GEBZE TECHNICAL

UNIVERSITY

ELECTRONIC

ENGINEERING

ELEC-227

Circuit Theory II Project

Prepared by
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1. Answer the following questions by assigning the first two digits and the last two digits of your school number (XX……...YY) to the resistance (XX) and reactance (YY) of load, respectively in the balanced three-phase circuit shown in Figure 1.

a) Determine the power delivered to the load (apparent power, complex power, active and reactive power).

b) Determine the each line current (Ia, Ib, Ic).

c) Determine the each line to neutral voltage (VAN, VBN, VCN).

d) Determine the compensating impedance to the load to adjust the power factor to 1.

e) Determine items a, b and c after compensation.

f) Make comparisons and comments on items a, b, c, and e. Verify with any application (i.e. PSpice, Multisim, etc.

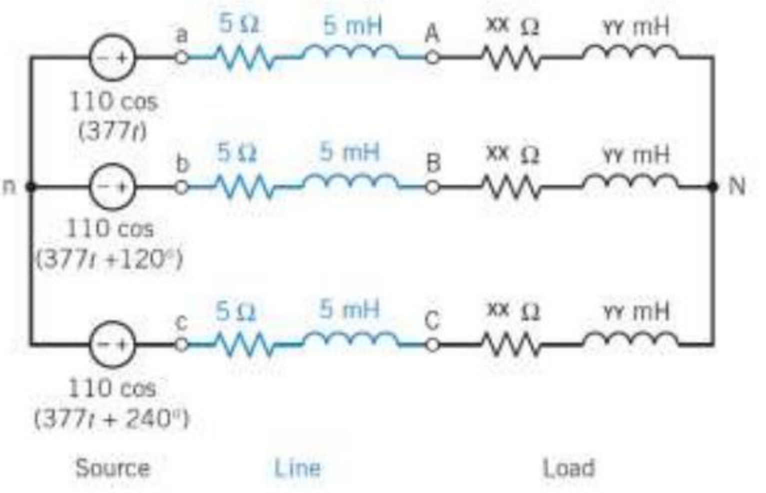


Figure 1

XX = 20 → First two digits of school number

YY = 43 → Last two digits of school number

SOLUTİON :

