Harmonic and Transient simulation of Transformer in IES's FARADAY program

1. Introduction

This application note provides a detailed overview of how to model, configure, and analyze transformer systems in harmonic and transient setup using Integrated's FARADAY program. It covers the full workflow from geometry preparation to simulation setup and post-processing.

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2. Geometry Preparation

Transformer geometries can be created directly in FARADAY using the built-in Geometry and Modify Geometry tools or imported from CAD software as STEP (.stp) files. A typical imported transformer model is shown in **Figure 1**, which provides an example of a multi-volume assembly ready for material assignment and coil definition.

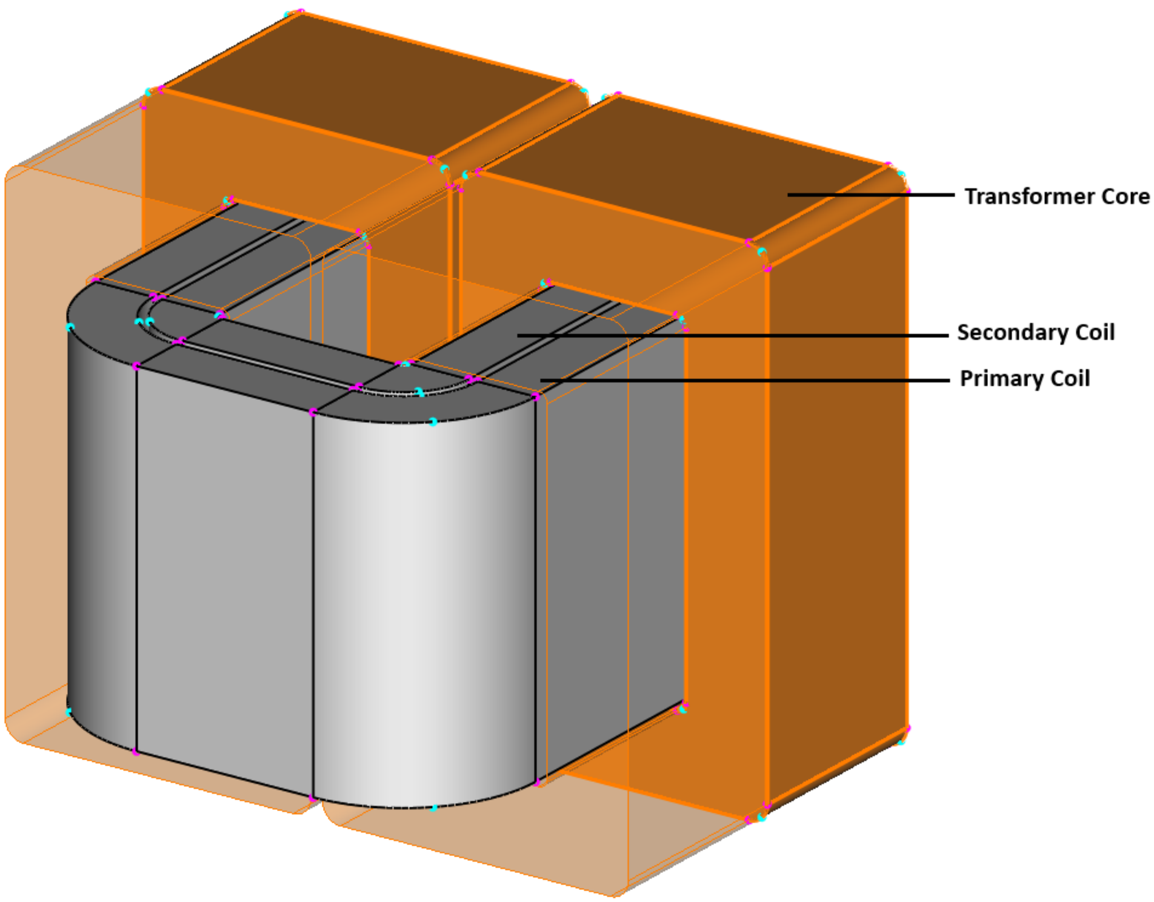

Figure 1: Transformer Model

Each coil sub-volume must consist of exactly six faces to be recognized properly during the coil creation stage. The example transformer includes multiple sub-volumes for both the primary and secondary coils, each meeting this requirement.

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3. Material Assignment

Materials are assigned by opening the Material section under the Physics menu of the program. Core materials such as Stainless Steel M4 can be applied to the transformer core, while the coil volumes default to copper unless modified.

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4. Coil and Winding Definition

Coils are created by selecting the corresponding geometry and entering the necessary electrical parameters. The primary coil is defined as a Type 1 coil with 1660 turns and a resistance of 20 ohms (Figure 2).

