

PQ load



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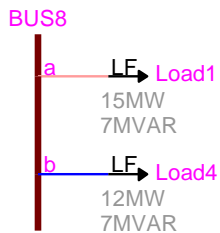
1 Description

This device models a 1-phase or 3-phase load. It is a built-in device and both a load-flow (LF) and non-load-flow device. It participates in all solution options.

1.1 Parameters and Rules

Entered data is 1-phase data. When the device becomes 3-phase due a change in its signal line type, EMTP repeats the 1-phase data 3 times to create a balanced load.

Load on a given bus can be made unbalanced by simply connecting to individual phases.



The parameters are the load **Nominal Voltage** ($V_{load_nominal}$), the load **Active Power P** ($P_{nominal}$) and the load **Reactive Power Q** ($Q_{nominal}$).

The extra parameters **Np** and **Nq** are used for both the Load-Flow and Steady-State solutions.

The entered **Nominal Voltage** units are used to convert $V_{load_nominal}$ to node-to-ground value before model computations.

The default circuit calculated by EMTP for Steady-state and Time-domain simulations is the parallel combination of equivalent R, L and C branches. The following rules are enforced:

- ❑ If $P=0$ and $Q=0$ this device becomes disconnected in all solution methods.
- ❑ If $P \geq 0$ and $Q > 0$ an RL series equivalent can be optionally used in Frequency scan, Steady-state and Time-domain solutions.

The RL series equivalent is calculated using:

$$R + j\omega L = \frac{V_{load}^2}{P_{load} - jQ_{load}} \quad (1)$$

The resistance value in the parallel combination is given by:

$$R = \frac{V_{load}^2}{P} \quad (2)$$

When the entered $Q > 0$, the inductance value in the parallel combination becomes:

$$L = \frac{V_{load}^2}{\omega Q_{load}} \quad (3)$$

When the entered $Q < 0$, the capacitance value in the parallel combination is found from:

$$C = \frac{|Q_{load}|}{\omega V_{load}^2} \quad (4)$$

The parameters V_{load} , P_{load} and Q_{load} are determined according to the simulation options (see below).

1.1.1 Show Ground Pin option

If the Ground pin is not shown, then the load is automatically connected to ground. If the Ground pin is made available by checking the “Show Ground pin” option, then it becomes ungrounded and allows to build various configurations, such as delta connection of loads or addition of extra elements in series with the load.

2 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.

A Netlist example for the default device data is given below:

```
_PQload;Load1;1;1;s1,
230kVRMSLL,15MW,0,7MVAR,0,60,1,0,?i,?p,
```

| Field | Description |
|---------------|---|
| PQload | Part name, including code to account for user changes |
| Load1 | Instance name, any name |
| 1 | Total number of pins |
| 1 | Number of pins given in this data section, this number is 2 when the ground pin is used |
| s1 | Signal name connected to k-pin (positive), any name |
| 230kVRMSLL | Voltage |
| 15MW | Power P |
| 0 | Np |
| 7MVAR | Power Q |
| 0 | Nq |
| 60 | Frequency |
| 1 | Retrieve Load-Flow solution when 1 |
| 0 | Use RL series model when 1 |
| Current scope | ?i is the request for current scopes on all branches |
| Power scope | ?p is the request for voltage scopes on all branches |

In the 3-phase version EMTWork automatically generates 3 separate devices, one per phase. The phase identification character (a, b or c) is automatically appended to the device instance name and signals. All data fields are saved into the ParamsA, ParamsB and ParamsC attributes. Since a copy of ParamsA is always kept in ParamsB and ParamsC, changing phases (from 1-phase to 3-phase) will keep a balanced load data.

3 Load-Flow model

The Load-Flow model equations of this device are given by:

$$P_{\text{specified}} = P_{\text{nominal}} \left[\frac{V_{LF}}{V_{\text{loadnominal}}} \right]^{Np} \quad (5)$$

$$Q_{\text{specified}} = Q_{\text{nominal}} \left[\frac{V_{LF}}{V_{\text{loadnominal}}} \right]^{Nq} \quad (6)$$

The $P_{\text{specified}}$ and $Q_{\text{specified}}$ powers become the Load-Flow constraints for this device. The voltage V_{LF} is the actual voltage magnitude solution on the load bus. V_{LF} is found from the load-flow solution and may differ from $V_{\text{loadnominal}}$.

At the end of the Load-Flow solution, this device saves its voltages and currents into the "Load-Flow solution data file".

If this device becomes disconnected from the rest of the network, then its power constraints cannot be enforced and the Load-Flow solution will not converge.

4 Steady-state model

The model impedance is found using equations (1) to (4).

If the “Retrieve Load-Flow solution data” checkbox is checked:

1. The voltage V_{LF} is found in the Load-Flow solution file “Load-Flow solution data file”.
2. Equations (5) and (6) are used to find $P_{\text{specified}}$ and $Q_{\text{specified}}$, then $P_{\text{load}} = P_{\text{specified}}$ and $Q_{\text{load}} = Q_{\text{specified}}$ in (1) to (4). When N_p and N_q are zero, then $P_{\text{specified}} = P_{\text{nominal}}$ and $Q_{\text{specified}} = Q_{\text{nominal}}$.

The above option is activated only when a previously saved “Load-Flow solution data file” exists and “Start from Load-Flow solution” is turned on in the Simulation Options.

When the “Retrieve Load-Flow solution data” checkbox is not checked, the following conditions are applied in (1) to (4):

1. $V_{\text{load}} = V_{\text{load}_{\text{nominal}}}$.
2. $P_{\text{load}} = P_{\text{nominal}}$ and $Q_{\text{load}} = Q_{\text{nominal}}$.

5 Frequency Scan model

The equivalent load impedance is calculated at each frequency.

The following conditions are applied in (1) to (4):

1. $V_{\text{load}} = V_{\text{load}_{\text{nominal}}}$.
2. $P_{\text{load}} = P_{\text{nominal}}$ and $Q_{\text{load}} = Q_{\text{nominal}}$.

6 Time-domain model

The load is modeled as an RLC device.

The R, L or C values are calculated as in the Steady-State solution.

If the Steady-State solution does not precede the Time-domain solution, then the following conditions are applied in (1) to (4):

1. $V_{\text{load}} = V_{\text{load}_{\text{nominal}}}$.
2. $P_{\text{load}} = P_{\text{nominal}}$ and $Q_{\text{load}} = Q_{\text{nominal}}$.