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# 1. Introduction

## 1.1 Features

- Non-directional earth-fault protection
- Definite-time (DT) operation
- NEF1Low: fourteen inverse-time (IDMT) characteristics
- Neutral current measurement with a conventional current transformer
- Two alternative measuring principles: the average value of consecutive instantaneous peak-to-peak values or the numerically calculated fundamental frequency component of the earth-fault current
- Integrated circuit-breaker failure protection (CBFP) function

## 1.2 Application

This document specifies the functions of the non-directional earth-fault protection function blocks NEF1Low, NEF1High and NEF1Inst used in products based on the RED 500 Platform. The inverse-time operation is only included in the low-set stage (NEF1Low).

The non-directional earth-fault protection function blocks are designed for non-directional earth-fault protection whenever the DT characteristic or, as concerns NEF1Low, the IDMT (Inverse Definite Minimum Time) characteristic is appropriate. Suppression of harmonics is possible.

*Table 1 . Protection diagram symbols used in the relay terminal*

ABB	IEC	ANSI
NEF1Low	Io>	51N-1
NEF1High	Io>>	51N-2
NEF1Inst	Io>>>	51N-3

For IEC symbols used in single line diagrams, refer to the manual “Technical Descriptions of Functions, Introduction”, 1MRS750528-MUM.

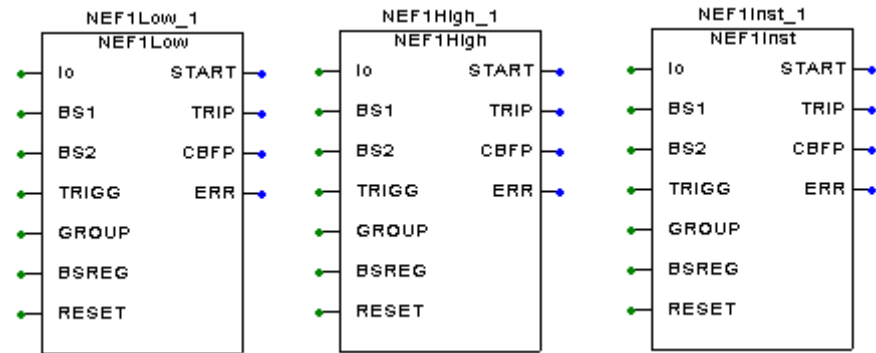


Figure 1.2.-2 Function block symbols of NEF1Low, NEF1High and NEF1Inst

### 1.3

#### Input description

Name	Type	Description
I0	Analogue signal (SINT)	Input for measuring neutral current $I_0$
BS1	Digital signal (BOOL, active high)	Blocking signal 1
BS2	Digital signal (BOOL, active high)	Blocking signal 2
TRIGG	Digital signal (BOOL, pos. edge)	Control signal for triggering the registers
GROUP	Digital signal (BOOL, active high)	Control input for switching between the setting groups 1 and 2. When GROUP is FALSE, group 1 is active. When GROUP is TRUE, group 2 is active.
BSREG	Digital signal (BOOL, active high)	Input for blocking the recording function
RESET	Reset signal (BOOL, pos. edge)	Input signal for resetting the trip signal and registers of NEF1Low, NEF1High or NEF1Inst

### 1.4

#### Output description

Name	Type	Description
START	Digital signal (BOOL, active high)	Start signal
TRIP	Digital signal (BOOL, active high)	Trip signal
CBFP	Digital signal (BOOL, active high)	Delayed trip signal for circuit-breaker failure protection (CBFP)
ERR	Digital signal (BOOL, active high)	Signal for indicating a configuration error

## 2. Description of operation

### 2.1 Configuration

Neutral current  $I_0$  can be measured with a conventional current transformer. If the neutral of the network is either isolated or earthed by a high impedance, a core balance current transformer is recommended to be used in earth fault protection. To ensure sufficient accuracy of neutral current measurements and consequently the selectivity of the scheme, core balance current transformers should have a transformation ratio of at least 70:1. Lower transformation ratios like 50:1 or 50:5 are not recommended.

The measuring devices and signal types for analogue channels are selected and configured in a special dialogue box of the Relay Configuration Tool included in the CAP 505 Tool Box. Digital inputs are configured in the same programming environment (the number of selectable analogue inputs, digital inputs and digital outputs depends on the type of the hardware used).

When the analogue channels and digital inputs have been selected and configured in the dialogue box, the inputs and outputs of the function block can be configured on a graphic worksheet of the configuration tool. The neutral current  $I_0$  can be connected to the  $I_0$  input of the function block. Furthermore, digital inputs are connected to the Boolean inputs of the function block and in the same way, the outputs of the function block are connected to the output signals.

### 2.2 Measuring mode

The operation of the function block is based on two alternative measuring principles: the average value of consecutive instantaneous peak-to-peak values or the numerically calculated fundamental frequency component of the neutral current. The measuring mode is selected by means of an HMI parameter or a serial communication parameter.

