DIVISIONE ELETTRONICA E SISTEMI

ZFP8N

GENERATOR OUT-OF-STEP PROTECTION RELAY

USER MANUAL

P501D810 **September 2004**

INDEX

1 GENERAL CHARACTERISTICS

The protection relay ZFP8N is designed to perform the following functions:

Generator out-of-step protection ANSI 78

The operation of the ZFP8N protection relay is based on the impedance measurement method; the impedance vector is computed from the positive sequence components of the measured voltages and currents; the protection relay verifies the absence of negative sequence components of the currents and voltages and the absence of residual current.

The evolution of the measured impedance vector is checked on the X-R diagram with the polygonal out-of-step characteristic to identify power swing occurrences.

When an out-of-step condition occurs, a timer is started and a counter is increased; during the programmed time delay the protection relay will verify the number of out-of-step occurrences and will increase the counter if any.

The protection relay will trip if the counter reaches the programmed maximum number of allowed out-of-step occurrences in the time delay.

All the set-up and measured parameters can be visualized on the front panel display and transmitted on the RS485 communication serial port.

THRESHOLDS - the ZFP8N protection relay manages the following independent thresholds:

- polygonal out-of-step characteristic (two zones with counters **NZ1** and **NZ2**)
- 1 positive sequence minimum current threshold **I1<**
- 1 negative sequence overcurrent threshold **I2>**
- 1 negative sequence overvoltage threshold **U2>**
- 1 residual overcurrent threshold **Ir>**
- 1 undervoltage threshold (for voltage memory functionalities) **U<<**

The available settings for each threshold are listed in Table A; the operation of the protection relay is described in paragraph 1.1.

TIME DELAYS - programmable time delays related to the protection functions are available; specifically the available time delays are the followings:

- time length to check out-of-step occurrences (**TLIM**)
- activation time of the output relay signaling the first out-of-step occurrence (**TSIGN**)
- voltage memory duration (**TMem**)

All time delay are time definite; the available settings for each time delay are listed in Table A

OUTPUT RELAYS - the ZFP8N controls 4 output relays (named R1, R2, R3 and R4); these relays can be programmed to be activated on thresholds or functions.

START	instantaneous activation of the output relay when the parameter exceeds the programmed threshold value or following function activation
TRIP	activation of the output relay when the programmed maximum number of out-of-step occurrences is reached for one of the two zones of the polygonal characteristics (counters **NZ1** and **NZ2**)

The quiescent state of each single relay R1, R2, R3 and R4 can be programmed as normally energized (ON) or normally de-energized (OFF).

An additional relay R5 (normally energized) is controlled by the self-diagnosis routines to report detected fault conditions.

Related to each counter, partial and total counters of TRIP conditions are available.

DIGITAL INPUTS - there are available 6 digital inputs to activate the following functions (when enabled by the programmed set-up):

- additional time delay on **TLIM**
- on/off of one or more of the polygonal zones
- STATUS function (recording of measures on external event)
- pilot wire fault monitoring

For each digital input can be programmed the condition that activates the related functions:

HI voltage =	> 20V dc / ac
LO voltage =	0 ÷ 10 V dc / ac

The digital input acquisition is valid when the voltage value stays in the range HI or LO for at least 40 ms.

EVENTS - information related to the last 8 events (TRIP or STATUS) are recorded in the EEPROM memory.

Information includes the thresholds set-up, the activated relays (TRIP event only), the measured or computed parameters (measured currents and voltages, negative sequence current and voltage), the digital input status and date and time of the event.

SELF-DIAGNOSIS - the software includes a non stop monitoring module that controls the functionality of all hardware and software resources of the protection relay.

Detected fault conditions are reported by:

- diagnostic message on the display
- glow of a red LED on front panel
- R5 output relay drop-off

The fault condition signaling stays as far as faults are pointed out by the monitoring module; during this condition the protection functions are suspended to avoid unsuitable tripping.

STATUS FUNCTION - when the STATUS function is activated by one of the digital input (when programmed) the protection relay memorizes information related to measured parameters and digital input status (see par. 5.10 - EVENTS). The recorded information allows an analysis of trip causes in co-operative protection relays systems.

PILOT WIRE FAULT MONITORING - when the function is programmed, the digital input DIG2 is used to control the correct functionality of the pilot wire. Digital input DIG2 is always expected to be complementary of DIG1 input (HI-LO or LO-HI) to identify faults on pilot wire.

The fault condition is reported as detected by the self-diagnosis module but the protection functions are not suspended; only the functions related to DIG1 digital input are suspended as the DIG1 status cannot be longer considered as true.

When the function is activated, the fault condition will be detected when the status of DIG1 and DIG2 are equals for more then 100 ms.

REMOTE COMMUNICATION - the opto-insulated serial port RS485 can communicate with a personal computer or a remote control and monitoring system equipped with an RS485 interface or with a standard RS485/RS232 converter.

It is possible to select the communication standard between MODBUS (ASCII mode, SLAVE) or STANDARD (ASCII 7-bit - SEB).

All the set-up and measured parameters can be transmitted on the RS485 communication serial port; when communication is active (LED REMOTE glows), the operator on front panel can visualize the relay set-up but changes of parameters are disabled (ENTER and [+] buttons disabled).

