Note: For other organizations, use the appropriate title and address.

Technical Memo

Model Design Document
DC DC Power Converter (Electrical)

5/3/2016

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REVISION HISTORY

Version Number	Date	Comments
1.0.0	5/3/2016	Initial documentation for DC to DC Power Converter model in Electrical discipline

Table of Contents

1 Functionality

1.1 Model Capabilities

1.1.1 Functional description

A DC to DC Power Converter equipment will step the a DC voltage up or down

A power converter is also limited by the amount of power that it can safely transfer. This is captured in the model via the attribute named “Rated Electrical Power”. The power converter should, at a maximum, supply the amount of power as is specified by the “Rated Electrical Power” attribute. However, if the power required by the loads is above the “Rated Electrical Power” attribute value the converter will transfer the amount of required power and the user will be warned by the raising of a Simulation Event and the displaying of a warning after the simulation is completed.

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.

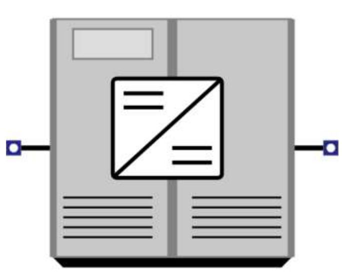
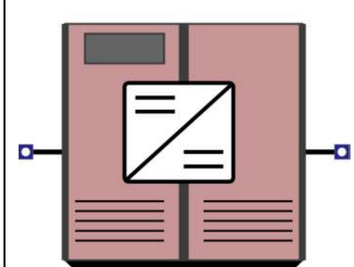
$$S = V \cdot \sum_{k=1}^{n} Y_k^* \cdot V_k^* \qquad \textit{Eq. 1.1}$$

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.

For cables, switches, and converter models, the model is responsible for supplying the admittance matrix Y. The model is therefore represented by the addition of *Eq. 1.2* between every two ports with an admittance between them. If the admittance is to ground, that row and column is omitted.

$$Y = \begin{bmatrix} k & -k \\ -k & k \end{bmatrix} \qquad \textit{Eq. 1.2}$$

1.1.2 Control Modes

Notional	State	Non-notional
	This equipment does not have multiple states.	

1.1.3 Cross-Discipline Effects

The power converter could be power a defined load however the amount of power required from the generator will actually be slightly above the power required by the connected downstream load(s). This is due to the fact that the power converter is not ideal and has a loss corresponding to its efficiency at the current operating point. The power converter will consume power based on its efficiency as well as the amount of power that is being drawn through the device. The amount of power that is lost due to inefficiencies is considered to be expended, in total, as heat.

This requires that the equipment needs to be cooled. If the equipment is liquid cooled, it will have an equivalent model available in the Thermal Fluid Designer. The model has an inlet and outlet port for the cooling fluid to flow through and cool the equipment to an appropriate operating temperature. If the equipment is air cooled, it will have an equivalent model available in the HVAC Designer.

1.1.4 Operating range limitations

This model will produce results even when it is being operated out of the bounds set by the "Rated Electrical Power" attribute.

1.2 Fault Modeling

1.2.1 Simulation Events

Electrical Power Greater Than Rating

This event is raised by the simulation model whenever the power being transferred by the converter is greater than the value for the "Rated Electrical Power" attribute. This is displayed to the user as a warning condition as is shown in Figure 1.

