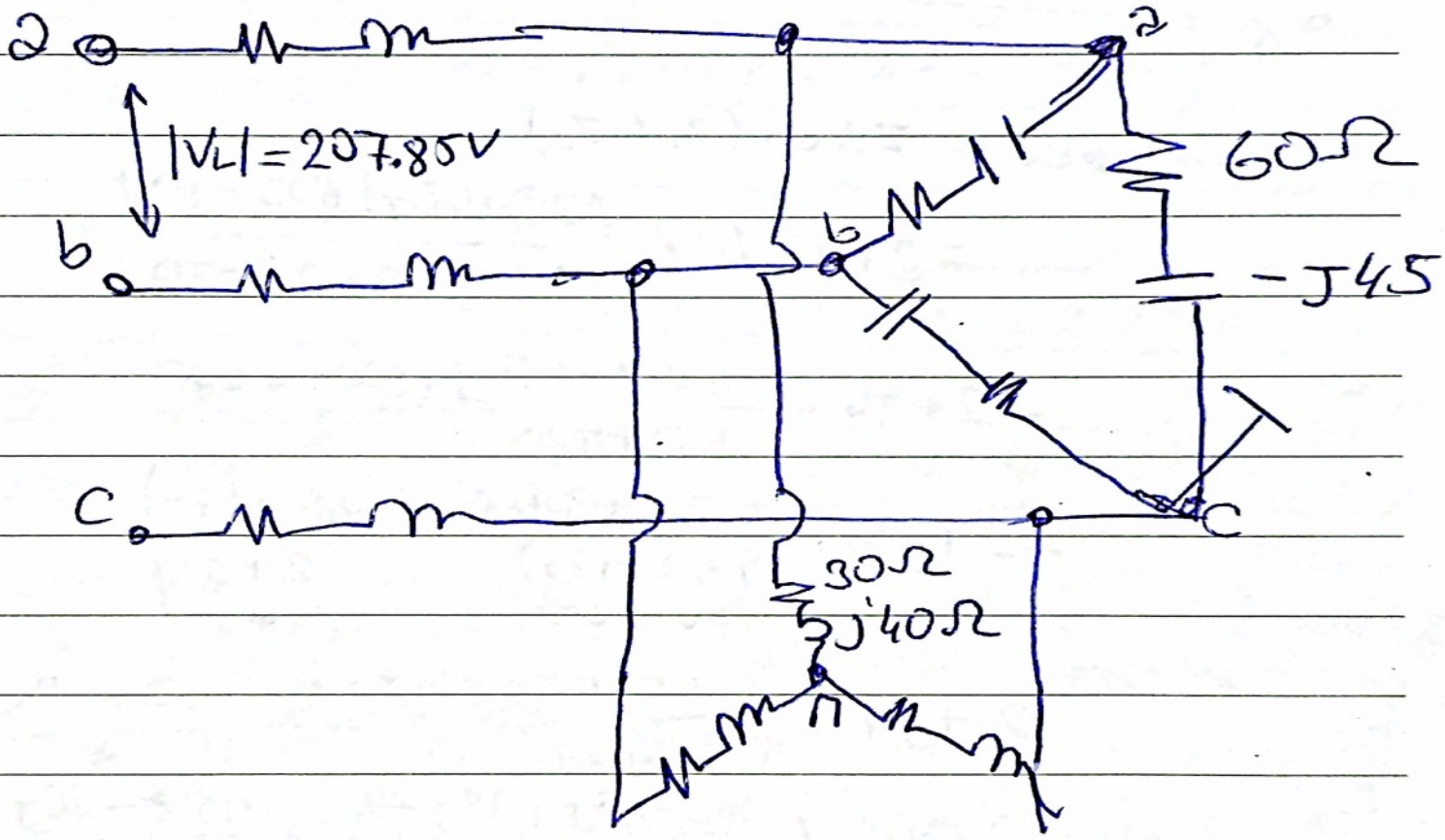
3-phase Systems

A 3-phase line has an impedance of $2+j4\,\Omega$ as shown below. Two loads are connected in parallel as shown below.