VOLTAGE MEMORY FUNCTION – power swings in the electrical network could cause, on transient base, a very low voltage at protection measurement point.

The protection relay manages an undervoltage threshold (**U<<**) to detect this condition and to start-up the voltage memory function; the voltage memory function will keep for a programmed time length (**Tmem**, programmable up to 1 second) a voltage reference corresponding to the system voltage prior to the fault and thus the relay will be able to operate properly.

The memorized reference voltage is related to system frequency before the incidence of the event.

When the **Tmem** time expires, the out-of-step protection functions will be disabled.

1.1 Threshold operations

The ZFP8N protection relay measures the currents and voltages of a generator and computes:

- negative sequence current
- negative sequence voltage
- positive sequence current
- positive sequence voltage
- residual current

The positive sequence current component is verified with a programmable **I1>** threshold; the out-of-step protection function will operate only if the threshold is exceeded.

The negative sequence voltage is verified with a programmable **U2>** threshold, whilst the negative sequence current is verified with a programmable **I2>** threshold and the residual current with the programmable **Ir>** threshold; the out-of-step protection function will be disabled if one of the previous thresholds is exceeded.

These thresholds assure that the out-of-step protection operates under symmetrical occurrences and not in presence of other electrical system failures to be detected by other protection functions.

The positive sequence components of the voltages and the currents are used to compute the impedance vector. The evolution of the impedance vector is checked on the diagram X-R with the polygonal out-of-step characteristic.

The measurement characteristic of the protection relay is a polygonal represented by a rectangle with programmable widths and inclination angle.

The inclination angle matches the centre points of the circles representing the locus of the impedances seen from the measuring point (voltage transformers location) with out-of-step occurrences.

The widths are defined as function of the impedance of the generator and of the unit transformer.

The rectangle characteristic is defined by two zones:

Zone 1 covers the condition with the electrical centre of the power swings in the generator and unit transformer

Zone 2 covers the condition with the electrical centre of the power swings in the network system

The out-of-step condition is detected when the impedance vector enters the power swing characteristic at one side and leaves it at the other side. This means a loss of synchronism condition.

If the vector impedance enters and leaves the polygonal characteristic at the same side, the power swing will evolve toward a stabilized condition.

When the impedance vector enters in the polygonal characteristic, the programmable timer **TLIM** will start.

For each characteristic's zone a separate counter is defined (**NZ1**, **NZ2**) and each of them is increased when the impedance vector enters and leaves the corresponding zone.

For each counter a maximum number of out-of-step conditions can be independently programmed; when the corresponding counter reaches the programmed value, the protection relay will trip.

If the programmed value of the counter is not reached within the programmed **TLIM** time delay, the protection relay will reset (reset of **NZ1** and **NZ2** counters).

When the impedance vector enters in the polygonal characteristic for the first time, a signaling output relay can be activated; the time length **TSIGN** of the output relay activation is programmable.

Every out-of-step protection function can be programmed ON / OFF or disabled with an external command through digital inputs

Insertion of the protection relay
At set-up level (ref. chapter 5.4, point C1) it is possible to select the protection relay insertion as:

- STAR operations measuring the phase to earth voltages
- DELTA operations measuring the phase to phase voltages

Voltage memory function

Power swings in the electrical network could cause, on transient base, the presence of a very low voltage where the measurement point.

The protection relay manages an undervoltage threshold (**U<<**) to detect this condition and to start-up the voltage memory function; the voltage memory function will keep for a programmed time length (**Tmem**, programmable up to 1 second) a voltage reference corresponding to the system voltage prior to the fault and thus the relay will be able to operate properly.

The memorized reference voltage is related to system frequency before the incidence of the event.

When the **Tmem** time expires, the out-of-step protection functions will be disabled.

