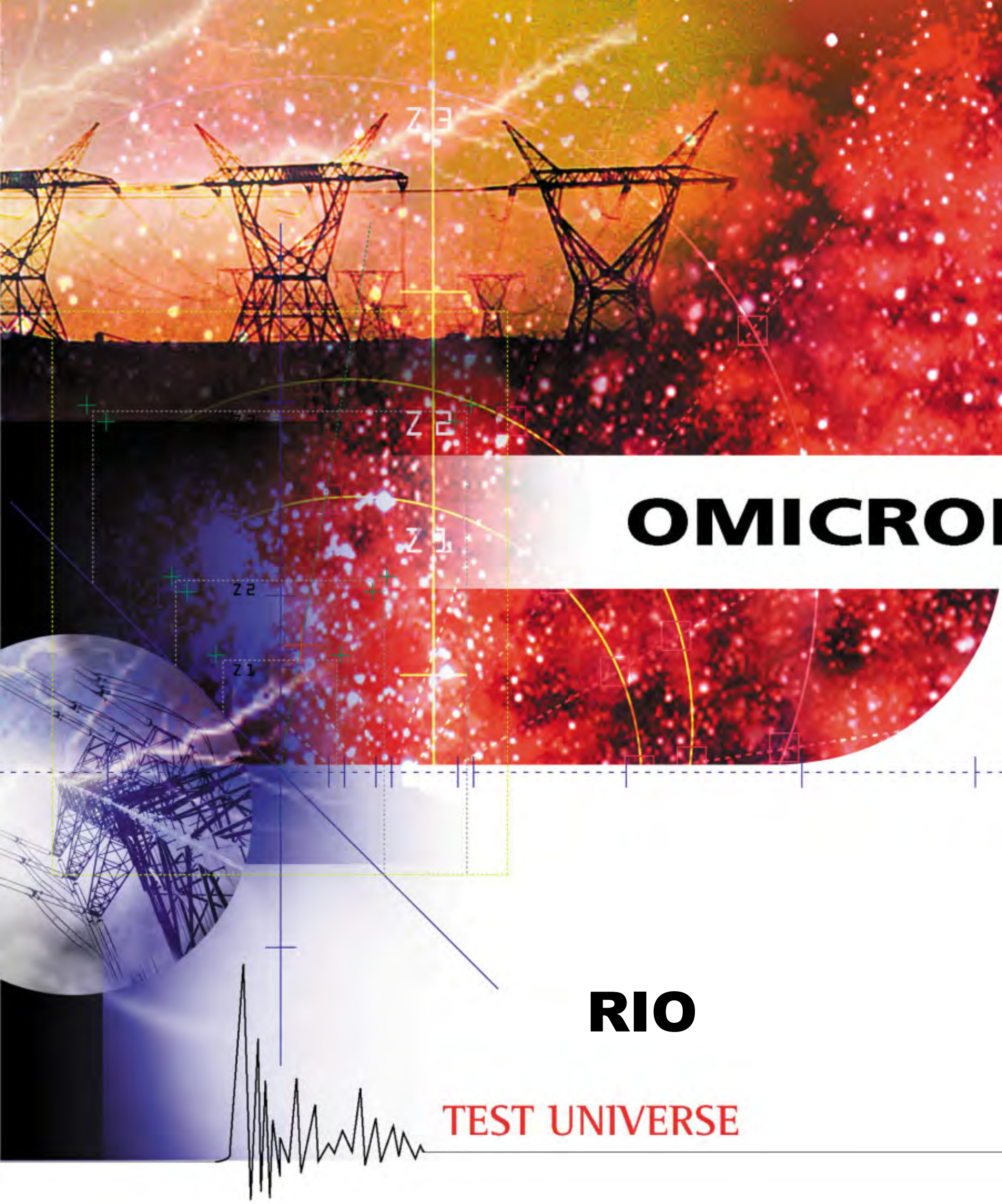


OMICRON

RIO

Reference Manual

TEST UNIVERSE

Article Number VESD5000 - Manual Version: RIO.AE.3

This Reference Manual is a publication of OMICRON electronics GmbH, Oberes Ried 1, 6833 Klaus, Austria.

Table of Contents

1 Introduction to RIO

The **R**elay **I**nterface by **O**MICRON (RIO) was developed out of a need for a uniform data format for the parameters and settings of protective relays produced by different manufacturers. RIO provides a common structure to allow functionally similar relays from diverse manufacturers to be tested with similar test procedures. Moreover, RIO permits relay settings and characteristics to be imported into the OMICRON Test Universe software from external sources.

Since RIO's inception, it has established itself as the quasi-standard for storing relay data. Various manufacturers of protective relays have adopted RIO for exporting relay data to support testing and, in some cases, configuration.

The RIO format is open and is not proprietary to a specific relay manufacturer or limited to a specific relay type. Moreover, RIO can be extended to handle future requirements for protective relay testing.

RIO files are ASCII text based. Hence, they can be read and modified by any text editor, or can be output from software programs. RIO uses a structure involving keywords, blocks, and nesting. Indentation aids in visualizing hierarchy and grouping of entries. Much of its notation has been carried over from modern programming languages, including the ability to add comments to make the RIO file readable and understandable.

2 Basic Elements of the RIO Format

The RIO format consists of:

- a nested block structure
- lexical elements
  - nested comments
  - floating point
  - integer
  - boolean and string constants
  - keywords

2.1 RIO Format Structure

RIO data is organized in a block structure. A block can aggregate rows and other blocks, called subblocks. If blocks are nested in other blocks, they can appear in any order but must adhere to the block hierarchy. Every block and row has a name which serves as a type of keyword.

The reasons for organizing the RIO data in a block structure include:

- The RIO format can be extended for a new function just by adding a new block describing the parameters for the test function.
- The **Om**icron **U**niversal **R**IO **P**arser (OMURP), which reads and writes RIO files, can easily be extended for new test functions.
- Blocks used in different test functions (e.g. characteristics) can be used multiple times.
- Blocks can be combined from other test functions to create new test object descriptions.

2.1.1 Blocks

Every RIO file must contain at least one TESTOBJECT block. Moreover, the TESTOBJECT block must contain a DEVICE block.

Multiple TESTOBJECT blocks are allowed at the outermost block-level. Outside the outermost blocks, no data may appear excepted comments.

A block can have a minimal and maximal cardinality. The minimum cardinality describes how often a block must appear when it is nested. The exception to this is the TESTOBJECT block which is “nested” in the RIO file.

In a similar manner, the maximum cardinality describes how often a block may appear. The maximum must be greater or equal to the minimum cardinality. Theoretically the maximum value for the maximum cardinality can be infinite. Additionally a block can be related to other blocks or rows.

For detailed informations about these relationships, refer to Section 2.1.3 "Dependencies" on page 13.

2.1.2 Rows

A block also may contain rows. Similar to blocks, every row has a minimum and maximum cardinality. Additionally a row can be related to other rows or blocks. For detailed informations about these relationships see Section 2.1.3 "Dependencies" on page 13.

Every row has a name and a set of values. The name serves as a keyword for that row. The set of values holds the data of that row. A value could be one of the following types:

- Integer
  - freely defined.[1]
  - defined within a range.[2]
  - defined within an enumeration.[3]
- Double
  - freely defined.[1]
  - defined within a range.[2]
  - defined within an enumeration.[3]
- Boolean
  - Possible values are TRUE or FALSE, or
  - YES or NO.
- String
  - freely defined. Any kind of string is allowed.
  - defined within an enumeration.[3]

---

[1] Means the value is not restricted in any way. Theoretically it can have a range of $-\infty \ldots +\infty$.

[2] The value range is bounded by a minimum and a maximum. The bounds are included.

[3] The allowed values are provided in an enumeration list.

For some value data, a default value may be defined. The parser uses the default value if no value was set.

A value can be made optional. In such cases, if the value is missing, the parser does not produce an error message and does not use the default value while reading a RIO file.

2.1.3 Dependencies

Blocks and rows can be depended on each other in logical relationships such as OR, AND, or XOR.

If blocks and rows are in an AND relationship, all of them must exist in the RIO file at least once. In an OR relationship, one of them must exist. In an XOR relationship, only one of them can exist in the RIO file.

- If row X and row Y are in an AND relationship in a block Z, there is only one correct RIO entry:

  BEGIN Z
  X value1, value2
  Y value1, value2
  END Z

- If row X and row Y are in an OR relationship in a block Z, there are three possibilities for describing the block Z in the RIO file:

  a) **BEGIN Z**
  X value1, value2
  Y value1, value2
  END Z

  b) **BEGIN Z**
  X value1, value2
  END Z

  c) **BEGIN Z**
  Y value1, value2
  END Z

- If row X and row Y are in a XOR relationship, there are two ways to describe the block Z including X and Y:

  a) **BEGIN Z**
  X value1, value2
  END Z

  b) **BEGIN Z**
  Y value1, value2
  END Z

It is also possible to have row/block and block/block relationships. The various logical relationships have the same meaning as the row/row relationships.

2.1.4 Unknown Data

Unknown blocks and rows generally have no affect on the RIO parser when reading RIO files. The parser ignores them in terms of performing special operations, but keeps track of where the unknown data occurred. When the parser outputs a RIO file, it tries to write the unknown data at the same locations as before.

2.1.5 Error Output from the RIO Parser

The RIO parser produces error messages during parsing if the RIO file was not defined according to the RIO specifications. Error messages include:

- **"The parser block structure is invalid"**

  Means that there are mismatched END/BEGIN statement. It is possible that an END or a BEGIN keyword is missing.

- **"Wrong token found"**

  Means that a string was read which is not part of the RIO format.

- **"Too much RIO data"**

  Means that a row or block is restricted to a maximum cardinality and the count of read rows/block exceeds this maximum limit.

- **"Row: name is missing"**

  Means there is a violation of the minimum cardinality of rows.

- **"Block: name is missing"**

  Means there is a violation of the minimum cardinality of blocks.

- **"RIO data of OR relationship still missing. Involved context: name1,..."**

  Means a violation of an OR relationship has occurred, because none of the specified rows/blocks within this relationship are present in the RIO file. The involved context shows the names of the blocks/rows which are part of this relationship. To correct the RIO file, add one of these rows/blocks.

- **“RIO data of AND relationship still missing. Involved context: name1,...”**

  Means that an AND relationship is violated, because one or more of the specified rows/blocks within this relationship are not present in the RIO file. The involved context shows the names of the blocks/rows which are missing data. To correct the RIO file, add all of the rows/blocks which are shown as the involved context.

- **“RIO data of XOR relationship still missing. Involved context: name1,...”**

  Means that an XOR relationship has been violated, because none of the specified rows/blocks within this relationship are present in the RIO file. The involved context shows the names of the blocks/rows which are part of this relation. To correct the RIO file, add only one of these rows/blocks.

- **“RIO data in XOR conflict. Involved context: name1,...”**

  Means that the XOR relationship has a conflict, because more than one elements that are part of the relationship are present. To correct the RIO file, delete all but one row/block in this relationship.

- **“Row: name Invalid name of RIO data”**

  Means that the parser found a row within a block which is not part of the specification of the block. It is a warning to inform you that unknown data was found. This unknown data will be written back without any changes.

- **“Block: name Invalid name of RIO data”**

  Means that the parser found a subblock within a block which is not part of the specification. It is a warning to inform you that unknown data was found. The unknown data will be written back without any changes.

- **“Invalid value type.”**

  Means that the actual read value differs from the expected. For example, if a row X specifies one value of type integer, the parser reports this error if while reading this row it encounters a value like “3.5”.

- **“Value still missing”**

  Means that a row is missing its value and it was not previously specified as an optional value or given a default value.

- **"Violation of value restriction. Please check specification."**

  Means that a value was encountered that is outside of the specified enumeration or bounds range. For example, a row with one double value and a lower bound of zero results in an error if a value of "-1" is entered.

- **"Invalid value index."**

  Means that a given row has more values than specified. This message occurs if more values are entered for one row than were specified.

2.1.6 RIO Parser Corrections

The RIO parser can be defined in different ways to correct corrupt RIO files. However, these functions are for special use. They are not used except in deleting rows or blocks which violate the specification for the maximum cardinality. Items are deleted if they exceed the specified bound. The last invalid data is the first delete [last-in/first-out (LIFO).]

In addition, the parser passes over unknown data, which means that the unknown data is written back without any changes. This behavior is not elaborated on in later sections for the various test module RIO specifications, because it is valid for all rows and blocks of all test modules by default.

2.2 Lexical Elements

In this chapter we describe the syntax to write a RIO file.

2.2.1 Separators

A distinction is made between three kinds of separators: commas, spaces, and tabs.

1. Commas are used to separate different values of a row. All types of values, such as integers, doubles, and string values, can be separate with a comma.
2. Tabs and spaces are used to separate non string values on the one hand and keywords on the other hand. Every begin and end of a block must be separate with tabs or spaces from the block name. The following example shows a wrong setting of a block:

   BEGINZ
   ENDZ

   These two lines will not be interpreted as a Z block. The parser reads them as two separate lines with the names "BEGINZ" and "ENDZ". To declare a Z block, write the lines with spaces or tabs.

BEGIN Z
END Z.

Please note that spaces and tabs cannot separate values of type string. To separate string values, use commas only. The reason is that it is possible to write string values with or without quotes.

Suppose that a row X was specified with two string values. One way to write it is with quotes like:

X "The first value", "The second value"

On the other, it is also possible to write the row X without quotes like

X The first value, The second value.

The restriction is needed to separate strings with commas only. Otherwise, there would be six unintended values in the example above.

2.2.2 Comment

In a RIO file, comments have the following forms.

- REM comments. The keyword "REM" indicates the beginning of the comment. It terminates at the end of the line. A separator is required between the REM keyword and the beginning of the comment text. This is similar to the "remark" comments used in batch files. For example:

  REM This is a REM comment

- C-line comments. The syntax "//" or ";" mark the begin of this kind of comment. Like the REM comment, they terminate at the end of the line. This is similar to the line comments used in the C programming language. For example:

  // This is a C-line comment

  ; This is another C-line comment

- C-block comment. It is bounded with "/*" at the beginning and "*/" at the end of the comment. The whole text between these delimiters is part of the comment. This is similar to the block comments used in the C programming language. For example:

  / This is a block comment*
  with multiple
  *lines */*

2.2.3 Floating Point Constant

The syntax for floating point constants is given as:

[whitespace][sign][uint][.[uint]] [{e | E}[sign]uint]

sign	plus (+) or minus (-).
uint	unsigned integer.
e or E	optional. Means 10 to some power, such as 10^{+4}.

A separator must follow floating point constants. The separators comma, tabulator, and whitespace are allowed for floating point constants. Some examples are shown below:

13.5	is read as a floating point constant.
13	is also read as a floating point constant if the corresponding value was defined.
13.5 abc	is read as a floating point constant followed by a string constant
13.14abc	is read as a string constant and not as a floating point constant followed by a string constant
abc13.14de	is also read as a string constant

2.2.4 Integer Constant

The syntax for integer constants is given as:

[whitespace] [sign] [0{x | X}] [uint]

sign	plus (+) or minus (-).
uint	unsigned integer or hexidecimal integer.
0x or 0X	optional. Means the number is hexidemical.

A separator must follow integer constants. The separators comma, tabulator and whitespace are allowed.

For example:

13	is read as a integer constant
13.5	is read as the integer constant 14 if the type of the corresponding value was defined as an integer
13.4	is read as the integer constant 13
13, abc	is read as a integer constant followed by a string constant
13abc	is read as a string-constant and not as a integer constant followed by a string constant
abc13de	is also read as a string constant.

2.2.5 String Constant

A string constant is defined as any text. The text can be written in quotation marks. Therefore, the separators for string values have to be commas only (“,“).

If the row is specified to hold only one string value, the whole text is read as a string. Comments are only valid at the beginning and the end of the string. For example in a row X:

- *X /*comment*/ This is an example /*comment*/*

  The string for the first value of the row X is “This is an example“.

- *X /*comment*/ “This is /*pseudo-comment */ an example” /*comment*/*

  The string for the first value of the row X is “This is /* pseudo-comment*/ an example“.

- *X 1234.6685*

  Will be read as the **string** 1234.6685 for the first value of row X, because the first value type of row X was defined to be a string.

- *X “1234.6685”*

  Will also be read as the **string** 1234.6685 for the first value of row X.

If the row is specified to hold more than one value, the string values must be separated with the comma separator. Otherwise, all characters are read as one string. If row X is specified as a row with two values, the first one as a string and the second as an integer value.

- *X This is text, 123*

  It will be read as “This is text” for the first value and “123” as an integer for the second

- *X This is a text 123*

  It will be read as the string “This is a text 123” for the first value and a missing value for the second.

2.2.6 Boolean Constant

Boolean constants can be TRUE or FALSE. It is also permitted to write them as YES or NO. They do not have to be written in uppercase letters, but it is recommended for readability. For example for a given row X:

- *X TRUE*
- *X FALSE*
- *X True*
- *X False*
- *X Yes*
- *X NO*

2.2.7 Keywords

Keywords are names assigned to blocks and rows and also are used as part of the delimiters for a block. The delimiters for a block are BEGIN and END followed by a whitespace or tabulator and the name of the block. BEGIN shows the beginning of the block and END the end. Keywords are not case-sensetive. For example:

- **BEGIN my_Block**1
    Row1 value1, value2
    Row2 value1
END my_Block1
- **Begin my_Block**1
    Row1 value1
    Row2 value2

    Begin my_Block2
        Row1 value1
        Row2 value2
    End my_Block2

End my_Block1

2.3 DEVICE Block

The next sections describe the block definitions within a RIO file used by the various test modules in the OMICRON Test Universe.

