**بسم الله الرحمن الرحيم**

**إخواني الطلاب...**

السلام عليكم و رحمة الله و بركاته..

تجدون في هذا المستند حلول المسائل التي وردت في تجارب المعمل و هي:

1- Experiment # 3 : Real Power and Reactive Power.
2- Experiment # 4 : Power Flow and Voltage Regulation of a Simple Transmission Line.
3- Experiment # 5 : Current Transformer ( Burden ).

و نظرا لقلة المسائل قمت باختيار أفضل الإجابات التي وردت في تقاريركم و وضعها كحلول لهذه المسائل مع كتابة اسم صاحب الحل و ليس لسبب إلا تقديرا - لهم و للجميع - على مجهوداتكم الرائعة خلال هذا الفصل الدراسي.

الكل يستحق الإشادة و الشكر .. فشكرا لكم..

أخوكم

م. فهد حريري

# Solutions

## Experiment # 3 : Real Power and Reactive Power

**Answer of Q.1: ( by: Eng. Rayan Al-Amoudi )**

| | Direction of real and reactive power flow with Ideal element load | | |
|---|---|---|---|
| | Load | Real Power | Reactive Power |
| a | Resistance | +VE | O |
| b | Inductance | +VE | +VE |
| c | Capacitance | 0 | -VE |
| d | Resistance & Inductance | +VE | +VE |
| e | Resistance & Capacitance | +VE | -VE |

**Answer of Q.2: ( by : Eng. Emad Al-Zzahrani )**

a) $S = \frac{V^2}{Z^*}$

V = 120 V,

Z* = 40 - j 30 Ω,

$$S = \frac{120^2}{40 - j\,30} = 230.4 + j\,172.8 \text{ VA}$$

**P = 230.4 W**,

**Q = 172.8 var**.

b) $S = \frac{V^2}{Z^*}$

V = 120 V,

Z = 40 // ( j60 // -j90 ) = 40 // j180 = 38.118 + j 8.47 Ω

Z* = 38.118 - j 8.47 Ω

$$S = \frac{120^2}{38.118 - \text{ j } 8.47} = 360 + j\,80\,VA$$

**P = 360 W**, **Q = 80 var**.

**Answer of Q.3: ( by : Eng. Mansoor Al-Zzahrani )**

$$I = \frac{\frac{69\,k}{\sqrt{3}}\angle 0}{100\angle 0} = 398.37\angle 0\ A$$

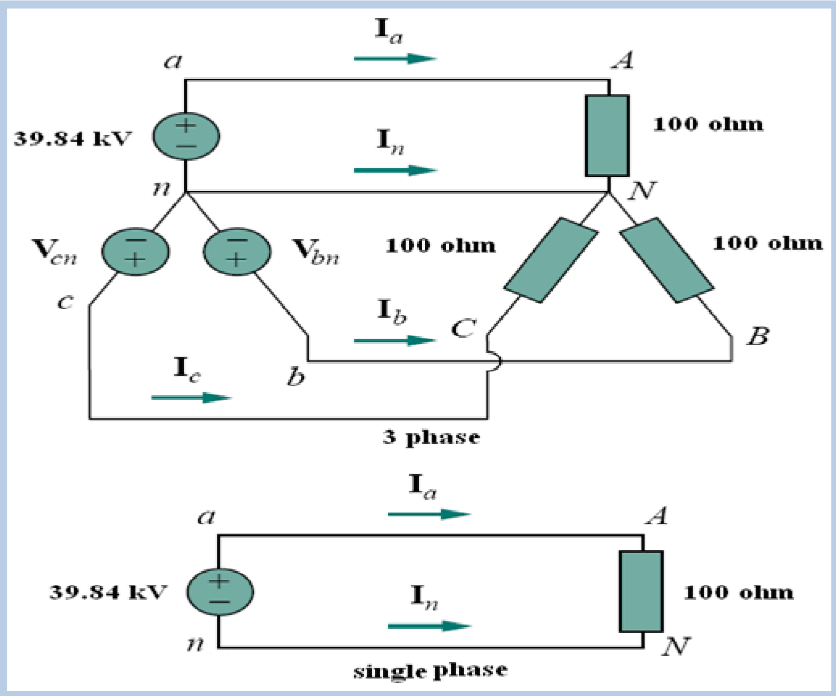


Fig. : Question no. 3 circuit.

$$\textbf{Complex power}(3\emptyset) = 3V_{L-N}\, I^* = 3\left(\frac{69k}{\sqrt{3}}\angle 0\right)(398.37\angle 0) = 47.610\angle 0\ \ MVA$$

$$\textbf{Complex power}(S_{3\emptyset}) = 47.610 + j0 = +P + j\,Q\ \ MVA$$

**P = + 47.6 MW**

**Answer of Q.4: ( by : Eng. Fahd Hariri )**

Power flows ***into*** the inductor.

Power flows ***out of*** the capacitor.