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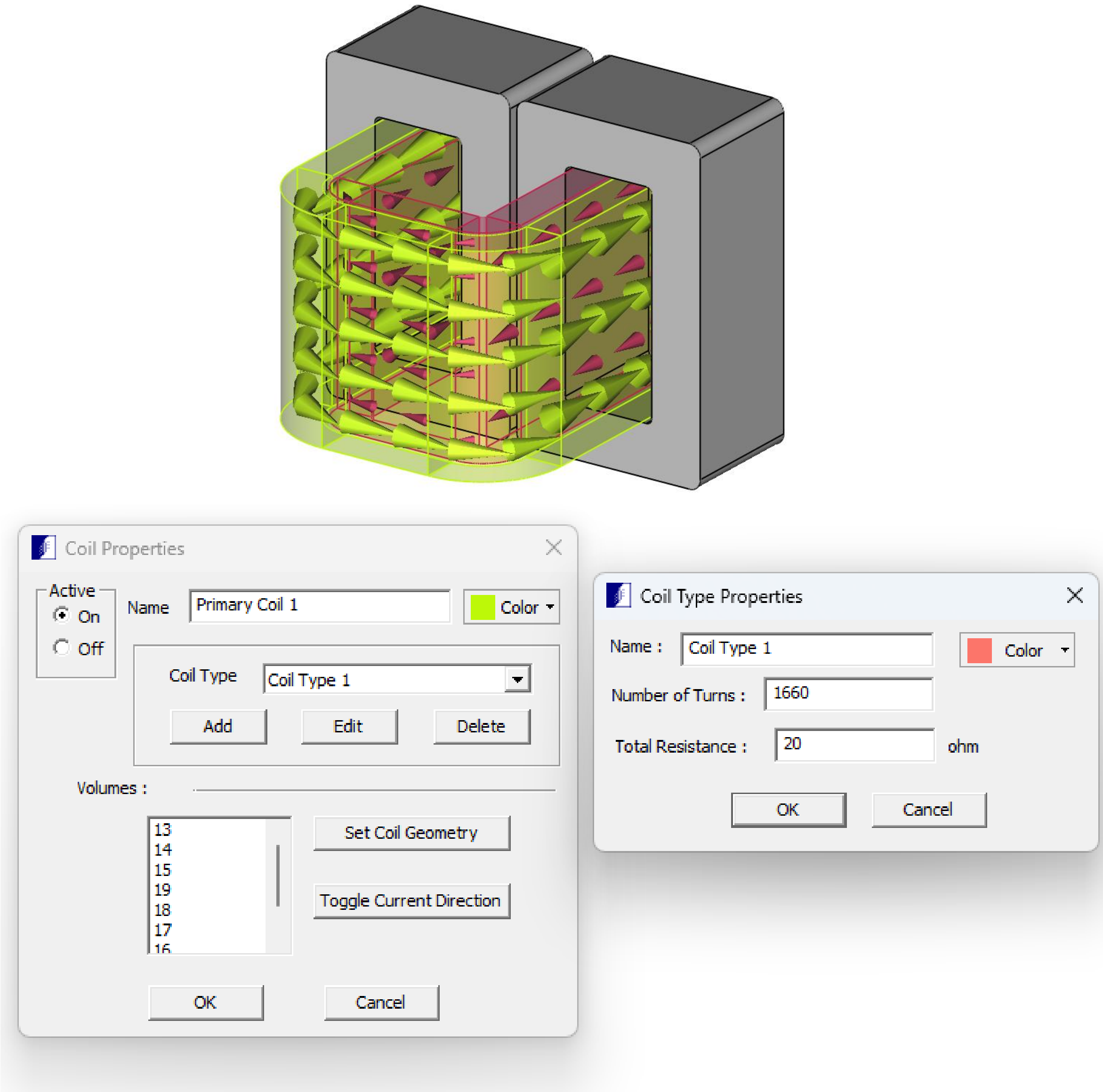

Figure 2: Coil Properties of Primary Coil

The secondary coil is configured as a Type 2 coil with 20 turns and a resistance of 0.002 ohms, with its direction reversed relative to the primary coil to reflect the correct magnetic orientation. These coil configurations can be seen in **Figure 3**, which shows the coil selection and settings window.

