# Diff6G
# Stabilized Three-Phase Differential Protection for Generators

## Contents

# 1. Introduction

## 1.1 Features

- Three-phase current differential protection with stabilized and instantaneous stages providing winding short-circuit protection for generators
- The stabilized stage is provided with saturation detection that blocks the stage internally in case of current transformer saturation at external faults
- The differential and stabilizing currents are calculated for every phase on the basis of the fundamental frequency components of currents
- A separately adjustable instantaneous differential current stage for severe internal faults. Instantaneous stage is not affected by saturation detection.
- The MMI monitoring of the phase current and phase difference values facilitates the commissioning of differential protection and the checking of connections and CT polarities
- Delayed trip output for the circuit-breaker failure protection (CBFP) function
- High stability at external faults, also with partially saturated current transformers
- Short operate times at faults occurring in the zone to be protected (internal faults), also with partially saturated current transformers

## 1.2 Application

This document specifies the function of the three-phase differential protection function block Diff6G used in products based on the RED 500 Platform.

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*Figure 1. Protection diagram symbol of Diff6G (For IEC symbols used in single line diagrams, refer to the manual “Technical Descriptions of Functions, Introduction”, 1MRS750528-MUM)*

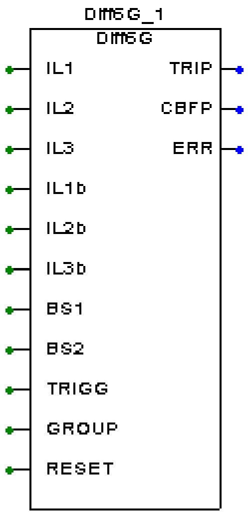


*Figure 2. Function block symbol of Diff6G*

## 1.3 Input description

| Name | Type | Description |
|---|---|---|
| IL1 | Analogue signal (SINT) | Input for measuring phase current $I_{L1}$ |
| IL2 | Analogue signal (SINT) | Input for measuring phase current $I_{L2}$ |
| IL3 | Analogue signal (SINT) | Input for measuring phase current $I_{L3}$ |
| IL1b | Analogue signal (SINT) | Input for measuring phase current $I_{L1b}$ |
| IL2b | Analogue signal (SINT) | Input for measuring phase current $I_{L2b}$ |
| IL3b | Analogue signal (SINT) | Input for measuring phase current $I_{L3b}$ |
| BS1 | Digital signal (BOOL, active high) | Blocking signal of the stabilized stage |
| BS2 | Digital signal (BOOL, active high) | Blocking signal of the instantaneous stage |
| TRIGG | Digital signal (BOOL, active high) | 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. |
| RESET | Reset signal (BOOL, pos. edge) | Input signal for resetting the trip signal and registers of Diff6G |

## 1.4 Output description

| Name | Type | Description |
|---|---|---|
| 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 Configuring the inputs and the outputs

Phase currents can be measured either via conventional current transformers or via Rogowski coils but no combination of these two is possible.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 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 phase currents $I_{L1}$, $I_{L2}$, $I_{L3}$, $I_{L1b}$, $I_{L2b}$ and $I_{L3b}$ are connected to the corresponding IL1, IL2, IL3, IL1b, IL2b and IL3b inputs of the function block. The currents $I_{L1}$-$I_{L3}$ are assumed to be measured at the neutral end and the currents $I_{L1b}$-$I_{L3b}$ at the line end of the generator (see Figure 3 below). 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.

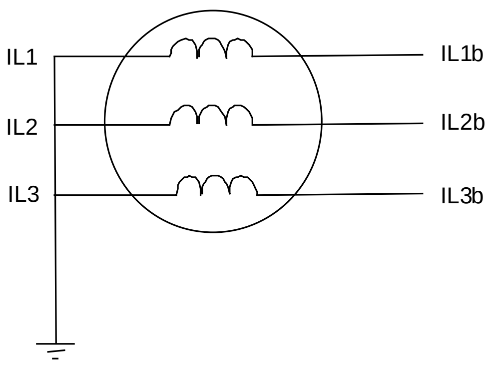


*Figure 3. Currents at the neutral end and at the line end of the generator*

## 2.2 Configuration error checking

When the relay is started, the function block checks the signal types and the measuring device types of the connected analogue inputs. If the signal types are not phase currents ($I_{L1}$, $I_{L2}$ $I_{L3}$, $I_{L1b}$, $I_{L2b}$ or $I_{L3b}$) or if all the measuring device types are not current transformers or Rogowski coils, the ERR output is activated. Also an event E13 is sent.

The program that the function block is instantiated within should be associated with a task the interval of which is not greater than one fourth of the fundamental cycle. The ERR output of the function block will be activated if an association with a slower task is made. Also an event E13 is sent.

## 2.3 Setting the rated values of the protected unit

A separate scaling factor can be set for each analogue channel. The factors enable differences between the ratings of the protected unit and those of the measuring device (CTs, VTs, etc.). A setting of 1.00 means that the rated value of the protected unit is exactly the same as that of the measuring device. For more information refer to Technical Reference Manual for REM 54_.

## 2.4 Operation criteria

The differential protection function block includes two stages for generator differential protection.

