

TRELEG data calculation function

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1 Introduction

The effects of a three-leg core in a transformer are apparent in the different values determined for short-circuit impedances in positive and zero sequence. These values are used by the program to calculate a $3n \times 3n$ impedance matrix model, where n = number of windings on any leg ($n \leq 5$). It is also possible to use this program to calculate an $n \times n$ matrix to represent a single-leg core, a shell type, or a 5-leg core transformer. In the latter cases, the values of the impedances (short-circuit and magnetizing) will be equal in both zero and positive sequence.

The program accepts data for short-circuit tests performed with up to two of the windings connected in delta. This is the standard form in which a manufacturer will provide test data.

TRELEG requires that winding data be entered so that *delta-connected windings appear last*. Also the windings are assumed to be concentrically-located on the core, and entered in the order from outer to inner winding. When windings are not concentric, or when the delta-connected windings are not innermost on the core, the program provides an option for the user to retain delta-connected windings as the last windings, and to provide the magnetizing impedance of each winding. In the absence of any test data, the positive sequence magnetizing impedance of windings in per unit can be assumed to increase with increasing diameter, while the zero sequence magnetizing impedance decreases. The variation from one winding to another will be approximately equal to the positive sequence short-circuit reactance between them. It does not appear that this approximation of magnetizing impedances has any significant effect on the resulting model.

2 Data tabs

The information on data fields is self-explanatory specially when tool tips are used, this is why the following presentation is minimal.

There are two data tabs for this device:

- Windings
- Test

The Windings tab presents connection data for each winding, rated winding voltage and winding nodes. The node names are mandatory, only trailing blanks are acceptable. The code name GND can be used to denote ground. The node names will appear on the 'RL coupled multiphase' device drawing after loading the data from this data calculation function. The names are used for reference; the actual connections must be made through the signals connected to the pins of the 'RL coupled multiphase' device into which the model data generated by TRELEG can be loaded.

The Test tab presents "Short circuit sequence impedances" for each winding. The zero sequence data is not used when there are 2 delta winding, in which case the program will generate appropriate numbers based upon the following section: "Sequence test between the wye and two delta windings". The last section on this tab presents the magnetizing impedances in positive and zero sequences. It is noticed that for single-phase transformers X positive is equal to X zero.

3 TRELEG model data file format

The design example used in this section can be found in Examples\transformer_data\test1.ecf. After entering all the required data, The TRELEG Data Calculation Function can be invoked from the “Run this case” data tab to generate the model data file. The model can be used with the “RL coupled multiphase” device using the “Load data from file” option of this device.

The TRELEG model data file format for a sample case is shown in Figure 3–1 for a request to save the resistance and the reactance in ohms in the model data file. This format used in the old EMTP-V3 files has been kept in this release of EMTP-EMTPWorks. It is documented here for reference purposes only, since users are not required to manipulate these data files.

The following sequence is enforced:

- ❑ Comment lines starting with “C” (in the first column) are allowed only up to the first actual transformer data line.
- ❑ The first comment line indicates that the model was generated with a TRELEG run.
- ❑ The next optional line indicates the frequency at which the reactance matrix is calculated. If the line is present it means that ohms are used for the reactance. It is noticed that this frequency must match the default power frequency of the design as selected in Simulation Options.
- ❑ Next lines are used to present the lower triangular part of the RL couple symmetric matrix. The first line for each row of the matrix has:
 - the winding number starting from 51 (old EMTP-V3 style)
 - k-node and m-node names. The node names will appear on the “RL coupled multiphase” device drawing after loading the data from this data calculation function. The names are used for reference, the actual connections must be made through the signals connected to the pins of the “RL coupled multiphase” device. The node names are comma separated.
 - The R and L values in pair separated by a comma (continued on the next lines). The extra commas and the “\$” character are not mandatory for EMTPWorks.

```
C TRELEG
C F= 60.00
51,HIGHA ,GND   ,,,,      0.473000000000E+00,  0.223333333341E+05 ,,,,,
52,LOWA  ,GND   ,,,,     -0.646793103332E-01,  0.107059927425E+05 $
                    0.298750000000E-01,  0.514227199959E+04 ,,,,,
53,TERTA ,TERTB ,,,,     -0.362556943699E-01,  0.215874652794E+04 $
                    -0.357184214476E-01,  0.103714560936E+04 $
                    0.112800000000E-01,  0.209767040000E+03 ,,,,,
54,HIGHB ,GND   ,,,,      0.000000000000E+00, -0.110000000004E+05 $
                    -0.733191019968E-01, -0.527320725720E+04 $
                    -0.494356580077E-01, -0.106342221589E+04 ,,,,,
                    0.473000000000E+00,  0.223333333341E+05 ,,,,,
55,LOWB  ,GND   ,,,,     -0.733191019968E-01, -0.527320725720E+04 $
                    0.000000000000E+00, -0.252774399980E+04 $
                    -0.325054568924E-01, -0.509650587464E+03 ,,,,,
                    -0.646793103332E-01,  0.107059927425E+05 $
                    0.298750000000E-01,  0.514227199959E+04 ,,,,,
56,TERTB ,TERTC ,,,,     -0.494356580077E-01, -0.106342221589E+04 $
                    -0.325054568924E-01, -0.509650587464E+03 $
                    0.000000000000E+00, -0.102798080000E+03 ,,,,,
                    -0.362556943699E-01,  0.215874652794E+04 $
                    -0.357184214476E-01,  0.103714560936E+04 $
                    0.112800000000E-01,  0.209767040000E+03 ,,,,,
57,HIGHC ,GND   ,,,,      0.000000000000E+00, -0.110000000004E+05 $
                    -0.733191019968E-01, -0.527320725720E+04 $
                    -0.494356580077E-01, -0.106342221589E+04 ,,,,,
                    0.000000000000E+00, -0.110000000004E+05 $
                    -0.733191019968E-01, -0.527320725720E+04 $
                    -0.494356580077E-01, -0.106342221589E+04 ,,,,,
                    0.473000000000E+00,  0.223333333341E+05 ,,,,,
```

```

58,LOWC ,GND ,,,, -0.733191019968E-01, -0.527320725720E+04 $
0.000000000000E+00, -0.252774399980E+04 $
-0.325054568924E-01, -0.509650587464E+03 ,,,,,
-0.733191019968E-01, -0.527320725720E+04 $
0.000000000000E+00, -0.252774399980E+04 $
-0.325054568924E-01, -0.509650587464E+03 ,,,,,
-0.646793103332E-01, 0.107059927425E+05 $
0.298750000000E-01, 0.514227199959E+04 ,,,,,
59,TERTC ,TERTA ,,,, -0.494356580077E-01, -0.106342221589E+04 $
-0.325054568924E-01, -0.509650587464E+03 $
0.000000000000E+00, -0.102798080000E+03 ,,,,,
-0.494356580077E-01, -0.106342221589E+04 $
-0.325054568924E-01, -0.509650587464E+03 $
0.000000000000E+00, -0.102798080000E+03 ,,,,,
-0.362556943699E-01, 0.215874652794E+04 $
-0.357184214476E-01, 0.103714560936E+04 $
0.112800000000E-01, 0.209767040000E+03 ,,,,,

