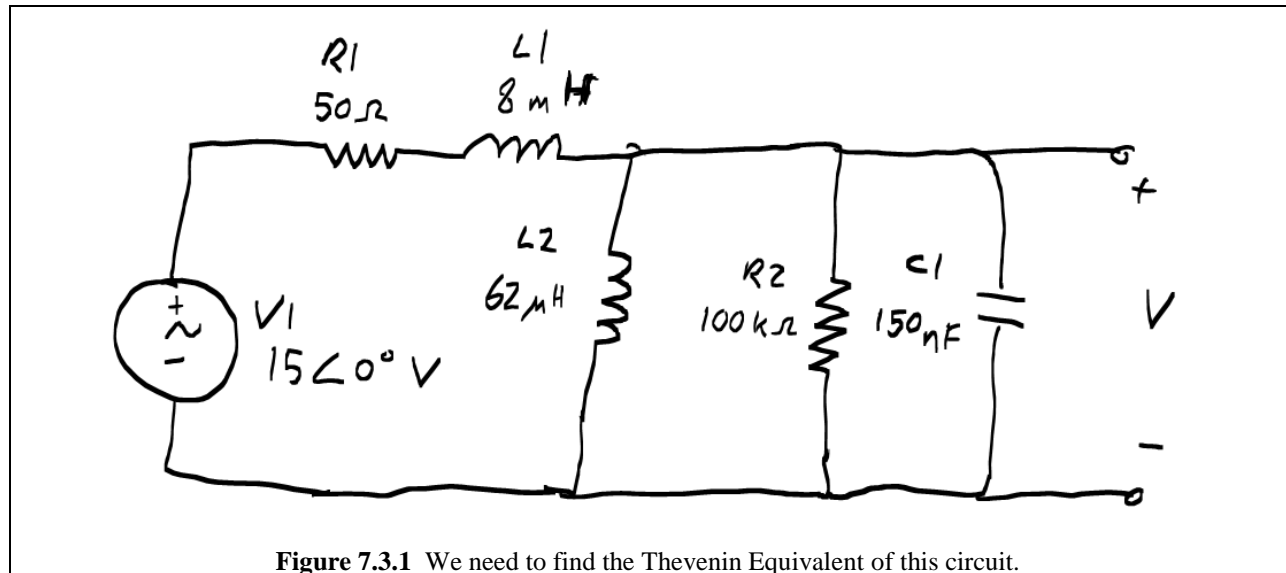


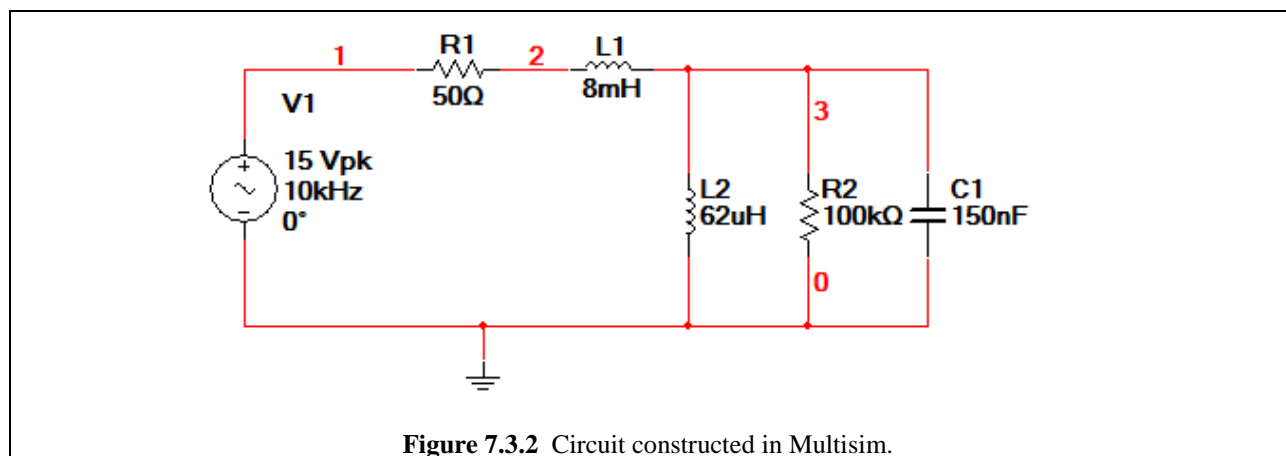
### MULTISIM DEMO 7.3: AC THEVENIN CIRCUIT DETERMINATION