### 2.4.1 Stabilized stage 3ΔI>

The operating characteristic of the stabilized stage 3ΔI> is determined by the parameters “Basic setting” and “Starting ratio” as well as by the parameters “Turn-point 1” and “Turn-point 2” for the turning points of the characteristic. The settings are the same for each phase. When the differential current exceeds the operating characteristic, the function block trips unless it internally blocks the trip function or is blocked by the external blocking signal BS1.

The phasors $\bar{I}_1$ and $\bar{I}_2$ denote the fundamental frequency components of the CT secondary currents on the input side and output side of the protected object. The amplitude of the differential current $I_d$ is obtained as follows:

$$I_d = \left|\bar{I}_1 - \bar{I}_2\right| \tag{1}$$

In a normal situation there is no fault in the area protected by the function block. Then the currents $\bar{I}_1$ and $\bar{I}_2$ are equal and the differential current $I_d = 0$. In practise, however, the differential current sligthly deviates from zero in normal situations. In generator protection the deviation is caused by CT inaccuracies.

In a stabilized differential relay the differential current required for tripping is the higher the higher the load current is. The stabilizing current $I_b$ of the relay is obtained as follows:

$$I_b = \frac{\left|\bar{I}_1 + \bar{I}_2\right|}{2} \tag{2}$$

The operation of the relay is affected by stabilization as shown by the operating characteristic illustrated in Figure 4 below.

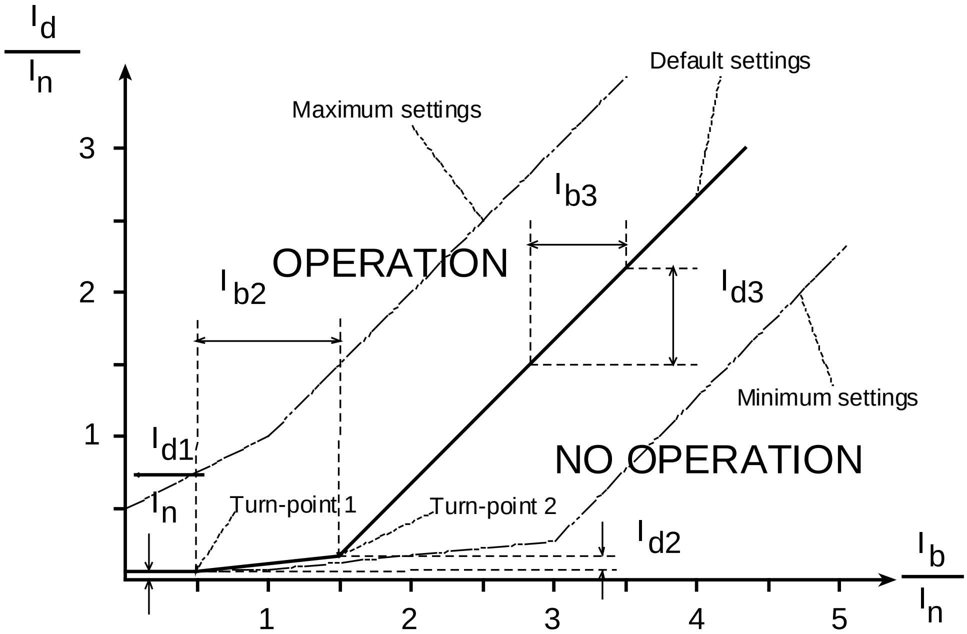


*Figure 4. Operating characteristic for the stabilized stage of the generator differential protection function block Diff6G*

The basic setting for the stabilized stage of the function block is determined according to Figure 4:

Basic setting = $I_{d1}/I_n$

The starting ratio is determined correspondingly:

Starting ratio = $I_{d2}/I_{b2}$

The first turning point “Turn-point 1” can be set at a desired point within the range 0.0...1.0. Accordingly, the second turning point “Turn-point 2” can be set within the range 1.0...3.0.

The slope of the operating characteristic for the function block varies in different parts of the range. In part 1 ($0.0 \leq I_b/I_n <$ Turn-point 1), the differential current required for tripping is constant. The value of the differential current is the same as the basic setting selected for the function block. The basic setting basicly allows for small inaccuracies of current transformers but it can also be used to influence the overall level of the operating characteristic.

The part 2, i.e. when Turn-point 1 $\leq I_b/I_n <$ Turn-point 2, is called the influence area of the setting “Starting ratio”. In this part, variations in the starting ratio affect the slope of the characteristic i.e. how big the change in the differential current required for tripping is in comparison with the change in the load current. The starting ratio allows for CT errors.

At high stabilizing currents, i.e. when $I_b/I_n \geq$ Turn-point 2, the slope of the characteristic is constant (part 3). The slope is 100%, which means that the increase in the differential current is equal to the corresponding increase in the stabilizing current.

The required differential current for tripping at a sertain stabilizing current level can be calculated using the following formulas:

If the stabilizing current is lower than Turn-point 1,

$I_{d,operate}$ = Basic Setting.

If the stabilizing current is greater than Turn-point 1 but lower than Turn-point 2,

$I_{d,operate}$ = Basic Setting + ($I_b$ - Turn-point 1) × Starting ratio.

For greater stabilizing current values, that is beyond Turn-point 2,

$I_{d,operate}$ = Basic Setting + (Turn-point 2 – Turn-point 1) × Starting ratio +
(Ib – Turn-point 2).

