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Comparison of signals in the Time Domain and Frequency Domain:

Signal Waveforms and harmonics

- **As a known information, our houses and offices electricity are provided to with 230V and 50Hz.**

- **The first step in analysis is to know exactly the Measurement condition and the Observation condition.**

- **The second step is to study and analyze the main large loop (in any project) and searching the signals with this loop and consider the small details and the non irregular signal form in order to obtain the correct measurements.**

Comparison of signals in the Time Domain and Frequency Domain:

Ideal Sine Wave

- **Ideal Sine Wave must have two characteristics:**

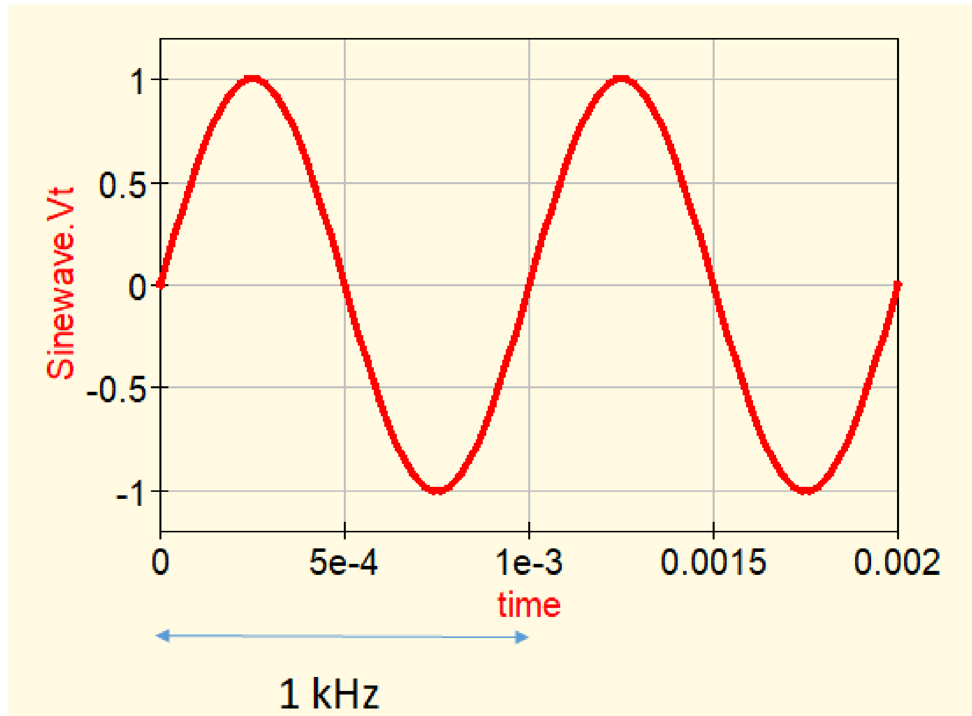
A) The wave form signal must be a perfect complete sine wave.

B) The signal wave must be very continues (a Sine Wave from eternity to eternity) from the start to the ending point of the sine curve.

Comparison of signals in the Time Domain and Frequency Domain:

Ideal Sine Wave

- **One important Sine wave signal (f= 1kHz) as it a very popular commonly used signal since long time and still usable till now and in the future.**



Comparison of signals in the Time Domain and Frequency Domain:

Introduction

- Usually, there is some noise (Disturbance) occured in every changing applied to the regular signal form (Turning ON and OFF switching)

- There are some other types of voltage signal waveforms besides the widely used Sine waveform such as the (Rectangular, Triangular, Sawtooth, Trapezoidal, and some other voltage signal forms) which they are also used in different industrial fields based on their special characteristics.

Experiment No. 1: Spectrum of a Single Voltage Pulse

- Very simple example is to examine a voltage pulse with the following properties:
  Umin = 0V / Umax = 1000 V
  Rise Time and Fall Time = 1 Microsecond
  Pulse Length = 1 Millisecond
  Delay time = 2 Milliseconds

- To create a signal curve in Qucsstudio, it possible to use „file based voltage source“ (= PWL = piece wise linear voltage source) and feed this source with the following input data:

at t = Null	U = 0
at t = 2 Milliseconds	U = 0
at t = 2,001 Milliseconds	U = 1000 V
at t = 3,001 Milliseconds	U = 1000 V
at t = 3,002 Milliseconds	U = 0
at t = 50 Milliseconds	U = 0

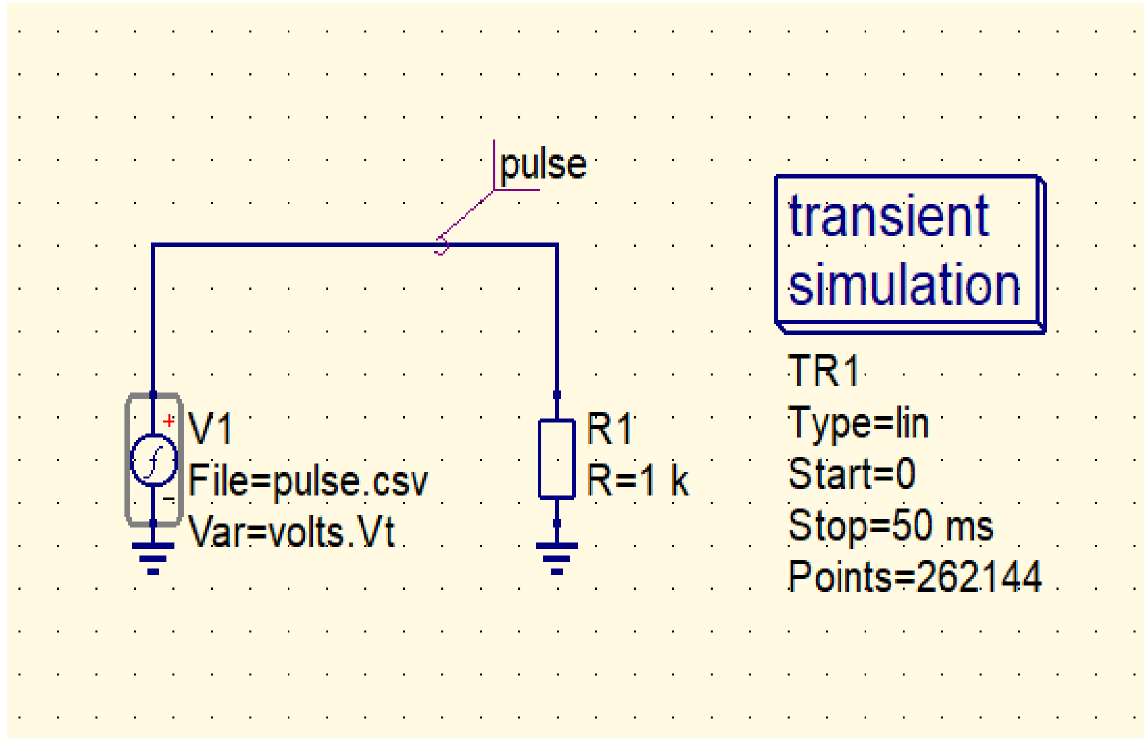
Experiment No. 1: Spectrum of a Single Voltage Pulse

- Create a „pulse.csv“ text file and feed it to the applied „file based voltage source“ with a content as shown.
- The file properties must be set as „All files / ANSI“ .

