University of Jordan
School of Engineering
Electrical Engineering Department

EE 219
Electrical Circuits Lab

EXPERIMENT 8
DELTA-WYE CONVERSION

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EXPERIMENT 8
DELTA-WYE CONVERSION

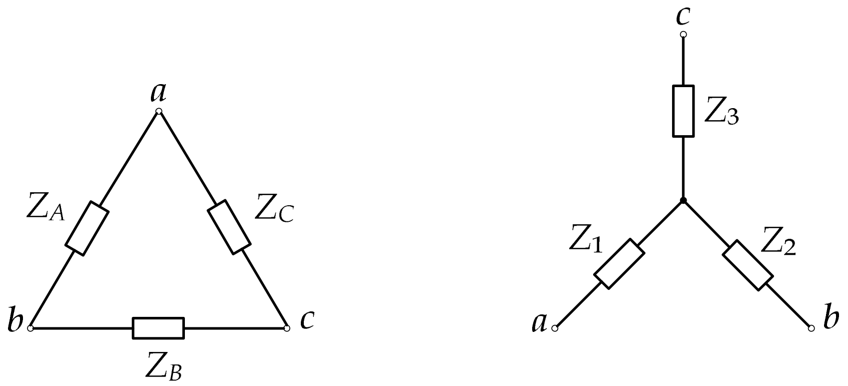
OBJECTIVE

This experiment investigates the Δ-Y and Y-Δ impedance conversion, and how can this be used to simplify the analysis of DC and AC circuits.

DISCUSSION

Delta-Wye and Wye-Delta Conversion

The following two impedance connections are electrically equivalent, because both result in the same voltage values across the three nodes *a*, *b* and *c*.



To convert from the Y configuration to the Δ configuration, we use the following equations:

$$Z_A = \frac{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}{Z_2}$$

$$Z_B = \frac{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}{Z_3}$$

$$Z_C = \frac{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}{Z_1}$$

Hence, the general rule is:

$$Z_\Delta = \frac{sum\ of\ pairwise\ products\ of\ Z_Y's}{the\ opposite\ Z_Y}$$

And to convert from Δ to Y, we use the following equations:

$$Z_1 = \frac{Z_AZ_B}{Z_A + Z_B + Z_C}$$

$$Z_2 = \frac{Z_BZ_C}{Z_A + Z_B + Z_C}$$

$$Z_3 = \frac{Z_CZ_A}{Z_A + Z_B + Z_C}$$

Hence, the general rule is:

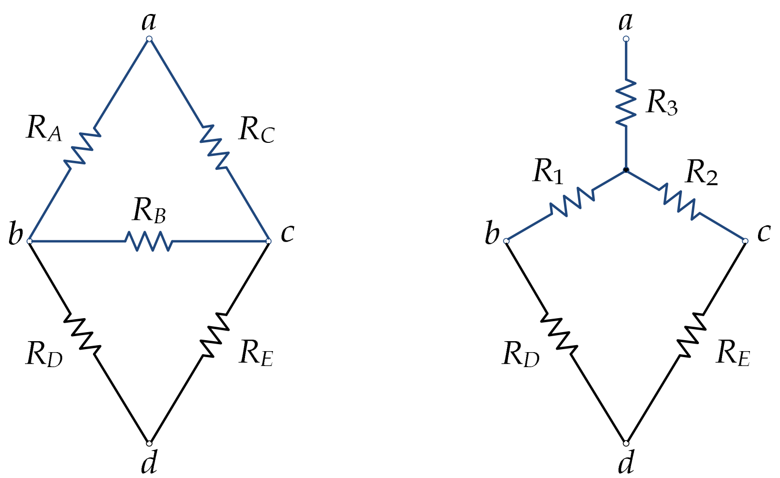
$$Z_Y = \frac{product\ of\ adjacent\ Z_\Delta's}{sum\ of\ Z_\Delta's}$$

If all the impedances are equal, the equations reduce to the following simple form:

$$Z_\Delta = 3 \times Z_Y$$

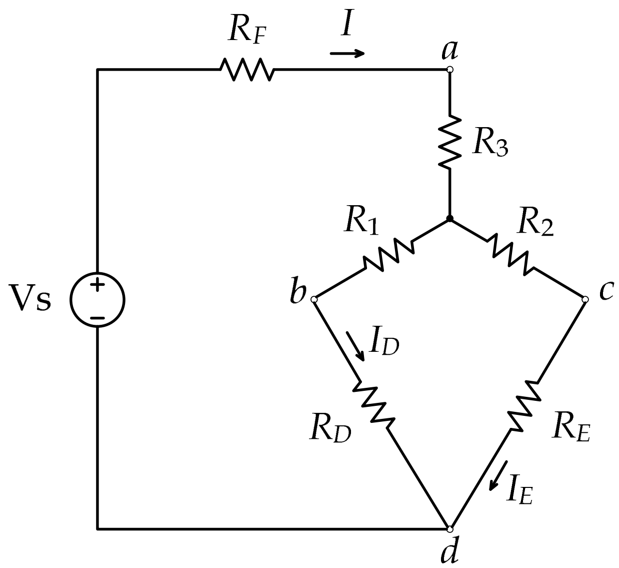
$$Z_Y = \frac{1}{3} \times Z_\Delta$$

The Δ-Y and Y-Δ impedance conversion is useful in many cases to quickly analyze circuits that otherwise require a more complex nodal or mesh analysis. An example is shown below, where a Δ-Y transformation of the left circuit to the right one allows us to apply a simple current divider to find the currents in R_D and R_E resistances, or to find the equivalent resistance between nodes a and d using parallel and series rules.



PROCEDURE A – Y-Δ TRANSFORMATION

1. Construct the circuit shown below. Assume that R_1 = 1000 Ω, R_2 = 3000 Ω, R_3 = 1710 Ω, R_D = 1600 Ω, R_E = 820 Ω, and R_F = 2200 Ω. The resistor R_3 can be built using a 510 Ω resistor in series with another 1200 Ω resistor.



2. Set the DC supply output voltage control to minimum then connect it to the circuit. Switch the DC supply ON, and set its voltage to Vs = 8 Volts. Verify this voltage using a voltmeter.

3. Use the current divider rule to calculate the theoretical currents I, I_D, and I_E and also to evaluate the theoretical voltages V_{ad}, V_{bd}, and V_{cd}. Record your answers in the theory part of Tables 1 and 2.

4. Using a voltmeter, measure the voltages V_{ad}, V_{bd}, and V_{cd}, and record the values in Table 1. Pay attention to polarity.

Table 1

V_{ad} (V)		V_{bd} (V)		V_{cd} (V)	
Theory	**Meas.**	**Theory**	**Meas.**	**Theory**	**Meas.**

5. Use an ammeter to measure the DC currents I, I_D, and I_E, and record the values in Table 2. Pay attention to polarity.

Table 2

I (mA)		I_D (mA)		I_E (mA)	
Theory	**Meas.**	**Theory**	**Meas.**	**Theory**	**Meas.**

6. Convert the Y connection in the above circuit (represented by R_1, R_2, and R_3) into a Δ connection, and draw the resulting circuit below.

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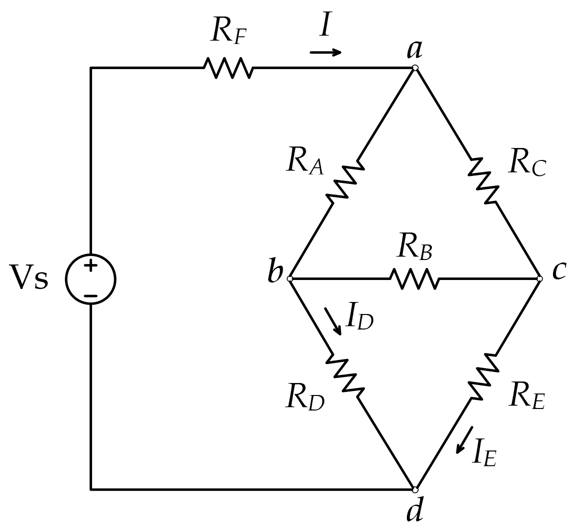
7. Now construct the circuit shown below. Assume that R_A = 3300 Ω, R_B = 5600 Ω, R_C = 10000 Ω, R_D = 1600 Ω, R_E = 820 Ω, and R_F = 2200 Ω.



8. Set the DC supply output voltage control to minimum then connect it to the circuit. Switch the DC supply ON, and set its voltage to Vs = 8 Volts. Verify this voltage using a voltmeter.

9. How is this circuit different than the equivalent circuit you sketched in part 6 above?

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10. Use nodal or mesh analysis in the above circuit to calculate the theoretical voltages V_{ad}, V_{bd}, and V_{cd} and theoretical currents I, I_D, and I_E. Record your answers in the theory part of Tables 3 and 4.

11. Using a voltmeter, measure the voltages V_{ad}, V_{bd}, and V_{cd}, and record the values in Table 3. Pay attention to polarity.

Table 3

V_{ad} (V)		**V_{bd} (V)**		**V_{cd} (V)**	
Theory	**Meas.**	**Theory**	**Meas.**	**Theory**	**Meas.**

12. Use an ammeter to measure the DC currents I, I_D, and I_E, and record the values in Table 4. Pay attention to polarity.

Table 4

I (mA)		I_D (mA)		I_E (mA)	
Theory	**Meas.**	**Theory**	**Meas.**	**Theory**	**Meas.**

13. Are the results in Tables 1 and 2 close to the values in Tables 3 and 4?

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14. Why are the values in Tables 1 and 2 not exactly the same as the values in Tables 3 and 4?