### 2.4.2 Saturation detection

The stabilized stage is provided with a current transformer saturation detection based on the waveforms of the currents. The saturation detection blocks Diff6G internally in case of current transformer saturation during an external fault.

### 2.4.3 Instantaneous stage 3ΔI>>

In addition to the stabilized stage, the differential function block includes an instantaneous stage which does not allow for stabilization. This stage trips when the amplitude of the fundamental frequency component of the differential current exceeds the set operate value “Inst. setting” or when the instantaneous value of the differential current exceeds 2.5 x Inst. setting. The factor 2.5 (1.8 x √2) is due to the maximum asymmetric short-circuit current. The internal blocking signals of the function block do not prevent the operate signal of the instantaneous stage. When required, the operate signal of the stage can be blocked by the external control signal BS2.

## 2.5 Recommendations for current transformers

The more important the object to be protected, the more attention should be paid to the current transformers. Normally, it is not possible to dimension the current transformers so that they repeat currents with high DC components without saturating when the residual flux of the current transformer is high. The differential protection function block Diff6G operates reliably even though the current transformers are partially saturated. The purpose of the following current transformer recommendations is to secure the stability of the relay at high through currents and the quick and sensitive operation of the relay at faults occurring in the protected area, where the fault currents may be high.

The accuracy class recommended for current transformers to be used with the differential function block Diff6G is 5P, in which the limit of the current error at the rated primary current is 1% and the limit of the phase displacement is 60 minutes. The limit of the composite error at the rated accuracy limit primary current is 5%.

The approximate value of the accuracy limit factor $F_a$ corresponding to the actual CT burden can be calculated on the basis of the rated accuracy limit factor $F_n$ (ALF) at the rated burden, the rated burden $S_n$, the internal burden $S_{in}$ and the actual burden $S_a$ of the current transformer as follows:

$$F_a = F_n \times \frac{S_{in} + S_n}{S_{in} + S_a} \tag{3}$$

EXAMPLE 1

> In the example the rated burden $S_n$ of the line end CTs 5P20 is 10 VA, the secondary rated current 5A, the internal resistance $R_{in} = 0.07\ \Omega$ and the accuracy limit factor $F_n$ (ALF) corresponding to the rated burden is 20 (5P20). Thus the internal burden of the current transformer is $S_{in} = (5A)^2 \times 0.07\ \Omega = 1.75$ VA. The input impedance of the relay at a rated current of 5A is < 20 m$\Omega$. If the measurement conductors have a resistance of 0.113 $\Omega$, the actual burden of the current transformer is $S_a = (5A)^2 \times (0.113 + 0.020)\ \Omega = 3.33$ VA. Thus the accuracy limit factor $F_a$ corresponding to the actual burden will be about 46.

The CT burden may grow considerably at the rated current of 5A. At the rated current of 1A the actual burden of the current transformer decreases, while the repeatability simultaneously improves.

At faults occurring in the protected area, the fault currents from the line end may be very high compared to the rated currents of the current transformers. Thanks to the instantaneous stage of the differential function block, it is enough that the current transformers are capable of repeating, during the first cycle, the current required for instantaneous tripping.

Thus the current transformers should be able to reproduce the asymmetric fault current without saturating within the next 10 ms after the occurrence of the fault, to secure that the operate times of the relay comply with the times stated in section “Technical Data”.

The accuracy limit factors corresponding to the actual burden of the phase current transformer to be used in differential protection shall fulfill the following requirement:

$$F_a > ( I_{kmax} / I_{1n} ) \times 3/(1-r) \tag{4}$$

where $I_{kmax}$ is the maximum through-going fault current at which the protection is not allowed to operate and $I_{1n}$ is the nominal primary current of the CT.

The parameter r gives the maximum remanence flux density in the CT core. The value of the parameter r depends on the magnetic material used and on the construction of the CT. For example the value r = 0.4 means that the remanence flux density may be 40 % of the saturation flux density. The manufacturer of the CT should be contacted when an accurate value of the parameter r is needed. The value r = 0.4 is recommended to be used in practice. The requirement can then be rewritten as follows:

$$F_a > ( I_{kmax} / I_{1n} ) \times 5 \qquad (5)$$

If the actual burden of the current transformer ($S_a$) in equation (3) cannot be reduced low enough to provide a sufficient value for $F_a$, there are two alternatives to deal with the situation.

1 A current transformer with a higher rated burden $S_n$ can be chosen (which also means a higher rated accuracy limit $F_n$) or

2 a current transformer with a higher nominal primary current $I_{1n}$ (but the same rated burden) can be chosen

The alternative 2. is more cost effective and therefore often better although the sensitivity of the scheme is slightly reduced.

EXAMPLE 2

If we assume the maximum through-going fault current $I_{kmax}$ to be 6000 A and the nominal primary current of the CT is 1500 A, we get for $F_a$:

$$F_a = ( 6000 / 1500 ) \times 5 = 20$$

In generator protection it is important that the accuracy limit factors ($F_a$ ) of the phase current transformers at the neutral end and at the line end of the generator correspond to each other, i.e. the burdens of the current transformers on both sides are as equal as possible. Should high inrush or start currents with high DC components pass through the protected generator when it is connected to the network, special attention should be paid to the performance and the burdens of the current transformers and to the settings of the function block.

