Model Design Document – Generic DC Load Multistage (Electrical)

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Technical Memo

Model Design Document
Generic DC Load Multistage (Electrical)

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Prepared by
Kristin Clarey

Verified by
Rod Leonard

REVISION HISTORY

Version Number	Date	Comments
1.0.0	5/4/2016	Initial documentation for Generic DC Load Multistage model

Table of Contents

1 Functionality

1.1 Model Capabilities

1.1.1 Functional description

The Generic DC Load Multistage is an electrical load with the distinction of having three pre-set operating modes that allows the user to quickly change between power states. The attributes named Low Energy Power, Medium Energy Power and High Energy Power are used to set the power draw for the different operating modes. The equipment cycles between operating states by double clicking on the model icon.

This device is capable of requesting power from electrical sources. The equipment has an attribute, “Rated Electrical Power”, that specifies the load’s power rating, which should not to be exceeded. This attribute should be set to the value appropriate for the actual equipment that it represents. During simulation, the user will be warned if the electrical power consumed by the load exceeds the “Rated Electrical Power”. The “Rated Frequency”, “Rated Voltage”, and “Current Type” are attributes associated with the load’s electrical port and should be set to match the specific equipment’s specifications.

The “Actual Electrical Power” attribute defines how much power the load will request under the current operating condition. The load may also be cycled between online and offline.

The general power-flow system of equations used is of the form shown in *Eq. 1.1*. The solver can use a variety of methods to solve this system, such as Gauss-Seidel or Newton-Raphson to solve for the V vector.

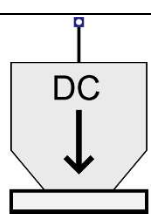
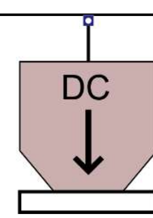
$$S = V \cdot \sum_{k=1}^{n} Y_k^* \cdot V_k^* \qquad \textit{Eq. 1.1}$$

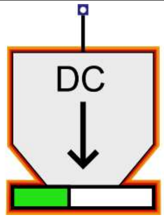
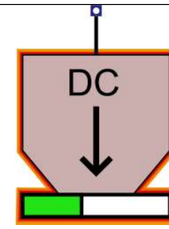
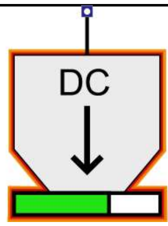
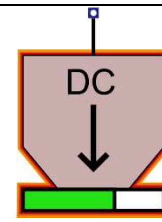
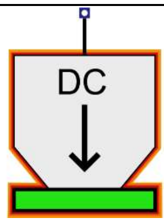
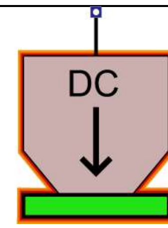
The length of S and V vectors is equal to the total number of nodes n, and the Y matrix is of size n x n. From the individual model’s perspective, n represents the total number of ports in the model, under the assumption that they may each be connected to a different node. If multiple ports are shorted into the same node, the solver is responsible for combining the equations into one node equation.

Load models are responsible for supplying the value of S. The model is therefore represented by *Eq. 1.2*.

$$S = -ActualElectricalPower \qquad \textit{Eq. 1.2}$$

1.1.2 Control Modes

Notional	State	Non-notional
	Offline In this State the model does not request power	

	Low In this state the model requests the amount of power set via the Low Energy Power attribute	
	Medium In this state the model requests the amount of power set via the Medium Energy Power attribute	
	High In this state the model requests the amount of power set via the High Energy Power attribute	

1.1.3 Special Actions

Double Clicking

Double clicking the equipment icon will cause the equipment to cycle the amount of energy it is requesting in the following sequence: Low, Medium, High and offline. When in Offline mode, the attribute Online is set to false, in all other operating modes the attribute is set to true.

1.1.4 Operating range limitations

This model produces results even when it is being operated out of the bounds set by the “Rated Electrical Power” attribute. The user will need to pay attention to any warnings generated during simulation in order to determine if the radar is being used properly.

1.2 Fault Modeling

1.2.1 Simulation Events

Electrical Power Greater Than Rating

This event is raised by the simulation model whenever the “Actual Electrical Power” causes the load to request and receive more power than which it is rated. The “Rated Electrical Power” attribute establishes the maximum power rating for the device. An example is shown in Figure 1.

