SafeGrid™ Earthing Tutorial

How to Perform a Transient Calculation

22/11/2022

Introduction

ELEK SafeGrid Earthing Software has a transient calculations mode which allows users to analyse the earthing response to a lightning waveform defined in the time-domain.

The transient calculations in SafeGrid can be used for:

a) Determining the earthing response to lightning waveforms defined in the time-domain.
b) Modelling standard transient waveform types including from IEC 62305, CIGRE, Heidler, Double-exponential waveforms as well as Custom waveforms from spreadsheets.
c) Analysing the response in the time-domain which is displayed in plots versus time or animated with time 3D/2D surface plots (which can be downloaded as video files).

How to perform a transient calculation is explained with the following example as follows.

1. Sample earthing system

In this tutorial, the earthing system shown in Figure 1 (drawn in AutoCAD) will be used for the transient calculations. The earthing system is a simple 10 m by 10 m grid with 1 m rods at each corner. The response to a lightning strike applied to the faulted segment will be calculated.

Commented [EC1]: Which segment is the faulted segment? We can highlight in the Figure 1.

Commented [G2R1]: Faulted segment is very short segment so not visible

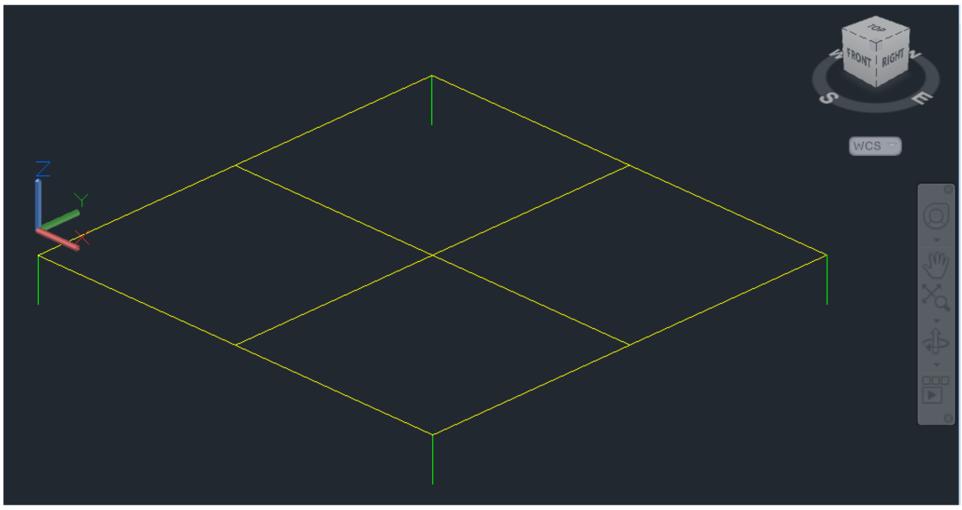

Figure 1 – Example earthing system drawn in CAD

Commented [EC3]: Please show this diagram with rod facing down

2. Design Settings

Start the transient calculation in Design Settings.

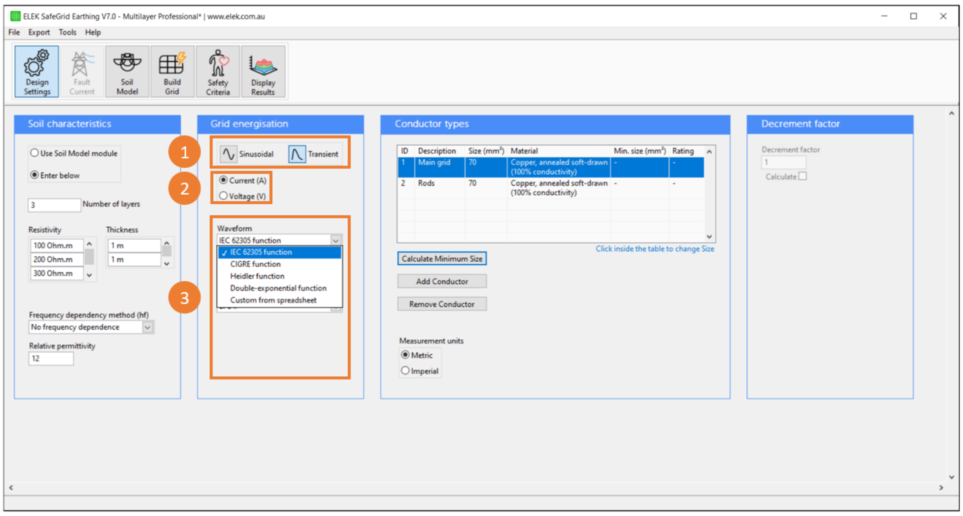

Figure 2 – Design Settings

① Under Grid energisation. Select **Transient.**

② Select either **Current (A) or Voltage (V)** as Grid energisation.

