Electrical Power Engineering Fundamentals

Third partial exam (3rd May 2018)

Three balanced three phase loads are connected in parallel:

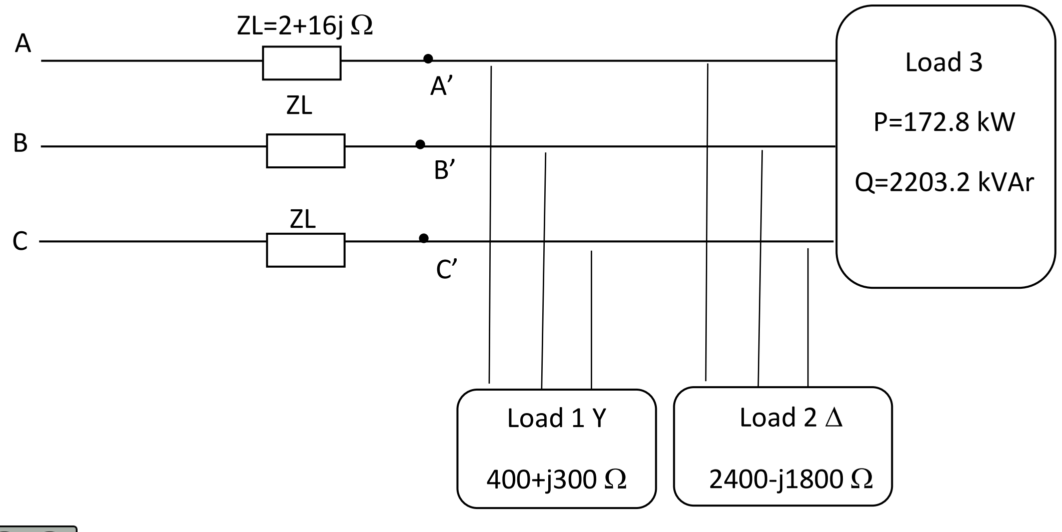
Load 1: Y connected, with an impedance of 400+j 300 Ω per phase,

Load 2: Δ connected with an impedance of 2400-j1800 Ω per phase

Load 3: Absorbs 172.8 kW and 2203.2 kVAr

The loads are fed from a distribution line with an impedance of 2+16j and the magnitude of the line voltage at the load end of the line (A'B'C') is 72 kV and the f=50 Hz.

a) Calculate the impedance per phase of Load 3
b) Draw the one phase equivalent of the system.
c) Calculate the magnitudes of the phase and line currents absorbed by each load and the total line current absorbed by the whole system as a phasor.
d) Calculate the voltage drop across the distribution line and the line voltage (phasor) at the sending end of the line (ABC).
e) Calculate the complex power absorbed by the system, by the distribution lines and by the loads.
f) Calculate the percentage of the apparent power that is absorbed by the loads (i.e. the efficiency of the system).
g) Would it be possible to improve the efficiency of the system by compensating the reactive power? (Explain your answer). Calculate the values of the elements that must be connected to the system and where should they be connected obtain the higher possible efficiency. Draw a diagram indicating the layout of the system.
h) Considering that the line voltage at the loads remains unchanged after the compensation calculate the new efficiency of the system.



a) P3=172.8 kW
Q3=2203.2 kvar
fi3=atan(Q3/P3)=85.51°

I3=P3/sqrt(3)·UL·cos fi3=172.8·10^3/sqrt(3)·72·10^3·cos(85.81)=17.82A

|Z3Y|=UL/sqrt(3)/I3=72·10^3/sqrt(3)/17.82=2.35·10^3 Ω

Z3Y=2.35·10^3/85.51°Ω

b) In the three-phase equivalent the three impedances Z1Y, Z2Y and Z3Y are in parallel
Z2Y=Z2Δ/3=800-600j Ω

c) I1A=UA'N'/Z1Y=72·10^3/sqrt(3)/400+300j =66.51-49.88j=83.14/-36.8 A

I2A=UA'N'/Z2Y=72·10^3/sqrt(3)/800-600j =33.25+24.94j=41.57 /36.8 A

I3A=17.82 /-85.5 A

ITA= I1A+ I2A+ I3A=101.15-42.61j=109.76 /-22.84 A

d) UAA'= I1T·ZL=(40+16j)· 109.76 /-22.84 = 4728.6 /-1.041 V

UAN= UAA'+ UA'N'=45644 /2.032 V

UAB= UAN· sqrt(3) /30 V= 79058 /32.032 V

e) $\mathbb{S}$DL=3·UAA·ITA*=1445.7+578.26 j kVA=13688 /22.84 kVA

$\mathbb{S}$G=3·UAN·ITA*=14060+5891j kVA

$\mathbb{S}$LOADS= $\mathbb{S}$G- $\mathbb{S}$DL= 12614 +5313j kVA

f) The system is inductive, so we compensate with capacitors connected in A'B'C'

QC=-QLOADS=-5313 kvar

QCΔ=3·ω·CΔ·UL^2

CΔ=5313·10^3/3·2·π·50·72·10^3=1.087·10^{-6} F

IL'=P/sqrt(3)·UL=12614/ sqrt(3)·72000= 101 A