Cable HV^{TM} Tutorial

Cable Crossing Module

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Introduction

When circuits cross each other, each circuit acts as a heat source that influences the other cable's ratings. The vertical distance between the crossing circuits and their relative crossing angle are important parameters that determine crossing ratings. Mutual heating between multiple buried cable circuits near one another are at a maximum when they are in parallel which therefore leaves their current ratings at a minimum. When circuits are at right angles to one another, the thermal interaction is at a minimum and thus the cable current ratings are at a maximum [1].

The Cable Crossings module in Cable HV™ Software allows the user to model multiple buried circuits at various depths and estimate the permissible current and derating factors depending on whether the circuits are in parallel with one another or whether they cross each other at a specific angle.

Capabilities:

- Capable of modelling multiple (2 or more) cable circuit crossings in the same installation.
- Cable crossings are supported for direct buried, buried ducts and buried in backfill underground.
- Any cable type (single core and multi-core) and any number of cables.
- Heat from buried steam pipes can be included in the modelling.
- Crossing angles from 0 to 179 degrees.

As per the IEC Standard, the following limitations apply:

- Transient analysis is not supported.
- Temperature based ratings and unequally loaded analysis is not supported.
- Cyclic or emergency loadings are not supported.

The following practical example will show you how to use the Cable Crossing module.

Example: Single core 132 kV cable circuit crossing a three-phase multicore 22 kV cable

The objective of the example is to show the current ratings for both circuits when the 22 kV circuit crosses at angles ranging from 15-90°.

Table 1 and Table 2 display the cable data for a single core 132 kV cable and three core PVC-SWA-PVC sheathed cable, respectively.

Table 1 – 132 kV Cable data

Nominal section area (mm²)	**Conductor diameter (mm)**	**DC conductor resistance (Ω/km)**	**Thickness of Insulation (mm)**	**Copper screen**		**Nylon Sheath**
				Sectional area (mm²)	**Outside diameter of conductor screen (mm)**	**Outside diameter (mm)**
1000 S[1]	39.7	0.0176	20	296.13	92.3	104.6

1 S: segmental stranded

Table 2 – 22 kV Cable data

Nominal section area (mm²)	**Conductor diameter (mm)**	**DC conductor resistance (Ω/km)**	**Thickness of Insulation (mm)**	**Copper screen**		**PVC Sheath**
				Sectional area (mm²)	**Outside diameter of conductor screen (mm)**	**Outside diameter (mm)**
400	23.6	0.047	5.5	22.7	39.6	105.6

Figures 1 and 2 display the cable models in the Cable Model Editor of Cable HV™.

The 132 kV single core cables are buried at 1 m with a phase spacing 0.5 m. The 22 kV multi-core cable is buried at 0.7 m.