0	0
2e-3	0
2.001e-3	1e3
3.001e-3	1e3
3.002e-3	0
50e-3	0

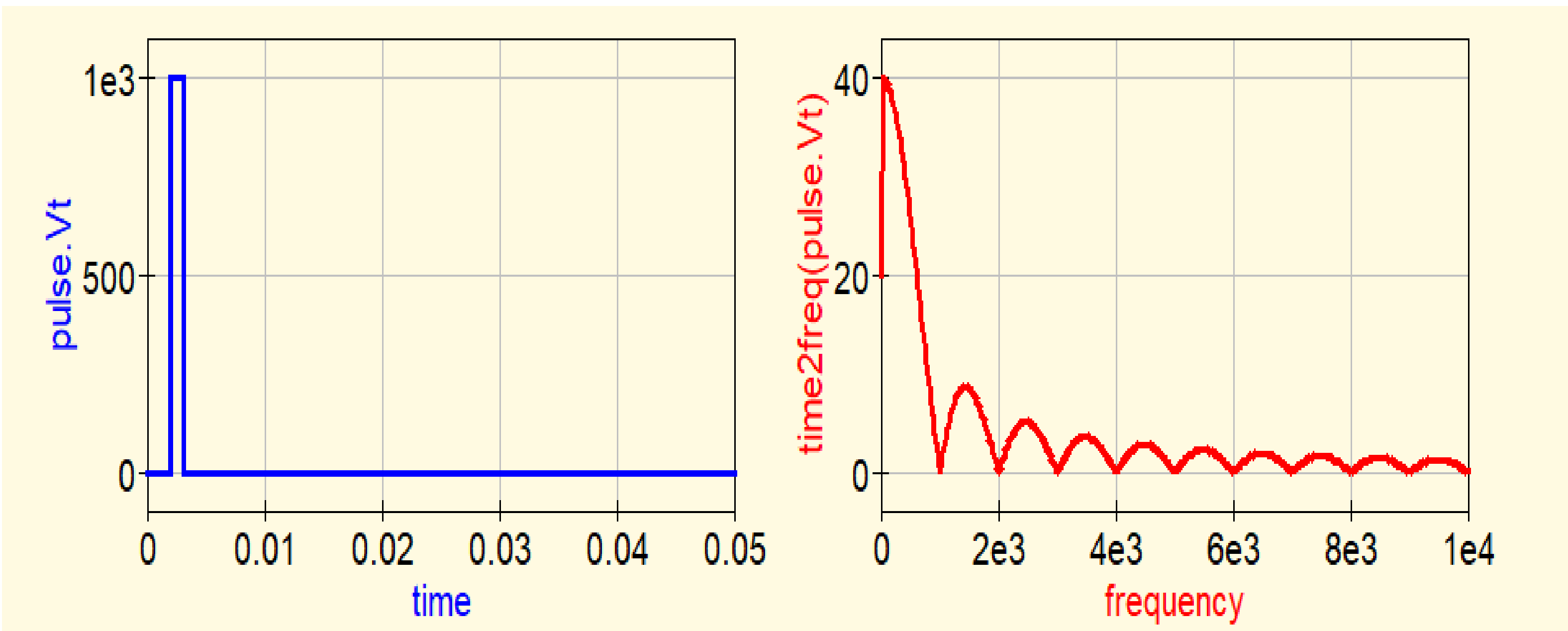
Experiment No. 1: Spectrum of a Single Voltage Pulse

- **The circuit to create single voltage pulse for a time of (50 ms) is:**
- **The spectral content (spectral energy density) of this circuit shows that every Hertz of bandwidth is completely filled with energy**



Experiment No. 1: Spectrum of a Single Voltage Pulse

- The obtained pulse signal and it‘s frequency are shown as:
- The “Zero Values” are founded only at every multiple of f = (1/Pulse Length)

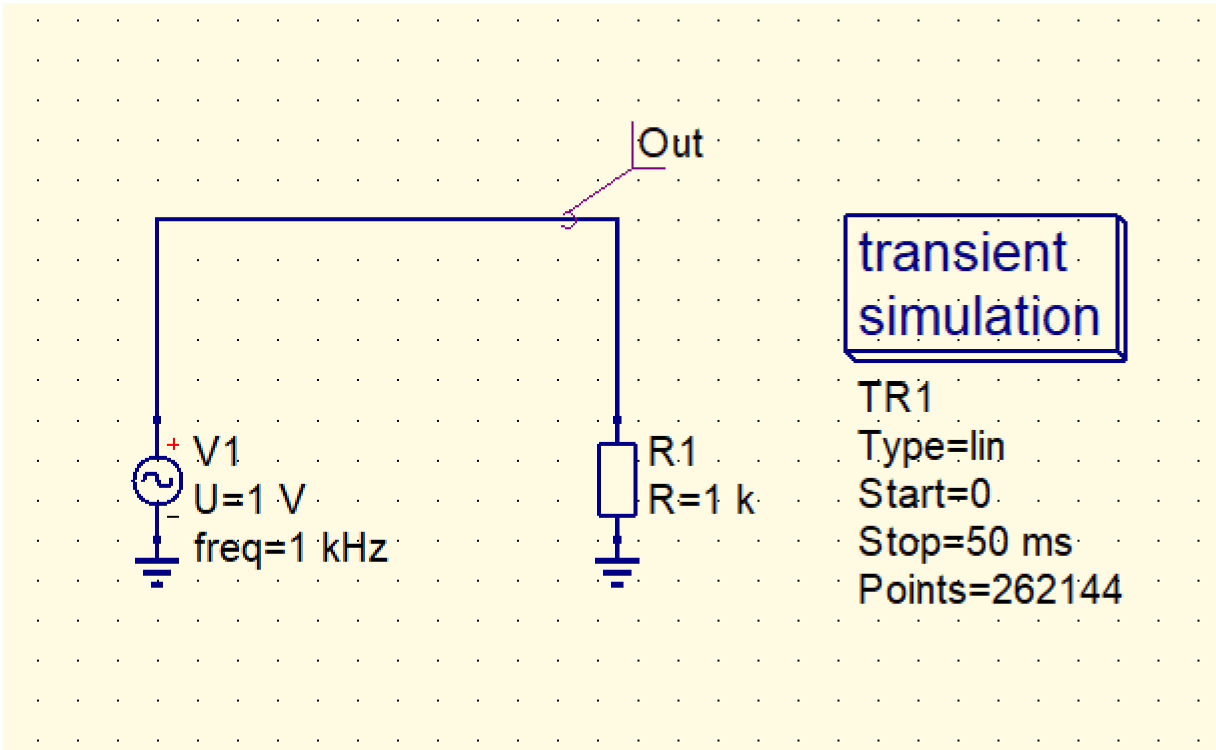


Experiment No. 2: An ideal Sine Wave

- **The sine wave signal is the only signal with no end that consists of only one spectral line.**

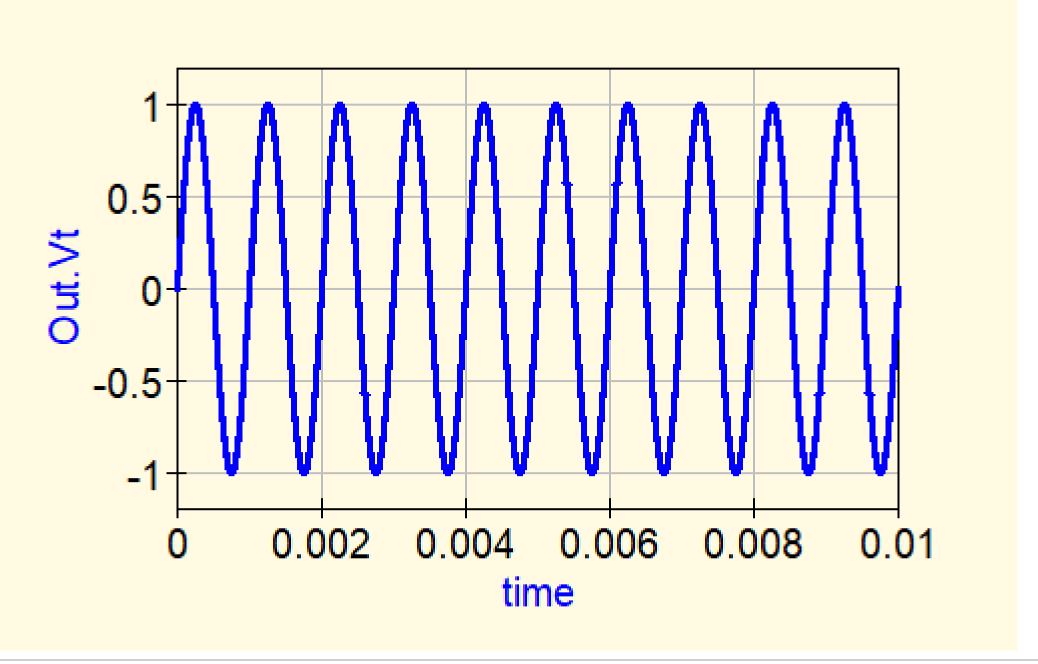
- **To prove this by using qucsstudio, testing a Sine Voltage source with f = 1 kHz and an amplitude of U = 1V with a simulation time = 50 ms.**

Experiment No. 2: An ideal Sine Wave



Experiment No. 2: An ideal Sine Wave

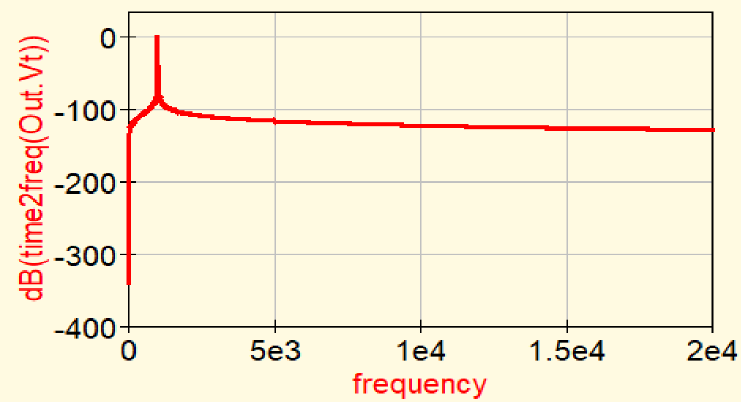
- The result shows a repeatable non ending sine wave signal of ± 1V.

