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**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 𝐶𝑜𝑠 ∅1to 𝐶𝑜𝑠 ∅2where ∅1>∅2;**

**𝑃1= 𝑃2; 𝑄1> 𝑄2; and 𝑆1> 𝑆2to determinethekVARratingof the capacitor(𝑄𝐶𝐴𝑃) and the magnitude of the capacitor (C) in farads required to correct the power factor of the complex. USE APPROPRIATE PHASORDIAGRAMS.**

**Answer**

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**Oio 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 givenas**

**Cos(𝛼 ± 𝛽) ; what is the state of the pf of the complex when 𝛼 > 𝛽; 𝛽 > 𝛼 and 𝛼=**

**𝛽. Draw the respective Phasor diagrams. Answer**

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**Question 4**

**For 𝛼 > 𝛽; 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**

* **Savings on the electricitybill**
* **Power factor correction eliminates penalties on reactive energy, decreases demand on kVA, and reduces power losses generated in the transformersand conductors of theinstallation.**
* **Increased availablepower**
* **Fitting PFC equipment on the low voltage side increases the power available at the secondary of a MV/LV transformer. A high power factor optimises an electrical installation by allowing better use of thecomponents.**
* **Reduced installationsize**
* **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**
* **Installingcapacitorsallowsvoltagedropstobereducedupstreamofthepoint where the PFC device is connected, therefore preventing overloading of the network and reducingharmonics.**

**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 to withstand and prevent voltagecollapse.**
* **Decreasing reactive power causing voltage to fall while increasing it causing voltagetorise.Avoltagecollapsemaybeoccurswhenthesystemtrytoserve much more load than the voltage cansupport.**
* **When reactive power supply lower voltage, as voltage drops current mustincrease to maintain power supplied, causing system to consume more reactivepowerandthevoltagedropsfurther.Ifthecurrentincreasetoomuch, transmission lines go off line, overloading other lines and potentially causing cascadingfailures.**
* **If the voltage drops too low, some generators will disconnect automatically toprotect themselves. Voltage collapse occurs when an increase in load or less generation or transmission facilities causes dropping voltage, which causes a further reduction in reactive power from capacitor and line charging, andstill there further voltage reductions. If voltage reduction continues, these will causeadditionalelementstotrip,leadingfurtherreductioninvoltageandloss 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 powerdemands**
* **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 transmissionconfiguration.**

**.**

**Section B**

**Question 7**

**Anindustrialloadabsorbs5MVAatapfof40%capacitiveat6kV.Toimprove 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 thisload.**

**Answer**

**Load(s) = 5000KVA**

**Power factor = 40% = 0.4 (capacitive) Frequency = 50Hz**

**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= 2.96×10-4C= 29.6mf**

**3342608.997**

**2 × 3.142 × 50 × (6000)2**

**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**

**Power factor = 40% = 0.4 (inductive) Frequency = 50Hz**

**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= 2.96×10-4C= 29.6mf**

**3342608.997**

**2 × 3.142 × 50 × (6000)2**

**If this load is an electric motor or most any other industrial AC load, it will have a lagging(inductive)powerfactor,whichmeansthatwe’llhavetocorrectforitwith**

**a ofappropriatesize,wiredinparallel.Thiscorrection,ofcourse,will**

capacitor

**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 poweredby a415V,threephase,4wirepowersupply.Thepowerfactor is0.85lagging andNUC 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 andC.**

**Answer**

**Real power, p=100KW**

**V=415V 3 phase transformer Originalpf=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 andusetechno–economicfactsanddatatoadviceaclient(GlobacomNigeriaLtd) requiring a 20kW induction motor to power its intended fruit juice factory from motor choices 𝑀1𝑎𝑛𝑑 𝑀2given the followingdetails:**

|  |  |  |
| --- | --- | --- |
| **Motor/parameters** | **𝐌𝟏** | **𝐌𝟐** |
| **kW** | **20** | **20** |
| **Phases** | **3** | **3** |
| **Line Voltage** | **415** | **415** |
| **pf** | **0.85** | **0.95** |
| **S** | **𝑆1** | **𝑆2** |
| **Q** | **𝑄1** | **𝑄2** |
| **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** |
| **ReactivePower****(kVAR)Charge** | **#25/kVAR** |

**Justify clearly your choice of recommended motor.**

**Answer**

**S1= 23529.41176 var S2= 21052.63158 var**

**Where S1and S2are gotten from the equation P/ Pf Where P1and P2= 20×103**

**𝜃1= cos-1(0.85) =31.79**

**𝜃2= cos-1(0.95) =18.19**

**Q1= sin(31.79) × 23529.41176 Q1= 12395.46948var**

**Q2= sin(18.19) × 21052.63158 Q2= 6571.981313var**

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

**Inordertopickthebestchoiceofinductionmotor,theclientmustconsiderthefollowingfactors:**

* **Determine cost-effectiveness AC motors are available in a range of efficiencies. Although the economics will vary by application, replacing an old standard-efficiency motor with a newlyinstalled,premium-efficiencymotorundertypicaloperationwilloftenpayforitsprice in reduced energy bills within a year ortwo.**

**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**

* **Account for the motor’s impact on power factor Power factor is an indicator of how muchof a power system’s capacity is available for productive work. Low power factor is undesirable because it increases the load on a building’s electrical system, and utilities sometimes charge customers a penalty for facilities with low power factor. Because power factor is lower when amotorislightlyloaded,besuretochoosetheright-sizedmotor.Youcanalsospecifyamotor with a high power factor, but such models sometimes have lower efficiency. The ultimate selection depends, in part, on whether a facility is subject to power factor penalty charges. A facility with a significant number of induction motors and a low power factor can solve the problem with premium-efficiency motors that are properly sized. If new motors are not an option,otherpowerfactor–correctionmethodsareavailable,includingstaticcapacitorbanks, rotary condensers, and static and dynamic volt-ampere reactivedevices.**

**From the above factors mentioned above, the best and most economical motor choice to go with would be motor 2(M2)**

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