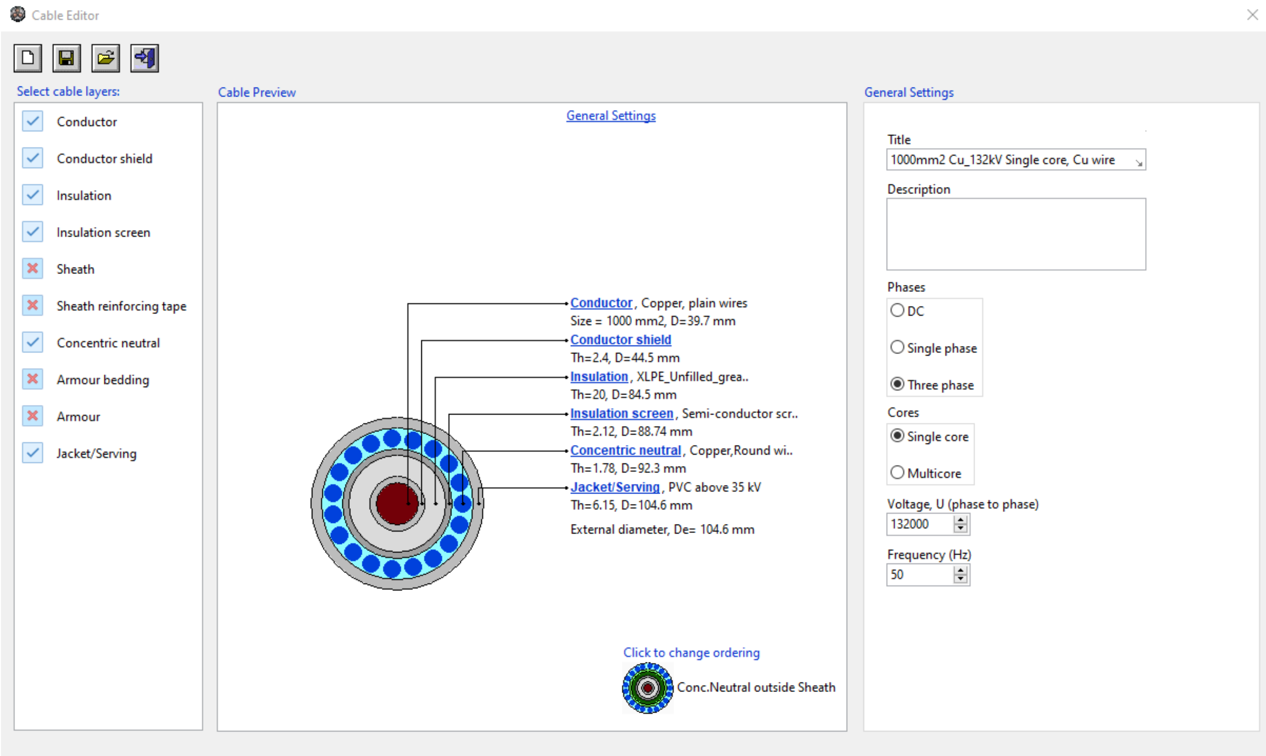

Figure 1 – Cable model for 132 kV single core cable

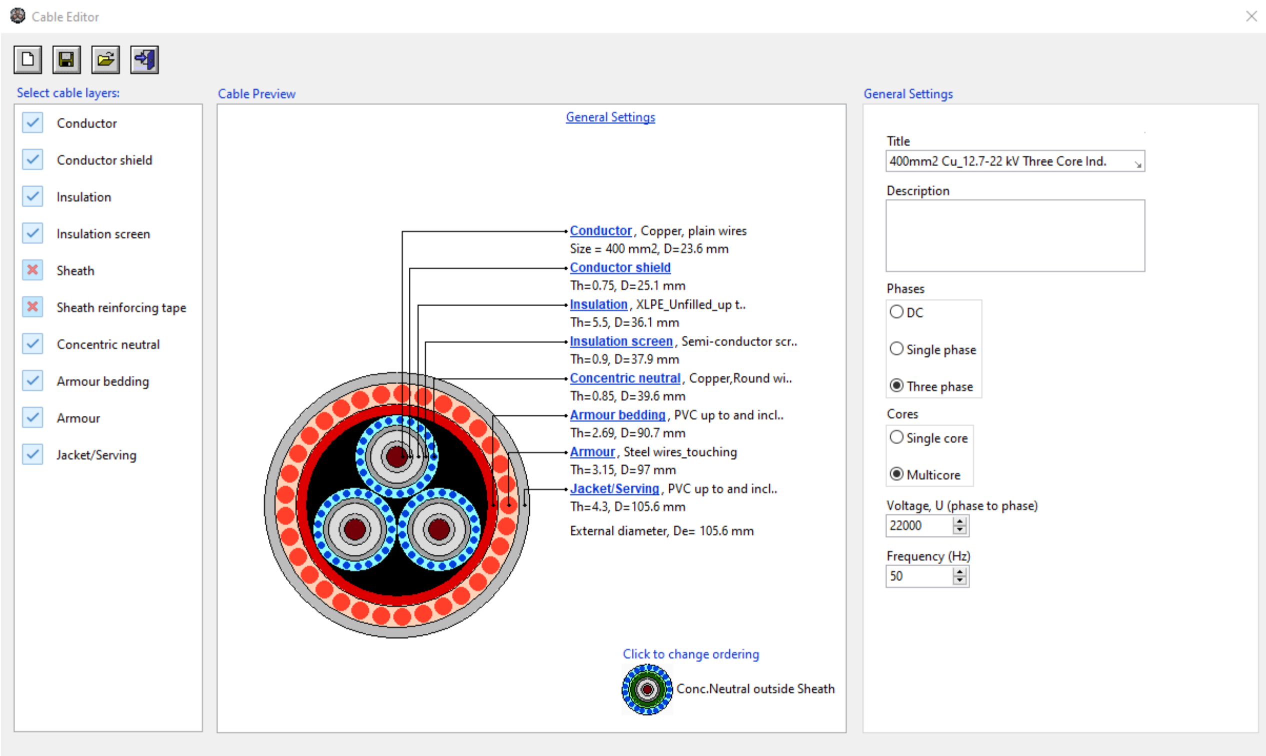

Figure 2 – Cable model for 22 kV three core cable