The DEVICE block comes first, because it is part of every test module and describes common settings of a device. Then, the RIO specifications are described for OMICRON Distance, OMICRON Overcurrent, OMICRON Differential (which includes basic and advanced), and OMICRON Meter test modules.

The DEVICE block describes general data for the relay. In the DEVICE block, only data is stored that is not specific to any protection function. The ININOM and the VLVN row have been added in OMICRON Test Universe 1.3. Older versions of the RIO parser ignore these new rows and write them back with no modifications.

2.3.1 DEVICE Block Structure

The DEVICE block has a flat structure. It contains no subblocks and no context relationship between rows. Every row can be either omitted or supplied once.

Table 2-1:
Device structure

Keyword	Min	Max	Refer to
BEGIN DEVICE	0	1	
NAME	0	1	page 23
MANUFACTURER	0	1	page 23
SERIALNO	0	1	page 23
DEVICE-TYPE	0	1	page 23
DEVICE-ADDRESS	0	1	page 23
SUBSTATION	0	1	page 23
SUBSTATION_ADRESS	0	1	page 24
BAY	0	1	page 24
BAY-ADDRESS	0	1	page 24
PROTECTED-OBJECT-NAME	0	1	page 24
ADDITIONAL-INFO2	0	1	page 24
PHASES	0	1	page 24
VNOM	0	1	page 24
VMAX-LL	0	1	page 25
VPRIM-LL	0	1	page 25
INOM	0	1	page 25
IMAX	0	1	page 25
IPRIM	0	1	page 25
FNOM	0	1	page 25
DEGLITCHTIME	0	1	page 26
DEBOUNCSTIME	0	1	page 26
ININOM	0	1	page 26
VLNVN	0	1	page 27
END DEVICE			

2.3.2 Row and Value Descriptions

NAME

Type	Range/Enumeration	Default	Optional
String	No restrictions	-	Yes

The name or description of the device.

MANUFACTURER

Type	Range/Enumeration	Default	Optional
String	No restrictions	-	Yes

The name of the manufacturer of the device.

SERIALNO

Type	Range/Enumeration	Default	Optional
String	No restrictions	-	Yes

The serial- or model-number of the device.

DEVICE-TYPE

Type	Range/Enumeration	Default	Optional
String	No restrictions	-	Yes

The type of the device.

DEVICE-ADDRESS

Type	Range/Enumeration	Default	Optional
String	No restrictions	-	Yes

The address of the device.

SUBSTATION

Type	Range/Enumeration	Default	Optional
String	No restrictions	-	Yes

The name of the plant.

SUBSTATION-ADDRESS

Type	Range/Enumeration	Default	Optional
String	No restrictions	-	Yes

The address of the plant.

BAY

Type	Range/Enumeration	Default	Optional
String	No restrictions	-	Yes

The name of the device feeder.

BAY-ADDRESS

Type	Range/Enumeration	Default	Optional
String	No restrictions	-	Yes

The address of the device feeder.

PROTECTED-OBJECT-NAME

Type	Range/Enumeration	Default	Optional
String	No restrictions	-	Yes

The name of the protected equipment. Also called “additional information1”.

ADDITIONAL-INFO2

Type	Range/Enumeration	Default	Optional
String	No restrictions	-	Yes

PHASES

Type	Range/Enumeration	Default	Optional
Integer-Enumeration	2; 3	3	No

The number of phases.

VNOM

Type	Range/Enumeration	Default	Optional
Double	0.0... $+\infty$	100.0	No

The nominal or secondary voltage in volts L-L.

VMAX-LL

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	200.0	No

The maximum voltage in volts L-L that the test device should be able to output (max. possible values are determined by the test hardware).

VPRIM-LL

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	110000.0	No

The primary voltage in volt L-L.

INOM

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	1.0	No

The nominal or secondary current Ampere.

IMAX

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	50.0	No

The maximal current in ampere that the test device should be able to output. (max. possible values are determined by the test hardware).

IPRIM

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	1000.0	No

The primary current in ampere.

FNOM

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	50.0	No

The nominal frequency in Hertz.

DEGLITCHTIME

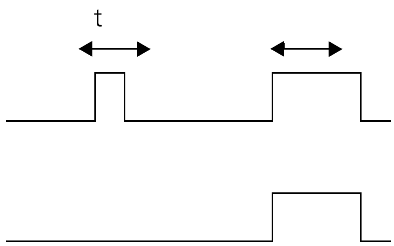
Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No

The deglitch time in seconds. This value is used where signal smoothing algorithms are implemented.

Figure 2-1:
Deglitch time

Signal before filter:

Signal after filter:



DEBOUNCETIME

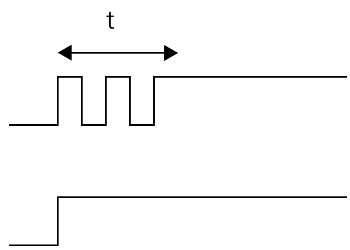
Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No

The debounce time in seconds. This value is used where signal smoothing algorithms are implemented.

Figure 2-2:
Debounce time

Signal before the filter:

Signal after the filter:



ININOM

Type	Range/Enumeration	Default	Optional
Double	-∞ ... +∞	1.0	No

The ININOM parameter and the VLNVN parameter are only relevant if the relay has separate potential/current transformers for the residual voltage/current (to increase their sensitivity). The ratio of these separate transformers relative to the transformer ratios of the single phases is expressed as a factor.

The factors ININOM and VLNVN are supported by the Distance and Advanced Distance modules.

VLNVN

Type	Range/Enumeration	Default	Optional
Double	-∞ ... +∞	sqrt(3.0)	No

For detailed information please refer to ININOM on page 26

2.3.3 Example for the "Device" Block

The following shows an example of a device block within a RIO file and the corresponding Device settings dialog.

```
BEGIN DEVICE
    NAME "Anlage ABB/Abzweig 2"
    DEVICE-TYPE "ABB LZ95"
    SUBSTATION "Anlage ABB"
    BAY "Abzweig 2"
    PHASES 3
    VNOM  5.77350269189626E+0001
    VMAX-LL  2.16506350946110E+0002
    VPRIM-LL  1.00000000000000E+0005
    INOM  1.00000000000000E+0000
    IMAX  1.25000000000000E+0001
    IPrim  1.00000000000000E+0003
    FNOM  5.00000000000000E+0001
    DEBOUNCETIME  5.00000000000000E-0003
END DEVICE
```

Figure 2-3:
Device settings dialog.

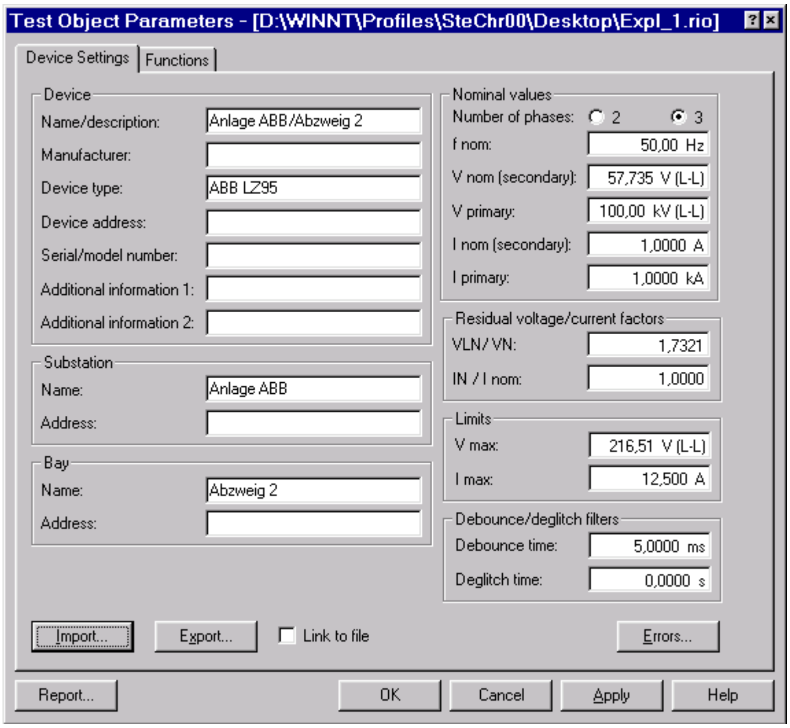


Figure 2-3 shows you the corresponding test object dialog after import a RIO file with a device block shown above.

3 Distance and Advanced Distance Test Modules

The RIO format for Distance protection is integrated into the RIO format definition. The overall RIO format consists of multiple independent blocks. The general test object parameters are defined in the device block. For the distance protection, a new "distance" block is added.

3.1 Structure of the DISTANCE Block

The DISTANCE block has a more complicated structure then the device block. The block consists of additional ZONE and the DEFAULTS subblock.

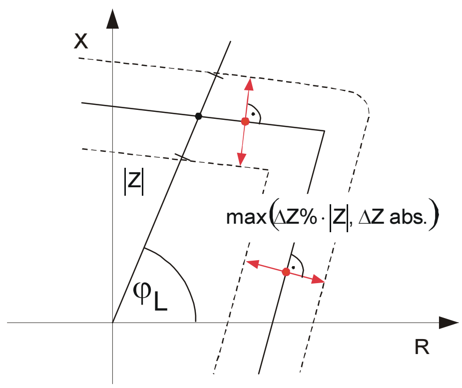
The zone block holds three additional subblocks: SHAPE, MHOSHAPE, and LENSTOMATOSHAPE.

As shown in the Table 3-1 on page 35, some XOR relationships exist between rows and blocks. For example the KL row in the block DISTANCE has an XOR relationship with the rows RERL_XEXL and Z0Z1. That means one and only one of these rows has to be included in a RIO file. Otherwise the parser produces an error.

Tolerances can be specified on a global basis in the distance block or on a per zone basis in the zone blocks. Per zone values overwrite the global settings if they exist.

Tolerances for trip times are set both relative in percent (TTOLREL) and absolute in Ohms (ZTOLABS). Tolerances for impedances are also set both relative in percent (ZTOLREL) and absolute in Ohms (ZTOLABS). The relative impedance tolerance for a zone is converted into an absolute value on the line angle. Specifically, the reach of the zone on the line angle is multiplied by the percent value.

Figure 3-1:
Impedance tolerances

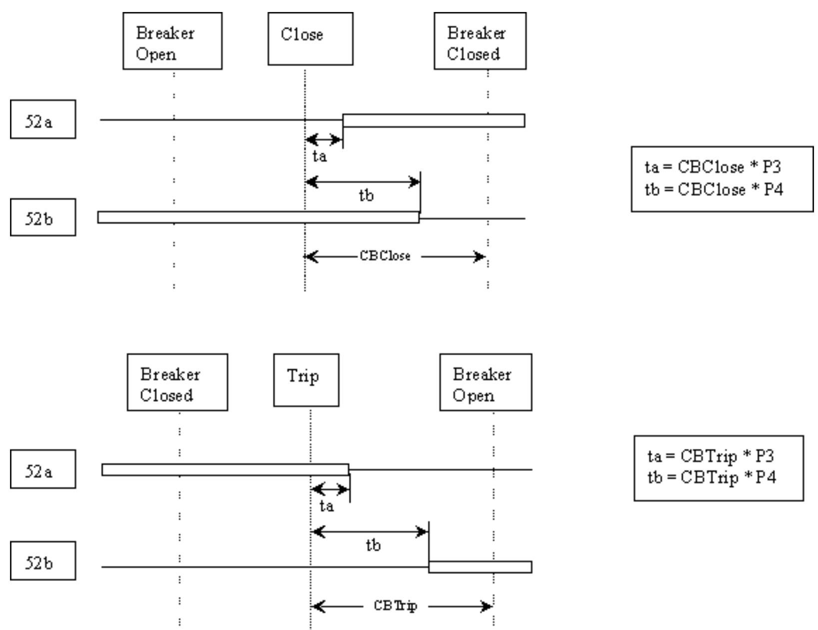


The grounding factor can be set either with kL, RE/RL, and XE/XL or Z0/Z1. Only one of these settings is allowed to determine the grounding factor mode. To express these requirement with the RIO format, all three rows (KL, RERL_XEXL, Z0Z1) are together in a XOR relation. This means that only one of these rows can be set in the RIO description (please refer to KL on page 40, RERL_XEXL on page 40 and Z0Z1 on page 41).

Also the mutual coupling factor could be describe in three different ways. It can be set either with kM, RM/RL, and XM/XL or Z0M/Z1. Because only one of these settings is allowed, the rows are described with a XOR relationship (please refer to KM on page 41, RMRL_XMXL on page 41 and Z0MZ1 on page 42).

TCBTRIP, TCBCLOSE, PERC52A and PERC52B together determine the times for the circuit breaker simulation. The CB trip time is used to delay the transition into the post-fault stage after trip. It is applied whether CB simulation is turned on or off. The CB close time is used to delay the transition into the pre-fault stage. It is applied whether CB simulation is turned on or off. The value of 52a% (52b%) determines the delay of the 52a (52b%) contact relative to the CB trip time on breaker opening or relative to the CB close time on breaker closing. See the following figures for the timing.

Figure 3-2:
Circuit breaker simulation



There are three different types of shapes for a zone: a general shape defined by individual lines and arcs, mho shape, and lens/tomato shape. This is determined by the SHAPE, MHOSHAPE, and LENSTOMATOSHAPE block. They are in a XOR relationship because only one of these blocks per zone is allowed.

A general SHAPE is constructed from multiple individual border elements, which can be lines and arcs.

The following border elements with its parameters are possible for a shape:

LINE	Defined by its start point with R and X in Cartesian coordinates and the line angle in degrees.
LINEP	Defined by its start point with Z and Phi in polar coordinates and a line angle.
ARC	Defined by its center point with R and X in Cartesian coordinates, the radius of the arc, the starting angle in degrees, the end angle in degrees, and the direction of the arc (clockwise or counter-clockwise).
ARCP	Defined by its center point with Z and Phi in polar coordinates, the radius of the arc, the starting angle in degrees, the end angle in degrees, and the direction of the arc (clockwise or counter-clockwise).

The border elements are kept in an ordered list to form the overall border of the shape. It is recommended to specify the border elements in counter-clockwise direction.

It is assumed that a shape is only a "single" shape, which means that there is only one single connected area where all points are considered "inside" of the shape and only one additional area (the inversion in relationship to the whole Cartesian space) where all points are considered "outside".

A shape does not necessarily have to be "closed". An "open" shape divides the Cartesian space into two areas (half-spaces) which both extend to infinity. A "closed" shape defines a finite area for "inside" and an infinite area for "outside".

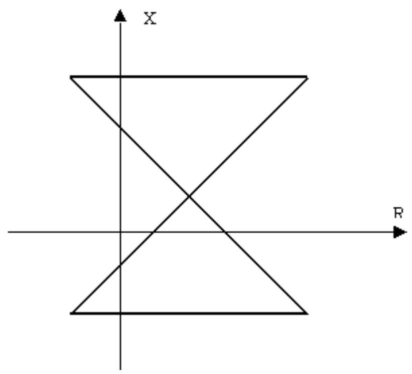
Because each characteristic shape is considered to be a "single" shape, there are a few constraints for the elements which are checked to get a valid characteristic:

- Two adjacent elements in the ordered list of elements must have at least one intersection point. Thus, two adjacent lines are not allowed to be parallel and the radius of an arc must allow intersection.

- No intersection between two non adjacent elements in the ordered list of elements is allowed within the segment of the element which is defined by the two intersection points with the preceding and succeeding element. Otherwise the characteristic would fall apart into multiple independent parts and is no longer "single".

The following figure illustrates a **non-valid** shape constructed from 4 lines:

Figure 3-3:
A non-valid shape



These constraints are verified by the geometrical algorithms. A non-valid shape is rejected by the software.

A characteristic has a certain impedance tolerance associated with it. For each individual characteristic, both an absolute DZ and a relative tolerance DZ% for the impedance values are specified, where the wider tolerance is applied. The relative tolerance is converted into an absolute value in the following way:

- Cut the characteristic shape with the line angle line. The first intersection point with the line angle defines the reach of the zone.
- The magnitude of this reach value (|Z|) is multiplied by the percentage of the relative tolerance to get an absolute value.

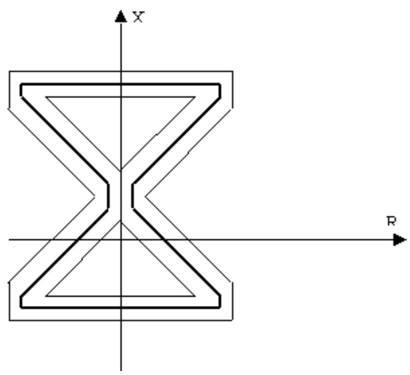
The geometrical algorithms calculate a tolerance band around the nominal characteristic shape with a constant width which is the calculated Z tolerance. The tolerance band is constructed in a way such that the euclidian distance from the nominal shape for all point on the tolerance border is constant (and is the Z tolerance). Therefore, the edges around vertices of the nominal shape are rounded in the tolerance shapes.

With the implementation of the impedance tolerance, an "outer" and an "inner" tolerance figure can be constructed. The tolerance figures do not necessarily have to be single shapes any more.

