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Department: Electrical and Electronics Engineering

Course Title: Electrical Machines 2

Course Code: EEE326

Assignment on Power Factor Correction

Section A

Question 1

Develop the theoretical framework required for the correction of the power factor for a multi - sectioned industrial complex from to where ; ; ; and to determine the kVAR rating of the capacitor and the magnitude of the capacitor (C) in farads required to correct the power factor of the complex. **USE APPROPRIATE PHASOR DIAGRAMS.**

Answer



Question 2

What determines the power factor of the Dangote Cement Factory at Abajana, Kogi State?

Answer

Power factor is an expression of energy efficiency. It is usually expressed as a percentage—and the lower the percentage, the less efficient power usage is.

Power factor (PF) is the ratio of working power, measured in kilowatts (kW), to apparent power, measured in kilovolt amperes (kVA). Apparent power, also known as demand, is the measure of the amount of power used to run machinery and equipment during a certain period. It is found by multiplying (kVA = V x A). The result is expressed as kVA units.

PF expresses the ratio of true power used in a circuit to the apparent power delivered to the circuit. A 96% power factor demonstrates more efficiency than a 75% power factor. PF below 95% is considered inefficient in many regions.

Question 3

The power factor (pf) of Eleme Petrochemical Industry PortHarcourt is given as ; what is the state of the pf of the complex when ; and . Draw the respective Phasor diagrams.

Answer



Question 4

For ; Write an expression for P and Q respectively with units in W and VAR. What does P and Q REPRESENT?

Answer

P=I\*Vcos (α±β)

 Q=I\* Vsin (α±β)

Where,

P: active power(kW)

Q: reactive power(kVAR)

Question 5

Justify the need for power factor correction to ABUAD and PHCN or an IPP

Answer

* Power factor correction eliminates penalties on reactive energy, reduces the demand of kVA, and reduces power losses generated in the transformers and conductors of the installation
* Improving the PF can maximize current-carrying capacity, improve voltage to equipment, reduce power losses, and lower electric bills
* Installing PFC equipment allows conductor cross-section to be reduced, as less current is absorbed by the compensated installation for the same active power.
* Reduced voltage drops
* Installing capacitors allows voltage drops to be reduced upstream of the point where the PFC device is connected, therefore preventing overloading of the network and reducing harmonics.
* PF correction capacitors can switch on every day when the inductive equipment starts

Question 6

Why is Q needed in an industrial complex with numerous induction motors?

Answer

* Voltage control in an electrical power system is important for proper operation for electrical power equipment to prevent damage such as overheating of generators and motors, to reduce transmission losses and to maintain the ability of the system
* When reactive power supply lower voltage, as voltage drops current must increase to maintain power supplied, causing system to consume more reactive power and the voltage drops further . If the current increase too much, transmission lines go off line, overloading other lines and line charging, and still there further voltage reductions. If voltage reduction continues, these will cause additional elements to trip, leading further reduction in voltage and loss of the load. The result in these entire progressive and uncontrollable declines in voltage is that the system unable to provide the reactive power required supplying the reactive power demands
* First, the transmission system itself is a nonlinear consumer of reactive power, depending on system loading. At very light loading the system generates reactive power that must be absorbed, while at heavy loading the system consumes a large amount of reactive power that must be replaced. The system’s reactive-power requirements also depend on the generation and transmission configuration.

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Section B

Question 7

An industrial load absorbs 5 MVA at a pf of 40% capacitive at 6kV. To improve the pf upto 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.

Answer

Load(s)= 5000KVA

Frequency = 50Hz

Power factor = 0.4 (capacitive)

P = ׀s׀cosØ

P = ׀s׀Pf (old) = 5000×103(0.4) = 2000KW

Ø (old) = cos-1Pf (old) = cos-1 (0.4) = -66.42

The angle will be negative because the old power factor is inductive

Using trigonometry

Tan 𝜃old= Q(old) ̸ P

Qold = Ptan(old) = (2000×103)(tan(-66.42))

Q(old) = -4582178.329 var

(new) = cos-1Pf(new) = cos-1(0.85) = -31.79 (because also its capacitive)

Tan(new) = Q(new) ̸ P

Q(new) = Ptan𝜃(new) = 2000×103(tan(-31.79)) = -1239569.332 var

ΔQ = Q(new) – Q(old)

ΔQ = -1239569.332 – (-4582178.329)

ΔQ = 3342608.997 var

C=ΔQ/(2πf (Vs2))

 C =

C= 2.96×10-4

C= 29.6mf

Question 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?