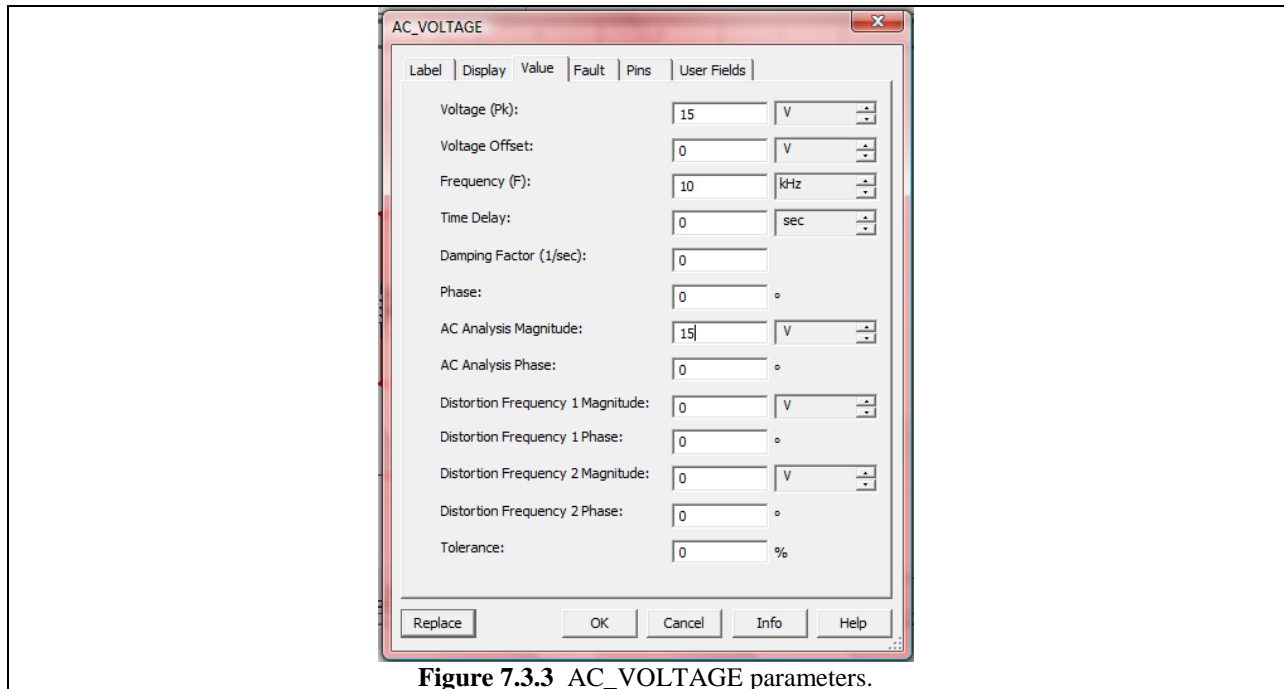
Just like in Multisim Demo 3.4, we can use Multisim to determine the AC Thevenin Equivalent Circuit. In the previous two sections we learned some of the fundamental tools for AC analysis...the Network Analyzer and AC Analysis. We can use these to construct an AC Thevenin Equivalent circuit.

Let's find the Thevenin Equivalent of the circuit shown below in Fig. 7.3.1 at a frequency of 10 kHz.



