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EXPERIMENT 1 (A)

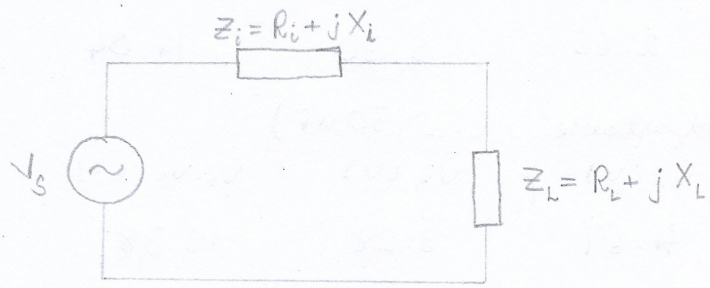
MAXIMUM POWER TRANSFER THEOREM

⇒ AIM

Verification of maximum power transfer theorem.

⇒ THEORY

Consider the following circuit



The power dissipated in load is given by $P = |I|^2 R_L = \dfrac{V_s^2 R_L}{(R_i+R_L)^2 + (X_i+X_L)^2}$ — ①

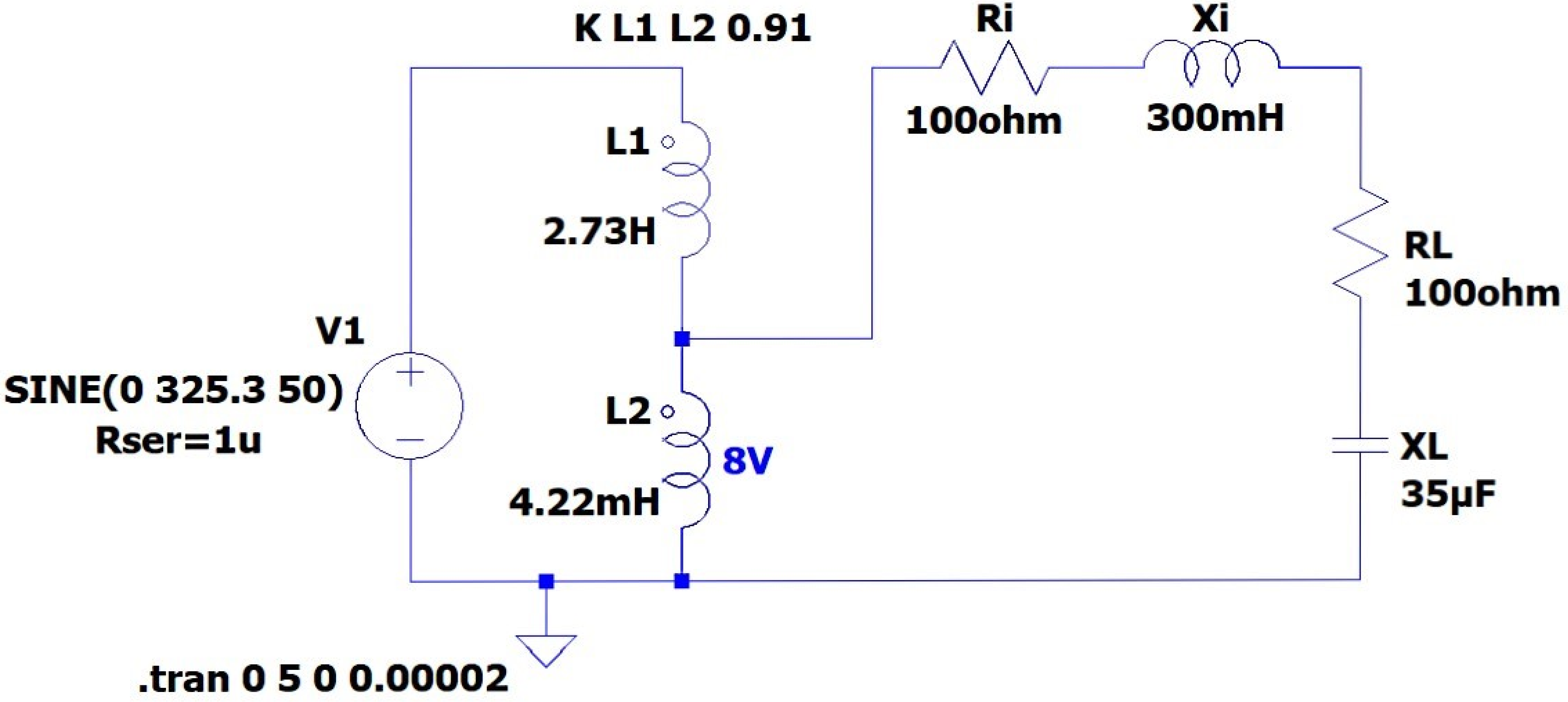
When only X_L is adjustable P can be maximised by selecting $X_L = -X_i$.