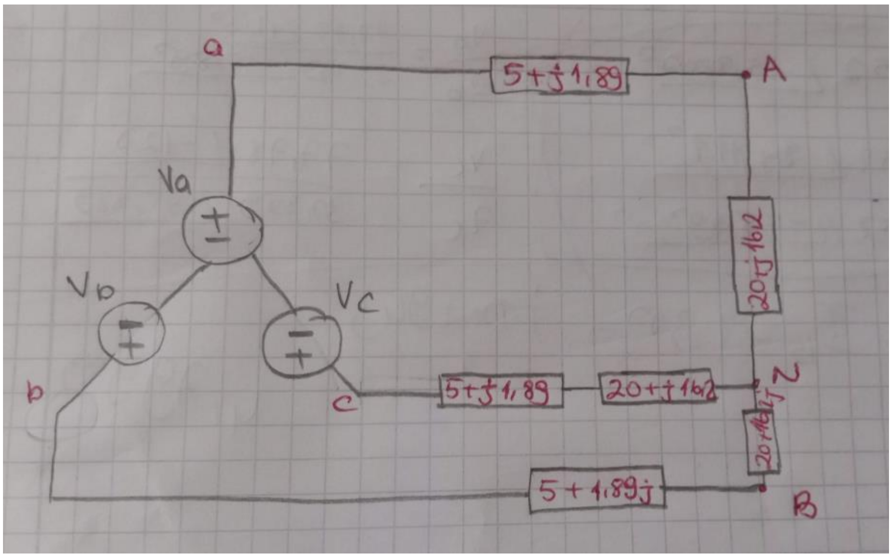


Figure 2

$V_a = 110 * \cos(377t) \quad = 77{,}78 \angle 0° \ V_{rms}$

$V_b = 110 * \cos(377t + 120) \quad = 77{,}78 \angle 120° \ V_{rms}$

$V_a = 110 * \cos(377t + 240) \quad = 77{,}78 \angle {-120}° \ V_{rms}$

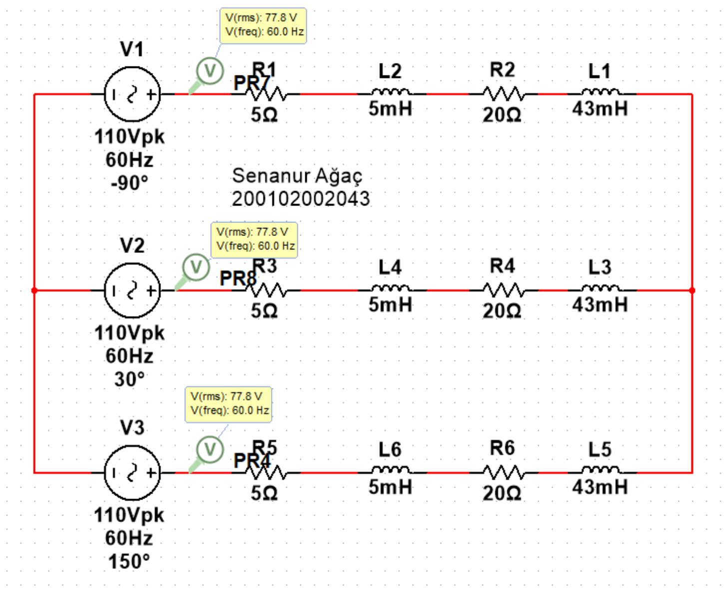


Figure 3

$Z_{LİNE} = 5\Omega + 5mH \quad = 5\Omega + jwl = 5 + j1{,}89\ \Omega$

$Z_{LOAD} = 20\Omega + 43mH = 2\Omega + jwl = 20 + j16{,}2\ \Omega$

$Z_{sum} = 25 + j18{,}09\ \Omega$

$I_A = \dfrac{Va}{Zsum} = \dfrac{77{,}78 \angle 0°}{28 + j18{,}09\,\Omega} = 2{,}52 \angle {-35{,}889}°\ A$

$I_B = \dfrac{Vb}{Zsum} = \dfrac{77{,}78 \angle 120°}{28 + j18{,}09\,\Omega} = 2{,}52 \angle 84{,}111°\ A$

$I_C = \dfrac{Vc}{Zsum} = \dfrac{77{,}78 \angle {-120}°}{28 + j18{,}09\,\Omega} = 2{,}52 \angle {-155{,}89}°\ A$

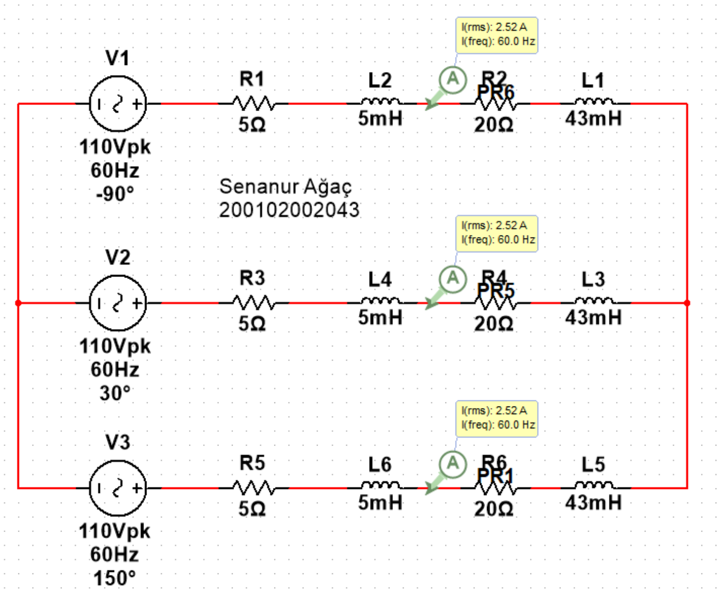


Figure 4 : Simulation

It should be $I_A + I_B + I_C = 0$. Let's verify this ;

(2,52 ∠-35,889° A) + (2,52 ∠84,111° A) + (2,52 ∠-155,89° A) = 0.00001 + j0.00004

It is very close to 0 due to the rounding in mathematical calculations.

