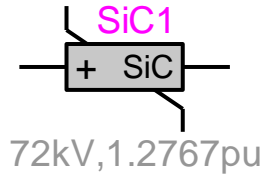


SiC arrester device



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1 Available versions

This device accepts both 1-phase and 3-phase signals. The 3-phase version is the equivalent of 3 decoupled branches (one for each phase). The only difference is that in the 3-phase version it is allowed to request scope data for the extra phases.

1.1 When changing phases

It is allowed to switch from 1-phase to 3-phase or from 3-phase to 1-phase. The user must only verify the scope requests according to requirements.

2 Description

Active gap surge arresters for HV systems are fairly complex to model. Dynamic mathematical models of these devices have been developed in the past but have been difficult to use, suffering complex data acquisition problems. The model shown here is simple, with adjustable parameters that can be used to represent any active gap arrester, consisting of an active gap unit attached to a nonlinear SiC (silicon-carbide) resistor (Figure 1 below) having the equation:

$$v = Ri^q \quad (1)$$

The arrester shown in Figure 1 has voltage dividing impedances Z_k , active spark gaps S_1 and a magnetic blowout coil L with protective shunt PE.

To remain general, specific nonlinear v - i characteristics can be approximated by an arbitrary number of segments, each with its own R and q values.

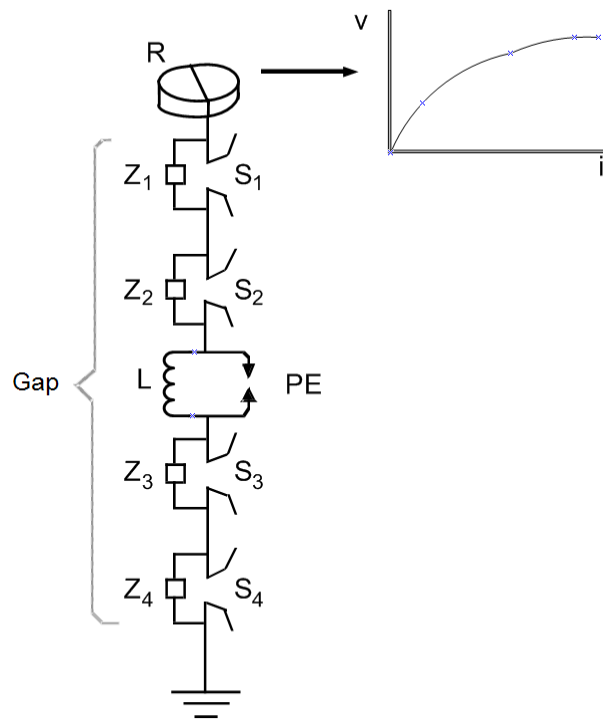


Figure 1 A typical active gap arrester circuit

The active gap voltage is modelled using three parameters:

- a time delay t_{delay} to represent the period during which the blowout coils are shunted
- a capacitance C_{gap} to simulate gap voltage buildup
- a peak gap voltage V_{maxgap} related to the gap geometry

2.1 Parameters and Rules

The Data tab allows entering all required parameters to model the SiC arrester:

- V_{ref} The reference voltage of the arrester, must be greater than 0. Used for converting the pu values and internal scaling the nonlinear segment equations.
- V_{flash} Gap flashover voltage, based on V_{ref} when pu are used.
- t_{delay} Time delay before the active gap voltage starts to build up after flashover. Note that during sparkover the blowout coils are shunted to reduce the arrester impedance and protect the low insulation level of the coil, so t_{delay} must be greater than 0.
- C_{gap} is the equivalent capacitance used to model the active gap.
- V_{maxgap} is the peak active gap voltage, based on V_{ref} when pu are used.
- I_{margin} is the current margin to specify gap extinction before current zero crossing.
- **Exponential segments** used for specifying the arrester nonlinear characteristic. The characteristic is monotonically increasing. Only the positive half must be entered since the characteristic is symmetrical. At least one segment must be defined. Each segment is defined through the parameters of equation (1):
 - R coefficient
 - Exponent (q)

- V_{min} (pu) is the minimum voltage defining a segment's lower voltage boundary. This value must be greater than 0 for the first segment. A linear segment is used to connect the first segment to the origin.

The default number of data rows for the exponential segments is 50, but the user can increase this size by selecting a row (click on the row number) and hitting the key "Insert". Blank rows (empty rows) will be automatically eliminated at the following opening of device data forms. It is not allowed to delete any pins.

3 Netlist format

The Netlist format is illustrated using an example:

```
SiC;SiC1;2;2;s18,s19,
72kVRMS,1.2767pu,25us,8.5uF,.6875pu,0,
1e-06,15,5,1,?v,?i,?p,>v,>i,>p,>e,
9780 0.3 0.5
```

Field	Description
SiC	Part name
SiC1	Instance name, any name.
2	Total number of pins
2	Number of pins given in this data section
S18	Signal name connected to k-pin, any name
S19	Signal name connected to m-pin, any name
V_{ref}	See Parameters above
V_{flash}	See Parameters above
t_{delay}	See Parameters above
C_{gap}	See Parameters above
V_{maxgap}	See Parameters above
I_{margin}	See Parameters above
tolerance	Convergence tab data relative tolerance
Panic	Convergence tab data Panic iterations
Max tolerance factor	Convergence tab data Max tolerance factor
Use guess correction	Convergence tab data guess correction method selection when 1
?v, ?i, ?p	Optional scopes
>v, >i, >p, >e,	Optional observable variable requests
Characteristic	3 values per row, blank character separator

In the 3-phase case EMTWorks automatically appends the phase characters to device names and signal names and creates 3 separate devices sharing the same data. The extra phase lines are used to carry scope and observe requests in addition to connectivity.

