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Department: Electrical/Electronics Engineering
Course Title: Electric Machine
Course Code: EEE 326
Assignment: 5
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SECTION A: THEORETICAL FRAMEWORK

1. Develop the theoretical framework required for the correction of the power factor for a multi - sectioned industrial complex from $\text{Cos } \phi_1$ to $\text{Cos } \phi_2$ where $\phi_1 > \phi_2$; $P_1 = P_2$; $Q_1 > Q_2$; and $S_1 > S_2$ to determine the kVAR rating of the capacitor (Q_{CAP}) and the magnitude of the capacitor (C) in farads required to correct the power factor of the complex. **USE APPROPRIATE PHASOR DIAGRAMS.**
2. What determines the power factor of the Dangote Cement Factory at Abajana, Kogi State ?
3. The power factor (pf) of Eleme Petrochemical Industry Port Harcourt is given as $\text{Cos } (\alpha \pm \beta)$; what is the state of the pf of the complex when $\alpha > \beta$;
 $\beta > \alpha$ and $\alpha = \beta$. Draw the respective Phasor diagrams.
4. For $\alpha > \beta$; Write an expression for P and Q respectively with units in W and VAR. What does P and Q represent.
5. Justify the need for power factor correction to ABUAD and PHCN or an IPP.
6. Why is Q needed in an industrial complex with numerous induction motors?

SECTION B: APPLICATION OF THEORETICAL FRAMEWORK

7. An industrial load absorbs 5 MVA at a pf of 40% capacitive at 6kV. To improve the pf up to 85% capacitive, determine Q and C of the required capacitor. State how the correcting equipment will be integrated into the industrial power network for this load.
8. An industrial load absorbs 5 MVA at a pf of 40% inductive at 6kV. To improve the pf. upto 85% inductive, determine Q and C of the required and necessary capacitor. State how the correcting equipment will be integrated into the industrial power network for this load. How different are the values of Q7 and Q8 in terms of magnitude and type of pf correction?
9. The National Universities Commission (NUC) Complex in Abuja has a total load of 100kW. It is powered by a 415 V, three phase, 4 wire power supply. The power factor is 0.85lagging and NUC desires to avoid the payment of penalties for this poor power factor. What

should the facility manager advise NUC management to do? If an improved pf of 0.95 lagging is desired, determine the magnitude of the required Q and C.

10. Undertake a comparative analysis as an Electrical Power Management Consultant and use techno – economic facts and data to advice a client (Globacom Nigeria Ltd) requiring a 20kW induction motor to power its intended fruit juice factory from motor choices M_1 and M_2 given the following details:

Motor/parameters	M₁	M₂
kW	20	20
Phases	3	3
Line Voltage	415	415
pf	0.85	0.95
S	S_1	S_2
Q	Q_1	Q_2
PREVIOUS METER READING (kWhr)	23,000	
NEW METER READING (kWhr)	25,000	
kWhr charge	#55/kWhr	
Demand(kW) Charge	#35/kW	
Capacity (kVA) Charge	#70/kVA	
Reactive Power (kVAR) Charge	#25/kVAR	

Justify clearly your choice of recommended motor.

Answers

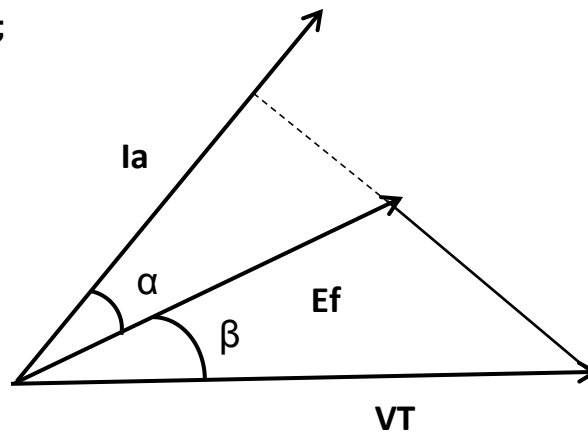
2. Firstly, Power Factor is a measure of how effectively electricity is used. What determines the power factor of the Dangote cement factory is the Working power (True or real) and the Non-working power (Reactive). The Working power is the power used by the factory in performing actual work like heating or any motion (resistive loads).