## 2.6 Connection of current transformers

The connections of the main current transformers are designated as Type I and Type II. In case the earthings of the current transformers are either inside or outside the area to be protected, the setting parameter “CT connection” is of Type I (Figure 5). In case the earthings of the current transformers are both inside and outside the area to be protected, the setting parameter “CT connection” is of Type II (Figure 6). The default setting is Type I.

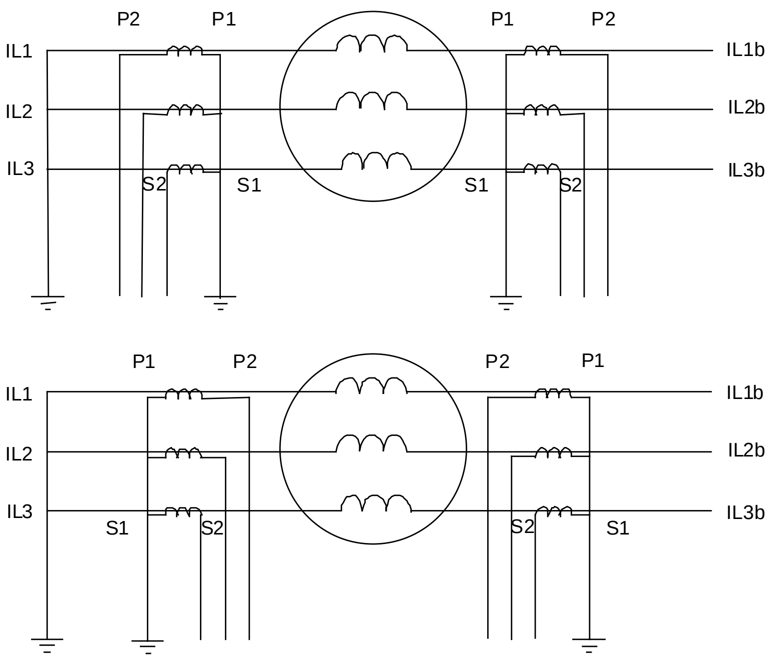


*Figure 5. Connection of current transformers of Type I*

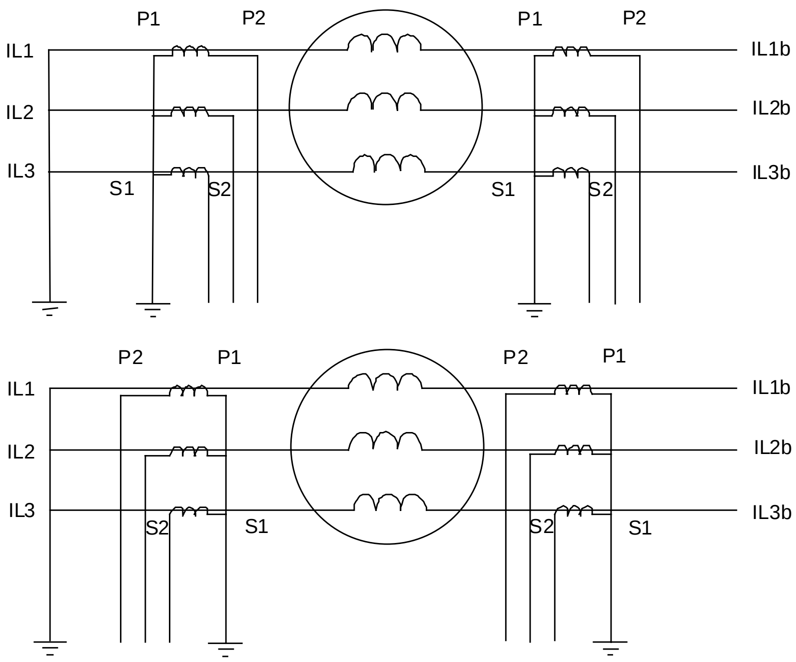


*Figure 6. Connection of current transformers of Type II*

## 2.7 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”[1)] of the MMI

2 Over the communication bus by writing the parameter V2[1)]

3 By means of the input signal GROUP when allowed via the parameter “Group selection” (i.e. when V2 = 2[1)])

[1)] Group selection (V2): 0 = Group 1; 1 = Group 2; 2 = GROUP input

The control parameter “Active group” indicates the setting group valid at a given time.

## 2.8 Test mode

The TRIP and CBFP digital outputs of the function block can be activated with separate control parameters for each output either locally via the MMI 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.

## 2.9 TRIP and CBFP outputs

The output signal TRIP may have a non-latching or latching feature. When the latching mode has been selected, the TRIP signal remains active until the output is reset even if the operation criteria have reset. When the non-latching mode has been selected, the TRIP signal remains active until the operation criteria have reset and the time determined by the the control parameter “Trip pulse” has elapsed.

The function block provides a delayed trip signal CBFP after the TRIP signal unless the fault has disappeared during the set CBFP time delay. In circuit-breaker failure protection the CBFP output can be used to operate a circuit breaker in front of the circuit breaker of the machine. The control parameter “Trip pulse” also sets the width of the CBFP output signal.

