

# Power Cable Ampacity Rating - Additional Modules - Analyses

## Perform analyses of interest for cable installations in addition to thermal analysis

These add-on modules provide the ability to evaluate the magnetic flux density at any point on or above the ground of an underground cable installation, determine the positive and zero sequence impedances and admittances for all the cables in an installation, calculate short-circuit cable ratings, determine the optimal placement of multiple circuits within a ductbank given specified constraints and calculate the ampacity of two circuits crossing each other.

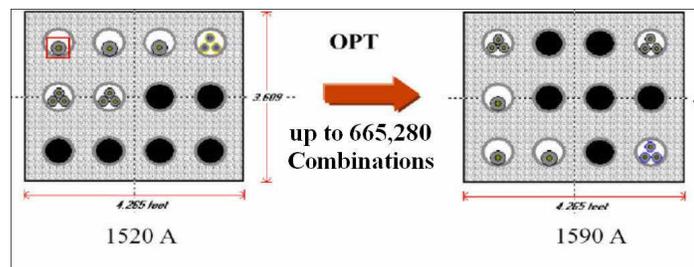
### Duct Bank Optimizer Module

The Duct Bank Optimizer add-on module allows the user to determine the optimal placement of several circuits within a duct bank. More specifically, the module can recommend various circuit configurations within a duct bank so that:

- The duct bank overall ampacity, i.e. the sum of the ampacities for all circuits, is maximized
- The duct bank overall ampacity, i.e. the sum of the ampacities for all circuits, is minimized

- The ampacity of any given circuit is maximized
- The ampacity of any given circuit is minimized

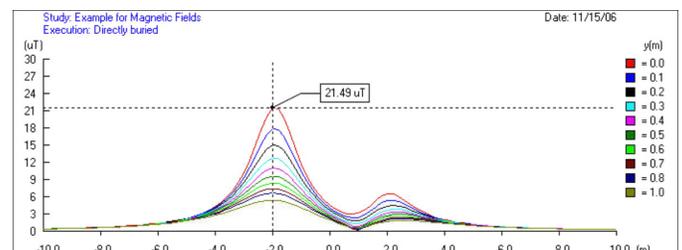
For a 3 by 4 duct bank with three trefoils and one three-phase circuit (one phase per conduit), there are up to 665,280 possible combinations. The elaborated mathematical algorithm of the module prevents the repetitive calculation of equivalent cases, therefore the solution is obtained very efficiently. The condition presented on the right hand side of the illustration shows the cable locations for maximum ampacity.



### Magnetic Fields

The Magnetic Fields Module (EMF) is an add-on module to the CYMCAP software. After a steady-state ampacity or temperature simulation, the module computes the magnetic flux density at any point on or above the ground of an underground cable installation. The output is a plot (or a table) of magnetic flux density versus position. Modeling features include:

- Infinite-length thin-wire two-dimensional approach
- Consideration of time-varying currents producing an elliptically polarized rotating magnetic vector
- The currents in a three-phase circuit can be unbalanced (in magnitude and phase)
- All media is assumed homogenous, isotropic and linear
- The induced currents are neglected



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## Cable Impedance Calculation

The Cables Impedance Calculation add-on module (ZMat) calculates the electrical parameters for cables necessary for performing load flow and short-circuit studies at the power frequency (50/60 Hz). The calculation of impedances is performed after a steady-state ampacity or temperature simulation has been successfully completed. The final results are the positive and zero sequence impedances and admittances for all the cables present in the installation.

