

Cable HV[™] 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.

Nominal section area (mm²)	Conductor diameter (mm)	DC conductor resistance (Ω/km)	Thickness of Insulation (mm)	Coppe Sectional area (mm ²)	r screen Outside diameter of conductor screen (mm)	Nylon Sheath Outside diameter (mm)
1000 S ¹	39.7	0.0176	20	296.13	92.3	104.6

Table 1 – 132 kV Cable data

1 S: segmental stranded

Table	2 –	22	kV	Cable	data
IGNIO	-	~~		Cabio	aata

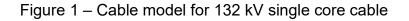
Nominal section area (mm ²)	Conductor diameter (mm)	DC conductor resistance (Ω/km)	Thickness of Insulation (mm)	Coppe Sectional area (mm ²)	r screen Outside diameter of conductor screen (mm)	PVC Sheath Outside diameter (mm)
400	23.6	0.047	5.5	22.7	39.6	105.6

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.



Ø Cable Editor		×
0		
Select cable layers:	Cable Preview	General Settings
Conductor Conductor shield	General Settings	Title 1000mm2 Cu_132kV Single core, Cu wire Description
 Insulation screen Sheath 		
	Conductor, Copper, plain wires	Phases
Sheath reinforcing tape	Size = 1000 mm2, D=39.7 mm	ODC
Concentric neutral	Conductor shield Th=2.4, D=44.5 mm	○ Single phase
X Armour bedding	Insulation, XLPE_Unfilled_grea Th=20, D=84.5 mm	Three phase
X Armour	Insulation screen, Semi-conductor scr	Cores
Jacket/Serving	Th=2.12, D=88.74 mm Concentric neutral, Copper,Round wi Th=1.78, D=92.3 mm Jacket/Serving, PVC above 35 kV Th=6.15, D=104.6 mm External diameter, De= 104.6 mm	Single core Multicore Voltage, U (phase to phase) 132000 Frequency (Hz) 50
	Click to change ordering Conc.Neutral outside Sheath	



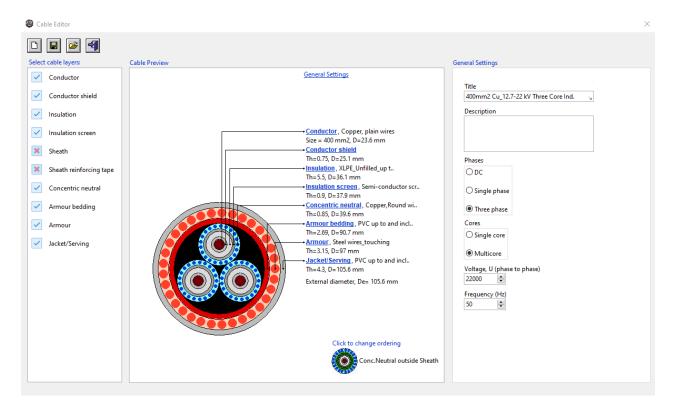


Figure 2 – Cable model for 22 kV three core cable



Ground level

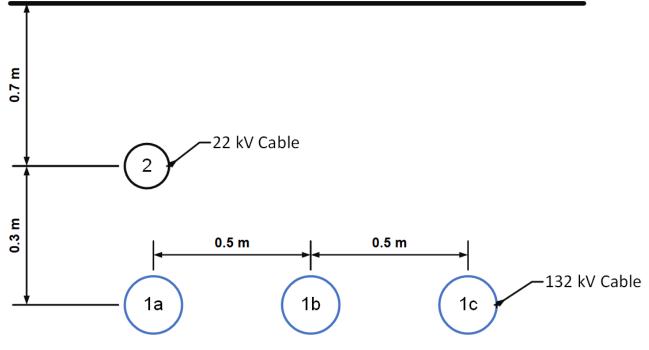


Figure 3 – Diagram of buried circuits (not to scale)

1. Obtain the isolated current ratings

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

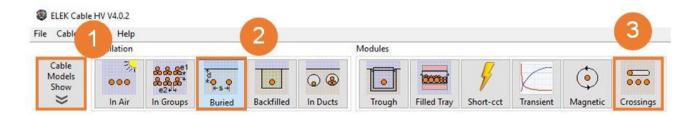


Figure 4 – Obtaining current values

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.



🛞 Ca	ble Editor			×
D				
Select	cable layers:	Cable Preview		General Settings
 Image: A start of the start of	Conductor		General Settings	Title
×	Conductor shield			
~	Insulation			Description
×	Insulation screen			
×	Sheath			Phases
×	Sheath reinforcing tape			O DC
×	Concentric neutral			○ Single phase
×	Armour bedding			Three phase
×	Armour			Cores
×	Jacket/Serving		→ <u>Conductor</u> , Copper, plain wires	Single core
	Jacket/Serving		Size = 16 mm2, D=4.8 mm	OMulticore
			Insulation, XLPE_Unfilled_up t Th=4, D=12.8 mm	Voltage, U (phase to phase)
			External diameter, De= 12.8 mm	1000
			External diameter, De= 12.6 mm	Frequency (Hz)
				50
			Click to change ordering	
			Conc.Neutral outside Sheath	

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.