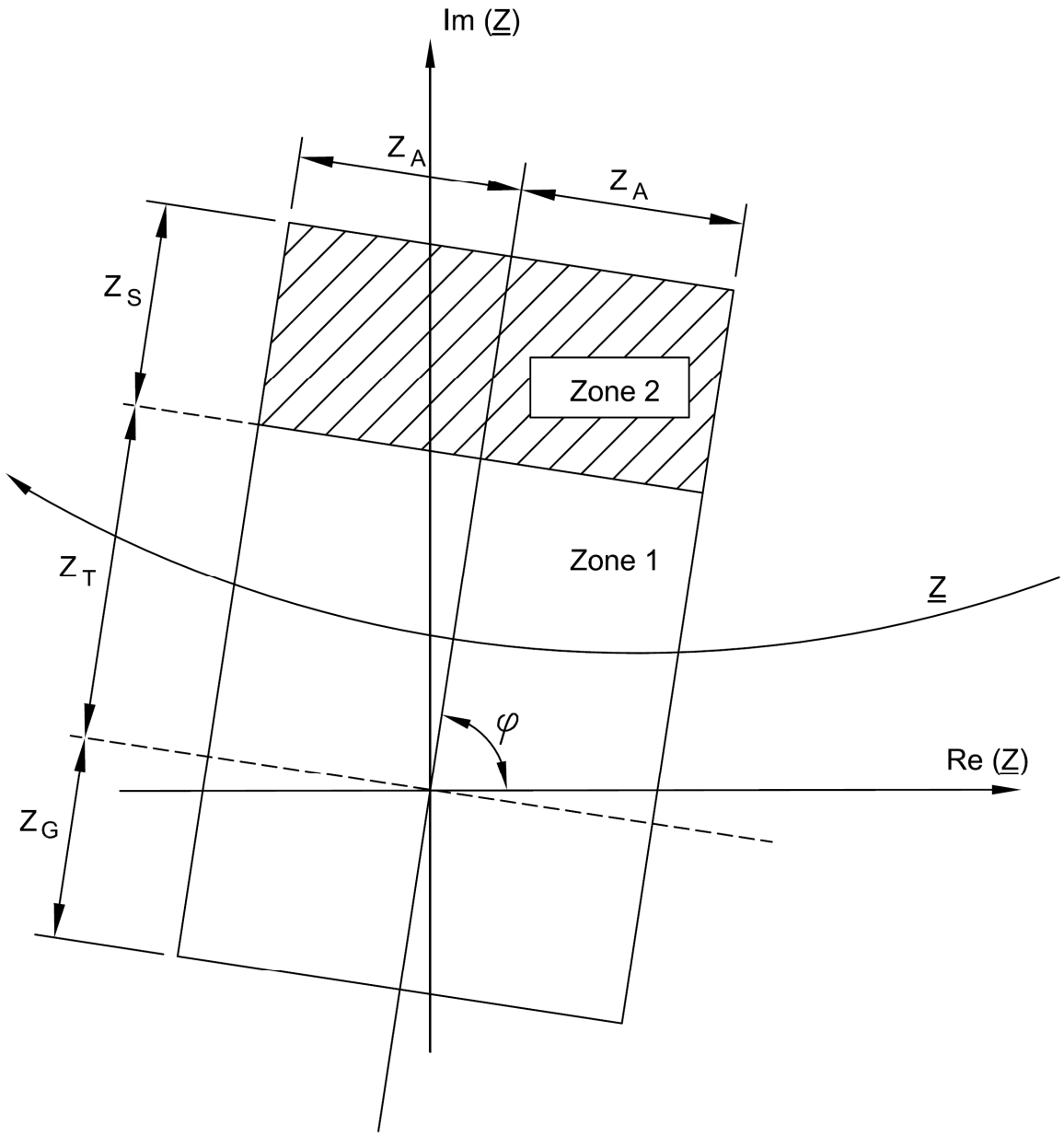


Figure 1 - Polygonal Characteristic

2 FRONT PANEL KEYS

The 5 push-buttons on the front panel allow to visualize all the protection parameters and to modify the protection set-up.

right arrow

down arrow

programming session activation or parameter confirmation

change or increment of the selected parameter

reset of the protection relay (rif. par. 4.3)

VISUALIZATION OF PARAMETERS

- all visualizations are circular and they can be displayed using the two arrow push-buttons.
- the structure of the visualizations and their contents are showed in figure from 2, 3 and 4.
- when the sealable transparent front panel is installed only the arrow push-buttons and the RESET push-button are accessible to prevent unauthorized modification of the protection set-up.

MODIFICATION OF PARAMETERS

- remove the transparent sealable front panel to access [ENTER] and  push-buttons.

3 FRONT PANEL LED SIGNALING

POWER (green)	⊗	auxiliary supply available
FAIL (red)	⊗	fault condition detected by SELF-DIAGNOSIS software or by PILOT WIRE FAULT MONITORING function
REMOTE (red)	⊗	communication session active on RS485 port
PZ1 (red)	⊗	out-of-step ZONE 1 (counter NZ1)
PZ2 (red)	⊗	out-of-step ZONE 2 (counter NZ2)
BLK (red)	⊗	out-of-step disabled (thresholds I2>, Ir>, U2>)

The last trip condition (threshold indication) is also showed on front panel display; more information on trip condition are presented in the recorded EVENT (see par. 5.10).

4 PROGRAMMING AND TEST

The protection relay is easily programmable following the instructions in the next paragraphs:

- HOW TO PROGRAM THE PROTECTION RELAY
- HOW TO MODIFY A VISUALIZED PARAMETER

All parameters can be freely modified; the proper protection set- up as required by the plant management is submitted to the operator's judgment.

4.1 How to program the protection relay

The programmable parameters are showed in figures 2, 3 and 4 at the following references:

B2 ÷ B7	relay address (RS485) and date/time
C1	protection relay insertion
D1 ÷ D6	nominal values, contrast etc.
E1 ÷ E17	polygonal characteristic parameters, thresholds set-up
F1 ÷ F13	output relays functions
G1 ÷ G6	digital input functions
R1, R3, R5	partial trip counters reset

The programming sequence is the following:

1) **SELECT** the visualization (on display) of the parameter to be modified using the arrow push-buttons

2) **ACTIVATE** the PARAMETER MODIFICATION session depressing the [ENTER] push-button and modify the parameter value

3) **END** the parameter modification session depressing again the [ENTER] push-button

4) **REPEAT** the procedure from 1) to 3) for all the parameters required to obtain the new protection relay set-up

5) **CONFIRM** the new protection relay set-up at the visualization CONFIRM PROG? (Fig. 3, ref. J1) within 5 minutes depressing the push-buttons [ENTER] and [+] up to visualize **YES** and [ENTER] again to confirm.

