Circuit Theory II Laboratory

LAPLACE TRANSFORM

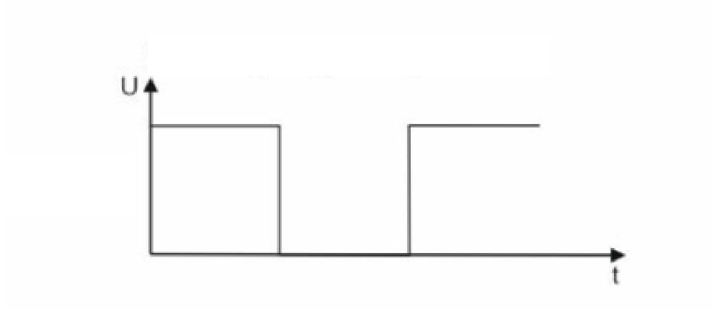
Aim of the exercise

The aim of the exercise is to experimentally verify the method of transient analysis in electrical circuits using the Laplace transformation. The aim of the exercise is realized by measuring voltages in RC and RLC circuits excited by a unit step.

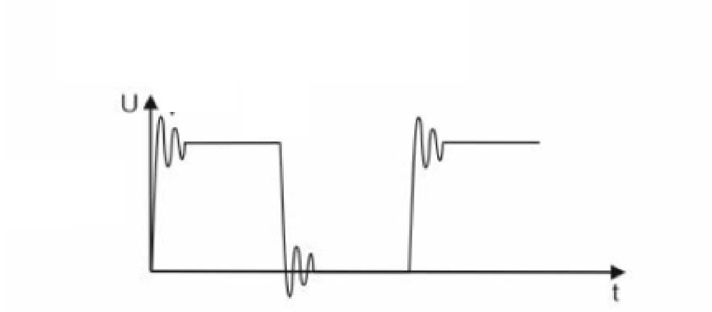
Measurements Methodology

During the exercise, the DUTs (Device Under Test) are excited by a unit step and simultaneously – the time domain graphs (oscillograms) have to be observed by using oscilloscope. For the circuits tested in the exercise, the unit step can be approximated by a square wave with a frequency of 100 Hz and a duty cycle of 50%, because for these circuits it can be assumed with very little error that the transient (theoretically infinitely long) disappears completely before the next edge of the excitation signal.

Input Signal

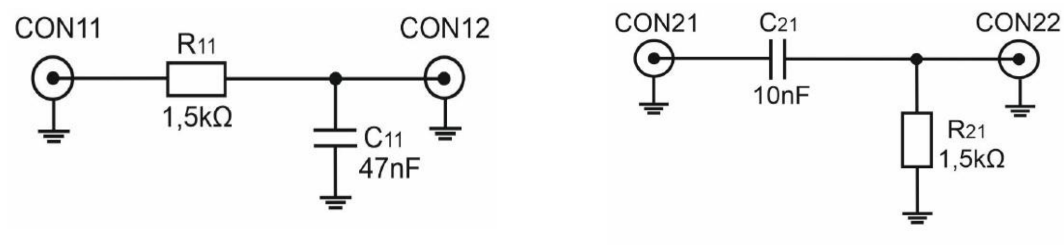


Output Signal



1.1. RC Circuit Response

In the first part of the exercise, the tested circuits are first-order RC circuits in the low-pass ("integrating" - circuit 1a) and high-pass ("derivative" - circuit 1b) configurations.



(a) *(b)*

Fig. 1. Schematics of RC circuits measured during exercise

The schematic of the measurement setup for this part of the exercise is shown in the figure below:

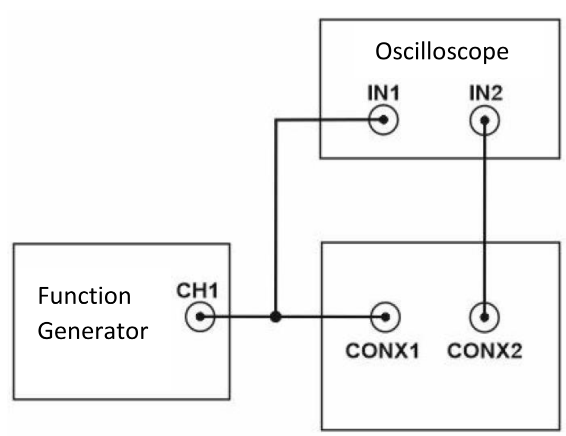


Fig. 2. Concept schematic of the measurement setup

In the function generator, a square wave should be set with the following parameters: frequency f=100 Hz, duty cycle D=50%, peak-to-peak voltage amplitude Vpp = 1 V and offset equal to Voffset = 0.5 V. To use the oscilloscope display effectively, it is suggested to set the scale of 200 mV per division on both channels and set the zero level of both signals to -600 mV position. To measure the parameters of the tested waveforms, it is suggested to use cursors in the "track" mode (cursors -> mode -> track). For each circuit you should:

- measure the output voltage at times 1τ, 5τ, 10τ, where τ is the *time constant*
- in moments for which the signal reaches 10% and 90% of the highest value (determination of the *rise time*)

The time constant parameter determines the speed of reaching the steady state by the system. For first-order inertial circuits with an exponential output $e-t/\tau$ for stepwise excitation, the time constant is the time taken for the signal to reach (1-1⁄e) ≈ 63.2% of the steady state value if the waveform is ramping, or 1⁄e ≈ 36.8% of the initial state value if the waveform is sloping.

1.2. RLC Circuit Response

In the second part of the exercise, a series resonant RLC circuit with switched series resistances is examined (Fig. 3). The voltage of the potential derived from the BNC connector and the voltage on the coil (using an oscilloscope probe) should be tested for all three cases of series resistance of the circuit. The conceptual schematic of the measurement setup is shown in Fig. 4.

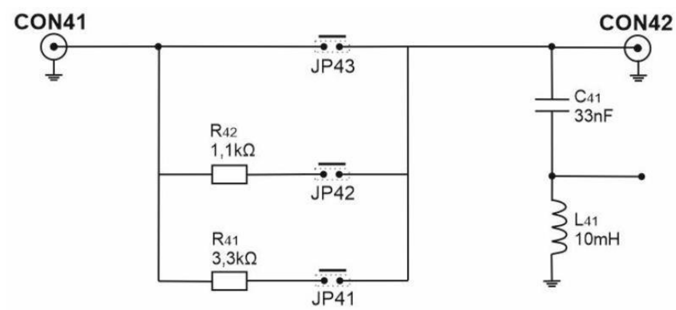


Fig.3. Schematic of the considered RLC circuit

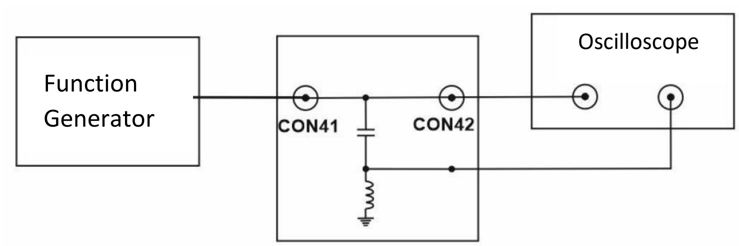


Fig.4. Concept schematic of the measurement setup

The series resistance is selected using jumpers. If the jumper is placed in the JP43 connector, the series resistance of the circuit will be the sum of the output resistance of the generator (50 Ω) and a small, unmarked resistance of the parasitic coil (about 5 Ω). Putting a jumper on JP42 will increase the resistance by 1.1 kΩ, and jumper on JP41 by 3.3 kΩ. Depending on the value of the series resistance of the circuit, its response to excitation with a unit step will have a different character:

- If the total series resistance of the circuit is lower than the critical resistance with the value RC = 2, then the response of the circuit is a sinusoidal oscillation with exponentially decreasing amplitude $e^{-\alpha t}$, these are the so-called damped vibrations.
- If the series resistance of the circuit is greater than the value of the critical resistance, then the response of the circuit is exponential decay, without harmonic oscillation, the so-called aperiodic waveform.
- If the series resistance of the circuit is equal to the critical resistance, then we speak of an aperiodic critical waveform, in which the transient state at the circuit's output decays the fastest and there is no oscillation, the so-called oscillation. aperiodic critical course.

Note the characteristic points of the signals: local maxima, local minima, time between successive local maxima/minimums (period of damped oscillations), number of visible local extremes (periods of oscillation), steady state value, etc. For waveforms with damped vibrations, determine on the basis of two consecutive maxima local vibration frequency.

Report requirements

The report should include a comparison of the obtained measurement results with theoretical calculations and comments on the obtained measurement results and calculations.