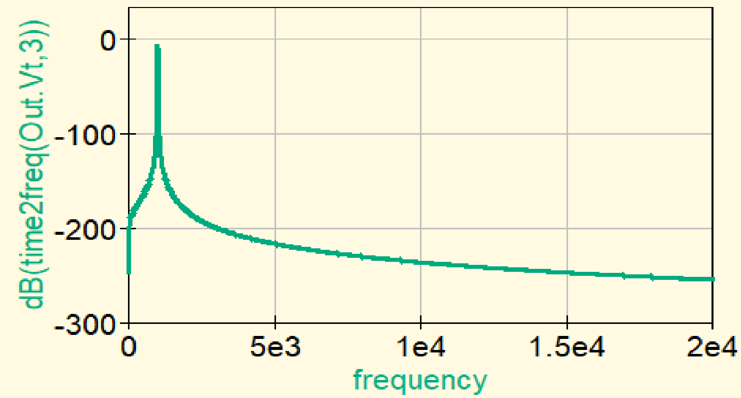


Experiment No. 2: An ideal Sine Wave

- The frequency representation in dB -dB(time2freq(Out.Vt))- shows a dynamic range of only 100 dB for an ideal sine wave caused by the influence of the „start transition“.

- By repeating the frequency representation in dB using the FFT (index = 3) -dB(time2freq(Out.Vt,3))-, the dynamic range has now increased to 200 dB.

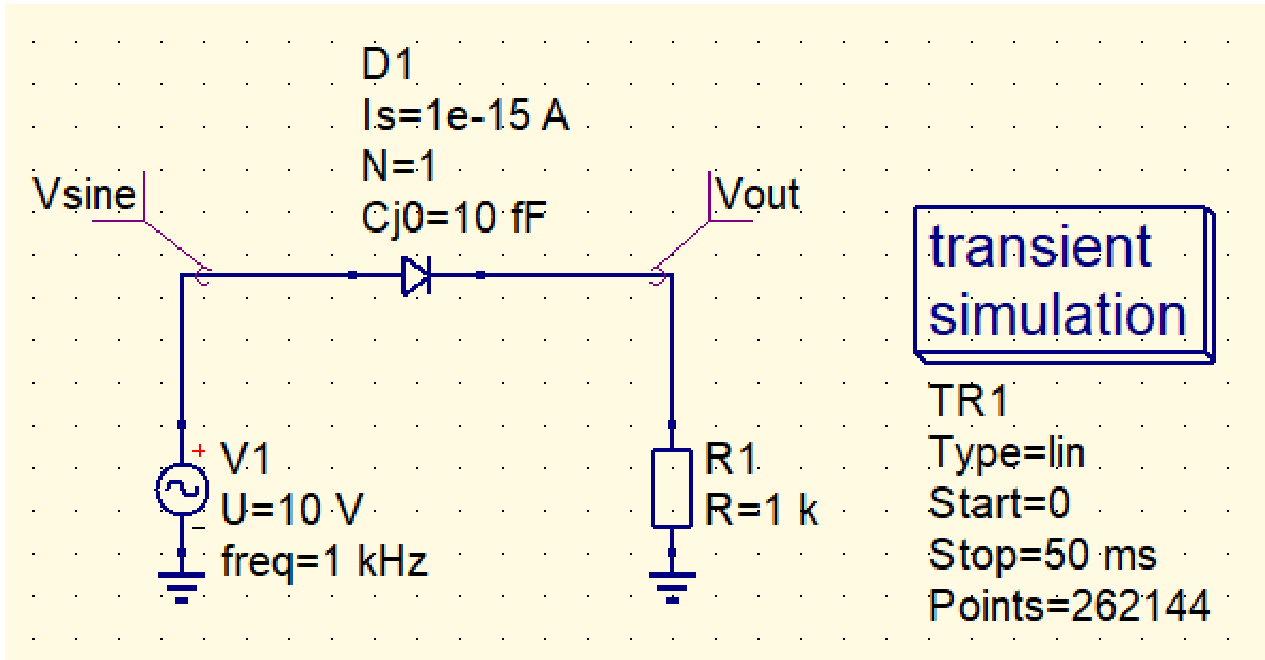




Experiment No. 3: An asymmetrically distorted Sine Wave

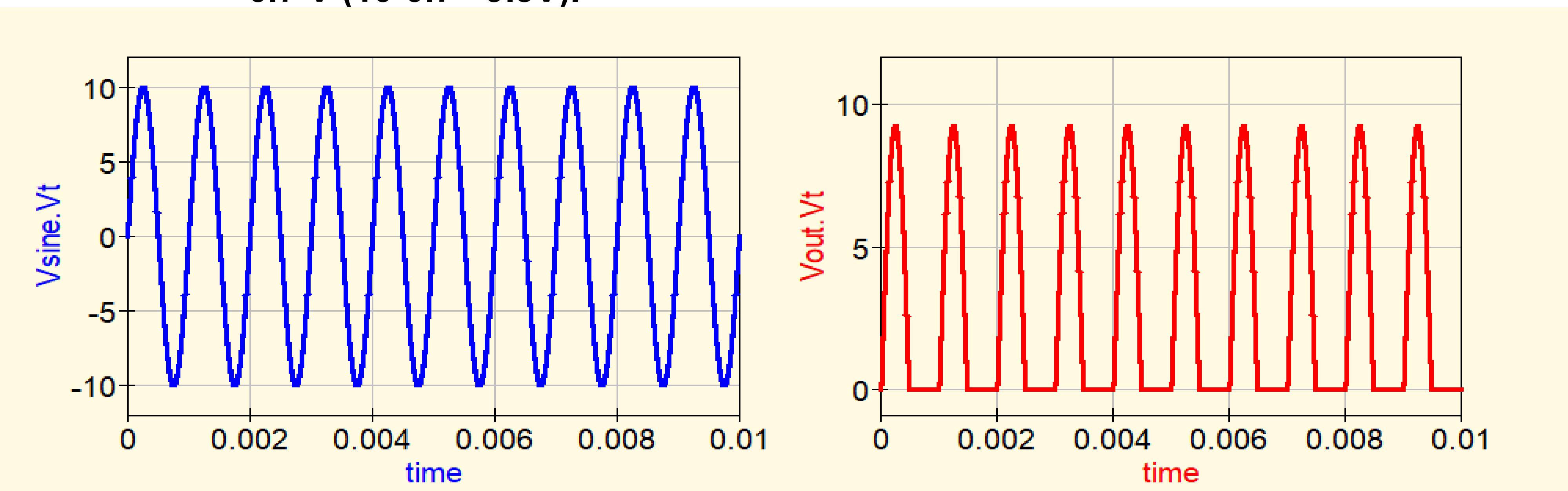
- To create an asymmetrically distorted Sine Wave, a diode should be inseted between the source and the load resistor.

Note: The diode can be found in „components / nonlinear components".



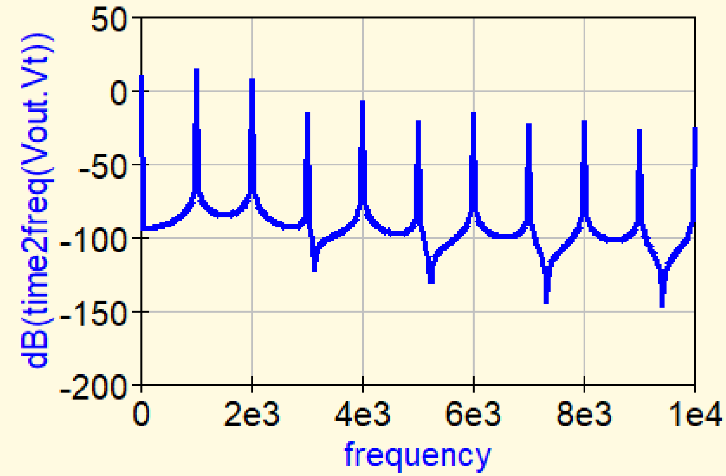
Experiment No. 3: An asymmetrically distorted Sine Wave

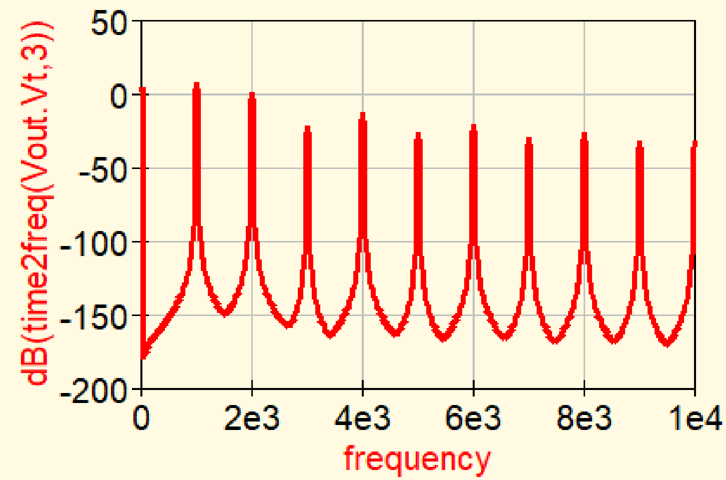
- **The peak value of the voltage is 10 V, the frequency is f = 1kHz, with a Simulation time of 50 ms.**
- **By this process, the negative part of the sine wave is not exist anymore. The output voltage peak value 10 V reduced by diode's „ON“ voltage of 0.7 V (10-0.7= 9.3V).**