NOTE The protection relay continues to operate using the previous set-up until the new set-up is confirmed as at point 5) above; the visualization of the modified parameters before the new set-up confirmation is only temporary to allow an easy definition of the new protection set-up.

If the new set-up is not confirmed within 5 minutes from the last pressed push-button, the protection relay visualizes again the previous set-up (the parameters set-up that the protection relay is still using).

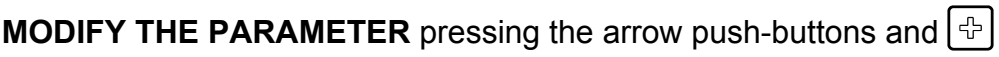
4.2 How to modify a visualized parameter

When the parameter to be modified is visualized on front panel display do the following sequence:

1) PRESS [ENTER] to activate the parameter modification session

If one or more parameters are modifiable, on the first of them will appear a blinking cursor.

If no parameters are modifiable, no blinking cursor will appear.

2) MODIFY THE PARAMETER pressing the arrow push-buttons and 

when two parameters are modifiable, the push-button allows to point-out the parameter to be modified (the selected parameter will blink)

when numerical parameters are pointed-out the push-button allows to select the digit to be modified

increasing of the parameter

a) the digits are increased by 1 unit

b) the other parameters are presented following the selection list

3) PRESS [ENTER] to end parameter modification session

The modification session is ended and the parameter stops to blink

NOTE if a numerical parameter is selected out of the accepted range (as shown in Table A) when the push-button [**ENTER**] is pressed for few seconds an error message will be displayed as:

```
Data
Error
```

and the parameter will be displayed again with the former value.

4.3 Reset

When the push-button [**RESET**] is pressed, the protection relays returns to the standard condition:

- reset of glowing LED's
- drop-off of tripped relays
- reset of any parameter changed but not confirmed (parameters are shown as confirmed at the end of the last programming session)

- display on STANDARD MODE (ref. A1 – par. 5.1)

4.4 Test of output relays

When the output relays test is selected (Figure 3, ref. F13) it is possible to command an output relay (one at the time) to trip from the current status allowing functional tests on electrical plants.

The output relays are activated with the following sequence:

1) **SELECT THE VISUALIZATION** of the desired output relay to be tested

```
TEST R1
OFF
```

2) **PRESS [ENTER]** to activate the test session; the message OFF will start to blink.

3) **PRESS** [⊕]; and the message on the display will change as:

```
TEST R1
ON
```

4) **PRESS [ENTER]** to command the instantaneous trip of the output relay (change of the current status).

The relay will stay on the new condition until:

- the [⇨] or [**RESET**] push-button is pressed
- the [**ENTER**] push-button is pressed and the sequence at points 3 and 4 is repeated (presenting OFF condition)

The same procedure will be used for R2, R3 and R4 relays.

5 DISPLAY AND PROGRAMMING

The contents and the structure of the displayed messages are shown in figures 2, 3 and 4; the references A1, B1, B2 etc. identify specific displayed messages in the figures.

5.1 Standard display

A1 - STANDARD DISPLAY(figure 2)

It is the standard displayed message without operator's intervention (no push-buttons pressed for at least 5 minutes) or when the RESET push-button has been pressed.

The displayed information is function of the protection relay status.

NORMAL FUNCTIONING
During this state the following information can be visualized (as defined by set-up):

- **Protection function (ANSI code)** - the display shows the ANSI code of the protection function.

ON TRIP CONDITION
When a trip condition occurs the protection relay visualizes the TRIP message that includes the polygonal zone interested by the protection intervention; the displayed messages are as the following:

TRIP PZ1	TRIP PZ2

where:

- **PZ1** trip for out-of-step related to **ZONE1** of the polygonal characteristic
- **PZ2** trip for out-of-step related to **ZONE2** of the polygonal characteristic

The information of the trip, as well the glowing of the related LED's, is displayed until the [RESET] push-button is pressed.

If a new trip condition occurs, the displayed information will be updated; information related to previous trips are recorded in EVENTS memory.

FAULT CONDITION
When a permanent or temporary fault condition is detected by the self-diagnosis module, the following message will be displayed:

FAIL eeeeeeee

The string eeeeeeee can be:

F.PILOT Detected fault condition on pilot wire; the function related to DIG1 digital input is suspended
Corrective action - verify pilot wire (short or open circuit)

HARDWARE Detected fault condition on hardware or software resources of the protection relay; all functions are suspended.
Corrective action - replace the protection relay and contact SEB post sales service

