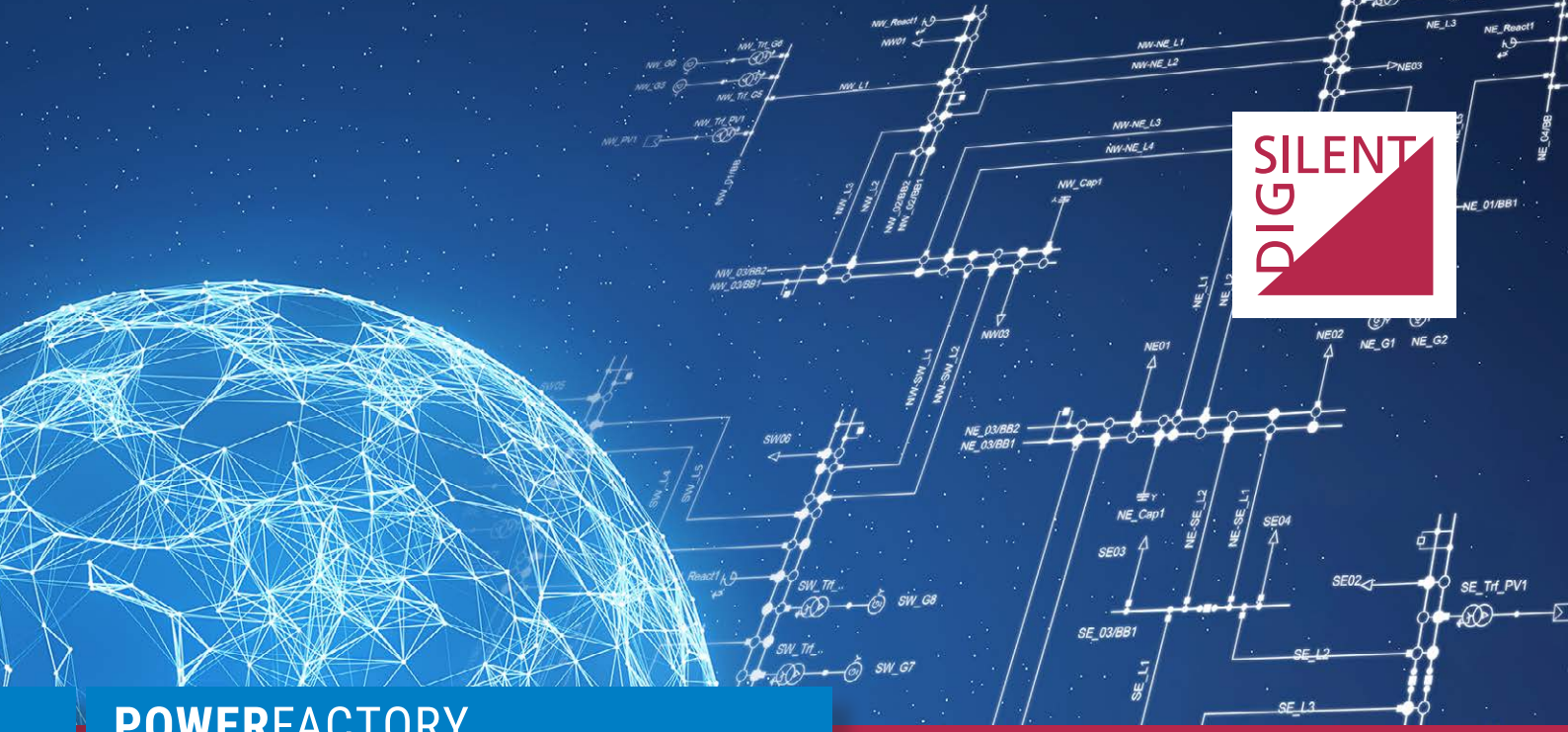

POWERFACTORY

PowerFactory 2021

Technical Reference

I-t Characteristic

TypChatoc

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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Contents

1 General Description

The “TCC” object (*TypChatoc* class) implements the base features and hosts the base data used to draw a “Time Current Characteristic”(TCC). A TCC is any line that can be drawn in a diagram having the current values plotted along the X-axis and the time values plotted along the y-axis (VisOcplot object). The “TCC” object is used by the *TypToc* class.