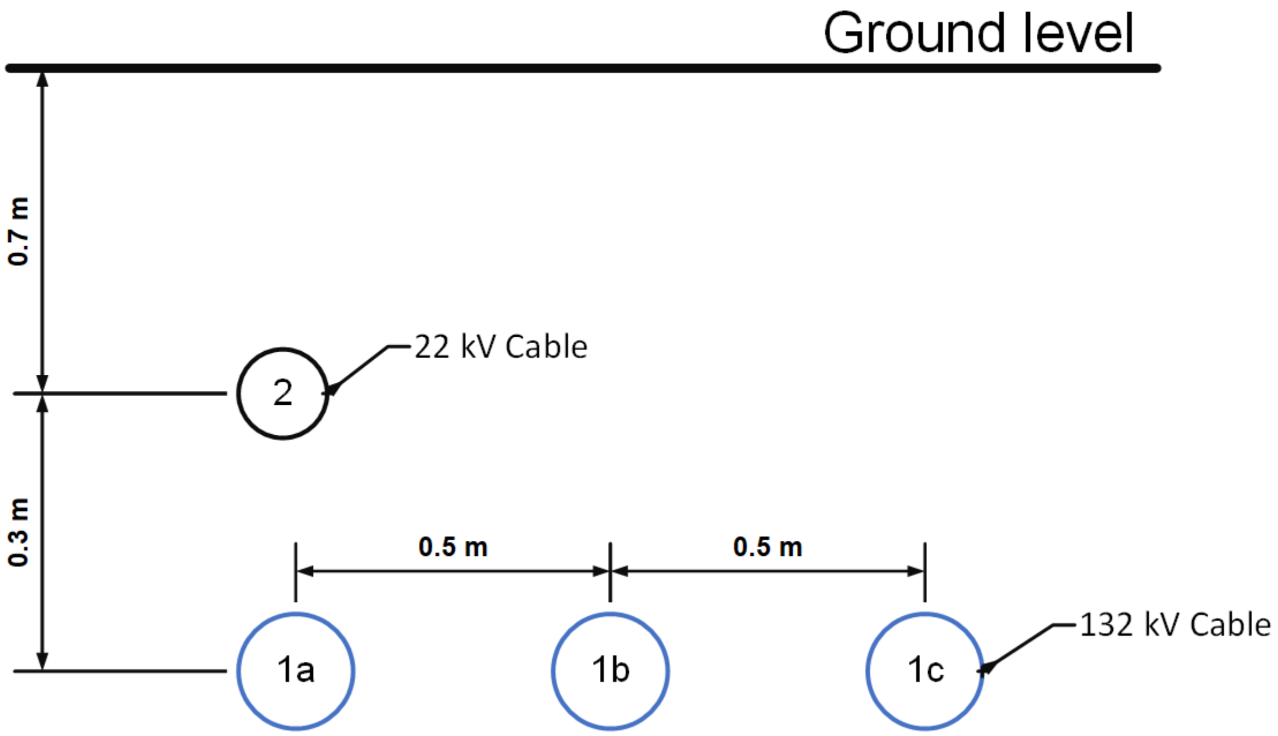

Figure 3 – Diagram of buried circuits (not to scale)

1. Obtain the isolated current ratings

Based on the cable installation requirements, the current rating can be calculated.