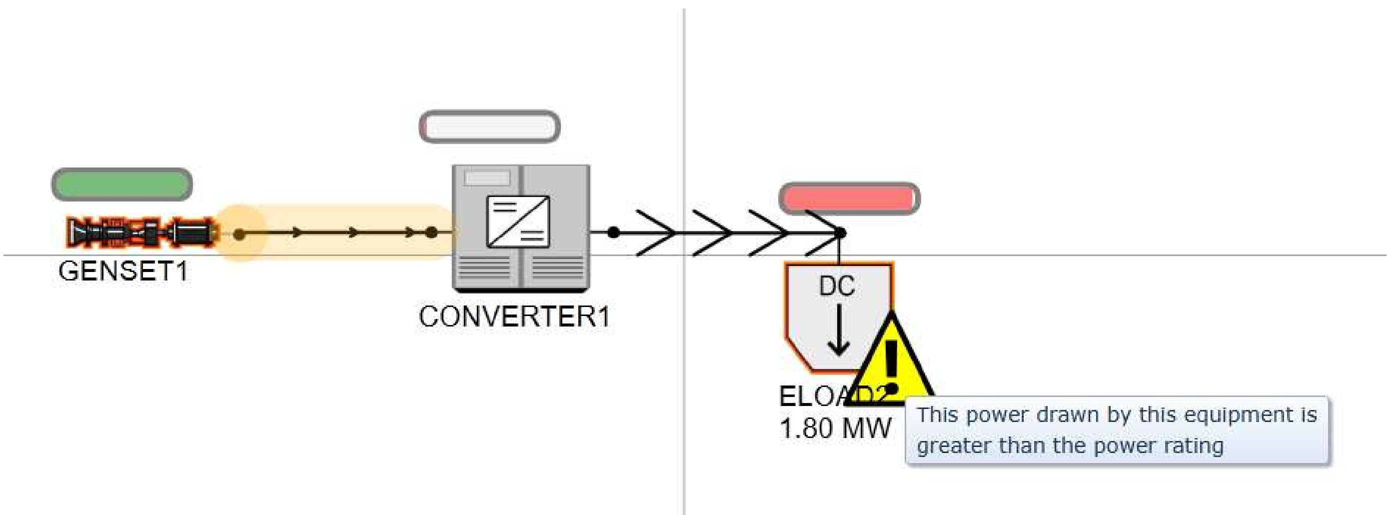


Figure 1. The amount of power being transferred is greater than the amount specified by the rated electrical power.

2 Analytical Methods

2.1 General Algorithms

This equipment is modeled as a ZIP load-flow model. This model provides a negative constant power injection and constant impedance.

The solver uses the constant ZIP parameters 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

Rated Electrical Power

This attribute defines the maximum amount of power the equipment should transfer. As said in the Model Limitations section, the equipment will still 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 redefined to match the equipment that it is being modeled.

Efficiency

This attribute is a read only attribute. It is derived from the Electrical Percent Power Efficiency Curve and the current operating point of the device as shown in the example below.

Electrical Percent Power Efficiency Curve

This attribute defines the efficiency at any given operating point, in terms of the amount of power delivered as a percentage of the total rated power for the converter.

The curve is used to determine the converter efficiency at the current operating point. The abscissa value, Percent Power, is equal to the output power divided by Rated Electrical Power. The Thermal Designer component associated with the equipment will use the resultant efficiency to calculate the heat load.

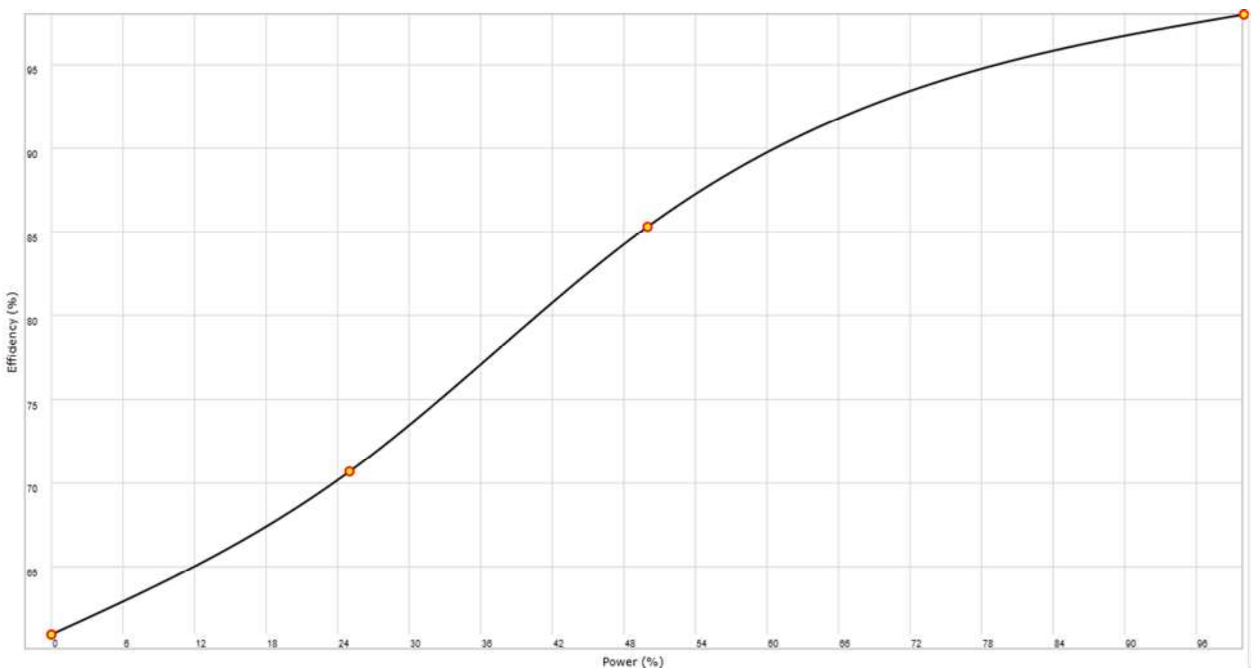


Figure 2. An example of the "Electrical Percent Power Efficiency Curve" attribute from which the equipment's efficiency will be derived, depending on its current operating point.

The yellow data points shown in the figure above represent specific data points that have been set in the Electrical Percent Power Efficiency Curve. A curve fit is performed in order to determine efficiency values between the known data points.

