PHASE TO PHASE

Protection calculations in Vision

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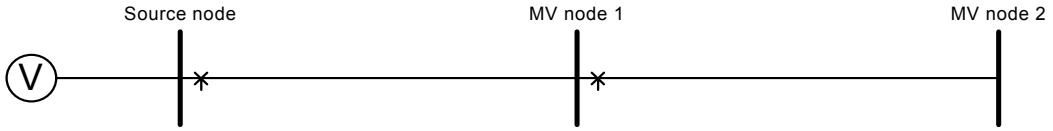
1 INTRODUCTION

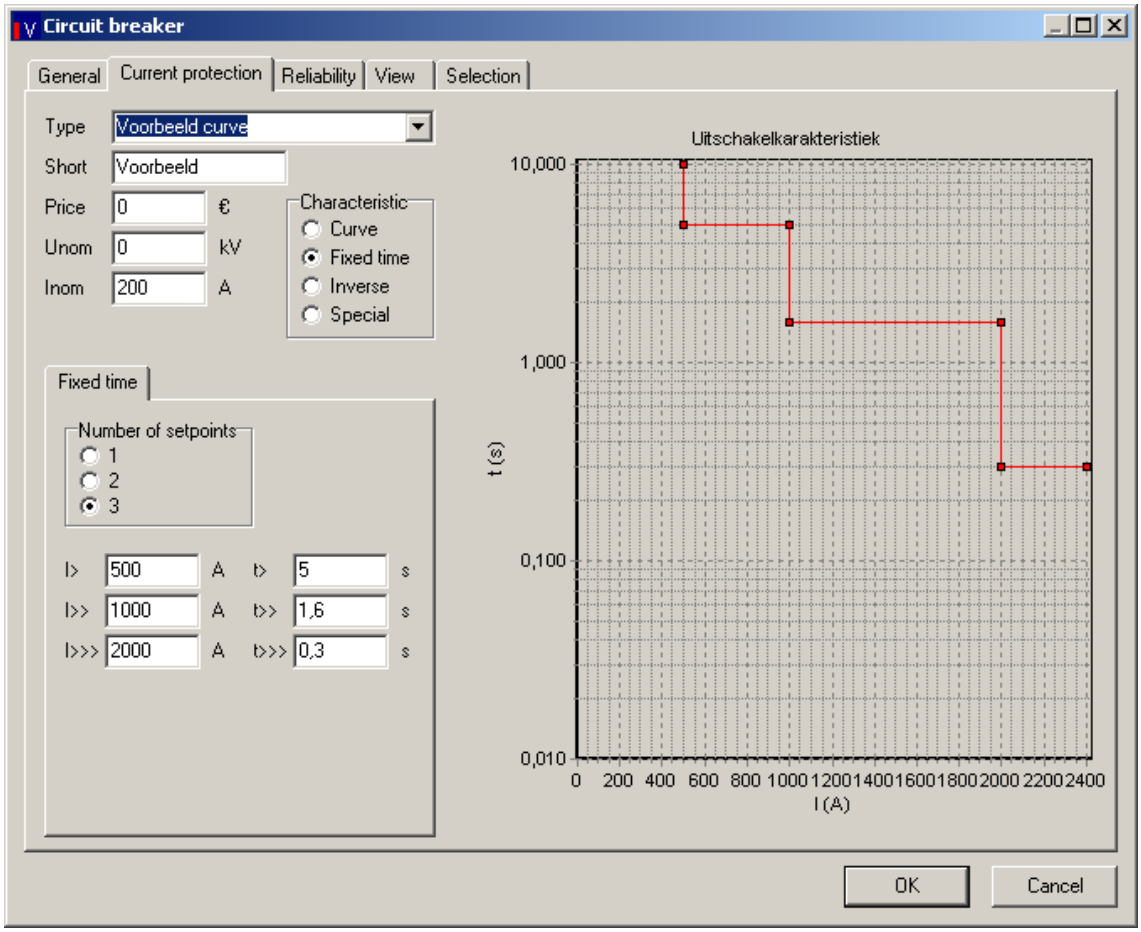
The protection system can be analysed using the simulation or the selectivity calculation in Vision. Vision has two types of protection calculations: Simulation and Selectivity. The simulation analysis gives detailed information about the events after the occurrence of a fault. The selectivity analysis gives a quick insight about the selectivity of all the protection equipment protecting a specific area.

