Experiment 4b: Three-Phase Power / Delta Connection

This experiment involves the measurement of voltage amplitudes and phase angles in a Three-phase wye-delta circuit. It demonstrates the effects of balanced, unbalanced, and reactive delta connected loads.

All measurements are from line to neutral. Line current and line to line voltage is calculated from the line to neutral measurements. Line resistance is represented by 10Ω resistors

Equipment and Parts

Voltage Source: Three Phase, 12Vp-p , Oscilloscope, and Breadboard.
Resistors: Three 10Ω, four 1k, all ¼ watt, 5%. Capacitor: 4.7µF ceramic.

Procedure: Part 1, Balanced Load

Connect the circuit in figure 4-19 below. The 3-phase source outputs are set to: **Va** = $12\angle 0^0$ V p-p, **Vb** = $12\angle 120^0$ V p-p, **Vc** = $12\angle -120^0$ V p-p.

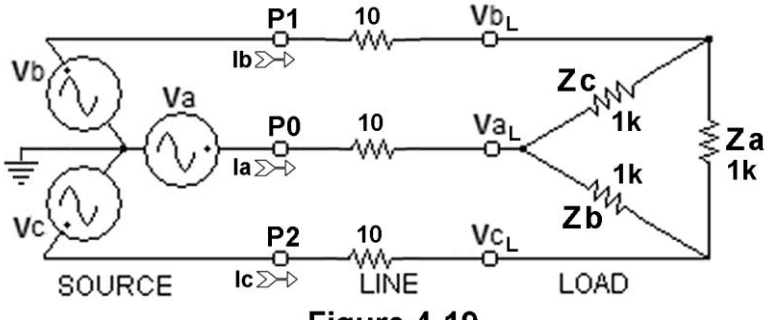

Figure 4-19

2. Connect channel 1 of the oscilloscope to P0. Trigger on channel 1. Connect channel 2 of the oscilloscope to P1. Measure and record the magnitude of **Va** and the magnitude and phase angle of **Vb**.

   Va:_____ V p-p **θa**: $\underline{0^0}$ **Vb**:_____ V p-p **θb**:_____^{0}

3. Connect channel 2 of the oscilloscope to P2. Measure and record the magnitude of **Vc** and the magnitude and phase angle of **Vc**.

   Vc:_____ V p-p **θc**:_____^{0}

4. **Balanced Load:** Measure and record the voltages and phase angles of **Val**, **Vbl**, and **Vcl** with channel 2 of the oscilloscope. Record below:

Step 4 node		**Val**	**Vbl**	**Vcl**
Mag. V p-p				
Angle Deg.				

5. **Unbalanced Load:** Connect a 1k resistor in parallel with Rc.
6. Measure and record the voltages and phase angles of **Val**, **Vbl**, and **Vcl** with channel 2 of the oscilloscope. Record below:

Step 6 node		**Val**	**Vbl**	**Vcl**
Mag. V p-p				
Angle Deg.				

7. **Reactive Load**: Remove the 1k resistor in parallel with Rc. Connect a 4.7µF (non-polarized ceramic) in parallel with Rc.
8. Measure the magnitudes and phase angles of the voltages at nodes **Val. Vbl**, and **Vcl** with the oscilloscope channel 2 and record results below.

Step 2 node		**Val**	**Vbl**	**Vcl**
Mag. V p-p				
Phase, Deg.				

Analysis

1. Use the mesh current method to calculate the theoretical line current per phase and load current per phase for the balanced load. Calculate the measured line currents using measurements in step 4 of the procedure. Compare the calculated and measured results.

2. Use the mesh current method to calculate the theoretical line current per phase and load current per phase for the unbalanced load. Calculate the measured line currents using measurements in step 6 of the procedure. Compare the calculated and measured results.
3. Use the mesh current method to calculate the theoretical line current per phase and load current per phase for the reactive load. Calculate the measured line currents using the measurements in step 8 of the procedure. Compare the calculated and measured results.
4. Simulate the reactive load circuit and compare the results to your measurements.
5. Calculate the total average and reactive power delivered by the source and supplied to the load.
6. Calculate the circuit's power factor and efficiency.

LTspice Example

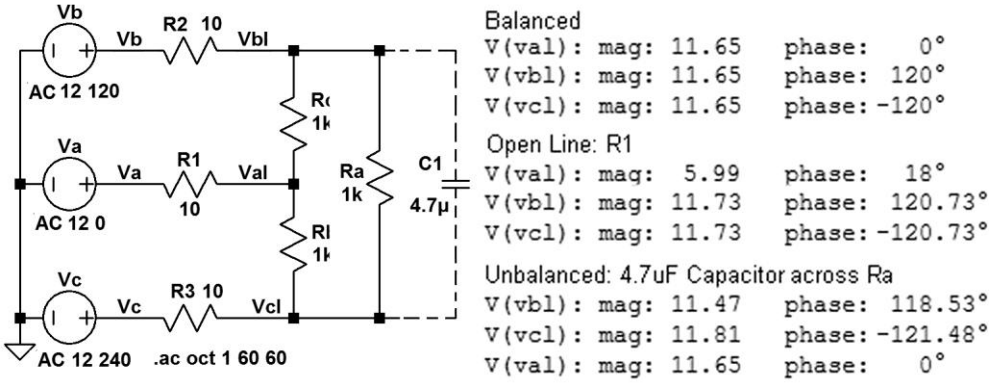

Figure 4-20

The circuit in figure 4-20 above was simulated for a balanced load and reactive load. In addition, a simulation was done with resistor R1 open (simulates an open transmission line).

TI-89 Example

Let **V**(nA) = x, **V**(nB) = y, **V**(nC) = z.

Equations:

$$\frac{x-12\angle 0}{100+37.7i}+\frac{x-y}{330}+\frac{x-z}{330}=0 \text{ and } \frac{y-12\angle 120}{100+37.7i}+\frac{y-x}{330}+\frac{y-z}{330}=0$$

$$\text{and } \frac{z-12\angle 240}{100+37.7i}+\frac{z-x}{330}+\frac{z-y}{330}=0$$

TI-89 input:

Balanced case:

csolve((x-12)/(100+37.7i)+(x-y)/330+(x-z)/330=0 and
(y-(12∠120))/(100+37.7i)+(y-x)/330+(y-z)/330=0 and
(z-(12∠240))/(100+37.7i)+(z-x)/330+(z-y)/330=0,{x,y,z})

x = (6.187∠-10.8) y = (6.187∠109.8)z = (6.187∠-130.2)

Unbalanced case:

csolve((x-12)/(100+37.7i)+(x-y)/330+(x-z)/220=0 and
(y-(12∠120))/(100+37.7i)+(y-x)/330+(y-z)/330=0 and
(z-(12∠240))/(100+37.7i)+(z-x)/220+(z-y)/330=0,{x,y,z})

x = (5.611∠-15.12) y = (6.187∠109.82) z = (5.477∠-127.29)