Once implemented in Multisim, the circuit should look something like Fig. 7.3.2. Make sure to set the AC\_VOLTAGE source to the settings shown in Fig. 7.3.3 on the next page. Since we will eventually run a Transient Analysis on this circuit, make sure that you set both the AC Analysis Magnitude AND the Voltage (Pk) fields to the 15 V, and set the frequency to 10 kHz.

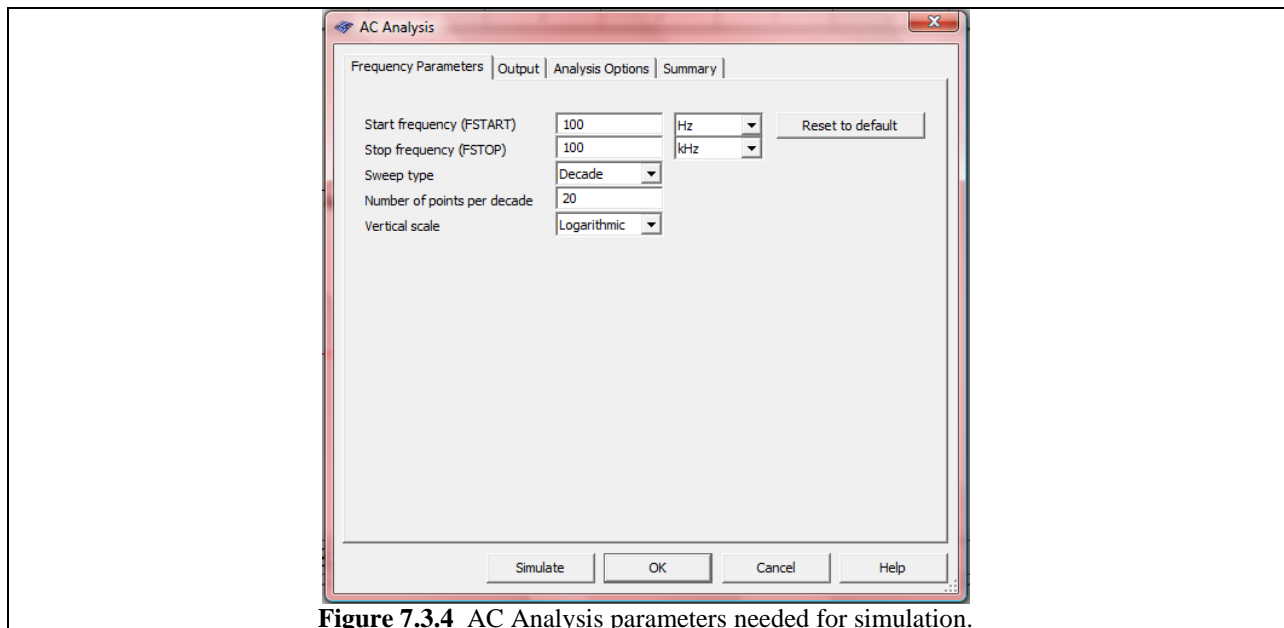




**Figure 7.3.3** AC\_VOLTAGE parameters.

Just like in a DC Thevenin and Norton circuit there are three values which can be found,  $V_{oc}$ ,  $Z_{Th}$ , and  $I_{sc}$ , and we need to find two of them. Let's first find  $V_{oc}$ . To do this run an AC Analysis using the Frequency Parameter settings shown in Fig. 7.3.4 below, and plot V(3), which corresponds to the output voltage.

The plot should look like Fig. 7.3.5 on the next page. Use the cursors to find both the magnitude and phase of V(3) at 10 kHz. Doing this we shows that the magnitude of the voltage at the output is 119.1376 mV, while the phase of this voltage is  $5.4034^\circ$  at a frequency of 10 kHz.