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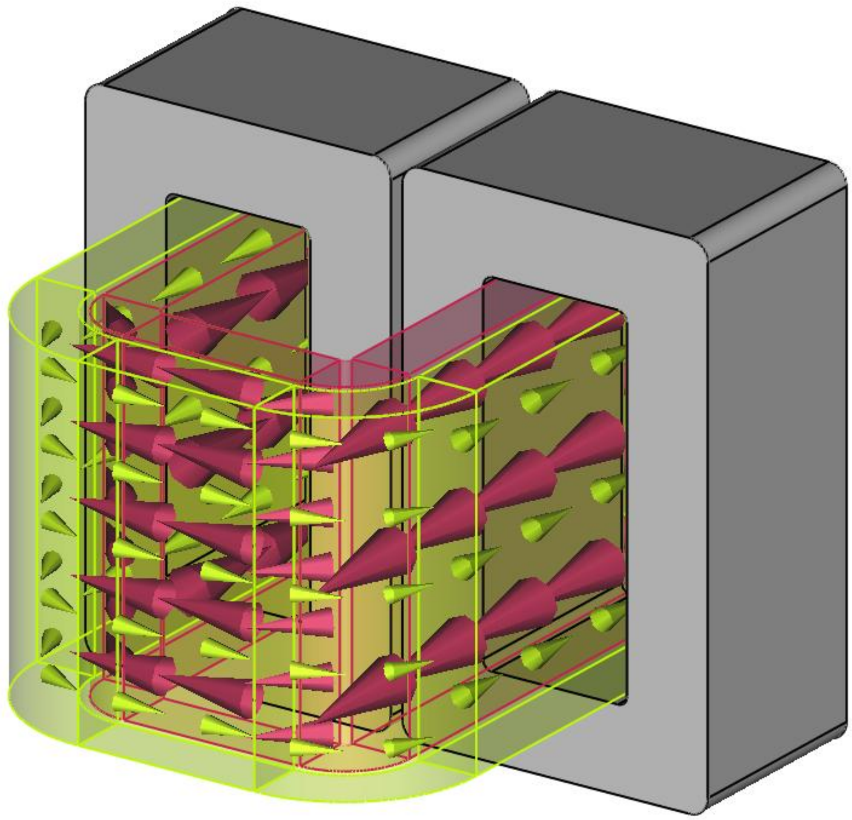

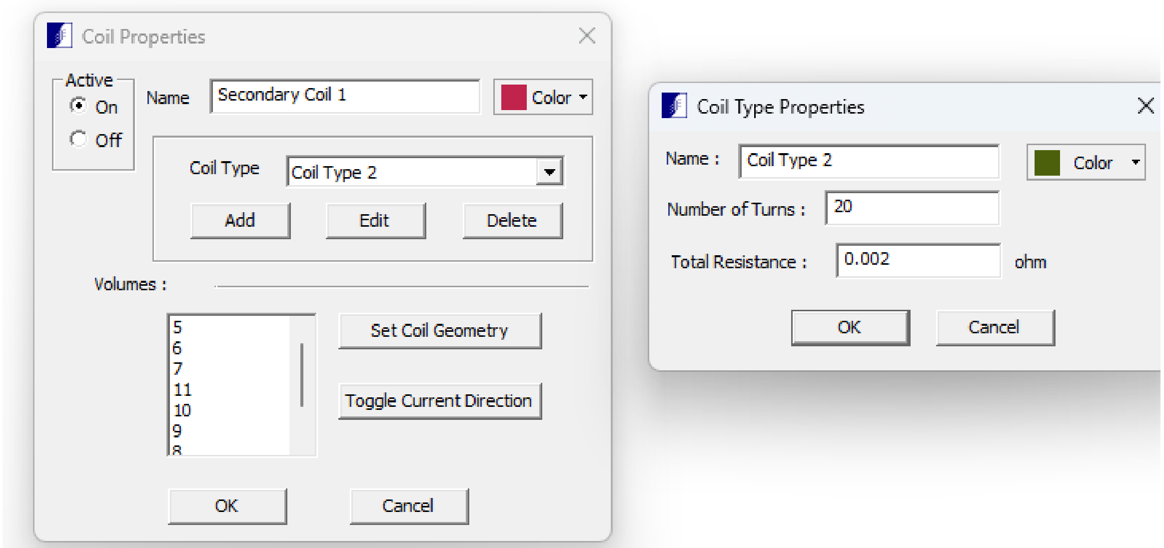

Figure 3: Coil Properties of secondary coil

The coils are then grouped into windings (Figure 4). The primary winding contains the primary coil, while the secondary winding contains the short-circuited secondary coil.

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Figure 4: Winding Properties of Primary and Secondary windings

A phasor voltage source is applied to the primary winding to drive the harmonic simulation. The source has an amplitude of 19.92 kV and a phase angle of zero degrees.