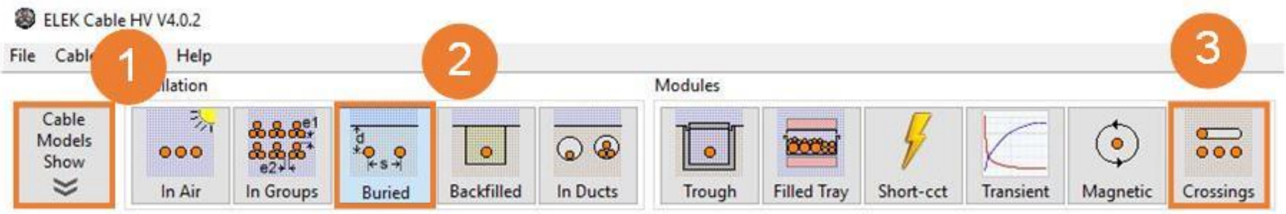

Figure 4 – Obtaining current values

① Select the **Cable Models Show** button at the top left-hand corner of Cable HV™. This will open a navigator that allows you to add new or edit existing cables. For the example case, the cables can be selected from Cable HV's built-in cable database. Click on the manila folder to use pre-set cables as shown by Figure 5.

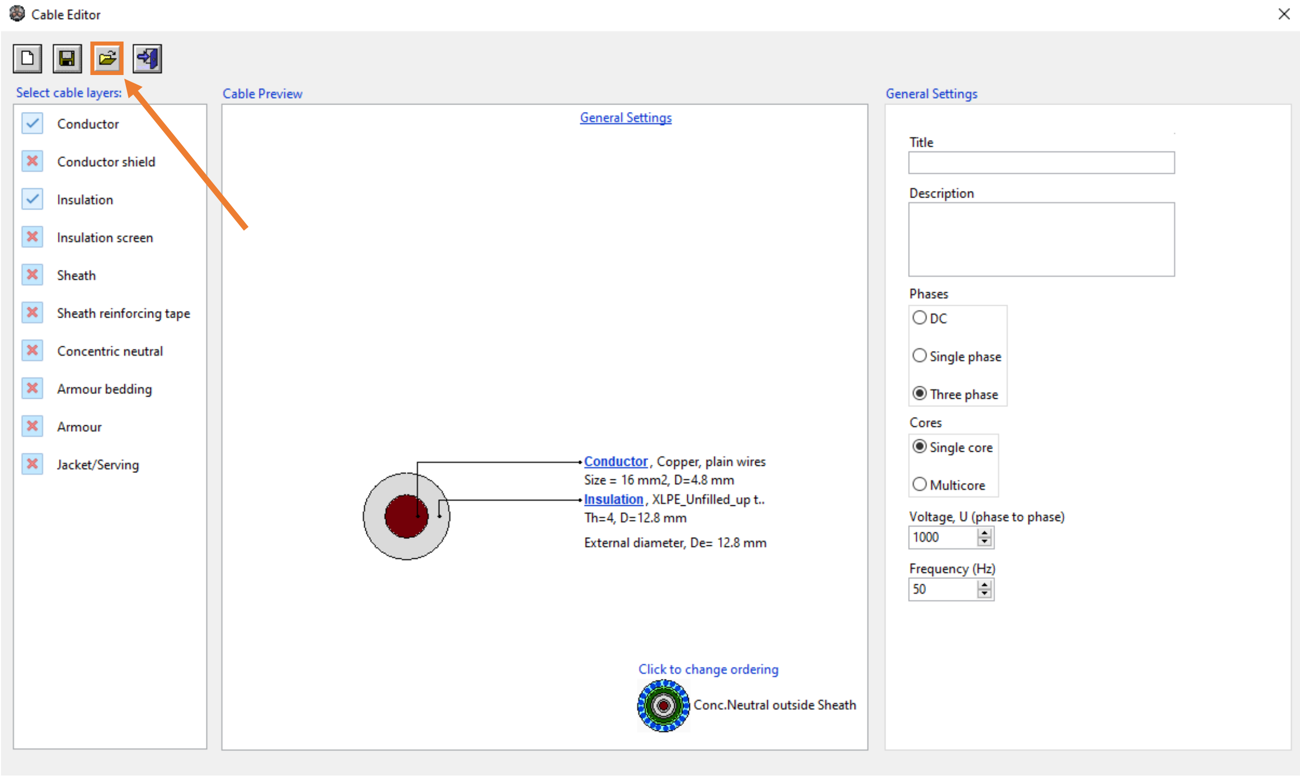

Figure 5 – Cable editor window

2. Configure the cable installation

② After configuring the cables, select the **Buried** installation. This will bring up a new box as shown by Figure 6 displaying the cables underground along an x and y axis. To add multiple cables, click the **Add** button and select the **Cable model** number that you wish to add. Adjust the depth measurements as per the example instructions.

