Breaker VTB Model

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Model name: Breaker

DLL name: Breaker.DLL

Version number: 1.0

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Pictorial Representation of Model

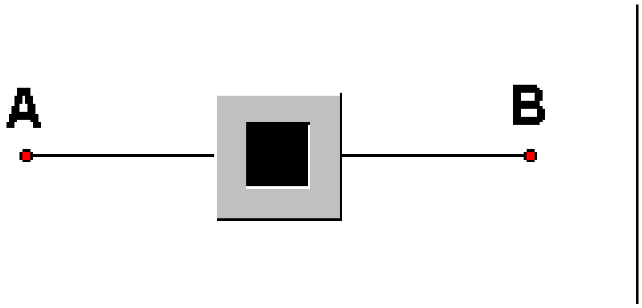

Figure 1

Brief Description of Model

The breaker is modeled as a device with three possible states:

- ***Closed***
- ***Arcing***
- ***Open***

The breaker is always initialized in the ***closed*** state. In this state, it behaves as an ideal resistor of a user specified value.

The breaker state changes from ***closed*** to ***arcing***, when the RMS current through it exceeds its current rating. The RMS current is evaluated as the average of the square of the breaker current over a user specified time interval.

While in the ***arcing*** state, the breaker is modeled as a constant voltage source. The voltage magnitude is user specified (arcing voltage parameter). The polarity of the voltage is the same as the current flow direction.

The breaker finally switches from ***arcing*** to ***open*** state, when the current falls below the extinction current.

While in the ***open*** state, the breaker is modeled as an ideal resistor (Off-Conductance).

Model Validity Range and Limitations

Rated current, trip time, arc-voltage, and on-conductance values must be positive. Off-Conductance can be zero or positive.

List of Model Parameters

Name	Description	Default Value	Units
Rated Current	The breaker current rating	10	Amperes
Trip Time	The time required for tripping the breaker at rated current.	0.5	seconds
On-Conductance	The conductance of the breaker while in the closed state	100	Mhos
Off-Conductance	The conductance of the breaker while in the open state	10^{-5}	Mhos
Arc Voltage	The voltage across the breaker while in the arcing state	100	Volts

List of Accessible Internal Variables

Name	Description	Units
Voltage	Voltage across device. Polarity is V_A-V_B.	Volts
Inst-Current	Instantaneous current through device. Positive flow is from node A to node B.	Amperes
RMS-Current	RMS current through device. Positive flow is from node A to node B.	Amperes
Breaker-State	0, 1, or 2 for ***closed***, ***arcing,*** and ***open*** states respectively.	N/A

Assumptions in Model Derivation

See model description.

Mathematical Description of Model

While in the closed state, the breaker is represented by an ideal resistor (of on-conductance value). In order to determine when the breaker must be tripped, the RMS current is continuously computed over a sliding time window as follows:

$$i_{RMS}(t) = \frac{1}{T}\int_{t-T}^{t} i^2(\tau)\,d\tau$$

where: T is the ***Trip-Time*** parameter

In order to achieve high computational efficiency, the integral is computed using a recurrence formula:

$$i_{RMS}(t) = \frac{1}{N}\left(N \cdot i_{RMS}(t - \Delta t) + i^2(t) - i^2(t - T)\right)$$

where N = T/Δt

When the i_{RMS} value exceeds the ***Rated-Current*** parameter, the breaker switches to the arcing state. While in this state, the breaker is modeled by a time varying resistor of value:

$$R = \frac{V_a}{i(t)}$$

where V_a is the ***Arc-Voltage*** parameter.

and ***i(t)*** is the current through the device.

Note that while in the arcing state the model is non-linear.

The breaker switches to the open state when the current falls below the extinction current. The extinction current is defined as one thousandth of the current at the instant the breaker trips.

Example of Model Use

N/A

Model Validation

Model was validated by comparing VTB results to analytic solutions.