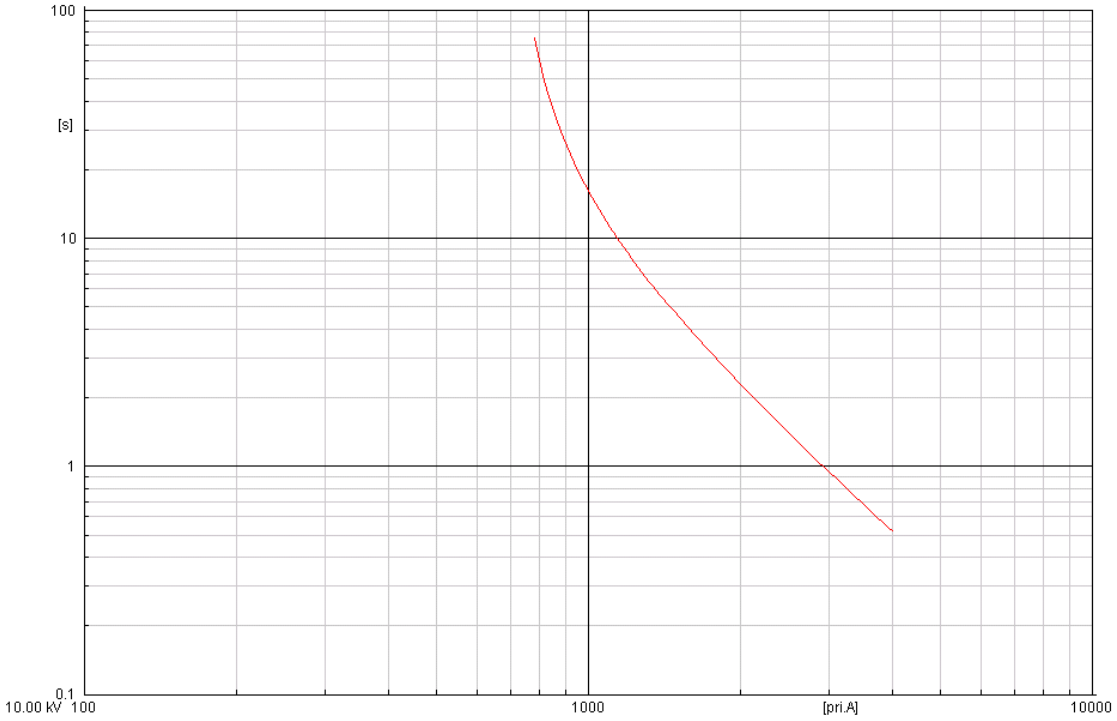


Figure 1.1: Time-Current diagram (a VisOCPlot object) with an extremely inverse TCC

The “TCC” object is defined by:

- The characteristic *Usage* (Time Overcurrent, Fuse, Damage Curve, Min Trip/Max Clear Time Overcurrent).
- The characteristic *Time dial* range. The *Plot curves* button allows drawing the TCCs accordingly with the inserted *Time dial* range. The *Time dial* control is not available when the *Fuse* or the *Damage Usage* is set. This range is used to define the *Time dial* setting in the *Time overcurrent* dialogue (*RelToc* class).
- The characteristic *Reset delay* range. This range is used to define the *Reset delay* setting (*ResetT* variable) in the *Time overcurrent* dialogue (*RelToc* class). The *ResetT* variable can be used in a DSL expression to define the reset characteristic of an inverse element.
- The characteristic graphical limits; the dialogue allows defining:
  - A *User Defined Min. Time* range which is used to define the *Min. Time* setting in the *Time overcurrent* dialogue (*RelToc* class). This setting value is the smaller time which can be reached by the TCC.
  - A *User Defined Max. Time* range which is used to define the *Max. Time* setting in the *Time overcurrent* dialogue (*RelToc* class). This setting value is the bigger time which can be reached by the TCC.

- A *Min Current* (in terms of trip threshold Ip). It is not available when the *Linear approximation* or the *Hermite polynom Function* is set.
- A *Max. Current* (in terms of trip threshold Ip). It is not available when the *Linear approximation* or the *Hermite polynom Function* is set.
- A *Min Tripping Time* (in seconds). If the characteristic calculated time value is smaller than the *minimum tripping time* the time value used to represent the characteristic is set equal to the *minimum tripping time*.

- the type of function used to describe the characteristic (Definite time , IEC 255-3 equation, ANSI/IEEE, Linear approximation etc, Hermite Polynom)
- The data defining the characteristic:
  - The time current points if the *linear approximation* or the *Hermite Polynom* function is selected(i_type variable).
  - The equation parameter values if the *Definite time*, *IEC 255-3*,*ANSI/IEEE*,*ANSI/IEEE squared*, *ABB/Westinghouse*, *Special equation* , *I sqrt T(based on Ir)* , *I sqrt T(based on In)*, *I sqrt T(based on Ip)* function is selected.
  - The user defined DSL equation string if *DSL -Equation* function is selected (i_type variable).
- The ability to define if the characteristic is including a vertical line in the initial part (i_drawt variable).
- When the *linear approximation* or the *Hermite Polynom* function is selected(i_type variable) two additional dialogue controls are displayed:
  - The *No. Of curves* edit box specifies how many curves we are defining and how many columns are available in the data matrix
  - The *Use Same x-Value* specifies if the time current points defining more than one TCC are sharing the same current