All impedance and admittance matrices are displayed in the report: starting from the primitive matrices per section per metallic component, the bonding matrices, then the phase and circuit matrices and finally the resulting symmetrical components matrices. The following features are supported:

- Computation of the sequence impedances for all the cables present in an installation
- Computation of the sequence admittances for all cables present in an installation
- Multiple cables per phase are supported
- One or more neutrals can be represented and are taken into account in the calculations
- Resistivity of the soil can be changed

| R_Sequence [ $\Omega$ /mile] |          |           |           |          |
|------------------------------|----------|-----------|-----------|----------|
|                              |          | Circuit 1 |           |          |
|                              | Sequence | 0         | 1         | 2        |
| Circuit 1                    | 0        | 0.479803  | 0.00315   | 0.003266 |
|                              | 1        | 0.003266  | 0.161351  |          |
|                              | 2        | 0.00315   | -0.008086 |          |

| X_Sequence [ $\Omega$ /mile] |          |           |           |   |
|------------------------------|----------|-----------|-----------|---|
|                              |          | Circuit 1 |           |   |
|                              | Sequence | 0         | 1         | 2 |
| Circuit 1                    | 0        | 0.160424  | 0.000879  |   |
|                              | 1        | 0.000727  | 0.136366  |   |
|                              | 2        | 0.000879  | -0.015419 |   |

## Short-Circuit Cable Rating

The Short-Circuit Cable Rating (SCR) add-on module is dedicated to the rating of cables for short-circuit currents. The implemented method is based on the IEC Standard 60949© (1988) "Calculation of thermally permissible short-circuit currents, taking into account non-adiabatic heating effects." The CYMCAP program computes both adiabatic and non-adiabatic ratings.

The module offers two possibilities according to the known input data:

- Compute the maximum short-circuit current that a cable component can carry given the short-circuit time together with the initial and final temperatures
- Compute the final temperature that a given cable component will reach for a specified short-circuit current, initial temperature and time interval

Short-circuit ratings can be computed for all metallic layers supported in the CYMCAP software:

- Conductor
- Sheath
- Sheath Reinforcement
- Concentric Neutral / Skid Wires
- Armour

## Circuits Crossing

The Circuits Crossing (Xing) add-on module allows the user to determine the steady-state ampacity of two circuits crossing each other.

When two circuits cross each other, each of them behaves as a heat source for the other one. The amount of generated heat, the vertical distance between the crossing circuits and the crossing angle are the main parameters that influence the crossing rating. In the absence of crossing calculations, the general practice is to use the conservative result where the circuits are assumed to be parallel. When the circuits are parallel, the thermal interaction is maximum. It goes to a minimum when they cross each other at a right angle. The conservative approach unnecessarily de-rates both circuits. By using the Circuits Crossing module, one can achieve ratings up to 20% higher than the conservative ampacities that are obtained based on the parallel installation scenario. Modeling features include:

- Modeling of two circuits crossings each other in the same installation
- Circuits crossing directly buried underground, in buried ducts and in buried pipes underground
- Rating methodology as per the IEC standard 60287-3-3©

The screenshot displays the software's calculation results and a 3D model of two crossing cables. The calculation window shows the following results:

| Cable Layer (metallic)       | Short Circuit Current (A) | Final Temperature (°C) | Initial Temperature |
|------------------------------|---------------------------|------------------------|---------------------|
| Conductor                    | 0                         | 250                    | 90                  |
| Sheath                       | 100000                    | 0                      | 90                  |
| Reinforcing tape             | 0                         | 200                    | 90                  |
| Concentric neutral/skid wire | 0                         | 200                    | 90                  |
| Armour                       | 0                         | 200                    | 90                  |

Summary Results:

- FINAL SHORT CIRCUIT TEMPERATURE: 250 C
- ADIABATIC SHORT CIRCUIT CURRENT: 171687 A
- PERMISSIBLE (NON ADIABATIC) SHORT CIRCUIT CURRENT: 172262 A

COMPONENT CALCULATED: Sheath

CALCULATE SHORT CIRCUIT TEMPERATURE FOR TIME = 0.100 s

- INITIAL SHORT CIRCUIT TEMPERATURE: 90 C
- GIVEN SHORT CIRCUIT CURRENT: 100000 A
- FINAL SHORT CIRCUIT TEMPERATURE: 244 C

The 3D diagram shows two cables crossing at an angle. Labels indicate: Angle: 0°, 512k @ 90°C; Angle: 0°, 512k @ 80°C; Angle: 90°, 55k @ 90°C.

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