



CABLES & LINES, Design, Analysis & Simulation

Electric, Magnetic and Thermal analysis of cables and lines

The analysis of cables and lines involves several physical domains and constraints. Magnetic, Electric and Thermal fields are of interest for the optimisation of any type of cables. Flux enables the simulation of steady, harmonic and transient states for magnetic, electric and thermal behaviour.

“FLUX (2D) was used to verify analytical derived and experimental results for the temperature rise and the changed temperature distribution over the cable cross-section due to non linear loads”.

*Dr Frederick D'Hulster,
Hogeschool West-Vlaanderen, Belgium.*

Advanced models for advanced simulation

In its standard range of tools, Flux offers many facilities for a proper design:

- Mixed mesh generator to perfectly account for physical anisotropy such as Eddy Currents,
- Propagation (copy paste) of geometry and mesh keeping parameter dependencies (e.g. 3-phase cables),
- High geometric tolerance that allows modelling of very small internal details in a cable, while also allowing modelling a sufficient amount of surrounding environment (e.g. seawater),
- CAD interface: formats such as STEP, IGES, DXF or mesh import from I-DEAS, Pro-E, Patran, Nastran...

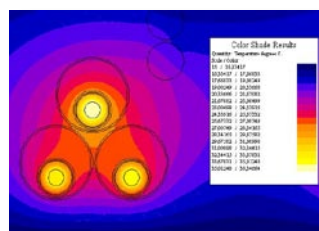
Moreover, surface impedance formulation allows accounting for eddy currents on thin regions, such as armour shells, while decreasing the number of nodes, hence the computation time.

Various physical domains

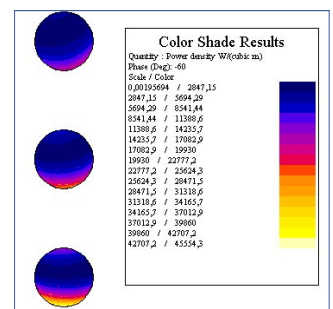
Various physical quantities are to be known while designing and analysing cables:

- Magnetic quantities to ensure the nominal power can be carried by the cable,
- Electric quantities to ensure that the breakdown electric field is not exceeded around the cable or the line,
- Thermal quantities to check temperature rise and temperature influence on material characteristics and performances.

Flux simulates those three behaviours and may easily couple them. For example, the thermal state may be computed as function of the magnetic state: indeed, the magnetic state will induce the thermal one. Furthermore, to better analyse dynamically the cables, Flux allows coupling the Finite Element model to an outer electrical circuit modelling the sources and the loads.



Temperature map over a 3-phase cable.



Power density display on cables accounting for frequency and proximity effects.

“FLUX(2D) is an excellent tool for analyses of induced quantities and thermal conditions in high voltage submarine cables - often combined cables, e.g. comprising steel tubes. Additionally, there is growing attention with respect to magnetic field exposure above cables, e.g. in beach zones, and thermal effects on marine life”.

>>> Jarle J. Bremnes, Nexans Norway AS, Norway.



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»» Flux to Simulink Technology

Flux may be complemented by a direct co-simulation link with MATLAB Simulink. This coupling allows the user to benefit from both the capabilities of Flux for electromagnetic simulation and SIMULINK for the drive and control part. The simulation then accounts for saturation, eddy currents, proximity effects as well as regulation loops if any.

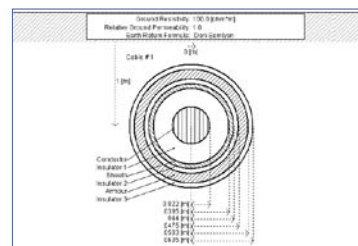
» Embedding in a complete system

As the base component of any power network, the cables and lines are often not even noticed in the simulation model, while they may have a great influence on this model.

»» Advanced models

In order to better account for all the phenomena occurring in a cable or a line when it is used in a complete power network, PSCAD offers several models:

- Bergeron model: constant frequency model used to get steady state impedance/admittance of the line or cable.
- Frequency dependent (mode) model: uses curve fitting to duplicate the frequency response of a line or cable and approximates the phase to mode transformation as a constant.
- Frequency dependent (phase) model: the most advanced model as it represents the full dependence of all line parameter. It may be used wherever the transient or harmonic behaviour of the line or cable is important.



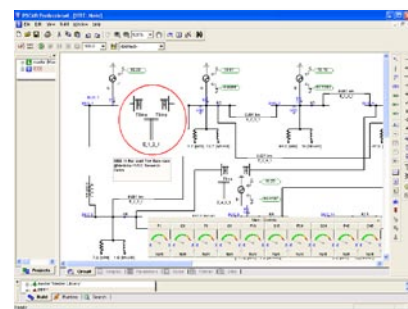
Description of an underground cable in PSCAD.

»» Precise definition

Moreover, the geometrical configuration of the cables or lines can also be defined. On the one hand, the cables usually have several layers of conducting and insulating material with different characteristics and thicknesses: each may be specified. On the other hand, the lines may have various configurations: 3, 6 or more conductors, horizontal or vertical arrangement, with or without ground wires...

»» Accurate results

The complete components library including any useful component from electrical machines to breakers, from relays to transformers, from wind turbine to HVDC and FACTS, virtually any power network may be studied on both static and transient point of view, including faults or not. The numerous control tools make PSCAD easy to control and modify.



Transmission line expanded model (oversized and circled) in PSCAD.

» References

CEDRAT supplies already many organisations worldwide

such as: ABB, Alstom, Bombardier Transportation, Central Japan Railway Company, Cesi, Chubu Electric Power, EDF, Ericsson, General Electric, Hydro-Quebec, Indian Institute of Technology, Jeumont Industrie, Kvaerner Oilfields Products, New York Power Authority, Nexans, Petrobras America Inc., PowerGrid Singapore, Sagem, Siemens, Smit transformatoren, SwedPower, Tractebel, VA Tech, Vestas Wind system...

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