)

PROCEDURE B – AC-EXCITED PARALLEL RC CIRCUIT

Table 5

AC Source Frequency (Hz)	$V_{R'}$ (peak) (V)		$\measuredangle V_{R'}$ with V_s (Lead = positive)		$V_R = V_C \approx V_S$ (peak) (V)		$\measuredangle V_R$ with V_s (degrees)	
	Theory	Meas.	Theory	Meas.	Theory	Meas.	Theory	Meas.
160	0.05	0.05	0.917°	1°	5	5	0°	0°
320	0.05	0.05	1.833°	2°	5	5	0°	0°
800	0.05	0.05	4.574°	4.5°	5	5	0°	0°
1100	0.05	0.05	6.277°	4.5°	5	4.95	0°	0°
1600	0.051	0.05	9.09°	9°	5	4.95	0°	0°
2200	0.051	0.05	12.407°	13.5°	5	4.95	0°	0°
3500	0.053	0.05	19.29°	18°	5	4.90	0°	0°
6500	0.0596	0.06	33.02°	31.5°	5	4.95	0°	0°

Table 6

AC Source Frequency (Hz)	I (peak) (mA) $= V_{R'}/R'$		$\measuredangle I$ with V_s (Lead = positive)		I_R (peak) (mA) $= V_R/R$		$\measuredangle I_R$ with V_s (degrees)	
	Theory	Meas.	Theory	Meas.	Theory	Meas.	Theory	Meas.
160	5	5	0.917°	1°	5	5	0°	0°
320	5	5	1.833°	2°	5	5	0°	0°
800	5	5	4.574°	4.5°	5	5	0°	0°
1100	5	5	6.277°	4.5°	5	4.95	0°	0°
1600	5.1	5	9.09°	9°	5	4.95	0°	0°
2200	5.1	5	12.407°	13.5°	5	4.95	0°	0°
3500	5.3	5	19.29°	18°	5	4.90	0°	0°
6500	5.96	6	33.02°	31.5°	5	4.95	0°	0°

Table 7

AC Source Frequency (Hz)	$I_C = I - I_R$ (mA) (magnitude (peak) and phase (degrees)) (phasor subtraction)	
	Theory	Measured
160	$0.08 \angle 90.5°$	$0.09 \angle 90.5°$
320	$0.16 \angle 90.9°$	$0.17 \angle 91°$
800	$0.4 \angle 92°$	$0.39 \angle 92°$
1100	$0.55 \angle 93°$	$0.39 \angle 85°$
1600	$0.81 \angle 87.4°$	$0.78 \angle 90.8°$
2200	$1.1 \angle 91°$	$1.17 \angle 94°$
3500	$1.75 \angle 89.9°$	$1.55 \angle 95°$
6500	$3.248 \angle 90°$	$3.14 \angle 87°$

Table 8

AC Source Frequency (Hz)	$B_C = \|I_C\|/\|V_C\|$ (peak/peak) (mS)		$\|Y\| = \|I\|/\|V_S\|$ (peak/peak) (mS)		$\measuredangle Y = \measuredangle I - \measuredangle V_S$ (degrees)	
	Theory	Meas.	Theory	Meas.	Theory	Meas.
160	0.016	0.018	1	1	0.917°	1°
320	0.032	0.034	1	1	1.833°	2°
800	0.08	0.078	1	1	4.574°	4.5°
1100	0.11	0.079	1	1.01	6.277°	4.5°
1600	0.162	0.158	1.02	1.01	9.09°	9°
2200	0.22	0.236	1.02	1.01	12.407°	13.5°
3500	0.35	0.316	1.06	1.02	19.29°	18°
6500	0.649	0.634	1.192	1.21	33.02°	31.5°

9. Using the *measured* values in Table 8, plot (by hand) the following figures using the graph paper attached at the end of the report: (1) B_C and $|Y|$ on the same plot versus source frequency; (2) $\measuredangle Y$ versus source frequency; (3) I_C and I_R on the same plot versus source frequency.

10. For the above plots, state your conclusions under the plot?

Table 9

AC Source Frequency (Hz)	$\|S\|$ (mVA)	$\measuredangle S$ (degrees)	P (mW)	Q (mVAR)	PF value	PF lead or lag
	Measured	Measured	Measured	Measured	Measured	Measured
160	12.5	−1°	12.5	−0.218	1	lead
320	12.5	−2°	12.49	−0.436	1	lead
800	12.5	−4.5°	12.46	−0.981	0.997	lead
1100	12.38	−4.5°	12.34	−0.971	0.997	lead
1600	12.38	−9°	12.23	−1.94	0.988	lead
2200	12.38	−13.5°	12.04	−2.89	0.973	lead
3500	12.25	−18°	11.65	−3.89	0.951	lead
6500	14.85	−31.5°	12.66	−7.76	0.853	lead