Native soil Thermal resistivity Ambient temperature 1.2 C.m/W 25 deg.C.	
Add Remove Cable model	Arrangement Soil temperature
Cable A Cable B Cable C X (m) X (m) X (m) 0 0 0.5 0 1 0 Y (m) Y (m) Y (m) 1 0 1 0 1 0 Arrangement O Standard © Custom	Ambient temp. = 25 deg.C. Native soil = 1.2 C.m/W 0.05 0.10 0.15 0.20 0.25 0.30 0.40 0.45 0.55 0.60 593 A 0.65 0.70 0.75 0.80 0.95 1.05 1.05 0.10 0.10 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.55 0.60 0.70 0.80 0.90 1.05 0

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.



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

Table 3 – Current ratings dependent on loading

3. Using the Cable Crossings module

③ To use the Cable Crossings module, the Isolated ratings button <u>must</u> 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.

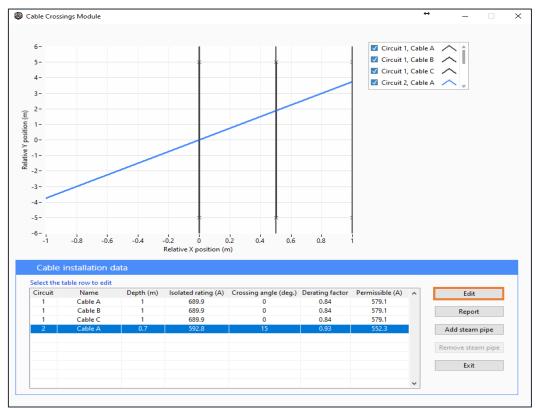


Figure 7 – Cable Crossings top-down module window at 15°



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.

132 kV C	able	22 kV Ca	22 kV Cable		
Permissible	Derating	Permissible	Angle (°)		
Current (A)	Factor	Current (A) 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	

Table 4 – Current and derating factor from cross angle



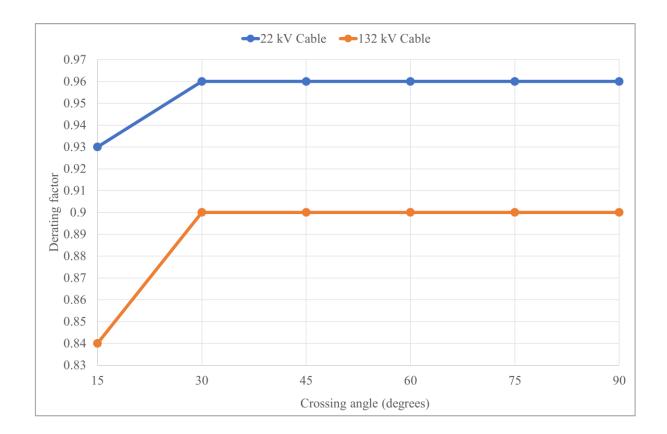


Figure 8 – Variation of derating factor with crossing angle

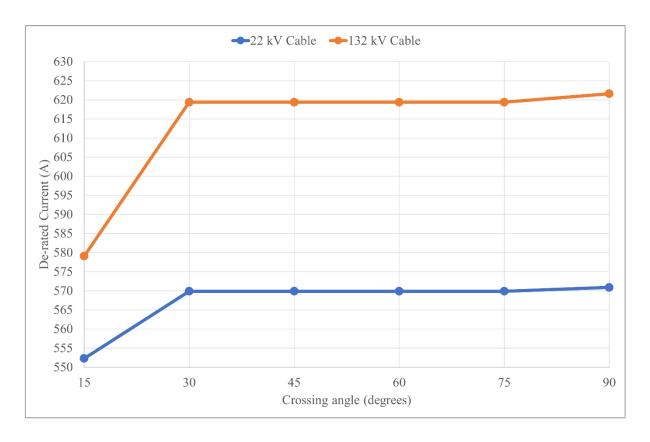


Figure 9 – Variation of de-rated current with crossing angle



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										
Installatio	nstallation Data									
	Soil thermal resistivity = 1.2 K.m/W Soil ambient temperature = 25 °C									
Cable / H	eat Sourc	e Data								
X position (m)	ion depth (m) Circuit Name area diameter Isolated Angle								Crossing Angle (deg.)	
0	1	1	Cable A		1000	0.1046	6	689.866	0	
0.5	1	1	Ca	ble B	1000	0.1046	6	689.866	0	
1	1	1	Ca	ble C	1000	0.1046	6	689.866	0	
0	0.7	2	Ca	ble A	400	0.1056	6	592.771	45	
Results										
Circuit Name				Derating factor		P	Permissible current (A)			
Cable A 1			0.9			619.4				
Cable B 1			0.9			619.4				
Cable C		1	0.9 619.4							

Figure 10 – PDF generated data

0.96



569.9

Cable A

2

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/elekcable-high-voltage/