There are cases where the figures can fall apart into separate shapes. Additionally, not all border elements from the nominal shape need to be part of the tolerance figures (such as whenever their "size" is smaller than the tolerance value).

Figure 3-4 illustrates a tolerance diagram with a few cases that have to be addressed. It has two separate inner tolerance shapes, and not all border elements are used as border elements for the tolerance shapes.

Figure 3-4:
Shape tolerances



A mho characteristic is a special kind of zone that is defined as a circle. The mho characteristic is considered constant as it is for non polarized mho characteristics and is parameterized with the following values:

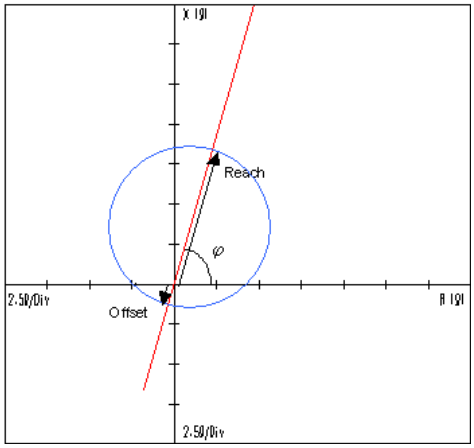
- ANGLE phi
- REACH
- OFFSET.

The center of the circle is located on the line with the ANGLE and the radius r is defined by the following equation:

$$r = (REACH + OFFSET) / 2$$

A positive OFFSET is in the opposite direction of the line.

Figure 3-5:
MHO shape



A lens / tomato shape is parameterized with the following values:

- ANGLE phi
- REACH
- OFFSET
- and either WIDTH or AB.

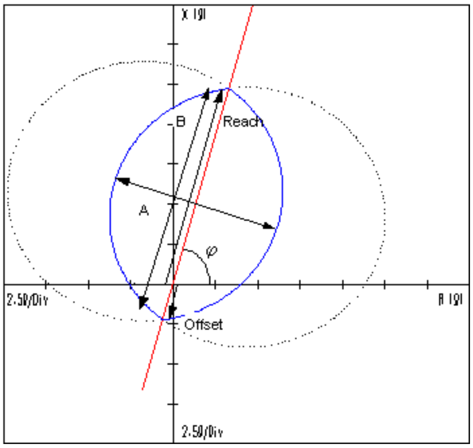
The distance B on the figure is deduced according to the following equation:

B = REACH + OFFSET

A positive OFFSET is in the opposite direction of the line.

WIDTH and AB ratio are depending on each other. Only one of these values can be specified.

Figure 3-6:
Lens tomato shape



For A < B, the shape is a lens. For A > B the shape is a tomato. The valid part is just the outer arcs of the two circles in the figure. For A = B, the lens/tomato is a circle which can more easily be modeled with a mho shape.

Table 3-1:
Distance structure

Keyword	Min	Max	XOR Relation	Refer to
BEGIN DISTANCE	0	1		
ACTIVE	0	1		page 37
LINEANGLE	0	1		page 37
PTCONN	0	1		page 38
CTSTARPOINT	0	1		page 38
IMPCORR	0	1		page 38
IMPPRIM	0	1		page 39
ARCRES	0	1		page 39
TTOLPLUS	0	1		page 39
TTOLMINUS	0	1		page 39
TTOLREL	0	1		page 39
ZTOLREL	0	1		page 40
ZTOLABS	0	1		page 40
KL	0	1	RERL_XEXL Z0Z1	page 40
RERL_XEXL	0	1	KL Z0Z1	page 40
Z0Z1	0	1	RERL_XEXL KL	page 41
KM	0	1	RMRL_XMXL Z0MZ1	page 41
RMRL_XMXL	0	1	Z0MZ1 KM	page 41

Keyword	Min	Max	XOR Relation	Refer to
Z0MZ1	0	1	KM RMRL_XMXL	page 42
TCBTRIP	0	1		page 42
TCBCLOSE	0	1		page 42
PERC52A	0	1		page 42
PERC52B	0	1		page 42
LINELENGTH	0	1		
BEGIN ZONE	0	no limit		
TYPE	1	1		page 43
FAULTLOOP	0	1		page 44
LABEL	0	1		page 44
TRIPTIME	0	1		page 44
ACTIVE	0	1		page 44
TTOLPLUS	0	1		page 39
TTOLMINUS	0	1		page 39
TTOLREL	0	1		page 40
INDEX	1	1		page 45
ZTOLABS	0	1		page 40
ZTOLREL	0	1		page 40
BEGIN SHAPE	0	1	**MHOSHAPE LENSTOMATOSHAPE**	
LINE	0	no limit		page 45
LINEP	0	no limit		page 45
ARC	0	no limit		page 46
ARCP	0	no limit		page 46
INVERT	0	1		page 46
AUTOCLOSE	0	1		page 47
END SHAPE				
BEGIN MHOSHAPE	0	1	**SHAPE LENSTOMATOSHAPE**	
ANGLE	0	1		page 47
REACH	0	1		page 47
OFFSET	0	1		page 48
INVERT	0	1		page 46
END MHOSHAPE				
BEGIN LENSTOMATOSHAPE	0	1	**SHAPE MHOSHAPE**	
ANGLE	0	1		page 47
REACH	0	1		page 47

Keyword	Min	Max	XOR Relation	Refer to
OFFSET	0	1		page 48
INVERT	0	1		page 46
WIDTH	0	1	AB	page 48
AB	0	1	WIDTH	page 48
END LENSTOMATOSHAPE				
END ZONE				
BEGIN DEFAULTS	0	1		
TESTMODE	0	1		page 48
ITEST	0	1		page 48
VTEST	0	1		page 48
TPREFAULT	0	1		page 49
TMAXFAULT	0	1		page 49
TPOSTFAULT	0	1		page 49
FAULTINCMODE	0	1		page 49
FAULTINCANGLE	0	1		page 49
DCOFFSET	0	1		page 49
TREF	0	1		page 50
ALLOWRED	0	1		page 50
END DEFAULTS				
END DISTANCE				

3.2 Row and Value Descriptions

Similar to the device block, the rows and values of the distance blocks are described here.

ACTIVE

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

Indicates if the function is active or not.

LINEANGLE

Type	Range/Enumeration	Default	Optional
Double	–360.0 ... +360.0	75.0	No

The line angle in degrees.

PTCONN

Type	Range/Enumeration	Default	Optional
String-Enumeration	BUS; LINE	LINE	No

Determines whether the voltages are turned off (dir busbar) or go back to nominal (dir line) in the post-fault stage if a trip has occurred.

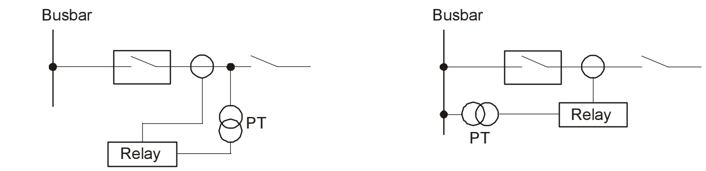


Figure 3-7:
Left-hand side:
Potential transformer on line side

Right-hand side:
Potential transformer on bus side

CTSTARPOINT

Type	Range/Enumeration	Default	Optional
String-Enumeration	BUS; LINE	LINE	No

This is used to invert the sign of the currents.

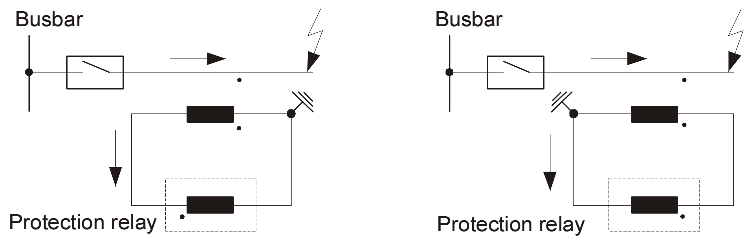


Figure 3-8:
Left-hand side:
Current transformer grounded on line side

Right-hand side:
Current transformer grounded on bus side

IMPCORR

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

If set, the fault impedance are multiplied by 1 A/I nom before the fault quantities are calculated.

IMPPRIM

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

If set, all impedances are considered as primary impedances and are multiplied by V_{nom} / V_{prim} I_{prim} / I_{nom} before the fault quantities are calculated.

ARCRES

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

If set ,the arc resistance is separated from the fault resistance so that the fault resistance is composed of the part on the line plus the pure resistive arc resistance. For the phase-to-ground faults, the arc resistance is not compensated with the grounding factor (multiplied by (1+kL)).

TTOLPLUS

Type	Range/Enumeration	Default	Optional
Double	0.0... $+\infty$	0.0	No

Tolerances can be specified on a global basis or on a per zone basis. Per zones values overwrite the global settings if they exist. This row determines the global or local time tolerance in positive direction.

TTOLMINUS

Type	Range/Enumeration	Default	Optional
Double	0.0... $+\infty$	0.0	No

Determines the global or local time tolerance in negative direction.

TTOLREL

Type	Range/Enumeration	Default	Optional
Double	0.0... 100.0	5.0 (0.0)	No

Determines the global or local time tolerance in percent.

ZTOLREL

Type	Range/Enumeration	Default	Optional
Double	0.0... 100.0	5.0	No

The global or local Z tolerance in percentage.

ZTOLABS

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.05	No

Tolerance of Z in Ohms.

KL

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No
Double	-360.0.... +360.0	0.0	No

Determines the complex grounding factor directly. The first value indicates the magnitude and the second the angle in degrees of the complex grounding factor.

RERL_XEXL

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	1.0	No
Double	-∞... +∞	1.0	No

This is the second option for describing the complex grounding factor. The first value R_E/R_L and the second value X_E/X_L are calculated into $\underline{k}_L$ according to the following equations for each individual $\underline{Z}_L$.

$$f_R = \frac{R_E}{R_L}$$

$$f_X = \frac{X_E}{X_L}$$

$$\underline{k}_L = \frac{\underline{Z}_E}{\underline{Z}_L} = \frac{R_E + jX_E}{R_L + jX_L}$$

$$\underline{k}_L = \frac{f_R \cdot R_L + jf_X \cdot X_L}{R_L + jX_L}$$

Z0Z1

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	4.0	No
Double	-360.0... +360.0	0.0	No

Z0Z1 is the third way to express the complex grounding factor. The first value describes the magnitude, and the second describes the angle in degrees of the complex grounding factor. $\underline{Z}_0$ and $\underline{Z}_1$ are converted into $\underline{k}_L$ according to the following equation.

$$\underline{k}_L = \frac{1}{3}\left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1\right)$$

KM

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No
Double	-360.0... +360.0	0.0	No

Determines the mutual coupling factor $\underline{k}_M$directly. The first value indicates the magnitude and the second the angle in degrees of the factor.

RMRL_XMXL

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No
Double	0.0... +∞	0.0	No

The second way to describe the mutual coupling factor via the values R_M/R_L and X_M/X_L. Both are calculated into $\underline{k}_M$ according to the following equations for each individual $\underline{Z}_L$.

$$f_R = \frac{R_M}{R_L}$$

$$f_X = \frac{X_M}{X_L}$$

$$\underline{k}_M = \frac{\underline{Z}_M}{\underline{Z}_L} = \frac{R_M + jX_M}{R_L + jX_L}$$

$$\underline{k}_M = \frac{f_R \cdot R_L + jf_X \cdot X_L}{R_L + jX_L}$$

Z0MZ1

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No
Double	-360.0... +360.0	0.0	No

Z0MZ1 is the last option for describing the mutual coupling factor. The first value describes the magnitude while the second contains the angle in degrees of the mutual grounding factor. $\underline{Z}_0$ and $\underline{Z}_1$ are converted into $\underline{k}_M$ according to the following equation.

$$\underline{k}_M = \frac{\underline{Z}_0}{3 \cdot \underline{Z}_1}$$

TCBTRIP

Type	Range/Enumeration	Default	Optional
Double	0.0... +1200.0	0.1	No

TCBTRIP, TCBCLOSE, PERC52A, and PERC52B together determine the times for the circuit breaker simulation. This row describes the circuit breaker trip time in seconds.

TCBCLOSE

Type	Range/Enumeration	Default	Optional
Double	0.0... +1200.0	0.1	No

TCBCLOSE describes the circuit breaker close time in seconds.

PERC52A

Type	Range/Enumeration	Default	Optional
Double	0.0... +100.0	0.0	No

The setting of the delay time of the 52a contact in percent of the CB trip/close time.

PERC52B

Type	Range/Enumeration	Default	Optional
Double	0.0... 100.0	100.0	No

Indicates the delay time of the 52b contact in percent of the CB trip/close time.

LINELENGTH

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞		No

Defines the length of the line in Ohms. If it is not set the length is undefined.

TYPE

Type	Range/Enumeration	Default	Optional
String enumeration	TRIPPING; STARTING; EXTENDED; NONTRIPPING	TRIPPING	No

The following different zone types are available:

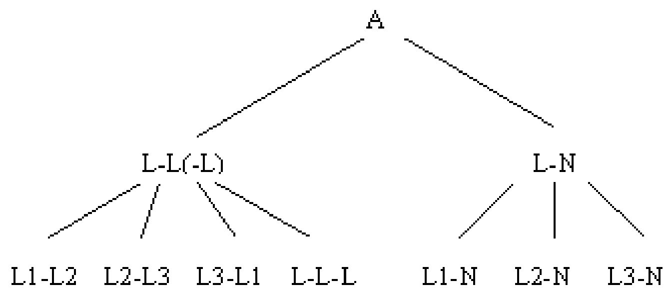
Tripping zone:	Describe where the relay is supposed to trip in the specified time.
Extended zone:	Behave exactly like normal tripping zones. It has the abiltiy to activate or deactivate all of them with a single setting in the test settings. No link from an extended zone to any corresponding tripping zone is maintained. Thus, no automatic activation of extended zone in relationship to the corresponding tripping zone or automatic deactivation of the tripping zone if the corresponding extended zone is active is possible.
Starting zone:	Cross all the tripping and extended zones. They have a trip time associated and block outside. Starting zones are always non-directional.
Non-Tripping zone:	Do not have an associated trip time (and therefore no time tolerances). They cross all the tripping and extended zones. Non-tripping zones are always non-directional.

FAULTLOOP

Type	Range/Enumeration	Default	Optional
String enumeration	L1N; L2N; L3N; L1L2; L2L3; L3L1; LN; LL; ALL; L1L2L3	ALL	No

In the fault loop column, the fault loop for the tripping characteristic is selected. The fault loops are organized according to the following hierarchy.

Figure 3-9:
Fault loop organization



The characteristic that is be applied for a specific fault type in the test is determined in a bottom up manner. The most specific fault loop is used. It is possible to have characteristics defined at different levels in the hierarchy. The more specific ones “override” the more general ones.

LABEL

Type	Range/Enumeration	Default	Optional
String	No restrictions	Z1	No

The characteristic label can be customized by the user. A default label can be deduced from the zone index, type and the fault loop, e.g. Z1 L-L.

TRIPTIME

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No

The trip time in seconds.

ACTIVE

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

Indicates if the zone is active or not.

INDEX

Type	Range/Enumeration	Default	Optional
Integer	-∞... +∞	1	No

INDEX sets a unique index for all zones with the same type and fault loop. This is necessary to reassign relative shots to the different zones of different relays. It is recommended to number the zones from inside to outside as usual (first zones number 1, second zone number 2,...).

LINE

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	0.0	No
Double	-∞... +∞	0.0	No
Double	-∞... +∞	0.0	No
String enumeration	LEFT; RIGHT	LEFT	Yes

A LINE statement can exist only in a general shape. A line is defined by its starting point with R and X in cartesian coordinates and a line angle (the third value in the table). The last value sets a direction and is optional.

LINEP

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	0.0	No
Double	-∞... +∞	0.0	No
Double	-∞... +∞	0.0	No
String enumeration	LEFT; RIGHT	LEFT	Yes

A LINEP statement can also exist only in a general shape. A line is defined by its starting point with Z and phi in polar coordinates and a line angle (the third value in the table) in degrees. With the last value a direction can be set. This is an optional value.

ARC

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	0.0	No
Double	-∞... +∞	0.0	No
Double	-∞... +∞	1.0	No
Double	-∞... +∞	0.0	No
Double	-∞... +∞	360.0	No
String enumeration	CW; CCW	CCW	Yes
String enumeration	LEFT; RIGHT	LEFT	Yes

An ARC statement can exist only in a general shape. An arc is defined by its center point with R and X in cartesian coordinates, the radius of the arc, the starting angle in degrees, the end angle in degrees, and the direction of the arc (clockwise or counter-clockwise). The last two values are optional.

ARCP

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	0.0	No
Double	-∞... +∞	0.0	No
Double	-∞... +∞	1.0	No
Double	-∞... +∞	0.0	No
Double	-∞... +∞	360.0	No
String enumeration	CW; CCW	CCW	Yes
String enumeration	LEFT; RIGHT	LEFT	Yes

An ARCP statement can exist only in a general shape. An arc is defined by its center point with Z and phi in polar coordinates, the radius of the arc, the starting angle in degrees, the end angle in degrees, and the direction of the arc (clockwise or counter-clockwise). The last two values are optional.

INVERT

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

The INVERT flag indicates which part of the cartesian space has to be considered as inside and outside. The flag toggles this notion of “inside” and “outside”. For border elements, the following rules determine what is "inside":

- A line has an implicit direction associated with the specification of the line angle. The area which is "left" of the line is considered "inside" of the shape.
- For an arc, the area that is inside of the circle with which the arc is defined is considered "inside" of the shape.