Experiment No. 3:
An asymmetrically distorted Sine Wave

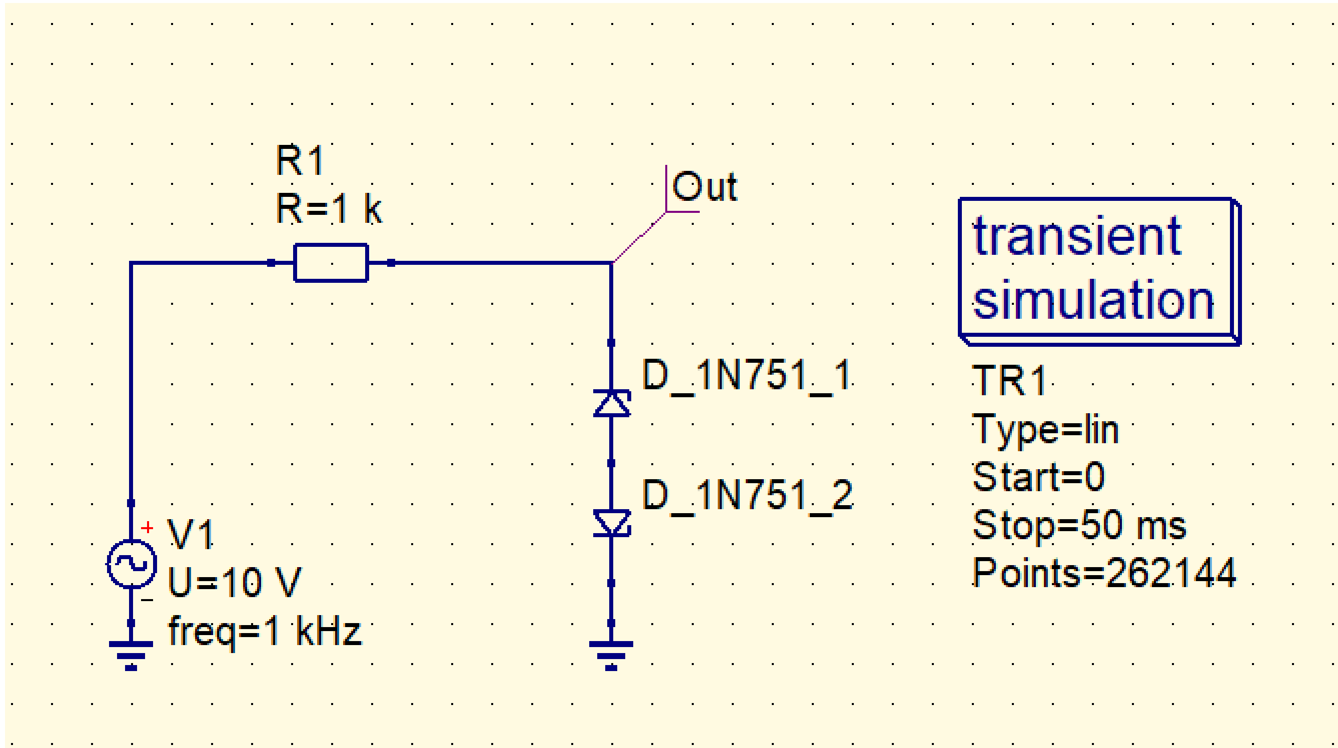
- Using the Hann windowing has successfully increased the dynamic range.
- By repeating the frequency representation in dB using the FFT (index=3) -dB(time2freq(VOut.Vt,3))-, the dynamic range has now increased 150 dB.
- The results also shows all the additional even and odd harmonics (= 2kHz + 3kHz +4kHz +5kHz.....)





Experiment No. 4: A symmetrically distorted Sine Wave

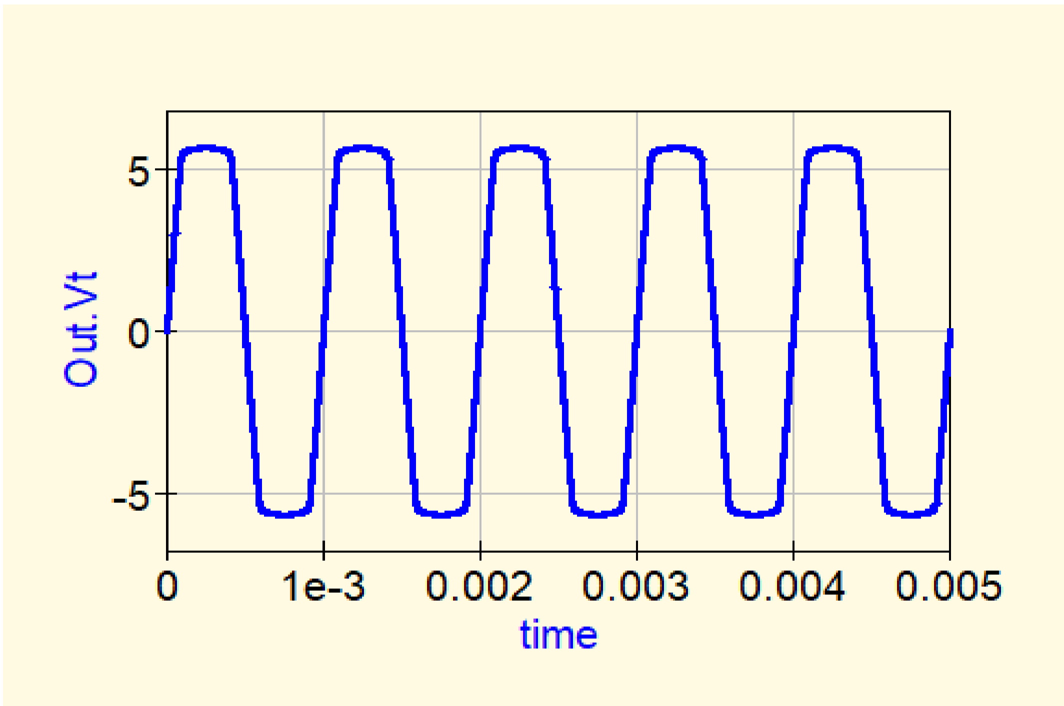
- **By using two Zener diodes in series as shown down in the circuit diagram.**



Note: Use the type „1N751“ with a breakdown voltage of 5.1V.This diode can be found in „libraries / Z-diodes“.

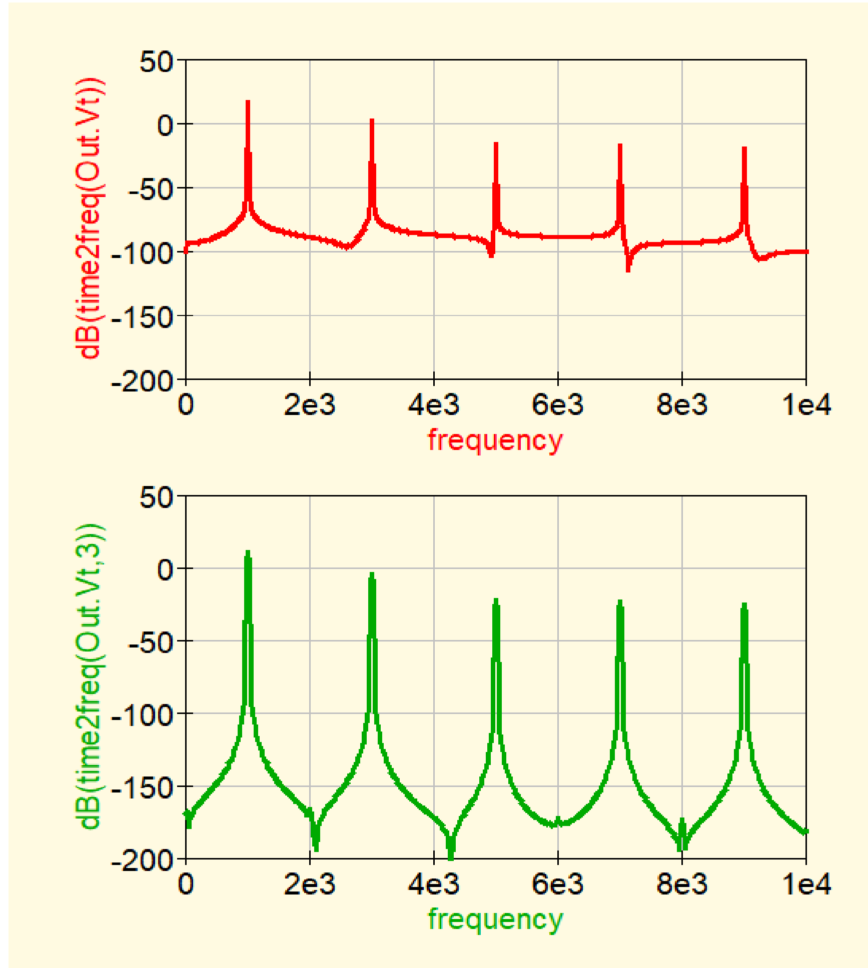
Experiment No. 4: A symmetrically distorted Sine Wave

- Through applying a sine wave with a peak value of 10 V and a frequency of 1 kHz for 50 ms simulation time, the results shows the „symmetrically clipped“ output voltage with a peak value of (5.1V + 0.7V) = 5.8V (with tmax = 5 ms)



Experiment No. 4:
A symmetrically distorted Sine Wave

- Using the Hann windowing has successfully increased the dynamic range
- By repeating the frequency representation in dB using the FFT (index=3) -dB(time2freq(VOut.Vt,3))-, the dynamic range has now increased 150 dB.
- The results also shows only the l odd harmonics (= 3kHz + 5kHz +7kHz +9kHz.....)
- Windowing has reduced the total energy content of the signal and thus the absolute amplitude values of the lines are reduced.