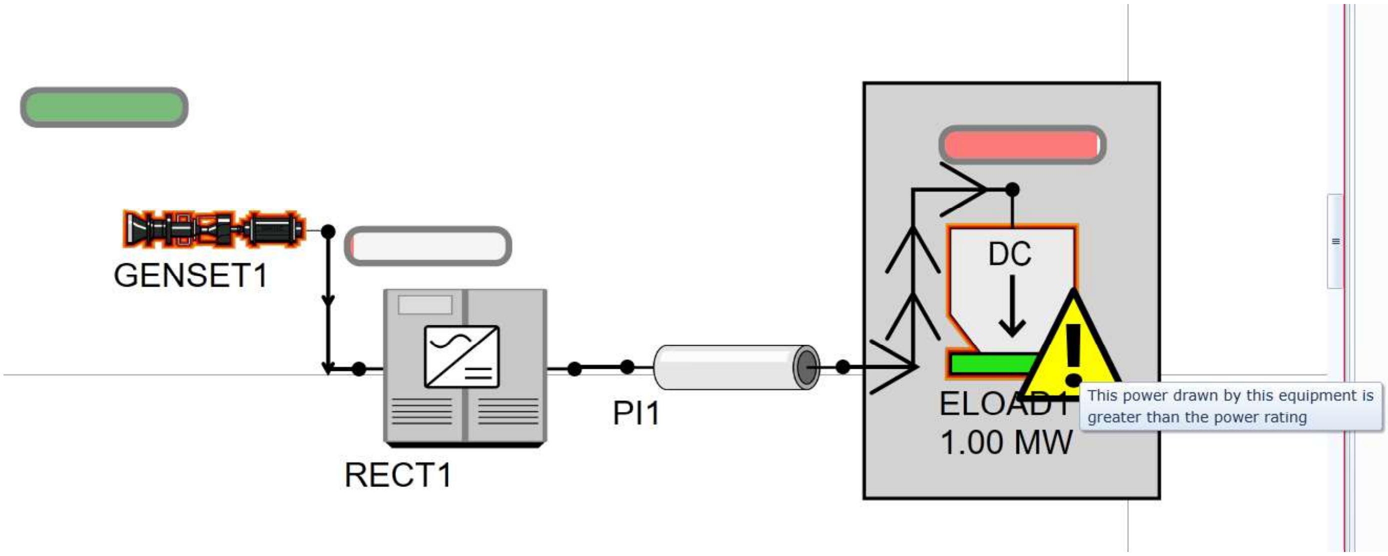


Figure 1. An example of the "Electrical Power Greater than Rating" simulation event. The amount of power being drawn by the DC Multistage Load is greater than the "Rated Electrical Power" attribute value.

2 Analytical Methods

2.1 General Algorithms

The device is modeled as a ZIP load-flow model. This device provides a (negative) constant power injection to the load-flow system model.

The solver uses the constant power injection provided to solve for system steady-state voltages at every node as well as currents and power flow through every branch using known algorithms such as Gauss-Seidel and Newton-Raphson methods.

2.2 Analytical Capabilities

Steady-State, load-flow analysis.

3 Data

3.1 Attributes

3.1.1 Equipment Attributes

Actual Electrical Power

The amount of power the load will request. This is different from the Rated Electrical Power because it defines the load's operating point rather than its physical capability. If the Actual Electrical Power is greater than the Rated Electrical Power, the user will be warned with the Simulation Event, "Electrical Power Greater Than Rating." The result of this is that the load will have a flashing warning that appears Figure 1 on the schematic, once it has been simulated.

Efficiency

This attribute defines the efficiency of the equipment. The inefficiency is considered as power lost due to heat.

Online

If this attribute is set to false, the equipment will not request any power from the system. If the attribute is set to true, then the load will request power from the system. The online attribute can be changed by double clicking on the attribute, where if the operating mode is different to offline the attribute will be true and if it is offline the attribute will be set to false. The attribute can also be changed by selecting the attribute and clicking the edit icon in the toolbar.

Rated Electrical Power

This attribute defines the maximum amount of power the equipment is capable of producing. As indicated in the Model Limitations section, the equipment will continue to operate if the power drawn is above the Rated Electrical Power but the user will be notified by the Simulation Event "Electrical Power Greater Than Rating." The rated electrical power can be modified to as long as the equipment that it is modeling is notional and not representative of an actual device.

3.1.2 Port Attributes

Current Type [AC or DC]

This attribute specifies the type of current produced (Alternating Current or Direct Current) at a specific electrical port.

Rated Frequency [Hz]

This attribute specifies the frequency of the electrical port. Typically, this will be 60Hz.

Rated Voltage [kV]

This attribute specifies the voltage produced at the electrical port. Attempting to simulate equipment connected at the same nodes that have different voltages specified for this port will produce an error.