③ Specify **Waveform** and related parameters. SafeGrid supports several standard input waveforms and user-defined custom waveforms which can be uploaded from spreadsheet files.

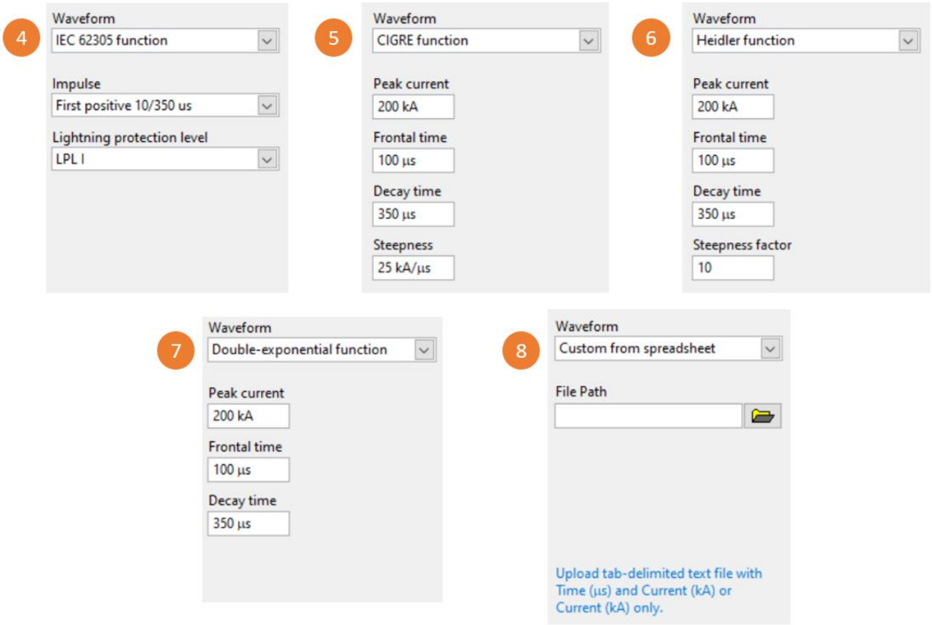

Figure 3 – Input waveform types

④ **IEC 62305 function**: The function defined in the IEC standard is same as the Heidler function. The difference is that the steepness factor is a constant in the IEC standard. The correction factor, the peak current, the frontal and tail time constants are defined with respect to the following impulse shapes and lightning protection level.

a) Impulse:
   i. First positive impulse (10/350 μs)
   ii. First negative impulse (1/200 μs)
   iii. Subsequent negative impulses (0.25/100 μs)
b) Lightning protection level:
   i. LPL I
   ii. LPL II
   iii. LPL III - IV

⑤ **CIGRE function:** The CIGRE function has been introduced in section 3.9 of CIGRE technical brochure No. 063. The inputs to this method are the peak current (kA), the frontal time (μs), the decay time (μs) and the steepness of the wave (kA/μs). There is a lower limit to the value of the decay time which is calculated from the frontal time.

⑥ **Heidler function:** The inputs to this method are the peak current (kA), the frontal time (µs), the decay time (µs) and the steepness factor. The decay time must be greater than 1.135 times the frontal time.

⑦ **Double-exponential function:** The inputs to this method are the peak current (kA), the frontal time (µs) and the decay time (µs).

⑧ **Custom from spreadsheet:** The data in a tab delimited file can be imported into SafeGrid and used for calculations. The file formats can be any of the following:

a) Only current values: The file will have only 1 column which contains the values of current. The additional input required in the user interface for this type of file will be the sampling time (µs).

b) Time and current values: This file will have 2 columns, time and current. The time may or may not be uniformly sampled.