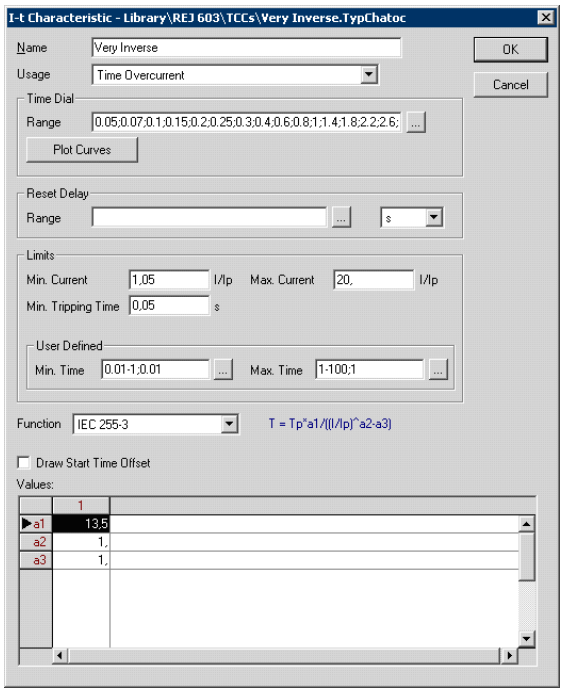


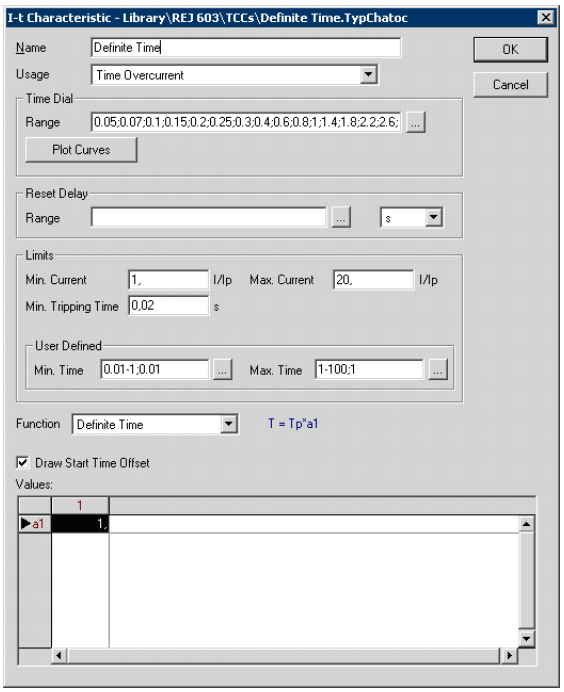
Figure 1.2: The *TypChatoc* dialogue when the *IEC 255-3* Function is selected

2 Available “Function” types

The “Function” combo box allows selecting how the *TypChatoc* object is modelling the TCC. 12 items are available:

1. Definite time
2. IEC 255-3
3. ANSI/IEEE
4. ANSI/IEEE squared
5. ABB/Westinghouse
6. linear approximation
7. Hermite Polynom
8. DSL- equation
9. Special equation
10. I sqrt T(based on Ir)
11. I sqrt T(based on In)
12. I sqrt T(based on Ip)

2.1 Definite time



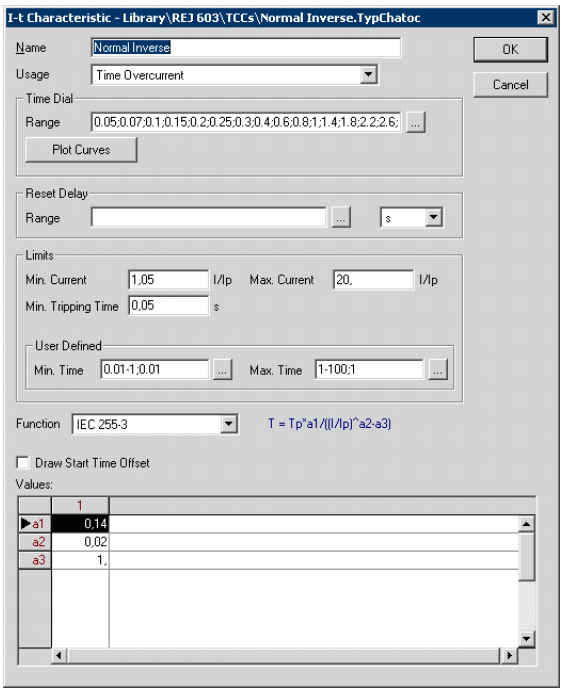
It defines a time constant TCC

Equation: $T = Tp \times a1$

Where:

T = characteristic time value
I = characteristic current value
Tp = *Time dial* in the relevant RelToc dialog
a1 = the value inserted in the first row first column of the *Values* matrix