The user can toggle the notion of the "inside" behavior of a single border element with the additional LEFT/RIGHT flag. For a line, the user could change the line angle (add 180°) so that the line points into the other direction as well.

By default, the area to the left of a line is considered "inside". This results in a standard behavior as long as the users enters the elements in counter-clockwise direction.

AUTOCLOSE

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

With the AUTOCLOSE flag, a shape can be forced to be closed automatically. This is done by implicitly setting the LEFT/RIGHT flag for the last border element so that the shape is closed. Additionally the AUTOCLOSE flag sets the "inside" notion of the shape so that the inside of the closed shape is inside.

This is the same behavior as within the old RIO specification and can be used for most cases.

ANGLE

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	75.0	No

This row can be set in the mho or the lens tomato shape. It describes the angle of the shape in degrees.

REACH

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	1.0	No

The reach of the mho or lens tomato shape in forward direction in Ohms.

OFFSET

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	0.0	No

The offset of the mho or lens tomato shape in backward direction in Ohms.

WIDTH

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	1.0	No

The width of the lens tomato shape in Ohms. Can only be set if the AB row was not set.

AB

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	1.0	No

The ratio A/B of the lens tomato shape. Can only be set if the row width was not set.

TESTMODE

Type	Range/Enumeration	Default	Optional
String enumeration	CONSTCURR; CONSTVOLT; CONSTSOURCEIMP	CONSTCURR	No

The default test mode. Can be constant test current or constant test voltage.

ITEST

Type	Range/Enumeration	Default	Optional
Double	0... +∞	2.0	No

The default test current for constant current model.

VTEST

Type	Range/Enumeration	Default	Optional
Double	0... +∞	10.0	No

The default test voltage for constant voltage model.

TPREFAULT

Type	Range/Enumeration	Default	Optional
Double	0... +∞	1.0	No

The default pre-fault time.

TMAXFAULT

Type	Range/Enumeration	Default	Optional
Double	0... +∞	3.0	No

The default maximum fault time.

TPOSTFAULT

Type	Range/Enumeration	Default	Optional
Double	0... +∞	0.5	No

The default post-fault time.

FAULTINCMODE

Type	Range/Enumeration	Default	Optional
String enumeration	RANDOM; ZERO; FIXED; MAXOFFSET	RANDOM	No

The default fault inception mode.

FAULTINCANGLE

Type	Range/Enumeration	Default	Optional
Double	-360.0... +360.0	0.0	No

The default fault inception angle for fixed angle fault inception mode.

DCOFFSET

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

The default flag for DC-offset.

TREF

Type	Range/Enumeration	Default	Optional
String enumeration	FAULT; START	FAULT	No

The default for the time reference.

ALLOWRED

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

The default flag for allow automatic reduction of ITest/VTest.

ZS

Type	Range/Enumeration	Default	Optional
Double	0.0 ... +∞	0.0	No
Double	-360.0... +360.0	75.0	No

The source impedance and source impedance grounding (KS page 50) factor in magnitude and angle. The 4 controls are: ZS magnitude in Ohms, ZS angle in degrees, KS magnitude, and KS angle in degrees.

KS

Type	Range/Enumeration	Default	Optional
Double	0.0 ... +∞	1.0	No
Double	-360.0... +360.0	0.0	No

ZS page 50

KSISKL

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

This setting fixes KS to KL.

3.3 Example for Distance

An example of a distance block is shown. It consists of six zones. Each zone is modeled with general shape. The zones have no specific tolerances defined. Therefore the general tolerances are applied.

```
BEGIN DISTANCE
  LINEANGLE 75.0
  PTCONN LINE
  CTSTARPOINT LINE
  IMPCORR NO
  TTOLPLUS 0.1
  TTOLMINUS 0.1
  TTOLREL 0.5
  ZTOLABS 0.1
  ZTOLREL 0.5
  KL 1.0, 0.0
  IMPPRIM NO
  IMPCORR NO
  BEGIN ZONE
    INDEX 1
    LABEL "Z1"
    TYPE TRIPPING
    FAULTLOOP LL
    TRIPTIME 0.02
    BEGIN SHAPE
      ARCP 1.5, 75.0, 1.5, 0.0, 360, ,
      AUTOCLOSE YES
    END SHAPE
  END ZONE
  BEGIN ZONE
    INDEX 1
    LABEL "Z1"
    TYPE TRIPPING
    FAULTLOOP LN
    TRIPTIME 0.02
    BEGIN SHAPE
      LINE 0.0, 0.0, -15.0,
      LINE 3.11364, 0.0, 74.4635,
      LINE 0.0, 2.9382, 176.997,
      LINE -3.09355, 0.0, -104.152,
      AUTOCLOSE YES
    END SHAPE
  END ZONE
```

```
BEGIN ZONE
    INDEX 2
    LABEL "Z2"
    TYPE TRIPPING
    FAULTLOOP LL
    TRIPTIME 0.32
    BEGIN SHAPE
        ARCP 2.25, 75.0, 2.25, 0.0, 360.0, ,
        AUTOCLOSE YES
    END SHAPE
END ZONE
BEGIN ZONE
    INDEX 2
    LABEL "Z2"
    TYPE TRIPPING
    FAULTLOOP LN
    TRIPTIME 0.32
    BEGIN SHAPE
        LINE 0.0, 0.0, -15.0,
        LINE 3.11132, 0.0, 74.6227,
        LINE 0.0, 4.40759, 176.997,
        LINE -3.09847, 0.0, -104.492,
        AUTOCLOSE YES
    END SHAPE
END ZONE
BEGIN ZONE
    INDEX 3
    LABEL "Z3"
    TYPE TRIPPING
    FAULTLOOP LL
    TRIPTIME 0.62
    BEGIN SHAPE
        ARCP 3.0, 75.0, 3.0, 0.0, 360.0, ,
        AUTOCLOSE YES
    END SHAPE
END ZONE
BEGIN ZONE
    INDEX 3
    LABEL TRIPPING
    FAULTLOOP LN
    TRIPTIME 0.62
```

```
            BEGIN SHAPE
                LINE 0.0,  0.0,  -15.0,
                LINE  3.11017,  0.0,  74.7017,
                LINE 0.0,  5.87696,  176.997,
                LINE  -3.10049, 0.0, -104.632,
                AUTOCLOSE  YES
            END SHAPE
        END ZONE
        BEGIN DEFAULTS
            ITEST  2.0
            TREF  FAULT
        END DEFAULTS
    END DISTANCE
```

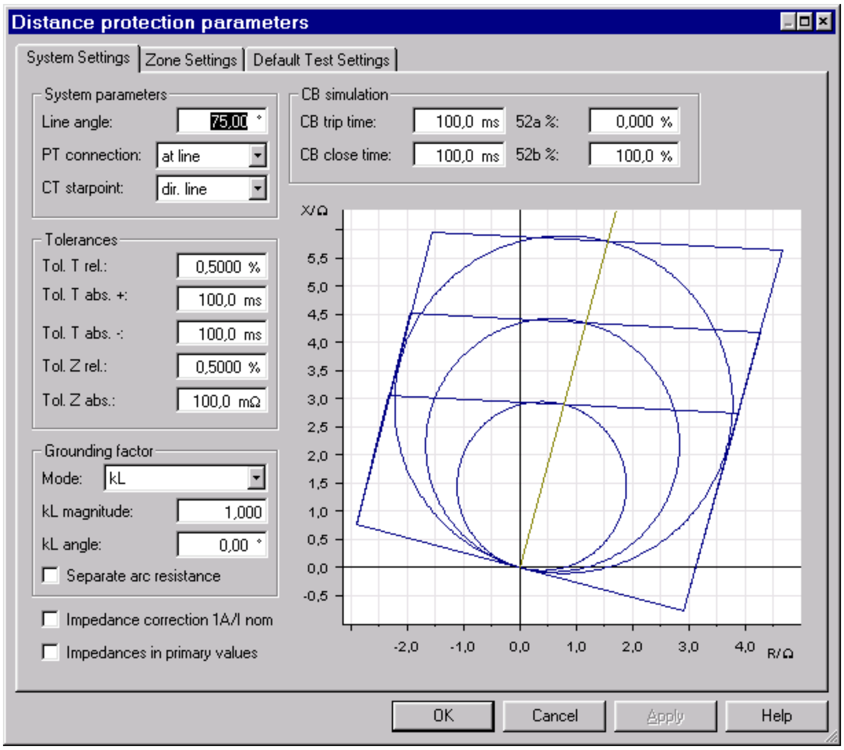


Figure 3-10:
Distance system settings.
General settings in the distance block of the example.

Figure 3-10 shows the general settings of the distance example. These settings are between the BEGIN DISTANCE and BEGIN ZONE delimiters.

Figure 3-11:
Distance zone settings of the first zone block in the above example.

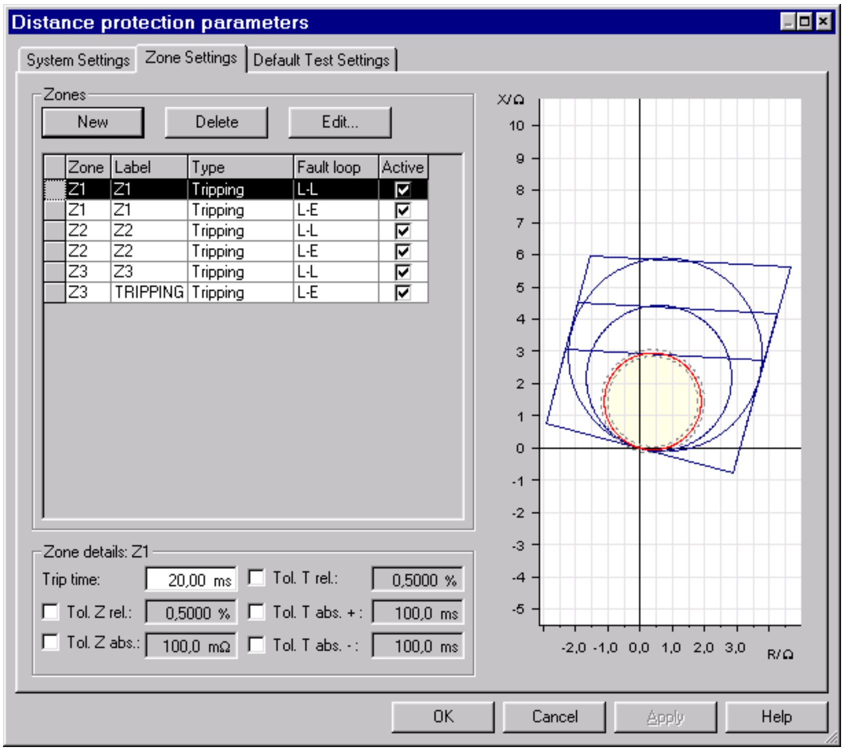


Figure 3-11 shows the zones settings of the first zone block. You can find the corresponding settings in the example above where the zone blocks are defined. The current selected zone-graphic in the figure is marked as yellow.

Figure 3-12:
Distance default block settings

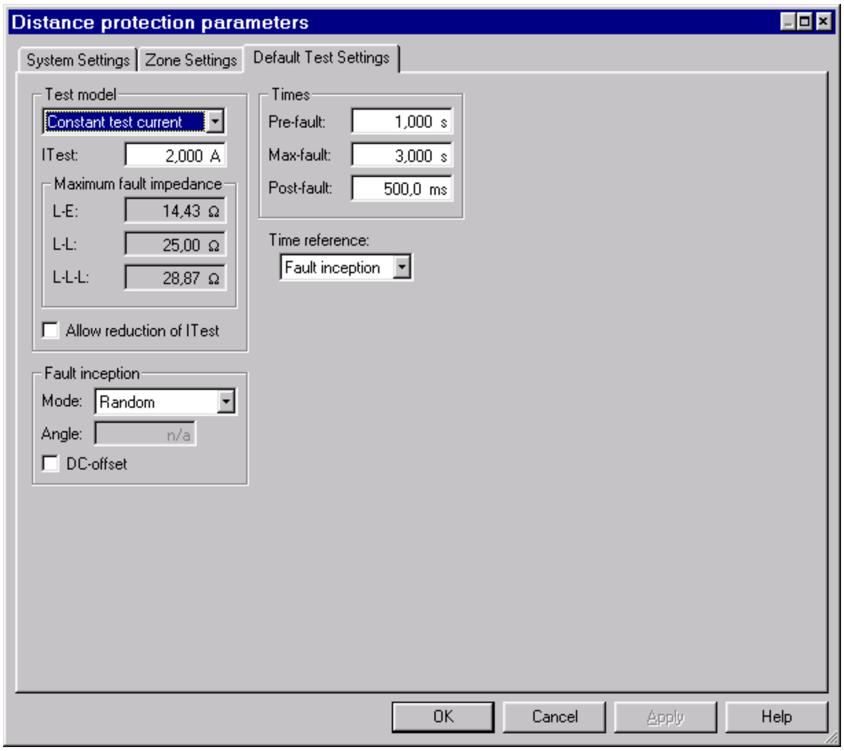


Figure 3-12 is the corresponding dialog box of the DEFAULT block in the distance RIO example above. Because only two settings are explicitly set in the example, most of the values are set by default as shown in the specification of the distance settings.

4 Overcurrent Test Module

This chapter describes the RIO format of the Overcurrent test module.

4.1 Structure of the OVERCURRENT Block

The module performs non directional overcurrent tests. The tests are executed in the Current / Time plane.

It is possible to define up to three pick-up regions for each fault group. The first region, labeled I>, can be definite time or inverse time. The other two pick-up regions (I>> and I>>>) are always definite time. Each zone can be defined as active or inactive, independently of the others.

The limitation to three pick-up regions is artificial and reduces the complexity of the parameter entry dialog box. However, the software could be easily modified in the future to permit any number of regions. Likewise, the additional regions could permit inverse time characteristics, if required.

The test module can operate in absolute current or in multiples of the pick-up current I> units (MTS, Multiples of Tap Setting). All the UI input fields are adapt to the selected mode, as required. In the report and in the test point table, both absolute and MTS values are displayed simultaneously.

The test points are entered in a list. The test points may be entered from the keyboard into the dialog box's fields or from the mouse by selecting points in the diagram.

When a point is entered in the table, its nominal trip time is automatically determined according to the device's settings. For evaluation, absolute and relative time tolerances are used. The user cannot edit a point's values after it is entered in the table. If changes are desired, the point has to be deleted and re-entered.

The voltage settings are test settings, common for all test points. The user can select a value for the fault voltage and a phase angle between the voltages and the currents. Its default value is the device's nominal voltage. A Test Object Setting called "Directional" controls the voltages. If the relay is defined as "Directional" the voltages are output; otherwise, no voltage is output.

The current settings are the fault current (different for each test point) and the load current (common for all points in the table). Each point, regardless whether it has been entered in the absolute or the relative input mode, stores its corresponding fault current as MTS. The absolute value is used for display only. If the nominal current setting changes, all absolute values are recalculated from the MTS values.

The load current is entered in times the device's nominal current, and must be smaller than the smallest I_{pickup} of all active units. This current is output during the Pre-Fault and Fault stages of the shot sequence.

The fault groups presently are Line-To-Ground, Line-To-Line, Negative Sequence and Zero Sequence. The Line-To-Ground group includes L1-N, L2-N and L3-N faults; the Line-To-Line group includes L1-L2, L2-L3, L3-L1 and L1-L2-L3 faults. Line-line-ground faults are not permitted. The test module permits testing of only one fault type at a time. If another fault type is desired, a new instance of the test module must be used and the test points entered again.

The Negative Sequence and Zero Sequence groups expand the module to allow testing of non-differential generator and motor protective units.

For each test point, a full shot sequence is executed, involving up to two triples: one current triple and one voltage triple. The current triple is divided in individual current signals which can be freely assigned as long as they all are assigned to the same triple. The software checks only for the assigned current signals, thus allowing the use of single-phase amplifiers. The voltage triple is required only if the relay is defined as "Directional", and in this case a full triple is required.

Alternatively, it is possible to test a point directly from the diagram. The point and the results of the shot is just be displayed, and is not be entered in the table or reported.

Both modes of testing are allowed only when the user has permission to test, according to the defined protection levels.

The test module incorporates a “Static Output” feature. When selected, a dialog opens in which the user is able to enter the fault type and the test current. The test module then calculates the output values which are under the control of an ON/OFF button. The dialog box provides a vector diagram of the output magnitudes, plus a textual representation of the values output, including angles. The values are not output if they exceed the maximum values for the test object or the test equipment. This feature is available only in on-line mode (CMC connected) and when the user has permission to test.

Table 4-1:
Overcurrent structure

Keyword	Min	Max	XOR-Relation	Refer to
BEGIN OVERCURRENT	0	1		
ACTIVE	1	1		page 60
DISPLAY_ABSOLUTE	0	1		page 60
ITOL	0	1		page 60
TTOL	0	1		page 60
PTCONN	0	1		page 60
CTSTARPOINT	0	1		page 61
DIRECTIONAL	0	1		page 61
BEGIN GROUP	0	no limit		
NAME	1	1		page 61
BEGIN UNIT	0	no limit		
NAME	1	1		page 61
ACTIVE	1	1		page 62
IPICKUP	1	1		page 62
TINDEX	1	1		page 62
PREDEFCHAR	0	1	CHAR CHARI2T **TABLE**	page 62
CHAR	0	1	PREDEFCHAR CHARI2T **TABLE**	page 63
CHARI2T	0	1	PREDEFCHAR CHAR **TABLE**	page 63
BEGIN TABLE	0	1	PREDEFCHAR CHAR CHARI2T	
NAME	1	1		page 64
POINT	1	no limit		page 64
END TABLE				
END UNIT				
END GROUP				
END OVERCURRENT				

4.2 Row and Value Descriptions

ACTIVE

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	YES	No

Indicates if the device is active or not.