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5. Solver Configuration

The harmonic solver is configured to operate at 60 Hz. (Figure 5)

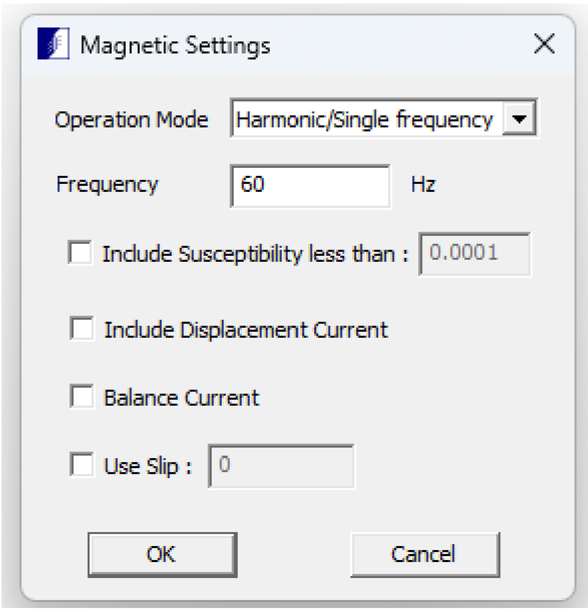

Figure 5: Magnetic settings in Transformer Model

Since transformer simulations involve coil and winding elements, FARADAY requires the use of the Finite Element Method. Linear FEM may be selected for quicker computations, while Quadratic FEM provides improved accuracy, particularly in regions with strong magnetic field gradients. (Figure 6)

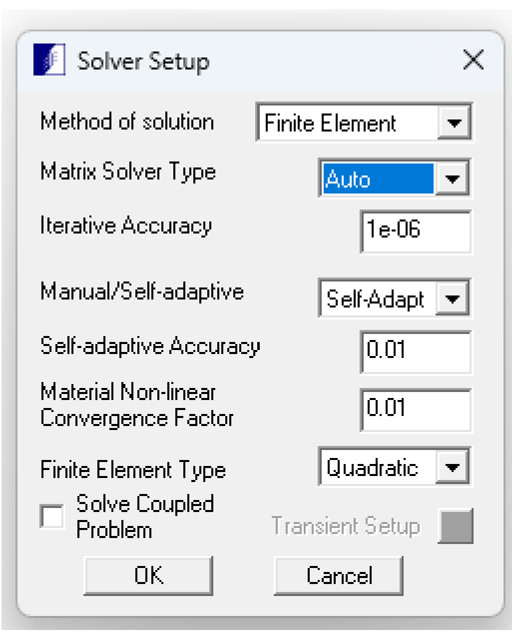

Figure 6: Solver Setup in the Transformer Model

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7. Harmonic Simulation Results

The harmonic simulation produces detailed magnetic field plots and electrical results. Magnetic flux density distributions can be visualized along selected cross-sections of the transformer, helping identify saturation-prone areas. Figure 7 shows the Magnetic field plot, showing peak flux density values near core corners.

