



Cable HVTM Tutorial

Magnetic Fields Module

7/04/2020

Table of contents

Table of contents	i
Introduction.....	1
A three-phase circuit example	2
1. Obtain the current ratings	3
2. Calculate the magnetic field intensity	6
3. Make use of magnetic field intensity interactive plots	8
4. Create a report	9
References	10

Introduction

The Magnetic Fields module in [Cable HV](#) Software calculates the magnetic field intensity in micro Tesla μT occurring around a cable, circuit or a group of circuits. The calculations are based on the Biot-Savart law which explains the fundamental quantitative relationship between and electric current which is flowing and the magnetic field it produces. The magnetic field produced by multiple conductors is calculated as the summation of the magnetic fields caused by the individual conductors.

Capabilities:

- Cables in air or buried cables at any x, y position.
- Any cable type (single core and multi-core) and any number of cables.
- The current magnitude and direction of flow as well as phase angle can be changed.
- Calculates magnetic field intensity at any height above the cables.
- The effect of relative permeability

The following practical example will show you how to use the Magnetic Fields module.

A three-phase circuit example

A three-phase circuit without neutral is installed in a lava field. The parameters of the cable are shown in Table 1.

Table 1 – Cable data

Nominal section area (mm ²)	Conductor diameter (mm)	DC conductor resistance (Ω/km)	Thickness of insulation	Aluminium screen		Lead sheath	
				Sectional area (mm ²)	Outside diameter of cable	Sectional area (mm ²)	Outside diameter of cable
2000 S ¹	57.2	0.0090	16.4	160	110	830	114

1 S: segmental stranded

Cables are directly buried at 0.8 m depth in flat arrangement (see Figure 1). The relative permeability of volcanic rock is assumed as 1.021. The thermal resistivity of volcanic rock is approximately 1.2 C.m/W.

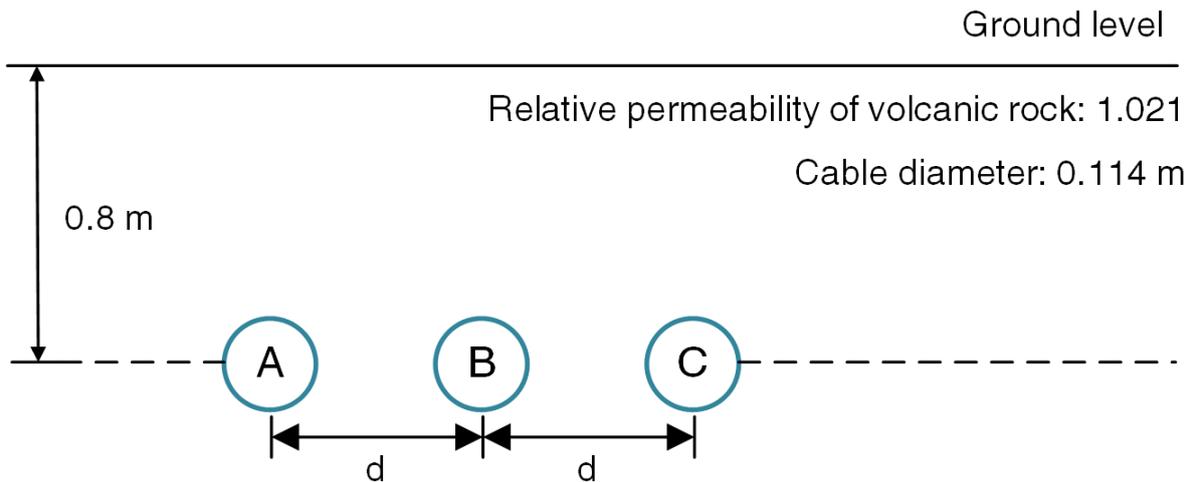


Figure 1 – Installation of cables

The magnetic field intensity at ground level and 1 m above ground will be calculated for cable touching and for the following distances between cables (shown as d in Figure 1): 0.2m, 0.3m, 0.5m.