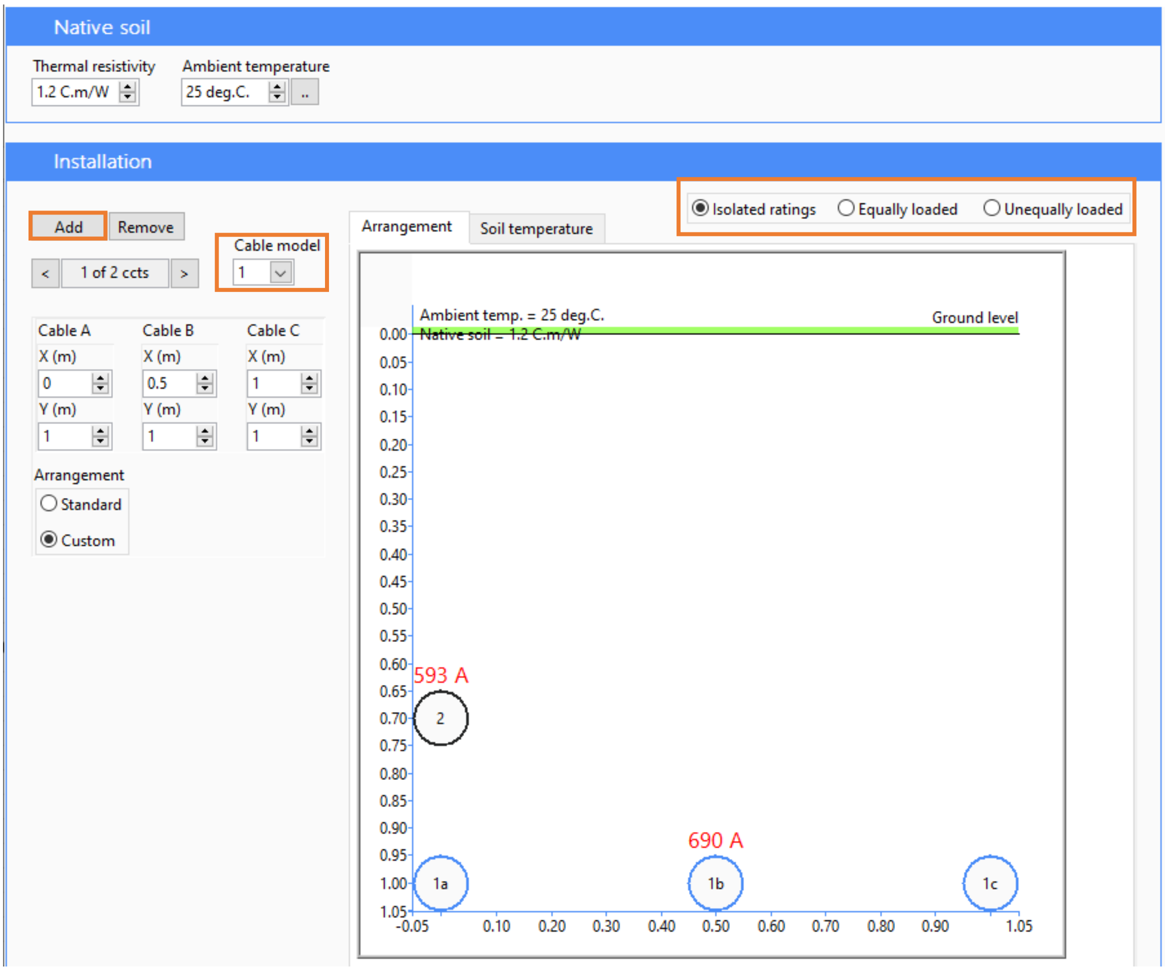

Figure 6 – Cable installation with trefoil and three core cables

When both circuits are assumed to be isolated, the current values for the 132 kV and 22 kV are 690 A and 593 A respectively. By selecting the buttons that read **Equally loaded** and **Unequally loaded**, different current values are produced. Table 3 displays the current values for each scenario.