$V_{AN} = I_A * Z_{LOAD}$ = 2,52 ∠-35,889° A * (20 + j16,2 Ω) = 64,64 ∠3,985° V

$V_{BN} = I_B * Z_{LOAD}$ = 2,52 ∠84,111° A * (20 + j16,2 Ω) = 64,86 ∠123,12° V

$V_{CN} = I_C * Z_{LOAD}$ = 2,52 ∠-155.89° A * (20 + j16,2 Ω) = 64,859∠-116,88° V

Figure 5: Simulation

Apparent Power = $V_{AN} * I_{LOAD}$ = 64,64 * 2,52 = 162,8 VA

Complex Power = $V_{AN} * I_{LOAD}^*$ = 64,64 ∠3,118° * 2,52 ∠35,889° = 162,89 ∠39,007

163,44 ∠39,007° = $\underbrace{127.004}_{\text{Active power}}$ + $\underbrace{j102.87 \text{ VA}}_{\text{Rective power}}$

Active Power = 127.004 W

Reactive Power = 102.87 VAR

Power Factor = Active Power / Reactive Power = 127.004/ 162.8 = 0.79

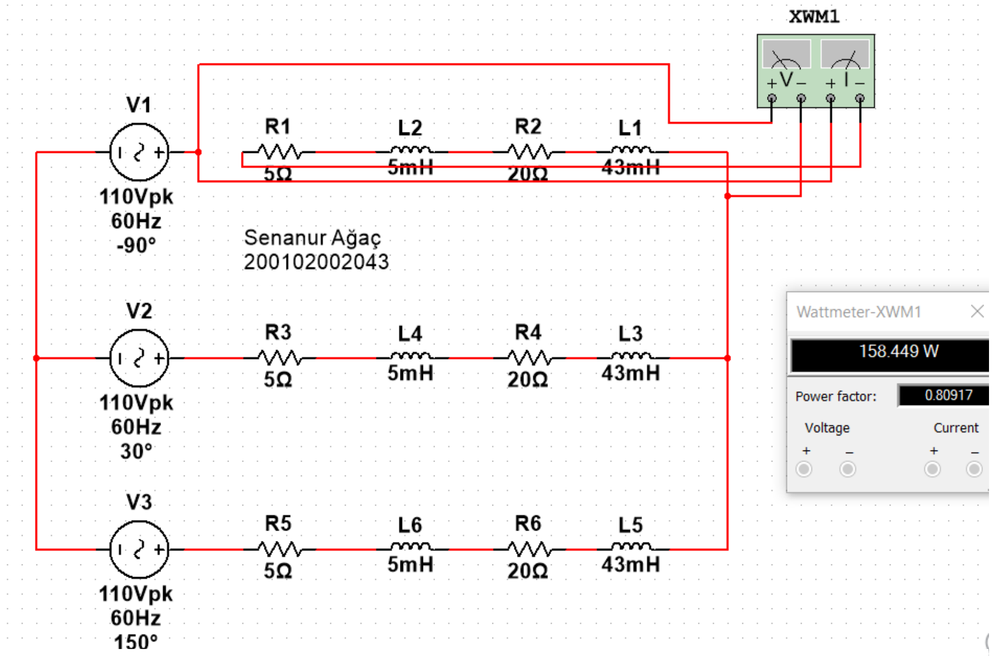
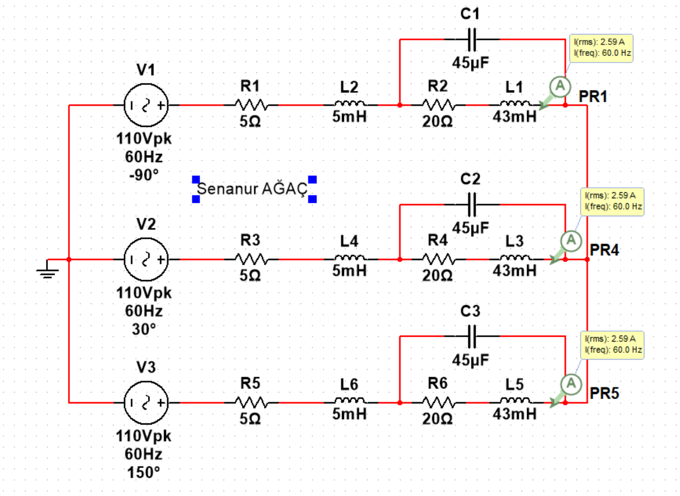


Figure 6 : Simulation

e)

Q



W= Vrms^2 / (w*c) → 102.87 = (77.78)^2 / (1/377*C) → C= 45 uF
Zc = j58.9 → j59

Zline = 5 + j1,89 Ω

Zload= 20 + 16.2 Ω

Zline + Zload = 25 + 18.09

2. Answer the following questions by assigning the first two digits and the last two digits of your school number (XX……….YY) to the resistance (XX) and reactance (YY) of each phase load, respectively in the unbalanced three-phase circuit shown in Figure 2.