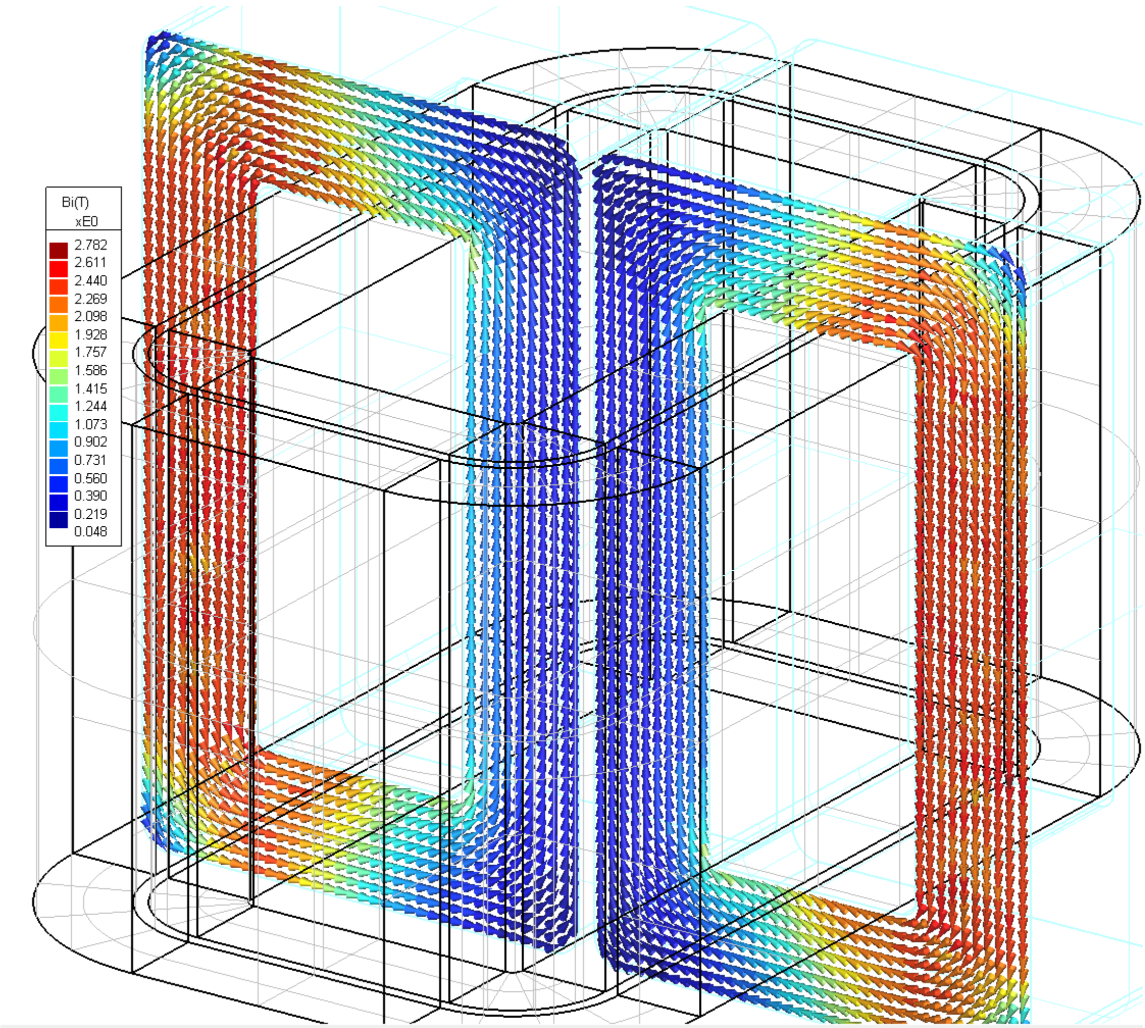

Figure 7: **Magnetic Field arrow plots on the Transformer Core**

Under the Analysis menu, we can find "Current in Winding" command. Using this command and selecting the primary and secondary winding, we can find the current (Figure 8). The harmonic results also show that the primary current is approximately 104.83 Amperes with a phase angle of –79°, while the secondary current reaches 8690 Amperes with the same phase angle. In a transformer, current ratio is inverse of turns ratio. These results verify that the turns ratio in Primary to secondary coil is 1660/20= 83 and current ratio in Secondary to Primary is also approximately 83 (8690/104.83).