12. Using the values in Table 9, 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.

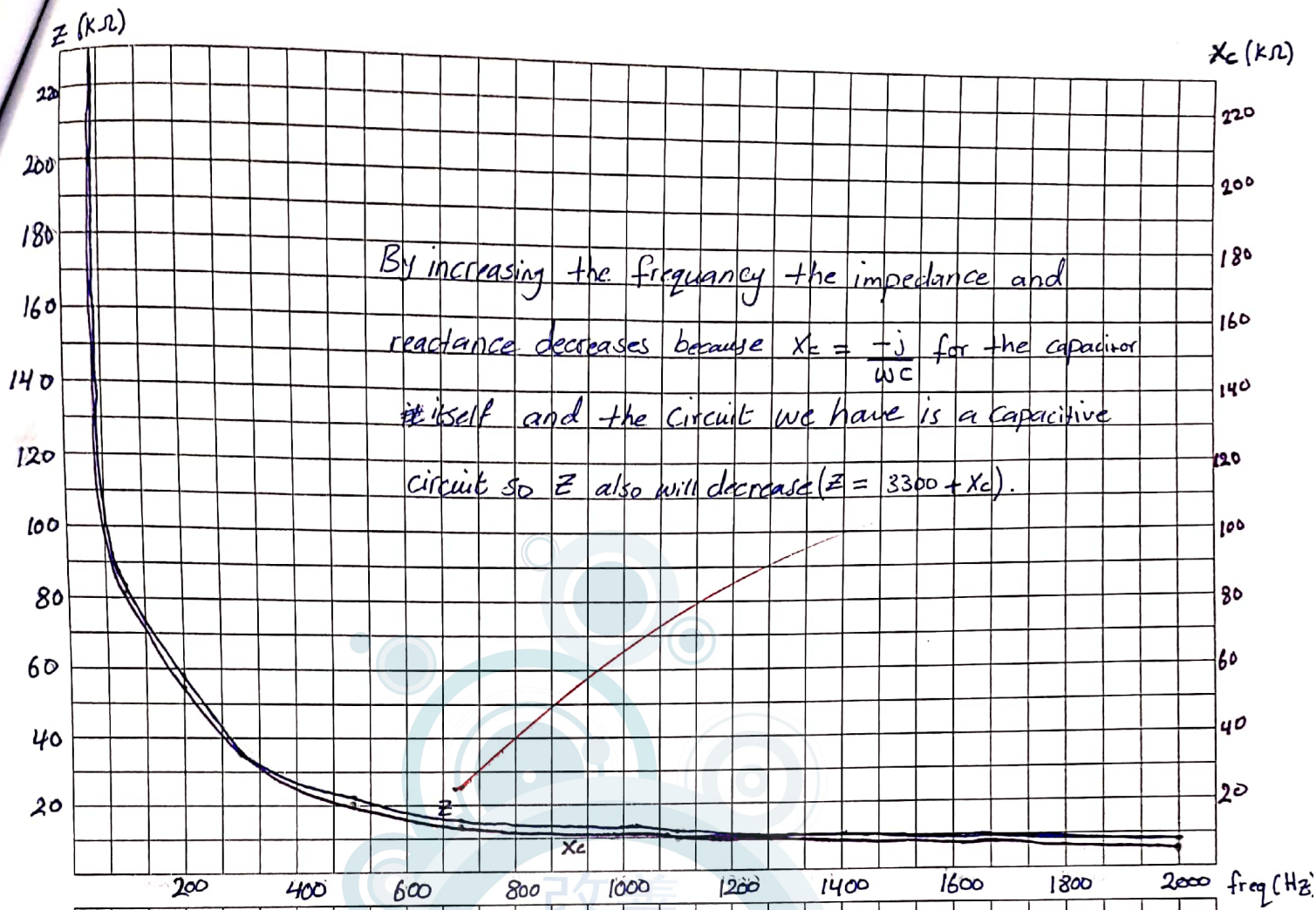
13. For the above plot, state your conclusions under the plot?