Table 3 – Current ratings dependent on loading

	132 kV Circuit (A)	22 kV Circuit (A)
Isolated Ratings	690	593
Unequally Loaded	235	587
Equally Loaded	645	432

3. Using the Cable Crossings module

③ To use the Cable Crossings module, the **Isolated ratings** button must be selected. Once selected, the cable cross angle can be altered. As per Figure 7, click on **Cable A** of circuit **2**. Click the **Edit** button to change the cross angle. For this example, a value of 15° is selected initially.

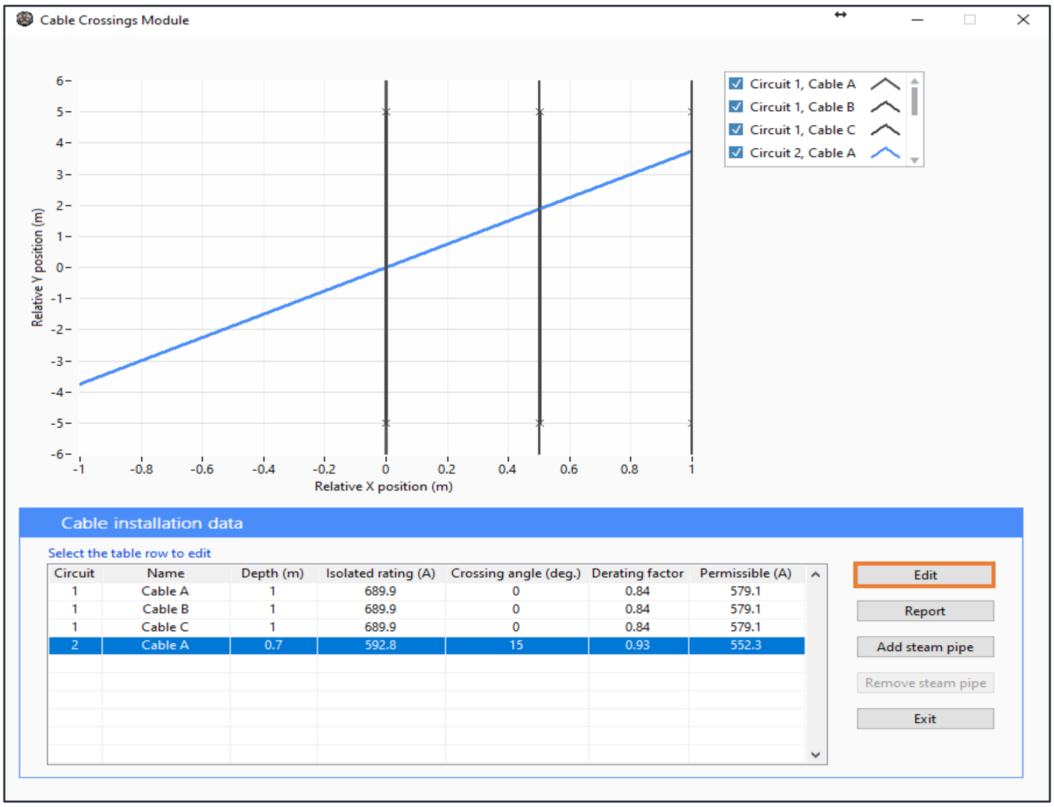

Figure 7 – Cable Crossings top-down module window at 15°

There is no difference in derating factors when a small angular change has been made between 0-15°. Table 4 displays the values for each angle change at intervals of 15°. Figure 8 displays a plot showcasing the relation between the change in derating factor and angle whilst Figure 9 displays the relation between the permissible current and cross angle.