With both the measuring principles, the operation is insensitive to the DC component and the operation accuracy is defined in the frequency range  $f/f_n=0.95...1.05$ . In peak-to-peak measurement, the harmonics of the neutral current are not suppressed, whereas in fundamental frequency measurement the harmonics suppression is at least -50 dB at  $f = n \times f_n$ , where  $n = 2, 3, 4, 5, ...$

### 2.3 Operation criteria

The function block starts if the neutral current exceeds the set start current. When the function block starts, the START signal is set to TRUE. Should the duration of the earth fault exceed the set definite operate time or, at the inverse-time operation, the time determined by the level of the measured current, the function block operates. The internal delay of the heavy-duty output relay is included in the total operate time.

When the function block operates, the TRIP signal is set to TRUE. Operation mode instantaneous is selectable in the function blocks NEF1High and NEF1Inst. In instantaneous mode the TRIP signal is immediately activated.

The DT or IDMT timer is allowed to run only if the blocking signal BS1 is inactive, i.e. its value is FALSE. When the signal becomes active, i.e. its value turns to TRUE, the timer will be stopped (frozen).

When the blocking signal BS2 is active, the TRIP signal cannot be activated. The TRIP signal can be blocked by activating the signal BS2 until the function block drops off.

## 2.4

### Delayed reset facility and drop-off time in DT and IDMT modes

The purpose of the delayed reset function is to enable fast clearance of intermittent faults, e.g. self-sealing insulation faults, and severe faults which may produce high asymmetrical fault currents that partially saturate the current transformers. It is typical for an intermittent fault that the fault current contains so-called drop-off periods during which the fault current is below the set start current. Without the delayed reset function the DT or the IDMT timer would reset once the current drops off. In the same way, an apparent drop-off period of the secondary current of the saturated current transformer might reset the DT or the IDMT timer. The adjustable delayed reset function also enables closer co-ordination with electromechanical induction disc relays.

When the DT timer has started, it goes on running normally even if the current drops off, provided the drop-off period is shorter than the set drop-off time. In the same situation, the IDMT timer is frozen. If the drop-off period is longer than the set drop-off time, the DT or the IDMT timer will be reset when the drop-off time elapses. The situation in the case of the DT timer is described in Figure 2.4.-1.

In Figures 2.4.-1 and 2.4.-2 the input signal IN of the DT timer is TRUE when the current is above the set start value and FALSE when the current is below the set start value.

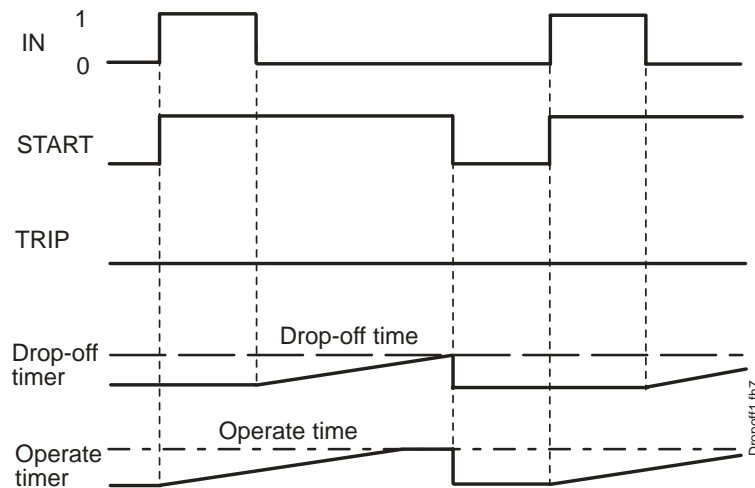


Figure 2.4.-1 The drop-off period is longer than the set drop-off time

If the drop-off period is shorter than the set drop-off time and the DT timer time has elapsed during the drop-off period, the function block will trip once the current exceeds the set value again (Figure 2.4.-2).

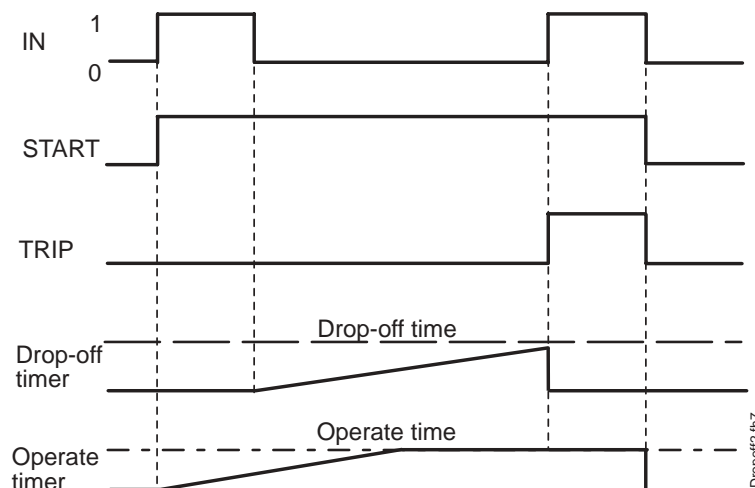


Figure 2.4.-2 The drop-off period is shorter than the set drop-off time

## 2.5

### IDMT type operation of NEF1Low

In the inverse-time mode, the operate time of the stage is a function of the current. The higher the current, the shorter the operate time is. Fourteen time/current curve groups are available. Four of the groups comply with the BS 142 and IEC 60255 standards, whereas the two curve groups RI and RD (RXIDG) are special type of curve groups corresponding to the ABB praxis. Eight IEEE curves comply with the IEEE C37.112 standard. The setting "Operation mode" is used for selecting the desired operate time characteristic.

