Name: BRIGGS FRANCIS

Mat No 17 /eng04/015

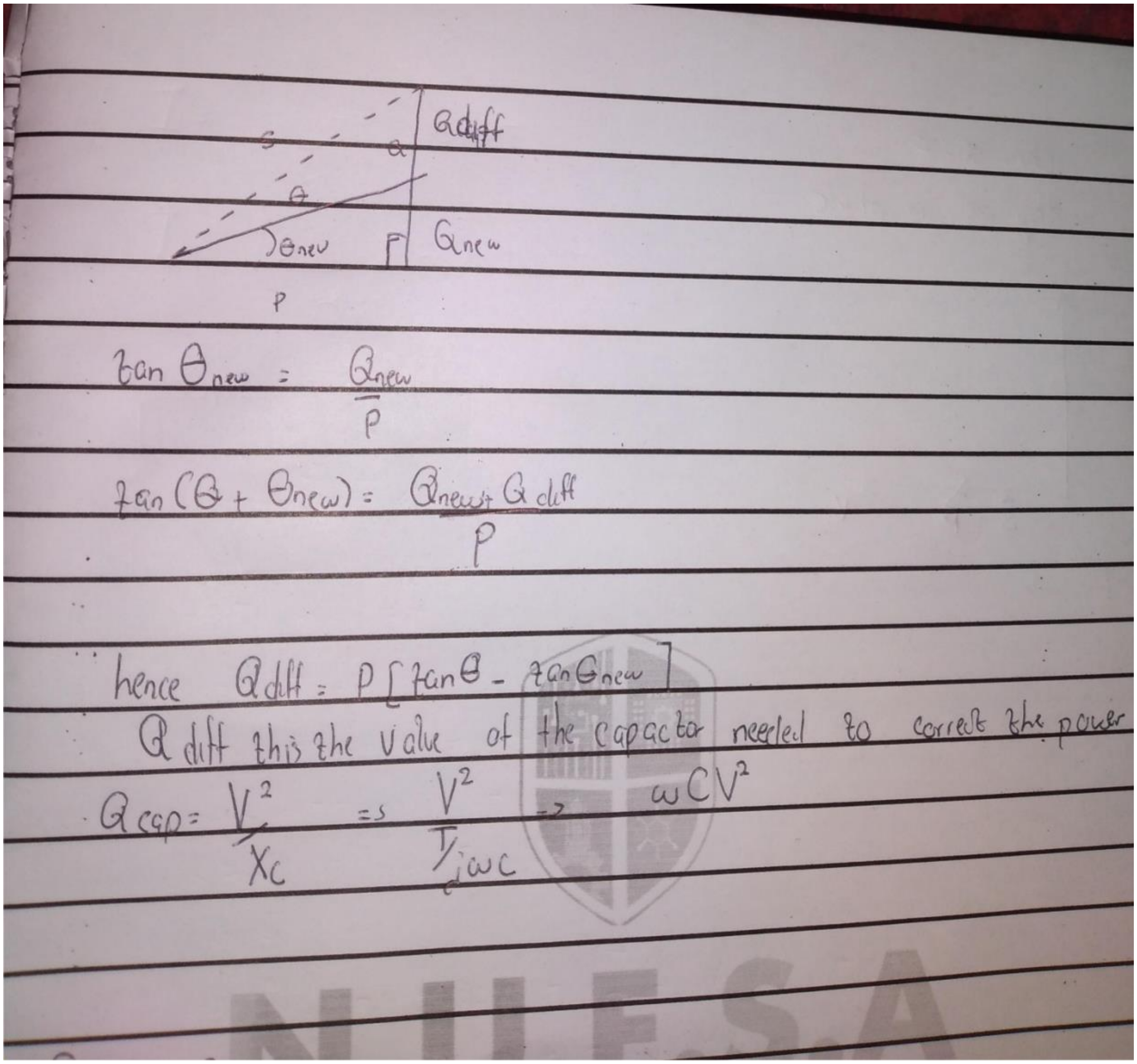
Department: Elect/Elect

Course Title: Electrical Machines II

Section A

Question 1

Answer



$\tan\theta_{new} = \frac{Q_{new}}{P}$

$\tan(\theta + \theta_{new}) = \frac{Q_{new} + Q_{diff}}{P}$

hence $Q_{diff} = P[\tan\theta - \tan\theta_{new}]$

Q_{diff} this the value of the capactor needed to correct the power

$Q_{cap} = \frac{V^2}{X_C} \Rightarrow \frac{V^2}{1/j\omega C} \rightarrow \omega C V^2$

