ECE 204 AC CIRCUITS

Lab # 5 Thévenin & Maximum Power Theorems

The objectives of this laboratory are to predict the Thévenin equivalent and maximum power output of a circuit in the phasor domain and to confirm the predictions with direct phasor measurements.

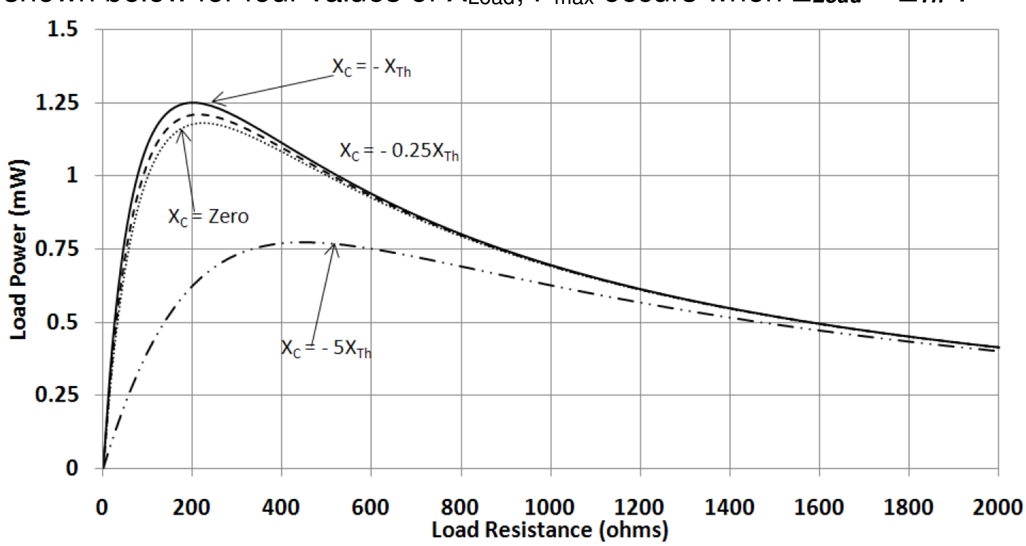
1.0 PRE-LAB

1.1 Read the complete laboratory procedure and be ready to apply it to your work. If you do not understand anything in the lab procedure, go and ask your instructor — don't wait until the lab has started; remember, the instructor has to deal with fifteen groups and you will be "waiting in line". Note that "waiting in line" is not a valid excuse for failing to finish the lab. You are expected to "budget your time" in lab and not waste it socializing.

1.2 Re-draw Figure 1 in the phasor domain, based on a frequency of 5 kHz.

1.3 Compute the Thévenin equivalent for the circuit described in Figure 1. Report your answer as a phasor, with peak voltage magnitude and give the angles in degrees. Model the 33 mH inductor with an inherent resistance of about 50 Ω and the 4.7 mH inductor with about 8 Ω.

1.4 At 5 kHz the Thévenin Impedance should be a resistor (R_{Th}) in series with an inductive reactance (jX_{Th}), R_{Th} should be slightly over 60 Ω and $X_{Th} \approx 2R_{Th}$. The power dissipated in the load is $P_{Load} = |I|^2 R_{Load}$ and will vary with both R_{Load} and jX_{Load}. Apply a software package of your choice (e.g. MATLAB, MAPLE, EXCEL, etc.) to model a Thévenin equivalent (like Figure 2 dotted line) with a variable load, comprised of a resistor (R_{Load}) and a capacitive reactance ($-jX_{Load}$). Plot a graph with P_{Load} as the y-axis and R_{Load} as the x-axis, as R_{Load} goes from zero to $10R_{Th}$ and X_{Load} equal to $-X_{Th}$. An example of this type of graph is shown below for four values of X_{Load}; P_{max} occurs when $\boldsymbol{Z_{Load} = Z_{Th}^*}$.



1.5 Submit a photocopy of the pre-lab at the ***start of the lecture preceding this lab.***

1.6 Follow the instructions for keeping lab notebooks (Lab B) in the course webpage.

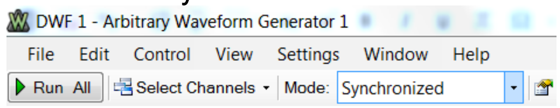
2.0 LAB PROCEDURE

2.1 <u>Measure Component Values</u>

Measure the nominal values of each individual component shown in Figure 1, using one of the R, L, C meters at the front of the lab and re-do the predictions in the pre-lab with the new nominal values. When doing the calculations the angle of AWG1 is zero so that $\boldsymbol{V_{Th}}$ is expressed with respect to AWG1. Also, predict the new value of P_{max}.