The shortest operate time at the inverse-time operation is limited by a special adjustable minimum time located in control settings. The definite minimum time will not allow operate times shorter than the set minimum time, which is why the inverse-time mode is called the IDMT mode (Inverse Definite Minimum Time).

### 2.5.1

#### Standard curve groups

The four internationally standardized inverse-time characteristics incorporated in the inverse-time operation of the function are:

- normal inverse (NI)
- very inverse (VI)
- extremely inverse (EI)
- long-time inverse (LI)

(For a graphical presentation of the curves, refer to the manual Technical Descriptions of Functions, Introduction.)

The relationship between time and current is in accordance with the standard IEC 60255-4 and can be expressed as follows

$$t[s] = \frac{k \times \beta}{\left(\frac{I}{I_{>}}\right)^{\alpha} - 1}$$

where

t	operate time in seconds
k	adjustable time multiplier, parameters S4, S44 and S74
I	phase current
I <sub>&gt;</sub>	adjustable start current, parameters S2, S42 and S72
α, β	constants to provide selected curve characteristics

The values of the constants a and b determine the slope as follows

Inverse-time characteristic	α	β
Normal inverse	0.02	0.14
Very inverse	1.0	13.5
Extremely inverse	2.0	80.0
Long-time inverse	1.0	120

According to the standard BS 142: 1966 the effective current range is defined as 2...20 times the set start current. If the time/current characteristic is normal inverse, very

inverse or extremely inverse, the function has to start at the latest when the current exceeds the set start current by 1.3 times. For the long-time inverse characteristic, the effective current range is specified to be 2...7 times the set start current and the relay is to start at the latest when the current exceeds the setting value by 1.1 times. The function block NEF1Low will start and the IDMT integration will begin once the current exceeds the set start current.

The operate time tolerances specified by the standard BS 142 : 1966 are the following (E denotes the accuracy in percent):

I/I >	Normal	Very	Extremely	Long time
2	2.22E	2.34E	2.44E	2.34E
5	1.13E	1.26E	1.48E	1.26E
7	-	-	-	1.00E
10	1.01E	1.01E	1.02E	-
20	1.00E	1.00E	1.00E	-

The tolerance factors are in accordance to those defined by the standard BS 142: 1966 for currents 2 and 5 times the setting. The NEF1Low complies with the tolerances of class 5 (E = 5.0%) for all inverse-time curves.

For example:

I/I ≥ 10, characteristic = Normal

Operate time tolerance = 1.01 x 5.0% = 5.05%

## 2.5.2

### RI curve groups

The RI-type inverse-time characteristic is a special characteristic mainly used to obtain time grading with mechanical relays. The characteristic can be expressed as follows:

$$t[s] = \frac{k}{0.339 - 0.236 \times \frac{I_{>}}{I}}$$

## 2.5.3

### RD curve groups

The RD-type characteristic is a special characteristic mainly used in earth-fault protection where a high degree of selectivity is required also at high-resistance faults. Mathematically, the characteristic can be expressed as follows:



$$t[s] = 5.8 - 1.35 \times \ln \frac{I}{k \times I_{>}}$$

The accuracy of the RI- and RD-type characteristics is 5%. Also with the RI- and RD-type characteristics, the function block will start and the IDMT integration will begin once the current exceeds the set start current.

## 2.5.4

### IEEE curve groups

IEEE time overcurrent curve equation according to the standard IEEE C37.112:

$$t[s] = \left( \frac{A}{\left( \frac{I}{I_{>}} \right)^p - 1} + B \right) \times n$$

where

$I_{>}$  adjustable start current, parameters S2, S42 and S72

$n$  adjustable IEEE time dial setting, parameters S5, S45 and S75

$A, B, p$  constants to provide selected curve characteristics

Curve	A	B	p
IEEE Extremely Inverse	6.407	0.025	2.0
IEEE Very Inverse	2.855	0.0712	2.0
IEEE Inverse	0.0086	0.0185	0.02
IEEE Short Time Inverse	0.00172	0.0037	0.02
IEEE Short Time Ext. Inverse	1.281	0.005	2.0
IEEE Long Time Ext. Inv.	64.07	0.250	2.0
IEEE Long Time Very Inv.	28.55	0.712	2.0
IEEE Long Time Inverse	0.086	0.185	0.02

## 2.6

### Setting groups

Two different groups of setting values, group 1 and group 2, are available for the function block. Switching between the two groups can be done in the following three ways:

- 1 Locally via the control parameter “Group selection”<sup>1)</sup> of the HMI
- 2 Over the serial bus with the command V3<sup>1)</sup>

- 3 By means of the input signal GROUP when allowed via the parameter “Group selection” (i.e. when  $V3 = 2^{1)}$ ).

<sup>1)</sup> Group selection (V3): 0 = Group 1; 1 = Group 2; 2 = GROUP input

The group settings come into effect immediately after selection. The control parameter "Active group" indicates that the setting group is valid at a given time.