The RF lines under various conditions in Simulation
Introduction about Cables

- **In any simple electrical circuit with a voltage source and a load resistor, the current comes from the source on a wire and flows to the consuming object, on the other line it returns to the lower connection back.**

- **The RF cables and their properties became very important once the source and load are not directly connected.**

- **At high frequencies, “direct connection" means only a few centimeters or even millimeters on the length of the cable for electrical energy transmission.**

The RF lines under various conditions in Simulation
Introduction about Cables

- **There are some important types of cabling between the voltage source and the load object as:**

1- Single pair cabling: consists of two covered parallel (forward and a return) lines.

2- Twisted pair cabling: is the standard form for the modern LANs, i.e. computer networks and Bus systems.

3- Coaxial cables: they are basically used to feed the antennas and every TV receiver.

4- Ribbon cables which exist in either multi-core rounded cables shape or a normal multi-core ribbon cable (used in PCs, hard disk or CD drive connection with the mainboard).

5- Waveguide is a hollow metal pipe used to connect microwave transmitters and receivers to their antennas. The waveguide is used as a transmission line mostly at microwave frequencies.

The RF lines under various conditions in Simulation
Introduction about Cables

- **In between the positive or negative poles, an electric field is formed directly represented by the Capacitance (C).**

- **As soon as a current flows in the wires, these wires surround itself with a magnetic field which is represented here by the coil (Inductance (L)).**

- **For impedance of electromagnetic waves, the characteristic Impedance equation will be:**

$$\mathbf{Z} = \sqrt{\frac{\textbf{Inductance (L)}}{\textbf{Capacitance (C)}}} = \quad \textbf{Ohm}$$

Simulation with Qucsstudio: Experiment No. 1

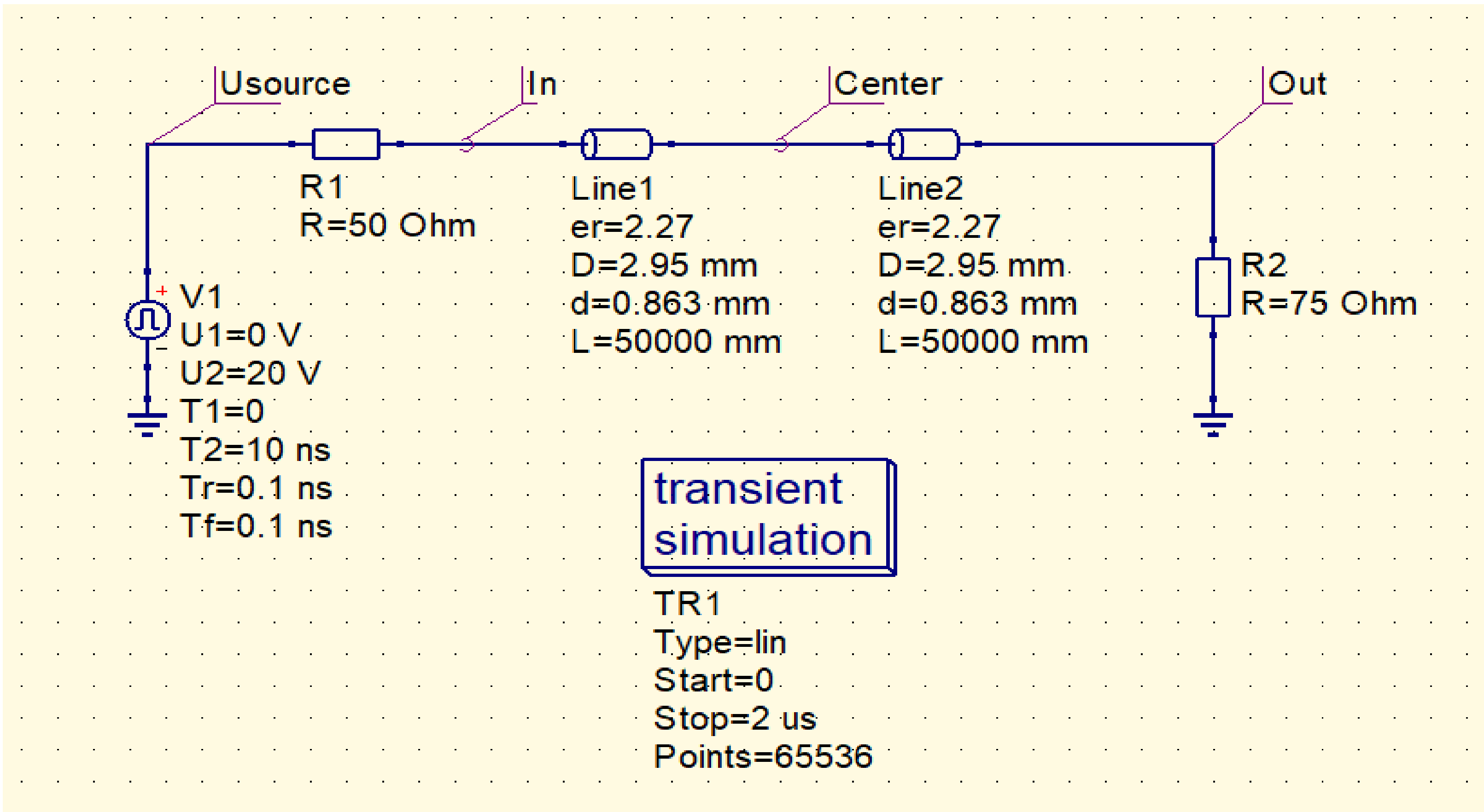
- **To start the circuit, a pulse voltage source is applied with the following inputs:**

Minimum voltage	**U1= 0**
Maximum voltage	**U2= 20 V**
Starting time of the Pulse	**T1= 0**
Ending time of the Pulse	**T2= 10 ns**
Rising time	**Tr= 0.1 ns**
Falling time	**Tf= 0.1 ns**

- **A well-known coaxial cable, RG58/U with Z = 50 Ω will be used. This cable has the properties of:**

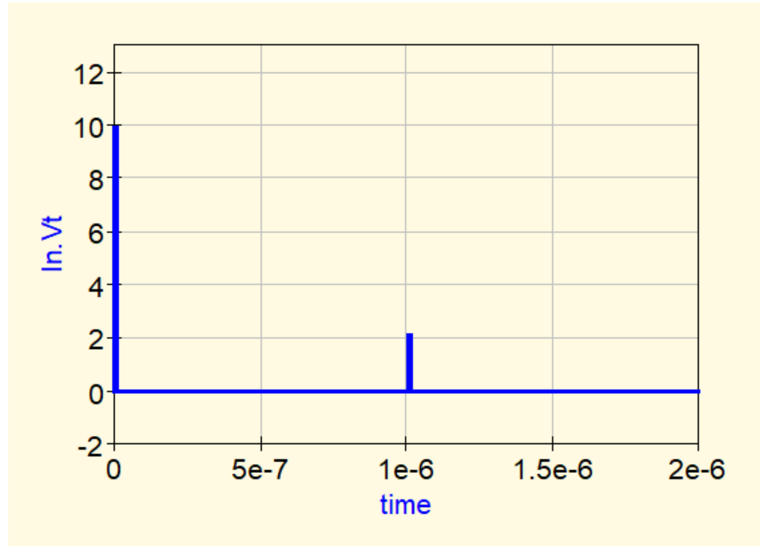
Diameter of the inner conductor:	**approx. 0.86 - 0.93 mm**
Inner Diameter of the shield	**approx. 2.95 mm**
Relative permittivity	**2.27**
Characteristic impedance	**50 ± 2 Ω**