```

Figure 3–1 BCTRAN model data file with R and X output request

In case the requested output is for the resistance in ohms and the inverse inductance matrix in 1/mH, the commented frequency line will be replaced with a non-commented USE RB line. The model data file for the same example with R and L^{-1} output is shown in Figure 3–2.

```

C TRELEG
USE RB
51,HIGHA ,GND ,,,, 0.473000000000E+00, 0.910763215501E-02 ,,,,,
52,LOWA ,GND ,,,, -0.646793103332E-01, -0.200028866249E-01 $
0.298750000000E-01, 0.723329586680E-01 ,,,,,
53,TERTA ,TERTB ,,,, -0.362556943699E-01, 0.896763291622E-02 $
-0.357184214476E-01, -0.152234801033E+00 $
0.112800000000E-01, 0.664346532952E+00 ,,,,,
54,HIGHB ,GND ,,,, 0.000000000000E+00, 0.374175869023E-03 $
-0.733191019968E-01, -0.898402681687E-03 $
-0.494356580077E-01, 0.445633864492E-02 ,,,,,
0.473000000000E+00, 0.910763215501E-02 ,,,,,
55,LOWB ,GND ,,,, -0.733191019968E-01, -0.898402681687E-03 $
0.000000000000E+00, 0.599808392277E-02 $
-0.325054568924E-01, -0.209064527393E-01 ,,,,,
-0.646793103332E-01, -0.200028866249E-01 $
0.298750000000E-01, 0.723329586680E-01 ,,,,,
56,TERTB ,TERTC ,,,, -0.494356580077E-01, 0.445633864492E-02 $
-0.325054568924E-01, -0.209064527393E-01 $
0.000000000000E+00, 0.597396292823E-01 ,,,,,
-0.362556943699E-01, 0.896763291622E-02 $
-0.357184214476E-01, -0.152234801033E+00 $
0.112800000000E-01, 0.664346532952E+00 ,,,,,
57,HIGHC ,GND ,,,, 0.000000000000E+00, 0.374175869023E-03 $
-0.733191019968E-01, -0.898402681687E-03 $
-0.494356580077E-01, 0.445633864492E-02 ,,,,,
0.000000000000E+00, 0.374175869023E-03 $
-0.733191019968E-01, -0.898402681687E-03 $
-0.494356580077E-01, 0.445633864492E-02 ,,,,,
0.473000000000E+00, 0.910763215501E-02 ,,,,,
58,LOWC ,GND ,,,, -0.733191019968E-01, -0.898402681687E-03 $
0.000000000000E+00, 0.599808392277E-02 $
-0.325054568924E-01, -0.209064527393E-01 ,,,,,
-0.733191019968E-01, -0.898402681687E-03 $
0.000000000000E+00, 0.599808392277E-02 $
-0.325054568924E-01, -0.209064527393E-01 ,,,,,
-0.646793103332E-01, -0.200028866249E-01 $
0.298750000000E-01, 0.723329586680E-01 ,,,,,
59,TERTC ,TERTA ,,,, -0.494356580077E-01, 0.445633864492E-02 $
-0.325054568924E-01, -0.209064527393E-01 $
0.000000000000E+00, 0.597396292823E-01 ,,,,,
-0.494356580077E-01, 0.445633864492E-02 $
-0.325054568924E-01, -0.209064527393E-01 $
0.000000000000E+00, 0.597396292823E-01 ,,,,,
-0.362556943699E-01, 0.896763291622E-02 $
-0.357184214476E-01, -0.152234801033E+00 $
0.112800000000E-01, 0.664346532952E+00 ,,,,,

USE RL

```

Figure 3–2 TRELEG model data file with R and L⁻¹ output request