2.2 IEC 255-3



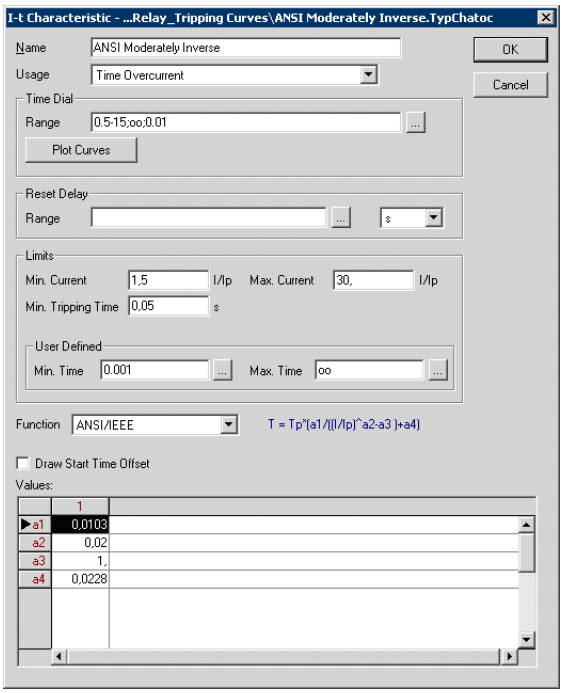
It defines a TCC acccordingly with the IEC 255-3 standard

Equation: $T = Tp \times a1/((I/Ip)^{a2} - a3)$

Where:

T = characteristic time value
I = characteristic current value
Ip = characteristic trip threshold
Tp = *Time dial* in the relevant RelToc dialog
a1 = the value inserted in the first row first column of the *Values* matrix
a2 = the value inserted in the 2nd row first column of the *Values* matrix
a3 = the value inserted in the 3rd row first column of the *Values* matrix

2.3 ANSI/IEEE

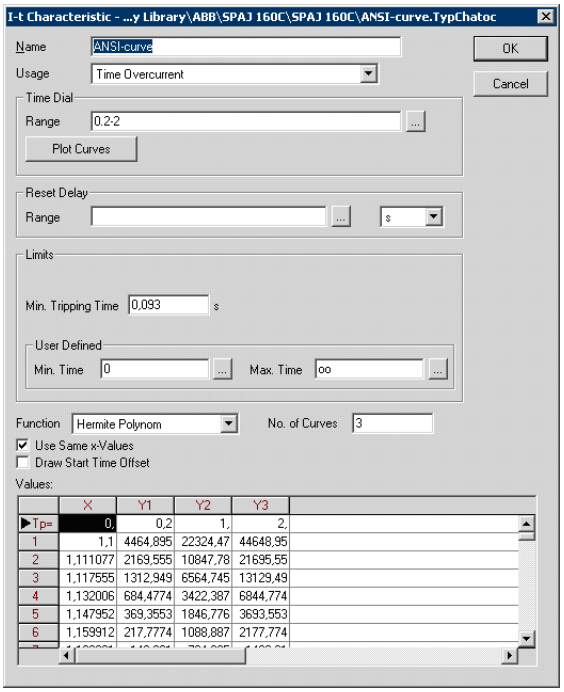


It defines an equation accordingly with the US standards. This equation is an “extension” of the IEC equation. Equation: $T = Tp \times (a1/((I/Ip)^{a2} - a3) + a4)$

Where:

T = characteristic time value
I = characteristic current value
Ip = characteristic trip threshold
Tp = *Time dial* in the relevant RelToc dialog
a1 = the value inserted in the first row first column of the *Values* matrix
a2 = the value inserted in the 2nd row first column of the *Values* matrix
a3 = the value inserted in the 3rd row first column of the *Values* matrix
a4 = the value inserted in the 4th row first column of the *Values* matrix

2.4 ANSI/IEEE squared

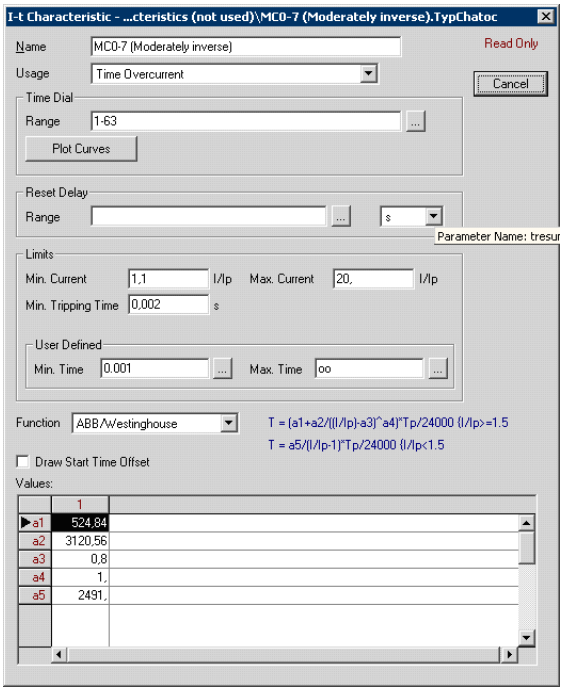


Equation: $T = (Tp \times a1 + a2)/(I/Ip)^2$

Where:

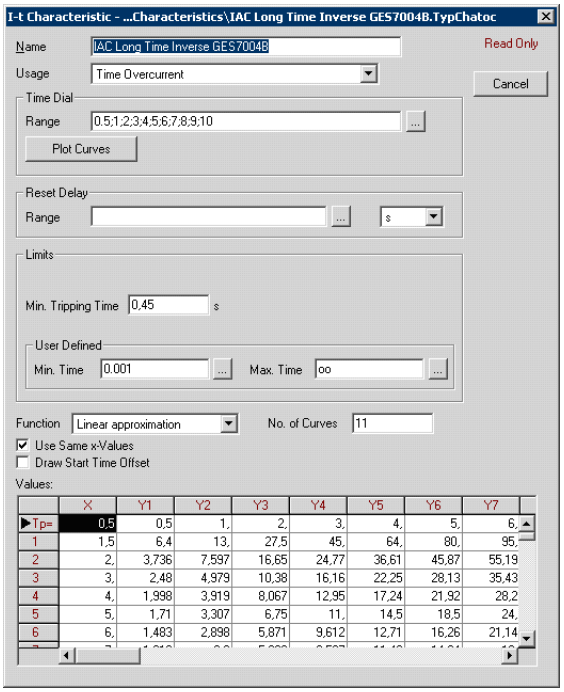
T = characteristic time value
I = characteristic current value
Ip = characteristic trip threshold
Tp = *Time dial* in the relevant RelToc dialog
a1 = the value inserted in the first row first column of the *Values* matrix
a2 = the value inserted in the 2nd row first column of the *Values* matrix

2.5 ABB/WEstinghouse



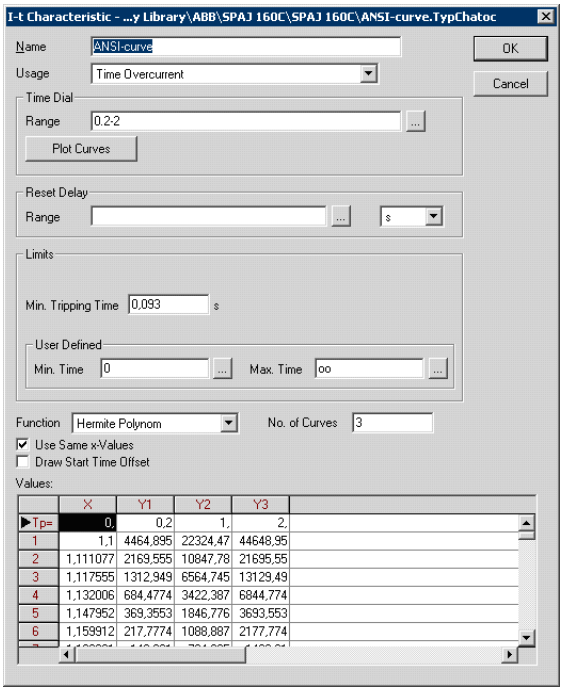
Equation:
$I/Ip < 1.5$
$T = a5 \times Tp/(24000 \times (I/Ip - 1))$
$I/Ip > 1.5$
$T = (a1 + a2/((I/Ip) - a3)^{a4}) \times Tp/24000$
Where:
T = characteristic time value
I = characteristic current value
Ip = characteristic trip threshold Tp = *Time dial* in the relevant RelToc dialog
a1 = the value inserted in the first row first column of the *Values* matrix
a2 = the value inserted in the 2nd row first column of the *Values* matrix
a3 = the value inserted in the 3rd row first column of the *Values* matrix
a4 = the value inserted in the 4th row first column of the *Values* matrix
a5 = the value inserted in the 5th row first column of the *Values* matrix

