Faculty of engineering and Technology

Department of electrical and computer Engineering

Basic Electrical Engineering Lab [ENEE2101]

Report of Experiment 9:

AC & DC Power Analysis and Design

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Section: 1

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Tables

1. Abstract

In the laboratory, we conducted an experiment to measure power by using some devices such as Digital Multimeter, Function Generator Oscilloscope, Resistors, Inductor 100mH. to measure voltage and current, and subsequently calculate power in a DC system. As for the AC system, we used a device to measure v, I, ▲t then calculate θ, pf, P, Q.

2. Theory

The pace at which electrical energy is delivered to an electric load or transformed into another kind of energy (heat, light, mechanical energy, etc.) is referred to as power in the context of electrical systems. Watts (W) are used to measure it. Because power in AC circuits involves the interaction of voltage and current waveforms, which may or may not be in phase, calculating power in AC circuits can be more complicated than in DC circuits.
In terms of electrical energy transmission and distribution, alternating current (AC) power systems outperform direct current (DC). These benefits are critical to the design and operation of contemporary power systems, providing efficient, dependable, and cost-effective electricity distribution to both industrial and residential consumers. When comparing AC to DC power systems, two major advantages stand out: efficient long-distance transmission and the use of transformers to adjust voltage levels.

1. **Real Power (P):**
   - Represents the actual power consumed by resistive loads to perform useful work (e.g., producing heat or motion).
   - Measured in watts (W).
   - Formula: $P=V \cdot I \cdot \cos(\phi)$.
2. **Reactive Power (Q):**
   - Represents the power stored and returned by inductive (coils) and capacitive (capacitors) elements without being converted into useful energy.
   - Measured in volt-ampere reactive (VAR).
   - Formula: $Q=V \cdot I \cdot \sin(\phi)$
3. **Apparent Power (S):**
   - The total power transmitted, combining real and reactive power.
   - Measured in volt-amperes (VA).
   - Formula: $S=P + j*Q$

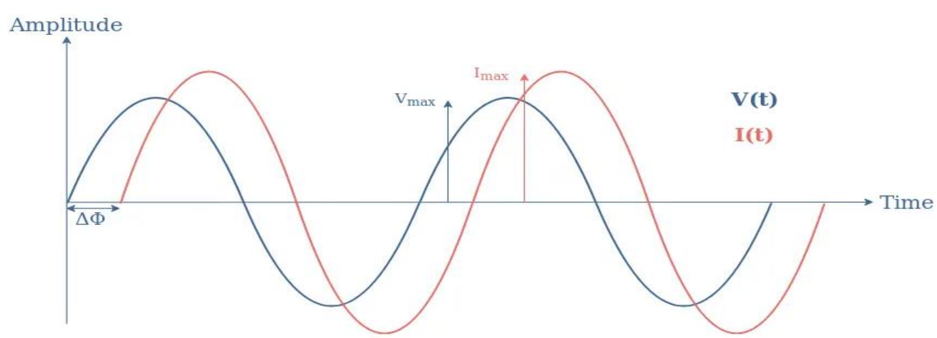


Figure 1 Phase Difference Between Voltage and Current in AC Circuits

$v = V_m \cos(\omega t + \theta_v)$

$I = I_m \cos(\omega t + \theta_i)$

$$P = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i) \longrightarrow [W]$$

$$Q = \frac{1}{2} V_m I_m \sin(\theta_v - \theta_i) \longrightarrow [VAR]$$

[1] R

$P = \frac{1}{2} V_m I_m$

$Q = 0$

absorbed

[2] L

$P = 0$

$Q = \frac{1}{2} V_m I_m$

absorbed

[3] C

$P = 0$

$Q = -\frac{1}{2} V_m I_m$

generated

- Power Factor

$P = \frac{1}{2} V_m I_m \, \underline{\underline{PF}}$

$PF = \cos(\theta_v - \theta_i)$

laging (+)

leading (−)

$$P = VI \cos(\theta_v - \theta_i)$$

$$Q = VI \sin(\theta_v - \theta_i)$$

$V_{RMS} = \frac{V_m}{\sqrt{2}}$

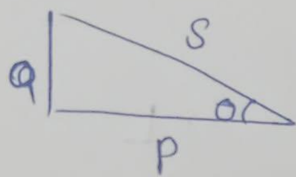
$I_{RMS} = \frac{I_m}{\sqrt{2}}$

- $P = V\hat{I} = R\hat{I}^2 = \frac{V^2}{R}$
- $Q = V\hat{I} = \frac{V^2}{X_L} = \hat{I}^2 X_L$, $X_L = \omega L$
- $Q = V\hat{I} = \frac{V^2}{X_c} = \hat{I}^2 X_c$, $X_c = \frac{1}{\omega C}$