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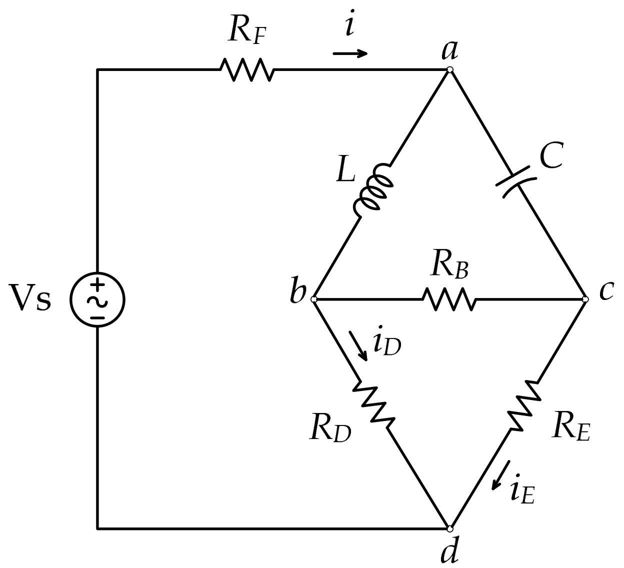
PROCEDURE B – Δ-Y TRANSFORMATION

1. Construct the circuit shown below. Assume that L = 10 mH, C = 2.2 μF, R_B = 10000 Ω, R_D = 680 Ω, R_E = 2200 Ω, and R_F = 100 Ω.



2. Set the function generator to produce a sinusoidal waveform (AC) with frequency of 10000 Hz, and *peak voltage* of V_p = 3 V.

CAUTION: Some older function generators have a defect and produce an AC signal with a slight DC shift. Hence, if you do not see a symmetric sinusoidal signal above and below zero volts, adjust the DC offset knob slightly to force a zero DC offset in the function generator output.

3. Use theoretical Δ-Y transformation of L, C and R_B to evaluate the currents $\boldsymbol{I_D}$ and $\boldsymbol{I_E}$ in the circuit, and also the voltages $\boldsymbol{V_{bd}}$ and $\boldsymbol{V_{cd}}$ and record the answers in Tables 5 and 6 at the different frequencies shown in the tables. Make sure to evaluate both magnitude and phase for each complex quantity.

4. Draw the equivalent circuit after you did the Δ-Y transformation for the frequency 10000 Hz.

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5. Use the oscilloscope to measure the peak values of the voltages $\boldsymbol{V_{bd}}$ and $\boldsymbol{V_{cd}}$ and their phase shifts compared to $\boldsymbol{V_S}$**.** Remember that you can change the horizontal sweep setting of the oscilloscope to make more accurate measurements of the phase. Record the measurements in Table 5, then evaluate the currents $\boldsymbol{I_D}$ and $\boldsymbol{I_E}$ and record the answers in Table 6.

CAUTION: Whenever you change the frequency of the function generator, verify the period of the signal from the oscilloscope to get accurate readings. Also re-check the peak-to-peak voltage as the function generator might change the amplitude when you change the frequency.

6. Where did you place the oscilloscope channel probes when measuring $\boldsymbol{V_{bd}}$?

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Table 5

AC Source Frequency (Hz)	$\boldsymbol{V_{bd}}$ **(peak) (V)**		$\measuredangle\boldsymbol{V_{bd}}$ **with** $\boldsymbol{V_s}$ **(degrees)**		$\boldsymbol{V_{cd}}$ **(peak) (V)**		$\measuredangle\boldsymbol{V_{cd}}$ **with** $\boldsymbol{V_s}$ **(degrees)**	
	Theory	**Meas.**	**Theory**	**Meas.**	**Theory**	**Meas.**	**Theory**	**Meas.**
10000								
60000								

Table 6

AC Source Frequency (Hz)	$\boldsymbol{I_D}$ **(peak) (mA)** $= \boldsymbol{V_{bd}}/R_D$		$\measuredangle\boldsymbol{I_D}$ **with** $\boldsymbol{V_s}$ **(=** $\measuredangle\boldsymbol{V_{bd}}$ **with** $\boldsymbol{V_s}$**)**		$\boldsymbol{I_E}$ **(peak) (mA)** $= \boldsymbol{V_{cd}}/R_E$		$\measuredangle\boldsymbol{I_E}$ **with** $\boldsymbol{V_s}$ **(=** $\measuredangle\boldsymbol{V_{cd}}$ **with** $\boldsymbol{V_s}$**)**	
	Theory	**Meas.**	**Theory**	**Meas.**	**Theory**	**Meas.**	**Theory**	**Meas.**
10000								
60000								

7. Does changing the frequency affect the answers in the above tables? Why?

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**** End ****