2.6 Linear approximation



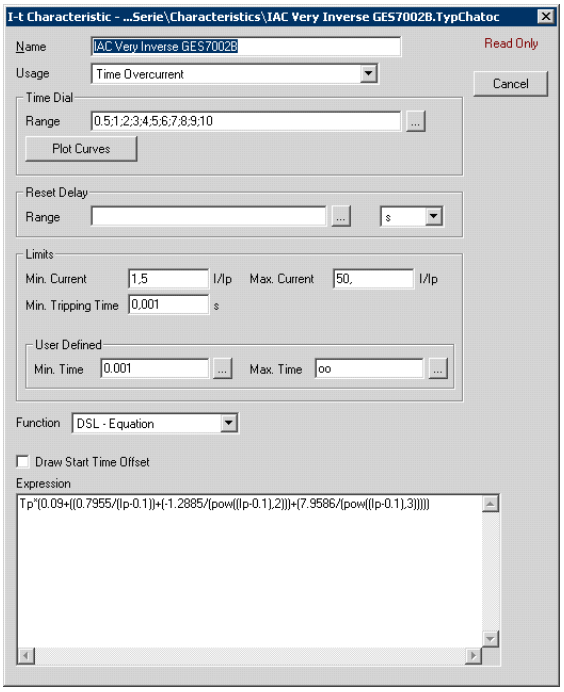
The characteristic is defined by points using a linear approximation between the sets of input points.
The number present in the *No. of Curves* represents how many set of points are defined. In the picture on the right there are 3 set of points defined for “0.2”, “1” and “2” time dial (the time dials are listed in the first row 2nd ,3rd and 4th column). In the 1st column the current values are listed. The 1st column, 1st row cell contains a dummy value (0 in the picture). To draw for instance the characteristic for time dial equal = 0.5 the time dial = 0.2 and the time dial = 1 point sets will be interpolated. Please notice that the *Use Same x-Values* check box is on and so the matrix first column contain a set of current values which is common to all the time value sets present in the “Y1”, “Y2” and “Y3” column.

2.7 Hermite Polynon



The characteristic is defined by points using a hermite approximation between the sets of input points.
The number present in the *No. of Curves* represents how many set of points are defined. In the picture on the right there are 3 set of points defined for “0.2”, “1” and “2” time dial (the time dials are listed in the first row 2^{nd} ,3^{rd} and 4^th column). In the 1^{st} , 3^{rd} and 5^{th} column the current values are listed.
The 1^{st} column, the 3^{rd} and 5^{th} row cells contain a dummy value (0 in the picture). To draw for instance the characteristic for time dial equal = 0.5 the time dial = 0.2 and the time dial = 1 point sets will be interpolated in a linear way. Please notice that the *Use Same x-Values* check box is off and so there is a column containing a set of current values for each column containing a set of time valued.

2.8 DSL equation



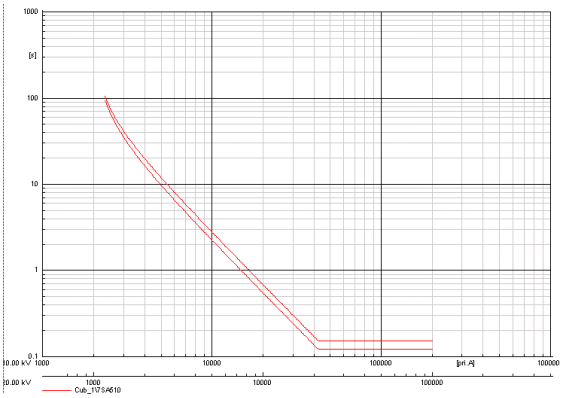
Equation: any valid DSL equation
Please notice that the equation must not include T or I (Ip represents already I/Ip)
Equation example:
$1 \times Tp/(0.339 - (0.236/Ip))$

Where the allowed variable names are:
Ip = *Current threshold* in the RelToc dialogue (*Ipset* variable)
Tp = *Time dial* in the RelToc dialogue (*Tpset* variable)
Ipre = Pre-fault current/Ip (for the thermal image)
Tshift = *time shift* in the RelToc dialogue (*Tshift* variable)
Minresp = *Min.response time* in the RelToc dialogue (*minresptime* variable)
Tadd = *Time adder* in the RelToc dialogue (*Tadder* variable)
ResetT = *Reset delay* in the RelToc dialogue (*ResetT* variable)
Udeftmin = *Min. Time* in the RelToc dialogue (*udeftmin* variable)
Udeftmax = *Max. Time* in the RelToc dialogue (*udeftmax* variable)

Please note that the *Time adder* and the *Min.response time* settings usually should not be inserted inside the DSL equation; indeed they are already automatically applied to the time value provided by the DSL equation calculation.

2.8.1 Thermal Image

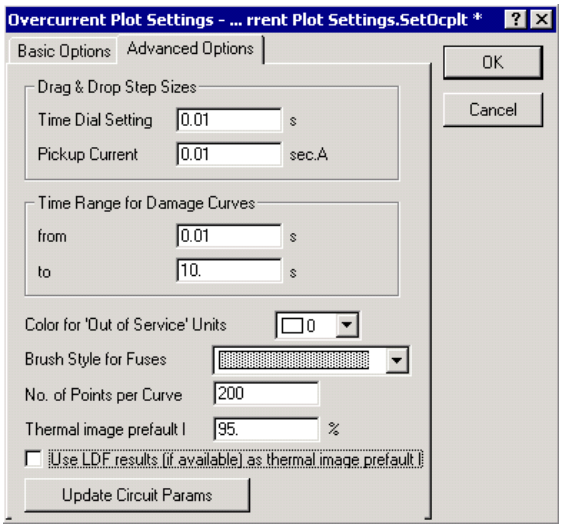
The thermal image can be modelled using a DSL equation where the “Ipre” variable represents the current flowing before the fault. The thermal image will be represented using two characteristics:



The *upper* characteristic is drawn assuming a null value of the pre-fault current.