4 User Guidelines

4.1 Test Cases

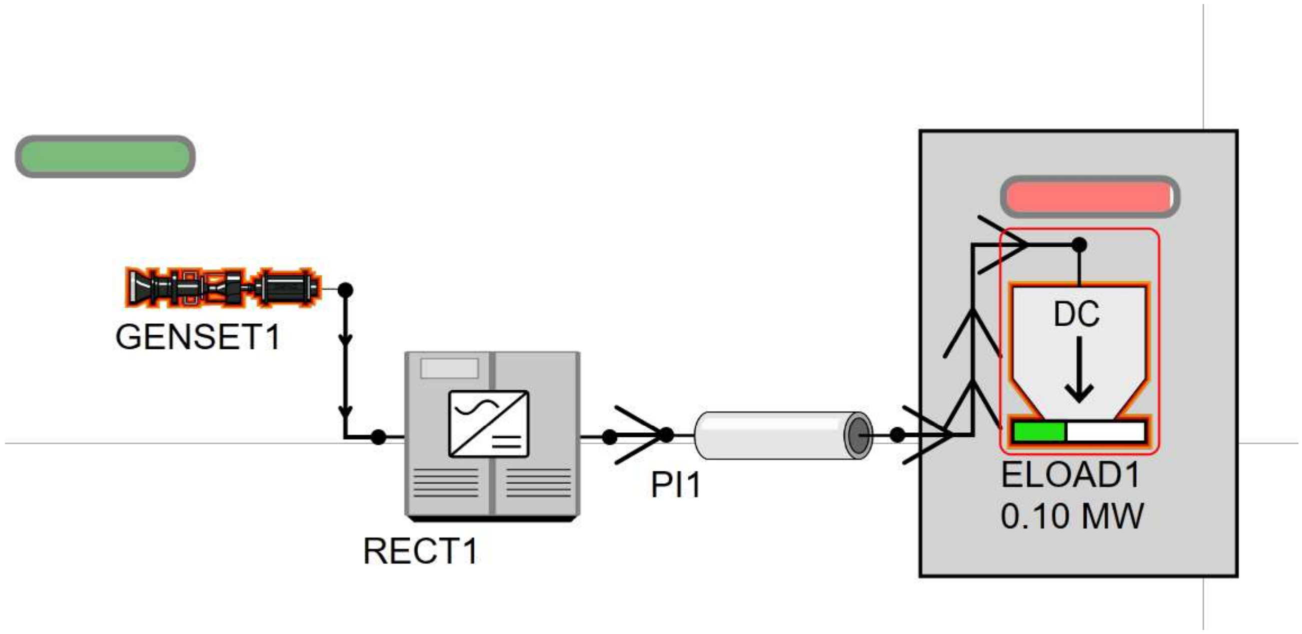


Figure 2. In this example the equipment is functioning in low energy power mode

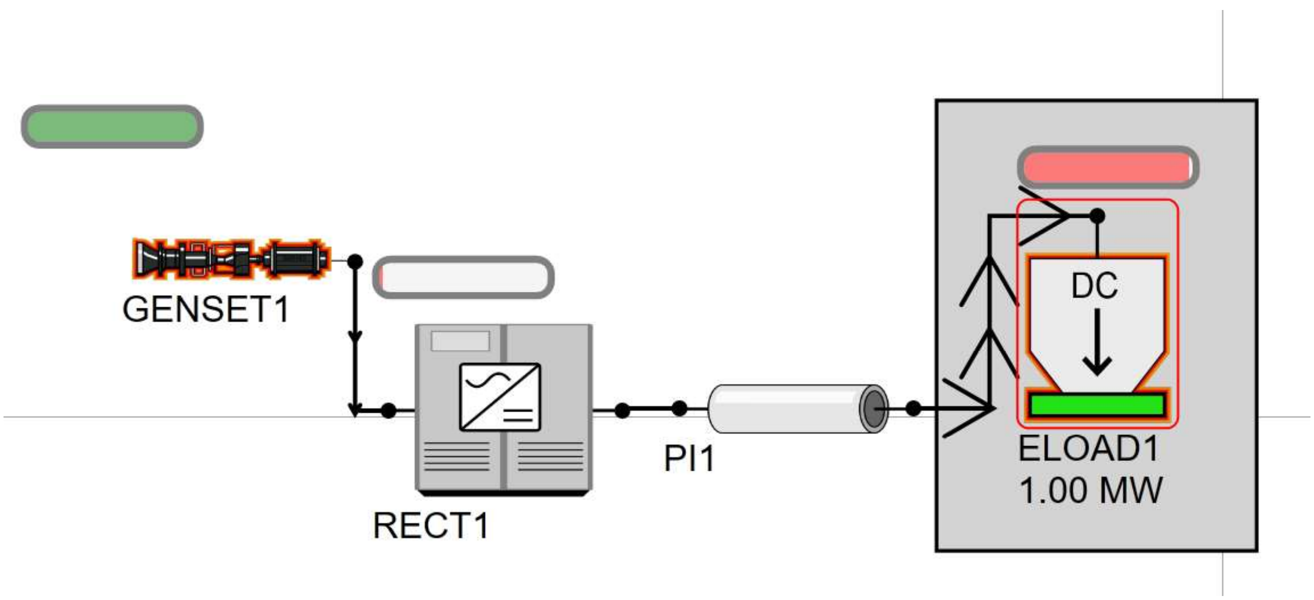


Figure 3. In this example the equipment is functioning in high energy power mode

Appendix A: Abbreviations and Acronyms

Acronym List	
ZIP	Standard steady-state load-flow model. Constant impedance (Z), constant current (I), constant power (P).