Voltage drop and losses simulation

Voltage drop and losses simulation is a part of the Introduction to electrical Power Systems course. The goal of this simulation is to highlight some of the effects of transferring power in an electrical power grid. The simulation consists of an unchanging grid supplying the system, a powerline on a scale of distribution line and load consuming power. The main focus on this simulation is the voltage drop over the transmission line and how different load and line parameters affect the load voltages and currents.

The simulation can be opened from the simulator's startup menu and the opening view is similar to figure 1. The basic controls of the simulation are explained in the user manual.

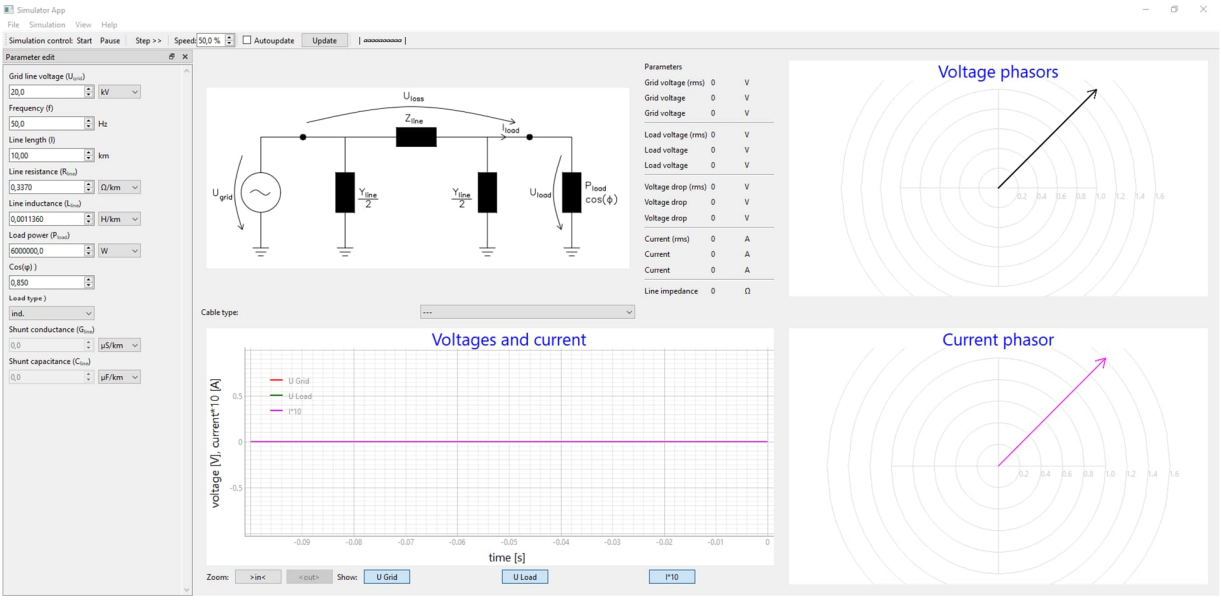

Figure 1. Simulation view of the voltage drop and losses simulation.

The simulator view has circuit diagram of the simulated circuit, numerical parameter view of grid voltages, load voltages, voltage drop, load currents and line impedance. Voltages and currents are shown in rms (root mean square, tehollisarvo in Finnish), rectangular complex and polar complex forms. Note that all shown voltages are line-to-line voltages. The voltages and currents graph shows the grid and load voltages and **ten times** the load current in time domain. The current is shown **ten times as high** since it would otherwise its scale would be too low to read. The voltage phasors figure shows the system voltages in phasor domain including grid and load voltages, and voltage drop as total and in its complex terms. The

phasor color are explained in the table 1. The Current phasor graph shows load current phasor. Lastly, the simulation view has a dropdown menu to select some predefined line parameters.

Table 1. Voltage phasors graph colors and phasor definitions.

Phasor	color	Definition
Grid voltage	Red	Supplying grid voltage
Load voltage	Green	Received load voltage
Total voltage drop	Cyan	Total voltage drop over the power line
Resistive voltage drop	Blue	Resistive component of the voltage drop
Reactive voltage drop	Black	Reactive component of the voltage drop

When the simulation is set to run, the phasor graphs re-adjust to represent the current conditions of the system and the time domain graph shows the changes in voltages and current in time domain. When either load or line parameters is changed the graphs adjust to show the new conditions of the system. This simulation is not dynamic and will not show the transition state changes. Viewing the voltage phasors, zooming into the graph may be necessary. The cable type can be selected from the dropdown menu under the circuit diagram. Selecting value from this and updating parameters will override the parameter edit line values.

The simulation has many interesting points of observation, however some points for closer inspection may be:

- Relation between load power, voltage drop and load current.
- Phase angle of current and its relation to line and load parameters.
- Voltage drop components.

Editable parameters are explained in table 2. In the simulation PI-equivalent transmission line model is used. Since the voltage of the grid is known, computation of the load voltages requires use of iterative methods. The simulation uses Newton-Raphson load flow methods to calculate the load voltage. The load and/or line parameters may be set to such values that the grid voltage may not be high enough to supply the given load over the given line. In this case the simulator will give an error message and pause the simulation.

Table 2. Parameter edit parameters, symbols, units and definitions.

Parameter	Symbol	Unit	Definition
Grid line voltage	U_{grid}	V	Voltage of the supplying grid, assumed to be rigid and unchanging
Frequency	f	Hz	Grid frequency, assumed to be unchanging
Line length	l	km	Length of the powerline between the grid and load
Line resistance	R_{line}	Ω/km	Resistance of the line per kilometer
Line inductance	L_{line}	H/km	Inductance of the line per kilometer
Load power	P_{load}	W	Active power of the load
Cos(ϕ)	-	-	Load angle of the load
Load type	-	-	Type of load, whether capacitive or inductive
Line conductance	G_{line}	S/km	Shunt conductance of the powerline per kilometer. Advanced edit.
Line capacitance	C_{line}	F/km	Shunt capacitance of the powerline per kilometer. Advanced edit.