**Answer of Q.5: ( by : Eng. Mohammad Bahadeg )**

Line KW = $KW_1 - KW_2$

Line Kvar = $Kvar_1 - kvar_2$

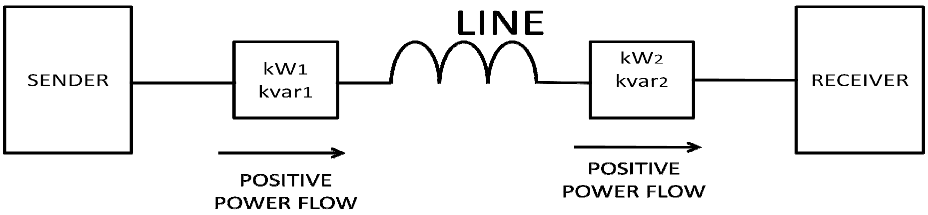


Fig. Transmission line inductor model

| kW1 | Kvar1 | kW2 | Kvar2 | LINE kW | LINE kvar |
|---|---|---|---|---|---|
| +100 | +95 | +5 | +5 | +5 | +5 |
| +100 | +95 | -10 | -10 | +5 | +20 |
| +100 | +95 | -25 | -25 | +5 | +15 |
| -100 | -105 | +5 | +5 | +5 | +5 |

**Answer of Q.6: ( by : Eng. Sultan Al-Ghamdi )**

$$P = 3\,Ep\,Ip = 3 * \frac{E}{\sqrt{3}} * \frac{E}{\sqrt{3} * Z} = \frac{E^2}{Z}$$

# Experiment # 4 : Power Flow and Voltage Regulation of a Simple Transmission Line

**Answer of Q.1: ( by : Eng. Badr al-jehani)**

a) The line-to-neutral voltage per phase.

$$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{70000\ \text{V}}{\sqrt{3}} = \mathbf{40410\ \ V}$$

b) The line current per phase.

$$I_{Line} = \frac{V_{ph}}{z} = \frac{40410\ \text{V}}{160 + j120} = \mathbf{202.05\quad A}$$

c) The real and reactive power supplied to the load.

$$P_{Load(3\emptyset)} = 3P_{Load(1\emptyset)} = \mathbf{19595.6\ kW}$$

$$Q_{Load(3\emptyset)} = 3Q_{Load(1\emptyset)} = \mathbf{0\ VAR}$$

d) The real and reactive power absorbed by the line.

$$P_{Line(3\emptyset)} = 3P_{Line(1\emptyset)} = \mathbf{0\ W}$$

$$Q_{Line(3\emptyset)} = 3Q_{Line(1\emptyset)} = \mathbf{14696.7\ kVAR}$$

e) The line-to-line voltage at the load.

$$V_{Load(line)} = \sqrt{3}\ V_{load(ph)} = 55993.7\text{V} = \mathbf{56}\ \boldsymbol{KV}$$

f) The voltage drop per phase in the line.

$$V_{LD} = I_{Line} * Z_{line} = 202.05\ \llcorner(-0.644\text{rad})(j120) = 24246\ \text{KV} = \mathbf{24.2\ KV}$$

g) The total apparent power supplied by the source.

$$S_{(ph)} = I_{rms}\ \ V_{rms} = 202.05\ (40410\ \text{V}) = 8164\ \ \text{kVA}$$

$$S_{(3ph)} = 3S_{(ph)} = 3(8164\quad) = \mathbf{24494\ kVA}$$

h) The total real and reactive power supplied by the source.

$$S_{(ph)} = \sum P + j\sum Q$$

$$= (6531.9\ \text{kW}) + j(4898.9\ \text{kVAR}) = 8164\ \llcorner(0.64\text{rad})\ \text{kVA}$$

$$S_{(3ph)} = 3S_{S(ph)} = 3(8164\ \llcorner(0.64\text{rad})) = \mathbf{19595.7} + j\mathbf{14696.7}\ \ \text{kVA}$$

**Answer of Q.2: ( by Eng. Rayan Al-Amoudi )**

**A)**

Since R is open the we neglect j120 therefore the voltage across R is the same as the voltage across C

$$V_R = Vc = \frac{-j600}{-j600 + j120} \times 330kv = \mathbf{412.5kv}$$

**B)**

$$S = 3 * V * I^* = 3 * \frac{330k}{\sqrt{3}} * \left( \frac{\frac{330k}{\sqrt{3}}}{j120 - j600} \right)^* = -226.874645j\ VA$$

$$Q = -226.874645\ Mvar$$

Or

$$Q = 3 * |I|^2 * X = 3 * 396.928^2 * (j120 - j600) = -226.875\ Mvar$$

And since the power is –ve (the power absorbed by the source)

# Experiment # 5 : Current Transformer ( Burden )

**Answer of Q.2: ( by Eng. AbdulRaheem AL-Obaidi)**

Total burden = cable burden+ burden of relay

**Case 1**

Rated burden of relay = 0.1 VA

Cable burden $=\frac{2*lc*\rho*Isc^{\wedge}2}{A}=\frac{2*50*.0203104*1}{4}$=0.50776VA

Total burden $=0.50776\text{VA} + 0.1\text{VA}$

=.606776 VA

In case 2 the burden is equal burden in case 1 because the Is in case 1 equal Is in case 2.

**Since** $P_{total} < P_n$

Therefore the C.T can handle the burden of the relay and the cables.