DISPLAY_ABSOLUTE

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

Reserved for future use and not implemented yet.

ITOL

Type	Range/Enumeration	Default	Optional
Double	0.0... 100.0	10.0	No
Double	0.0... $+\infty$	0.1	No

The current tolerance of the test module. The first value is relative in percent; the second absolute in I/In.

TTOL

Type	Range/Enumeration	Default	Optional
Double	0.0... 100.0	3.0	No
Double	0.0... $+\infty$	0.1	No

The tolerance of the time of the device. The first value is relative in percent the second absolute in seconds.

PTCONN

Type	Range/Enumeration	Default	Optional
String enumeration	BUS; LINE	LINE	No

The connection of the voltage transformer. It could be at line or at busbar.

CTSTARPOINT

Type	Range/Enumeration	Default	Optional
String enumeration	BUS; LINE	LINE	No

The grounding of the current transformer star point. The direction is line or busbar.

DIRECTIONAL

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	YES	No

The relay type. It describes if the voltages are incoming or outgoing.

NAME (in subblock **GROUP**)

Type	Range/Enumeration	Default	Optional
String enumeration	LN; LL; I2; I0	-	No

The name of the group from the set of standard group names. A group contains only its name and several protective units. Each group is linked to a group of faults, and represents the relay's response to the faults. There are four groups in the test object:

Group name	Faults in the group
LN	L1N, L2N, L3N
LL	L1L2, L2L3, L3L1, L1L2L3
I2	Negative sequence
I0	Zero sequence

NAME (in subblock **UNIT**)

Type	Range/Enumeration	Default	Optional
String enumeration	I>; I>>; I>>>	-	No

The name of the unit from a set of standard unit names. Currently, I>> and I>>> must be definite time. Because this may change in the future, it should not be implemented in the parser. The checking and transfer function in the module takes care of this.

ACTIVE (in subblock **UNIT**)

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

Indicates if the unit is active or not.

IPICKUP

Type	Range/Enumeration	Default	Optional
Double	0.0... $+\infty$	1.0	No

The pickup current of the unit.

TINDEX

Type	Range/Enumeration	Default	Optional
Double	0.0... $+\infty$	1.0	No

The time index of the unit.

PREDEFCHAR

Type	Range/Enumeration	Default	Optional
String enumeration	DEFTIME; INVERSE; VERY_INVERSE; EXTR_INVERSE	DEFTIME	No

The selection of a pre-defined characteristic. A test module has the following pre-defined characteristics:

- Definite Time
- IEC normally inverse
- IEC very inverse
- IEC extremely inverse

The user is not be able to edit these characteristics or to give the same name to any newly defined characteristic.

CHAR

Type	Range/Enumeration	Default	Optional
String	no restrictions	-	No
Double	-∞... +∞	-	No
Double	-∞... +∞	-	No
Double	-∞... +∞	-	No
Double	-∞... +∞	-	No
Double	-∞... +∞	-	No
Double	-∞... +∞	-	No

The definition for a characteristic based on the IEEE standard equation. The order of parameters is: Name, A, B, P, Q, K1, K2. There are no default values; each parameter must be specified. The IEEE standard equation is defined as followed:

$$t(I_T) = \frac{A \cdot D + K1}{\left(\frac{I_T}{I_S \cdot I_n}\right)^P - A} + B \cdot D + K2$$

$t(I_T)$ is the theoretical tripping time in seconds

CHARI2T

Type	Range/Enumeration	Default	Optional
String	no restrictions	-	No
Double	-∞... +∞	-	No
Double	-∞... +∞	-	No
Double	-∞... +∞	-	No

The definition for a characteristic based on the I2T equation. The order of parameters is: Name, A, P, Q,. There are no default values; each parameter must be specified. The I2T equation is defined as:

$$t(I_T) = A \cdot D \cdot ln \frac{\left(\frac{I_T}{I_S \cdot I_n}\right)^P}{\left(\frac{I_T}{I_S \cdot I_n}\right)^P - Q}$$

$t(I_T)$ is the theoretical tripping time in seconds

NAME (in subblock **TABLE**)

Type	Range/Enumeration	Default	Optional
String	no restrictions	-	No

The name of the table if the definition of I/t characteristics is defined in tabular form. Must be present and cannot be empty.

POINT

Type	Range/Enumeration	Default	Optional
Double	0.0... $+\infty$	-	No
Double	0.0... $+\infty$	-	No

These are the coordinates of one point in the current/time plane if the definition of I/t characteristics may be made in tabular form. For this purpose, the factors I/(In * Is) and the corresponding tripping times (t) are entered, and stored as a table. The points are therefore be defined in times the Ipickup value, which gives the user defined characteristic the same behavior as the others.

Linear interpolation is carried out between the values given.

For those points of the characteristic which are smaller than the first value given, it is considered that the first segment stretches to the left until it reaches the desired point.

For points of the characteristic that are greater than the highest value given, it is considered that the last segment stretches to the right until it reaches the desired point.

The coordinates of one point in the current/time plane.

4.3 Example for Overcurrent

This example shows the overcurrent block with default settings. It has four groups named LN, LL, I2 and I0. Every subblock of kind group has three units named I>, I>> and I>>>. Every unit uses a predefined characteristic PREDEFCHAR. Therefore no tables (user defined), IEEE standard equation and I2T characteristics are used.

```
BEGIN OVERCURRENT
    ACTIVE    YES
    DISPLAY_ABSOLUTE    NO
    DIRECTIONAL    YES
    PTCONN    LINE
    CTSTARPOINT    LINE
    ITOL    5, 0.1
    TTOL    10, 0.1
    BEGIN GROUP
        NAME    LN
        BEGIN UNIT
            NAME    I>
            ACTIVE    YES
            IPICKUP    1
            TINDEX    1
            PREDEFCHAR    INVERSE
        END UNIT
        BEGIN UNIT
            NAME    I>>
            ACTIVE    YES
            IPICKUP    4
            TINDEX    0.1
            PREDEFCHAR    DEFTIME
        END UNIT
        BEGIN UNIT
            NAME    I>>>
            ACTIVE    NO
            IPICKUP    10
            TINDEX    0.05
            PREDEFCHAR    DEFTIME
        END UNIT
    END GROUP
    BEGIN GROUP
        NAME    LL
```

```
        BEGIN UNIT
            NAME    I>
            ACTIVE    YES
            IPICKUP    1
            TINDEX    1
            PREDEFCHAR    INVERSE
        END UNIT
        BEGIN UNIT
            NAME    I>>
            ACTIVE    YES
            IPICKUP    4
            TINDEX    0.1
            PREDEFCHAR    DEFTIME
        END UNIT
        BEGIN UNIT
            NAME    I>>>
            ACTIVE    NO
            IPICKUP    10
            TINDEX    0.05
            PREDEFCHAR    DEFTIME
        END UNIT
    END GROUP
    BEGIN GROUP
        NAME    I2
        BEGIN UNIT
            NAME    I>
            ACTIVE    YES
            IPICKUP    1
            TINDEX    1
            PREDEFCHAR    INVERSE
        END UNIT
        BEGIN UNIT
            NAME    I>>
            ACTIVE    YES
            IPICKUP    4
            TINDEX    0.1
            PREDEFCHAR    DEFTIME
        END UNIT
        BEGIN UNIT
            NAME    I>>>
            ACTIVE    NO
            IPICKUP    10
            TINDEX    0.05
            PREDEFCHAR    DEFTIME
        END UNIT
```

```
    END GROUP
    BEGIN GROUP
        NAME    I0
        BEGIN UNIT
            NAME    I>
            ACTIVE    YES
            IPICKUP    1
            TINDEX    1
            PREDEFCHAR    INVERSE
        END UNIT
        BEGIN UNIT
            NAME    I>>
            ACTIVE    YES
            IPICKUP    4
            TINDEX    0.1
            PREDEFCHAR    DEFTIME
        END UNIT
        BEGIN UNIT
            NAME    I>>>
            ACTIVE    NO
            IPICKUP    10
            TINDEX    0.05
            PREDEFCHAR    DEFTIME
        END UNIT
    END GROUP
END OVERCURRENT
```

Figure 4-1:
Overcurrent general settings

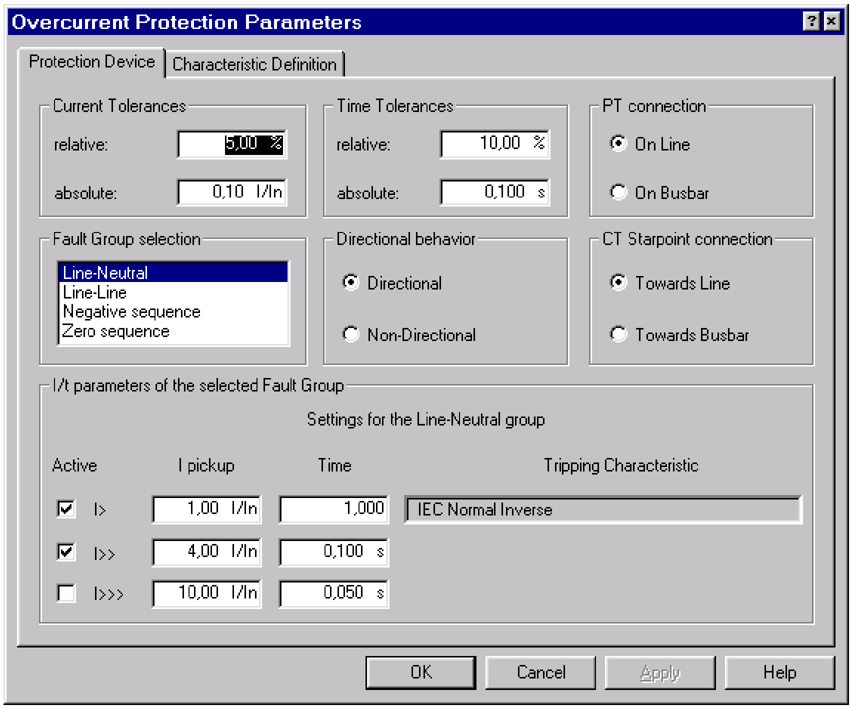


Figure 4-1 shows the general settings and the settings for the Line-Neutral group in the RIO file example. This group is described in the group block with the row “NAME LN”.

5 Basic and Advanced Differential Test Modules

This chapter describes the RIO format of the differential protection. It provides a short overview about the structure and some general information. Then it presents detailed information about the rows and values used in the differential block and its subblocks.

5.1 Structure of the DIFFERENTIAL Block

The DIFFERENTIAL block consists of three subblocks: the LINEDIFF, DIFFBIAS and WINDING.

The DIFFBIAS block has the DIFF, BIAS, and TRIPCHAR subblocks. IDiff>> and IDiff> are defined in the DIFF block within the DIFFBIAS block. The characteristic is created from points in the I_{Diff}/I_{Bias}-plane. Each point is defined by a value I_{Bias} / I_{NPORef} in the x-axis and a value $I_{Diff}/_{INPORef}$ in the y-axis. The representation with points was chosen such that vertical lines (with infinite slope) can be described easily.

The values for IDiff>> / IDiff> provided in the DIFF block do not influence the characteristic. The differential protection software limits the defined characteristic at IDiff>> and IDiff>, because these are the upper and lower limit lines.

In the DIFFBIAS tripping characteristic, only START, LINE, and STOP statements may appear. This is particularly important for future format definitions, because no new keywords/statements may be inserted in this section. Between the characteristic keywords, only empty lines and comments are allowed. However, it is not recommended to use them, because they are not copied to the output file by the parser. If any unknown statements occur in the characteristic block, the parser invalidates the whole characteristic.

The sequence order of the START, LINE, and STOP statements is fixed. Hence, the START statement must appear first, the optional LINE statement(s) second, and the optional STOP statement third. In the DIFFBIAS block, only one characteristic may be defined.

The harmonic characteristic is defined in the CHARHARM subblock of the BIAS block. Just as in the DIFFBIAS tripping characteristic, the sequence order of the START, LINE, and STOP statements is fixed. However, CHARHARM permits more than one characteristic to be defined.

If each line segment is defined with its starting point and its slope, no START or STOP commands are needed. This definition cannot be mixed with the definition with START and STOP.

Example: LINESLOPE 1.0,0.2, 1.0

- First Parameter: I_{Bias} /I_{NPO} Ref of the starting point
- Second Parameter: I_{Diff}/I_{NPO} Ref of the starting point
- Third Parameter: Slope of the line segment

For steps, the starting point of the second line is defined lying above or below the previous line. The last line segment can be defined with slope 0.0 for characteristics which are limited at the top.

The winding block can appear multiple times and has a basic structure. No other subblocks are used within the WINDING block. Please note that every row of this block must appear once.

The LINEDIFF subblock has a simple structure. The block and its rows have a minimum and maximum cardinality of one. This means they must appear once in the RIO definition of differential device.

Table 5-1:
Differential structure

Keyword	Min	Max	Refer to
BEGIN DIFFERENTIAL	0	1	
ACTIVE	1	1	page 72
WINDING-COUNT	0	1	page 72
REF-WINDING	0	1	page 72
OBJECT-TYPE	0	1	page 72
ITOL	0	1	page 72
TTOL	0	1	page 73
TREF	0	1	page 73
TRET	0	1	page 73
TMAX	0	1	page 73
IREF	0	1	page 73
USECT	0	1	page 73
CONVRELAY	0	1	page 74
BEGIN WINDING	0	no limit	
NAME	1	1	page 74
INULL_ELIMINATION	1	1	page 74
CONNECTION	1	1	page 74
CONNECTIONNUMBER	1	1	page 74
NOM-PD-PH	1	1	page 74
NOM-CT-PH	1	1	page 75
GROUNDING-CT-PH	1	1	page 75

Keyword	Min	Max	Refer to
NOM-PD-N	1	1	page 75
NOM-CT-N	1	1	page 75
GROUNDING-CT-N	1	1	page 75
VN	1	1	page 75
SN	1	1	page 76
GROUNDING-TRF	1	1	page 76
END WINDING			
BEGIN DIFFBIAS	0	1	
ACTIVE	1	1	page 76
BEGIN DIFF	1	1	
IDIFF>>	1	1	page 76
TDIFF>>	1	1	page 76
IDIFF>	1	1	page 76
TDIFF>	1	1	page 77
END DIFF			
BEGIN BIAS	1	1	
DEFBIAS	1	1	page 77
BIASDIVISOR	1	1	page 77
TOLHARM	0	1	page 77
BEGIN CHARHARM	0	no limit	
ORDER-HARM	1	1	page 77
DELAY-HARM	1	1	page 78
START	1	1	page 78
LINE	0	0	page 78
STOP	1	1	page 78
END CHARHARM			
END BIAS			
BEGIN TRIPCHAR	1	1	
START	0	1	page 78
LINE	0	no limit	page 78
STOP	0	1	page 78
END TRIPCHAR			
END DIFFBIAS			
BEGIN LINEDIFF	1	1	
ACTIVE	1	1	page 79
METHOD	1	1	page 79
I-PICKUP>	1	1	page 79
D-PHI	1	1	page 79
TTRIP>	1	1	page 79
END LINEDIFF			
END DIFFERENTIAL			

5.2 Row and Value Descriptions

ACTIVE

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

Indicates if the device is active or not.

WINDING-COUNT

Type	Range/Enumeration	Default	Optional
Integer	0... +∞	2	No

The number of windings. Up to three windings may be defined. Further definitions are read by the parser (without any error message) and inserted in the internal data structure. Whether or not the data is used depends on the test module. An error message is shown, if the number of defined windings is not the same as defined in the WINDING-COUNT statement.

REF-WINDING

Type	Range/Enumeration	Default	Optional
String	no restrictions	-	No

The reference winding.

OBJECT-TYPE

Type	Range/Enumeration	Default	Optional
String enumeration	TRANSFORMER; GENERATOR; BUSBAR; MOTOR	TRANSFORMER	No

The type of the protected object.

ITOL

Type	Range/Enumeration	Default	Optional
Double	0.0... 100.0	2.0	No
Double	0.0... +∞	0.05	No

The tolerance of the current of the device. It can be set in relative in percent or absolute.

TTOL

Type	Range/Enumeration	Default	Optional
Double	0.0... 100.0	3.0	No
Double	0.0... +∞	0.01	No

The time tolerance of the device. It can be set relative in percent or absolute in seconds.

TREF

Type	Range/Enumeration	Default	Optional
String enumeration	FAULT; GSTART	FAULT	No

The time reference of the fault inception (FAULT) or the general starting (GSTART).

TRET

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.25	No

The reset delay time of the protection device.

TMAX

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	1.5	No

IREF

Type	Range/Enumeration	Default	Optional
String enumeration	INOM-PO; INOM-CT	INOM-PRO	No

Norming of the relays to

- INOM-PRO: the protected object nominal current
- INOM-CT: the current transformer nominal current

USECT

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

YES if the ct grounding inputs should be used. Otherwise NO.