The *lower* characteristic is drawn using a default current value or the pre-fault current calculated by the LDF. When a short circuit calculation is run the trip time is calculated using such characteristic.

The thermal image representation can be “controlled” using the SetOcPlot dialogue.

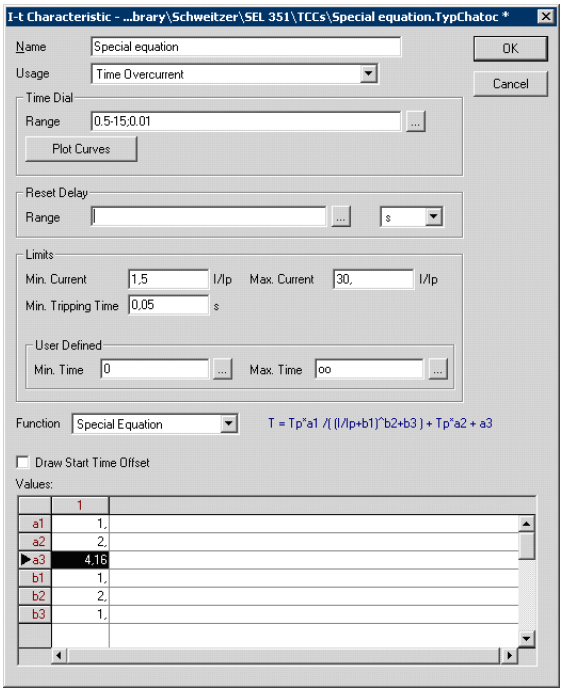


In the *Advanced options* tab page you can find the *Thermal image prefault I* % which allows setting a default value for the pre-fault current value which is used to draw the *lower* thermal image characteristic. The *upper* characteristic is always drawn assuming a null value of the pre-fault current.

The *use LDF results(if available)as thermal image pre-fault I* check box allows setting which kind of value must be used to draw the thermal image characteristic.

If it is checked and the LDF has been run the “lower” thermal image characteristic is drawn using the LDF current as pre-fault current. If it is not checked or if the LDF hasn’t been run yet the *Thermal image prefault I* % value is used as pre-fault current value.

2.9 Special equation

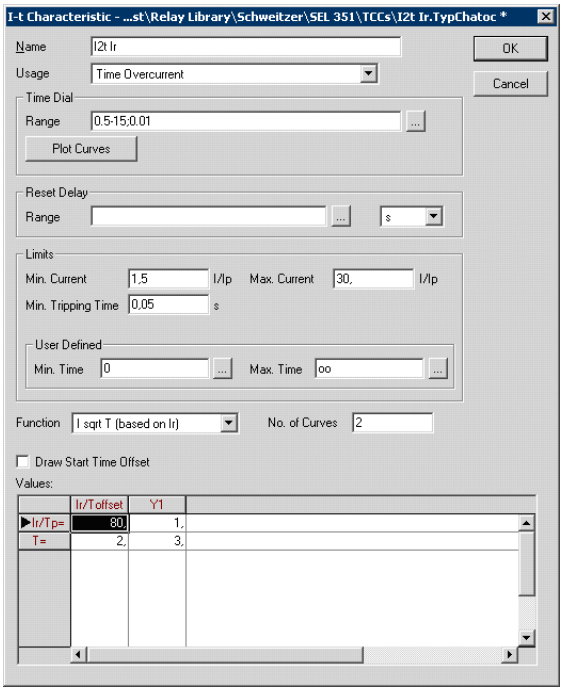


Equation:
$T = Tp \times a1/((I/Ip + b1)^{b2} + b3) + Tp \times a2 + a3$

Where:

T = characteristic time value
I = characteristic current value
Ip = characteristic trip threshold
Tp = *Time dial* in the relevant RelToc dialog
a1 = the value inserted in the first row first column of the *Values* matrix
a2 = the value inserted in the 2nd row first column of the *Values* matrix
a3 = the value inserted in the 3rd row first column of the *Values* matrix
b1 = the value inserted in the 4th row first column of the *Values* matrix
b2 = the value inserted in the 5th row first column of the *Values* matrix
b3 = the value inserted in the 6th row first column of the *Values* matrix