## 2.7

### Test mode

The digital outputs of the function block can be activated with separate control settings for each output either locally via the HMI or externally via the serial communication. When an output is activated with the test parameter, an event indicating the test is generated.

The protection functions operate normally while the outputs are tested.

## 2.8

### START, TRIP and CBFP outputs

The output signal START is always pulse-shaped. The minimum pulse width of the START and TRIP output signals is set via a separate parameter on the HMI or on the serial communication. If the start situation is longer than the set pulse width, the START signal remains active until the start situation is over.

The output signal TRIP may have a non-latching or latching feature. If the start situation is longer than the set pulse width and the non-latching mode has been selected, the TRIP signal remains active until the start situation is over. When the latching mode has been selected, the TRIP signal remains active until the output is reset even if the operation criteria have reset.

The circuit-breaker failure protection function provides a delayed trip signal, CBFP, after the TRIP signal unless the fault has disappeared during the set CBFP time delay. The CBFP output can be used to operate a circuit breaker in front of the circuit breaker of the feeder.

Note! The control parameter "Trip pulse" also sets the pulse width of the CBFP output signal. The CBFP signal resets when the set pulse width elapses, even if the start situation is still active. Therefore, if the CBFP function is used, a setting value of 200ms or longer for the control parameter "Trip pulse" is recommended.

## 2.9

### Resetting

The TRIP output signal and the registers can be reset either via the RESET input, or over the serial bus or the local HMI.

The operation indicators, latched trip signal and recorded data can be reset as follows:

	Operation indicators	Latched trip signal	Recorded data
RESET input of the function block <sup>1)</sup>		X	X
Parameter F038V013 for NEF1Low <sup>1)</sup>		X	X
Parameter F039V013 for NEF1High <sup>1)</sup>		X	X
Parameter F090V013 for NEF1Inst <sup>1)</sup>		X	X
General parameter F001V011 <sup>2)</sup>	X		
General parameter F001V012 <sup>2)</sup>	X	X	
General parameter F001V013 <sup>2)</sup>	X	X	X
Push-button C <sup>2)</sup>	X		
Push-buttons C + E (2 s) <sup>2)</sup>	X	X	
Push-buttons C + E (5 s) <sup>2)</sup>	X	X	X

<sup>1)</sup> Resets the latched trip signal and recorded data of the particular function block.

<sup>2)</sup> Affects all function blocks.

### 3. Parameters and events

#### 3.1 General

- Each function block has a specific channel number for serial communication parameters and events. The channel for NEF1Low is 38, that for NEF1High 39 and that for NEF1Inst 90.
- The data direction of the parameters defines the use of each parameter as follows:

Data direction	Description
R, R/M	Read only
W	Write only
R/W	Read and write

- The different event mask parameters (see section “Control settings”) affect the visibility of events on the HMI or on serial communication (LON or SPA) as follows:

Event mask 1 (FxxxV101/102)	SPA / HMI (LON)
Event mask 2 (FxxxV103/104)	LON
Event mask 3 (FxxxV105/106)	LON
Event mask 4 (FxxxV107/108)	LON

For example, if only the events E3, E4 and E5 are to be seen on the HMI of the relay terminal, the event mask value 56 (8 + 16 + 32) is written to the “Event mask 1” parameter (FxxxV101).

In case a function block includes more than 32 events, there are two parameters instead of e.g. the “Event mask 1” parameter: the parameter “Event mask 1A” (FxxxV101) covers the events 0...31 and “Event mask 1B”(FxxxV102) the events 32...63.

## 3.2 Setting values

### 3.2.1 Actual settings

#### NEF1Low

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Operation mode	S1	0 ... 15 <sup>1)</sup>	-	1	R	Selection of operation mode and inverse-time characteristic
Start current	S2	1.0...500.0	% In	1.0	R	Start current
Operate time	S3	0.05...300.00	s	0.05	R	Operate time in DT mode
Time multiplier	S4	0.05...1.00	-	0.05	R	Time multiplier 'k' in IDMT mode
IEEE time dial	S5	0.5...15.0	-	0.5	R	IEEE time dial 'n' in IDMT mode

<sup>1)</sup> Operation mode  
 0 = Not in use; 1 = Definite time; 2 = Extremely inv.; 3 = Very inverse;  
 4 = Normal inverse; 5 = Long-time inv.; 6 = RI-type inverse; 7 = RD-type  
 inverse; 8 = IEEE Ext. inv.; 9 = IEEE Very inv.; 10 = IEEE Inverse;  
 11 = IEEE S.T. inv.; 12 = IEEE S.T.E. inv.; 13 = IEEE L.T.E. inv.;  
 14 = IEEE L.T.V. inv.; 15 = IEEE L.T. inv.