The Non-working power is the power that requires reactive power to generate and sustain a magnetic field in order to operate like a motor, compressor or ballast(Inductive loads).

3. Given;

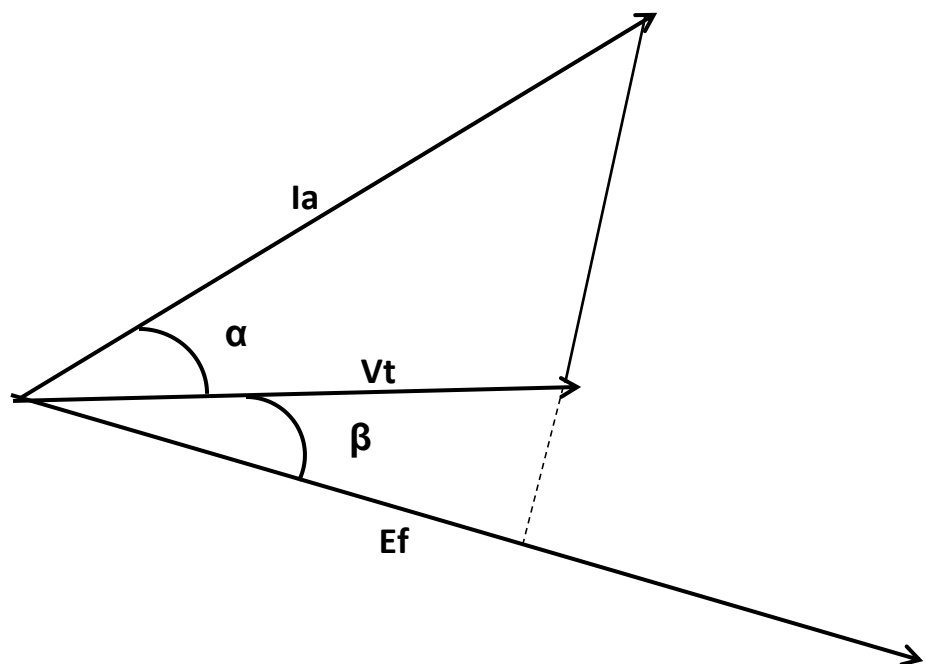
Power factor, Pf of Eleme petrochemical industry, port Harcourt=
 $\text{Cos}(\alpha \pm \beta)$

For $\alpha > \beta$;



The State of the power factor is Leading.

For $\beta > \alpha$;



4. P is the Active or Real or True power.

Q is the Reactive power.

The Active power and the reactive power can be calculated by finding the product of voltage to current. That is,

$$= (V e^{j\alpha}) \times (I e^{j\beta})$$

$$= V I e^{j(\alpha+\beta)}$$

$$= V I \cos(\alpha+\beta) + j V I \sin(\alpha+\beta)$$

$(\alpha+\beta)$ is the angle between voltage and current, so the [phase difference is denoted as ϕ .

$$P= VI\cos\phi$$

$$Q= jVI\sin\phi$$

5. The need for power factor correction for ABUAD and PHCN or IPP is :

- a) To improve voltage levels in their power system.
- b) To reduce losses which will increase system capacity.
- c) To reduce demand of peak active power thereby reduces utility fees.
- d) To eliminate power factor penalty.

6. Why Q is needed is because in an industrial complex it is needed to control voltage to prevent damage, to reduce transmission losses and maintain the ability of the system to withstand and prevent voltage collapse. The reactive power serves as a "Phantom power" which is used to put several induction motors on standby.