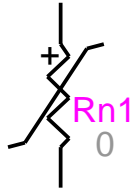


# R nonlinear device



R nonlinear device .....	1
1 Available versions .....	1
1.1 When changing phases.....	1
2 Description.....	1
2.1 Parameters and rules.....	2
3 Netlist format .....	3
4 Steady-state model and Initial conditions.....	4
5 Frequency Scan model .....	4
6 Time domain representation.....	4

Jean Mahseredjian, 12/29/2013 2:01 AM

## 1 Available versions

The “R nonlinear device” device accepts both 1-phase and 3-phase signals. The 3-phase version is the equivalent of 3 decoupled branches (one for each phase). The only difference is that in the 3-phase version it is allowed to request scope data for the extra phases.

### 1.1 When changing phases

It is allowed to switch from 1-phase to 3-phase or from 3-phase to 1-phase. The user must only verify the scope requests according to requirements.

## 2 Description

This device is based on a piecewise linear representation of the voltage-current resistance characteristic as shown in Figure 1. Linear interpolation is used between the data points.

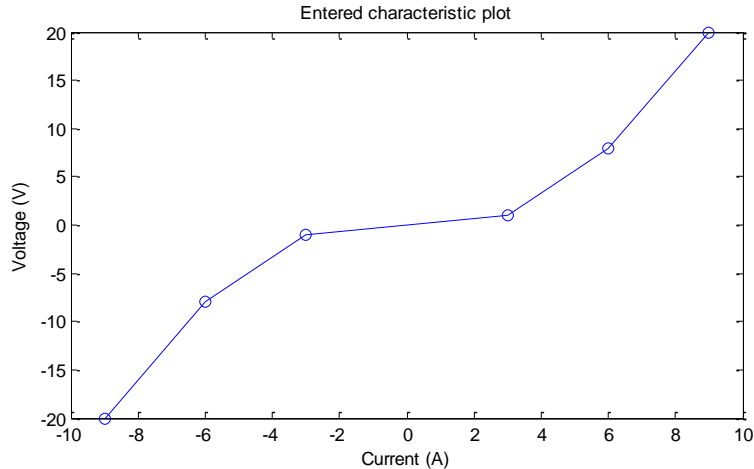


Figure 1 Piecewise nonlinear resistance representation

## 2.1 Parameters and rules

The Data tab allows entering all model parameters:

- **V<sub>start</sub>** The device becomes connected when the absolute value of its voltage becomes greater or equal to this value.
- **Y<sub>ss</sub>** Steady-state admittance. When the admittance  $Y_{ss} = 0$  this device is disconnected in steady-state. When  $Y_{ss} > 0$  the device is represented by the linear admittance  $Y_{ss}$  in the steady-state solution and  $V_{start} = 0$  (forced to zero).
- **R<sub>lin</sub>** Linear resistance connected in series with the nonlinear resistance. Default value is 0, meaning no such resistance.
- **t<sub>delay</sub>** The device can be allowed to open (become an open-circuit) after this time delay has elapsed since the most recent firing. The opening condition is detected on device voltage  $v_{km} < V_{seal}$  or device current crossing zero. Click on the Never button if the device is never allowed to open after firing.
- **N<sub>start</sub>** indicates how many times the device can restart conducting based on the voltage  $V_{start}$  condition. Click on the Always button if it is allowed to restart an infinite number of times.
  - $N_{start} > 0$  means that the device can restart  $N_{start}$  times and stay permanently open thereafter.
  - $N_{start} = 0$  means that the device can restart infinite number of times.
  - $N_{start} < 0$  (any number) means that the device can start once and stay closed thereafter.
- **V<sub>seal</sub>** Only when  $V_{seal}$  is greater than zero, the device will stop conducting (open-circuit) if its voltage becomes less than  $V_{seal}$ . The default value is zero, meaning that the current crossing zero condition is used to allow opening the device after the delay  $t_{delay}$ .
- **Characteristic** Allows entering the voltage-current function which constitutes the nonlinear resistance. The following conditions must be verified:
  - The characteristic must be entered with at least 2 points.
  - The first voltage point is extended to negative infinity in EMTP.
  - The last voltage point is extended to positive infinity in EMTP.
  - The characteristic must be monotonically increasing.
  - The (0,0) pair must be entered explicitly only when a slope change is occurring after crossing the origin.
  - Connecting segments with equal slopes is illegal.
  - It is not mandatory to cross the origin, although such characteristics are risky and can create numerical problems in EMTP.
  - The resistance cannot be infinite. The total resistance cannot be zero.

- The number of characteristic rows can be increased by selecting a row (click on the row number) and hitting the “Insert key”.

It is not allowed to delete any pins.

### 3 Netlist format

The Netlist format can be explained using the following example:

```
_Rn;Rn1;2;2;s5,s8,
1,0,0,1ms,5,1,1,1,0,1e-06,15,5,0,
-9 -20
-6 -8
-3 -1
3 1
6 8
9 20
```

Field	Description
Rn	Part name
Rn1	Instance name, any name.
2	Total number of pins
2	Number of pins given in this data section
s5	Signal name connected to k-pin, any name
s8	Signal name connected to m-pin, any name
V <sub>start</sub>	See Parameters above
Y <sub>ss</sub>	See Parameters above
R <sub>lin</sub>	See Parameters above
t <sub>delay</sub>	See Parameters above
N <sub>start</sub>	See Parameters above
V <sub>seal</sub>	See Parameters above
Units	Characteristic current units
Units	Characteristic voltage units
Symmetric	Must be made symmetric when 1
tolerane	Convergence tab data relative tolerance
Panic	Convergence tab data Panic iterations
Max tolerane factor	Convergence tab data Max tolerance factor
Use guess correction	Converge tab data guess correction method selection when 1
Current-Voltage data	Characteristic data rows, current-voltage pairs
?v	Request for voltage scope, sent to scope group vb (branch voltages), optional
?i	Request for current scope, sent to scope group ib (branch currents), optional
?p	Request for power scope, sent to scope group p (branch power), optional

A 3-phase example is given by:

```
_Rn;Rn1a;2;2;s11a,s8a,
1,0,0,1ms,5,1,1,1,0,1e-06,15,5,0,?v,?i,
_Rn;Rn1b;2;2;s11b,s8b,
,?v,?i,
```

```
_Rn;Rn1c;2;2;s11c,s8c,  
,?v,?i,  
-9 -20  
-6 -8  
-3 -1  
3 1  
6 8  
9 20
```

EMTPWorks automatically appends the phase characters and creates 3 separate devices sharing the same data. The extra phase lines are used to carry scope requests in addition to connectivity.

The comma separated data fields are saved into ParamsA, ParamsB and ParamsC attributes of this device. The current-voltage characteristic is saved into the ModelData attribute.

#### **4 Steady-state model and Initial conditions**

The steady-state model is a linear admittance when a non-zero  $Y_{ss}$  value is entered. It becomes disconnected when the time-domain solution is entered. It can be used to force initial conditions into the surrounding network and continuity from steady-state into time-domain when the time-domain initial operation is predictable by the user.

#### **5 Frequency Scan model**

When a non-zero  $Y_{ss}$  value is entered it is used to represent this device for all frequencies of a frequency scan.

#### **6 Time domain representation**

In the time-domain solution this device is a nonlinear function. It is solved through the iterative process of EMTP until convergence according to the relative tolerance option given in the Convergence data tab. A true simultaneous solution with network equations is achieved.