**Figure 7.3.4** AC Analysis parameters needed for simulation.

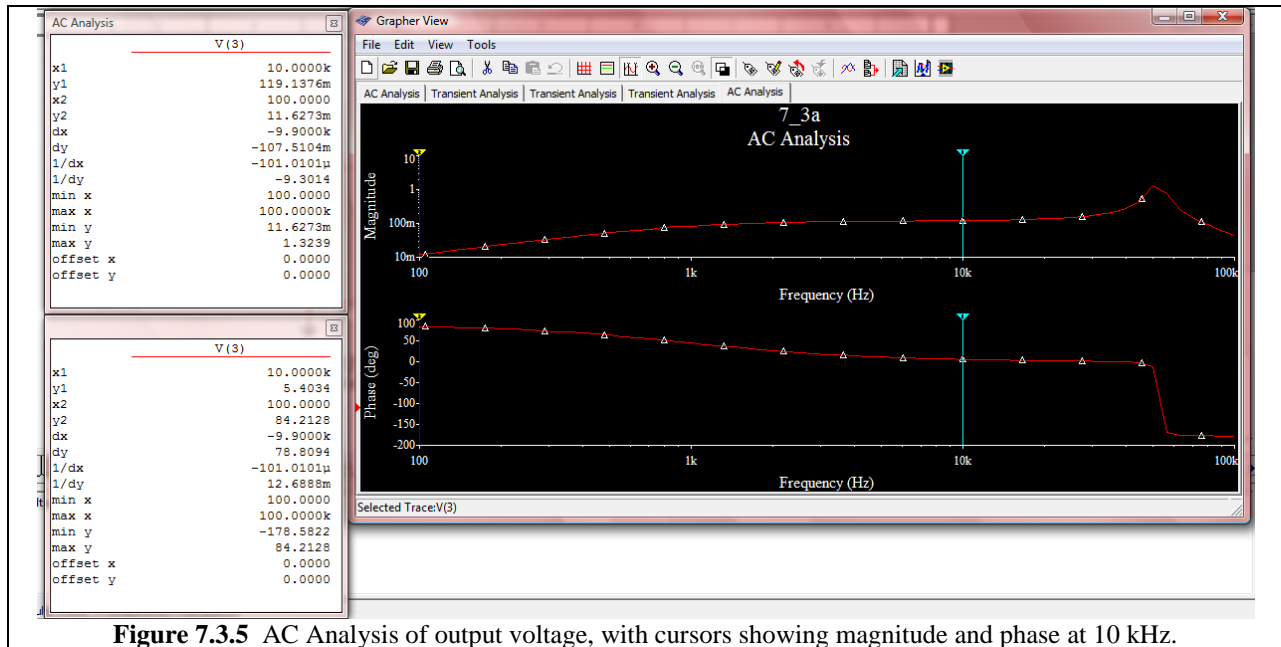


Figure 7.3.5 AC Analysis of output voltage, with cursors showing magnitude and phase at 10 kHz.

So now that we've found  $V_{oc}$  we need to find one of two other quantities:  $I_{sc}$  or  $Z_{Th}$ . In order to get more practice with the Network Analyzer, we'll opt for the latter.

In order to find the Thevenin Impedance, we need to turn off all independent sources. This means that we have to short the AC\_VOLTAGE source. You can either switch its magnitude to 0 V or just remove it and add a wire in its stead. Hook up the Network Analyzer across the output terminals of the circuit as shown in Fig. 7.3.6 below.