#### NEF1High and NEF1Inst

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Operation mode	S1	0 ... 2 <sup>1)</sup>	-	1	R	Selection of operation mode
Start current	S2	0.10...12.00	x In	0.10	R	Start current
Operate time	S3	0.05...300.00	s	0.05	R	Operate time in DT mode

<sup>1)</sup> Operation mode  
 0 = Not in use; 1 = Definite time; 2 = Instantaneous

## 3.2.2

## Setting group 1

## NEF1Low

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Operation mode	S41	0 ... 15 <sup>1)</sup>	-	1	R/W	Selection of operation mode and inverse-time characteristic
Start current	S42	1.0...500.0	% In	1.0	R/W	Start current
Operate time	S43	0.05...300.00	s	0.05	R/W	Operate time in DT mode
Time multiplier	S44	0.05...1.00	-	0.05	R/W	Time multiplier 'k' in IDMT mode
IEEE time dial	S45	0.5...15.0	-	0.5	R/W	IEEE time dial 'n' in IDMT mode

<sup>1)</sup> Operation mode      0 = Not in use; 1 = Definite time; 2 = Extremely inv.; 3 = Very inverse; 4 = Normal inverse; 5 = Long-time inv.; 6 = RI-type inverse; 7 = RD-type inverse; 8 = IEEE Ext. inv.; 9 = IEEE Very inv.; 10 = IEEE Inverse; 11 = IEEE S.T. inv.; 12 = IEEE S.T.E. inv.; 13 = IEEE L.T.E. inv.; 14 = IEEE L.T.V. inv.; 15 = IEEE L.T. inv.

## NEF1High and NEF1Inst

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Operation mode	S41	0 ... 2 <sup>1)</sup>	-	1	R/W	Selection of operation mode
Start current	S42	0.10...12.00	x In	0.10	R/W	Start current
Operate time	S43	0.05...300.00	s	0.05	R/W	Operate time in DT mode

<sup>1)</sup> Operation mode      0 = Not in use; 1 = Definite time; 2 = Instantaneous

## 3.2.3

## Setting group 2

## NEF1Low

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Operation mode	S71	0 ... 15 <sup>1)</sup>	-	1	R/W	Selection of operation mode and inverse-time characteristic
Start current	S72	1.0...500.0	% In	1.0	R/W	Start current
Operate time	S73	0.05...300.00	s	0.05	R/W	Operate time in DT mode
Time multiplier	S74	0.05...1.00	-	0.05	R/W	Time multiplier 'k' in IDMT mode
IEEE time dial	S75	0.5...15.0	-	0.5	R/W	IEEE time dial 'n' in IDMT mode

<sup>1)</sup> Operation mode  
 0 = Not in use; 1 = Definite time; 2 = Extremely inv.; 3 = Very inverse;  
 4 = Normal inverse; 5 = Long-time inv.; 6 = RI-type inverse; 7 = RD-type  
 inverse; 8 = IEEE Ext. inv.; 9 = IEEE Very inv.; 10 = IEEE Inverse;  
 11 = IEEE S.T. inv.; 12 = IEEE S.T.E. inv.; 13 = IEEE L.T.E. inv.;  
 14 = IEEE L.T.V. inv.; 15 = IEEE L.T. inv.

## NEF1High and NEF1Inst

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Operation mode	S71	0 ... 2 <sup>1)</sup>	-	1	R/W	Selection of operation mode
Start current	S72	0.10...12.00	x In	0.10	R/W	Start current
Operate time	S73	0.05...300.00	s	0.05	R/W	Operate time in DT mode

<sup>1)</sup> Operation mode  
 0 = Not in use; 1 = Definite time; 2 = Instantaneous

## 3.2.4

## Control settings

## NEF1Low

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Measuring mode	V1	0 or 1 <sup>1)</sup>	-	1	R/W	Selection of measuring mode
Drop-off time	V2	0...1000	ms	0	R/W	Resetting time of the operate time counter
Group selection	V3	0 ... 2 <sup>2)</sup>	-	0	R/W	Selection of the active setting group
Active group	V4	0 or 1 <sup>3)</sup>	-	0	R/M	Active setting group
Start pulse	V5	0...1000	ms	0	R/W	Minimum pulse width of START signal
Trip signal	V6	0 or 1 <sup>4)</sup>	-	0	R/W	Selection of latching feature for TRIP output
Trip pulse	V7	40...1000	ms	40	R/W	Minimum pulse width of TRIP and CBFP
Minimum time	V8	0.03...10.0 0	s	0.03	R/W	Minimum operate time in IDMT mode
CBFP time	V9	100...1000	ms	100	R/W	Operate time of the delayed trip CBFP
Reset registers	V13	1=Reset	-	0	W	Resetting of latched trip signal and registers
Test START	V31	0 or 1 <sup>5)</sup>	-	0	R/W	Testing of START
Test TRIP	V32	0 or 1 <sup>5)</sup>	-	0	R/W	Testing of TRIP
Test CBFP	V33	0 or 1 <sup>5)</sup>	-	0	R/W	Testing of CBFP
Event mask 1	V101	0...4095	-	63	R/W	Event mask 1 for event transmission (E0 ... E11)
Event mask 2	V103	0...4095	-	63	R/W	Event mask 2 for event transmission (E0 ... E11)
Event mask 3	V105	0...4095	-	63	R/W	Event mask 3 for event transmission (E0 ... E11)
Event mask 4	V107	0...4095	-	63	R/W	Event mask 4 for event transmission (E0 ... E11)

<sup>1)</sup> Measuring mode 0 = Peak-to-peak; 1 = Fundam.freq.