2.10 I sqrt T(based on Ir) I sqrt T(based on In)



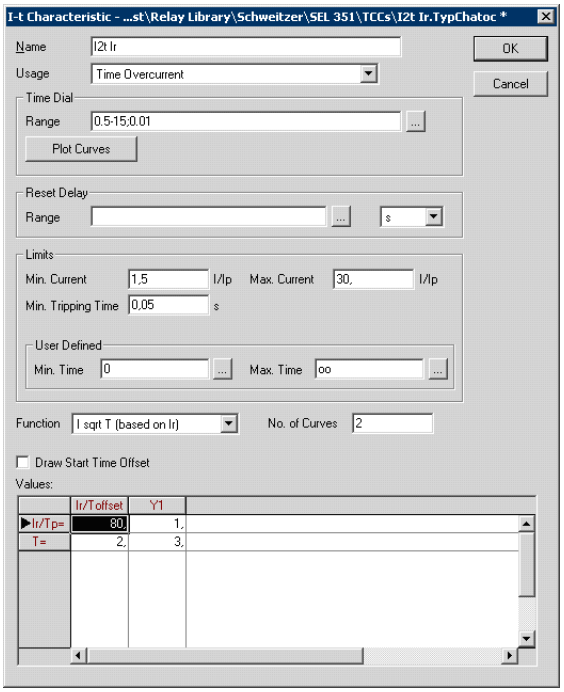
Equation:
$T = (TS + a3) \times a1^2/(I^2)$

Where:

TS = $Tp \times a2$
T = characteristic time value
I = characteristic current value
Ip = characteristic trip threshold in pu
Tp = *Time dial* in the relevant RelToc dialog

a1 = the value inserted in the first row first column of the *Values* matrix(80 in the picture)
a2 = the value inserted in the 2nd row 2nd column of the *Values* matrix(3 in the picture)
a3 = the value inserted in the 2nd row 1st column of the *Values* matrix(2 in the picture)

2.11 I sqrt T(based on Ip)



Equation:

$$T = max((TS + a3), a1^2/Ip^2)$$

Where:

TS = $Tp \times a2$
T = characteristic time value
I = characteristic current value
Ip = characteristic trip threshold in pu
Tp = *Time dial* in the relevant RelToc dialog

a1 = the value inserted in the first row first column of the *Values* matrix(80 in the picture)
a2 = the value inserted in the 2nd row 2nd column of the *Values* matrix(3 in the picture)
a3 = the value inserted in the 2nd row 1st column of the *Values* matrix(2 in the picture)

3 Available “Usage”

The *Usage* combo box allows selecting which kind of TCC the object is modelling. 4 items are available:

1. Time Overcurrent
2. Fuse
3. Damage Curve
4. Min Trip/Max Clear Time Overcurrent

The *time overcurrent* item is the standard type used to represent a single trip characteristic of a relay. Any “Function” can be used when the *time overcurrent* item is set.

The “Fuse” item allows define together a *Min melt* and a *Max clear* TCC to model the fuse characteristic. Only the *Linear approximation*, *Hermite Polynom Function* can be used when the “Fuse” item is set. The *Values* matrix will display a *Min Melt (in s)* and a *Total Clear (in s)* column.

The *Damage* item allows defining the a TCC representing the damage characteristic of a motor, a transformer, a cable etc. . . Only the *Linear approximation*, *Hermite Polynom Function* can be used when the *Damage* item is set.

The *Min trip/Max clear Time overcurrent Usage* allows defining a protective device double characteristic: it can be used to model Low Voltage breaker or any other protective device which can be modelled with a characteristic representing the minimum time spent by the device to detect the fault and a characteristic representing the maximum time spent by the device to remove the fault conditions. Please notice that when the *Min trip/Max clear Time overcurrent* item is selected only the *Linear approximation*, *Hermite Polynom* and the *DSL equation* must be used. The format for the *DSL equation* must be

max (<max clear equation>∗maxclear, ¡min trip equation>)

where:

<max clear equation> is the DSL equation representing the maximum time spent by the device to remove the fault conditions

<min trip equation>> is the DSL equation representing the minimum time spent by the device to detect the fault

The DSL interpreter will set the *maxclear* variable equal to 1 when the *max clear* characteristic points will be calculated and equal to -1 when the *min trip* characteristic points will be calculated.

4 TypChatoc input parameters definition

Table 4.1: Parameter Definitions

Parameter	Description	Unit
loc_name	Name assigned by the user to the block type	Text
i_use	Characteristic usage (Time Overcurrent, Fuse, Damage Curve, Min Trip/Max Clear Time Overcurrent)	Integer
i_type	The type of function used to define the characteristic (Definite time , IEC 255-3 equation, ANSI/IEEE, Linear approximation etc, Hermite Polynom etc)	Integer
rTp	Time dial range	Text
rResetT	The reset delay range	Text
udeftmin	The user defined TCC minimum time range	Text
udeftmax	The user defined TCC maximum time range	Text
imin	Drawn characteristic minimum current value	Float
imax	Drawn characteristic maximum current value	Float
tmin	Drawn characteristic minimum time value	Float
i_multx	“Use the same current values” flag.	Integer
i_curves	Number of curves	Integer
i_drawt	“Draw start time offset” flag	Integer
vmat	The double precision point matrix storing the values defining a characteristic by points or the function parameter values	Matrix
expression	The DSL equation string	Text