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

Technical Memo

Model Design Document
Breaker (Electrical)

4/21/2016

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Verified by
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REVISION HISTORY

Version Number	Date	Comments
1.0.0	4/21/2016	Initial documentation for Breaker model in Electrical discipline

Table of Contents

1 Functionality

1.1 Model Capabilities

1.1.1 Functional description

The breaker is used to protect electrical equipment from an overcurrent condition. The breaker will detect whenever the current through the device exceeds the rated limit. Once it detects an unsafe current, the breaker will open the circuit disallowing the power to be transferred to the downstream loads. When the breaker attempts to opens the circuit, a potential is created across the breaker's terminals. This potential, if large enough, is capable of creating an arcing condition, which must be handled by the breaker. This effect is not currently modeled by the device.

Breakers are used to isolate downstream faults from the power sources. If the load malfunctions, the breaker will automatically open, preventing further damage to the load and other equipment on the circuit. Circuit breakers are typically used with AC signals whereas, DC Disconnects are used with DC signals.

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.

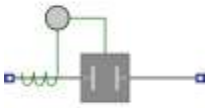
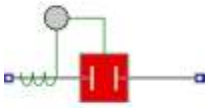
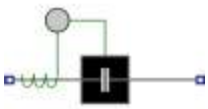
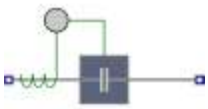
$$S = V \cdot \sum_{k=1}^{n} Y_k^* \cdot V_k^* \qquad \textit{Eq. 1.1}$$

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
	**Open**	
	**Closed**	

1.1.3 Special Actions

Double Clicking

Double clicking the breaker icon will cause the breaker to cycle between the closed and open states. For instance, if the breaker is double clicked while the "Switch State" attribute is set to closed, then the attribute will be set to open and vice versa.

1.1.4 Cross-Discipline Effects

This equipment does not have any cross-discipline effects.

1.2 Assumptions

The system impedances allow the breaker to translate the requested power at the requested voltage. A situation resulting in voltage collapse will result if the simulation is unable to converge to a result.

1.3 Fault Modeling

1.3.1 Simulation Events

Continuous Current Greater than Rating

If the amount of continuous current through the breaker exceeds the "Rated Continuous Current" attribute then the breaker will automatically open preventing any power to be transferred downstream. The user will be warned with an error message as shown below.

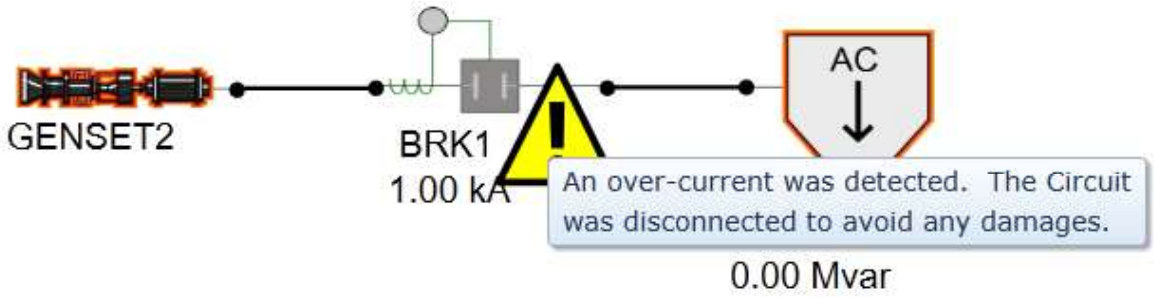


Figure 1 The current exceed the breaker's rating causing the breaker to open.

2 Analytical Methods

2.1 General Algorithms

This equipment is modeled as a ZIP load-flow model. This model provides a 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

Switch State

This attribute defines whether the breaker is open or closed. This attribute can be manually changed by selecting the attribute out of the properties tab or it can be edited by using the double clicking special action.

Rated Continuous Current

The breaker prevents an overcurrent from damaging the components of the circuit. If the current through the breaker is greater than the rated continuous current then the breaker will “pop” or turn offline.

Use Script

Enables an interface window that can be used to define mode transitions in the system. When true, the interface window can be accessed using the double click event.

3.1.2 Port Attributes

Current Type [AC or DC]

This attribute specifies the type of current at a specific electrical port. The user will be warned if the attempt to connect the breaker to equipment that requires a different current type.

Rated Frequency [Hz]

This attribute specifies the frequency of the electrical port. Typically, this will be 60Hz for an AC current type.

Rated Voltage [kV]

This attribute specifies the voltage produced or required at the electrical port.

4 User Guidelines

4.1 Test Cases

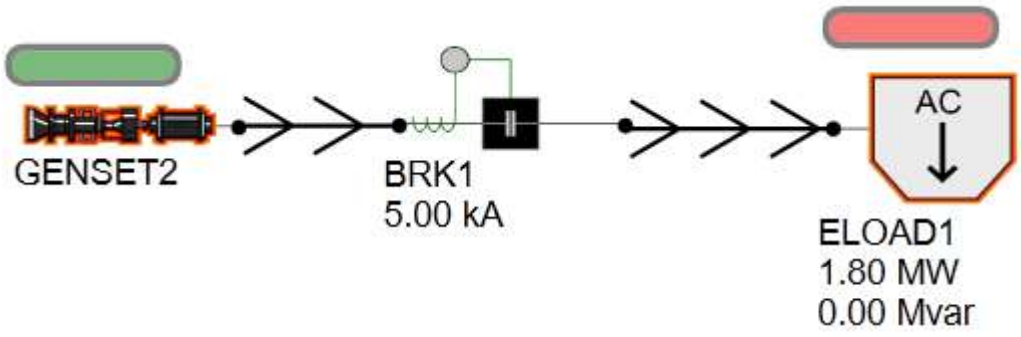


Figure 2 Breaker transferring power to an AC load from a genset

Appendix A: Abbreviations and Acronyms

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