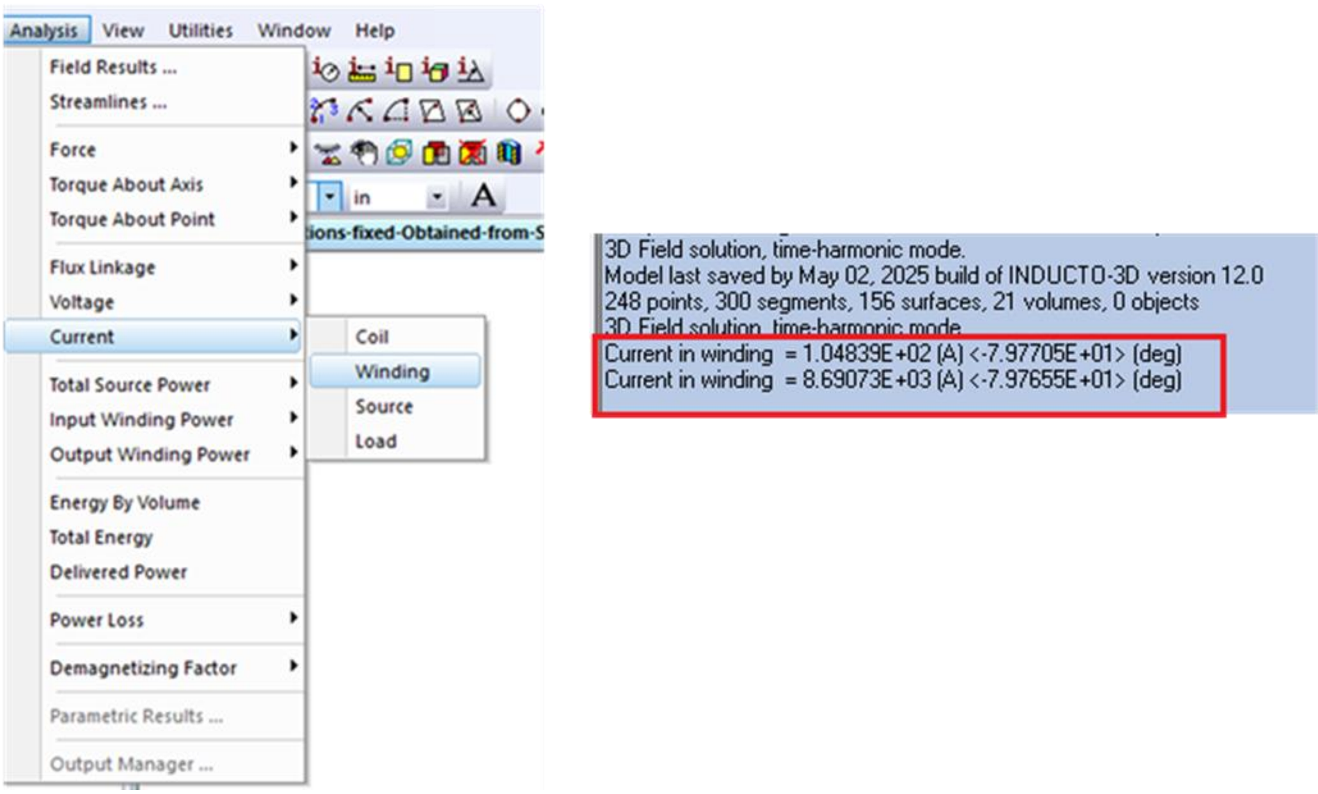

Figure 8: Current values calculated using Current in Winding Command

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8. Transient Time-Domain Analysis

For transient analysis, magnetic settings are changed to Transient mode **(Figure 9)**

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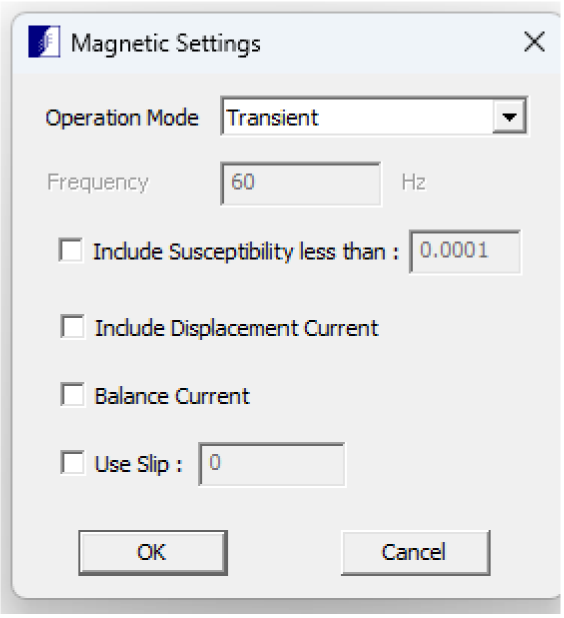

Figure 9: Magnetic Settings for Transient mode

The voltage source for the primary winding is converted into a time-domain signal operating over five cycles. For 60 Hertz frequency and 5 cycles stop times comes to be 1/60x5= 0.0833 seconds (Figure 10)