14. At what frequency the real power P is maximum? Why?

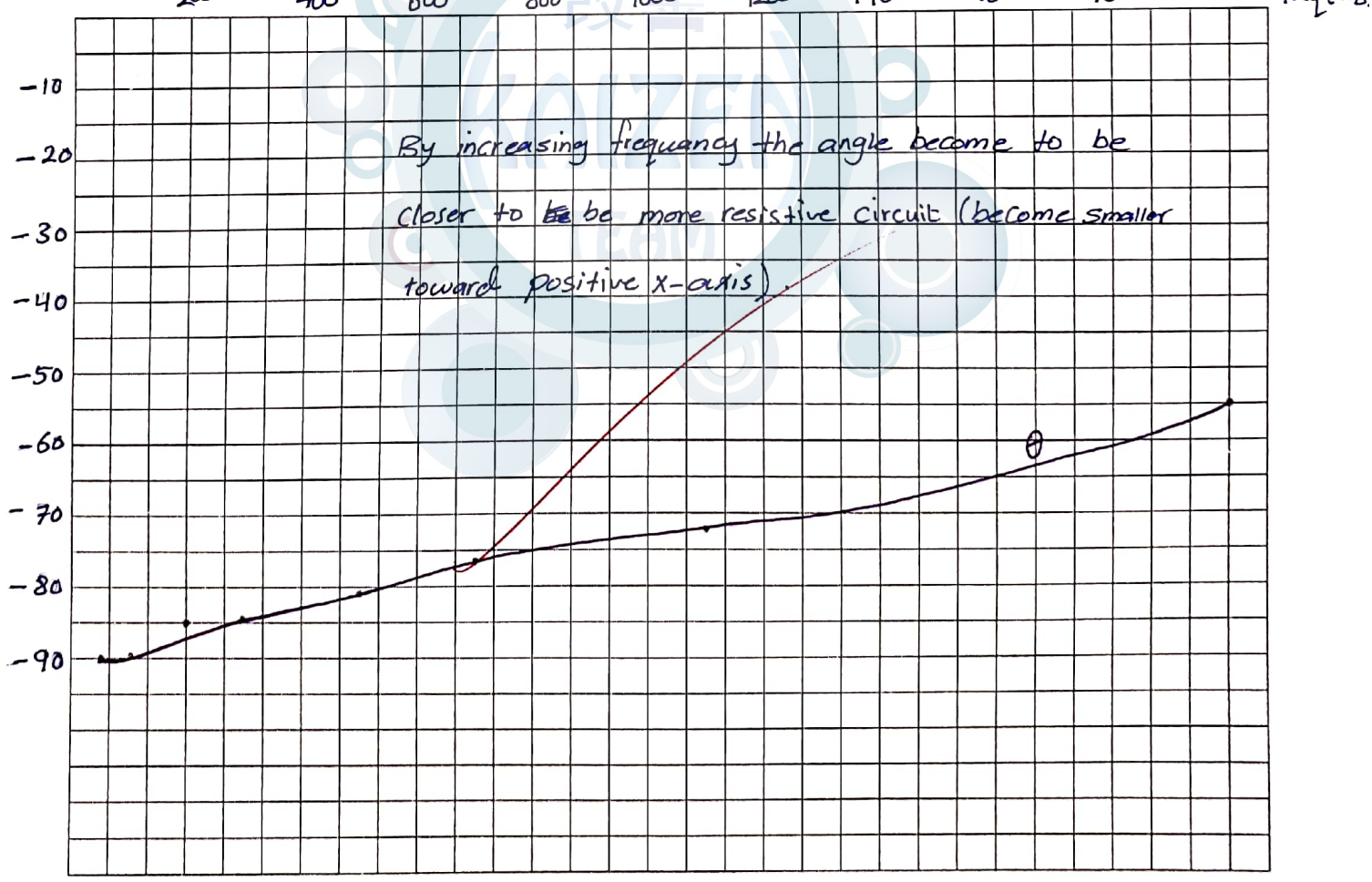
...The real power is constant because the change in freqeuncy will not affect on the resistance (~~cancel~~ connected on parallel with the source and don't have W)

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

...At 6500 because by increasing the frequency (F↑, X_C↓, V const., I↑, Q↑). and the angle increases so sin(θ) will increase too.