5.2 Visualization structure

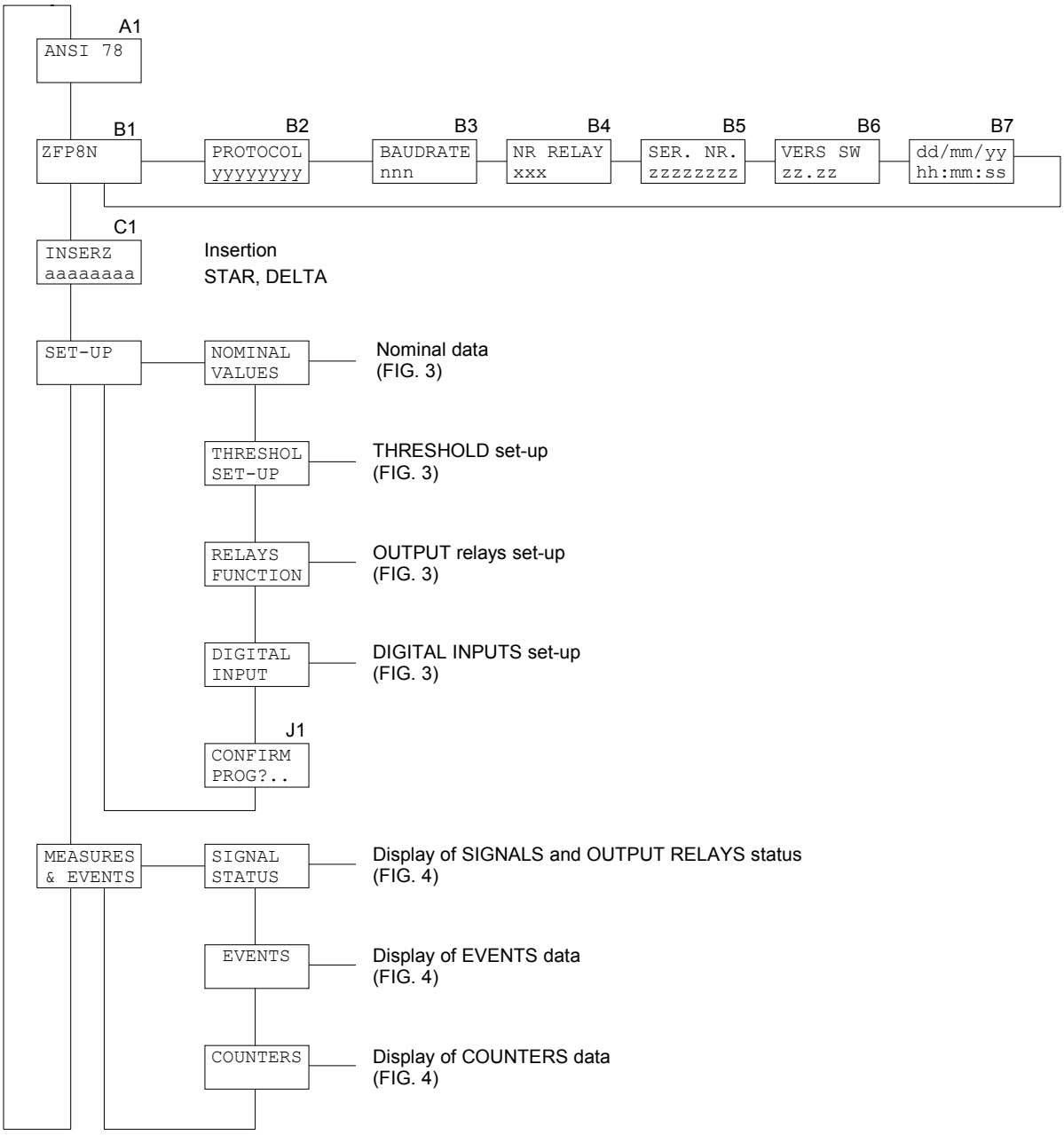


Figure 2

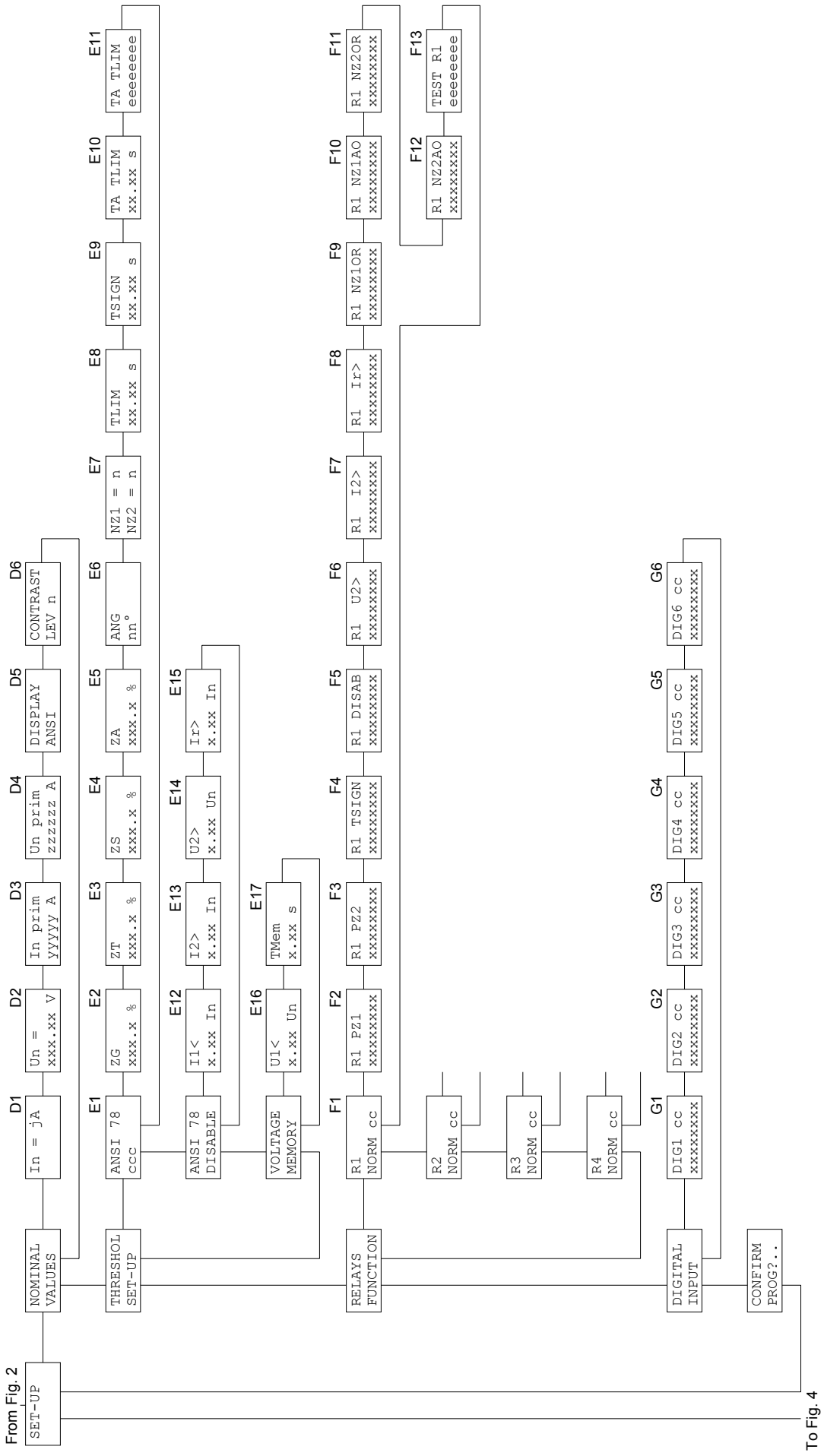

From Fig. 2
SET-UP
NOMINAL VALUES
THRESHOL SET-UP
RELAYS FUNCTION
DIGITAL INPUT
CONFIRM PROG?..
To Fig. 4
D1 In = jA
D2 Un = xxx.xx V
D3 In prim yyyyy A
D4 Un prim zzzzzz A
D5 DISPLAY ANSI
D6 CONTRAST LEV n
E1 ANSI 78 ccc
E2 ZG xxx.x %
E3 ZT xxx.x %
E4 ZS xxx.x %
E5 ZA xxx.x %
E6 ANG nn°
E7 NZ1 = n NZ2 = n
E8 TLIM xx.xx s
E9 TSIGN xx.xx s
E10 TA TLIM xx.xx s
E11 TA TLIM eeeeeee
E12 I1< x.xx In
E13 I2> x.xx In
E14 U2> x.xx Un
E15 Ir> x.xx In
E16 U1< x.xx Un
E17 TMem x.xx s
ANSI 78 DISABLE
VOLTAGE MEMORY
F1 R1 NORM cc
F2 R1 PZ1 xxxxxxxxx
F3 R1 PZ2 xxxxxxxxx
F4 R1 TSIGN xxxxxxxxx
F5 R1 DISAB xxxxxxxxx
F6 R1 U2> xxxxxxxxx
F7 R1 I2> xxxxxxxxx
F8 R1 Ir> xxxxxxxxx
F9 R1 NZ1OR xxxxxxxxx
F10 R1 NZ1AO xxxxxxxxx
F11 R1 NZ2OR xxxxxxxxx
F12 R1 NZ2AO xxxxxxxxx
F13 TEST R1 eeeeeeee
R2 NORM cc
R3 NORM cc
R4 NORM cc
G1 DIG1 cc xxxxxxxxx
G2 DIG2 cc xxxxxxxxx
G3 DIG3 cc xxxxxxxxx
G4 DIG4 cc xxxxxxxxx
G5 DIG5 cc xxxxxxxxx
G6 DIG6 cc xxxxxxxxx