Table 4 – Current and derating factor from cross angle

132 kV Cable		**22 kV Cable**		**Cross Angle (°)**
Permissible Current (A)	**Derating Factor**	**Permissible Current (A)**	**Derating Factor**	
579.1	0.84	552.3	0.93	15
619.4	0.9	569.9	0.96	30
619.4	0.9	569.9	0.96	45
619.4	0.9	569.9	0.96	60
619.4	0.9	569.9	0.96	75
621.6	0.9	570.9	0.96	90

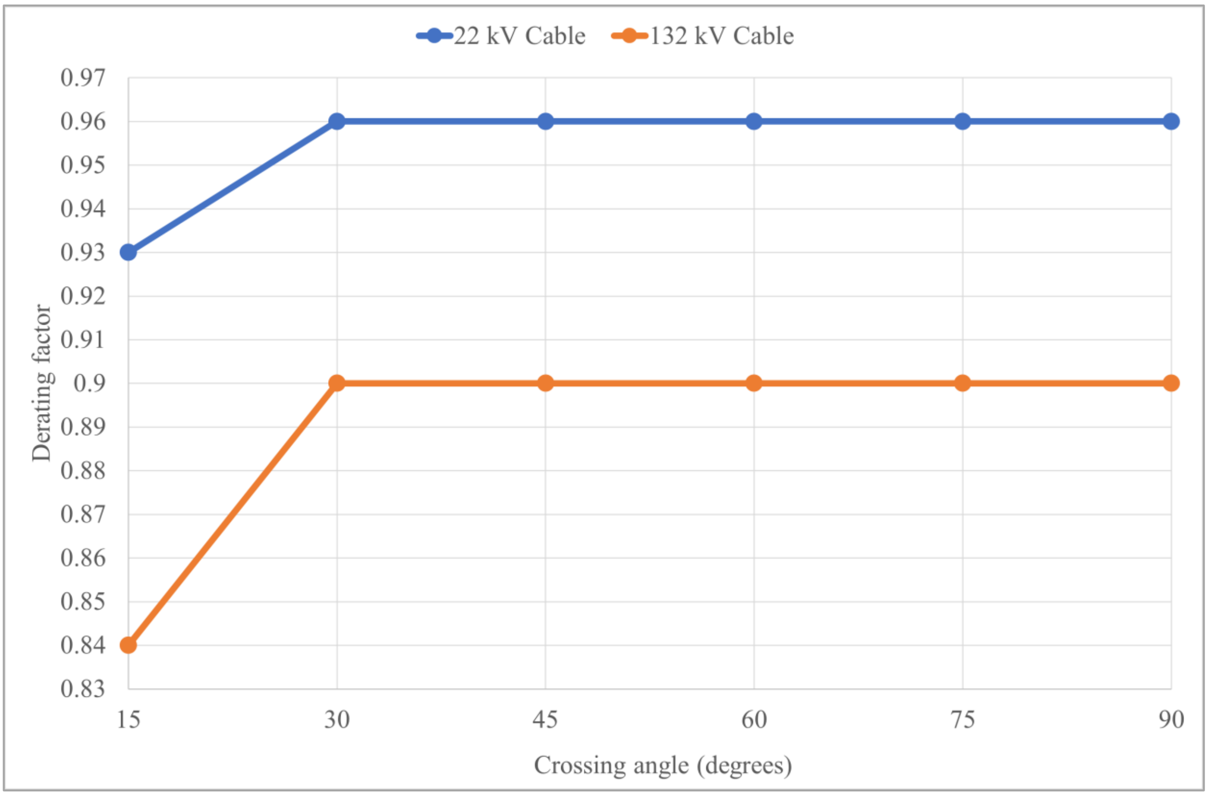

Figure 8 – Variation of derating factor with crossing angle

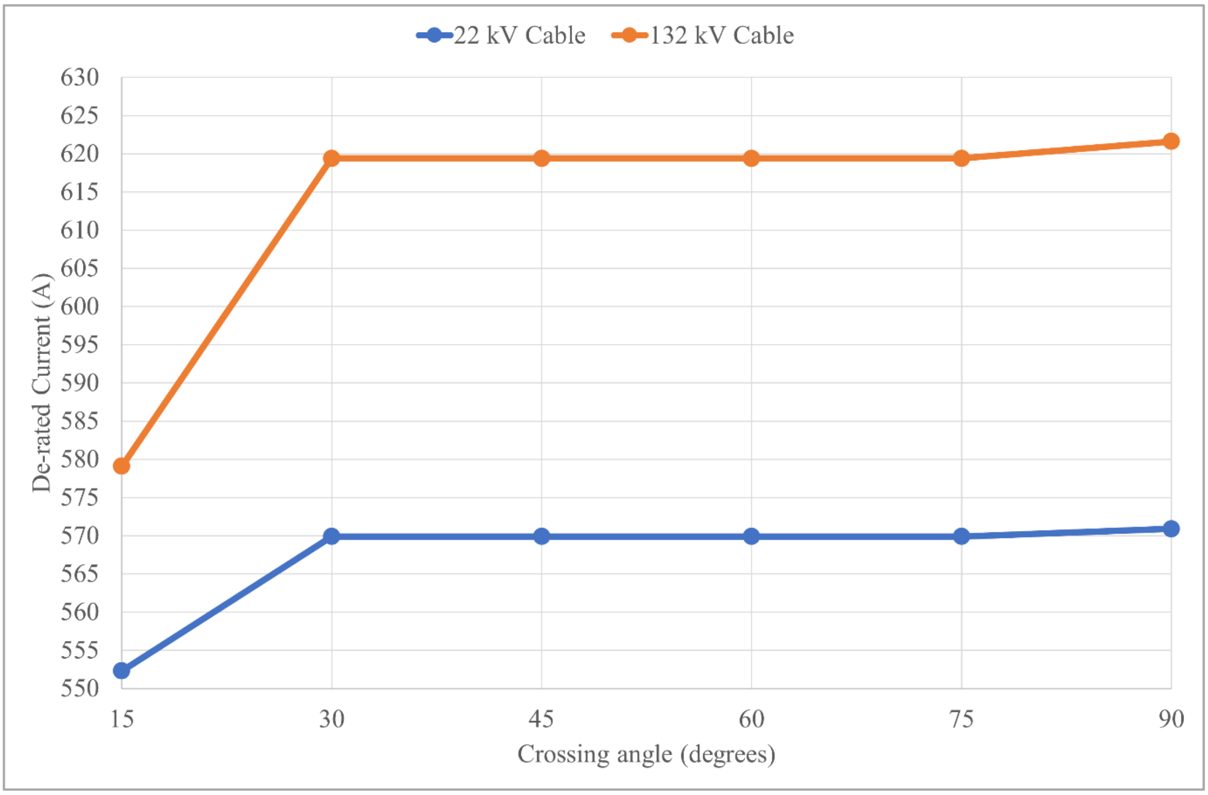

Figure 9 – Variation of de-rated current with crossing angle

4. Results

From Figure 8, there is a significant difference in the derating factor between angles 15-30° where the derating factor increasing linearly. Between 30-90° the derating factor remains relatively constant for both the single and multi-core cables (this is for this example and may not be the case for other examples). In Figure 9, the current increases linearly between 15-30° and then remains constant between 30-75° with a slight linear increase at an angle greater than 75°.

5. Creating a report