1. Obtain the current ratings

Based on the cable and installation conditions, the current rating can be calculated. The cable physical positions and steady-state current rating will then be imported to the Magnetic Fields module automatically.

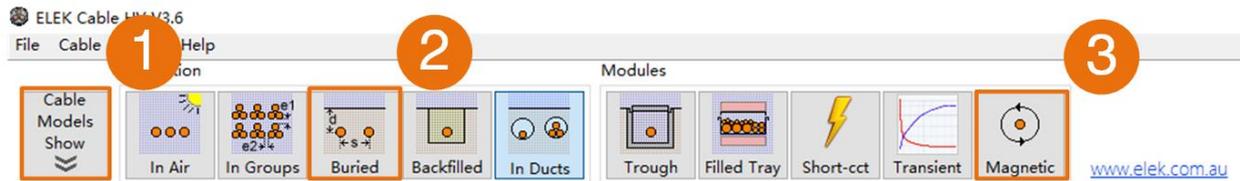


Figure 2 – Obtain the current ratings

- ① Edit and load the cable model by clicking **Cable Models Hide/Show**. Alternatively, you can load a cable model from the library of pre-modelled power cables.
- ② Select **Buried** of Installation method and specify relevant parameters to obtain a current rating or a set of current ratings for multiple cable circuits.
In this case, arrangement of flat touching and flat spaced are set to obtain the current ratings.