- Complex power

$$\vec{S} = P + jQ$$

$\vec{S} \rightarrow$ VA, $P \rightarrow$ W, $Q \rightarrow$ VAR



$$\vec{S} = \frac{1}{2} \vec{V}_m \vec{I}_m^{*} \quad , \quad \vec{S} = \vec{V}_{RMS} \vec{I}^{*}_{RMS}$$

- Maximum power Transfer

RMS: $P = \frac{V_{Th}^2}{4 R_{Th}}$, Peak: $P = \frac{V_{Th}^2}{8 R_{Th}}$

3. Procedure

➢ Part A: DC power measurement

Connect the circuit of figure 2

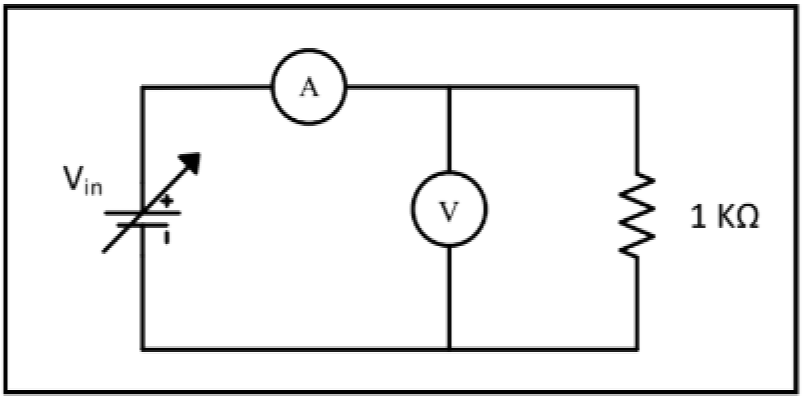


Figure 2 DC power measurement

Measure the resistor current as input voltage

Table 1 DC power measurement

Vin[V]	0	2	4	6	8	10
I[mA]	0	2.08	4.16	6.00	8.04	10.17
P[mW]	0	4.16	16.64	36	68.32	101.7

➢ Part B: Maximum DC power transfer

Connect the circuit of Figure 3

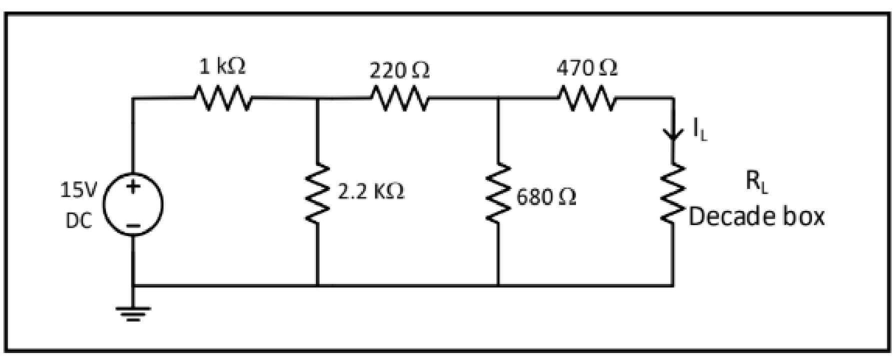


Figure 3 Maximum DC power transfer

Measure the current IL for each value of the load resistor RL

Table2 Maximum DC power transfer

RL	0	100	400	700	800	850	900	1k	1.1K	1.3K	1.5K
I[mA]	5.1	4.66	3.61	2.9	2.72	2.63	2.56	2.19	2.11	1.94	1.78
P[mW]	0	2.17	5.21	5.887	5.92	5.879	5.898	4.796	4.897	4.89	4.75

Req = 840Ω

➢ Part C: Power factor measurement

Set up the circuit as shown in Figure 4. Adjust the function generator to output a sinusoidal voltage with a peak-to-peak value of 8V and a frequency of 1 kHz. Use a digital multimeter (DMM) to measure the RMS values of VLV_L (the voltage across the load) and II (the current).