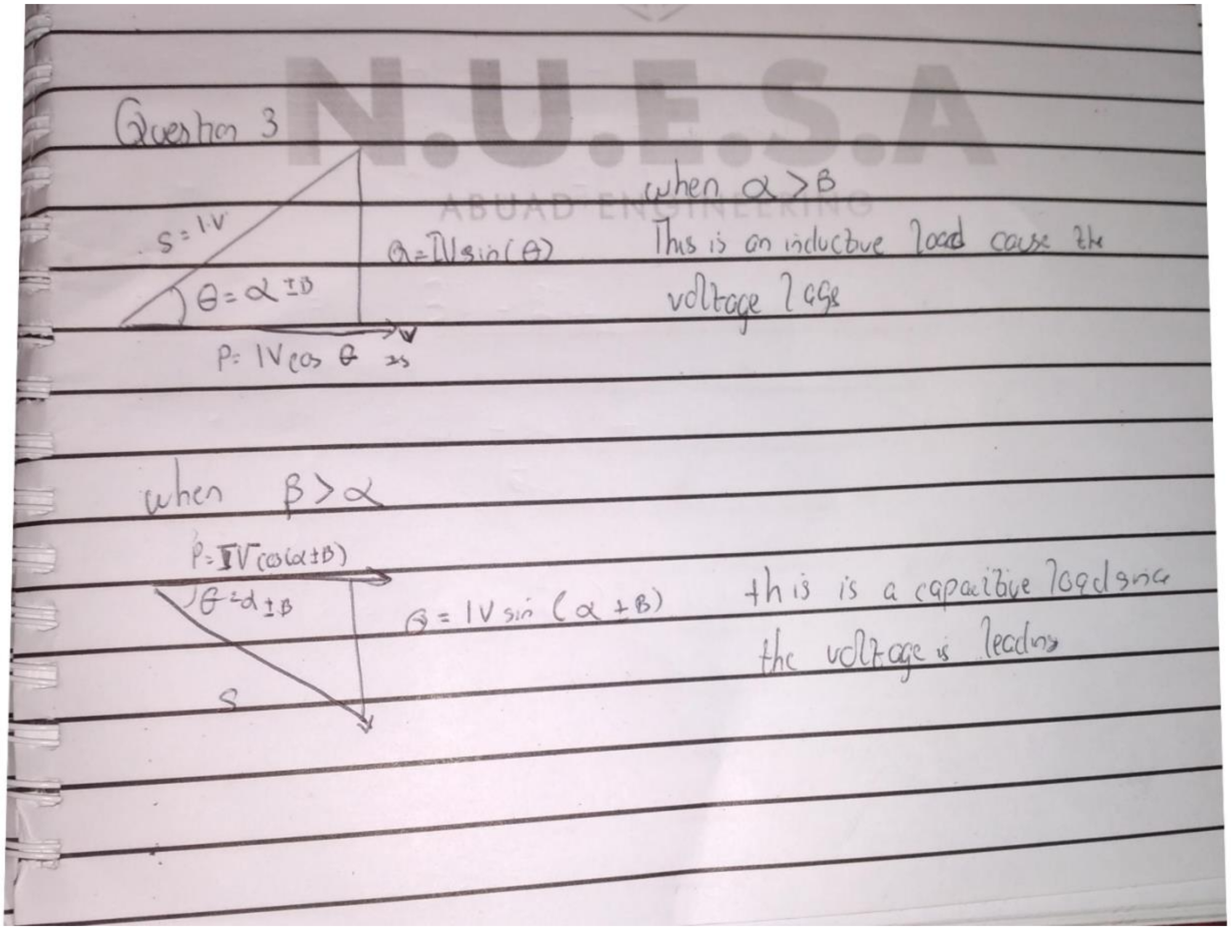
Question 2

Power factor is an expression used to measure the effectiveness in utilizing the apparent power drawn in a circuit. It is often depicted in percentages or ratios with values ranging from 0 to 1 hence a higher PF value means a more efficient machine

Power factor (PF) is the ratio of Real power, measured in kilowatts (kW), to apparent power, measured in kVA.

Apparent power, 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.