2.2 <u>Measure the Thévenin Equivalent Components</u>

Connect the circuit of Figure 1. Set the AWGs to give 7 V_{peak} at 5 kHz sinusoidal output. Be sure the AWG "Mode" is set to "Synchronized" as shown:



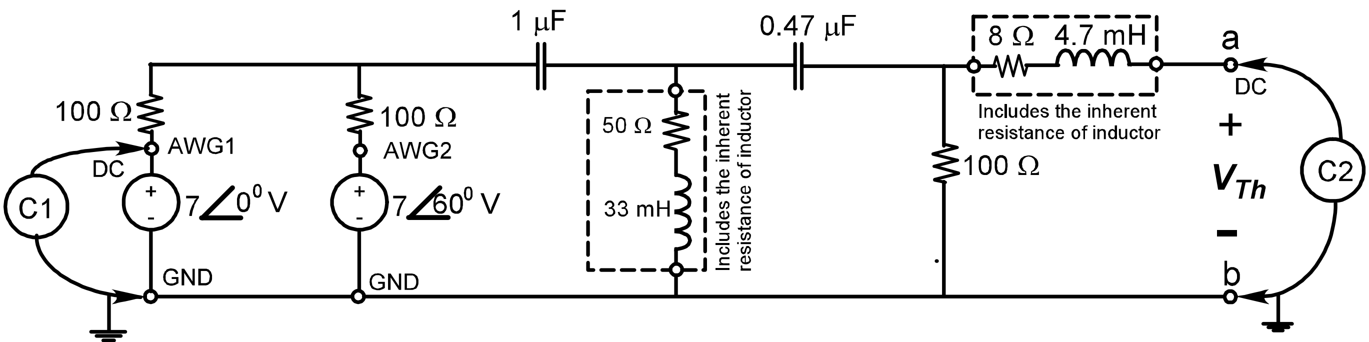


Figure 1—Circuit Diagram for *Thevenin Analysis*

Measure the magnitude and phase shift of the Thévenin Voltage. The Oscilloscope should be triggered off AWG1. Calculate the percent error of the Thévenin Voltage magnitude and state the phase error in degrees.

2.3 <u>Cancel Reactance and Measure Power as a Function of Load Resistance</u>

Predict the load reactance (X_{Load}) needed to cancel the Thévenin reactance (X_{Th}). Use a standard capacitor value to get close. Then add in parallel a variable capacitor to tune the capacitance to the exact amount needed to cancel the reactance and keep it constant. Next, attach a variable resistor in series with the capacitive load as shown in Figure 2. Trigger the Oscilloscope off the Load Voltage ($\boldsymbol{V_{Load}}$) and measure the load current phasor as the load resistance is varied from $0.1R_{Th}$, $0.3R_{Th}$, $0.6R_{Th}$, R_{Th}, $2R_{Th}$, $3R_{Th}$, and $10R_{Th}$.

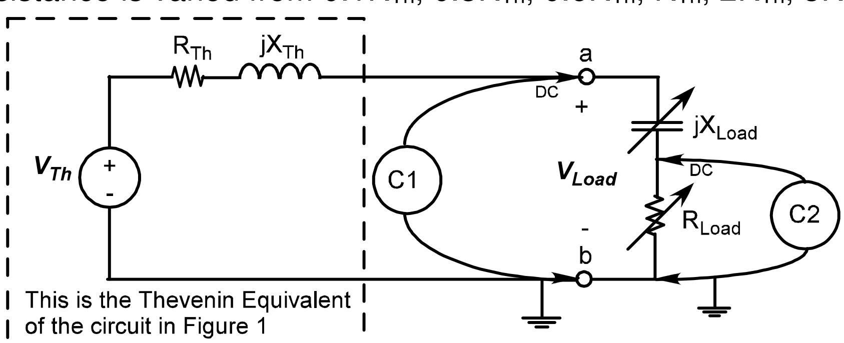


Figure 2—Circuit Diagram for *Load Power Measurement*

Calculate the load power from the current and load resistance values and plot it against load resistance. Compare these data to the pre-lab data on the same plot.

2.4 <u>Completion</u>

The lab-work is finished now make sure your lab notebook is properly completed by following the format of Lab B. Be sure to write a conclusion.