Learning Outcomes

Students will:
1. Validate the impedance of a resistor, capacitor, and inductor using steady-state time domain simulations.

Pre-Laboratory Assignment: NONE

Procedures

Resistor

1. Consider the circuit of Figure 1 with a 16V peak-to-peak 5000 Hz sinusoidal voltage source. Rs_{cr} is a current sampling resistor. Since the voltage at node 2 would be adjusted in lab to 16V peak-peak, the internal resistance of the waveform generator would have no effect on this experiment, and is not included in the schematic. Resistor Rs_{cr} would enable display of the current i(t) through R1 using an oscilloscope (an instrument that can only display voltage).

Using phasor analysis, find the voltage phasor \( V \) across R1 and current phasor \( I \) through R1. ASSUME Rs_{cr} = 0 in your calculations. NOTE: The voltage source in Figure 1 is a cosine source created by shifting a sine wave by 90 degrees.

2. Simulate the circuit using LTspice® with Rs_{cr} = 10 ohms using a transient analysis. Set “Stop Time” to 3 ms, “Time To Start Saving Data” to 1 ms, and “Maximum Time Step” to 0.01 µs. The delay in saving data is to enable the circuit to reach steady state.
   a. Plot v(t) for 1 ms by plotting v(2)-v(1).
   b. Plot i(t) on same plot.
   c. What is the phase relationship between voltage v(t) and current i(t)? Does it match your hand calculation?
      You may notice a small error here… WHY?
   d. What is the peak amplitude of the current i(t)? Does it match your hand calculation?
      You may notice a small error here… WHY?
   e. Plot 1000*(v(1)/10) to show the current i(t) through R1 in mA. This is how current i(t) will be measured in lab. Note that LTspice® will show units of V instead of mA.

Your final plot for R1 should look like Figure 2.
Inductor

3. Replace R1 with a 39 mH inductor and repeat steps 1-2. Run the simulation. Does something look strange? Yes… The circuit has not reached steady-state! Change the simulation command to \texttt{.tran 0 32ms 30ms .01us} and rerun the simulation.

Capacitor

4. Replace R1 with a 0.026 uF capacitor and repeat steps 1-2.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Circuit to Measure Steady-State Behavior of a Resistor}
\end{figure}

Since the voltage at node 2 is adjusted to be the desired peak voltage, the output resistance of the waveform generator is ignored.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{Steady state voltage and currents for the circuit of Figure 1.}
\end{figure}
Analysis

1. Why can the voltage $v(2)$ be considered roughly the same as $v(2)-v(1)$?

2. Sketch three phasor diagrams that show phasors $V$ and $I$ for the resistor, inductor and capacitor as obtained in the procedures for $R_{csr}=10$ ohms.

Credits and Copyright

Adapted from material developed by current and former ECE faculty, including Professor Joseph Kelemen. Thanks to Mohammad El Yabroudi, Sepehr Emamian, Masoud Panahi, and Simin Masihi for improvements to this lab.

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