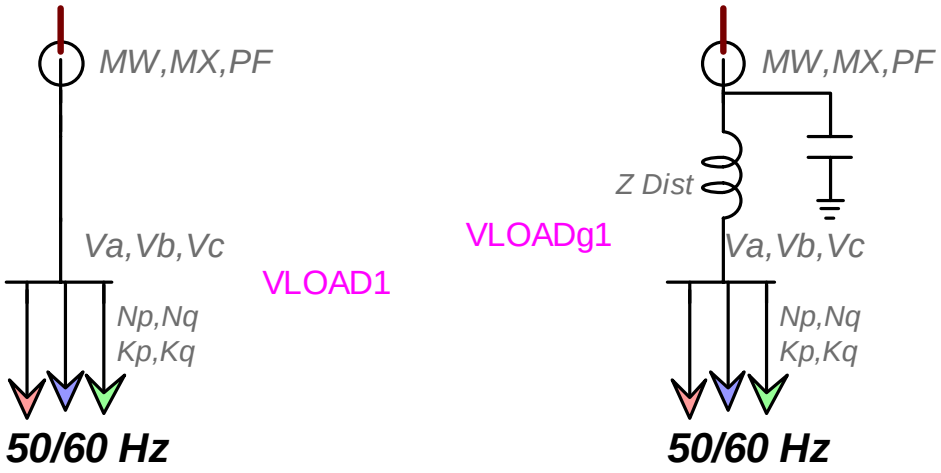
Variable static load device



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1 Description

This device is an implementation of the variable static load as defined in the traditional exponential model. This model is expressed as function of the bus voltage magnitude and the network frequency. The active power component P and the reactive power component Q are considered separately.

There are two versions of this device. The first version named “Variable Load individual”, does not model the distribution feeder. Several devices of this type can be connected individually to a distribution feeder. The second version is named “Variable Load global” and models the distribution feeder and shunt compensation.

These devices are based on masked subnetworks. The subnetworks can be unlocked to learn about internal model design and can be modified by the user.

2 Model design

The three phase load is composed of 3 independent single-phase loads. Each load can be represented by constant impedance and a current source which is controlled to satisfy:

$$P = P_0 \left(\frac{V}{V_0} \right)^{N_p} \left[1 + K_p \frac{(f - f_0)}{f_0} \right] \quad (1)$$

$$Q = Q_0 \left(\frac{V}{V_0} \right)^{N_q} \left[1 + K_q \frac{(f - f_0)}{f_0} \right] \quad (2)$$

The exponent coefficients N_p and N_q determine the nature of the load, when these exponents are equal to 0, 1 or 2 the model represents constant power, constant current or constant impedance characteristics, respectively.
The paralleled constant impedance resistance and reactance are given by:

$$R = n_R \frac{V_0^2}{P_0}$$

$$X = n_x \frac{V_0^2}{Q_0}$$

In these equations the subscript 0 indicates nominal quantities.
The controlled current sources are located in the subcircuit named Current_inject. The contents of this subcircuit are shown in Figure 2-1. The model has a parameterized initialization branch. It is switched off after a startup time of 0.1ms.

