POWERFACTORY

PowerFactory 2021

Technical Reference

Impulse Source

ElmImpulse

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POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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Contents

1 General Description

A lightning strike can cause damage or affect an electrical installation and persons. In order to make studies regarding protection of electric-power lines or other electrical installation it is important to have a model of a lightning strike.

The Impulse Source element (*ElmImpulse*) is used to represent a lightning strike current waveform. It is modelled in *PowerFactory* as a current impulse source. It is a single-phase, single-port element and it can be connected to any AC Terminal.

The Impulse Source element is relevant mainly for EMT (instantaneous values) simulations and for Unbalanced Load Flow calculations.

The *ElmImpulse* supports three different current impulse waveforms:

- Waveform according to the IEC 62305-1 standard;
- Heidler waveform;
- Double-Exponential waveform.

The equations and parameters of the different waveforms are documented in the following sections.

2 Load Flow Analysis

The *ElmImpulse* element is a single-phase element and therefore it is only being considered for unbalanced AC Load Flow calculations.

2.1 AC Load Flow

2.1.1 Unbalanced Calculations

The equivalent circuit of the model valid for the Load Flow calculations is depicted in Figure 2.1.

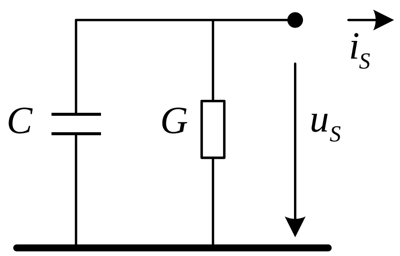

Figure 2.1: *DIgSILENT* Impulse Source Load Flow model

From Figure 2.1 can be seen that the model only consists of two internal parameters (capacitance C_i and conductance G_i). The model has been introduced to the Unbalanced Load Flow calculation so that the EMT simulation can be initialised properly.

The default values of the internal parameters are zero which, in this case, makes the element an ideal source. If the values are set to zero, there will be no current contribution from the Impulse Source for the Unbalanced Load Flow calculation.

2.2 Calculation parameters

The calculation parameters used in the load flow model are presented in Table 2.1.

Table 2.1: Calculation parameters (AC Load Flow)

Name	Symbol	Unit	Description
Gi	G_i	S	Internal conductance
Ci	C_i	F	Internal capacitance

3 EMT-Simulation

The equivalent circuit of the EMT model is depicted in Figure 3.1. As in the Unbalanced Load Flow calculation, the current source will be ideal if the internal parameters C_i and G_i are set to zero.

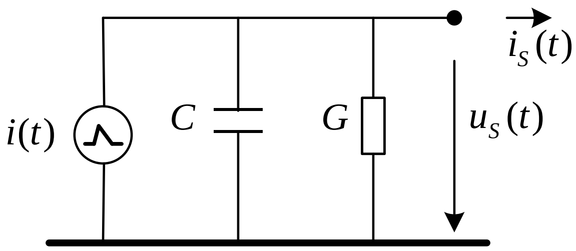

Figure 3.1: *DIgSILENT* Impulse Source EMT model

As already mentioned in Section 1, the user can select between three different waveforms, which will be presented in the following section.

3.1 Waveform description

3.1.1 Heidler and IEC 62305-1 waveforms

The Heidler waveform is implemented according to [2] and is described by Equation (1):

$$i = \frac{I}{k} \cdot \frac{(t/\tau_1)^n}{1 + (t/\tau_1)^n} \cdot \exp(-t/\tau_2) \tag{1}$$

where:

- I is the peak current in kA (it can also be negative);
- k is the correction factor for the peak current;
- t is the time;
- τ_1 is the front time constant in μs;
- τ_2 is the tail time constant in μs;
- n is the exponent or steepness factor.

The IEC 62305-1 waveform is implemented in *PowerFactory* according to [1] in which lightning current time functions are presented. The IEC 62305-1 current waveform is defined in Equation (2).

$$i = \frac{I}{k} \cdot \frac{(t/\tau_1)^{10}}{1 + (t/\tau_1)^{10}} \cdot \exp(-t/\tau_2) \tag{2}$$

Basically, the IEC 62305-1 waveform is equal to the Heidler waveform if the steepness factor n is set to 10.

The default parameters of the Heidler/IEC 62305-1 source correspond to the *LPLI* (Lightning Protection Level) parameters given in [1]. If the values of the internal variables C_i and G_i of the model are set to 0 (default values), the Heidler/IEC 62305-1 source is an ideal source.

3.1.2 Double-Exponential waveform

The Double-Exponential waveform is implemented according to [3] and [4] and is described by Equation (3):

$$i = \frac{I}{k} \cdot \left(\exp^{-t/\tau_2} - \exp^{-t/\tau_1} \right) \tag{3}$$

where:

- I is the peak current in kA (it can also be negative);
- k is the correction factor for the peak current;
- t is the time;
- τ_1 is the front time constant in μs;
- τ_2 is the tail time constant in μs.

The disadvantages of the Double-Exponential function are that the current starts at maximum steepness and the introduction of a discontinuity at time $t = 0$.

3.2 Triggering of the Impulse Source

The *ElmImpulse* can be triggered by the *trigger* signal. Depending on this signal, the element can operate in two different states as shown in Table 3.1.

Table 3.1: *ElmImpulse* Triggering (EMT-Simulation)

State	Threshold
On	$trigger > 0.5$
Off	$trigger < 0.5$

Using the *trigger* signal, the user can manually turn the output of the Impulse Source on or off.

3.3 Signals of the EMT model

The signals used in the EMT model are presented in Table 3.2.

Table 3.2: Signals (EMT-Simulation)

Name	Symbol	Unit	Type	Description
$trigger$			IN	Triggers the model on/off

3.4 Calculation parameters of the EMT model

The calculation parameters used in the EMT model are presented in Table 3.3.

Table 3.3: Calculation parameters (EMT-Simulation)

Name	**Symbol**	**Unit**	**Description**
$I0$	I_0	A	Peak current
k			Correction factor for the peak current
$tau1$	τ_1	s	Front time constant
$tau2$	τ_2	s	Tail time constant
n			Exponent or Steepness factor
Gi	G_i	S	Internal conductance
Ci	C_i	F	Internal capacitance

4 References

[1] IEC 62305-1 protection against lightning - part 1: General principles.

[2] F. Heidler and J. M. Cvetic. A Class of Analytical Functions to study the Lightning Effects associated with the Current Front. *ETEP*, 12(2), March/April 2002.

[3] F. Heidler, J. M. Cvetic, and B.V Stanic. Calculation of Lightning Current Parameters. *IEEE Transactions on Power Delivery*, 14(2), April 1999.

[4] F. Heidler, W. Zischank, Z. Flisowski, Ch. Bouquegneau, and C. Mazzetti. Parameters of Lightning Current given in IEC 62305 - Background, Experience and Outlook. In *29th International Conference on lightning protection*, 2008.

List of Figures

List of Tables