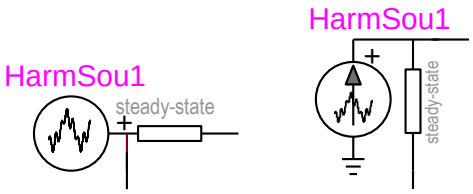
Harmonics



Henry Gras, Jean Mahseredjian, 2021-07-06 11:24:00

1 Available versions

This device accepts both 1-phase and 3-phase signals. The 1-phase version is the primitive device used in the composition of the subcircuit based 3-phase version.
Both Thevenin and Norton source versions are available. This is selectable on the device mask.

1.1 When changing phases

- When the device is in its 1-phase state and its signal is changed to 3-phase, the device inherits a subcircuit with 3 sources. The sources of the 3-phase version are balanced (positive sequence).
- When the device is in its 3-phase state and its signal is changed to 1-phase, then the subcircuit is eliminated and only 1-phase (wire) data becomes available.

1.2 The generic version data

1.3 Parameters

All version of this device (Thevenin and Norton) have 2 pins.
The parameters are:

- **Fundamental frequency** Used when the harmonics are specified as harmonic numbers. It is also used to determine the angles of phases-b and -c for the 3-phase version, assuming balanced conditions. The following formula is used (phase b):

$$\varphi_{b_i} = \varphi_{a_i} - \frac{2\pi}{3}\frac{f_i}{f_n} \tag{1}$$

  where i is the harmonic index, φ_{b_i} is the source phase angle for phase-b, φ_{a_i} is the source phase angle for phase-a, f_i is the harmonic frequency and f_n is the fundamental frequency (Hz).
- **Fundamental magnitude** Magnitude of the fundamental frequency component. This input is enabled for some **Magnitude** unit options selectable below.

- **Amplitude units** For **Fundamental magnitude** and harmonic magnitudes specified in the table **Harmonics data table**.
- **Type of source** Norton or Thevenin.
- **Harmonics data table units**
  - **Frequency** For **Harmonics data table** units of frequency
  - **Magnitude** For **Harmonics data table** units of magnitude
  - **Angle** For **Harmonics data table** units of phase
- **Harmonics data table**
  - **Additional rows** Allows to add rows into the table. It is possible to copy and paste into this grid from an Excel spreadsheet. Simply select the first row (or any starting point row) using the mouse (the row cells become yellow) and paste all rows from the Excel spreadsheet. There should be enough rows for pasting the external data.
  - **Harmo** Column of harmonic frequencies.
  - **I or V Mag** Magnitudes of Norton current or Thevenin voltage harmonics.
  - **I or V Angle** Phase angles of Norton current or Thevenin voltage harmonics.
  - **Z** Impedance magnitudes.
  - **Z angle** Impedance phase angles.

1.4 Netlist format

This device allows method-based scripting. The object data and methods are described in the script file referenced by the device Script.Open.Dev attribute.
The following format is for primitive (single phase) units. The parameters are saved into ParamsA and ModelData attributes.

```
_DLL;HarmSou2;2;2;s3,s1,
2,1,0,0,0,0,3,3,
harmonicSourceAndImpedance.dll,
1
1
3
376.99111843077514
14.142135623730951
0.17453292519943295
1
0.03490658503988659
565.4866776461628
2.8284271247461903
0
3
0.06981317007977318
753.9822368615503
0.7071067811865476
0.3490658503988659
5
0.10471975511965976
```

Field	Description
_DLL	Part name, may be followed by extra characters, such as _DLLThev1
HarmSou2	Instance name, any name.
2	Total number of pins
2	Number of pins given in this data section
s3	Signal name connected to k-pin (source connection point to the network), any name
s1	Signal name connected to m-pin (voltage source positive pin in Thevenin

	case and impedance grounding pin in the Norton source case), any name
ParamsA attribute:	
2	DLL data string: number of power signals
1	DLL data string: number of voltage sources in this DLL, 1 for Thevenin source, 0 for Norton source
0	DLL data string: number of current sources in this DLL, 0 for Thevenin source, 1 for Norton source
0	DLL data string: number of nonlinear nodes in this DLL
0	DLL data string: number of control signals in this DLL (controllables)
0	DLL data string: number of observable signals in this DLL (observables)
3	DLL data string: relative path option, 3 means that the DLL is searched in the Toolboxes folder of EMTPWorks
3	Number of harmonics, used for steady-state initialization.
ModelData attribute:	
harmonicSourceAndImpedance.dll,	The name of the DLL used for this device.
1	Not used in this version
1	1 is Thevenin source, 0 is Norton source
3	Number of harmonics
Harmonics data table	The following lines present the harmonics data. All data is converted into peak values and radians. There is one parameter per line.

2 Steady-state model

This device requests steady-state calculations in the network for each harmonic source frequency. EMTP will account for all source harmonics and calculate the steady-state solutions. The Thevenin and Norton impedances are accounted for in network solutions only at the provided source harmonic frequencies, the source impedances are infinite otherwise.

3 Load-flow model

This device does not participate in the load-flow solution: the Thevenin and Norton sources become open circuits (no current injections).

4 Frequency Scan model

For the Thevenin and Norton sources there are three options:

1. When the “Match source frequency” option is checked (see Simulation Options):
    - The magnitude and phase (angle) of the matched harmonic for the scanned frequency, are used to calculate the source voltage or current for Thevenin and Norton versions, respectively.
2. When the “Match source frequency” option is not checked (see Simulation Options):
    - The magnitude and phase (angle) of the first harmonic (first row in “Harmonics data table”) are used to calculate the source voltage or current for Thevenin and Norton versions, respectively.
3. The sources are set to zero during some EMTP calculation options, such as the “Input Impedance” option used to determine Thevenin impedances from any network node.

For the Thevenin and Norton source impedances there are two options:

1. If the scanned frequency matches a harmonic frequency from the “Harmonics data table”, the matched impedance (from harmonic row) is connected to the network.
2. If the scanned frequency is not matched, the source impedance is set to infinity

5 Time-domain model

In time-domain computations, the harmonic source impedances are eliminated: open circuit for Norton source and short-circuit for Thevenin source.

The *calculated harmonics* from the sources are injected directly into the network using the corresponding Fourier series. The *calculated harmonics* are found from the steady-state solution for each frequency at the connection point.