Nonlinear Inductance Data Function

Lcon1

L nonlinear
Data function

Ready

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1   Generation of nonlinear inductance model data

The nonlinear inductance model ('L nonlinear') of EMTP requires to input an instantaneous flux-current ($\varphi - i$) saturation curve as shown in Figure 1-1. However, typical test data consists of RMS voltage and current readings (see Figure 1-2). This Nonlinear Inductance Data Calculation Function, is designed to convert from a given RMS voltage-current curve to the $\varphi - i$ curve.
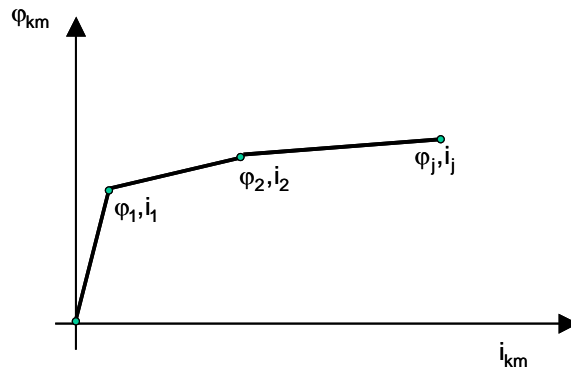

Figure 1-1 Instantaneous $\varphi - i$ data required by the "L nonlinear" device for current flowing from positive k node to m node
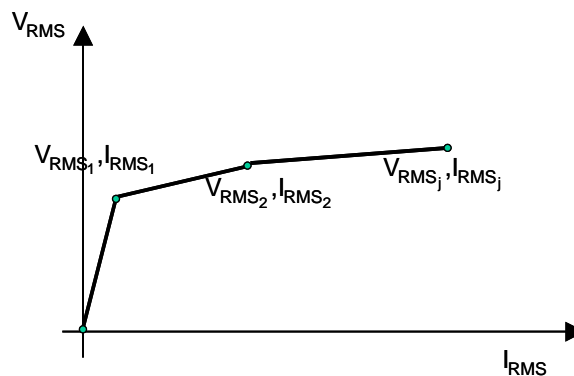

Figure 1-2 RMS voltage and current data

1.1 Input data

This tab allows to enter the characteristic to be converted. There are two input types.

The first input type allows entering $I_{RMS} - V_{RMS}$ points. The following parameters are required:
- **Frequency f**. Frequency of sinusoidal excitation.
- **V_{base}**. Base voltage on which the input points are based.
- **P_{base}**. Base power on which the input points are based.
- **I_{RMS}-V_{RMS} matrix**. This two column matrix area describes the nonlinear characteristic. RMS current in pu appears on the first column and RMS voltage in pu appears on the second column. At least one blank character should separate 2 values on a given line. A value field is limited to 16 characters. No (0,0) pair for the origin should be entered. At least two points are required. The points must start with the pair closest to the origin and then move continuously away in monotonically increasing fashion. Values are in per-unit on the previously specified base, where

$$I_{base} = \frac{P_{base}}{V_{base}}$$

$$I_{RMS_{pu}} = \frac{I_{RMS}}{I_{base}}$$

$$V_{RMS_{pu}} = \frac{V_{RMS}}{V_{base}}$$

Where I_{RMS} units are A, I_{base} units are A, V_{RMS} units are kV and V_{base} units are kV.

The output produces the same number of points as the input curve. The resulting curve is exact except for the fact that linear interpolation between points and a finite difference approximation for the sinusoidal excitation. A one-degree time-step is used along with trapezoidal integration where needed. It is also noticed that hysteresis effect is ignored.
The calculated flux φ is in Webers and the current is in Amperes.

The second input type allows entering the characteristic as an inductance function of current (see in Figure 1-3).
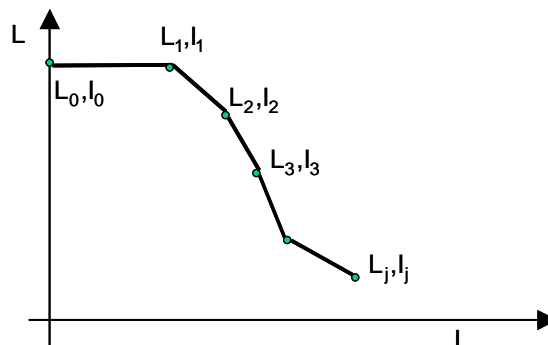
Figure 1-3 Alternate input of inductance-current points

The following parameters are required for this type of input selection:
- **Current factor**. Multiplying factor of input current coordinates. Should be set to 1 when no scaling is desired.
- **Inductance factor**. Multiplying factor of input inductance coordinates. Should be set to 1 when no scaling is desired.
- **I_j-L_j matrix.** This is a two column matrix providing the current (A) and inductance (H) breakpoints. The current breakpoints must be monotonically increasing. Incremental inductance values must all be positive. At least two points are required. No (0,0) pair for the origin should be entered. The

trapezoidal rule of integration is used to convert the characteristic into the desired $\varphi - i$ output. By definition:

$$\varphi(i) = \int_0^i L(\eta) d\eta \qquad\qquad \varphi_0 = 0$$

and using the trapezoidal rule of integration:

$$\varphi_j = \varphi_{j-1} + \frac{L_j + L_{j-1}}{2}\left[i_j - i_{j-1}\right] \qquad\qquad \text{for } j = 1, 2, ...$$

The calculated flux φ is in Webers and the current is in Amperes.

2   Calculating model data

After entering data the user can click the OK button and the device will request to generate (calculate) data. If the entered data is valid, the model data will be calculated and the Ready value will appear on this device. At this stage the device right-click menu Copy/Paste can be used to Copy and then Paste on any nonlinear inductance 'L nonlinear' (target) device using the Paste command of the target device.
The calculated data is also available in the ModelData attribute of this device.