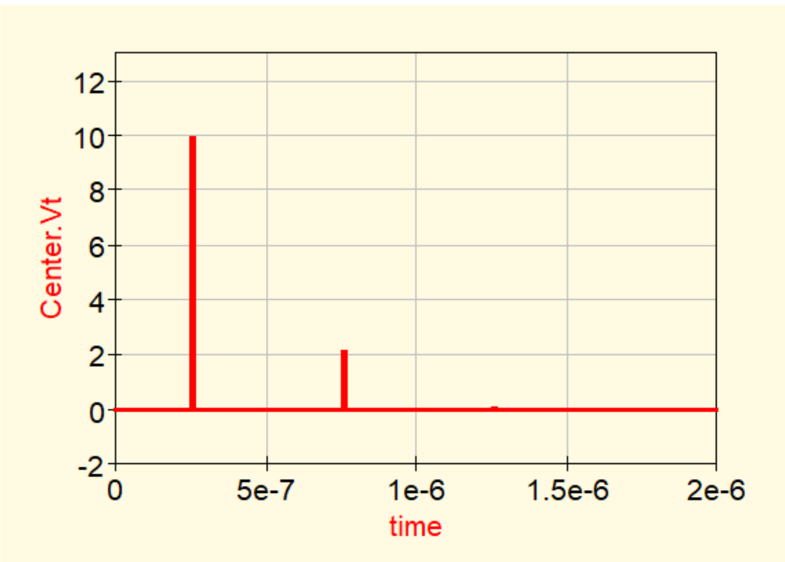
Experiment No. 1: Measurements in Different positions



Experiment No. 1: Measurements in Different positions

- At the In_stage, the Incident wave with 10V at the cable entrance and the Reflected wave (Echo) will reach 2V after 1 microsecond at the cable entrance.



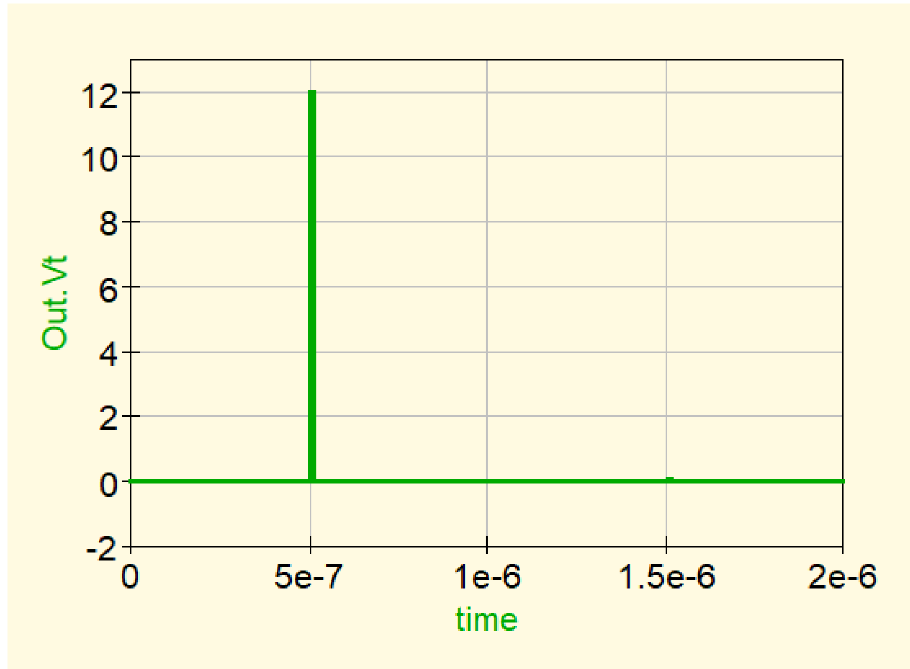


- At the Center_stage, the Incident wave will reach 10V at the cable middle part after 0,25 microsecond and the Reflected wave (Echo) will reach 2V after 0,75 microsecond at the cable middle part.

Experiment No. 1: Measurements in Different positions

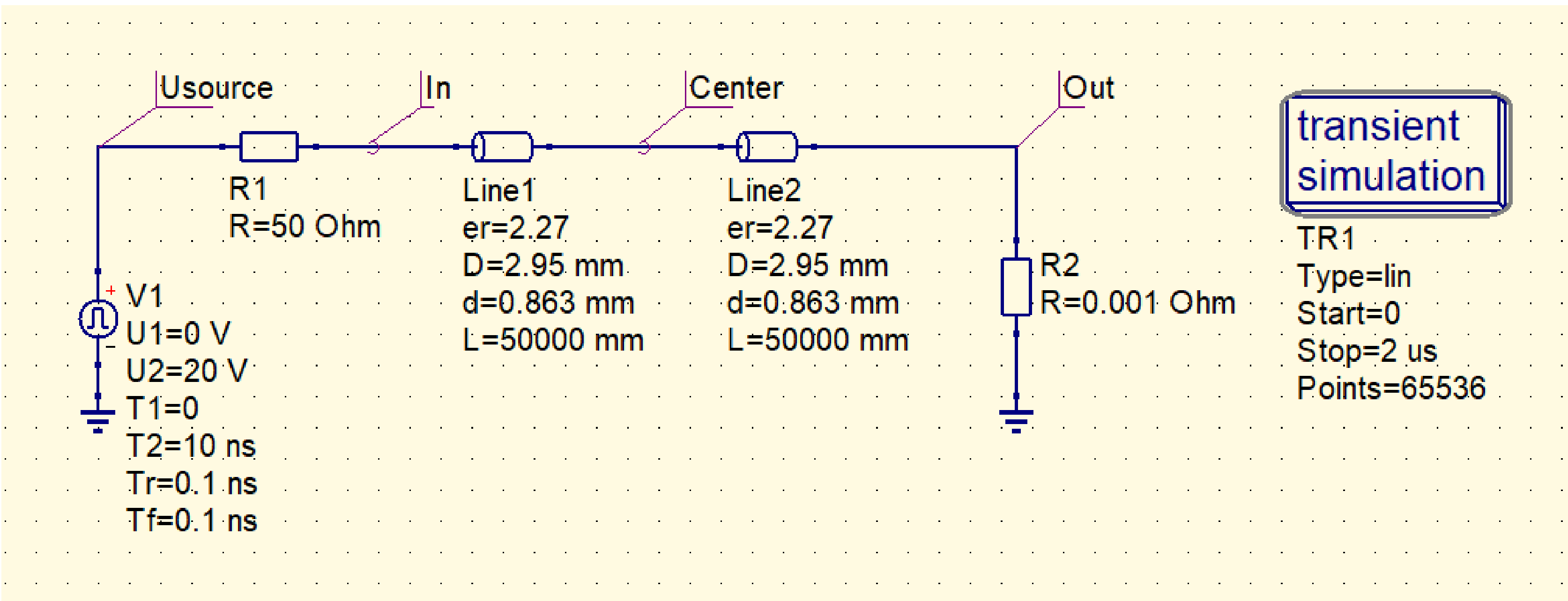
- At the Out_stage, the final voltage will reach 12 V at the last resistance part.

$$V_{last} = V_{Incident} + V_{Reflected} = 10V + 2V = 12V$$



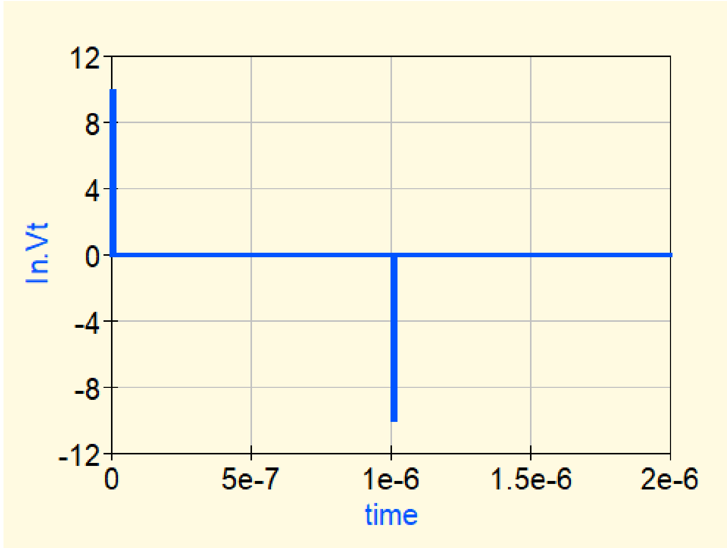
Experiment No. 2: Short circuit as a load at the end of the cable