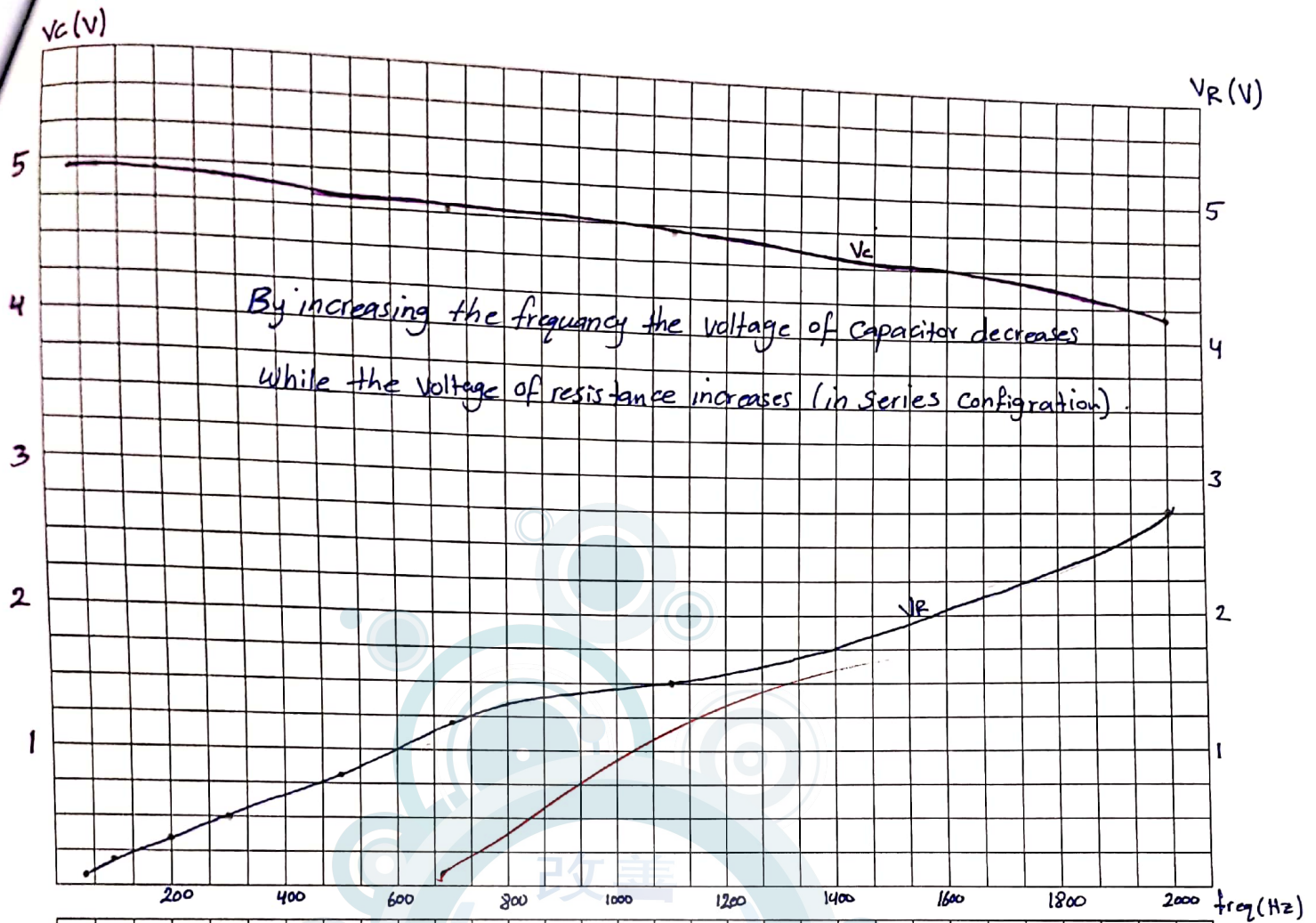


By increasing the frequancy the impedance and reactance decreases because $X_c = \frac{-j}{\omega C}$ for the capacitor itself and the circuit we have is a capacitive circuit so Z also will decrease ($Z = 3300 + X_c$).