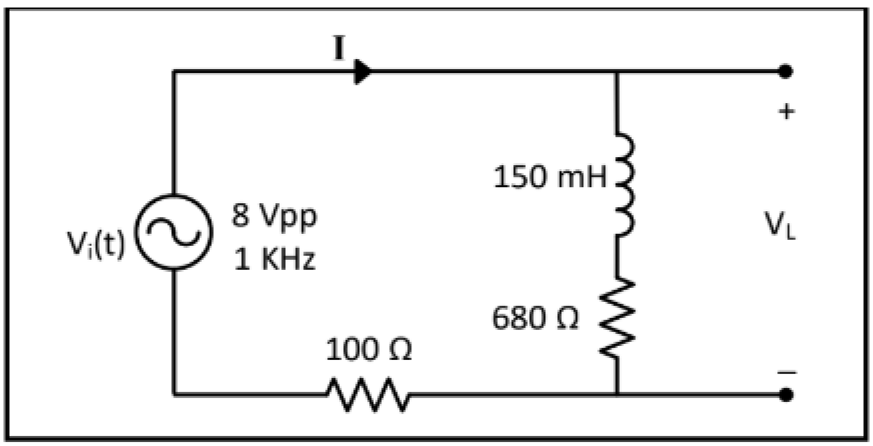


Figure 4 Power factor measurement

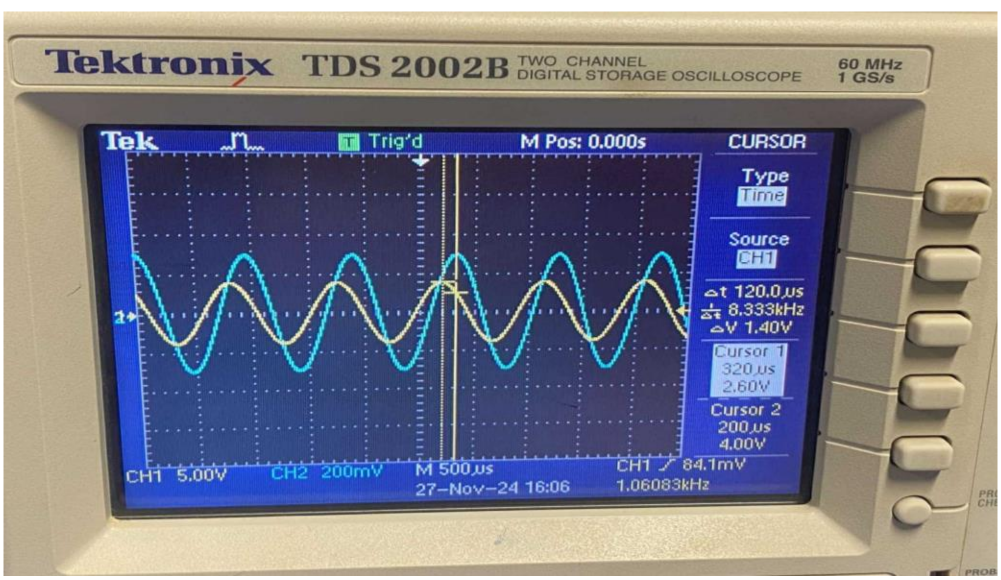


Figure 5 Power factor measurement wave

Table 3 Power factor measurement

VL	I	T ▲	Lθ	PF	P[mW]	Q[mVAR]
2.09	2.55	120µ	43.2	0.73	3.885	3.648

➢ PART D: Power factor correction

For the circuit in Figure 6, connect the capacitor in parallel with the load, as shown in Figure 6. Use CH1 of the oscilloscope to measure Vin and CH2 to measure the voltage across the 100 Ω resistor. Capture an image of the oscilloscope display to include in your report. Then, use a digital multimeter (DMM) to measure the RMS values of VL (the load voltage) and IL (the current).