<sup>2)</sup> Group selection 0 = Group 1; 1 = Group 2; 2 = GROUP input

<sup>3)</sup> Active group 0 = Group 1; 1 = Group 2

<sup>4)</sup> Trip signal 0 = Non-latching; 1 = Latching

<sup>5)</sup> Test 0 = Do not activate; 1 = Activate



## NEF1High and NEF1Inst

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Measuring mode	V1	0 or 1 <sup>1)</sup>	-	1	R/W	Selection of measuring mode
Drop-off time	V2	0...1000	ms	0	R/W	Resetting time of the operate time counter
Group selection	V3	0 ... 2 <sup>2)</sup>	-	0	R/W	Selection of the active setting group
Active group	V4	0 or 1 <sup>3)</sup>	-	0	R/M	Active setting group
Start pulse	V5	0...1000	ms	0	R/W	Minimum pulse width of START signal
Trip signal	V6	0 or 1 <sup>4)</sup>	-	0	R/W	Selection of latching feature for TRIP output
Trip pulse	V7	40...1000	ms	40	R/W	Minimum pulse width of TRIP and CBFP
CBFP time	V8	100...1000	ms	100	R/W	Operate time of the delayed trip CBFP
Reset registers	V13	1=Reset	-	0	W	Resetting of latched trip signal and registers
Test START	V31	0 or 1 <sup>5)</sup>	-	0	R/W	Testing of START
Test TRIP	V32	0 or 1 <sup>5)</sup>	-	0	R/W	Testing of TRIP
Test CBFP	V33	0 or 1 <sup>5)</sup>	-	0	R/W	Testing of CBFP
Event mask 1	V101	0...4095	-	63	R/W	Event mask 1 for event transmission (E0 ... E11)
Event mask 2	V103	0...4095	-	63	R/W	Event mask 2 for event transmission (E0 ... E11)
Event mask 3	V105	0...4095	-	63	R/W	Event mask 3 for event transmission (E0 ... E11)
Event mask 4	V107	0...4095	-	63	R/W	Event mask 4 for event transmission (E0 ... E11)

<sup>1)</sup> Measuring mode 0 = Peak-to-peak; 1 = Fundam.freq.

<sup>2)</sup> Group selection 0 = Group 1; 1 = Group 2; 2 = GROUP input

<sup>3)</sup> Active group 0 = Group 1; 1 = Group 2

<sup>4)</sup> Trip signal 0 = Non-latching; 1 = Latching

<sup>5)</sup> Test 0 = Do not activate; 1 = Activate

### 3.3 Measurement values

#### 3.3.1 Input data

##### NEF1Low

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Current I <sub>0</sub>	I1	0.0...2000.0	% In	0.0	R/M	Neutral current I <sub>0</sub>
Input BS1	I2	0 or 1 <sup>1)</sup>	-	0	R/M	Block signal BS1
Input BS2	I3	0 or 1 <sup>1)</sup>	-	0	R/M	Block signal BS2
Input TRIGG	I4	0 or 1 <sup>1)</sup>	-	0	R/M	Signal for triggering the registers
Input GROUP	I5	0 or 1 <sup>1)</sup>	-	0	R/M	Signal for switching between the groups 1 and 2
Input BSREG	I6	0 or 1 <sup>1)</sup>	-	0	R/M	Signal for blocking the recording function
Input RESET	I7	0 or 1 <sup>1)</sup>	-	0	R/M	Signal for resetting the output signals and registers of NEF1Low

<sup>1)</sup> Input      0 = Not active; 1 = Active

##### NEF1High and NEF1Inst

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Current I <sub>0</sub>	I1	0.00...60.00	x In	0.00	R/M	Neutral current I <sub>0</sub>
Input BS1	I2	0 or 1 <sup>1)</sup>	-	0	R/M	Block signal BS1
Input BS2	I3	0 or 1 <sup>1)</sup>	-	0	R/M	Block signal BS2
Input TRIGG	I4	0 or 1 <sup>1)</sup>	-	0	R/M	Signal for triggering the registers
Input GROUP	I5	0 or 1 <sup>1)</sup>	-	0	R/M	Signal for switching between the groups 1 and 2
Input BSREG	I6	0 or 1 <sup>1)</sup>	-	0	R/M	Signal for blocking the recording function
Input RESET	I7	0 or 1 <sup>1)</sup>	-	0	R/M	Signal for resetting the output signals and registers of NEF1High or NEF1Inst

<sup>1)</sup> Input      0 = Not active; 1 = Active

### 3.3.2 Output data

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Output START	O1	0 or 1 <sup>1)</sup>	-	0	R/M	Status of start signal
Output TRIP	O2	0 or 1 <sup>1)</sup>	-	0	R/M	Status of trip signal
Output CBFP	O3	0 or 1 <sup>1)</sup>	-	0	R/M	Status of CBFP signal

<sup>1)</sup> Output      0 = Not active; 1 = Active

### 3.3.3 Recorded data

#### 3.3.3.1 General

The information required for later fault analysis is recorded when the function block starts or trips, or when the recording function is triggered via an external triggering input.

The data of the last three events are stored in Recorded data 1...3, beginning from Recorded data 1. These registers are updated in a cyclical manner, where the values of the most recent event overwrite the oldest recorded data. If recorded data has been reset or the relay has been restarted, the first event is again stored in Recorded data 1.