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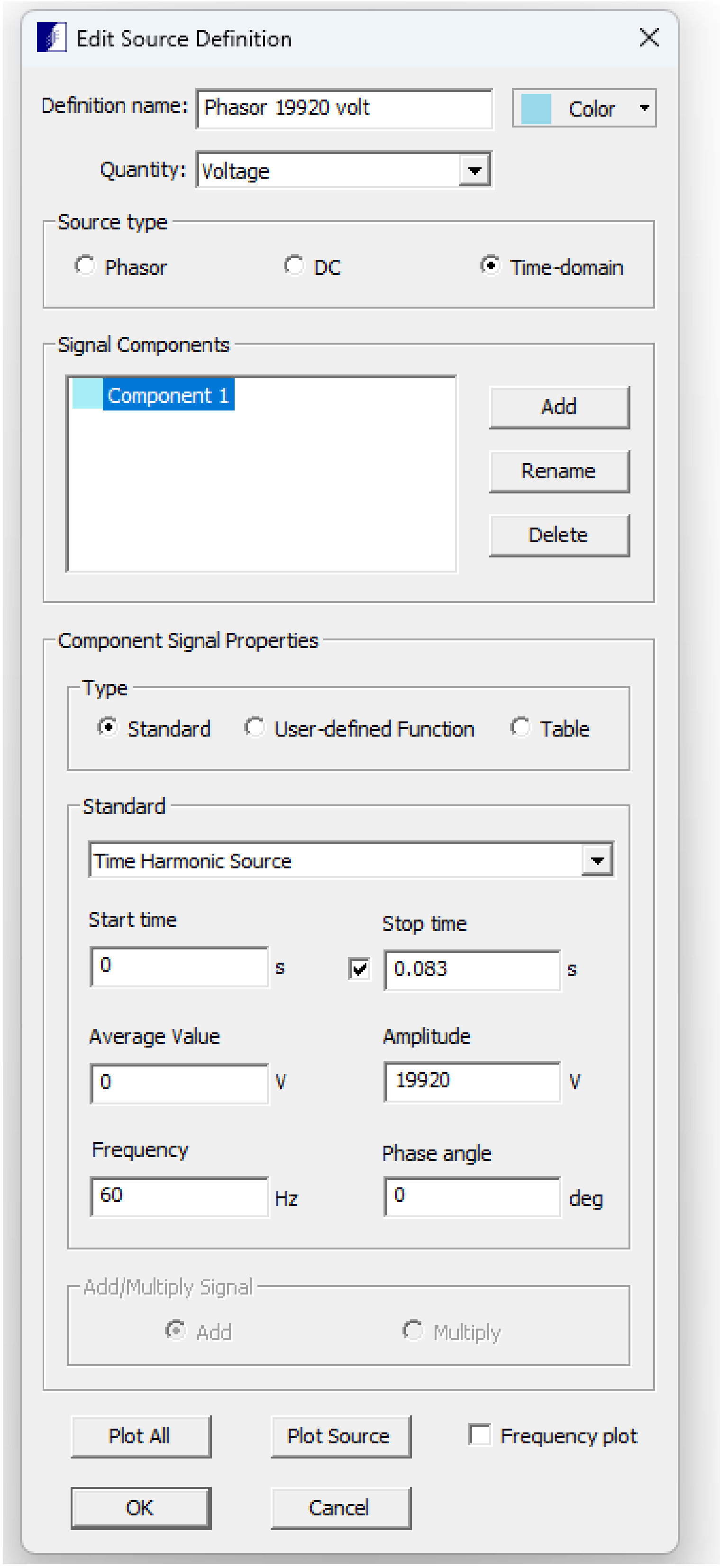

Figure 10: **Transient Source Defination in Primary Winding**

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The simulation runs with 50 time steps and uses a linear material model for demonstration purposes. Figure 11 shows the solver setup with these details.

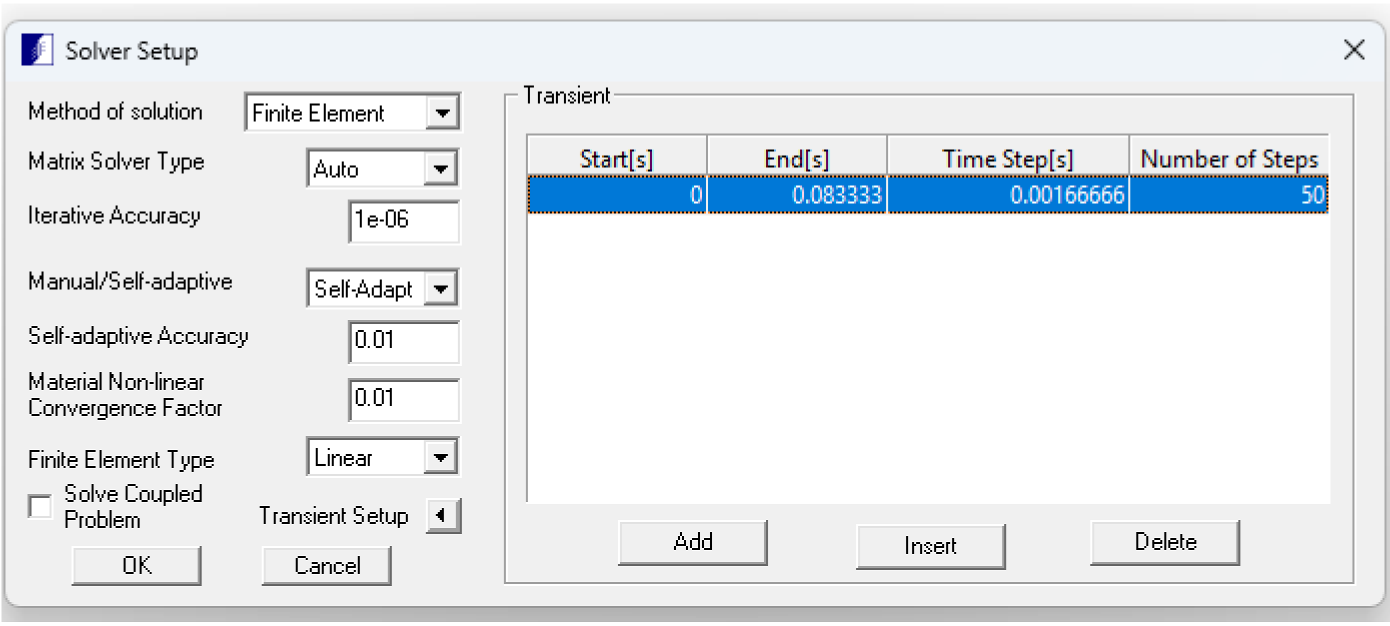

Figure 11: Solver Setup for the Transient simulation

After running the solver and plotting the primary secondary winding current graphs (Figure 12), it can be seen that it is a step up transformer, and the resulting currents exhibit sinusoidal behavior, stabilizing after several cycles.