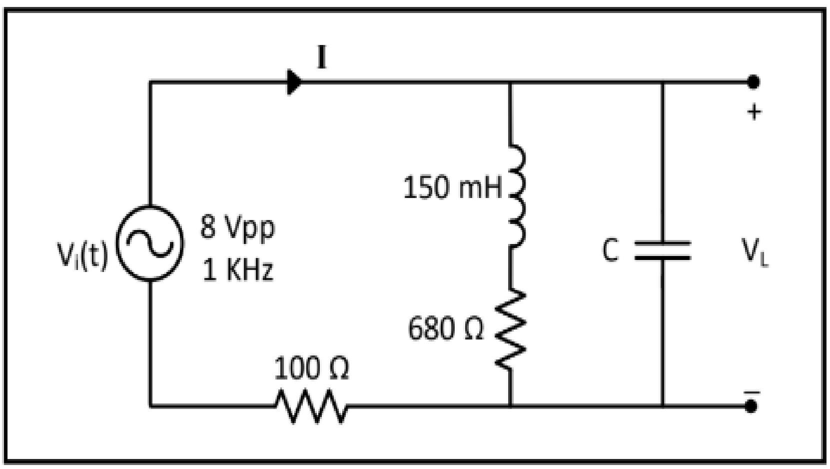


Figure 6 Power factor correction

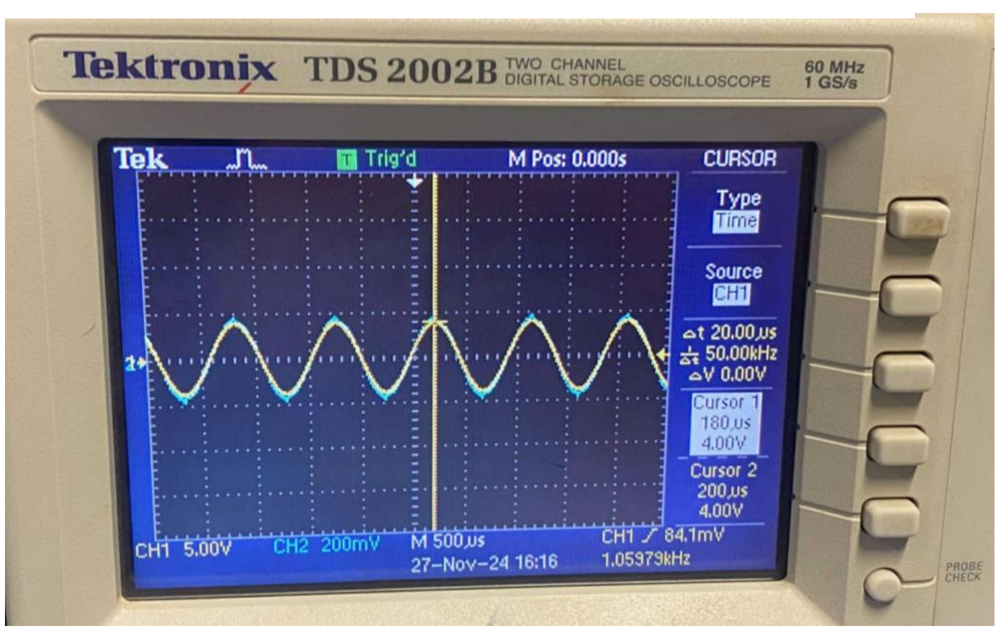


Figure 7 Power factor correction wave

Table4 Power factor correction

VL	I	T ▲	$\angle\theta$	PF	P[mW]	Q[mVAR]
2.54	1.27	0	0	1	3.226	0

➢ PART E: Maximum average power transfer

For the circuit shown in Figure 8, connect the load designed to achieve maximum power transfer to the circuit terminals. Measure the current through the load using a suitable instrument.

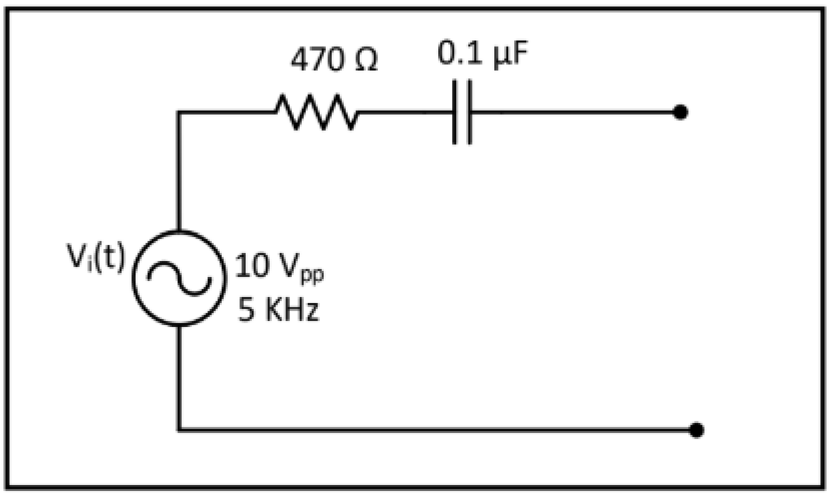


Figure 8 Maximum average power transfer

Table5 Maximum average power transfer

IL	3.40mA

4. Calculation, and Analysis of results

Question 1: Calculate the power of R using data in Table

P = I * V

P = (2) * (2.08) = 4.16 mW

Question 2: Use excel to draw a graph of (power vs. current).