Question 3



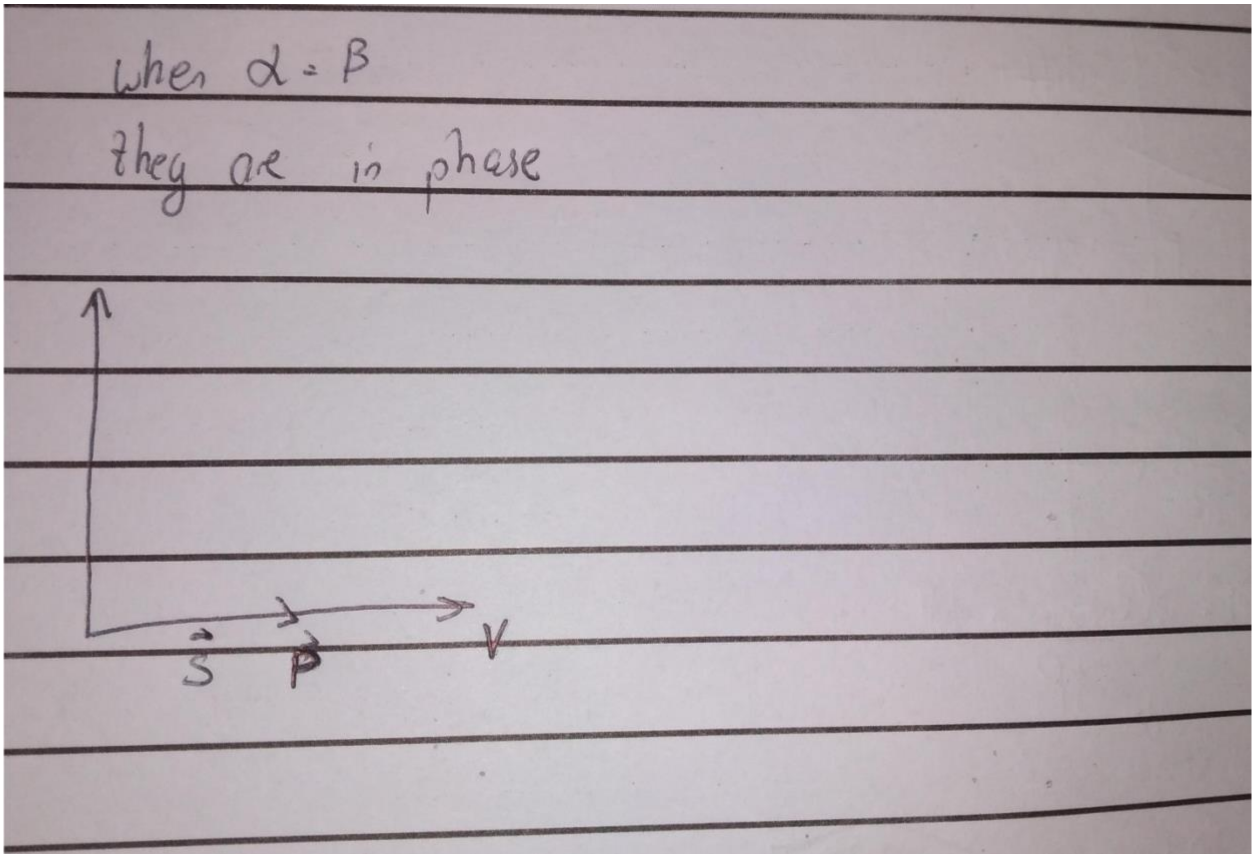
Question 3

when $\alpha > B$

This is an inductive load cause the voltage lags

when $\beta > \alpha$

this is a capacitive load since the voltage is leading



when α = β
they are in phase

Question 4

P=I*Vcos(α±β) active power(kW)
Q=I*Vsin(α±β) reactive power(kVAR) Where,

Question 5

1. Power factor correction eliminates penalties on reactive energy, decreases demand on kVA, and reduces power losses generated in the transformers and conductors of the installation.

2. It saves cost on behalf of the company equipment which in turn saves cost for the consumer
3. 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 the components.
4. Installing PFC equipment allows conductor cross-section to be reduced, as less current is absorbed by the compensated installation for the same active power.
5. 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.