## 2.10 Resetting

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

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 1) | | X | X |
| Parameter F099V013 1) | | X | X |
| General parameter F001V011 2) | X | | |
| General parameter F001V012 2) | X | X | |
| General parameter F001V013 2) | X | X | X |
| Push-button C 2) | X | | |
| Push-buttons C + E (2 s) 2) | X | X | |
| Push-buttons C + E (5 s) 2) | X | X | X |

1) Resets the latched trip signal and recorded data of this particular function block.
2) 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 Diff6G is 99.
- 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 MMI or on serial communication (LON or SPA) as follows:

| | |
|---|---|
| Event mask 1 (FxxxV101/102) | SPA / MMI (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 MMI 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

| Parameter | Code | Values | Unit | Default | Data direction | Explanation |
|---|---|---|---|---|---|---|
| Basic setting | S1 | 5...50 | % | 5 | R | The lowest ratio of differential and nominal current to cause a trip |
| Starting ratio | S2 | 10...50 | % | 10 | R | Slope of the second line of the operating characteristics |
| Turn-point 1 | S3 | 0.0...1.0 | x In | 0.5 | R | Turn-point between the first and the second line of the operating characteristics |
| Turn-point 2 | S4 | 1.0...3.0 | x In | 1.5 | R | Turn-point between the second and the third line of the operating characteristics |
| Inst. setting | S5 | 5...30 | x In | 5 | R | Tripping value of the instantaneous stage |

### 3.2.2 Setting group 1

| Parameter | Code | Values | Unit | Default | Data direction | Explanation |
|---|---|---|---|---|---|---|
| Basic setting | S41 | 5...50 | % | 5 | R/W | The lowest ratio of differential and nominal current to cause a trip |
| Starting ratio | S42 | 10...50 | % | 10 | R/W | Slope of the second line of the operating characteristics |
| Turn-point 1 | S43 | 0.0...1.0 | x In | 0.5 | R/W | Turn-point between the first and the second line of the operating characteristics |
| Turn-point 2 | S44 | 1.0...3.0 | x In | 1.5 | R/W | Turn-point between the second and the third line of the operating characteristics |
| Inst. setting | S45 | 5...30 | x In | 5 | R/W | Tripping value of the instantaneous stage |

### 3.2.3 Setting group 2

| Parameter | Code | Values | Unit | Default | Data direction | Explanation |
|---|---|---|---|---|---|---|
| Basic setting | S71 | 5...50 | % | 5 | R/W | The lowest ratio of differential and nominal current to cause a trip |
| Starting ratio | S72 | 10...50 | % | 10 | R/W | Slope of the second line of the operating characteristics |
| Turn-point 1 | S73 | 0.0...1.0 | x In | 0.5 | R/W | Turn-point between the first and the second line of the operating characteristics |
| Turn-point 2 | S74 | 1.0...3.0 | x In | 1.5 | R/W | Turn-point between the second and the third line of the operating characteristics |
| Inst. setting | S75 | 5...30 | x In | 5 | R/W | Tripping value of the instantaneous stage |

## 3.2.4 Control settings

| Parameter | Code | Values | Unit | Default | Data direction | Explanation |
|---|---|---|---|---|---|---|
| Diff6G | V1 | 0 or 1[1] | - | 1 | R/W | Protection block in use or not in use |
| Group selection | V2 | 0...2 [2] | - | 0 | R/W | Selection of the active setting group |
| Active group | V3 | 0 or 1 [3] | - | 0 | R/M | Active setting group |
| Trip signal | V4 | 0 or 1[4] | - | 0 | R/W | Selection of latching feature for TRIP output |
| Trip pulse | V5 | 40...1000 | ms | 40 | R/W | Minimum pulse width of TRIP and CBFP |
| CBFP time | V6 | 100...1000 | ms | 100 | R/W | Operate time of the delayed trip CBFP |
| CT connection | V7 | 0 or 1 [5] | - | 0 | R/W | Determined by the directions of the connected currents transformers |
| Reset registers | V13 | 1=Reset | - | 0 | W | Resetting of latched trip signal and registers |
| Test TRIP | V32 | 0 or 1[6] | - | - | R/W | Testing of TRIP |
| Test CBFP | V33 | 0 or 1[6] | - | - | R/W | Testing of CBFP |
| Event mask 1 | V101 | 0...16383 | - | 8255 | R/W | Event mask 1 for event transmission (E0 ... E13) |
| Event mask 2 | V103 | 0...16383 | - | 8255 | R/W | Event mask 2 for event transmission (E0 ... E13) |
| Event mask 3 | V105 | 0...16383 | - | 8255 | R/W | Event mask 3 for event transmission (E0 ... E13) |
| Event mask 4 | V107 | 0...16383 | - | 8255 | R/W | Event mask 4 for event transmission (E0 ... E13) |

[1] Status 0 = Not in use; 1 = In use
[2] Group selection 0 = Group 1; 1 = Group 2; 2 = GROUP input
[3] Active group 0 = Group 1; 1 = Group 2
[4] Trip signal 0 = Non-latching; 1 = Latching
[5] CT connection 0 = Type I; 1 = Type II
[6] Test 0 = Do not activate; 1 = Activate

