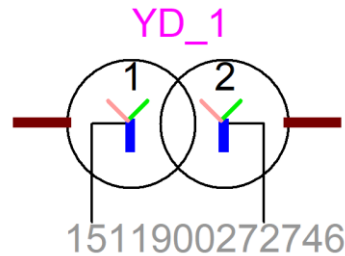


Topological Transformer



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Henry Gras, 2020-08-05 15:44:00

1 Introduction

The Topological Transformer is an hybrid transformer model modelling 2, 3 or 4 winding transformers. The core construction can be 3-legged core, 5-legged core, shell core or 3 ideal units.

The model can be built using test data or design data.

After the data are entered in the mask, the content of the transformer device in the Graphical user Interface (GUI) is updated. A confirmation to proceed to the parameter calculation is then requested. When the user grants it, a parameter calculation routine is started. This routine can take a while to complete the calculation. During the process, several EMTP simulations are ran using the EDF Matlab API to adjust and validate parameters.

When the Parameter calculation routine is started, a workspace folder named *topologicaltransformerdata* is created in the design project folder (*designName_pj*). This folder contains several files:

- YD_1_inputs.dat: contains all the parameters required by the Parameter calculation routine in a Matlab format.
- YD_1_process.log: is the Topological Transformer setup log file. This file can be visualized during the Parameter calculation process by double clicking on the transformer device in the GUI (see Figure 1). At any time, the user can interrupt the calculation routine.
- YD_1_caseID_XXXXXX.dat: is the Case file. It contains the final Topological Transformer FormData and Modeldata attributes. Its name contains a unique identifier (ID) which is changed anytime the Parameter Calculation routine is started.
- topologicalTransformerSetup.ecf: is an EMTP test design where the Topological Transformer device is placed and where open-circuit tests are simulated to fit the behavior of the transformer to the test-data entered.