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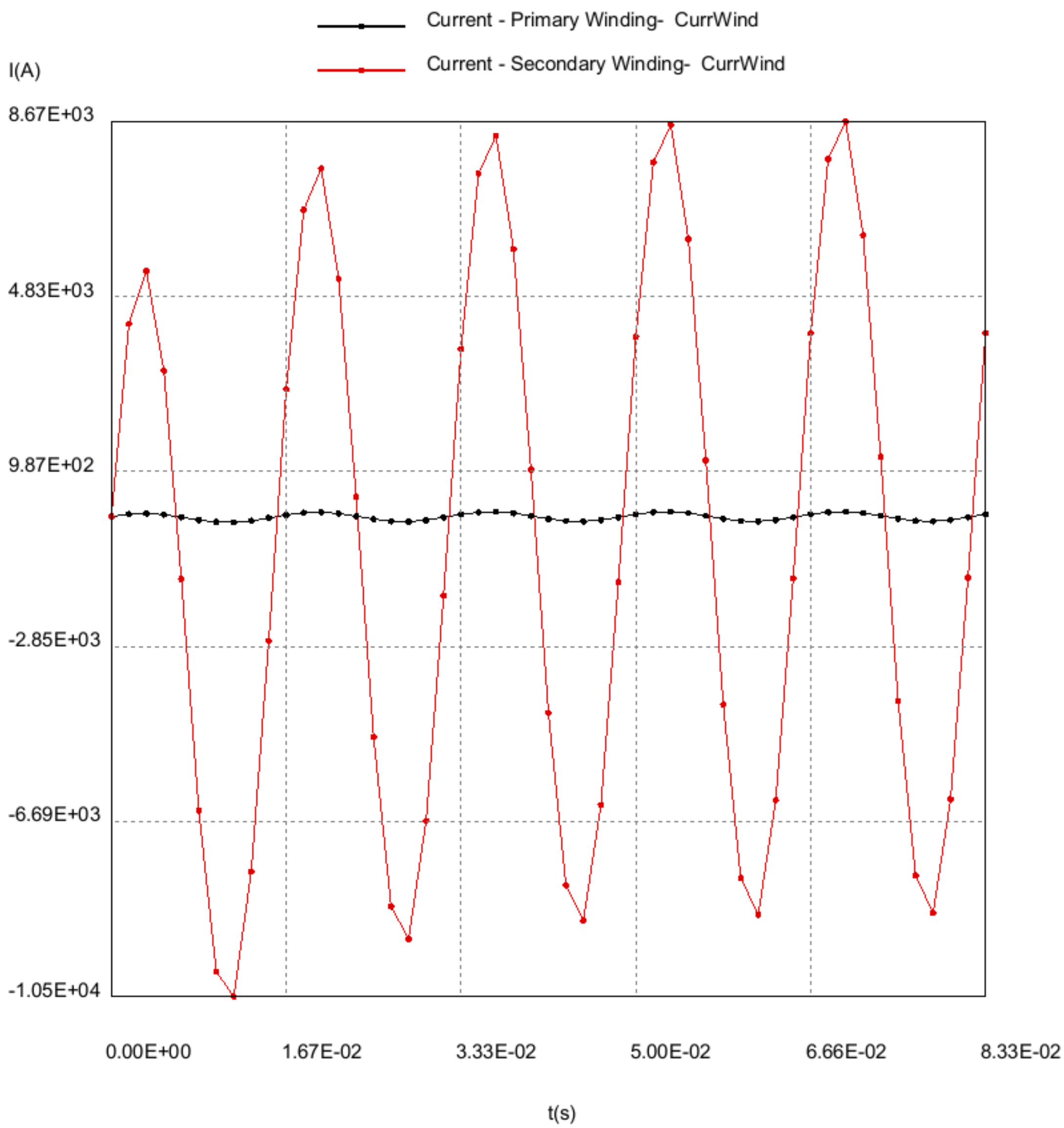

Figure 12: Solver Setup for the Transient simulation

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10. Conclusion

FARADAY provides a complete and powerful environment for performing transformer simulations. Its integrated finite element solver, flexible coil and winding tools, and detailed post-processing capabilities allow accurate prediction of magnetic field distributions, current behavior and turns ratio performance.