The recording function can be blocked via the BSREG input. For example, if an auto-reclose sequence is initiated by the trip signal of the function block, the values most reliable for later fault analysis are those recorded just before Shot 1. When the auto-reclose sequence has started, no recordings are needed at the moment of tripping. The output signal ACTIVE in AR5Func indicating AR in progress is connected to the BSREG input to prevent useless recording.

#### 3.3.3.2 Date and time

The time stamp indicates the rising edge of the START, TRIP or TRIGG signal.

#### 3.3.3.3 Duration

In the DT mode of operation the duration of the start situation is recorded as a percentage of the set operate time and, as concerns NEF1Low, in the IDMT mode of operation as a percentage of the calculated operate time.

### 3.3.3.4 Neutral current

If the function block trips, the current values are updated at the moment of tripping i.e. on the rising edge of the signal TRIP. For external triggering the current values are updated at the moment of triggering i.e. on the rising edge of the input signal TRIGG. If the function block starts but does not trip, the neutral current value captured one fundamental cycle (20 ms at rated frequency 50 Hz) after the beginning of the start situation is recorded. The value of the neutral current  $I_0$  is recorded as a multiple of the rated current  $I_N$ .

### 3.3.3.5 Status data

The status data of the input signals BS1 and BS2 as well as the “Active group” parameter are recorded at the moment of recording. The “Active group” parameter indicates the setting group valid for the recorded data.

### 3.3.3.6 Priority

The priority of the recording function is the following:

- 1 Tripping
- 2 Starting
- 3 External triggering,

which means that if the function block has started, it will neglect an external triggering request.

## 3.3.3.7

## Recorded data 1

## NEF1Low

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Date	V201	YYYY-MM-DD	-	-	R/M	Recording date
Time	V202	hh:mm:ss.mss	-	-	R/M	Recording time
Duration	V203	0.0...100.0	%	0.0	R/M	Duration of start situation
Io mean	V204	0.0...2000.0	% In	0.0	R/M	Filtered value of $I_0$
Io peak	V205	0.0...2000.0	% In	0.0	R/M	Momentary peak of $I_0$
BS1	V206	0 or 1 <sup>1)</sup>	-	0	R/M	Status of BS1 input
BS2	V207	0 or 1 <sup>1)</sup>	-	0	R/M	Status of BS2 input
Active group	V208	0 or 1 <sup>2)</sup>	-	0	R/M	Active setting group

<sup>1)</sup> BS\_ 0 = Not active; 1 = Active

<sup>2)</sup> Active group 0 = Group 1; 1 = Group 2

## NEF1High and NEF1Inst

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Date	V201	YYYY-MM-DD	-	-	R/M	Recording date
Time	V202	hh:mm:ss.mss	-	-	R/M	Recording time
Duration	V203	0.0...100.0	%	0.0	R/M	Duration of start situation
Io mean	V204	0.00...60.00	x In	0.00	R/M	Filtered value of $I_0$
Io peak	V205	0.00...60.00	x In	0.00	R/M	Momentary peak of $I_0$
BS1	V206	0 or 1 <sup>1)</sup>	-	0	R/M	Status of BS1 input
BS2	V207	0 or 1 <sup>1)</sup>	-	0	R/M	Status of BS2 input
Active group	V208	0 or 1 <sup>2)</sup>	-	0	R/M	Active setting group

<sup>1)</sup> BS\_ 0 = Not active; 1 = Active

<sup>2)</sup> Active group 0 = Group 1; 1 = Group 2

## 3.3.3.8

## Recorded data 2

## NEF1Low

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Date	V301	YYYY-MM-DD	-	-	R/M	Recording date
Time	V302	hh:mm:ss.mss	-	-	R/M	Recording time
Duration	V303	0.0...100.0	%	0.0	R/M	Duration of start situation
Io mean	V304	0.0...2000.0	% In	0.0	R/M	Filtered value of $I_0$
Io peak	V305	0.0...2000.0	% In	0.0	R/M	Momentary peak of $I_0$
BS1	V306	0 or 1 <sup>1)</sup>	-	0	R/M	Status of BS1 input
BS2	V307	0 or 1 <sup>1)</sup>	-	0	R/M	Status of BS2 input
Active group	V308	0 or 1 <sup>2)</sup>	-	0	R/M	Active setting group

<sup>1)</sup> BS\_ 0 = Not active; 1 = Active

<sup>2)</sup> Active group 0 = Group 1; 1 = Group 2

## NEF1High and NEF1Inst

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Date	V301	YYYY-MM-DD	-	-	R/M	Recording date
Time	V302	hh:mm:ss.mss	-	-	R/M	Recording time
Duration	V303	0.0...100.0	%	0.0	R/M	Duration of start situation
Io mean	V304	0.00...60.00	x In	0.00	R/M	Filtered value of $I_0$
Io peak	V305	0.00...60.00	x In	0.00	R/M	Momentary peak of $I_0$
BS1	V306	0 or 1 <sup>1)</sup>	-	0	R/M	Status of BS1 input
BS2	V307	0 or 1 <sup>1)</sup>	-	0	R/M	Status of BS2 input
Active group	V308	0 or 1 <sup>2)</sup>	-	0	R/M	Active setting group