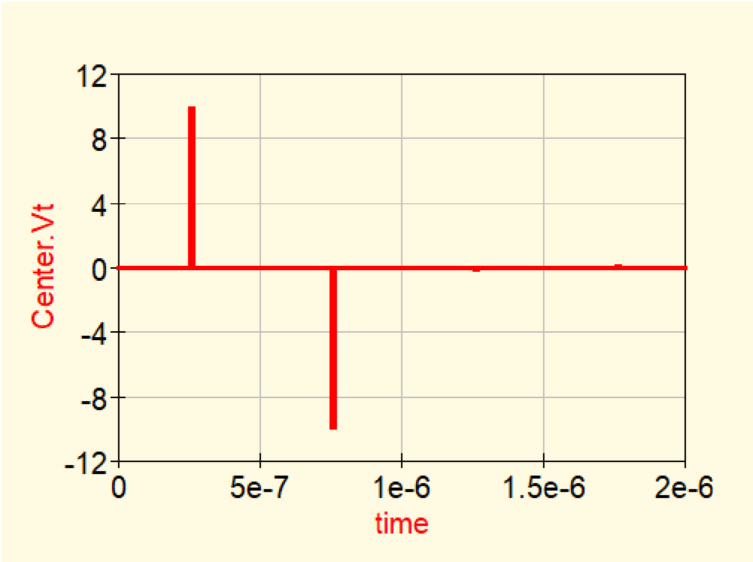
A) Short Circuit : A 0.001 Ω resistance is applied at the cable end for logical and realistic simulation rusults



Experiment No. 2: Short circuit as a load at the end of the cable

- **At the In_stage, the Incident wave with 10V at the cable entrance and the Reflected wave (Echo) will reach -10V after 1 microsecond at the cable entrance.**





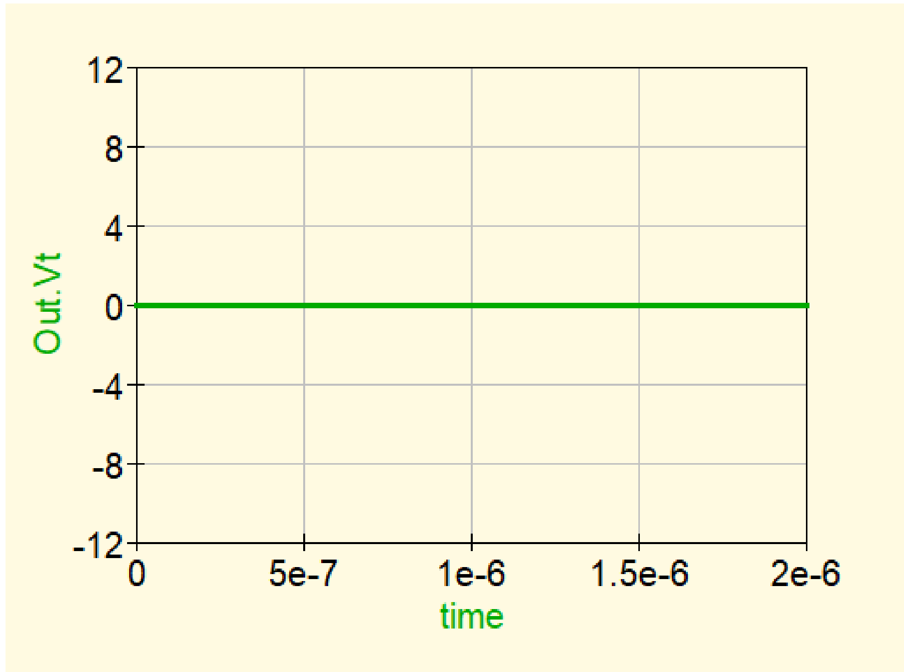
- **At the Center_stage, the Incident wave will reach 10V at the cable middle part after 0,25 microsecond and the Reflected wave (Echo) will reach -10V after 0,75 microsecond at the cable middle part.**

Experiment No. 2: Short circuit as a load at the end of the cable

- **At the Out_stage, the final voltage will reach 0V at the last resistance part as the short circuit result.**

- **At the cable end, the Incident wave is acting as a reflected wave, so they cancel each other to be like:**

$$V_{last} = V_{Incident} - V_{Reflected} = 10V - 10V = 0V$$



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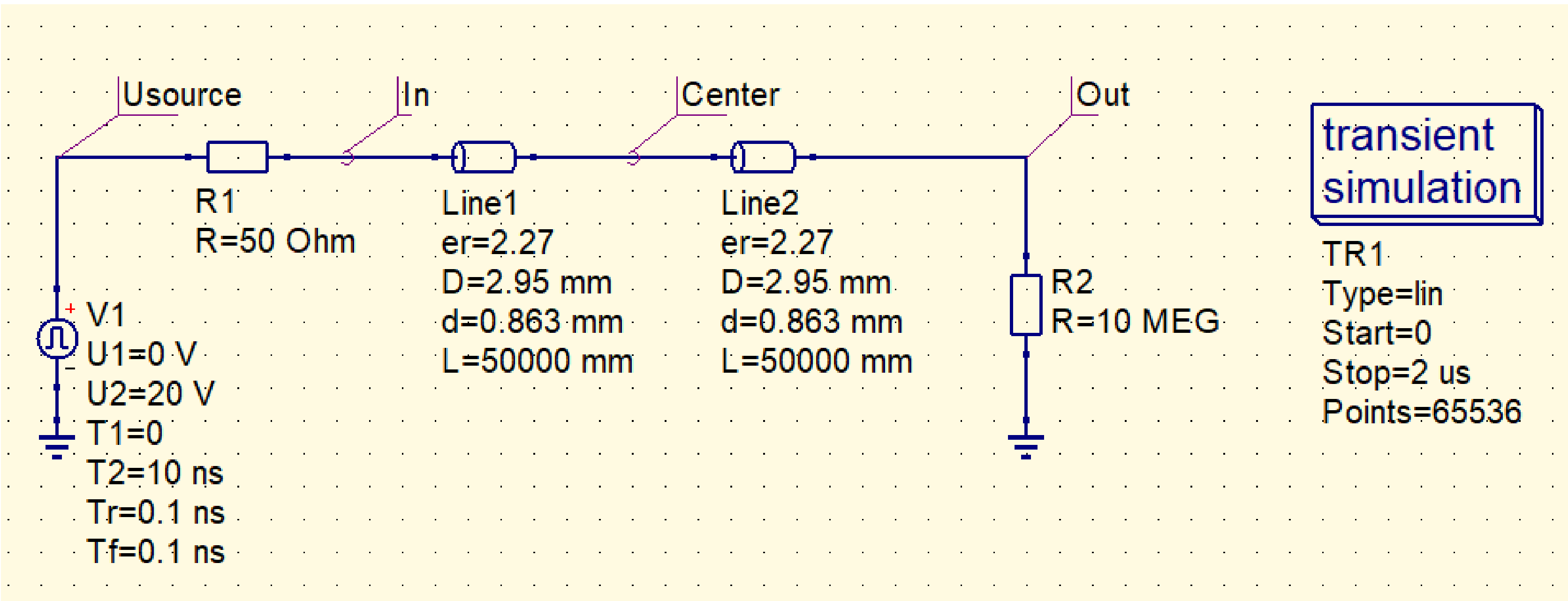
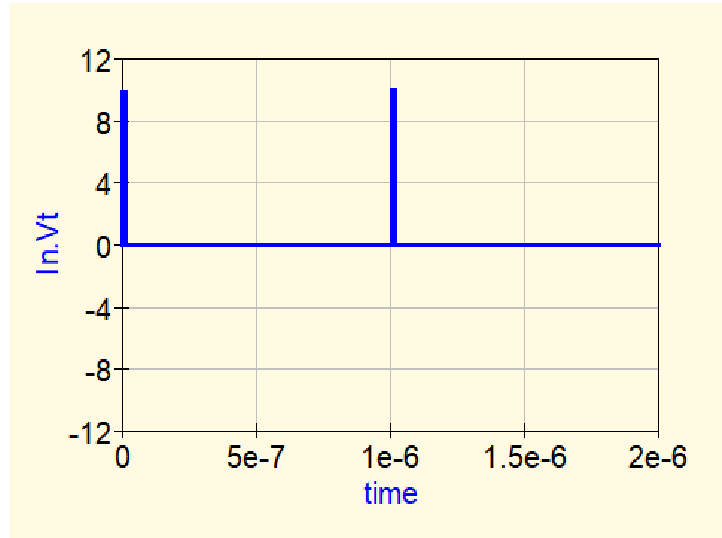
Experiment No. 3: Open circuit as a load at the end of the cable

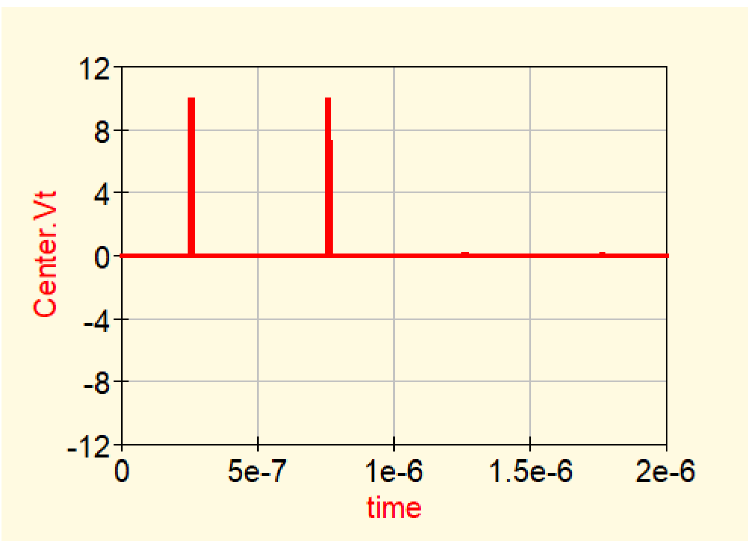
B) Open Circuit : A 10 MΩ resistance is applied at the cable end for logical and realistic simulation rusults



Experiment No. 3: Open circuit as a load at the end of the cable

- At the In_stage, the Incident wave with 10V at the cable entrance and the Reflected wave (Echo) will reach 10V after 1 microsecond at the cable entrance.