CONVRELAY

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

YES if the transformer model should be deactivated. Otherwise NO.

NAME

Type	Range/Enumeration	Default	Optional
String	no restrictions		No

The name of the winding.

INULL-ELIMINATION

Type	Range/Enumeration	Default	Optional
Integer	0... +∞	0	No

The I0 elimination of the protection device.

CONNECTION

Type	Range/Enumeration	Default	Optional
String enumeration	Y; D; Z	Y	No

The connection of the P0 winding.

CONNECTIONNUMBER

Type	Range/Enumeration	Default	Optional
Integer	0... 11	0	No

The connection number of the P0 winding.

NOM-PD-PH

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	-	No

The nominal current of the protection device current transformer.

NOM-CT-PH

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	-	No

The nominal primary current of the protection device current transformer.

GROUNDING-CT-PH

Type	Range/Enumeration	Default	Optional
String enumeration	BUS; TRANSFORMER	TRANSFORME R	No

The star point grounding of the current transformer. Can be BUS which means internal -1 or TRANSFORMAR which means internal +1.

NOM-PD-N

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	-	No

The nominal primary current of the ground current transformer.

NOM-CT-N

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	-	No

The nominal primary current of the ground current transformer.

GROUNDING-CT-N

Type	Range/Enumeration	Default	Optional
String enumeration	BUS; TRANSFORMER	TRANSFORME R	No

The star point grounding of the ground current transformer. Can be GROUND which means internal -1 or TRANSFORMER which means internal +1.

VN

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No

The nominal voltage of the winding.

SN

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No

The nominal power of this winding in watt.

GROUNDING-TRF

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

Indicates if the star point is grounded.

ACTIVE

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

Indicates if the Diffbias is active or not.

IDIFF>>

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No

The higher differential current in I/I_{NPO}

TDIFF>>

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No

The higher differential pick-up time.

IDIFF>

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No

The differential current in I/I_{NPO}

TDIFF>

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No

The differential current pickup time.

DEFBIAS

Type	Range/Enumeration	Default	Optional
Integer	0... +∞	1	No

The definition of the tripping characteristic related to I_{NPO}:

- Bias = $|I_P+I_S|$ / d
- Bias = $|I_P+I_S|$/d
- Bias = ($|I_P|+|I_S|$ * K) / d
- Bias = max(I_P, I_S)
- Bias = sqrt (I_P* I_S * cos(a))

d stands for the divisor. Refer to BIASDIVISOR.

BIASDIVISOR

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	1.0	No

The divisor for the DEFBIAS statement.

TOLHARM

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.1	No
Double	0.0... 100.0	3.0	No

The tolerance absolute and relative.

ORDER-HARM

Type	Range/Enumeration	Default	Optional
Integer	0... +∞	-	No

The order of the harmonic characteristic.

DELAYHARM

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No

The time delay.

START

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	-	No
Double	0.0... +∞	-	No

The first point of the harmonic or the tripping characteristic. The START statement is required in the characteristic in any case. In a tripping characteristic, the (double) parameters d_1, d_2 specify the START point, where d_1 is the I_{Bias}/I_{NPO} and d_2 the I_{Diff}/I_{NPO} reference value.

LINE

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	-	No
Double	0.0... +∞	-	No

With a LINE statement, the next line-segment of the characteristic is defined. The LINE statement(s) are optional and may appear multiple times. The starting point of the line is defined by START point or by the endpoint of the previous last line. The (double) parameters d_1, d_2 specify the endpoint of this line. In the case of a tripping characteristic, d_1 is the I_{BIAS}/I_{NPO} and d_2 the I_{DIFF}/I_{NPO} reference value.

STOP

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	-	No
Double	0.0... +∞	-	No

The endpoint of the harmonic or tripping characteristic. In case of tripping I_{BIAS}/I_{NPO}, I_{DIFF}/I_{NPO}. As the LINE statement, the STOP statement is optional, too. If STOP is left out, the characteristic is not limited at its top. Then the characteristic continues infinitely in the direction which is given by the last line. If the STOP statement is left out, at least one LINE **must** be specified.

ACTIVE

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

Indicates if the line protection is active or not.

METHOD

Type	Range/Enumeration	Default	Optional
String enumeration	CURRENT; ANGLE	CURRENT	No

Switch between current comparison or phase angle comparison.

I-PICKUP>

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No

The pickup value of the phase current I/I_{NPD}

D-PHI

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No

The differential angle between I_P and I_S for non-tripping.

TTRIP>

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.0	No

The command time.

5.3 Example for Differential

The following shows an example of a differential block.

BEGIN DIFFERENTIAL

```
ACTIVE    YES
WINDING-COUNT    2
REF-WINDING    "PRIMARY"
OBJECT-TYPE    TRANSFORMER
ITOL    2, 0.05
TTOL    3, 0.01
TREF    FAULT
TRET    0.25
TMAX    1.5
IREF    INOM-PO
BEGIN WINDING
    NAME    "PRIMARY"
    INULL-ELIMINATION    2
    CONNECTION    Y
    CONNECTIONNUMBER    0
    NOM-PD-PH    1
    NOM-CT-PH    200
    GROUNDING-CT-PH    TRANSFORMER
    NOM-PD-N    1
    NOM-CT-N    200
    GROUNDING-CT-N    TRANSFORMER
    VN    115500
    SN    4E+007
    GROUNDING-TRF    NO
END WINDING
BEGIN WINDING
    NAME    "SECONDARY"
    INULL-ELIMINATION    2
    CONNECTION    Y
    CONNECTIONNUMBER    0
    NOM-PD-PH    1
    NOM-CT-PH    800
    GROUNDING-CT-PH    TRANSFORMER
    NOM-PD-N    1
    NOM-CT-N    800
    GROUNDING-CT-N    TRANSFORMER
    VN    30000
    SN    4E+007
    GROUNDING-TRF    NO
END WINDING
```

```
        BEGIN DIFFBIAS
            ACTIVE    YES
            BEGIN DIFF
                IDIFF>>    2
                TDIFF>>    0.023
                IDIFF>    0.5
                TDIFF>    0.03
            END DIFF
            BEGIN BIAS
                DEFBIAS    1
                BIASDIVISOR    1
                TOLHARM    0.1, 3
                BEGIN CHARHARM
                    ORDER-HARM    2
                    DELAYHARM    0.1
                    START    20, 0.5
                    STOP    20, 2
                END CHARHARM
                BEGIN CHARHARM
                    ORDER-HARM    5
                    DELAYHARM    0.15
                    START    45, 0.5
                    STOP    45, 2
                END CHARHARM
            END BIAS
            BEGIN TRIPCHAR
                START    0, 0.4
                LINE    5, 1
                STOP    9, 2.2
            END TRIPCHAR
        END DIFFBIAS
        BEGIN LINEDIFF
            ACTIVE    NO
            METHOD    CURRENT
            I-PICKUP>    0
            D-PHI    0
            TTRIP>    0
        END LINEDIFF
    END DIFFERENTIAL
```

Figure 5-1 shows the settings for the two defined windings in the RIO file example.

Figure 5-1:
First differential winding settings.

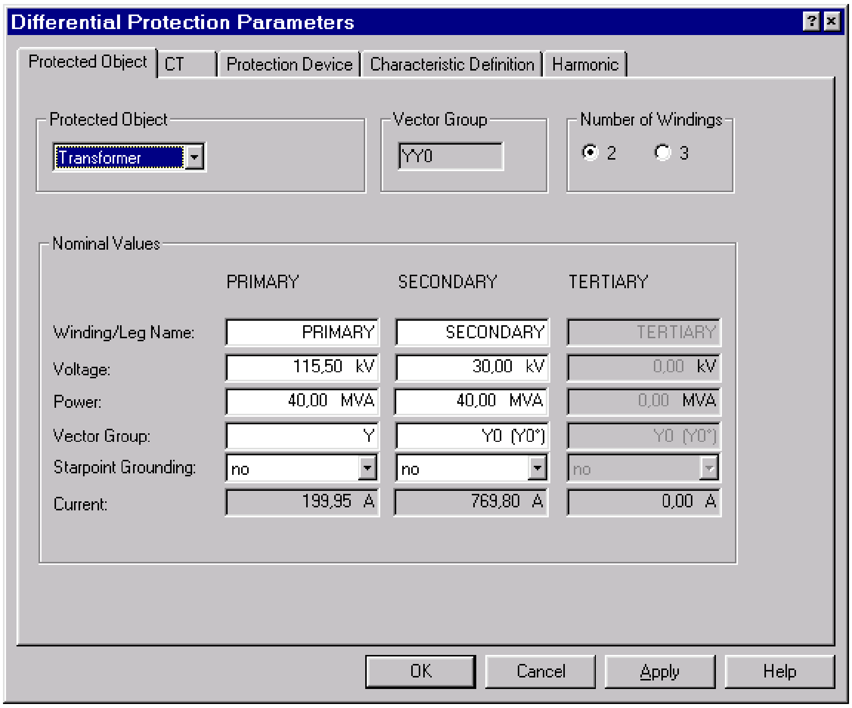


Figure 5-2 shows the CT-parameters in the primary and secondary winding block. The USECT settings are mapped to the “Use Ground Current Measurement Inputs (CT) checkbox.

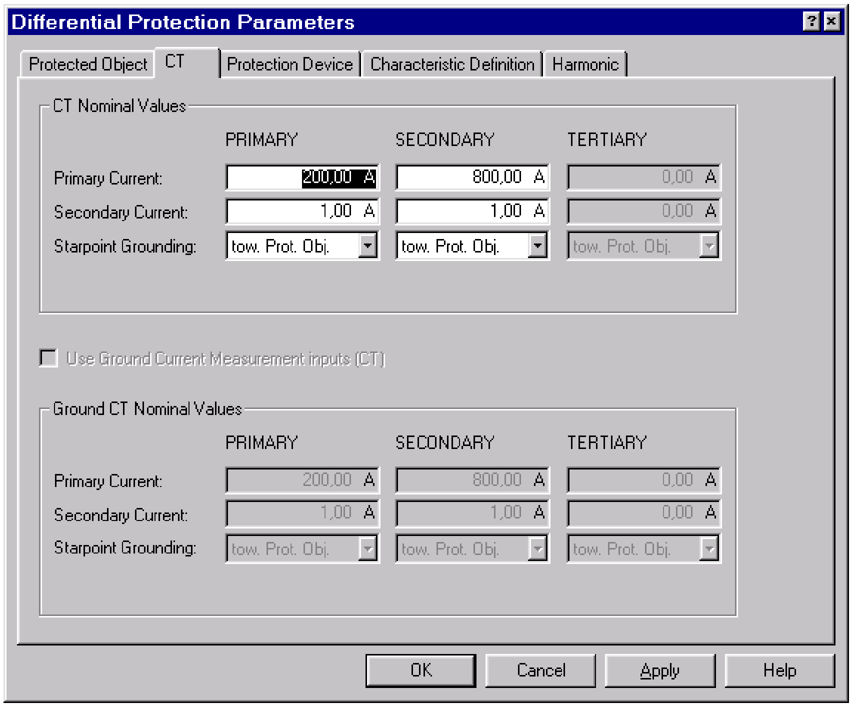


Figure 5-2:
Second differential winding settings

Figure 5-3 shows the general settings. They are set between the BEGIN DIFFERENTIAL and BEGIN WINDING delimiters. The CONRELAY settings are shown in the “no Transformer Model(deactivated)” checkbox.

Figure 5-3:
Differential general settings

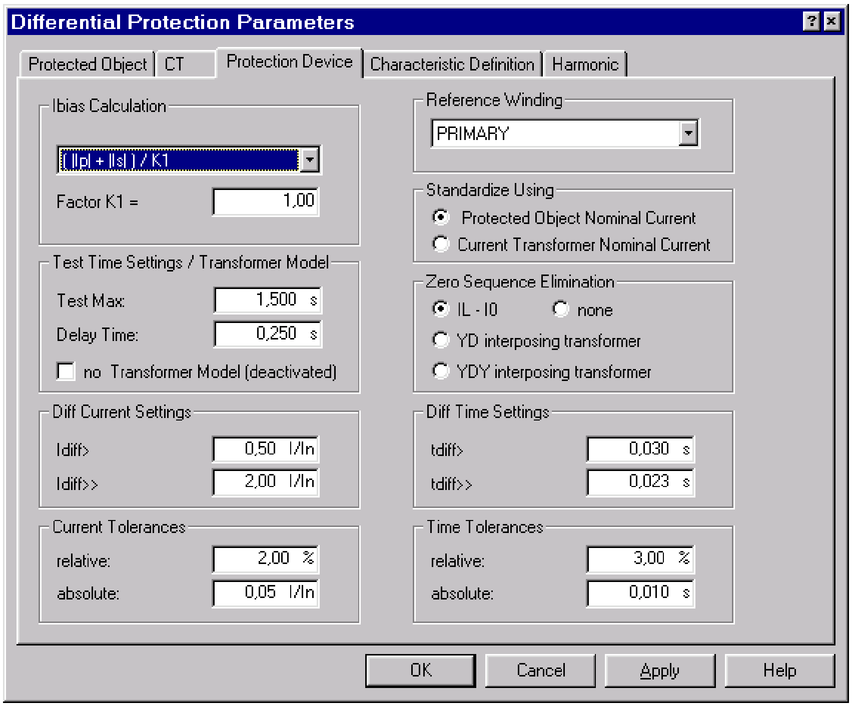


Figure 5-4 shows the corresponding dialog box for the TRIPCHAR block.

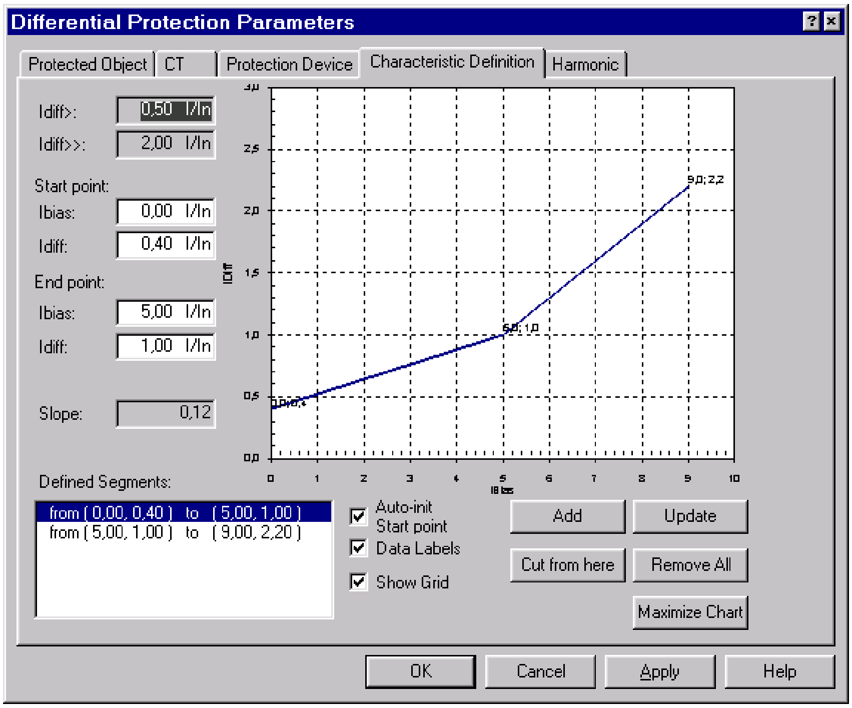
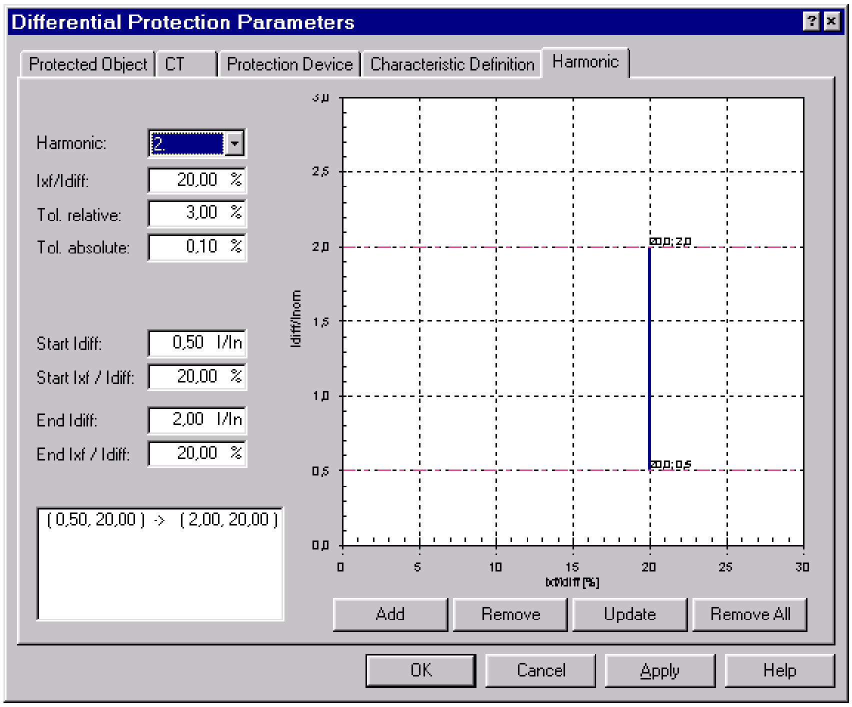


Figure 5-4:
Differential bias
characteristic

Figure 5-5 shows the harmonic settings as defined in the BIAS block, as well as the second harmonic. It is defined in the CHARHARM block which is a subblock of the BIAS block.