The protection analysis is the examination of type and parameter specifications. Vision itself does not propose any setting, but checks the thermal load of branches and the protection selectivity. For this Vision automatically creates short circuits on user specified nodes and branches, by using the fault analysis method. The calculations may be verified in detail by executing a fault analysis study.

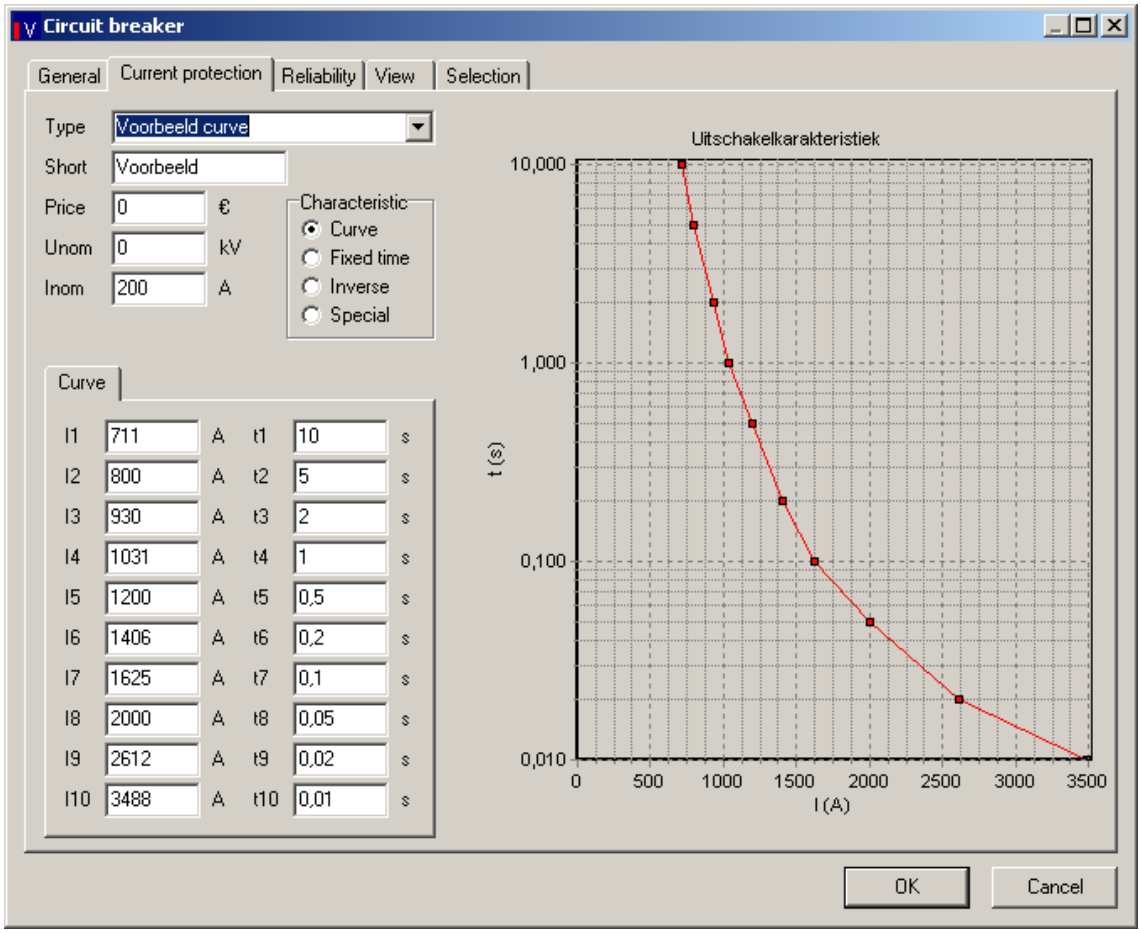
In this document the two types of calculations are illustrated by the simplified network below.