On the **Cable Crossing Module** as per Figure 7, click the **Report** button to generate a PDF report containing the cables' ratings, results and a cable cross diagram. – PDF generated data shows the type of data compiled by the PDF report.

Cables Crossing Heat Sources Report

Installation Data

Soil thermal resistivity = 1.2 K.m/W
Soil ambient temperature = 25 °C

Cable / Heat Source Data

X position (m)	Burial depth (m)	Circuit	Name	Conductor area (mm²)	Cable diameter (mm)	Isolated rating (A)	Crossing Angle (deg.)
0	1	1	Cable A	1000	0.1046	689.866	0
0.5	1	1	Cable B	1000	0.1046	689.866	0
1	1	1	Cable C	1000	0.1046	689.866	0
0	0.7	2	Cable A	400	0.1056	592.771	45

Results

Circuit	Name	Derating factor	Permissible current (A)
Cable A	1	0.9	619.4
Cable B	1	0.9	619.4
Cable C	1	0.9	619.4
Cable A	2	0.96	569.9

Figure 10 – PDF generated data

References

[1] E. Fernandez, J. Patrick & E. Chen, "Derating for Cable Crossings," 2020. [Online]. Available: https://elek.com.au/wp-content/uploads/2020/07/Derating-for-Cable-Crossings_Cable-HV-Software.pdf.

[2] Cable HV Software, Version 4.0. Visit: https://elek.com.au/electrical-software/elek-cable-high-voltage/