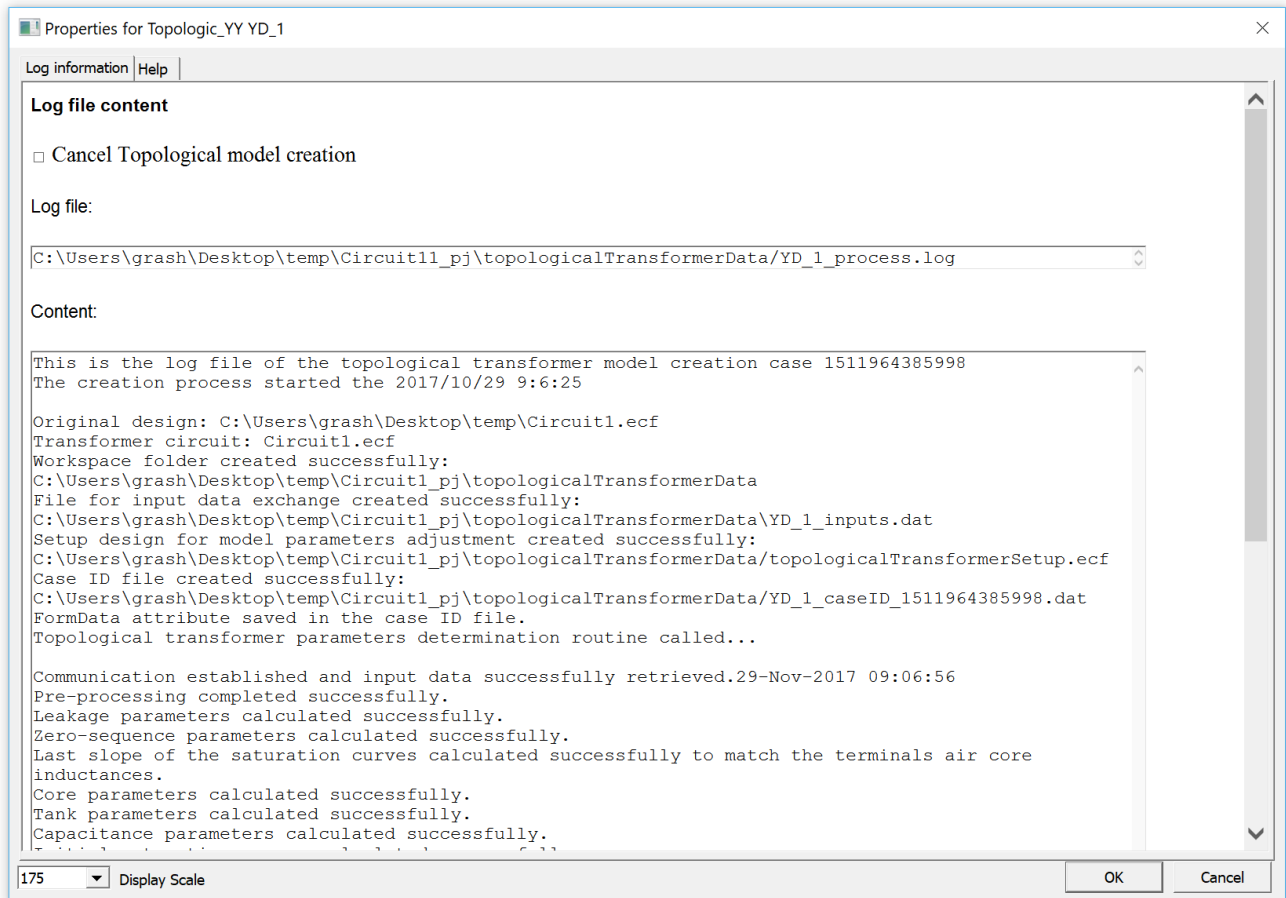


Figure 1: Parameter calculation log information

Warning: It has been observed that saving a design in a location where is path is long could cause problem to the calculation routine.

The current version of the Topological Model is only available in debug mode which mean that Matlab is started any time the Parameter Calculation routine is called. It allows the user to follow the process in Matlab and, in case of a problem, to access the routine code.

When the Parameter Calculation process is completed, the ModelData attribute of the transformer device is populated by the Parameter Calculation routine and its Value attribute is populated with the case ID (the same as the Case file contained in the workspace folder).

2 Parameters

General tab

- Core type:** topology of the core construction. According to the selection, the Core component of the Topological transformer subcircuit is updated (see Figure 2)
- Connection Type:** Winding connection type. Determine the number of windings and adjust the mask input fields accordingly.
- Nominal frequency:** Power frequency.
- Nominal powers:** Nominal power of each winding. The base of the data provided in per unit are calculated with these values.

- ❑ **Voltages:** Rated voltage of each winding. The base of the data provided in per unit are calculated with these values.

Positive-sequence short-circuit test

- ❑ **Short-circuit impedance Winding i/Winding j:** Short-circuit positive-sequence impedance between windings *i* and *j*.

If the unit selected in per unit, the Nominal power and Voltages inputs are used to determine the actual value.

- ❑ **Short-circuit losses Winding i/Winding j:** Losses during the positive-sequence short-circuit test between windings *i* and *j*.

Zero-sequence short-circuit test

These data should be entered only for 3-legged core transformers. They are not taking into consideration for other core construction types.

- ❑ **Test winding number:** Number of the winding on which the zero-sequence tests have been performed.

- ❑ **Impedance:** Short-circuit zero-sequence impedance.

If the unit selected in per unit, the Nominal power and Voltages inputs are used to determine the actual value.

- ❑ **Delta/short-circuited windings:** Check if the winding is short-circuited or delta-connected during the zero-sequence test.

Air-core inductance

- ❑ **Air-core inductance values available for:** Select the windings for which the Air-core inductance values are available. If the values are not available for all, or if numerical problems occurred during a previous computation, select the winding on the side where the transformer is energized.

- ❑ **Air-core inductances**

Excitation tests

- ❑ **Excitation test winding number:** Number of the winding on which the excitation tests have been performed.

- ❑ **Current-Voltage-Loss:** Open-circuit current test results used as a target for the optimization routine. The error between the transformer model behavior and these results is minimized.

If less than 2 excitation test points are entered, a Frolich function is used to defined the core non-linear inductance branches. The expression is:

$$\varphi = \frac{i}{A + B|i|} + L_{inf}i \quad (1)$$

Where φ is the flux, i the current, L_{inf} the Air-core inductances and A,B the parameters to optimize.

If 3 excitation test points are entered, a Modified-Frolich function is used to defined the core non-linear inductance branches. The expression is:

$$\varphi = \frac{i}{A + B|i| + C\sqrt{|i|}} + L_{inf}i \quad (2)$$

When C is also a parameter to optimize.

If more than 3 excitation test points are defined, a Double-Frolich function is used to defined the core non-linear inductance branches. The expression is:

$$\varphi = \frac{i}{A + B|i|} + \frac{i}{D + E|i|} + L_{inf}i \quad (3)$$

When D is also a parameter to optimize.

Topological tab

- ❑ **Core parameters available:**
 - If *geometry ratios* is selected, core dimensions are provided as a ratio of the main-leg length. Typical magnetic material field-induction and induction-losses curves are assumed.
 - If *Detailed geometry* is selected, precise core dimensions are entered in mm and m². The magnetic material field-induction and induction-losses curves are entered. This option is not available in this version. Please contact the technical support to access it.