The demonstration network has a nominal voltage of 10 kV and it contains two circuit breakers. Both cables are 2000 m of 3x95 mm^2 Al. The first circuit breaker (Source CB) at the Source node has a fixed time current protection with the next settings:



The second circuit breaker (CB 1) has a curve defined current protection with the next settings:



The circuit breaker switching time is 0.020 s.

2 SIMULATION

The protection simulation calculation consists of a switching-off sequence of all relevant circuit breakers or fuses due to faults in the network. The circuit breakers may be equipped with a protection device. The user defines the fault location, the fault type (asymmetrical or symmetrical) and the fault impedance.

The protection simulation calculation evaluates the whole switching process for a specified fault. Executing a simulation analysis the next steps are carried out by Vision:

- a specified fault is created on a selected node or branch
- all network currents are calculated during that fault
- all protection switch off times are determined
- the first tripping protection opens the switch
- the network currents and voltages are calculated again
- if necessary and available the next switch opens according to the protection scheme
- the process is repeated until no protection devices trip.

This analysis is input by the user as follows:

- select the nodes for which the protection has to be evaluated
- choose **Calculation | Protection**
- choose calculation type: **Simulation**
- choose fault type (asymmetrical or symmetrical)
- specify fault impedance Zpp
- leave the form with OK.

For short circuits on each selected node the protective actions can be examined. The next table shows the result for a symmetrical short circuit on node “MV node 2” in the demonstration network.

```
Switch off sequence after symmetrical fault at node MV node 2 with Zpp=0+j0 Ohm

Ik"a  Ik"b  Ik"c  protection  name   trigger(s)                      sig        T sch
  kA    kA    kA                                                               s
----  ----  ----  ----------  -----  ------------------------------- --- -------- ---
2,96  2,96  2,96  current     CB 1   Ia=2961 A; Ib=2961 A; Ic=2961 A  abc    0,035 abc
0,00  0,00  0,00
```

This shows that the short circuit current equals 2.96 kA. The fault is switched off at 0.035 s, which is equal to a 0.015 s tripping time plus a 0.020 s circuit breaker switching time.

3 SELECTIVITY

The protection selectivity calculation evaluates the switching times for all protection devices in the network for a specified fault location. At the defined fault location a number of fault resistances, varying from 0 to 10000 Ohm (to be chosen at **Tools|Options|Calculation|Protection**) are simulated. For each fault resistance all protection devices switching times are calculated. Only the first times are calculated. The fault is not being switched off. The difference with the simulation is that the whole fault isolating sequence is not evaluated. As a result in the demonstration network the switching times for the second circuit breaker are calculated and the switching times for the first circuit breaker as if the second circuit breaker was not installed. In radial networks this is a valid assumption, but for meshed networks in a following version the whole protection scheme will be evaluated in order to determine the selectivity.

Executing a selectivity analysis the next steps are carried out:

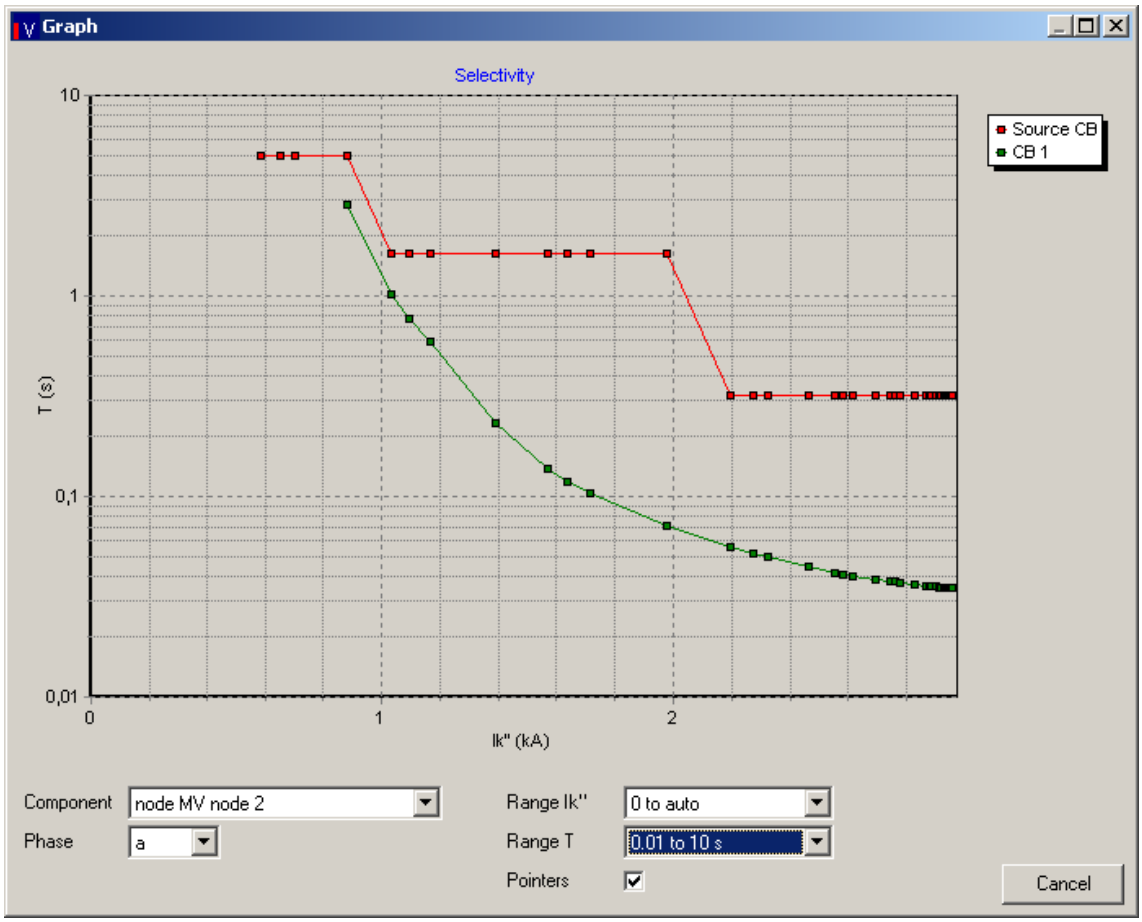
- for a specified fault type several faults each having a different fault resistance are created on the selected nodes
- for each fault all network currents and voltages are calculated
- for all protection devices all switch off times are calculated and saved
- the tripped switches are not opened

Result are fault current vs. time curves generated using various fault resistances. Presented in a graph, these curves provide insight in the protection selectivity.

The selectivity analysis is input by the user as follows:

- select the nodes for which the protection has to be evaluated
- choose Calculation | Protection
- choose calculation type: Selectivity
- choose fault type
- leave the form with OK.

The next graph shows the result for a symmetrical short circuit selectivity analysis on node "MV node 2" in the demonstration network.



It can be seen that for all short circuits on node "MV node 2" with fault resistance varying from 0 Ohm to 10000 Ohm, the second circuit breaker "CB 1" tripped first (green curve). If CB 1 does not trip, the first circuit breaker "Source CB" will trip according to the red curve.

In Vision the protection is defined selective if the largest switching time of the protection devices directly protecting the group of faulted components is smaller than the smallest switching time of all other protection devices in the network. In the demonstration network “CB 1” is directly protecting node “MV node 2” and according to the graph above for each single fault its switching time is smaller than that of “Source CB”. If for all faults the difference is larger than the “Graduated time” the protection is called selective.

The next table (from: **Results|Details|Details**) shows the switching times for one of the fault resistances. It shows that for an resistance of 12 Ohm the second circuit breaker “CB 1” switches off at t=1.013 s and that the first circuit breaker “Source CB” switches off at 1.620 s (if CB 1 does not trip). The difference of these two times is approximately 0.6 s. It depends on the “Graduated time” user setting at **Tools|Options|Calculation|Protection** if the protection is selective or not. If the smallest difference between the two curves is larger than the “Graduated time” the protection will be selective.

Rff=12 Ohm
Ik"a= 1,03 kA
Ik"b= 1,03 kA
Ik"c= 1,03 kA

protection	name	Ta s	Tb s	Tc s
current	Source CB	1,620	1,620	1,620
current	CB 1	1,013	1,013	1,013