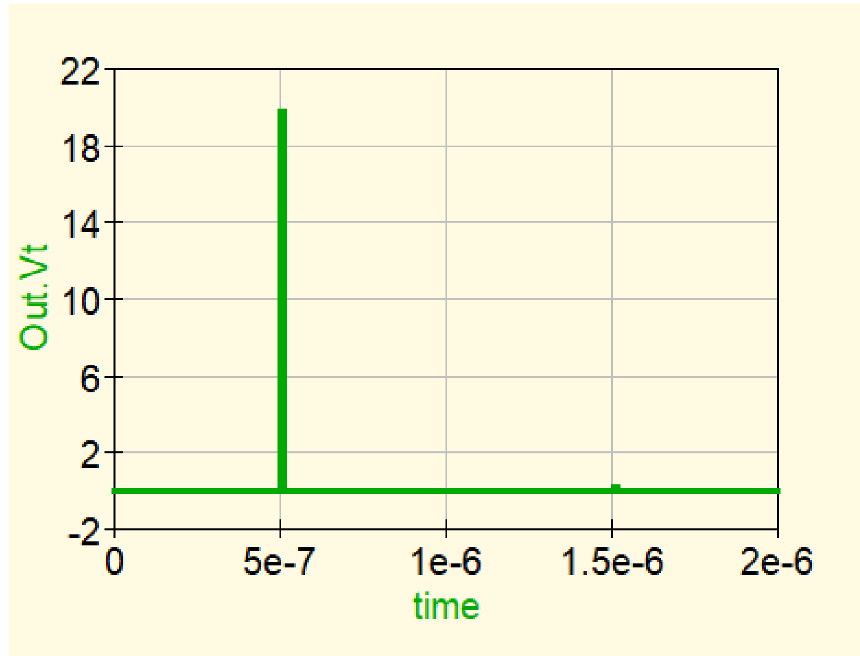
- At the Center_stage, the Incident wave will reach 10V at the cable middle part after 0,25 microsecond and the Reflected wave (Echo) will reach 10V after 0,75 microsecond at the cable middle part.

Experiment No. 3: Open circuit as a load at the end of the cable

- **At the Out_stage, the final voltage will reach 20V at the cable end part in the open circuit plan.**

- **At the cable end, there will be no current, and the original voltage (20V) will transfer back to the generator point:**

$$V_{out} = V_{Incident} + V_{Reflected} = 10V + 10V = 20V$$

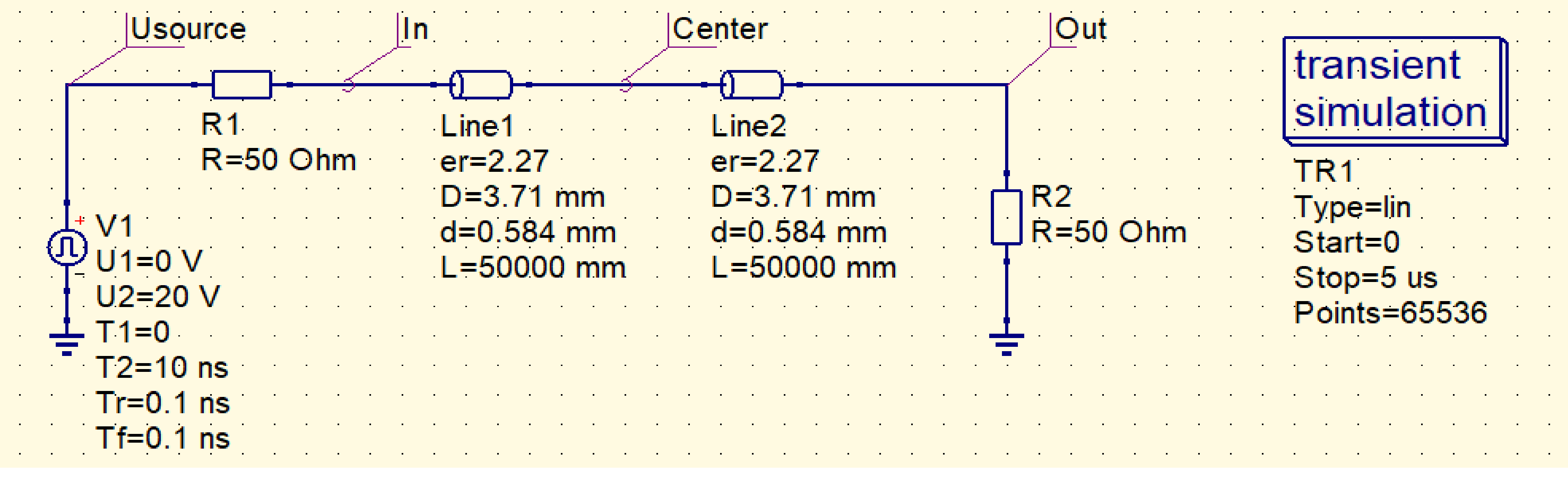


H.W. No. 1:

- **Another coaxial cable RG59/U with Z = 75 Ω (length 50m) will be used for (5 μsec). This cable has the properties of:**

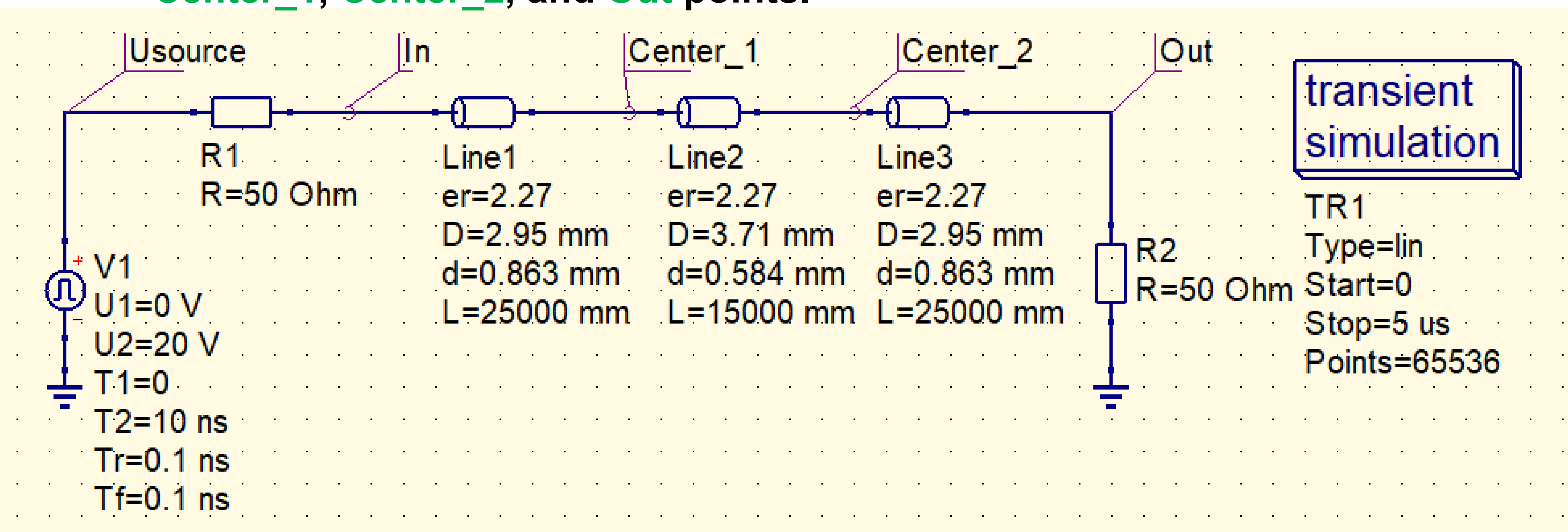
Diameter of the inner conductor:	**0.584 mm**
Inner Diameter of the shield:	**3.71 mm**

- **Please simulate the circuit below, find and discuss the results at the In, Center, and Out points.**



H.W. No. 2:

- **In this example, we will use both coaxial cables RG58/U and RG59/U with Z=50 Ω (length 25 m) and Z = 75 Ω (length 15m)respectively for (5 µsec).**
- **Please simulate the circuit below, find and discuss the results at the In, Center_1, Center_2, and Out points.**



For any questions or more details, you can contact me via:

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