Answer

Load(s) = 5000KVA

Frequency = 50Hz

Power factor = 0.4 (inductive)

P = ׀s׀cosØ

P = ׀s׀Pf (old) = 5000×103(0.4) = 2000KW

Ø (old) = cos-1Pf (old) = cos-1 (0.4) = 66.42

The angle will be positive because the old power factor is inductive

Using trigonometry

Tan 𝜃old= Q(old) ̸ P

Qold = Ptan(old) = (2000×103)(tan(66.42))

Q(old) = 4582178.329 var

(new) = cos-1Pf(new) = cos-1(0.85) = 31.79 (because also its inductive)

Tan(new) = Q(new) ̸ P

Q(new) = Ptan𝜃(new) = 2000×103(tan(31.79)) = 1239569.332 var

ΔQ = Q(old) – Q(new)

ΔQ = 4582178.329 – 1239569.332

ΔQ = 3342608.997 var

C=ΔQ/(2πf (Vs2))

 C =

C= 2.96×10-4

C= 29.6mf

If this load is an electric motor or most any other industrial AC load, it will have a lagging (inductive) power factor, which means that we’ll have to correct for it with a capacitor of appropriate size, wired in parallel. This correction, of course, will not change the amount of true power consumed by the load, but it will result in a substantial reduction of apparent power.

 Question 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.

Answer

Real power, p=100KW

V=415V 3 phase transformer

Original pf=0.85

Improved Pf desired=0.95

**Recall, Pf=cosθ**

**Therefore, θ= cos-1(pf)**

 θ1=cos-1(0.85) =31.7883

 θ2=cos-1(0.95) =18.1949

 Tan θ1=tan (31.7883) =0.6197

 Tan θ2=tan (18.1949) =0.3287

Therefore,

Reactive Power, Q=Psin (θ1 ± θ2)

 = (100×103) ×sin(31.7883-18.1949)

  **=23.503KVAR**

 Required capacitor, C=P (tan θ1 ±tan θ2)

 = (100×103) × (0.6197-0.3287)

  **=29.1KVAR**

Question 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 given the following details:

|  |  |  |
| --- | --- | --- |
| **Motor/parameters** |  |  |
| **kW** | 20 | 20 |
| **Phases** | 3 | 3 |
| **Line Voltage** | 415 | 415 |
| **pf** | 0.85 | 0.95 |
| **S** |  |  |
| **Q** |  |  |
| **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.**

Answer

S1 = 23529.41176 var

S2 = 21052.63158 var

Where S1 and S2 are gotten from the equation P/ Pf

Where P1 and P2 = 20×103

𝜃1 = cos-1(0.85) = 31.79

𝜃2  = cos-1(0.95) = 18.19

Q1 = sin(31.79) × 23529.41176

Q1 = 12395.46948 var

Q2 = sin(18.19) × 21052.63158

Q2 = 6571.981313 var

The above equation is to show the different induction motor the amount of reactive power they both possess

* **Determine cost-effectiveness** AC motors are available in a range of efficiencies. Although the economics will differ by application, to replace ancient standard-efficiency motor with a newly installed, premium-efficiency motor under typical operation will often pay for its price in reduced energy bills within a year or two.

Consider downsizing when a motor is operating at less than 40% of its rated output. The following circumstances are opportunities for choosing premium-efficiency motors:

When purchasing a new motor where lower-energy-efficient units can still be sold Instead of rewinding failed standard-efficiency or energy-efficient motors.To replace an operable-but-inefficient motor for greater energy savings and reliability

The best and most economical motor choice to go with would be motor 2(M2)

The calculation solved above showed that MOTOR 2 (M2) is the best option because when the reactive power is low it saves cost and increases efficiency