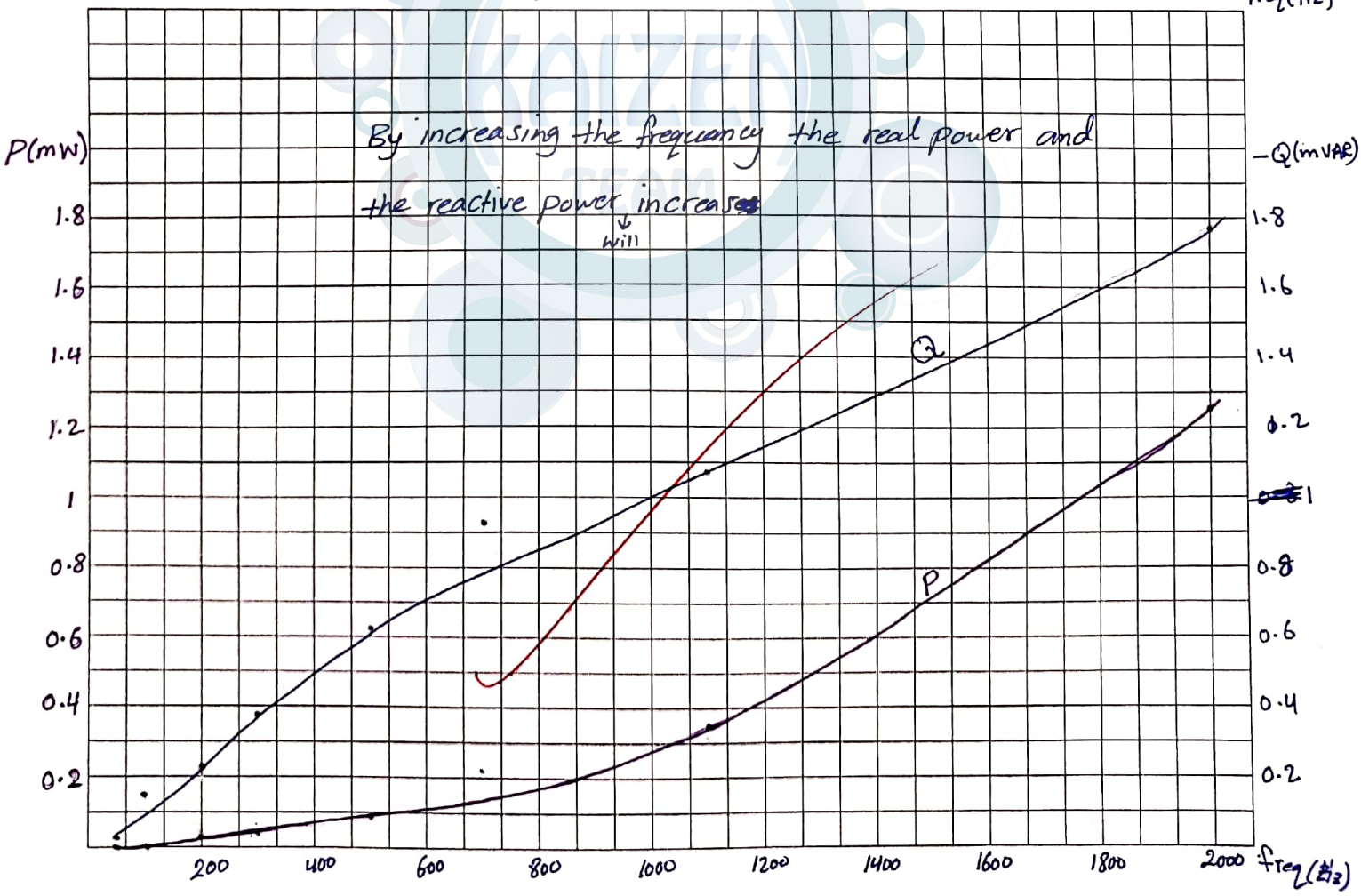


By increasing frequancy the angle become to be closer to be more resistive circuit (become smaller toward positive x-axis)

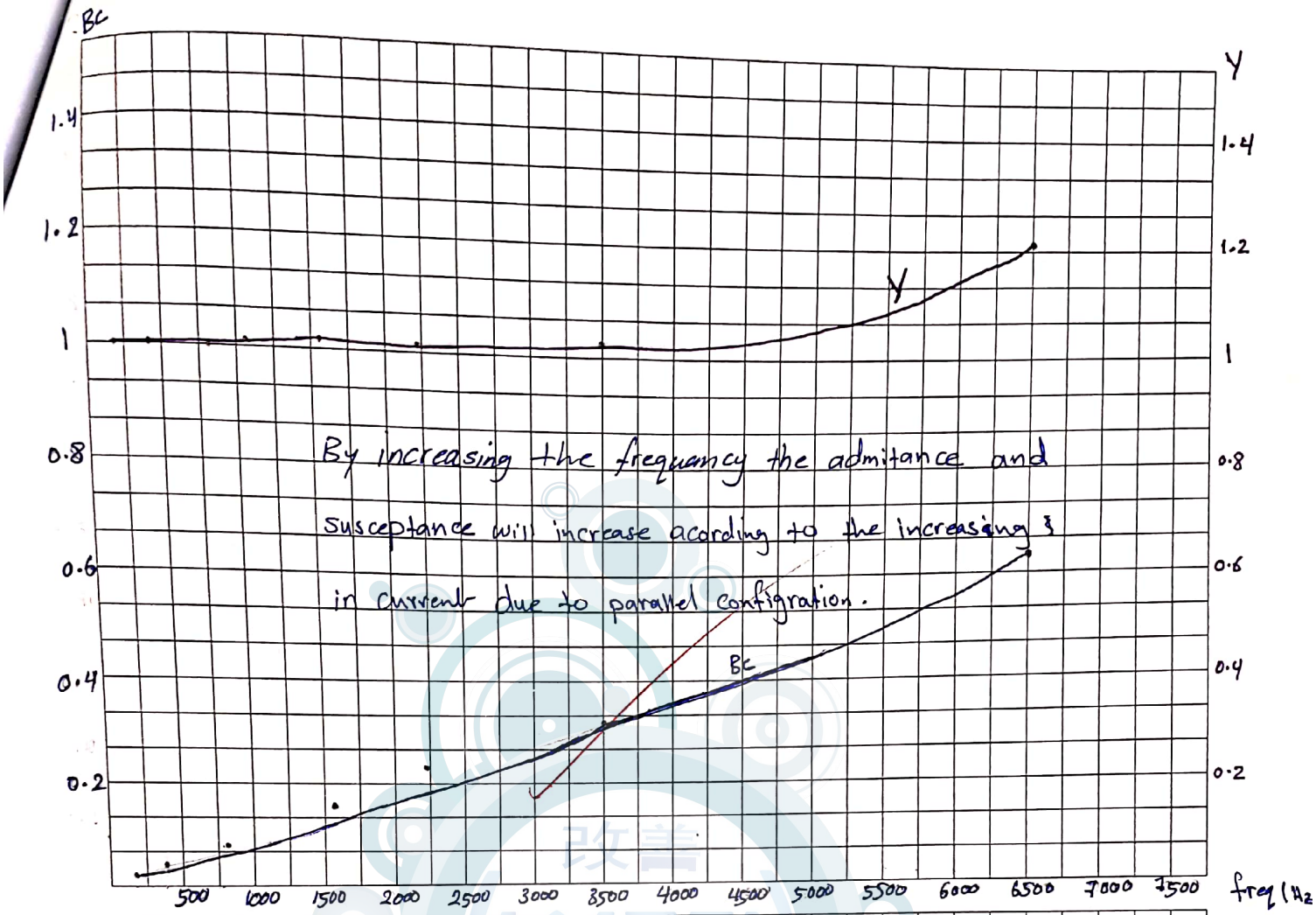
∠Z (degree).