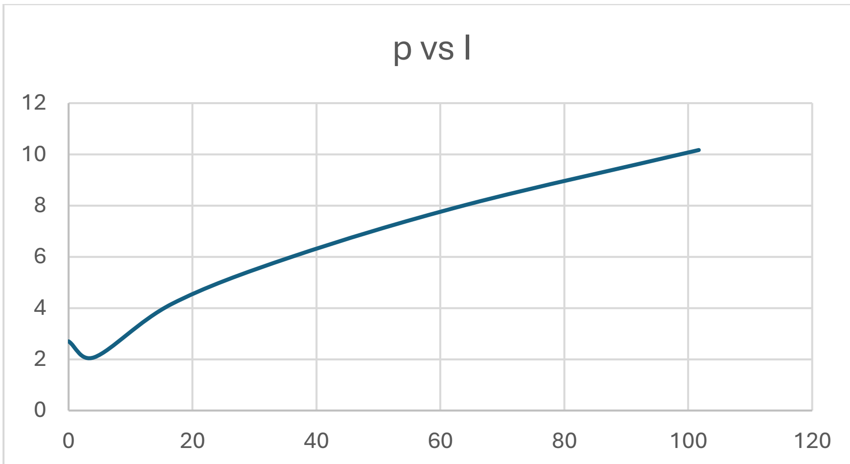


Figure 9 P VS. I Graph

Question 3: Calculate the power dissipated by RL

P=R*I^2

P= (100) (4.66) ^2= 2.17mW

Question 4: Use excel to plot a graph of power dissipated by the load against corresponding value of load. From the graph determine the load resistance which dissipated maximum power, compare it with the value measured

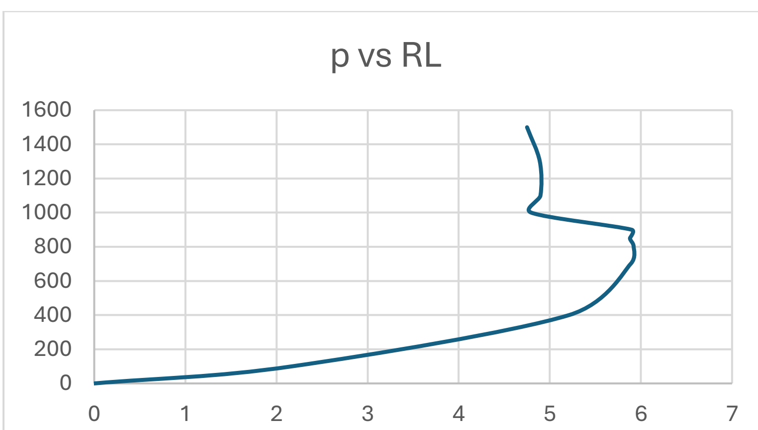


Figure 10 P VS. RL

Question 5: Calculate the phase shift Δθ between Vin and V100Ω signals.

ΔØ=360*f *ΔT

ΔØ=360*(1*10^3) (120*10^-6) =43.2

Question 6: Calculate the power factor of the circuit using measured data, indicate whether the load power factor is leading or lagging.

PF=cos(ΔØ)

PF=0.729 [lagging]

Question 7: Calculate the average power P and the reactive power Q delivered to the load using measured data.

P=V*I*PF

P= (2.09) * (2.55) * (0.73) =3.885 mW

Q=V*I*sin ΔØ

Q= (2.09) (2.55) sin 43.2 =3.648

Question 8: Calculate the new: power factor, average power P, and reactive power Q of the load using the data in Table
Discuss the effect of adding the capacitor on the measured

ΔØ=360*f *ΔT

ΔØ=360*(1*10^3) (0) =0

P=V*I*PF

P= (2.54) (1.27) (1) =3.226 mW

Q=V*I*sin ΔØ

Q= (2.54) (1.27) sin 0 =0

Adding the capacitor creates a resonant circuit with the inductor, influencing the circuit's impedance and frequency response

No visa shift [ΔØ=0] and reactive power Q=0

Question 9: Calculate the average power that is delivered to the load (P = I2 x R)

P= (3.4*10^-3) (100+j(2*3.14*1*10^3)(100*10^-3))

P= 0.0034 (100+j0.000628)

P=0.34+j(2.1352*10^-6) mW

Pmax=(Vth^2)/(4Rth)

5. Conclusion

The experiment focused on analyzing and understanding AC and DC power systems. It involved measuring voltage, current, power, and power factor in various circuit configurations. For DC circuits, the relationship between power, voltage, and current was explored, along with the concept of maximum power transfer. For AC circuits, the effects of phase difference and power factor were examined, emphasizing the importance of reactive power and power factor correction.

6. References

https://www.monolithicpower.com/en/learning/mpscholar/ac-power/introduction/basic-concepts-and-importance?srsltid=AfmBOooFo8mnMJi3-7_Dg5XOF1kQzdTaQvCSXmVljtGfzir202tRQ-R3

https://drive.google.com/drive/folders/16MIB6M55Kk9i4tI2V3-CmKjlnAzDFnlH