The comma separated data fields are saved into ParamsA, ParamsB and ParamsC attributes of this device. The characteristic segments are saved into the ModelData attribute.

4 Steady-state model

The arrester is an open-circuit in the steady-state solution.

5 Frequency Scan model

The arrester is an open-circuit at all frequencies.

6 Time domain representation

In the time-domain solution this device is a nonlinear function. It is solved through the iterative process of EMTP until convergence according to the relative tolerance option given in the Convergence data tab. A true simultaneous solution with network equations is achieved.

7 Example

The test circuit of Figure 2 is used to flashover the active gap arrester and observe its follow current. A capacitance precharged to 150 kV is used to flashover the 72 kV (rms) arrester. The arrester has a flashover voltage of 145 kV (peak) and its nominal voltage is used as V_{ref} . The nonlinear resistor has a single exponential segment: $v = 9300 i^{0.3}$. For 72 kV arresters typical coefficient R values range from 9300 to 12000 and the value of q may vary from 0.15 to 0.3. The remaining parameters are:

- $t_{delay} = 25\mu s$, possible range is 25 - 250 μs
- $C_{gap} = 8.5\mu F$, possible range is 5 - 12 μF
- $V_{max\ gap} = 70kV$, possible range is 40 - 70kV

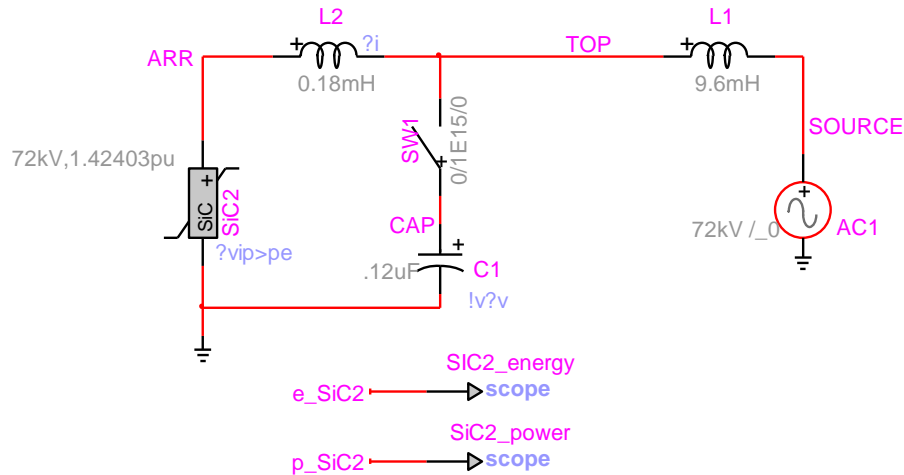


Figure 2 SiC arrester example ([sic90.ecf](#))

The arrester current after sparkover and the follow current waveform is shown in Figure 3. The energy calculation is made available through the observable signal e_SiC2.

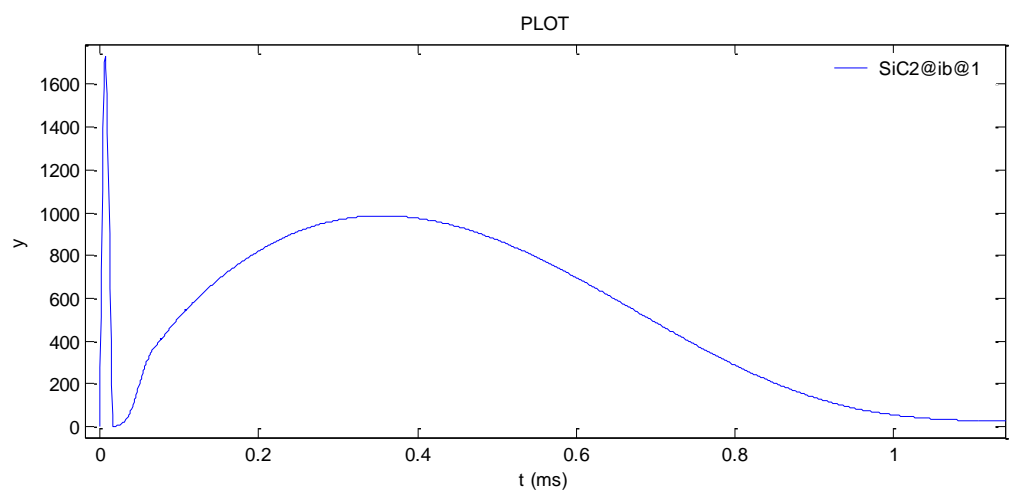


Figure 3 Arrester current