In this tutorial, we will use the following settings:

Waveform - IEC 62305 function

Impulse - First positive impulse (10/350 µs)

Lightning protection level - LPL II

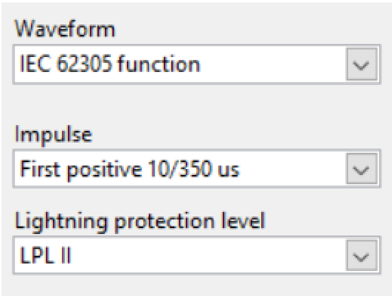

Figure 4 - Example input waveform settings

3. Build Grid

Import the sample grid in Figure 1 to the Build Grid module.

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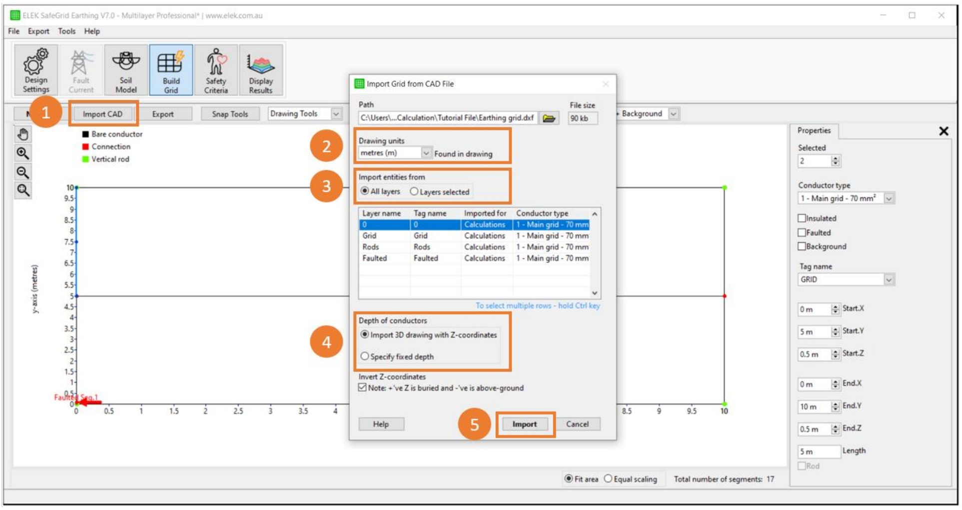

Figure 5 – Build Grid

① In **Build Grid** module press **Import CAD** and select the ASCII DXF file to import.

② Set the Drawing units with dropdown options or use the units that have been set in the drawing file

③ Import entities from **All layers** or the **Layers selected**. Hold Ctrl key to select multiple layers.

④ Import the grid in 3D by selecting **Import 3D drawing units with Z-coordinates** or in 2D by selecting **Specify fixed depth**.

⑤ Press **Import** to load the grid file.

4. Safety Criteria

Voltage profile(s) specify the area(s) where the actual surface and touch voltages will be calculated.

4.1. Add voltage profiles

① Safety Criteria has a default rectangle profile. Click **Fit to Grid** to auto-size the voltage profile to cover the entire grid area.

Commented [EC5]: Remove the Figure 6. And change number 4 to number 1 in the Figure 7.

② To add a line profile, press **Add Profile** and specify **Line** as the profile type and press **OK.**

Set the line profile to **Fit to Grid** to cover the entire grid area.

Commented [EC6]: Make number 3 to be 2 as well.

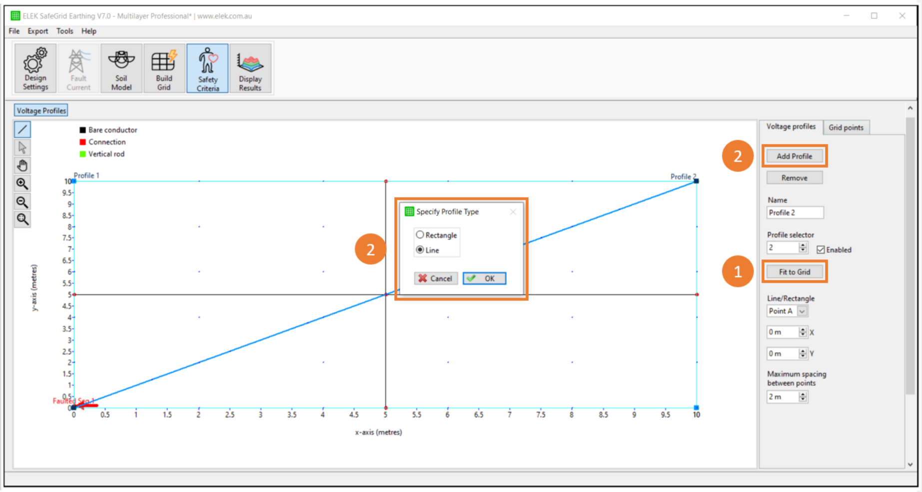

Figure 6 – Add Line Profile

4.2. Add grid points

Grid points specify the places on the grid where voltages and currents will be calculated.