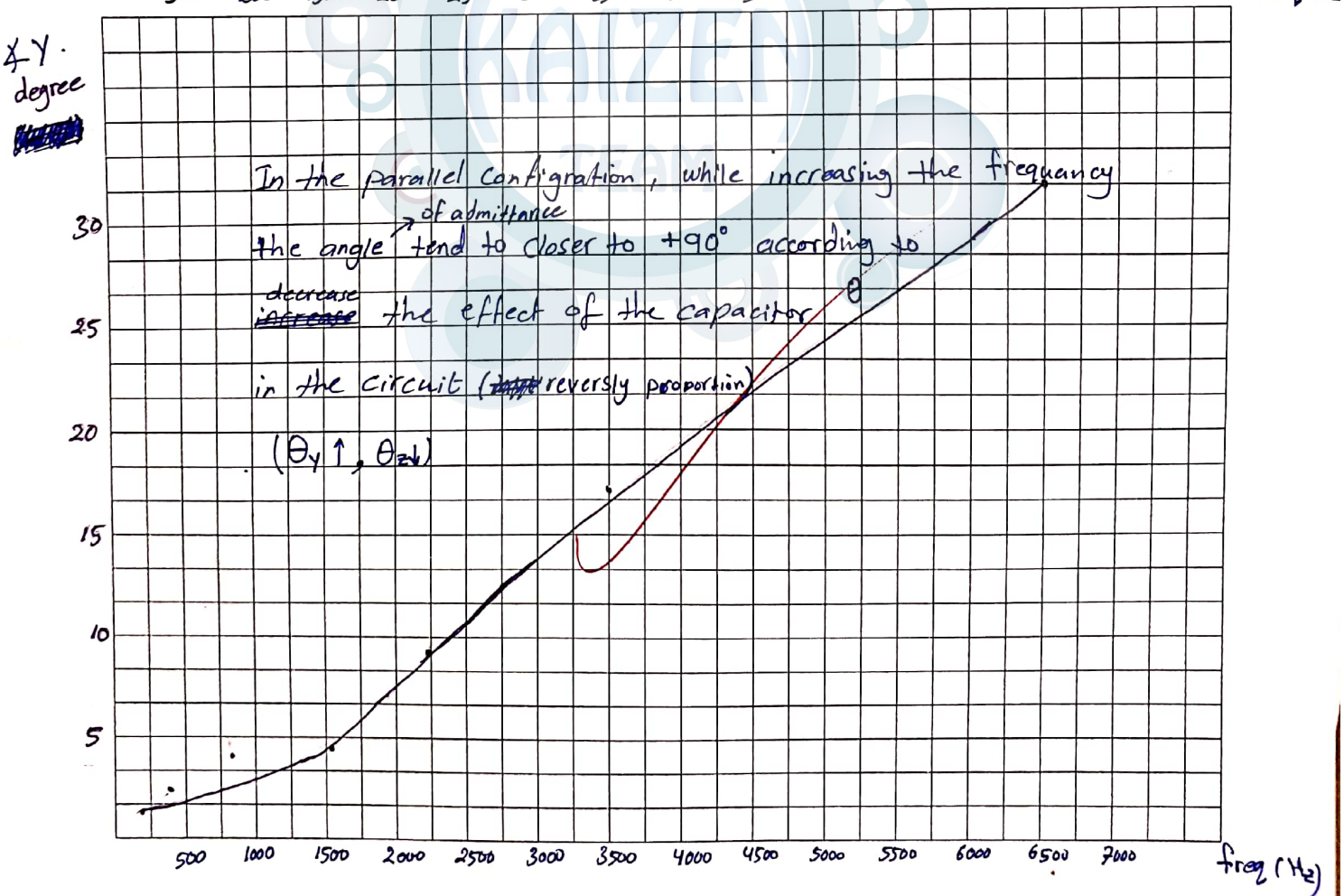
By increasing the frequency the voltage of capacitor decreases while the voltage of resistance increases (in series configration).