Question 6

1. Voltage control helps control losses in an electrical power system is important for proper operation for electrical power equipment to prevent damage such as overheating .
2. A voltage collapse may occur when the system try to serve much more load than the voltage can support.
3. 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 potentially causing cascading failures.
4. 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.

Question 7

Load(s) = 5000KVA

Power factor = 40% = 0.4 (capacitive)

Frequency = 50Hz

$P = |s|\cos\emptyset$

$P = |s|Pf_{(old)} = 5000\times10^{3}(0.4) = 2000KW$

$\emptyset_{(old)} = \cos^{-1}Pf_{(old)} = \cos^{-1}(0.4) = -66.42$

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

Using trigonometry

Tan θold= $Q_{(old)}/P$

$Q_{old} = P\tan_{(old)} = (2000\times10^{3})(\tan(-66.42))$

$Q_{(old)} = -4582178.329$ var

$_{(new)} = \cos^{-1}Pf_{(new)} = \cos^{-1}(0.85) = -31.79$ (because also its capacitive)

$\tan_{(new)} = Q_{(new)}/P$

$Q_{(new)} = P\tan\theta_{(new)} = 2000\times10^{3}(\tan(-31.79)) = -1239569.332$ var

$\Delta Q = Q_{(new)} - Q_{(old)}$

$\Delta Q = -1239569.332 - (-4582178.329)$

$\Delta Q = 3342608.997$ var

$C=\Delta Q/(2\pi f\,(Vs^{2}))$

C =

$$\frac{3342608.997}{2\times3.142\times50\times(6000)^{2}}$$

$C= 2.96\times10^{-4}$

C= 29.6mf

Question 8

Answer

Load(s) = 5000KVA

Power factor = 40% = 0.4 (inductive)

Frequency = 50Hz

$P = |s|\cos\varnothing$

$P = |s|Pf_{(old)} = 5000\times10^{3}(0.4) = 2000$KW

$\varnothing_{(old)} = \cos^{-1}Pf_{(old)} = \cos^{-1}(0.4) = 66.42$

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

Using trigonometry

Tan θold= $Q_{(old)}/P$

$Q_{old} = P\tan_{(old)} = (2000\times10^{3})(\tan(66.42))$

$Q_{(old)} = 4582178.329$ var

$_{(new)} = \cos^{-1}Pf_{(new)} = \cos^{-1}(0.85) = 31.79$ (because also its inductive)

$\text{Tan}_{(new)} = Q_{(new)}/P$

$Q_{(new)} = P\tan\theta_{(new)} = 2000\times10^{3}(\tan(31.79)) = 1239569.332$ var

$\Delta Q = Q_{(old)} - Q_{(new)}$

$\Delta Q = 4582178.329 - 1239569.332$

$\Delta Q = 3342608.997$ var

$C=\Delta Q/(2\pi f\,(Vs^{2}))$

C =

$$\frac{3342608.997}{2\times3.142\times50\times(6000)^{2}}$$

$C= 2.96\times10^{-4}$

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

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)

θ_1=cos^{-1}(0.85) =31.7883

θ_2=cos^{-1}(0.95) =18.1949

Tan θ_1=tan (31.7883) =0.6197

Tan θ_2=tan (18.1949) =0.3287

Therefore,

Reactive Power, Q=Psin ($\theta_1 \pm \theta_2$)

= (100×10^3) ×sin(31.7883-18.1949)

=23.503KVAR

Required capacitor, C=P (tan θ_1 ±tan θ_2)

= (100×10^3) × (0.6197-0.3287)
=29.1KVAR

Question 10

Answer

S_1 = 23529.41176 var

S_2 = 21052.63158 var

Where S_1 and S_2 are gotten from the equation P/ Pf

Where P_1 and $P_2 = 20\times10^3$

θ_1 = cos^{-1}(0.85) = 31.79

θ_2 = cos^{-1}(0.95) = 18.19

Q_1 = sin(31.79) × 23529.41176

Q_1 = 12395.46948 var

Q_2 = sin(18.19) × 21052.63158

Q_2 = 6571.981313 var

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

In order to pick the best choice of induction motor, the client must consider the following factors:

- **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 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
- **Account for the motor's impact on power factor** Power factor is an indicator of how much of 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 a motor is lightly loaded, be sure to choose the right-sized motor. You can also specify a motor 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, other power factor–correction methods are available, including static capacitor banks, rotary condensers, and static and dynamic volt-ampere reactive devices.

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