<sup>1)</sup> BS\_ 0 = Not active; 1 = Active

<sup>2)</sup> Active group 0 = Group 1; 1 = Group 2

## 3.3.3.9

## Recorded data 3

## NEF1Low

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Date	V401	YYYY-MM-DD	-	-	R/M	Recording date
Time	V402	hh:mm:ss.mss	-	-	R/M	Recording time
Duration	V403	0.0...100.0	%	0.0	R/M	Duration of start situation
Io mean	V404	0.0...2000.0	% In	0.0	R/M	Filtered value of $I_0$
Io peak	V405	0.0...2000.0	% In	0.0	R/M	Momentary peak of $I_0$
BS1	V406	0 or 1 <sup>1)</sup>	-	0	R/M	Status of BS1 input
BS2	V407	0 or 1 <sup>1)</sup>	-	0	R/M	Status of BS2 input
Active group	V408	0 or 1 <sup>2)</sup>	-	0	R/M	Active setting group

<sup>1)</sup> BS\_ 0 = Not active; 1 = Active

<sup>2)</sup> Active group 0 = Group 1; 1 = Group 2

## NEF1High and NEF1Inst

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Date	V401	YYYY-MM-DD	-	-	R/M	Recording date
Time	V402	hh:mm:ss.mss	-	-	R/M	Recording time
Duration	V403	0.0...100.0	%	0.0	R/M	Duration of start situation
Io mean	V404	0.00...60.00	x In	0.00	R/M	Filtered value of $I_0$
Io peak	V405	0.00...60.00	x In	0.00	R/M	Momentary peak of $I_0$
BS1	V406	0 or 1 <sup>1)</sup>	-	0	R/M	Status of BS1 input
BS2	V407	0 or 1 <sup>1)</sup>	-	0	R/M	Status of BS2 input
Active group	V408	0 or 1 <sup>2)</sup>	-	0	R/M	Active setting group

<sup>1)</sup> BS\_ 0 = Not active; 1 = Active

<sup>2)</sup> Active group 0 = Group 1; 1 = Group 2

## 3.3.4

## Events

Code	Weighting coefficient	Default mask	Event reason	Event state
E0	1	1	START signal from lo>, lo>> or lo>>> stage	Reset
E1	2	1	START signal from lo>, lo>> or lo>>> stage	Activated
E2	4	1	TRIP signal from lo>, lo>> or lo>>> stage	Reset
E3	8	1	TRIP signal from lo>, lo>> or lo>>> stage	Activated
E4	16	1	CBFP signal from lo>, lo>> or lo>>> stage	Reset
E5	32	1	CBFP signal from lo>, lo>> or lo>>> stage	Activated
E6	64	0	BS1 signal of lo>, lo>> or lo>>> stage	Reset
E7	128	0	BS1 signal of lo>, lo>> or lo>>> stage	Activated
E8	256	0	BS2 signal of lo>, lo>> or lo>>> stage	Reset
E9	512	0	BS2 signal of lo>, lo>> or lo>>> stage	Activated
E10	1024	0	Test mode of lo>, lo>> or lo>>> stage	Off
E11	2048	0	Test mode of lo>, lo>> or lo>>> stage	On



## 4. Technical data

<b>Operation accuracies</b>	Depends on the frequency of the current measured:  NEF1Low: $f/f_n = 0.95 \dots 1.05: \pm 2.5\% \text{ of set value} + 0.0005 \times I_n$ .  NEF1High and NEF1Inst: $f/f_n = 0.95 \dots 1.05: \pm 2.5\% \text{ of set value or } \pm 0.01 \times I_n$ .
<b>Start time</b>	Injected currents > 2.0 x start current:  $f/f_n = 0.95 \dots 1.05$ internal time                      < 32 ms  total time <sup>1)</sup> < 40 ms
<b>Reset time</b>	40...1000 ms (depends on the set minimum output pulse width)
<b>Reset ratio</b>	Typ. 0.95 (range 0.95...0.98)
<b>Retardation time</b>	Total retardation time when the current drops below the start value <sup>2)</sup> < 45 ms
<b>Operate time accuracy in definite-time mode</b>	Depends on the frequency of the current measured:  $f/f_n = 0.95 \dots 1.05: \pm 2\% \text{ of set value or } \pm 20 \text{ ms}^{2)}$
<b>Accuracy class index E in inverse-time mode (NEF1Low)</b>	Depends on the frequency of the current measured:  $f/f_n = 0.95 \dots 1.05: \text{Class index E} = 5.0 \text{ or } \pm 20 \text{ ms}^{2)}$
<b>Suppression of harmonics</b>	Measuring mode  0                      No suppression  1                      -50 dB at $f = n \times f_n$ , where $n = 2, 3, 4, 5, \dots$
<b>Configuration data</b>	Task execution interval (Relay Configuration Tool): 10 ms, at the rated frequency $f_n = 50 \text{ Hz}$

<sup>1)</sup> Includes the delay of the signal relay<sup>2)</sup> Includes the delay of the heavy-duty output relay

Technical revision history		
Function block	Technical revision	Change
NEF1Low	B	-
	C	-
	D	Added IEEE IDMT curves
	E	Extended start current setting range
NEF1High	B	-
	C	-
NEF1Inst	B	-
	C	(No change in the manual)
	D	-