Objectives

- To measure the internal (output) resistance of a function generator.
- To investigate the dynamic response of a simple R-C circuits due to a pulse excitation
- To investigate the dynamic response of simple R-L circuits due to pulse excitation.

Procedure

Part I: The Internal (Output) Resistance of the Function Generator

1. Connect the oscilloscope across the output terminals of the function generator to provide a **square wave** signal of **2V (peak)** and zero average value **1kHz**. Note that this **(open circuit)** output voltage represents the value of $\mathbf{V}_{TH}$ of the Thevenin's equivalent circuit of the function generator **for the resent setting**

2. Connect a decade resistance box $\mathbf{R}_L$ across the output terminals of the function generator. Adjust $\mathbf{R}_L$ until the output voltage drops to **1V (peak)**. The value of $\mathbf{R}_L$ is now equal to $\mathbf{R}_{TH}$ of the Thevenin's equivalent circuit of the generator, which is also referred to as the **internal** (or **output**) resistance of the generator.

   The internal resistance of the function generator is: 50Ω

3. Prove to yourself that the value of $\mathbf{R}_{TH}$ of the function generator remains the same regardless of the magnitude and wave shape of the output signal.

Part II. The RC-Circuit Pulse Response

4. Set the oscilloscope controls as follows:
   - Channel **"1"**: Signal Coupling **dc**, Y-position **screen bottom** and Vertical Sensitivity **1V/div**.
   - Channel **"2"**: Signal Coupling **dc**, Y-position **screen centre**, and Trigger Slope **Rising**.
   - Horizontal Sensitivity **0.1msec/div**, Trigger Source **Channel 1**, and Trigger Slope **Rising**

   Connect channel **"1"** across the output terminals of the function generator to provide a **squarewave** signal of **3V (peak)** and **3V** average value **1 kHz**.

(Note that the signal is actually a **positive-pulse train** with a height of **6V** and a duration of **500**µs). Adjust the **"X-position"** of the scope to set the beginning of the pulse to **left end** of the display

5. Connect the circuit as shown below. Note that the **20**kΩ resistor is a **current-sampling** resistor that provides a voltage across $= 20\Omega * i_c(t)$. Connect channel **"1"** of the oscilloscope to node A in order to display (approximately) the voltage waveform across the capacitor $\mathbf{v}_C\mathbf{(t)}$ & channel 2 to node B to display the scaled up current waveform $\mathbf{i}_C\mathbf{(t)}$.

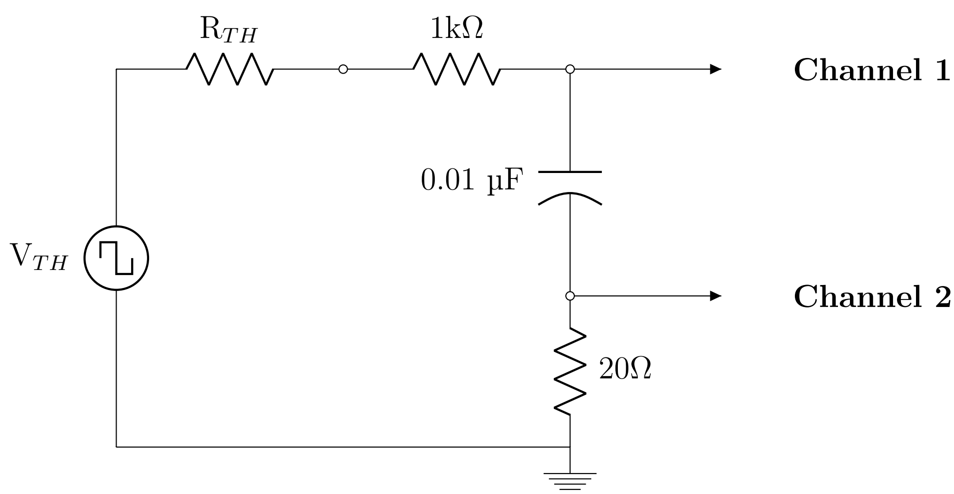

Fig. 1: RC Circuit

6. Use graphs 1 and 2 to plot the waveforms of $\mathbf{i}_C\mathbf{(t)}$ and $\mathbf{i}_C\mathbf{(t)}$ respectively

7. Use the $\mathbf{v}_C\mathbf{(t)}$ to measure the time constant τ_C as accurately as possible. Record your results in the table

8. Replace the 1k resistor in the figure above with another value of 6.8k and repeat the steps.

Part III The RL-Circuit Pulse Response

9. Replace the capacitor in your circuit with a decade inductance box with an **L=50mH** inductor, and let $\mathbf{R} = \mathbf{1k}\Omega$: Modify the positions of the oscilloscope-controls as:

   - Channel 1: Y-Position screen center and sensitivity 2V/div
   - Channel 2L Y-Position screen bottom and sensitivity 10mV/div

Repeat steps #4-7 using the graphs to plot the current and voltage waveforms $\mathbf{i}_C\mathbf{(t)}$ and $\mathbf{v}_C\mathbf{(t)}$

Data

Table 1: RC circuit

R (kΩ)	**R_{Total}(kΩ)**	**τ (µsec)**	**i_C(max) (mA)**
1.0	1.08	10.2	2.8
6.8	6.88	68.4	0.438

Table 2: RL circuit

L (mH)	**R_{Total}(kΩ)**	**τ (µsec)**	**v_C(max) (V)**
50	1.08	46.2	0.114
150	1.08	138.9	0.114

Graphs will be provided at the back

Conclusion

1. Compare the corresponding data from tables 2 and 5. Comment on the possible causes for any deviations from your expectations

   Our predictions in table 5.2 are very similar to the results in table 5.5. The predicted value for tau is nearly identical to the one obtained. Minor deviations include resistance form wires or inaccuracies from the instruments.

2. Discuss what you have observed from the plots on graph 1 and 2

   For the capacitor, as time approaches infinity the current approaches 0A and the voltage charges to 6V. It is also observed that voltage at time = 0 is 0V while current is 130µA

3. Compare the corresponding data observed in tables 4 and 6. Comment on the possible causes for any deviation from your expectations

   Tables 4 from the prelab and table 2 above differ due to the fact the prelab values were calculated with an assumed resistance of 600Ω whereas in the lab we used a total resistance as 1k from the resistor and the internal resistance form the oscilloscope. In short they differ because they were calculated differently.

4. Discuss what you have observed from the plots on graph 3 and 4

   Both graphs are exponential curves, both seem related. Although one is current and the other is the voltage of the load, which is the inductor. We find that current decreases while voltage increases exponentially. It shows that the inductor was discharging and recharging constantly.

5. Explain briefly the differences in the dynamic responses to pulse excitation of RL and RC circuits

   For RC circuits we noticed that it decreased exponentially while the RL circuit increased exponentially. This indicates how each sources charges and discharges differently. We know from theory, the current leads the voltage for RC circuits, whereas RL circuits the voltage leads the current.

6. What is the inherent error in our procedure for displaying both $\mathbf{i}_C\mathbf{(t)}$ and $\mathbf{v}_C\mathbf{(t)}$. How would you go about reducing the effect of this error

   The inherent error is the 20Ω resistor which exists in the setup of the lab. The capacitor is not connected straight to ground, instead there is a capacitor directly after it so we can measure the voltage and current. Additionally, there is also a built in resistance from the oscilloscope which may also add to the extra resistance, although we call this R_{TH} we are unaware as to the accuracy of this reading. This can be fixed by simply removing the resistor and all the measured values would match the calculated values better.