3.1.2 Port Attributes

Current Type [AC or DC]

Determines the type of current produced or required at a specific port. The user will be warned if they attempt to connect a port to another equipment's port that has a different current type specified.

Rated Voltage [kV]

Determines the voltage level produced at the port. This value can be redefined to match the equipment that is being modeled. Attempting to simulate equipment connected at the same nodes that have different voltages defined for this port attribute will produce an error.

Connection Problems:

This event is raised by the simulation model whenever the port attributes on connecting equipment does not agree with respect to voltage, current, and frequency. The user will be notified by the connector (the line connecting the equipment), being highlighted. For a Power Converter, the user is likely to encounter this condition because the input and output ports will generally have different Current Types or Rated Voltages.

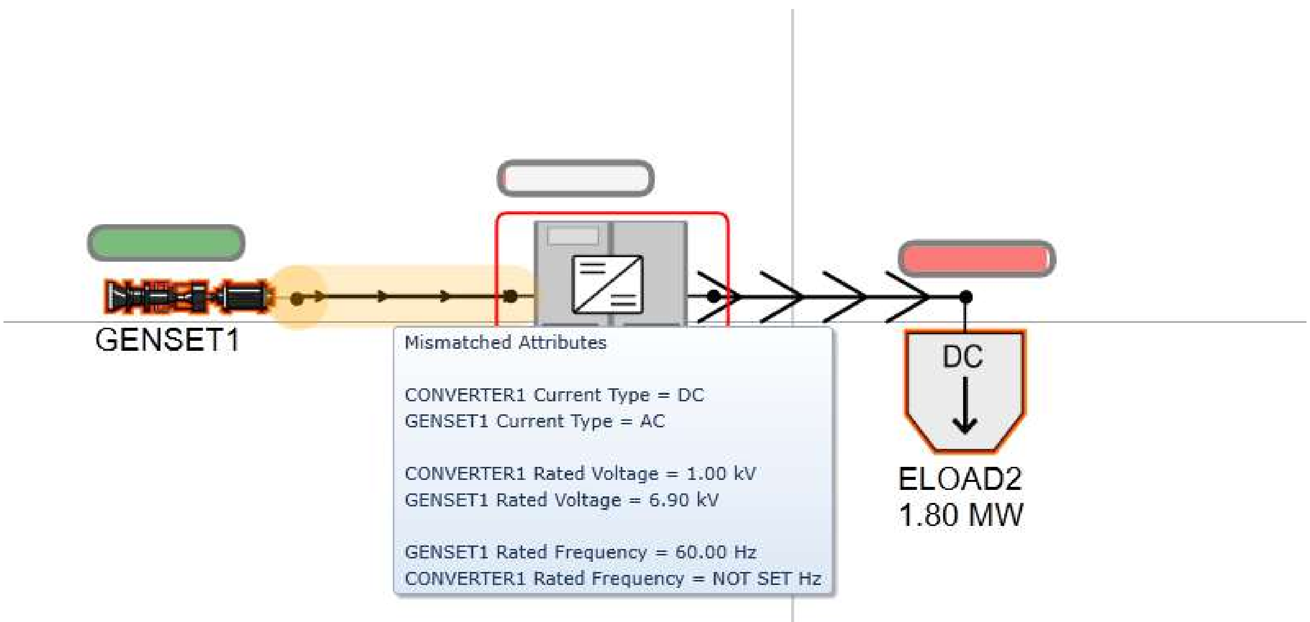


Figure 3 An example of the "Mismatched Attributes" simulation event. In this case, the current types, rated voltage and rated frequency are different.

To resolve the error in Figure 3, a DC source would need to be used, or a rectifier placed between the genset and the DC/DC converter.

4 User Guidelines

4.1 Test Cases

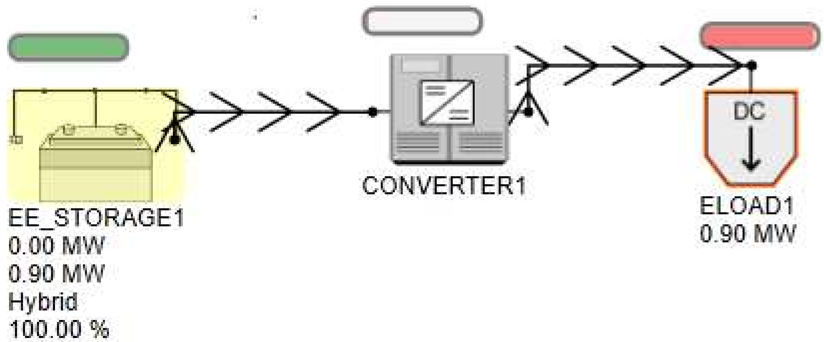


Figure 4. A Energy Storage powering a DC load with a DC to DC Power Converter converting the current for the DC Load