① To add grid points, switch to **Grid points** tab first on the side.
② Click **Add Point** to add grid points at four corners of the grid.
③ Set the calculate mode to **Voltage and Current** for all of them

Commented [EC7]: Add number 1 for grid points tab. Add point and calculate dropdown will be number 2 and 3.

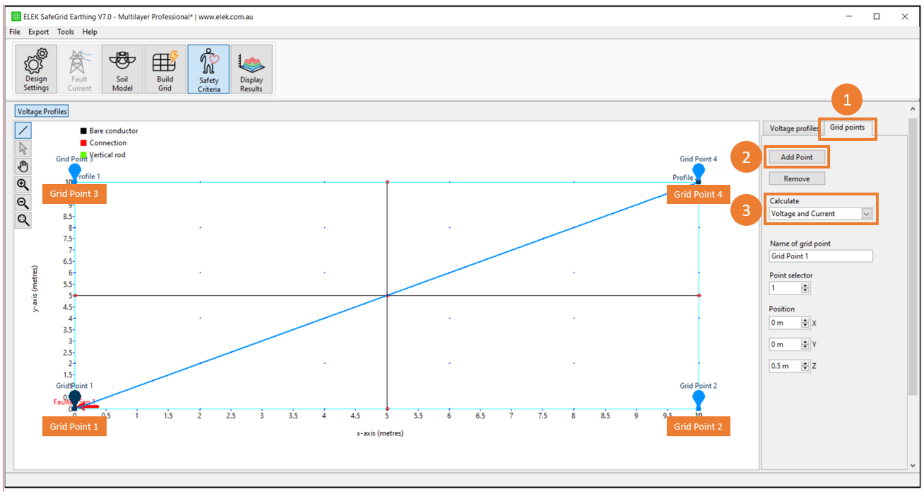

Figure 7 – Add Grid Points

5. Display Results

This module performs the transient calculation and displays results plots for analysis.

① Click **Calculate** to obtain the result plots. The calculated Grid Impedance (Z) and Max. Grid Potential Rise (GPR) will also be displayed.

② Click **Pop-out** to open the **Input Waveform Preview** which is helpful when comparing the output plots in the other tabs to the input waveform.

Commented [EC8]: Please show how to open the Input Waveform popup window.

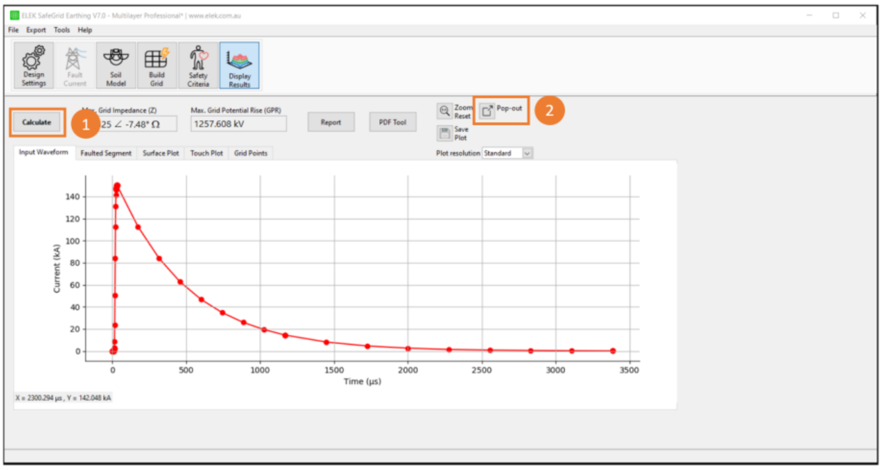

Figure 8 – Display Results

The following are the transient calculation results:

