Name (2 pts):____

Quiz 2, EE 303, September 14, 2017, Dr. McCalley. Closed book, closed notes, calculator allowed, communication devices not allowed; Answer on this sheet of paper.

1. A three-phase line has an impedance of 2+j4 ohms/phase, and the line feeds two balanced three-phase loads that are connected in parallel. The first load is Y-connected and has an impedance of 30+j40 ohms/phase. The second load is delta-connected and has an impedance of 60-j45 ohms/phase. The line is energized at the sending end from a three-phase balanced supply of line voltage 207.85 volts. Taking the phase voltage V_{an} at the supply as reference, determine:

a. (30 pts) The current, real power, and reactive power drawn from the supply.
b. (25 pts) The line voltage at the combined loads.
c. (25 pts) The current per phase in each load.

Solution:

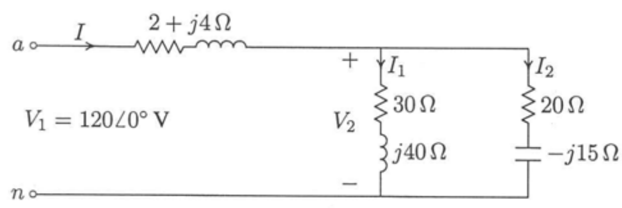
(a) The Δ-connected load is transformed into an equivalent Y. The impedance per phase of the equivalent Y is

$$Z_2 = \frac{60 - j45}{3} = 20 - j15\ \Omega$$

The phase voltage is

$$V_1 = \frac{207.85}{\sqrt{3}} = 120\ \text{V}$$

The single-phase equivalent circuit is shown in the following figure.



The total impedance is

$$Z = 2 + j4 + \frac{(30 + j40)(20 - j15)}{(30 + j40) + (20 - j15)} \quad = 2 + j4 + 22 - j4 = 24\ \Omega$$

with the phase voltage V_{an} as reference, the current in phase *a* is

$$I = \frac{V_1}{Z} = \frac{120\angle 0^\circ}{24} = 5\ \text{A}$$

The three-phase power supplied is

$$S = 3V_1 I^* = 3(120\angle 0^\circ)(5\angle 0^\circ) = 1800\ \text{W}$$

(b) The phase voltage at the load terminal is

$$V_2 = 120\angle 0^\circ - (2 + j4)(5\angle 0^\circ) = 110 - j20 = 111.8\angle -10.3^\circ\ \text{V}$$

The line voltage at the load terminal is

$$V_{2ab} = \sqrt{3}\angle 30^\circ V_2 = \sqrt{3}(111.8)\angle 19.7^\circ = 193.64\angle 19.7^\circ\ \text{V}$$

(c) The current per phase in the Y-connected load and in the equivalent Y of the Δ load is

$$I_1 = \frac{V_2}{Z_1} = \frac{110 - j20}{30 + j40} = 1 - j2 = 2.236\angle -63.4^\circ\ \text{A};\qquad I_2 = \frac{V_2}{Z_2} = \frac{110 - j20}{20 - j15} = 4 + j2 = 4.472\angle 26.56^\circ\ \text{A}$$

The phase current in the original Δ-connected load, i.e., I_{ab} is given by

$$I_{ab} = \frac{I_2}{\sqrt{3}\angle -30^\circ} = \frac{4.472\angle 26.56^\circ}{\sqrt{3}\angle -30^\circ} = 2.582\angle 56.56^\circ\ \text{A}$$

2. (18 pts) Consider the relation S=(√3)|**V**$\mathbf{V_{LL}}$||$\mathbf{I_L}$|[cosθ+jsinθ], where $\mathbf{V_{LL}}$ is the line-to-line voltage phasor and $\mathbf{I_L}$ is the line current phasor, and |•| indicates magnitude. Answer true/false for the below statements:

F____a) S is the per-phase complex power.
T____b) This relation can be used for both Y- and Δ-connected loads.
F____c) The angle θ is the angle by which V_{LL} leads I_L.