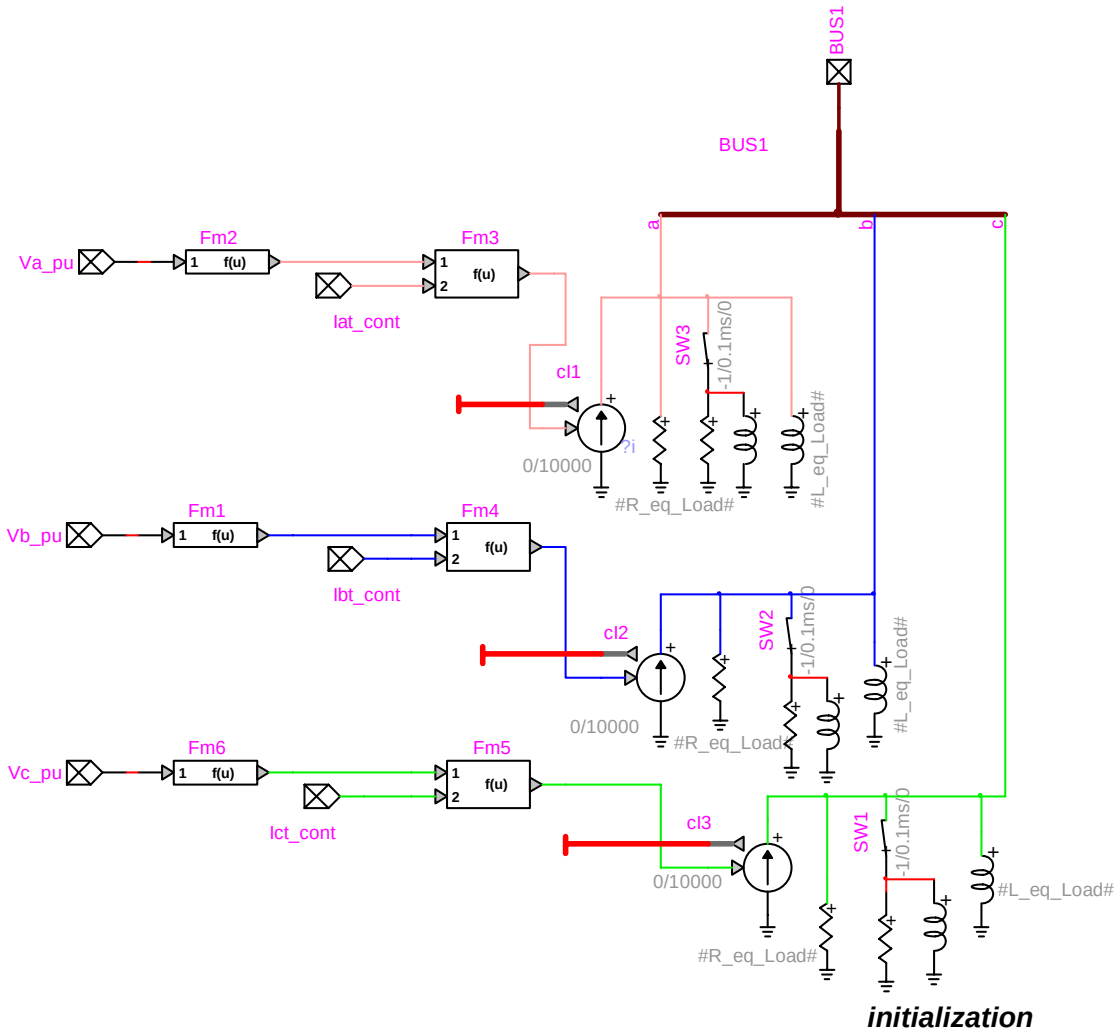

Figure 2-1 Subcircuit Current_inject

3 Parameters: initial values

The following parameters are used to define the model:

Symbol	Description	Units
Vnom	**The nominal bus voltage**	**kV-RMS-LL**
Freq	**The nominal Frequency**	**Hz**
nR	**Constant resistance multiplier (1 to 10)**	
nX	**Constant inductance multiplier (1 to 5)**	
MW_a	**Nominal active power for phase a, same for phases b and c.**	**Watt**
MX_a	**Nominal reactive power for phase a, same for phases b and c.**	**VAR**
Np	**Active power exponential multiplier**	
Nq	**Reactive power exponential multiplier**	
Kp	**Active power frequency multiplier**	
Kq	**Reactive power frequency multiplier**	
K_c_IMP	**Voltage ratio below which constant impedance applies (0.5-0.7)**	
Ratio_MVA_Dis	**The ration MVA/MW of the distribution transformer (1.3 to 2.0)**	
Iron_Dis_XFO	**The iron loss of the distribution transformer in percentage (0.3% to 0.6%).**	

The “Variable Load global” has 3 extra parameters:

Symbol	Description	Units
Perc_ZDist	**Distribution impedance on load MVA basis**	**pu**
Ratio_XR	**X/R ratio for distribution feeders (2 to 5)**	
Ratio_Comp	**Ratio of compensator C to load MVA in substation (0.1 to 0.3)**	

3.1 Scopes

The following scopes are turned on by default:

- Freq: measured frequency, control type variable
- VAR: measured total reactive power (VARS), control type variable
- W: measured total active power (W), control type variable
- PF: Power factor
- Va_pu: Per unit phase a voltage, control type variable
- Vb_pu: Per unit phase b voltage, control type variable
- Vc_pu: Per unit phase c voltage, control type variable
- Current_inject/cl1: phase a controlled current source amplitude (A), branch current (ib) type. Used to verify model stability.

The scope names are preceded by the load name. The scope Freq, for example, is named VLOAD1/Freq, for a load named VLOAD1.

3.2 Typical values

The following values can be used for the most common loads:

Fluorescent lighting	Incandescent lighting	Color TV	General substation load	
			Winter (Canada)	Summer (Canada)
Np=1.	Np=1.56	Np=2.0	Np=1.4	Np=1.
Nq=3.	Nq=0.	Nq=4.8	Nq=2.	Nq=3.
Kp=1	Kp=0	Kp=0	Kp=1	Kp=1
Kq=-2.8	Kq=0.	Kq=-4.6	Kq=-1	Kq=-1
nR=10	nR=1	nR=4	nR=2	nR=4
nX=2	nX=10	nX=2	nX=2	nX=2

4 Making subcircuit modifications

This device is using a scripted mask. Detailed information on scripted masks can be found by selecting the index Masking in “Help Docs>Using EMTP – Tutorials and Reference” and the documentation on “Mask Scripts”.

The user can enter data in the “Initial values” section. More advanced usage may require editing the “Rules” section. The “Rules” section is providing data preprocessing based on initial values. Help on enabling and disabling the Rules section can be found in the Masking documentation.

This device is using several subcircuit levels. Some subcircuit based devices are taken from existing (built-in) EMTPWorks libraries. All subcircuits are given a separate type name starting with “VLOAD__” and “VLOADg__” for individual and global models respectively. All contents (subcircuits) are unique and cannot be altered by modifying similar devices taken from built-in libraries and appearing within a design where this model is located.
As available from the library, the two load device subcircuit contents are also independent from each other. Changing the contents of one device will not affect the contents of the other device.

If the user needs to modify the subcircuit contents of this device to accommodate particular needs, it is needed to first make this model subcircuit unique (Options>Part Type>Make Unique Type). User changes will only affect the design contents and not the original library version of the device.
See also “Make Unique Type” in the electronic Help index before using this option and modifying the subcircuit contents.

5 References

[1] W.W.Price et al.: “Load Modeling for Power Flow and Transient Stability Studies”, IEEE Trans. On Power Systems, Feb. 1988.

[2] B. Khodabakhchian et al.: “Modeling A Mixed Residential-Commercial Load for Simulations Involving Large Disturbances”, IEEE PES Summer Meeting, Denver, Co., Aug. 1996.

[3] P.Kundur, “Power system stability and control”, EPRI, McGraw-Hill inc., 1993, pp 272-274.