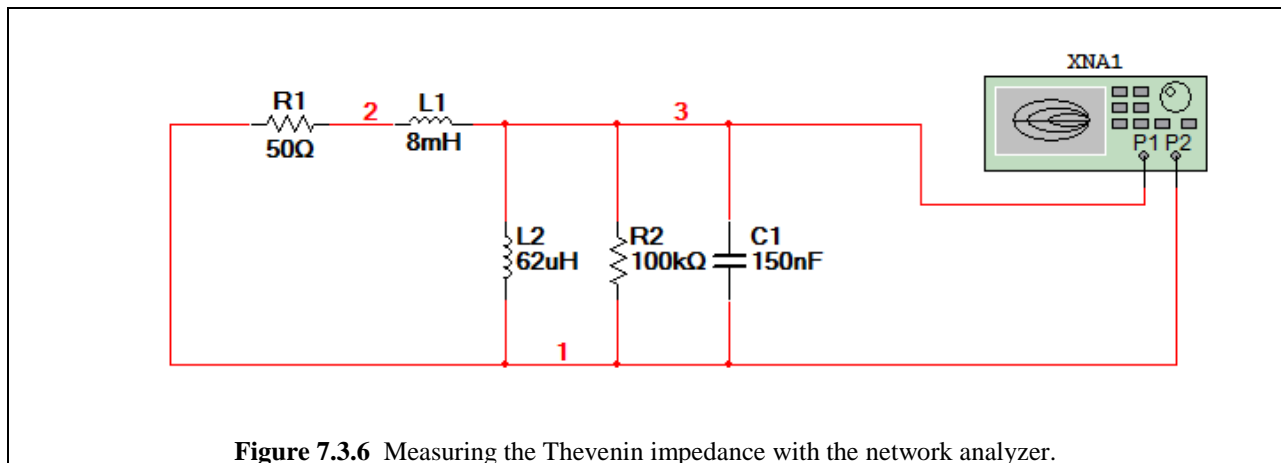


Figure 7.3.6 Measuring the Thevenin impedance with the network analyzer.

Set up the Network Analyzer so that we will be able to measure the impedance at 10 kHz. For information on how to use the Network Analyzer see Multisim Demo 7.1. Begin the Interactive Simulation to generate an output, and use the Network Analyzers cursors in order to find the impedance right at 10 kHz, as shown in Fig. 7.3.7 on the next page.