## 3.3 Measurement values

### 3.3.1 Input data

| Parameter | Code | Values | Unit | Default | Data direction | Explanation |
|---|---|---|---|---|---|---|
| Current IL1 | I1 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL1 |
| Current IL2 | I2 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL2 |
| Current IL3 | I3 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL3 |
| Current IL1b | I4 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL1b |
| Current IL2b | I5 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL2b |
| Current IL3b | I6 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL3b |
| Current Id1 | I7 | 0.00...60.00 | x In | 0.00 | R/M | Differential current of phase 1 |
| Current Id2 | I8 | 0.00...60.00 | x In | 0.00 | R/M | Differential current of phase 2 |
| Current Id3 | I9 | 0.00...60.00 | x In | 0.00 | R/M | Differential current of phase 3 |
| Current Ib1 | I10 | 0.00...60.00 | x In | 0.00 | R/M | Bias current of phase 1 |
| Current Ib2 | I11 | 0.00...60.00 | x In | 0.00 | R/M | Bias current of phase 2 |
| Current Ib3 | I12 | 0.00...60.00 | x In | 0.00 | R/M | Bias current of phase 3 |
| Angle IL1-IL2 | I13 | -180...180 | ° | 0 | R/M | Phase difference of the currents L1 and L2 |
| Angle IL2-IL3 | I14 | -180...180 | ° | 0 | R/M | Phase diff. of the currents L2 & L3 |
| Angle IL3-IL1 | I15 | -180...180 | ° | 0 | R/M | Phase diff. of the currents L3 & L1 |
| Angle IL1b-IL2b | I16 | -180...180 | ° | 0 | R/M | Phase diff. of the currents L1b & L2b |
| Angle IL2b-IL3b | I17 | -180...180 | ° | 0 | R/M | Phase diff. of the currents L2b & L3b |
| Angle IL3b-IL1b | I18 | -180...180 | ° | 0 | R/M | Phase diff. of the currents L3b & L1b |
| Angle IL1-IL1b | I19 | -180...180 | ° | 0 | R/M | Phase diff. of the currents L1 & L1b |
| Angle IL2-IL2b | I20 | -180...180 | ° | 0 | R/M | Phase diff. of the currents L2 & L2b |
| Angle IL3-IL3b | I21 | -180...180 | ° | 0 | R/M | Phase diff. of the currents L3 & L3b |
| Input BS1 | I22 | 0 or 1 [1)] | | 0 | R/M | Status of BS1 signal |
| Input BS2 | I23 | 0 or 1 [1)] | - | 0 | R/M | Status of BS2 signal |
| Input GROUP | I24 | 0 or 1 [1)] | - | 0 | R/M | Status of signal for switching between the groups 1 and 2 |
| Input RESET | I25 | 0 or 1 [1)] | - | 0 | R/M | Status of signal for resetting the output signals of Diff6G |

[1)] Input 0 = Not active; 1 = Active

## 3.3.2 Output data

| Parameter | Code | Values | Unit | Default | Data direction | Explanation |
|---|---|---|---|---|---|---|
| Output TRIP | O1 | 0 or 1 [1)] | - | 0 | R/M | Status of trip signal |
| Output ERR | O2 | 0 or 1 [1)] | - | 0 | R/M | Status of configuration error signal |

[1)] 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 trips or when the recording function is triggered via an external triggering input.

The data of three last operations (operation 1...3) are recorded, and the values of the most recent operation always replace the data of the oldest operation. The registers are updated in the following order: Operation 1, Operation 2, Operation 3, Operation 1, Operation 2,...

### 3.3.3.2 Date and time

The time stamp indicates the rising edge of the TRIGG signal or the moment of the highest fault current during the period of 50 ms after the rising edge of the TRIP signal.

### 3.3.3.3 Currents and phase differences

If the function block trips, all the recorded current and phase difference values will originate from the same moment determined by the highest differential current. For external triggering, the current values are recorded at the moment of triggering i.e. on the rising edge of the input signal TRIGG. Consequently, the values of the phase currents $I_{L1}$, $I_{L2}$, $I_{L3}$, $I_{L1b}$, $I_{L2b}$, $I_{L3b}$, the values of the differential currents $I_{d1}$, $I_{d2}$, $I_{d3}$, the values of the stabilizing currents $I_{b1}$, $I_{b2}$, $I_{b3}$ and the phase difference values always originate from the same moment. The current values are recorded as multiples of the rated current $I_n$ and the phase difference values are recorded in degrees.

### 3.3.3.4 Status data

The status data of the input signals BS1 and BS2 (Active or Not active) as well as the parameters “Active group” and “Reg. reason” are recorded at the moment of tripping and triggering. The “Active group” parameter indicates the setting group valid for the recorded data and the “Reg. Reason” parameter the reason for the particular registration (i.e. trip of the stabilized stage, trip of the instantaneous stage or activation of the TRIGG input).