When only R_L is adjustable, differentiating eq^n ① w.r.t. R_L and equating to 0 gives $R_L = \sqrt{R_i^2 + (X_i+X_L)^2}$.

When both X_L and R_L are adjustable combining the results of the above two parts gives us

$$X_L = -X_i$$

$$\text{and } R_L = \sqrt{R_i^2 + (X_i+X_L)^2} = \sqrt{R_i^2 + (X_i - X_i)^2} = R_i$$


K L1 L2 0.91
Ri
Xi
100ohm
300mH
L1
2.73H
RL
100ohm
V1
SINE(0 325.3 50)
Rser=1u
L2
8V
4.22mH
XL
35µF
.tran 0 5 0 0.00002

⇒ OBSERVATION TABLES

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When only X_L is adjustable ($R_L = 200\ \Omega$)

SL. NO.	C_L (μF)	V_1 (V)	V_3 (V)	$V_1 \cdot V_3$ (V^2)	Maximum $V_1 \cdot V_3$
1	15	2.48	4.96	12.30	
2	20	2.60	5.21	13.54	
3	25	2.65	5.30	14.04	
4	30	2.66	5.33	14.18	14.23
5	35	2.67	5.33	14.23	for $C_L = 35\ \mu$F
6	40	2.66	5.32	14.15	
7	45	2.66	5.31	14.12	
8	50	2.65	5.30	14.04	

When only R_L is adjustable ($C_L = 30\ \mu$F)

SL. NO.	R_L (Ω)	V_1 (V)	V_3 (V)	$V_1 \cdot V_3$ (V^2)	Maximum $V_1 \cdot V_3$
1	70	4.69	3.28	15.38	
2	80	4.43	3.55	15.73	
3	90	4.20	3.78	15.88	
4	100	3.99	3.99	15.92	15.92
5	110	3.80	4.18	15.88	for $R_L = 100\ \Omega$
6	120	3.63	4.36	15.83	
7	130	3.47	4.51	15.65	
8	140	3.33	4.66	15.52	

When both X_L and R_L are adjustable

SL. NO.	R_L (Ω)	C_L (μF)	V_1 (V)	V_3 (V)	$V_1 \cdot V_3$ (V^2)	Maximum $V_1 \cdot V_3$
1	70	20	4.39	3.08	13.52	
2	80	20	4.18	3.34	13.96	
3	80	30	4.43	3.55	15.73	
4	90	35	4.21	3.79	15.95	16.00
5	100	35	4.00	4.00	16.00	for $R_L = 100\ \Omega$, $C_L = 35\ \mu$F
6	110	35	3.81	4.19	15.96	
7	110	30	3.80	4.18	15.88	
8	100	30	3.99	3.99	15.92	

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⇒ CALCULATIONS AND INFERENCE

When only X_L is adjustable

From the experiment we obtained maximum power transfer when $C_L = 35\mu F$. (for $R_L = 200\,\Omega$)

From the theoretical condition $X_L = -X_i$

$$\frac{-1}{\omega C} = -\omega L \Rightarrow C = \frac{1}{\omega^2 L} = \frac{1}{4\pi^2 (50)^2\, 300 \cdot 10^{-3}} \quad (L = 300mH)$$

$$= 33.77\,\mu F$$

∴, The experimental value is quite close to the theoretical value thus obtained.

When only R_L is adjustable

From the experiment we obtained maximum power transfer when $R_L = 100\,\Omega$. (for $C_L = 30\mu F$)

From the theoretical condition, $R_L = \sqrt{R_i^2 + (X_i + X_L)^2}$

For $R_i = 100\,\Omega$, $X_i = \omega L = 2\pi 50 \cdot 300 \cdot 10^{-3} = 94.25\,\Omega$

$$X_L = \frac{-1}{\omega C} = \frac{-1}{2\pi 50 \cdot 30 \cdot 10^{-6}} = -106.10\,\Omega$$

$$R_L = \sqrt{(100)^2 + (94.25 - 106.10)^2} = \sqrt{10140.5} = 100.7\,\Omega$$

∴, The experimental value is quite close to the theoretical value.

When both X_L and R_L are adjustable.

The theoretical conditions are $X_L = -X_i$ and $R_L = R_i$

From case 1 we have the value of $C = 33.77\mu F$

and $R_i = 100\,\Omega \Rightarrow R_L = 100\,\Omega$.

The experimental values obtained are $100\,\Omega$ and $35\,\mu F$ for R_L and C_L respectively which are in agreement with our calculations.

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⇒ DISCUSSION AND COMMENTS

The maximum power transfer theorem was verified under experimental limits successfully.

It can be observed that maximum power transfer occurs when the reactance of the load cancels out the reactance from the source and the resistance of the load and source are same. Formally stating the impedance of load should be a complex conjugate of the impedance of source.

Also, one should not confuse the notions of maximum power transfer and maximum efficiency. Maximum power doesn't always mean maximum efficiency.