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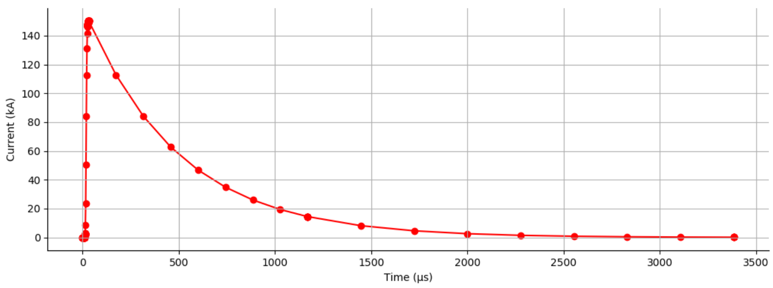

Figure 9 – Input Waveform plot

Input waveform plot shows the lightning waveform defined in Design Settings. In this example, the IEC 62305 function is plotted.

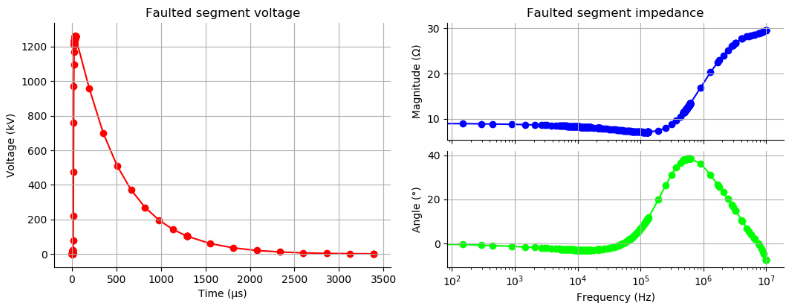

Figure 10 – Faulted segment plot

Faulted segment plot includes the faulted segment voltage and impedance. The voltage (kV) versus time is plotted which has the same shape as input waveforms. The impedance magnitude (Ω) and phase angle (°) are plotted against the frequency (Hz).

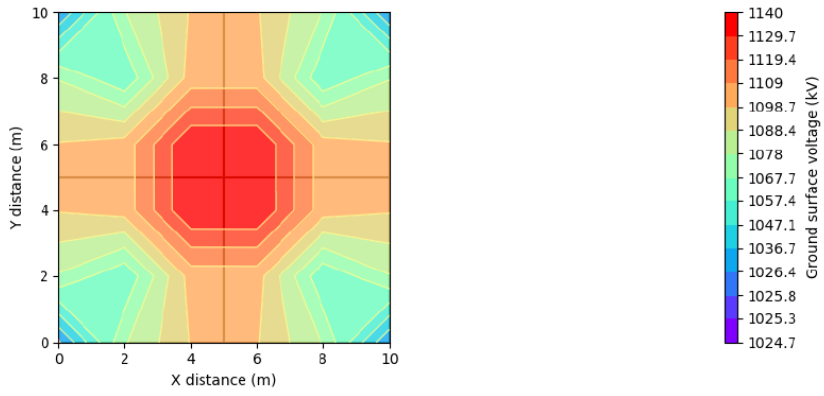

Figure 11 – Maximum surface voltage (kV) during the response of the rectangle profile

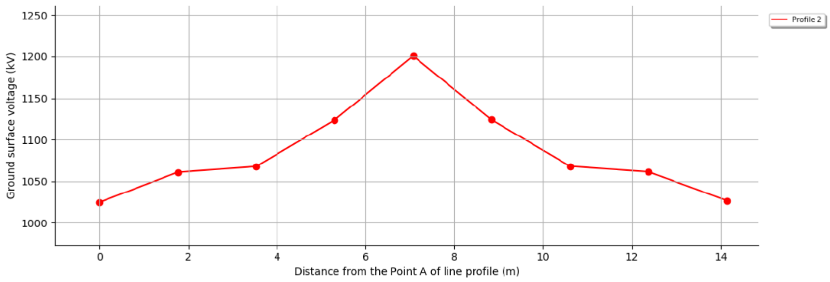

Figure 12 – Maximum surface voltage during the response along the line profile

The animated plots show the surface voltages on the grid and along the line profile during the response. With reference to the pop-out input waveform, you can jump to the moment in time of maximum surface voltage. The response can be downloaded as a video file.

Commented [EC10]: We need to show the plot with **maximum** surface and touch volage. Change the figure name accordingly.