## 3.3.3.5 Recorded data 1

| 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 |
| Current IL1 | V203 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL1 |
| Current IL2 | V204 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL2 |
| Current IL3 | V205 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL3 |
| Current IL1b | V206 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL1b |
| Current IL2b | V207 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL2b |
| Current IL3b | V208 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL3b |
| Current Id1 | V209 | 0.00...60.00 | x In | 0.00 | R/M | Differential current of phase 1 |
| Current Id2 | V210 | 0.00...60.00 | x In | 0.00 | R/M | Differential current of phase 2 |
| Current Id3 | V211 | 0.00...60.00 | x In | 0.00 | R/M | Differential current of phase 3 |
| Current Ib1 | V212 | 0.00...60.00 | x In | 0.00 | R/M | Bias current of phase 1 |
| Current Ib2 | V213 | 0.00...60.00 | x In | 0.00 | R/M | Bias current of phase 2 |
| Current Ib3 | V214 | 0.00...60.00 | x In | 0.00 | R/M | Bias current of phase 3 |
| Angle IL1-IL2 | V215 | -180...180 | ° | 0 | R/M | Phase difference of the currents L1 and L2 |
| Angle IL2-IL3 | V216 | -180...180 | ° | 0 | R/M | Phase difference of the currents L2 and L3 |
| Angle IL3-IL1 | V217 | -180...180 | ° | 0 | R/M | Phase difference of the currents L3 and L1 |
| Angle IL1b-IL2b | V218 | -180...180 | ° | 0 | R/M | Phase difference of the currents L1b and L2b |
| Angle IL2b-IL3b | V219 | -180...180 | ° | 0 | R/M | Phase difference of the currents L2b and L3b |
| Angle IL3b-IL1b | V220 | -180...180 | ° | 0 | R/M | Phase difference of the currents L3b and L1b |
| Angle IL1-IL1b | V221 | -180...180 | ° | 0 | R/M | Phase difference of the currents L1 and L1b |
| Angle IL2-IL2b | V222 | -180...180 | ° | 0 | R/M | Phase difference of the currents L2 and L2b |
| Angle IL3-IL3b | V223 | -180...180 | ° | 0 | R/M | Phase difference of the currents L3 and L3b |
| BS1 | V224 | 0 or 1 [1)] | - | 0 | R/M | Status of BS1 input |
| BS2 | V225 | 0 or 1 [1)] | - | 0 | R/M | Status of BS2 input |
| Active group | V226 | 0 or 1 [2)] | - | 0 | R/M | Active setting group |
| Reg. reason | V227 | 0...2 [3)] | - | 0 | R/M | Reason for registration |

[1)] Status 0 = Not active; 1 = Active
[2)] Active group 0 = Group 1; 1 = Group 2
[3)] Reg reason 0 = TRIP >; 1 = TRIP >>; 2 = TRIGG

## 3.3.3.6 Recorded data 2

| 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 |
| Current IL1 | V303 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL1 |
| Current IL2 | V304 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL2 |
| Current IL3 | V305 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL3 |
| Current IL1b | V306 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL1b |
| Current IL2b | V307 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL2b |
| Current IL3b | V308 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL3b |
| Current Id1 | V309 | 0.00...60.00 | x In | 0.00 | R/M | Differential current of phase 1 |
| Current Id2 | V310 | 0.00...60.00 | x In | 0.00 | R/M | Differential current of phase 2 |
| Current Id3 | V311 | 0.00...60.00 | x In | 0.00 | R/M | Differential current of phase 3 |
| Current Ib1 | V312 | 0.00...60.00 | x In | 0.00 | R/M | Bias current of phase 1 |
| Current Ib2 | V313 | 0.00...60.00 | x In | 0.00 | R/M | Bias current of phase 2 |
| Current Ib3 | V314 | 0.00...60.00 | x In | 0.00 | R/M | Bias current of phase 3 |
| Angle IL1-IL2 | V315 | -180...180 | ° | 0 | R/M | Phase difference of the currents L1 and L2 |
| Angle IL2-IL3 | V316 | -180...180 | ° | 0 | R/M | Phase difference of the currents L2 and L3 |
| Angle IL3-IL1 | V317 | -180...180 | ° | 0 | R/M | Phase difference of the currents L3 and L1 |
| Angle IL1b-IL2b | V318 | -180...180 | ° | 0 | R/M | Phase difference of the currents L1b and L2b |
| Angle IL2b-IL3b | V319 | -180...180 | ° | 0 | R/M | Phase difference of the currents L2b and L3b |
| Angle IL3b-IL1b | V320 | -180...180 | ° | 0 | R/M | Phase difference of the currents L3b and L1b |
| Angle IL1-IL1b | V321 | -180...180 | ° | 0 | R/M | Phase difference of the currents L1 and L1b |
| Angle IL2-IL2b | V322 | -180...180 | ° | 0 | R/M | Phase difference of the currents L2 and L2b |
| Angle IL3-IL3b | V323 | -180...180 | ° | 0 | R/M | Phase difference of the currents L3 and L3b |
| BS1 | V324 | 0 or 1 [1)] | - | 0 | R/M | Status of BS1 input |
| BS2 | V325 | 0 or 1 [1)] | - | 0 | R/M | Status of BS2 input |
| Active group | V326 | 0 or 1 [2)] | - | 0 | R/M | Active setting group |
| Reg. reason | V327 | 0...2 [3)] | - | 0 | R/M | Reason for registration |

[1)] Status 0 = Not active; 1 = Active
[2)] Active group 0 = Group 1; 1 = Group 2
[3)] Reg. reason 0 = TRIP >; 1 = TRIP >>; 2 = TRIGG