By increasing the frequency the real power and the reactive power will increase.

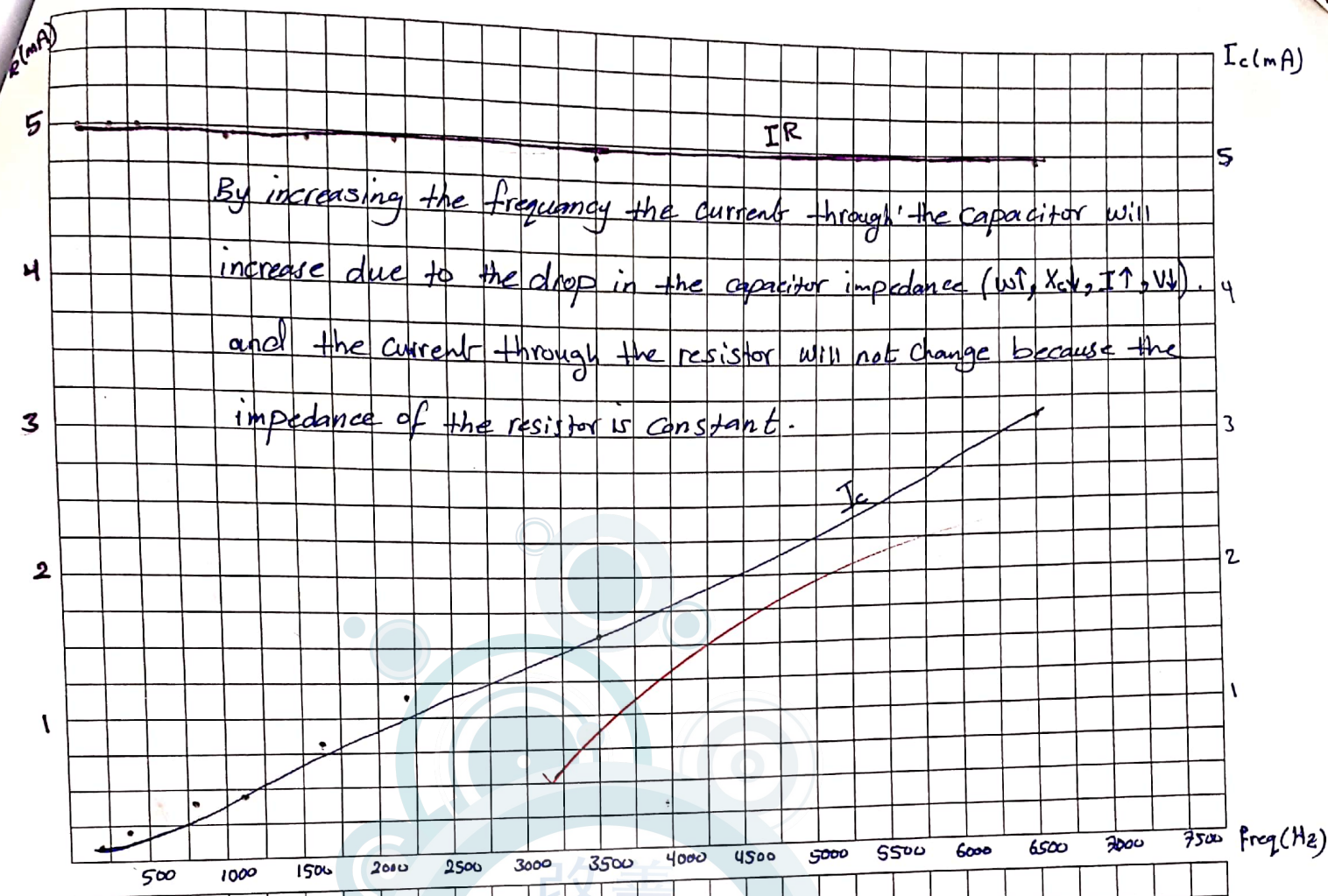


By increasing the frequancy the admitance and susceptance will increase acording to the increasing I in current due to parallel configration.