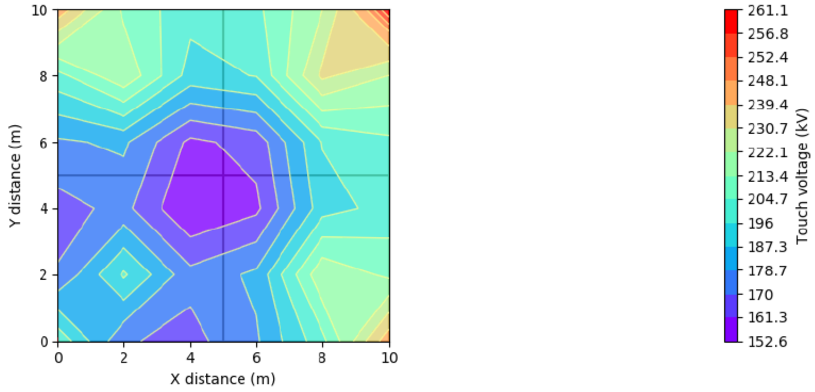

Figure 13 – Maximum touch voltage (kV) during the response of the rectangle profile

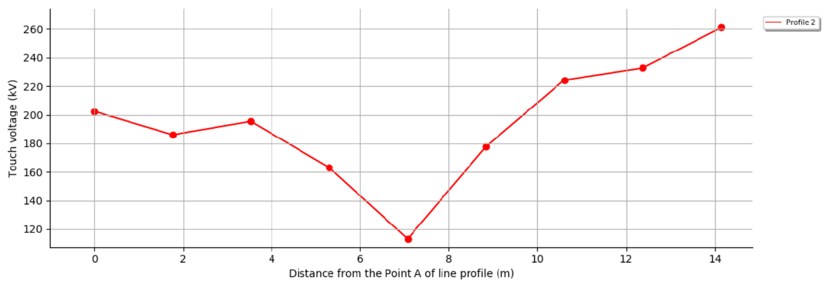

Figure 14 – Maximum touch voltage during the response along the line profile

The animated plots show the touch voltages on the grid and along the line profile during the response.

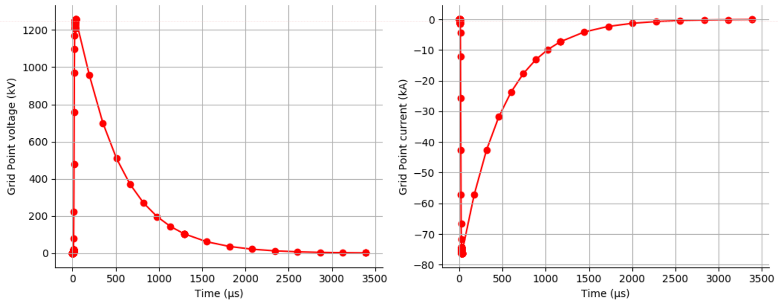

Figure 15 – Grid point response at faulted segment

The grid point plot shows the voltage and current at Grid Point 1 (0 m, 0 m) close to the faulted segment. Negative current signifies a negative direction in current flow from the end to the start of the segment.

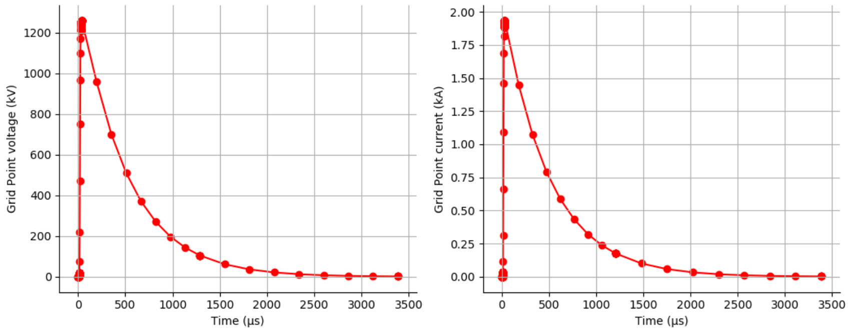

Figure 16 – Grid point response away from faulted segment

The grid point plot above shows the voltage and current at Grid Point 2 (10 m, 0 m) away to the faulted segment.

The voltage and current at Grid Point 3 and 4 are similar as Grid Point 2.

Commented [EC11]: Let's just show the plots of the first 2 points and state clearly which points these plots are drawing for. Can you also ask Edstan why there is negative current and explain underneath the plot.