Warning: Excitation tests data are used for the final parameter determination and are therefore of a prime importance compared to B-H and B-losses data. See Parameter calculation routine documentation for more information.

Warning: If the transformer leakage is intended to be determined with design parameters, the Detailed geometry of the core must be entered.

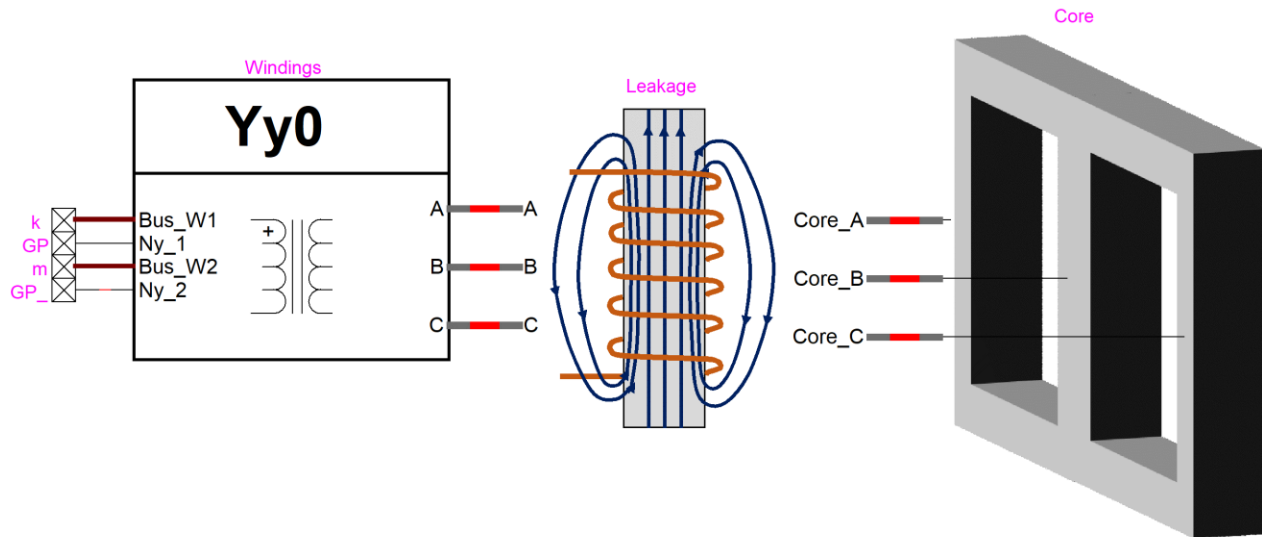


Figure 2: Topological transformer subcircuit for a 2-winding YY0 3-legged core transformer.

- ❑ **Core-to-tank air-gap inductance:** See Model documentation PDF. This parameter is important for 3-leg core transformers. Typical value is 3.5pu.
- ❑ **Tank saturation level:** See Model documentation PDF. This parameter is important for 3-leg core transformers. Typical value is 0.4pu.

Winding Parameters tab

- ❑ **Leakage data:**
 - if *Test data* is selected, only the winding DC resistances and the stray capacitance must be provided.
 - if *Design data* is selected, the detailed winding design parameters must be entered. This option is accessible only if the detailed core topology has been entered in the Topology tab. This option is not available in this version. Please contact the technical support to access it.
- ❑ **DC resistance measurement:** Input indicating how the 75 degrees Celsius DC resistance is determined in the test report. 3 options:
 - Not available: the information is missing.
 - Winding resistance: the DC resistance is the one of the winding by itself
 - Measured winding-to-winding: the DC resistance is measured between line terminales. This value is entered in the Winding DC resistance fields.
 - + If the windings are Wye connected, the resistance of two windings is measured. In this case, the winding resistance measurements entered are divided by 2.

+ If the windings are Delta connected, the resistance of one winding in parallel with the two other windings is measured. In this case, the winding resistance measurements entered are divided by 2/3.

- For Autotransformers, select Winding resistance. The DC winding resistance of winding 1 is the sum of the DC resistances of the series and common windings..

□ **Winding DC resistance:**

- If the windings are Wye connected, the resistance of two windings is measured. In this case, the winding resistance measurements entered are divided by 2.

- If the windings are Delta connected, the resistance of one winding in parallel with the two other windings is measured. In this case, the winding resistance measurements entered are divided by 2/3.

Initial Conditions tab

□ **Phase A residual flux:** Residual flux on phase A. When W_b is entered, it refers to winding 1. Same for phases B and C.

When the topology is 3-legged-core, the residual flux on one phase is determined by the residual fluxes of the two other phases. Only A and B inputs have to be entered.