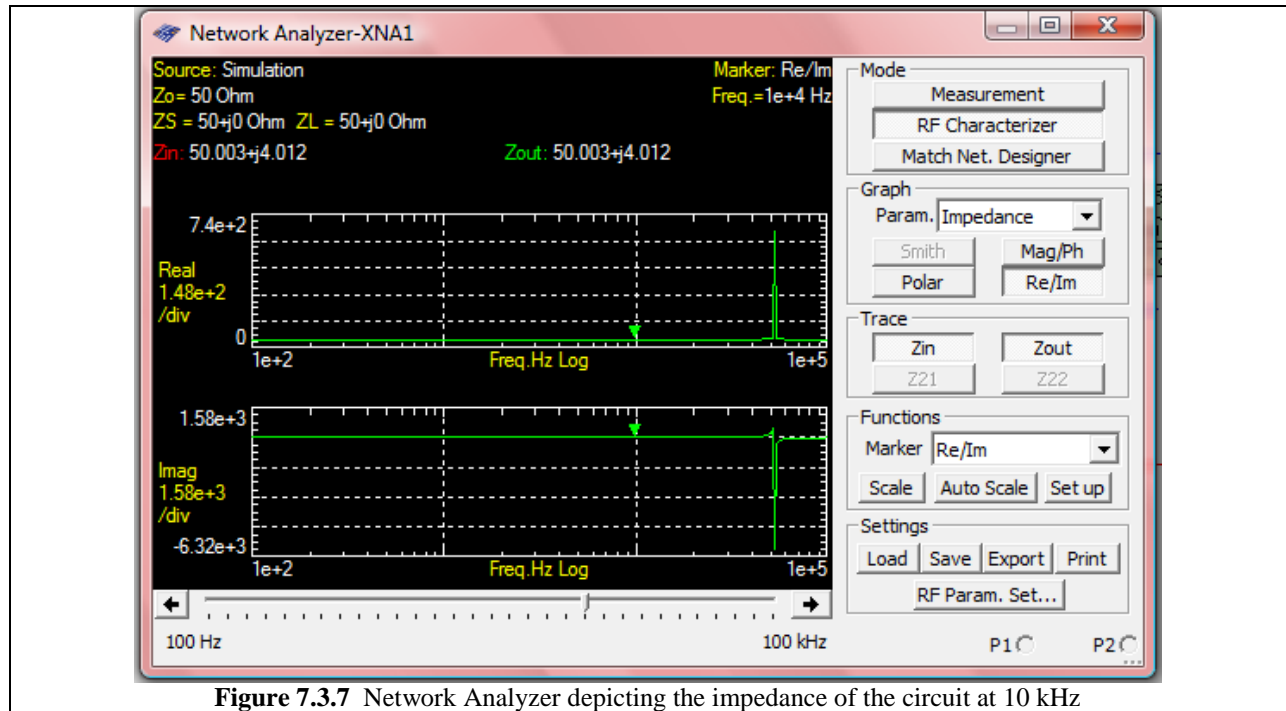


Figure 7.3.7 Network Analyzer depicting the impedance of the circuit at 10 kHz

Now the value shown in Fig. 7.3.7 is  $50.003 + j4.012 \Omega$ . We have to remember, however that the Network Analyzer adds an extra  $50 \Omega$  to this, so at 10 kHz, this corresponds to a Thevenin Impedance of approximately  $0.003 + j4.012 \Omega$ , which is almost purely imaginary.

Since the imaginary component is positive, it is inductive. This means that we could use an inductor of a certain value to produce this impedance at 10 kHz. What value should we use however? Using the equations below:

$$Z_{measured} = j\omega L \quad j4.012 = j2\pi \cdot 10^4 \cdot L$$

$$L = 63.85 \times 10^{-6} \text{ H}$$

This means that an inductor value of approximately  $63.85 \mu\text{H}$  is needed for the Thevenin impedance. Additionally, a slight resistance of  $3 \text{ m}\Omega$  could be added in series, however this is such a small value that we can most likely safely ignore it.

So now let's build the Thevenin equivalent right next to the original circuit in the same schematic. Make sure you set the correct Phase and Voltage (Pk) value for the Thevenin Voltage Source. (Make sure you set the "Phase" and not the "AC Analysis Phase" field.) When you're done building, your screen should look like Fig. 7.3.8.

Now run a Transient Analysis and plot the output voltage of both circuits from 10 ms to 10.5 ms. Observe how the waves are very similar, as shown in Fig. 7.3.9, indicating that we have successfully created the Thevenin equivalent circuit. The differences between the two signals are due to rounding and the limited resolution of the instruments and analyses.