Figure 5-5:
Differential harmonic restraint settings.



6 Meter Test Module

The meter test module checks many types of single function or multifunctional energy meters. It includes load test, no load test, creep test, and count mechanism test. In the following the RIO block of the meter test module will be described.

6.1 Structure of the METER Block

The METER block has a simple structure. There are no relationships and subblocks specified. The ACTIVE row is required, while all other rows are optional and can only appear once.

Table 6-1:
Meter structure

Keyword	Min	Max	Refer to
BEGIN METER	0	1	
ACTIVE	1	1	Section
TYPE	0	1	Section
DIRECTION	0	1	Section
QUADRANT	0	1	Section
PULSE_TYPE	0	1	Section
CERTIFIED	0	1	Section
CLASS	0	1	Section
PULSES_PER_REV	0	1	Section
SETTLING	0	1	Section
CONSTANT	0	1	Section
V_PRIM	0	1	Section
V_SEC	0	1	Section
I_PRIM	0	1	Section
I_SEC	0	1	Section
END METER			

6.2 Row and Value Descriptions

ACTIVE

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	YES	No

Indicates if the test module is active or not.

TYPE

Type	Range/Enumeration	Default	Optional
String enumeration	MULTIFUNCTION; W_H; VAR_H; VA_H; V2_H; V_H; I2_H; I_H	W_H	No

Describes the type of the meter test module.

DIRECTION

Type	Range/Enumeration	Default	Optional
String enumeration	IMPORTING; EXPORTING; BIDIRECTIONAL	EXPORTING	No

Specifies the energy direction. This setting applies only if either meter type W_H or VAR_H was selected in the row TYPE.

QUADRANT

Type	Range/Enumeration	Default	Optional
String enumeration	Q1; Q2; Q3; Q4; Q_ALL	Q_ALL	No

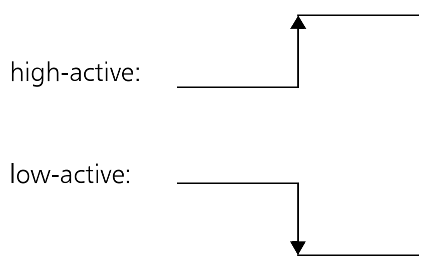
Specifies the quadrant 1, 2, 3, 4 or all. This setting applies if an apparent power meter (VA_H) was selected in the row TYPE.

PULSE_TYPE

Type	Range/Enumeration	Default	Optional
String enumeration	RISING; FALLING	RISING	No

Specifies the edge of the meter pulse which is considered by the hardware as the moment of the pulse. Rising means high-active, falling means low-active.

Figure 6-1:
Pulse type



CERTIFIED

Type	Range/Enumeration	Default	Optional
String	no restrictions		No

Specifies the entry that will late appear as "Certified". Principally, this can be any user-defined alphanumerical entry. It is recommended, however, to enter the certification date and / or code of series test of the respective energy meter.

CLASS

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.5	No

Specifies the meter class (serves as default value for the tolerance).

PULSES_PER_REV

Type	Range/Enumeration	Default	Optional
Integer	0... +∞	1	No

Specifies the number of pulses that are emitted during one full revolution of the disk.

SETTLING

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	5.0	No

The settling time is the time to allow the meter to establish a stable operating state. Enter the settling time as stated in the meter's data sheet. Pre-defined default value: 5 seconds. If there is no data sheet available, leave the default value.

CONSTANT

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	-	No

The meter's constant in pulses per measured unit, secondary

V_PRIM

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	100.0	No

Specifies the primary side value of the potential transformer.

V_SEC

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	100.0	No

Specifies the secondary side value of the potential transformer.

I_PRIM

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	1.0	No

Specifies the primary side value of the potential transformer in A.

I_SEC

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	1.0	No

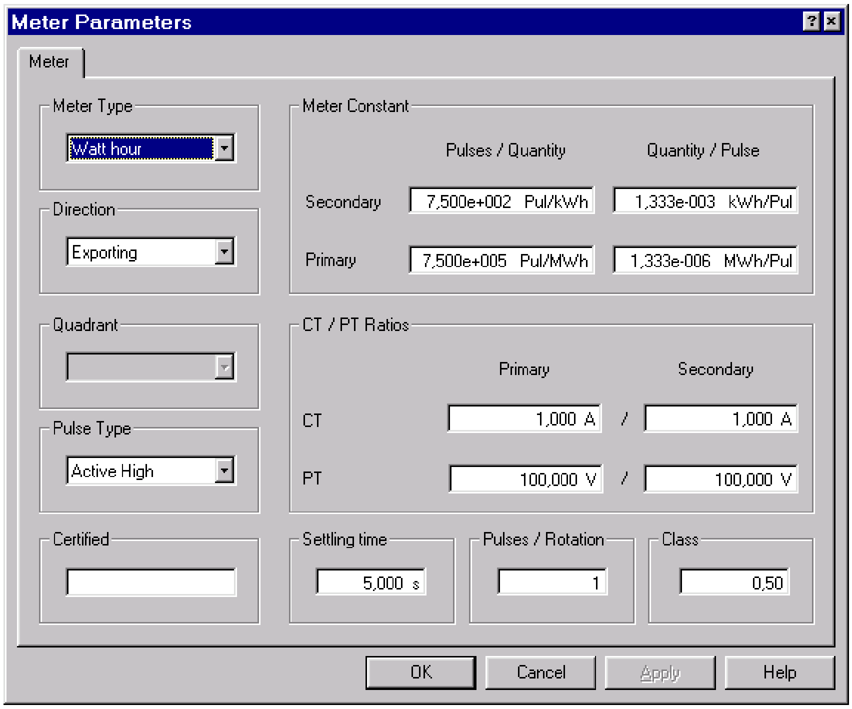
Specifies the secondary side value of the potential transformer in A.

6.3 Example for Meter

The following shows an example of the meter block and its associated dialog box (Figure 6-2).

```
BEGIN METER
    ACTIVE    YES
    TYPE    W_H
    DIRECTION    EXPORTING
    QUADRANT    Q_ALL
    PULSE_TYPE    RISING
    CERTIFIED
    CLASS    0.5
    PULSES_PER_REV    1
    SETTLING    5
    CONSTANT    750
    V_PRIM    100
    V_SEC    100
    I_PRIM    1
    I_SEC    1
END METER
```

Figure 6-2:
Meter settings



7 Synchronizer Test Module

Synchronization relays are used to assist:

- connecting a generator to the network or power grid;
- reestablishing the connection between two parts of the network;
- manually closing of breakers, and
- performing a synchronism check.

Synchronizing relays are designed to measure two voltages with respect to phase angle, frequency, and magnitude to safeguard against the interconnection of two unsynchronised systems. Synchronizing relays are also used in switching operations to link two parts of a system which are already synchronously connected via other paths in the system. Auto-reclose is a good example of such a switching operation.

7.1 Structure of the SYNCHRO Block

The rows of the SYNCHRO block correspond to the parameters of the system settings page of the synchronizing testobject and establishe settings for the systems that are to be synchronized. The Synchronizer Test Module can match 1-phase-to-1-phase, 1-phase-to-3-phase, 3-phase-to-1-phase, or 3-phase-to-3-phase. Moreover, the phases can be in a Wye or Delta configuration. System 1 is always considered the reference system.

The CHARSYNC subblock reflects the settings of the synchronizing tab in the testobject page. These parameters provide more details regarding how the synchronizing relay is configured for the application. Coupling of System 1 and System 2 through the circuit breaker is only permitted after synchronization to within the specified voltage, frequency, and phase ranges.

Table 7-1:
Synchronizing structure

Keyword	Min	Max	Refer to
BEGIN SYNCHRO	0	1	
ACTIVE	1	1	Section
TCBCLOSE	1	1	Section
TG_PHASE_SHIFT	1	1	Section
STARTING	1	1	Section
PHASE-SEQUENCE1	1	1	Section
PHASE-SYSTEM1	1	1	Section
PHASE-SEQUENCE2	1	1	Section
PHASE-SYSTEM2	1	1	Section
BEGIN CHARSYNC	1	1	
D-VMAX	1	1	Section

Keyword	Min	Max	Refer to
D-VMIN	1	1	Section
VTOLABS	1	1	Section
VTOLREL	1	1	Section
D-FMAX	1	1	Section
D-FMIN	1	1	Section
FTOLABS	1	1	Section
FTOLREL	1	1	Section
D-PHASEANGLE	1	1	Section
PHASEANGLE-TOLABS	1	1	Section
PHASEANGLE-TOLREL	1	1	Section
INNER_LIMIT	1	1	Section
OUTER_LIMIT	1	1	Section
END CHARSYNC			
END SYNCHRO			

7.2 Row and Value Descriptions

ACTIVE

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	YES	No

Indicates if the test module is active or not.

TCBCLOSE

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.1	No

This is the elapsed time between output of the CB close command and the actual closing of the circuit breaker. This is used to calculate the expected phase angle difference between the two systems at the time of the CB closure.

TG_PHASE_SHIFT

Type	Range/Enumeration	Default	Optional
Double	-360 ... +360	0.0	No

This value specify the phase shift (if any) coming from an optional block or coupling transformer. This value is given in degrees from +/-360 degrees.

STARTING

Type	Range/Enumeration	Default	Optional
String enumeration	PULSE; CONTINUOUS; NONE	PULSE	No

This defines the type of start signal to be applied to the test object after the pre-synchronization time. When set to pulse, a 50 ms start pulse is output at the same time that the maximum synchronization time starts. When set to continuous, the start signal is active during the maximum synchronization and post synchronization times. This also defines the type of release signal to be applied either at the end of the max-synchronization time (test fail) or at the end of the post-synchronization time (test pass).

PHASE-SEQUENCE1

Type	Range/Enumeration	Default	Optional
String enumeration	L1L2L3; L1L3L2	L1L2L3	No

This setting describes the direction of the phase rotation: either L1-L2-L3 or L1-L3-L2.

PHASE-SYSTEM1

Type	Range/Enumeration	Default	Optional
String enumeration	L1N; L2N; L3N; L1L2; L2L3; L3L1; L1L3; L3L2; L2L1; L1L2L3; L1L3L2; L12L23L31; L13L32L21	L1L2	No

The phase or phases from the system to use for synchronization and whether they are Wye or Delta. Systems 1 and 2 must be configured either both as Wye or both as Delta. When testing Wye, you can configure any combination of line-to-neutral voltages going from System 1 to System 2. Likewise when testing Delta, you can configure any combination of line-to-line going from System 1 to System 2.

PHASE-SEQUENCE2

Type	Range/Enumeration	Default	Optional
String enumeration	L1L2L3; L1L3L2	L1L2L3	No

Section

PHASE-SYSTEM2

Type	Range/Enumeration	Default	Optional
String enumeration	L1N; L2N; L3N; L1L2; L2L3; L3L1; L1L3; L3L2; L2L1; L1L2L3; L1L3L2; L12L23L31; L13L32L21	L1L2	No

Section

D-VMAX

Type	Range/Enumeration	Default	Optional
Double	0.0 ... +∞	2.0	No

System 1 and System 2 are required to have approximately the same voltage at the moment of synchronism and actual CB closure.

A maximum overvoltage (D-VMAX) and undervoltage (D-VMIN Section)) can be entered for the difference in System 1 and System 2 voltages. In addition, the over- and undervoltages can have a tolerance . The tolerances can be entered as either an absolute value (Section) in volts or as a percentage of the (DV) value (Section). If both an absolute and relative tolerance is specified, the larger of the two is used.

D-VMIN

Type	Range/Enumeration	Default	Optional
Double	0.0 ... -∞	-2.0	No

Section

VTOLABS

Type	Range/Enumeration	Default	Optional
Double	0.0 ... +∞	0.06	No

Section

VTOLREL

Type	Range/Enumeration	Default	Optional
Double	0.0 ... 100	3.0	No

Section

D-FMAX

Type	Range/Enumeration	Default	Optional
Double	0.0 ... +∞	0.1	No

System 1 and System 2 are required to have the same frequency at the moment of synchronism and actual CB closure.

A maximum above synchronous (D-FMAX) and subsynchronous (D-FMIN (Section)) value can be entered for the difference in System 1 and System 2 frequencies. In addition, these frequencies can have a tolerance. The tolerances can be entered as either an absolute value (Section) in volts or as a percentage of the (DF) value (Section). If both an absolute and relative tolerance is specified, the larger of the two is used.

D-FMIN

Type	Range/Enumeration	Default	Optional
Double	0.0 ... - ∞	-0.1	No

Section

FTOLABS

Type	Range/Enumeration	Default	Optional
Double	0.0 ... +∞	0.003	No

Section

FTOLREL

Type	Range/Enumeration	Default	Optional
Double	0.0... +100	3.0	No

Section

D-PHASEANGLE

Type	Range/Enumeration	Default	Optional
Double	-360... +360	20.0	No

System 1 and System 2 are required to be in phase after taking into consideration any CB closure delays and coupling transformer phase shifts.

The maximum difference in phase angle between System 1 and System 2 at the moment of synchronism and actual CB closure can be +/-360 degrees.

In addition, the phase difference can have a tolerance. The tolerances can be entered as either an absolute value in degrees (Section)or as a percentage of the value (Section) . If both an absolute and relative tolerance is specified, the larger of the two is used.

PHASEANGLE-TOLABS

Type	Range/Enumeration	Default	Optional
Double	-360 ... + 360	0.6	No

Section

PHASEANGLE-TOLREL

Type	Range/Enumeration	Default	Optional
Double	0.0 ...+100	3	No

Section

INNER_LIMIT

Type	Range/Enumeration	Default	Optional
Double	0.0 ... +∞	0.04	No

Generally, the synchronizing relay controls one of the systems (e.g., a generator) in order to get it to match the reference system in terms of voltage, phase, and frequency. The control signals are V> and V< for raising and lowering the output voltage and f> and f< for raising and lowering the output frequency.

The Dead Zones are areas when the synchronizing relay shout not output any adjustment control command .

The Dead Zones are specified with OUTER_LIMIT and INNER_LIMIT (Section). The Synchronizer Test Module verifies that the entered values are within the upper and lower limits for above synchronous and subsynchronous operation.

OUTER_LIMIT

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.08	No

Section

7.3 Example for Synchronizing

The following shows an example of the synchro block and its associated dialog box (also refer to figure 7-1 and figure 7-2).

```
BEGIN SYNCHRO
    ACTIVE    YES
    TCBCLOSE    0.1
    TG_PHASE_SHIFT    0
    STARTING    PULSE
    PHASE-SEQUENCE1    L1L2L3
    PHASE-SYSTEM1    L1L2
    PHASE-SEQUENCE2    L1L2L3
    PHASE-SYSTEM2    L1L2
    BEGIN CHARSYNC
        D-VMAX    2
        D-VMIN    -2
        VTOLABS    0.06
        VTOLREL    3
        D-FMAX    0.1
        D-FMIN    -0.1
        FTOLABS    0.003
        FTOLREL    3
        D-PHASEANGLE    20
        PHASEANGLE-TOLABS    0.6
        PHASEANGLE-TOLREL    3
        INNER_LIMIT    0.04
        OUTER_LIMIT    0.08
    END CHARSYNC
END SYNCHRO
```

Figure 7-1:
Synchro settings System Parameters

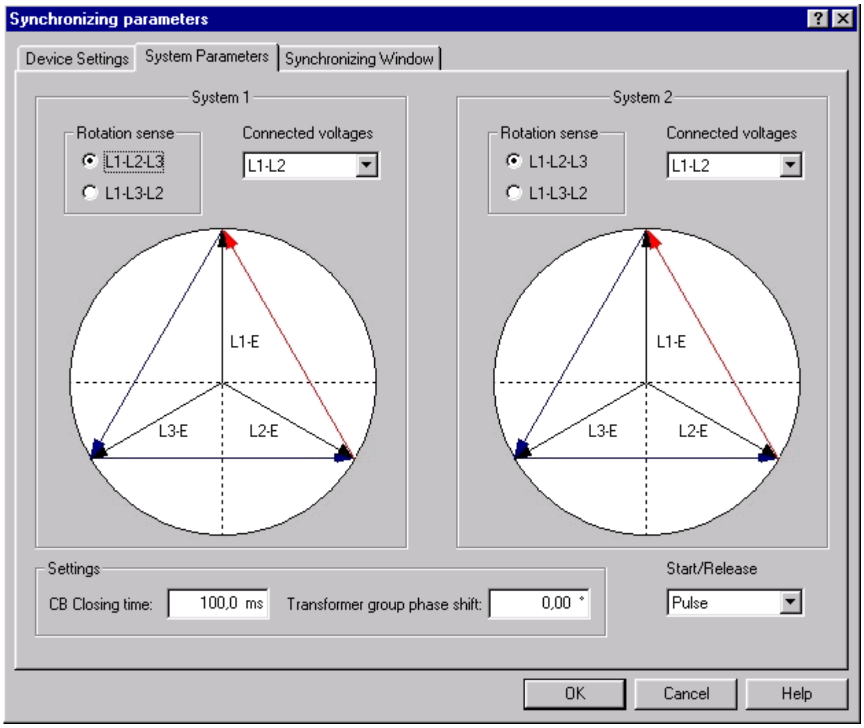
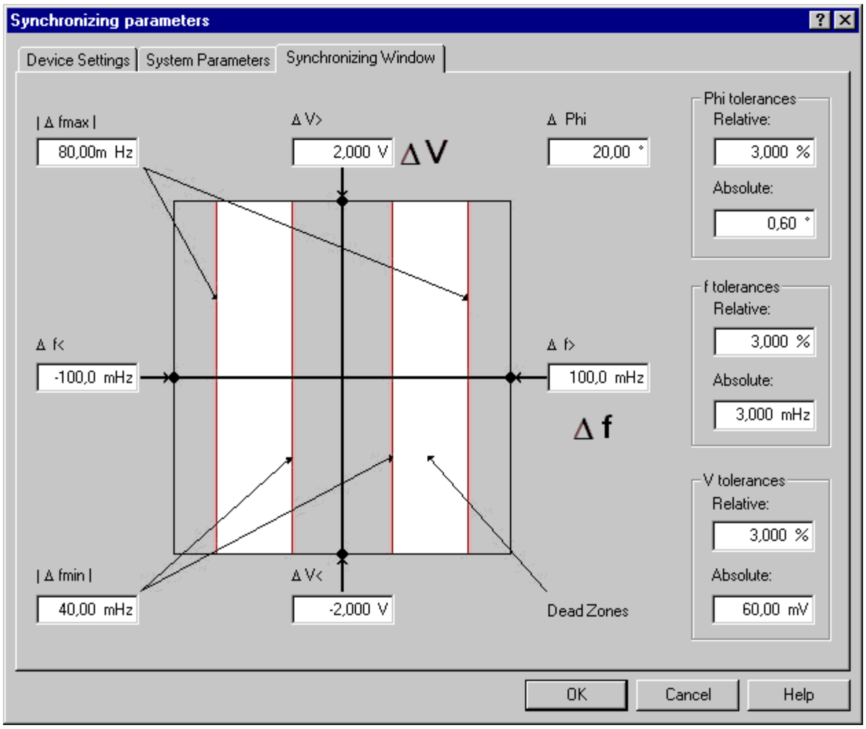


Figure 7-2:
Synchro settings
Synchronizing Window



8 Transducer Test Module

Transducers are used for precision electrical measurement and control. They are used across industry sectors such as electrical utilities, switchgear / switchboard manufacturers, energy management, building management and control, process control, and instrumentation. They provide local and remote indication in conjunction with instruments, recorders, and data loggers. Moreover, transducers with high accuracy and reliability are becoming increasingly important features in the provision of cost effective system control.

