Experiment 5b: Delta-Wye transformer

A delta-wye configuration is typically used to step down transmission line and distribution line voltages. For example, it may be used to step down a 13.2KV distribution line voltage to a 240V/120V single-phase residential supply or a 208V/120V Three-phase commercial supply. A four wire service can provide Three phases of 208V line to line voltage and three phases of 120V line to neutral voltage.

Equipment and Parts

Function Generator, Oscilloscope, DMM, and Breadboard.
Resistors: Three 10Ω, three 1k, all ¼ watt, 5%.
Capacitor: 0.68uF, 5%, Film type (4.7µF ceramic for 60Hz).
Transformer, Three 500Ω CT to 500Ω CT, 400mW (see appendix 2).
Recommended: ZICON 42TU500-RC (from Mouser Electronics)

Note: The specified 400mW transformer may be used at 60Hz. If 60Hz is used, use a 4.7µF capacitor instead of the 0.68µF. The results will show a somewhat lower efficiency.

Procedure: Part 1, No Fault

1. Connect the circuit in Figure 5-5 below. **J1** is a jumper that will be connected for part 1 and part 3 of this experiment, and disconnected for part 2. The frequency of the Three-phase source is 400Hz. The amplitude of each phase is 12V p-p at the phase angles indicated.

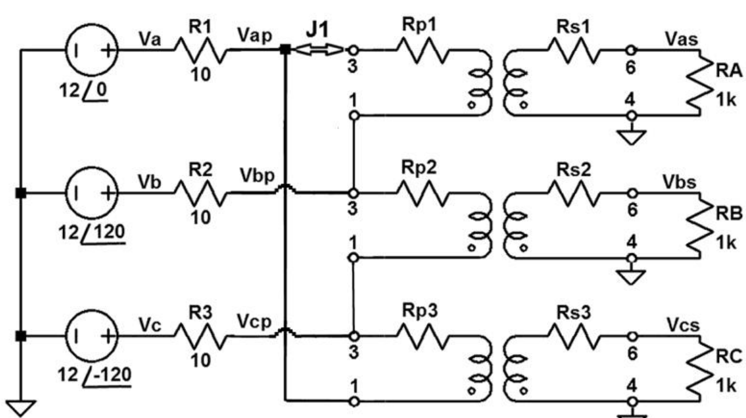


Figure 5-5

2. Connect oscilloscope channel 1 to **Va.** Trigger on channel 1. **Va** will be the reference phase for the entire experiment.
3. 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}

   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. Measure and record the primary voltages **Vap**, **Vbp**, and **Vcp**.

node		**Vap**	**Vbp**	**Vcp**
Mag. V p-p				
Angle Deg.				

5. Measure and record the secondary voltages **Vas**, **Vbs**, and **Vcs**.

node		**Vas**	**Vbs**	**Vcs**
Mag. V p-p				
Angle Deg.				

Procedure: Part 2, Open Primary Winding

1. Remove the jumper **J1**.
2. Measure and record the primary voltages **Vap**, **Vbp**, and **Vcp**.

node		**Vap**	**Vbp**	**Vcp**
Mag. V p-p				
Angle Deg.				

3. Measure and record the secondary voltages **Vas**, **Vbs**, and **Vcs**.

node		**Vas**	**Vbs**	**Vcs**
Mag. V p-p				
Angle Deg.				

Procedure: Part 3, Reactive Load

1. Reconnect the jumper **J1**. Connect a 0.68μF capacitor across Rc (4.7μF for 60Hz) .
2. Measure and record the primary voltages **Vap**, **Vbp**, and **Vcp**.

node		**Vap**	**Vbp**	**Vcp**
Mag. V p-p				
Angle Deg.				

3. Measure and record the secondary voltages **Vas**, **Vbs**, and **Vcs**.

node		**Vas**	**Vbs**	**Vcs**
Mag. V p-p				
Angle Deg.				

Analysis, Part 1

Use the part 1 measurements to make the calculations below.

1. Calculate the primary currents, **Ia**, **Ib**, and **Ic**.
2. Calculate the secondary line to line voltages and the total power, P, delivered to the load.
3. Calculate the total complex power, **S**, and total average power, P. Calculate the circuit's power factor.
4. Calculate the efficiency of the circuit and of the 3-phase transformer.
5. Compare your results to a simulation.

Analysis, Part 2

Use the part 2 measurements to make the calculations below.

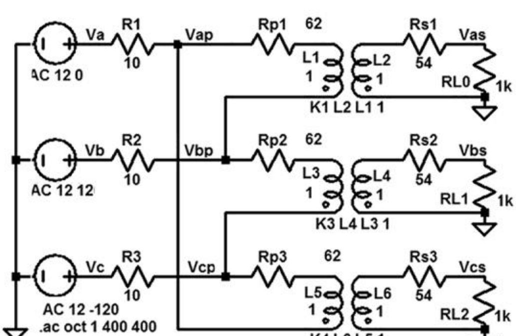
1. Calculate the primary currents, **Ia**, **Ib**, and **Ic**.
2. Calculate the secondary line to line voltages and the total power, P, delivered to the load. Calculate the efficiency of the circuit.
3. Calculate the total complex power, **S**, and total average power, P. Calculate the circuit's power factor.
4. Explain the voltage across the load resistor, Ra, when the primary winding of the phase **a** is open (R1 removed).

Analysis, Part 3

Use the part 3 measurements to make the calculations below.

1. Calculate the primary currents, **Ia**, **Ib**, and **Ic**.
2. Calculate the secondary line to line voltages and the total power, P, delivered to the load.
3. Calculate the total complex power, **S**, and total average power, P. Calculate the circuit's power factor.
4. Compare your results to a simulation.

LTspice Simulation



Normal

```
V(vap): mag: 11.68  phase:   0.59°
V(vbp): mag: 11.68  phase: 120.59°
V(vcp): mag: 11.68  phase:-119.40°
V(vas): mag: 18.12  phase: -28.07°
V(vbs): mag: 18.12  phase:  91.92°
V(vcs): mag: 18.12  phase:-148.07°
```

Open line (R1 open)

```
V(vap): mag:  5.99  phase: 180°
V(vbp): mag: 11.81  phase: 121.11°
V(vcp): mag: 11.70  phase:-120.23°
V(vas): mag:  9.06  phase: -88.07°
V(vbs): mag: 18.12  phase:  91.93°
V(vcs): mag:  9.06  phase: -88.07°
```