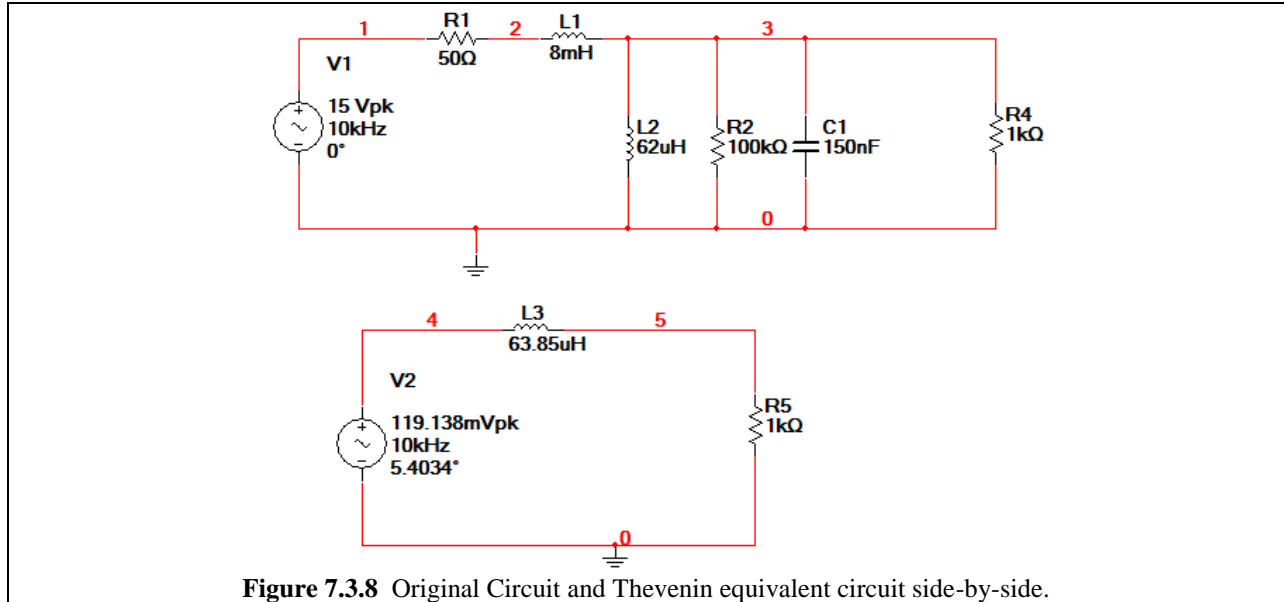


Figure 7.3.8 Original Circuit and Thevenin equivalent circuit side-by-side.

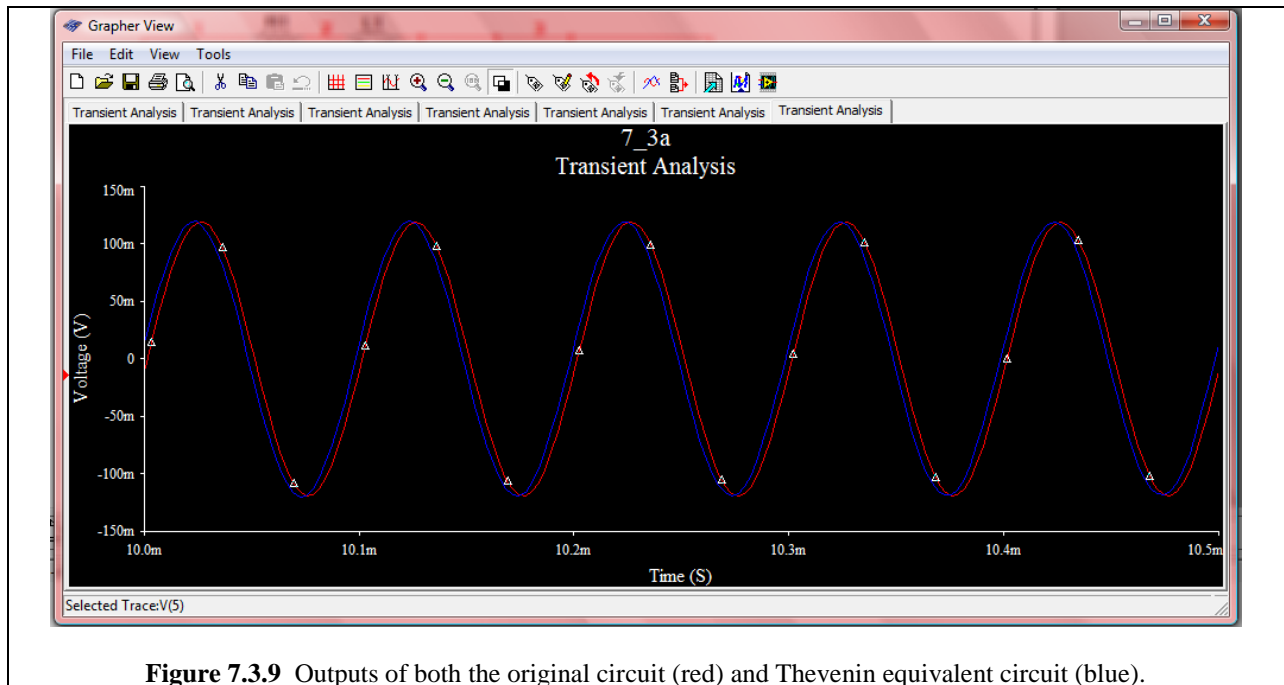


Figure 7.3.9 Outputs of both the original circuit (red) and Thevenin equivalent circuit (blue).