8.1 Structure of the TRANSDUCER Block

The transducer block could have additional subblocks. Every subblock describe a different functionality of the transducer. The functionality block also have a subblock where the charateristic is described. The operating characteristic is how the transducer transforms the input physical quantity to the output physical quantity.

Table 8-1:
Transducer block structure

Keyword	Min	Max	Refer to
BEGIN TRANSDUCER	0	1	
ACTIVE	1	1	Section
TRDCR_OUT	1	1	Section
ANGLE_REF	1	1	Section
ERROR_REF	1	1	Section
SETTLING	1	1	Section
BEGIN FUNCTION	1	no limit	
TYPE	1	1	Section
TOLERANCE	1	1	Section
PHASES	1	1	Section
BEGIN CHAR	0	1	
TYPE	1	1	Section
SYMMETRICAL	1	1	Section
MIN_INP	1	1	Section
MIN_OUT	1	1	Section
KNEE_INP	1	1	Section
KNEE_OUT	1	1	Section
MAX_INP	1	1	Section
MAX_OUT	1	1	Section
SAT_OUT	1	1	Section
END CHAR			
END FUNCTION			
END TRANSDUCER			

8.2 Row and Value Descriptions

ACTIVE

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	YES	No

Indicates if the test module is active or not.

TRDCR_OUT

Type	Range/Enumeration	Default	Optional
String enumeration	VOLTAGE; CURRENT	CURRENT	No

Define whether the transducer to be tested outputs DC voltage (0...10V) or DC current (0...20mA).

ANGLE_REF

Type	Range/Enumeration	Default	Optional
String enumeration	VOLTAGE; CURRENT	CURRENT	No

This setting reflects the method with which the power system phase angle is calculated. When the angle reference is Voltage, the angle is calculated as Phi(I) - Phi(V). When the angle reference is Current, the angle is calculated as Phi(V) - Phi(I).

ERROR_REF

Type	Range/Enumeration	Default	Optional
String enumeration	ZERO_MAX; MAX_MAX	ZERO_MAX	No

The full scale error refers to the maximum value of the transducer's operating characteristic... (as set in the Tr-Input entry field "Maximum value").

This selection is only enabled, if a symmetrical characteristic was chosen; else "0...+max." is set by default and cannot be changed.

For a transducer with a symmetrical characteristic, it can be defined whether the full scale error relates to the range 0...+max. or to -max...+max.

SETTLING

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	1.0	No

The settling time elapses before a test point is executed. In test mode "Auto Stepping", this parameter determines the time per step for each sweep.

TYPE

Type	Range/Enumeration	Default	Optional
String enumeration	ACT_PWR; REACT_PWR; FREQUENCY; APP_PWR; PWR_FACTOR; LF_TRDCR; VV_PHASE; II_PHASE; VI_PHASE; AC_CURRENT; AC_VOLTAGE; DC_CURRENT; DC_VOLTAGE; DC_PWR	ACT_PWR	No

This value describes the functionality of the transducer

TOLERANCE

Type	Range/Enumeration	Default	Optional
Double	0.0... +∞	0.5	No

Defines the maximum full scale error for the respective specific quantity. If a multifunctional transducer was chosen, it is possible to define a specific tolerance for each of the functions.

With the exception of the Frequency tab (value in mHz), the tolerance is defined in %.

PHASES

Type	Range/Enumeration	Default	Optional
Integer enumeration	1; 3	3	No

Specify whether your transducer operates with one phase or three phases.

TYPE

Type	Range/Enumeration	Default	Optional
String enumeration	SINGLE; COMPOUND; QUADRATIC	SINGLE	No

The operating characteristic reflects how the transducer transforms the input physical quantity to the output physical quantity. Transducer supports three different types of operating characteristics:

- linear operating characteristic
- quadratic operating characteristic
- compound operating characteristic.

A different operating characteristic can be defined for each transducer function.

SYMMETRICAL

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	NO	No

Check here whether or not your transducer's operating characteristic is symmetrical. Whether or not a characteristic is symmetrical depends on the transducer's output range. If you are in doubt, please refer to the transducer's operating instructions.

Input and output definitions are always made for the first quadrant. If the transducer's operating characteristic is symmetrical, the characteristic are mirrored in the third quadrant.

MIN_INP

Type	Range/Enumeration	Default	Optional
Double	$-\infty ... +\infty$	0.0	No

Enter the transducer's minimum input value (e.g. 0.000var input corresponds to 0.00mA output).

MIN_OUT

Type	Range/Enumeration	Default	Optional
Double	$-\infty ... +\infty$	0.0	No

Enter the transducer's minimum output value.

KNEE_INP

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	0.0	No

Only available in case of a compound operating characteristic. The knee point defines the "bend" in the two straight lines of the compound operating characteristic. An example is at 80 % of nominal load. The knee point divides the curve into two different sensitivity ranges. This value defines the knee point input.

KNEE_OUT

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	0.016	No

This value defines the knee point output. Section

MAX_INP

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	173.205	No

Enter the transducer's maximum input values (e.g. 173.205var input correspond to 20mA output).

MAX_OUT

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	0.02	No

Enter the transducer's maximum output values . Section

SAT_OUT

Type	Range/Enumeration	Default	Optional
Double	-∞... +∞	0.22	No

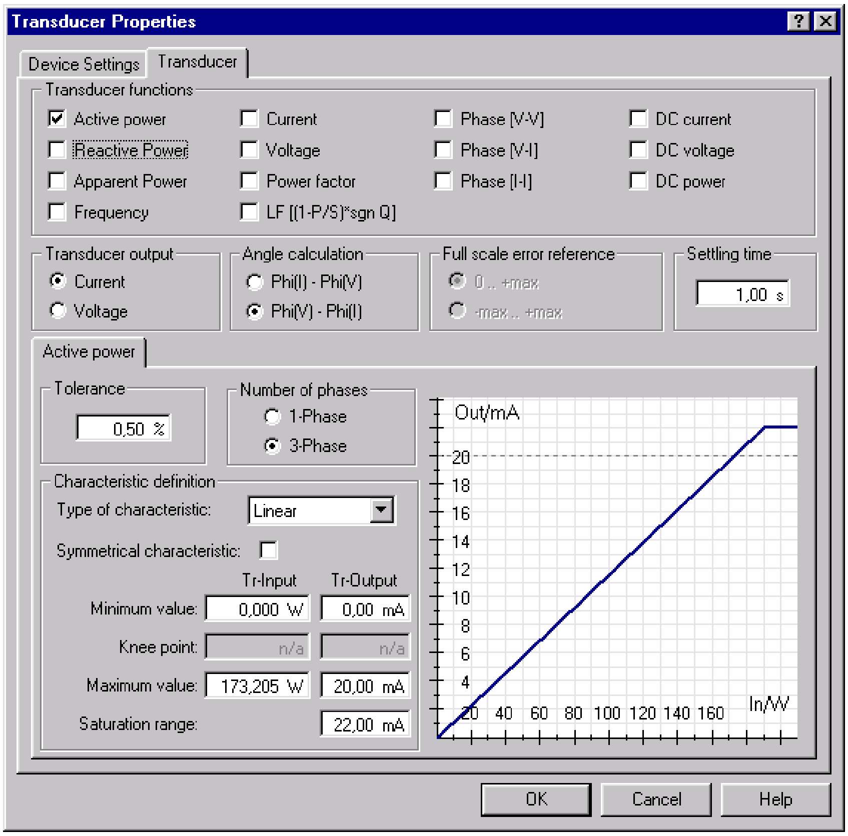
This is the limit of the operating characteristic.

8.3 Example for Transducer

The following shows an example of the transducer block and its associated dialog box (Figure 8-1).

```
BEGIN TRANSDUCER
  ACTIVE    YES
  TRDCR_OUT    CURRENT
  ANGLE_REF    CURRENT
  ERROR_REF    ZERO_MAX
  SETTLING    1
  BEGIN FUNCTION
    TYPE    ACT_PWR
    TOLERANCE    0.5
    PHASES    3
    BEGIN CHAR
      TYPE    SINGLE
      SYMMETRICAL    NO
      MIN_INP    0
      MIN_OUT    0
      KNEE_INP    0
      KNEE_OUT    0.016
      MAX_INP    173.205
      MAX_OUT    0.02
      SAT_OUT    0.022
    END CHAR
  END FUNCTION
END TRANSDUCER
```

Figure 8-1:
Transducer settings



9 VI-Starting Test Module

The test module VI-Starting verifies the characteristic of a voltage-dependent overcurrent starting function (VI-Starting function).

9.1 Structure of the VI-Starting Block

Table 9-1:
VI-Starting structure

Keyword	Min	Max	Refer to
BEGIN VISTARTING	0	1	
ACTIVE	1	1	page 111
ITOL	0	1	page 111
VTOL	0	1	page 112
BEGIN CHARVIS[1]	0	1	
I>	0	1	page 112
I>>	0	1	page 112
VLN(I>)	0	1	page 112
VLN(I>>)	0	1	page 112
VLL(I>)	0	1	page 112
VLL(I>>)	0	1	page 113
END CHARVIS	0	1	
END VISTARTING	0	1	

[1] BEGIN CHARVIS and END CHARVIS denote begin and end of the block for the VI characteristics.

9.2 Row and Value Descriptions

ACTIVE

Type	Range/Enumeration	Default	Optional
Boolean	TRUE (YES); FALSE (NO)	YES	No

Specifies whether the test module is active or not.

ITOL

Type	Range/Enumeration	Default	Optional
Double	0.1 ... 10%	5	No

Specifies the tolerance value of the test current threshold.

VTOL

Type	Range/Enumeration	Default	Optional
Double	0.1 ... 10%	5	No

Specifies the tolerance value of the test voltage threshold.

I>

Type	Range/Enumeration	Default	Optional
Double	0.05 ... I_{max}	0.20A	No

Specifies the first pick-up current threshold (I> stage).

I>>

Type	Range/Enumeration	Default	Optional
Double	0.05 ... I_{max}	1.8A	No

Specifies the second pick-up current threshold (I>> stage).

VLN(I>)

Type	Range/Enumeration	Default	Optional
Double	0.0 ... V_{max}	50.0V	No

Specifies the voltage threshold of the I> stage for line-neutral faults.

VLN(I>>)

Type	Range/Enumeration	Default	Optional
Double	0.0 ... V_{max}	80.0V	No

Specifies the voltage threshold of the I>> stage for line-neutral faults.

VLL(I>)

Type	Range/Enumeration	Default	Optional
Double	0.0 ... V_{max}	50V	No

Specifies the voltage threshold of the I> stage for line-line faults.

VLL(I>>)

Type	Range/Enumeration	Default	Optional
Double	0.0 ... V_{max}	80V	No

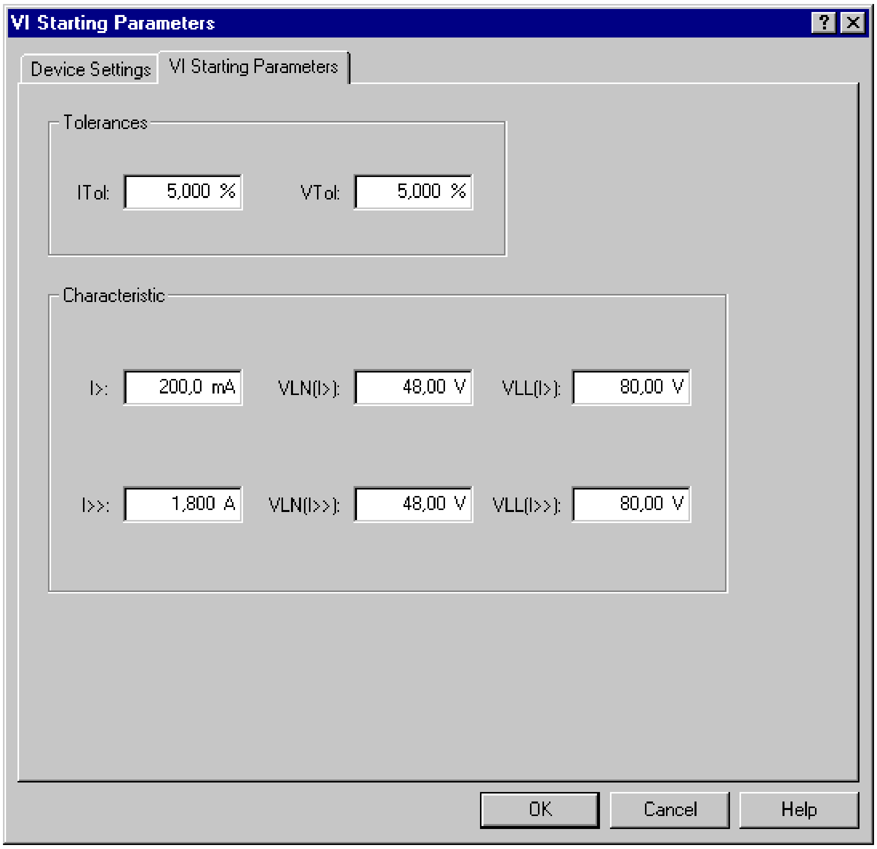
Specifies the voltage threshold of the I>> stage for line-line faults.

9.3 Example for VI-Starting

The following shows an example of the VI-Starting block and its associated dialog box (refer to figure 9-1).

```
BEGIN VISTARTING
    ACTIVE    YES
    ITOL    5
    VTOL    5
    BEGIN CHARVIS
        I>    0.2
        I>>    1.8
        VLN(I>)    48.0
        VLN(I>>)    48.0
        VLL(I>)    80.0
        VLL(I>>)    80.0
    END CHARVIS
END VISTARTING
```

Figure 9-1:
VI-Starting settings



10 Revision History

Revision	Date	Author	Changes
1.0	31/07/1998	Stephan Christmann	First version including Device, Differential, Overcurrent
1.1	05/11/1998	Stephan Christmann	Distance beta
2.0	03/12/1999	Glenn Maxey, Stephan Christmann	Distance, OMURP, Meter, general improvements
2.01	09/12/1999	Stephan Christmann	Distance: RERL_XEXL Default: -∞ page 40 Device: IMAX Default: 50.0 A page 25
2.1	16/08/2000	Stephan Christmann	Enhancements for distance (KS, KL, KSISKL, LINELENGTH) Bugfix for Device settings (VAUX, AC-FLAG deleted) Synchro block and Transducer block added.
2.2	21/03/2002	Thomas Wolff	New section Section 9 "VI-Starting Test Module" on page 111. Misc. layout and formatting revisions, re-insertion of graphics

Manufacturer Contact Information

OMICRON electronics GmbH

Oberes Ried 1

6833 Klaus

Austria

Phone:	+43 5523 507-0
Fax:	+43 5523 507-999
E-Mail:	support@omicron.at
Website:	http://www.omicron.at

Note: For addresses of OMICRON offices with customer service centers, regional sales offices or offices for training, consulting and commissioning please see our website.

Index

A

B

C

D

E

F

G

H

I

K

L

M

N

O

P

Q

R

S

T

U

V