Figure 3

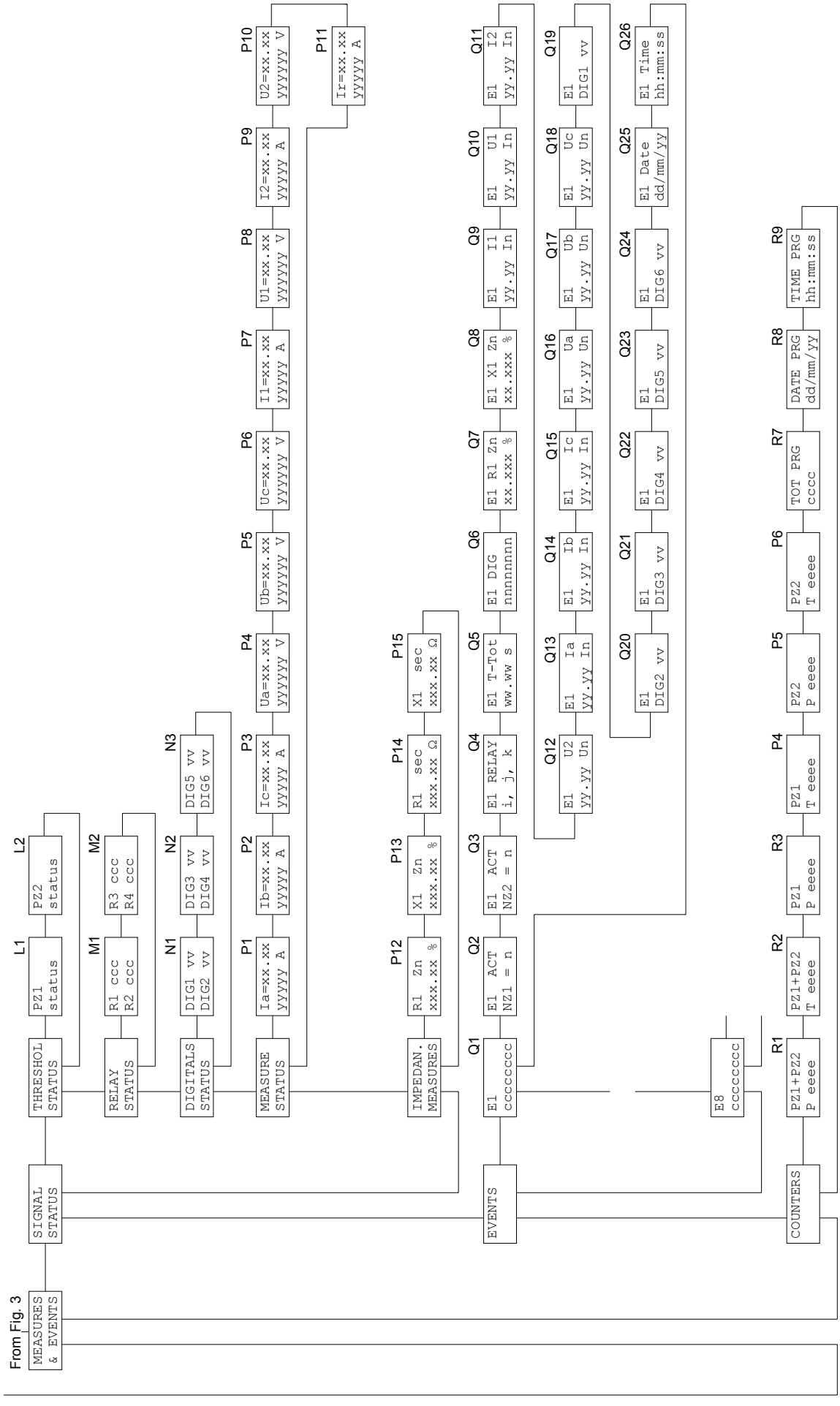

From Fig. 3
MEASURES & EVENTS
SIGNAL STATUS
THRESHOL STATUS
PZ1 status
PZ2 status
RELAY STATUS
R1 ccc R2 ccc
R3 ccc R4 ccc
DIGITALS STATUS
DIG1 vv DIG2 vv
DIG3 vv DIG4 vv
DIG5 vv DIG6 vv
MEASURE STATUS
Ia=xx.xx yyyyy A
Ib=xx.xx yyyyy A
Ic=xx.xx yyyyy A
Ua=xx.xx yyyyyy V
Ub=xx.xx yyyyyy V
Uc=xx.xx yyyyyy V
I1=xx.xx yyyyy A
U1=xx.xx yyyyyy V
I2=xx.xx yyyyy A
U2=xx.xx yyyyyy V
Ir=xx.xx yyyyy A
IMPEDAN. MEASURES
R1 Zn xxx.xx %
X1 Zn xxx.xx %
R1 sec xxx.xx Ω
X1 sec xxx.xx Ω
EVENTS
E1 cccccccc
E1 ACT NZ1 = n
E1 ACT NZ2 = n
E1 RELAY i, j, k
E1 T-Tot ww.ww s
E1 DIG nnnnnnnn
E1 R1 Zn xx.xxx %
E1 X1 Zn xx.xxx %
E1 I1 yy.yy In
E1 U1 yy.yy In
E1 I2 yy.yy In
E1 U2 yy.yy Un
E1 Ia yy.yy In
E1 Ib yy.yy In
E1 Ic yy.yy In
E1 Ua yy.yy Un
E1 Ub yy.yy Un
E1 Uc yy.yy Un
E1 DIG1 vv
E8 cccccccc
COUNTERS
PZ1+PZ2 P eeee
PZ1+PZ2 T eeee
PZ1 P eeee
PZ1 T eeee
PZ2 P eeee
PZ2 T eeee
TOT PRG cccc
DATE PRG dd/mm/yy
TIME PRG hh:mm:ss
E1 DIG2 vv
E1 DIG3 vv
E1 DIG4 vv
E1 DIG5 vv
E1 DIG6 vv
E1 Date dd/mm/yy
E1 Time hh:mm:ss

Figure 4

5.3 Address and time (figure 2)

B1 - RELAY MODEL (not programmable)

```
ZFP8N
```

B2 - B3 - COMMUNICATION PROTOCOL (programmable)

B2

```
PROTOCOL
xxxxxxxx
```

The communication protocol is programmable between the followings:

STANDARD	ASCII SEB protocol
MODBUS	Modbus protocol (SLAVE)

When the MODBUS protocol is selected the following display is showed to allow the selection of the transmission speed:

B3

```
BAUDRATE
xxxx
```

The xxxx parameter is selectable between the followings:

300 - 600 - 1200 - 2400 - 4800 - 9600

When the STANDARD protocol is selected the baud rate is automatically selected by the protection relay.