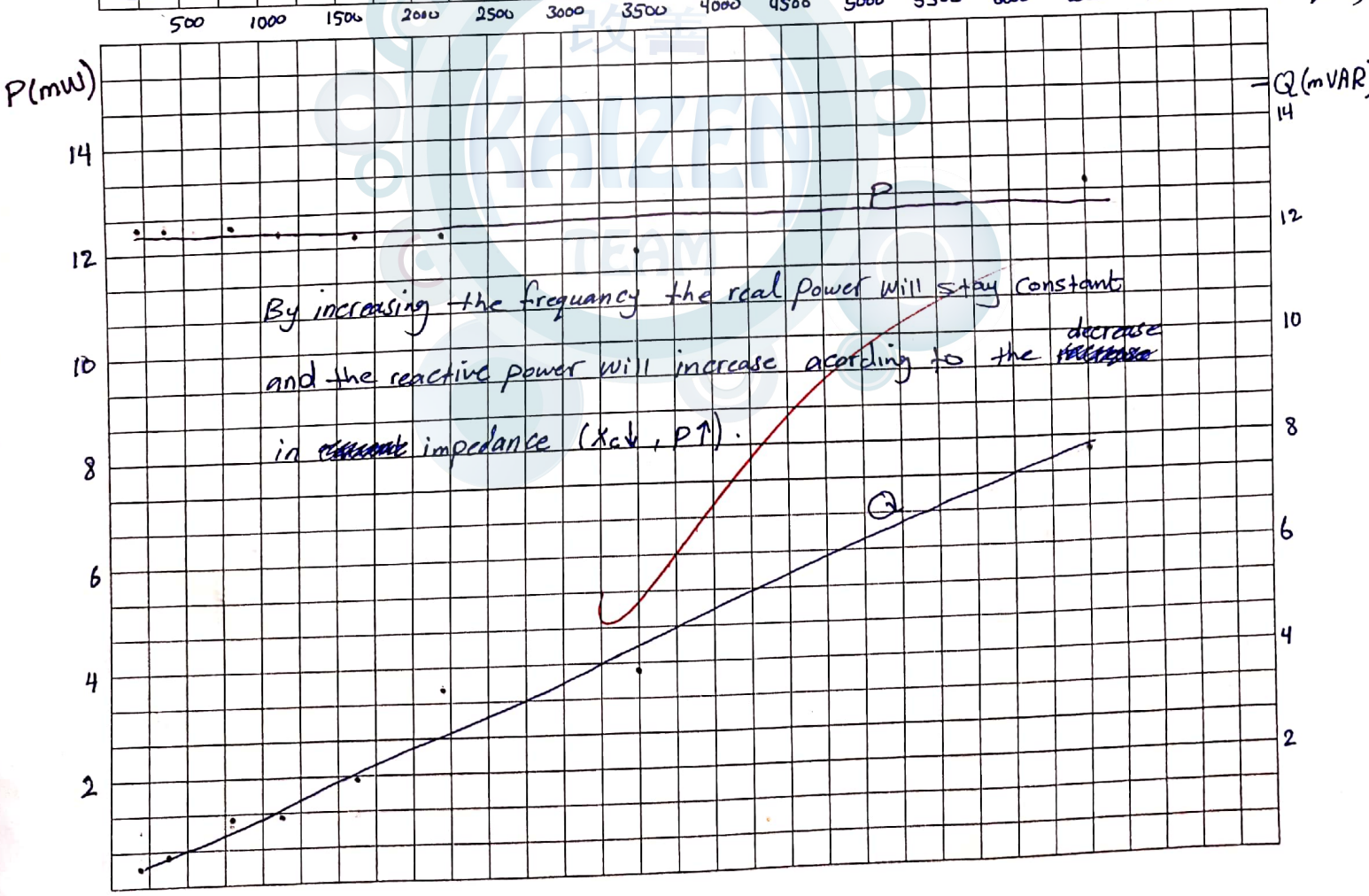


In the parallel configration, while increasing the frequancy the angle of admittance tend to closer to +90° according to ~~increase~~ decrease the effect of the capacitor in the circuit (reversly proportion)

$(\theta_Y \uparrow, \theta_{Z\downarrow})$



By increasing the frequancy the current through the capacitor will increase due to the drop in the capacitor impedance ($w\uparrow, X_c\downarrow, I\uparrow, V\downarrow$). and the current through the resistor will not change because the impedance of the resistor is constant.



By increasing the frequancy the real power will stay constant and the reactive power will increase acording to the ~~increase~~ decrease in ~~current~~ impedance ($X_c\downarrow, P\uparrow$).