EE 205 Circuit Theory

Lab 4

3-Phase Balanced Circuit Analysis

The aim of this lab is 3-phase balanced YY connection circuit.

Consider the example circuit given below. We have already solved this question in the previous lecture. Here, we want to verify the calculated results with the Proteus simulations. First we will analyze voltages and currents.

Ex: A balanced three-phase Y connected generator of $0.2 + j0.5\,\Omega$ impedence and 120V voltage.

The generator feeds a balanced three-phase Y-connected load having an impedence of $39 + j28\,\Omega$.

The impedence of the line is $0.8 + j1.5\,\Omega$.

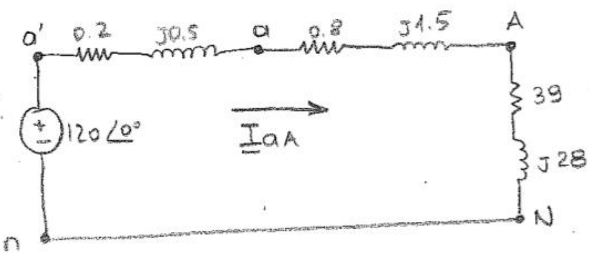
a) Construct the a-phase (reference) equivalent of the system.

b) Calculate the three line currents.

c) Calculate the three phase voltages at the load.

d) Calculate the phase voltages at the terminals of the generator.

Solution: a)



b) $\underline{I}_{aA} = \dfrac{120\angle 0}{(0.2+0.8+39)+j(0.5+1.5+28)} = \dfrac{120\angle 0°}{40+j30} = 2.4\angle -36.87°$ A

$\underline{I}_{bB} = 2.4\angle -156.87°$ A , $\underline{I}_{cC} = 2.4\angle 83.13°$ A

c) $\underline{V}_{AN} = (39+j28)(2.4\angle -36.87°) = 115.22\angle -1.19°$ V

$\underline{V}_{BN} = 115.2\angle -121.19°$ V , $\underline{V}_{CN} = 115.2\angle 118.81°$ V

d) $\underline{V}_{AB} = (\sqrt{3}\angle 30°)\,\underline{V}_{AN} = 199.58\angle 28.81°$ V

$\underline{V}_{BC} = 199.58\angle -91.19°$ V , $\underline{V}_{CA} = 199.58\angle 148.81°$ V

Procedure:

1. Draw the following circuit:
   Remember the values for the inductors have to evaluated beforehand.

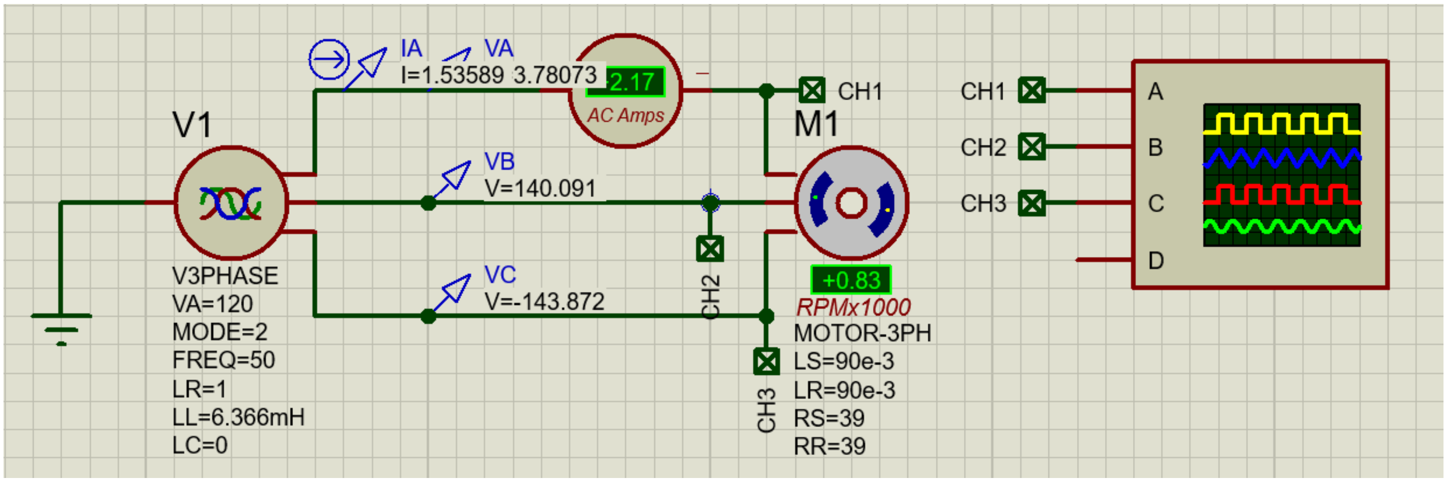


Fig.2. Circuit schematics

2. Place a 3 phase voltage source and 3 phase induction motor.
3. Place an AC amp-meter in series with the circuit.
4. Set the sum of the generator and line impedances inside the 3 phase voltage source as “line resistance and inductance”.
5. Set the load resistance and inductance for the motor.
6. Connect and oscilloscope at three phase load terminals. You may use dynamic terminals to eliminate wire congestion.
7. Run the simulation.
8. Observe the “line to neutral voltage” amplitudes and fill the table below. Do not consider their angles with respect to the generator. Just observe the angle difference between each pair of voltages.
9. As the motor rotates, it takes time for the speed to build up. Thus, you must wait for about 3-4 min. Only then you can measure the current amplitude. Do not consider its phase. Alternatively, you may use graphs to plot the line currents. This takes shorter, however, you must set the simulation time to start from 240 sec. or 300 sec.

Table 1. Voltage and Current Amplitudes

VA amplitude (calculated)	VA amplitude (measured)	Angle between VA, VB and VC (measured)	Single line current Amplitude (measured)
115V			

Power Calculations:

Consider the following example.

EX: a) Calculate the average power per phase delivered to the Y-connected load in the previous example.

b) Calculate P_{total} delivered to the load.

Ans: a) $V_\phi = 115.22\ V$, $I_\phi = 2.4\ A$, $\theta_\phi = -1.19 - (-36.87) = 35.68°$

$\Rightarrow P_\phi = (115.22V)(2.4A)\cos(35.68°) = 224.64\ W$

b) $P_{total} = 3P_\phi = 673.92\ W$

Procedure: Plot the instantaneous power p=VA*IA graph, and fill the table.

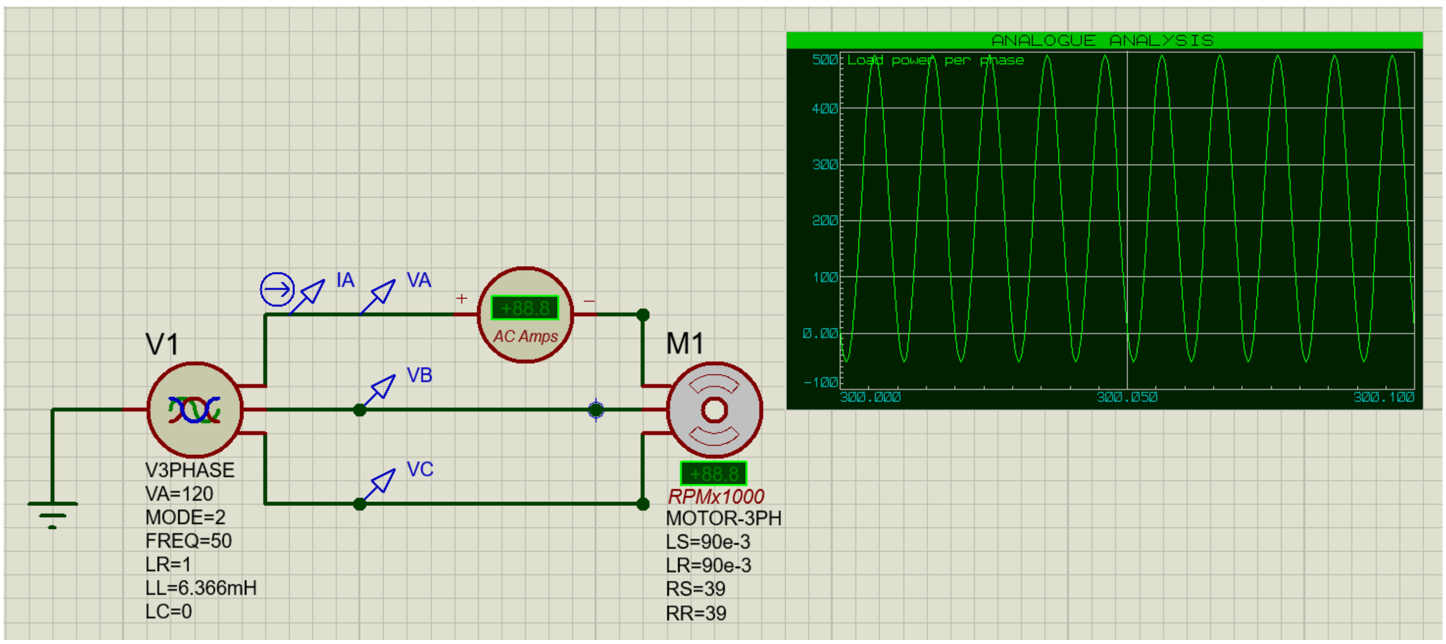


Table 2. Average power measurements

Average power Per phase (calculated)	Average power Per phase (measured)	Total average power (measured)	Single line current Amplitude (measured)
224 W			