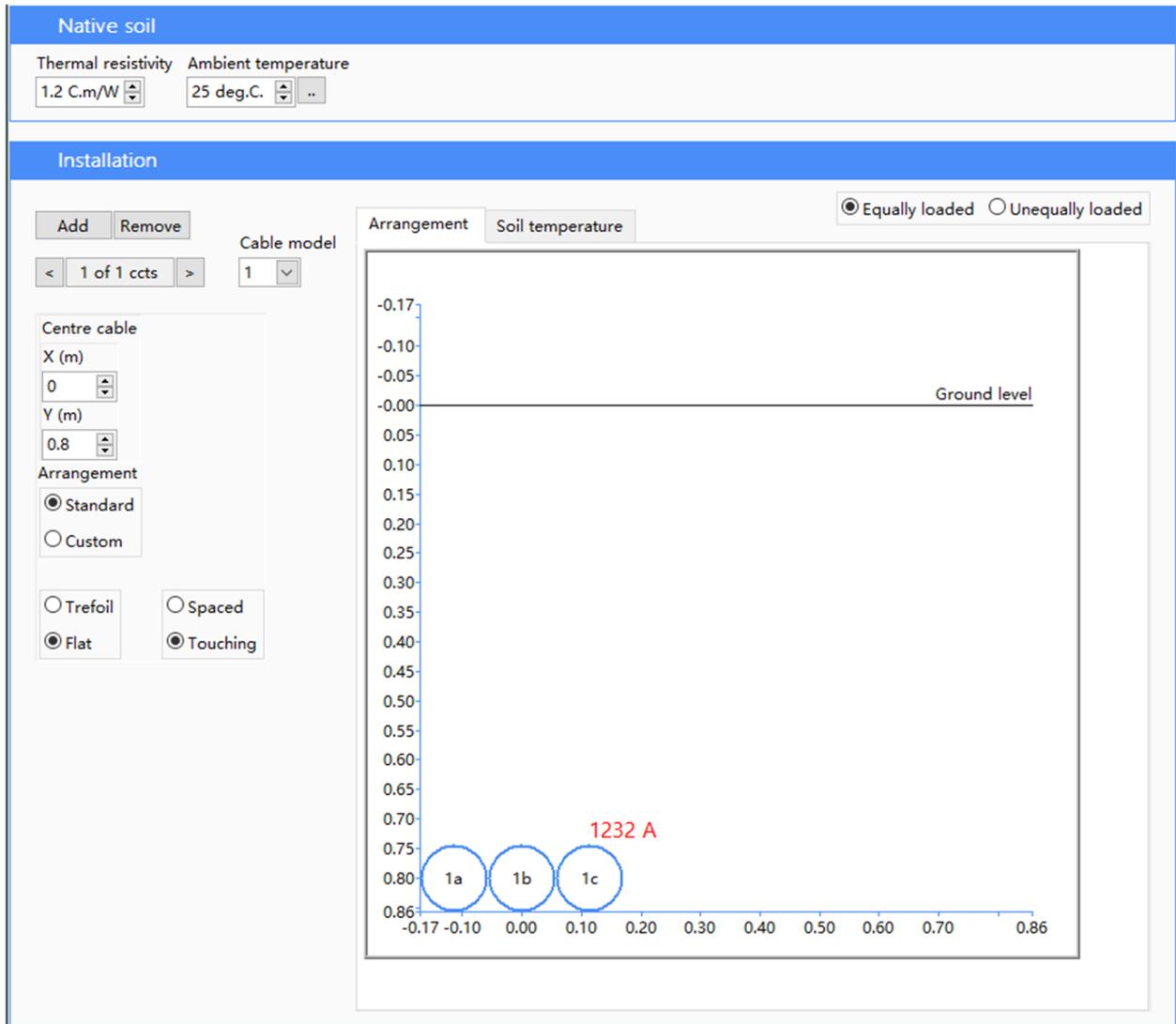


Figure 3 – Cable installation and cable arrangement (flat touching)

The calculated current rating of flat touching is 1232 A. Adjusting the distance between cables, we can separately get current ratings for the distances of 0.2 m, 0.3 m, 0.5 m between cables. Their current ratings are shown in the Table 2.

Table 2 – Current rating of different arrangements

Arrangement	Flat-touching	Flat-spaced (0.2 m)	Flat-spaced (0.3 m)	Flat-spaced (0.5 m)
Current rating (A)	1232	1130	1044	963

- ③ Open the Magnetic Fields module by clicking **Magnetic** button under Modules. The cable positions and steady-state current rating are automatically imported (Figure 4).

Cable installation data

Click the table cells to edit

Dir. No	Phase	position (m)	position (m)	Current (A)	Angle (deg.)	Direction	On / Off
1	A	-0.114	0.800	1232.100	0	FORWARD	ON
1	B	0.000	0.800	1232.100	-120	FORWARD	ON
1	C	0.114	0.800	1232.100	120	FORWARD	ON

Buttons: Add, Remove, Reset, Move Up, Move Down, Calculate, Report

Figure 4 – Cable positions and current ratings in Magnetic Fields module

2. Calculate the magnetic field intensity

The Magnetic Fields module calculates the magnetic field intensity at any height above the cables.



Figure 5 – Calculate the magnetic field intensity

- Enter or edit the cable installation data by clicking the table cells. Click **Add** or **Remove** buttons to add or remove cables and click **Reset** to reset the table and remove all the data.

The cable installation data includes positions (note positive Y is buried depth), phase designation (A, B, C, L, N), current magnitude, phase angle, current direction or switch current On / Off.

- Select **Installation method** and specify the **Relative soil permeability** of the Buried installation. The relative permeability of the in air installation is 1.

In this case, buried installation is selected and relative soil permeability is set as 1.021.

- Specify the calculation parameters which provides the inputs for setting the plots.

The horizontal inputs determine how wide the sweep of values are for the magnetic field intensity plot(s). The vertical inputs determine the heights of the calculated plots above the

ground surface (at 0 m) and the number of plots determined by the step size. Magnetic field intensity at ground level and at 1 m above ground level are calculated in this case.

- ④ Click **Calculate** to obtain the magnetic field intensity. The magnetic field intensity plots will then be calculated and updated.

Calculate the magnetic field of other scenarios by editing the cable installation data or importing data from main application.

3. Make use of magnetic field intensity interactive plots

The plot displays the calculated magnetic field intensity results.

- ① Move the cursor along the magnetic field intensity plots. Also click on the cables to display the physical positions.
- ② Zoom or pan the plots by pressing corresponding buttons in the upper right corner.
- ③ Select or deselect plots to show or hide their magnetic field intensity results.