a) The current, real power, and reactive power drawn
b) The line current at the load terminals
c) The current per phase for each load.
d) Total and reactive powers in each load and the line

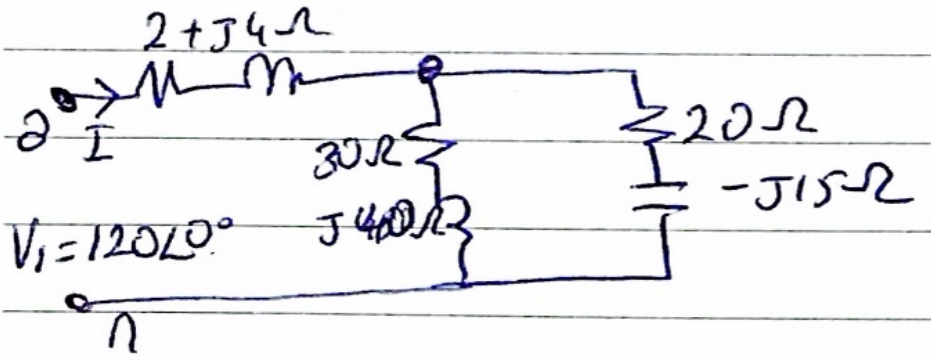
⇒ convert Δ load into Y

$$Z_Y = \frac{Z_\Delta}{3} \Rightarrow Z_2 = \frac{60-j45}{3} = 20-j15\,\Omega$$

$$V_{an} = \frac{207.85}{\sqrt{3}} = 120 V_{ac}$$

phase voltage

Draw single phase equivalent circuit



Total impedance = $Z_{line} + (Z_1 // Z_2)$

$$= 2+J4\Omega + \frac{(30+40J)(20-J15)}{30+J40+20-J15}$$

$$= 2+J4 + \frac{600-450J+800J+600}{50+J25}$$

$$= 2+J4 + \left(\frac{1200+350J}{(50+J25)} = \frac{48+14J}{(2+J)}\right)$$
$$\frac{(50+J25)}{(2+J)}$$

$$2+J4 + \left(\frac{96+48J+28J-14}{4+4} = \frac{82+76J}{5}\right)$$

$$2+J4 + \left(\frac{96-48J+28J+14}{5}\right) = \frac{110-20J}{5}$$

$$2+J4+22-J4 = 24\Omega$$ (all system behaves as resistive)

$$I_1 = \frac{V_1}{Z} = \frac{120}{24} = 5A\angle 0°$$

$$S = 3V_1 I_1^* = 3\ 120\angle 0°\ 5\angle 0° = 1800\,w$$

b) The phase voltage at the load terminals.

$V_2 = 120\angle 0 - (2+J4)\,5\angle 0°$

$= 110 - J20 \Rightarrow 111,8\angle -10,3°$ ✓

Line voltage

$V_{2,ab} = \sqrt{3}\cdot\angle 30° V_2 \Rightarrow \sqrt{3}\,111.8\angle 19.7 = 193,6\angle 19,7°$

c) Current per phase for each load.

$I_1 = \frac{V_2}{Z_1} = \frac{110 - J20}{30+J40} = 1 - J2 = 2,236\angle -63,4°$

↳ lagging

$I_2 = \frac{V_2}{Z_2} = \frac{110 - J20}{20 - J15} = 4 + J2 = 4.47\angle 26,6°$

↳ leading

d) Total reactive powers.

$S_1 = 3V_2 I_1^* = 3,\ 111.8\angle -10,3\,(2,236\angle 63,4) = 450 + J600\ VAR$

$S_2 = 3V_2 I_2^* \ 3.\ 111.8\angle 10,3\,(4.472\angle -26,56°) = 1200W$

$-J900\ VAR$

$S_L = 3(R_L + JX_L)\cdot |I|^2 = 3(2+J4)\cdot 5^2$

(Line)

$= 150W + J300\ VAR$

$S_{total} = S_1 + S_2 + S_{Line}$

$= 4500 + J600 + 1200 - J900 + 150 + J300$

$= 1800W$ ✓

no reactive power

(perfect power factor correction at load terminals).

source