RC and RL Circuits' Step Response

Materials:
- 2 Series Mixed Series Oscilloscope (MSO)
- Arbitrary/Function Generator (AFG): AFG1000 or internal 2 Series AFG
- Resistor
- Capacitor
- Inductor
- Breadboard
- Jumper wires

Procedure

Task 1: Analyzing the RC Circuit

R = 100 kΩ C = 10 nF

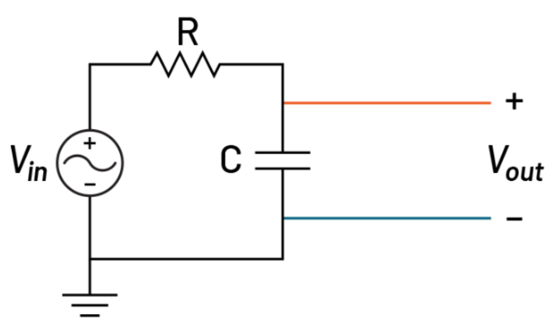

Figure 1. RC circuit diagram.

1. Build the circuit in Figure 1 using the corresponding components. Attach the Ch 1 probe to the input of the circuit (V_{in}) and the Ch 2 probe to the output of the circuit (V_{out}). Make sure the AFG ground and the probe ground are connected.

2. To set up the input (V_{in}), the built in AFG on the 2 Series MSO or an external AFG can be used. For the built in AFG, connect the "AFG/ Aux Out" output to the input of the circuit. To configure the AFG, locate the "AFG PG" button at the bottom of the screen. Select "AFG" and configure the following settings:
   - Waveform: "square"
   - Frequency: "5 kHz"
   - Amplitude: "500 mVpp"

   Once the settings are configured, select Output: "continuous" to turn on the AFG. For an external AFG, configure your square wave using the same parameters.

3. Observe the voltage across the capacitor compared to the square wave input. When the square wave changes amplitude does the output change instantaneously? Does the square wave look completely square? What is the peak amplitude that the capacitor voltage reaches?

4. Vary the square wave frequency and observe how the output changes. Find a frequency where the capacitor seems to reach the peak amplitude and fully charge before the square wave's amplitude falls again. Next, find a frequency that does not let the capacitor fully charge before the square wave's amplitude falls again.

5. Calculate the time constant of the RC circuit using the following formula:

$$\tau = R * C$$

This is the time in seconds it takes for the capacitor to fully charge. Convert the time constant to frequency by taking $1/\tau$. Set the AFG to this frequency and observe the output. Does the capacitor seem to fully charge and discharge with the square wave?

Task 2: Analyzing the RL Circuit

R = 10 Ω L = 100 uH

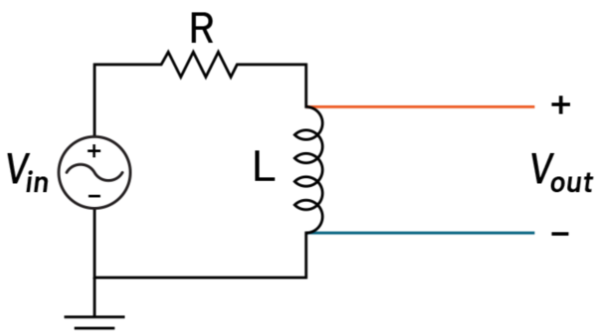

Figure 2. RL circuit diagram.

1. Build the circuit in Figure 2 using the corresponding components. Like Task 1, attach the Ch 1 probe to the input of the circuit (V_{in}) and the Ch 2 probe to the output of the circuit (V_{out}). Make sure the AFG input ground and the probe grounds are connected.

2. Set up the AFG (either internal or external) to the following parameters:
   - Waveform: "square"
   - Frequency: "50 kHz"
   - Amplitude: "500 mVpp"

3. Observe the voltage across the inductor compared to the square wave input. When the square wave changes amplitude does the output change instantaneously? Does the square wave look completely square? What is the peak amplitude that the inductor voltage reaches?

4. Vary the square wave frequency and observe how the output changes. Find a frequency where the inductor seems to reach its peak amplitude and can fully discharge before the square wave's amplitude falls again. Next, find a frequency that does not let the inductor fully discharge before the square wave's amplitude falls again.

5. Calculate the time constant of the RL circuit using the following formula:

$$\tau = {}^{L}/_{R}$$

This is the time in seconds it takes for the capacitor to fully charge. Convert the time constant to frequency by taking $1/\tau$. Set the AFG to this frequency and observe the output. Does the inductor seem to fully charge and discharge with the square wave?

Instructor Notes:

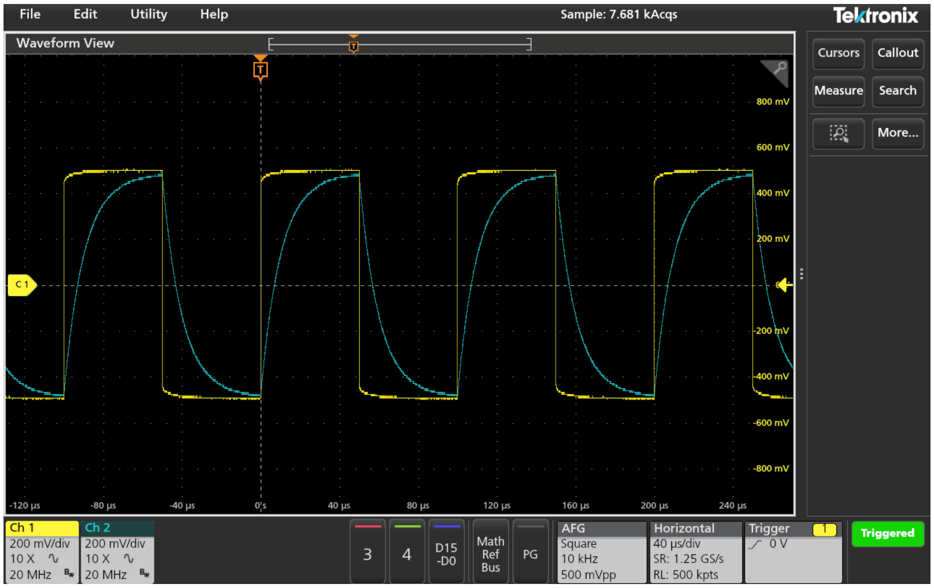

Figure 3. RC input and output waveforms.

Figure 4. RL input and output waveforms.