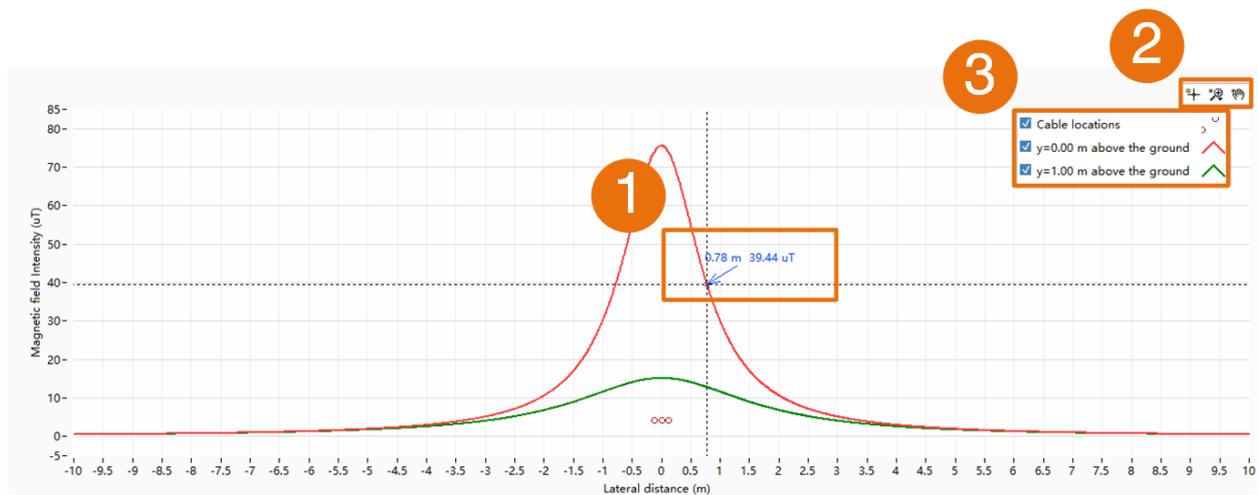


Figure 6 – Magnetic field intensity interactive plots

4. Create a report

Click **Report** to create a PDF report containing inputs and results of magnetic field intensity.

A snippet of the flat-touching arrangement report of is shown below.

Results

Height above the ground, Y (m)	Lateral distance, X (m)	Maximum field Intensity, B (uT)
0	0	75.54
1	0	15.12

Figure 7 – A snippet of the flat-touching arrangement report

The magnetic field intensity results of all arrangements are summarized in Table 3.

Table 3 – Maximum magnetic field intensity

Arrangement and calculated plots	Flat touching		Flat-spaced (0.2 m)		Flat-spaced (0.3 m)		Flat-spaced (0.5 m)	
	Ground level	1 m above ground	Ground level	1 m above ground	Ground level	1 m above ground	Ground level	1 m above ground
Maximum magnetic field intensity (μT)	75.54	15.12	117.50	24.16	153.62	33.07	201.33	48.91

The International Commission for the Protection against Non-Ionizing Radiation Protection Guide [2] has set 1 mT as the reference limit for occupational exposure and 200 μT as the public exposure limits [1-3]. In this case, the maximum magnetic field intensity at ground level of flat arrangement spaced by 0.5 m exceeds the public exposure limit.

References

- [1] E. Fernandez and J. Patrick, "Magnetic Fields from High Voltage Power Cables," 2018. [Online]. Available: <https://elek.com.au/wp-content/uploads/2018/09/Magnetic-Fields-from-High-Voltage-Power-Cables.pdf>.
- [2] M. Rüdiger *et al.*, "(International Commission on Non-Ionizing Radiation Protection). ICNIRP Guidelines for Limiting Exposure to Electric Fields Induced by Movement of the Human Body in a Static Magnetic Field and by Time-Varying Magnetic Fields below 1 Hz," 2014.
- [3] I. Guideline, "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)," *Health phys*, vol. 74, no. 4, pp. 494-522, 1998.