## 3.3.3.7 Recorded data 3

| 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 |
| Current IL1 | V403 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL1 |
| Current IL2 | V404 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL2 |
| Current IL3 | V405 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL3 |
| Current IL1b | V406 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL1b |
| Current IL2b | V407 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL2b |
| Current IL3b | V408 | 0.00...60.00 | x In | 0.00 | R/M | Phase current IL3b |
| Current Id1 | V409 | 0.00...60.00 | x In | 0.00 | R/M | Differential current of phase 1 |
| Current Id2 | V410 | 0.00...60.00 | x In | 0.00 | R/M | Differential current of phase 2 |
| Current Id3 | V411 | 0.00...60.00 | x In | 0.00 | R/M | Differential current of phase 3 |
| Current Ib1 | V412 | 0.00...60.00 | x In | 0.00 | R/M | Bias current of phase 1 |
| Current Ib2 | V413 | 0.00...60.00 | x In | 0.00 | R/M | Bias current of phase 2 |
| Current Ib3 | V414 | 0.00...60.00 | x In | 0.00 | R/M | Bias current of phase 3 |
| Angle IL1-IL2 | V415 | -180...180 | ° | 0 | R/M | Phase difference of the currents L1 and L2 |
| Angle IL2-IL3 | V416 | -180...180 | ° | 0 | R/M | Phase difference of the currents L2 and L3 |
| Angle IL3-IL1 | V417 | -180...180 | ° | 0 | R/M | Phase difference of the currents L3 and L1 |
| Angle IL1b-IL2b | V418 | -180...180 | ° | 0 | R/M | Phase difference of the currents L1b and L2b |
| Angle IL2b-IL3b | V419 | -180...180 | ° | 0 | R/M | Phase difference of the currents L2b and L3b |
| Angle IL3b-IL1b | V420 | -180...180 | ° | 0 | R/M | Phase difference of the currents L3b and L1b |
| Angle IL1-IL1b | V421 | -180...180 | ° | 0 | R/M | Phase difference of the currents L1 and L1b |
| Angle IL2-IL2b | V422 | -180...180 | ° | 0 | R/M | Phase difference of the currents L2 and L2b |
| Angle IL3-IL3b | V423 | -180...180 | ° | 0 | R/M | Phase difference of the currents L3 and L3b |
| BS1 | V424 | 0 or 1 [1)] | - | 0 | R/M | Status of BS1 input |
| BS2 | V425 | 0 or 1 [1)] | - | 0 | R/M | Status of BS2 input |
| Active group | V426 | 0 or 1 [2)] | - | 0 | R/M | Active setting group |
| Reg. reason | V427 | 0...2 [3)] | - | 0 | R/M | Reason for registration |

[1)] Status 0 = Not active; 1 = Active
[2)] Active group 0 = Group 1; 1 = Group 2
[3)] Reg reason 0 = TRIP >; 1 = TRIP >>; 2 = TRIGG

## 3.3.4 Events

| Code | Weighting coefficient | Default mask | Event reason | Event state |
|---|---|---|---|---|
| E0 | 1 | 1 | TRIP signal of 3d I> stage | Reset |
| E1 | 2 | 1 | TRIP signal of 3d I> stage | Activated |
| E2 | 4 | 1 | TRIP signal of 3d I>> stage | Reset |
| E3 | 8 | 1 | TRIP signal of 3d I>> stage | Activated |
| E4 | 16 | 1 | CBFB signal 3d I> or 3d I>> | Reset |
| E5 | 32 | 1 | CBFB signal 3d I> or 3d I>> | Activated |
| E6 | 64 | 0 | BLOCK signal of 3d I> stage | Reset |
| E7 | 128 | 0 | BLOCK signal of 3d I> stage | Activated |
| E8 | 256 | 0 | BLOCK signal of 3d I>> stage | Reset |
| E9 | 512 | 0 | BLOCK signal of 3d I>> stage | Activated |
| E10 | 1024 | 0 | Test mode of 3d I> and 3d I>> | Off |
| E11 | 2048 | 0 | Test mode of 3d I> and 3d I>> | On |
| E12 | 0 | 0 | - | - |
| E13 | 8192 | 1 | ERR: task / measuring device / signal type | Activated |

# 4. Technical Data

| | |
|---|---|
| **Operation accuracies** | At the frequency range $f/f_n$ = 0.95...1.05<br>Phase difference measurement: ± 4°<br>Operation of stabilized stage:<br>± 4% of set value or ± 2% x $I_n$<br>Operation of instantaneous stage:<br>± 4% of set value or ± 2% x $I_n$ |
| **Trip time** | Injected currents > 2.0 x operating current:<br>$f/f_n$ = 0.95...1.05 internal time < 35 ms<br>total time[1)] < 45 ms |
| **Reset time** | 60...1020 ms<br>(depends on the minimum pulse width set for the TRIP output) |
| **Reset ratio** | Typ. 0.95 (range 0.90...0.98) |
| **Retardation time** | Total retardation time when the current or voltage drops below the operate value[1)] < 40 ms |
| **Configuration data** | Task execution interval (Relay Configuration Tool): 5 ms at the rated frequency $f_n$ = 50 Hz |

[1)] Includes the delay of the heavy-duty output relay

| **Technical revision history** | |
|---|---|
| **Technical revision** | **Change** |
| C | - |