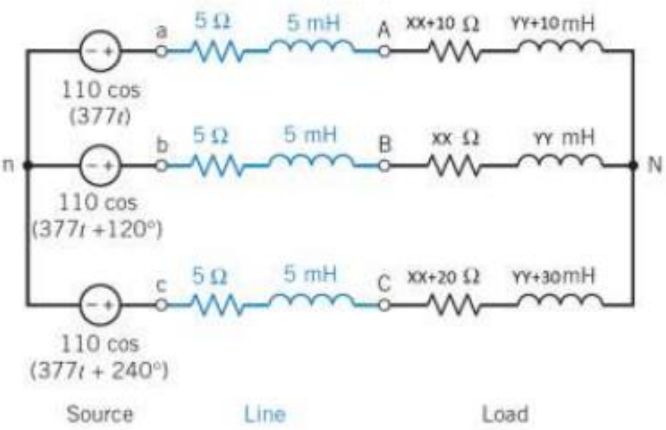
a) Determine the power delivered to the unbalanced load (apparent power, complex power, active and reactive power).

b) Determine the each line current (Ia, Ib, Ic).

c) Determine the each line to neutral voltage (VAN, VBN, VCN).

d) Determine the compensating impedance to the each phase load to adjust the power factor to 1.

e) Determine items a, b and c after compensation. f) Make comparisons and comments on items a, b, c, and e.



XX = 20 → First two digits of school number

YY = 43 → Last two digits of school number

Figure 2

$V_a = 110 * \cos(377t)$ $= 77,78 \angle 0°\ V_{rms}$

$V_b = 110 * \cos(377t + 120)$ $= 77,78 \angle 120°\ V_{rms}$

$V_c = 110 * \cos(377t + 240)$ $= 77,78 \angle -120°\ V_{rms}$

$Z_{load\text{-}a} = 30 + j*377*(53*10^{-3}) = 30 + j19.9\ \Omega$

$Z_{load\text{-}b} = 20 + j*377*(43*10^{-3}) = 20 + j16.2\ \Omega$

$Z_{load\text{-}c} = 40 + j*377*(73*10^{-3}) = 40 + j27.5\ \Omega$

$Z_{line\text{-}a} = Z_{line\text{-}b} = Z_{line\text{-}c} = 5 + j1,89\ \Omega$

$$I_A = \frac{Va}{Zline-a+load-a} = \frac{77,78 \angle 0°}{35 + j21,79\,\Omega} = 1,886 \angle -31,905°\ A$$

$$I_B = \frac{Vb}{Zline-b+load-b} = \frac{77,78 \angle 120°}{25 + j18,09\,\Omega} = 2,52 \angle 84,126°\ A$$

$$I_C = \frac{Vc}{Zline{-}c{+}load{-}c} = \frac{77{,}78\ \angle{-120°}}{45 + j29{,}39\ \Omega} = 1{,}447\ \angle{-153{,}149°}\ \text{A}$$

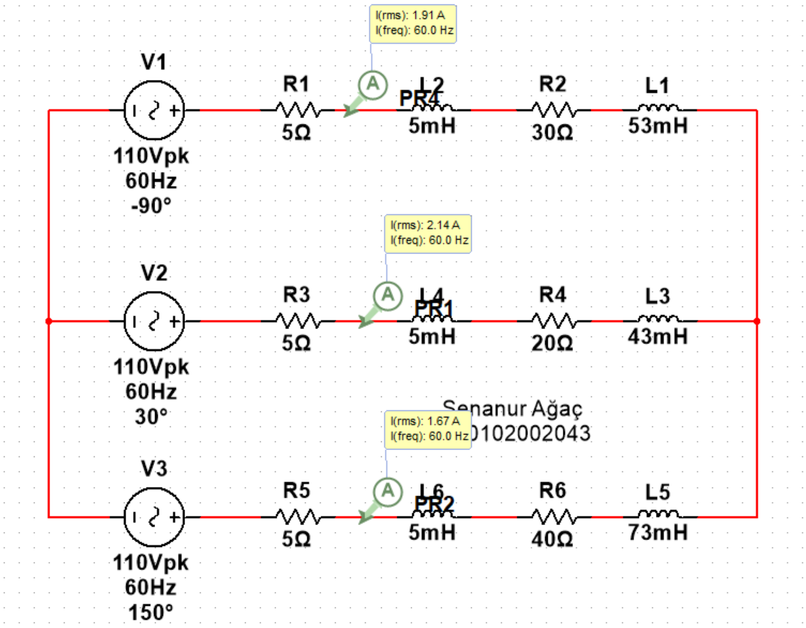


Figure 7 : Simulation