Short circuit simulation

Short circuit simulation is a part of the Introduction to electrical Power Systems course. The goal of this simulation is to demonstrate short circuit currents during symmetrical three phase short circuit. In the simulation a generator supplies a load through a power line. When the user presses the “Create 3-phase short circuit” button, the powerline is set to short circuit at the specified point.

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.

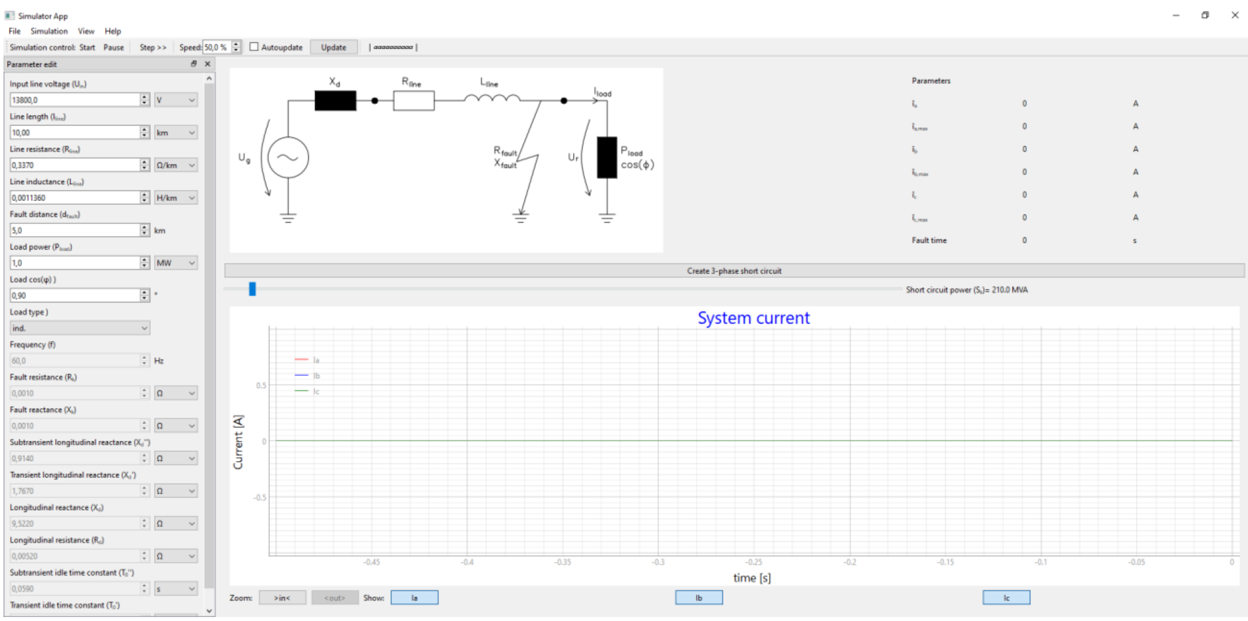

Figure 1. Simulation view of the short circuit simulation.

The simulator view has a circuit diagram of the simulated circuit, numerical parameter view, button for creating the fault, slider to change short circuit power (S_k) and time domain graph showing the phase currents of the system. The numerical parameter view shows peak currents of all phases ($\hat{i}_a$, $\hat{i}_b$, $\hat{i}_c$), these values are updated after each peak of the waveform. The current peak maximums ($\hat{i}_{a\ max}$, $\hat{i}_{b\ max}$, $\hat{i}_{c\ max}$) show the highest recorded peak current of each phase. And the fault time shows the time elapsed after the start of the short circuit. The reactances view shows the generator reactances calculated based on the short circuit power value, reduced to the line voltage level.

When the simulation is started the supplying generator supplies the set load in a static condition. When the short circuit button is pressed, a short circuit with given fault resistance and reactance is created to “fault distance” away from the supplying generator. The resulting line impedance and fault impedance act as the fault impedance Z_k of the short circuit. The maximum short circuit power -slider can be used to change the maximum suppliable power to the line connection point. This is used to emulate different types of supplying grids, where small values correspond to single generator and large values to a transmission line of national grid. The simulator simulates how the generator is affected by the short circuit, including the impulse and transition state currents. The simulator shortens the step time after the start of the short circuit for a one wave period to get better detail of information from the short circuit.

Some interesting observations may be:

- Effects of fault distance on the short circuit currents.
- Relationship between moment of short circuit and peak current of each phase.
- Effects of load power before the short circuit on the short circuit currents.
- Additionally, you can find parameters for different sized generators and see how the change in generator size affects the short circuit.

Editable parameters are expanded on table 1. The short circuit current calculations are based on *Teollisuusverkkojen oikosulkuvirtojen laskeminen* [1] paper (in Finnish) and the generator parameters are based on *Verification of Synchronous Generator Time Constants Given by Manufacturers Using the Short-Circuit Current Calculation* [2] research paper.

Table 1 on the next page.

Sources
[1] Huotari, K., Partanen, J. 1998. Teollisuusverkkojen oikosulkuvirtojen laskeminen. Lappeenrannan Teknillinen korkeakoulu. ISBN: 951-764-282-2. Available: https://www.uotila.cc/images/teollisuusverkkojen_oikosulkuvirrat.pdf Referenced: 24.6.2024

[2] Margitová, A., Kanálik, M., Kolcum, M. 2019. Verification of Synchronous Generator Time Constants Given by Manufacturers Using the Short-Circuit Current Calculation. The 10th International Scientific Symposium ELEKTROENERGETIKA 2019, 16.-18. 9. 2019, Stará Lesná, Slovak Republic. Available: https://dusan.medved.website.tuke.sk/VEGA/VEGA-1-0372-18/clanky/Margitova3.pdf Referenced: 16.7.2024.

Table 1. Parameter edit parameters, symbols, units and definitions.

Parameter	Symbol	Unit	Definition
Input voltage	U_2	V	Transformer secondary side voltage, line supply voltage
Line length	l_{line}	km	Total length of the powerline
Line resistance	R_{line}	Ω/km	Line resistance per kilometer
Line inductance	L_{line}	L/km	Line inductance per kilometer
Fault distance	d_{fault}	km	Distance between the generator and the fault
Load power	P_{load}	W	Real power of the load
Load Cos(ϕ)	-	-	Load angle of the load
Load type	-	-	Type of load, whether capacitive or inductive
Frequency	f	Hz	System frequency
Fault resistance	R_{fault}	Ω	Fault point resistance
Fault reactance	X_{fault}	Ω	Fault point reactance
Transformer reactance	X_T	Ω	Transformer reactance referred from transformer primary to secondary
Subtransient longitudal reactance	X_d''	Ω	Generator d-axis aligned reactance in sub-transient state referred in transformer secondary voltage
Transient longitudal reactance	X_d'	Ω	Generator d-axis aligned reactance in transient state from transformer primary to secondary
Longitudal reacance	X_d	Ω	Generator d-axis aligned reactance in static state referred from transformer primary to secondary
Longitudal resistance	R_d	Ω	Generator d-axis aligned resistance referred from transformer primary to secondary
Subtransient idle time constant	T_0''	s	Sub-transient state time constant, when generator is idle
Transient idle time constant	T_0'	s	Transient state time constant, when generator is idle