B4 - ADDRESS (programmable)

```
NR RELAY
001
```

Programmable address from 001 to 255.

The number is used on RS485 port to address a specific relay when two or more protection relays are linked on the same serial line.

B5 - RELAY SERIAL NUMBER (not programmable)

```
SER. NR
0012345
```

B6 - SOFTWARE REVISION LEVEL (not programmable)

```
SW REV
zz.zz
```

B7 - TIME / DATE (programmable)

```
dd/mm/yy
hh:mm:ss
```

Time and date are programmable and they are used to mark recorded events.

NOTE the clock is not provided with back-up battery, therefore a loss of auxiliary supply will force time/date to the following condition:

```
01/01/90
00:00:00
```

5.4 Protection insertion (figure 2)

C1 - INSERTION SELECTION (programmable)

```
INSERT
xxxxxx
```

The possible selections are the followings:

STAR	operations measuring the phase to earth voltages
DELTA	operations measuring the phase to phase voltages

Examples:

```
INSERT
STAR
```

```
INSERT
DELTA
```

5.5 Nominal values set-up (figure 3)

D1 - NOMINAL CURRENT SELECTION - In (programmable)

```
In  = jA
```

In nominal phase current programmable 1 A or 5 A

D2 - NOMINAL VOLTAGE SELECTION - Un (programmable)

```
Un =
xxx.xx V
```

Un nominal voltage selection (nominal secondary voltage of plant VT's)

selectable between the followings:

57.73 - 63.50 - 72.16 - 100 - 110 - 125 - 190 - 220 - 230 - 380 - 400

D3 - PRIMARY PHASE CURRENT (programmable)

```
In prim
yyyyy A
```

In prim primary phase current value of the installed phase CT's.

The values are programmable from 10 to 19999 A.

D4 - PRIMARY VT's VOLTAGES (programmable)

```
Un prim
zzzzzz V
```

Un prim primary voltage value of the installed VT's.

The values are programmable from 1000 to 999999 V.

D5 - STANDARD DISPLAY SELECTION (not programmable)

```
DISPLAY
ANSI
```

D6 - DISPLAY CONTRAST LEVEL (programmable)

```
CONTRAST
LEV x
```

The display contrast level is programmable from 0 to 9. The backlighted display is switched off if no push-button is pressed for at least 5 minutes; when one of the front panel push- button is pressed the display is switched on.

5.6 Thresholds and time delays set-up (figure 3)

The available settings of the parameters related to the thresholds are listed in Table A.

5.6.1 Out-of-step polygonal characteristic

E1 - ON / OFF THRESHOLD (programmable)

```
ANSI 78
ccc
```

ccc ON enabled threshold
OFF disabled threshold (available but not active)

E2 ÷ E5 - POLYGONAL PARAMETERS (programmable)

E2
```
ZG
xxx.x %
```

E3
```
ZT
xxx.x %
```

E4
```
ZS
xxx.x %
```

E5
```
ZA
xxx.x %
```

Programming of the parameters related to the polygonal characteristic of the out-of-step function.

ZG impedance generator direction
ZT impedance transformer direction

ZS additional impedance network direction
ZA rectangle half-width

All the parameters are expressed as % of Zn, where Zn = Un/In (**Un** programmed in D2, **In** programmed in D1).

The available settings for each parameter are listed in Table A.

E6 - ANGLE OF THE POLYGONAL CHARACTERISTICS (programmable)

```
ANG
nn°
```

Programming of the angle φ of the polygonal characteristic of the out-of-step function.

The available settings of the parameter are listed in Table A.

E7 - MAXIMUM PERMITTED OUT-OF-STEP OCCURRENCES (programmable)

```
NZ1 = n
NZ2 = m
```

Programming of the maximum number of permitted out-of-step occurrences for each zone of the polygonal characteristic:

NZ1 counter of the out-of-step allowed conditions Zone 1

NZ2 counter of the out-of-step allowed conditions Zone 2

The two counters are independently programmable from 1 to 9.

E8 - TIME DLENGTH FOR OUT-OF-STEP OCCURRENCES CHECK (programmable)

```
TLIM
xx.xx s
```

Programming of the time length to check the out-of-step occurrences; the time length is programmable from 0.20 to 99.99 seconds.

E9 - OUTPUT RELAY ACTIVATION TIME (programmable)

```
TSIGN
xx.xx s
```

Programming of the activation time of the output relay to signal the occurrence of the first power swing; the time delay is programmable from 0.20 to 99.99 seconds.

E10 - ADDITIONAL TIME LENGTH FOR OUT-OF-STEP OCCURRENCES CHECK (programmable)

```
TA TLIM
xx.xx s
```

The additional time TA is programmable from 00.00 to 99.99 seconds; please note that at least one of the digital inputs should be programmed to activate the time function (ref. G1 ÷ G6 - paragraph 5.8).

The additional time TA is added to the time length **TLIM** to obtain the total time length equals to TLIM+TA.

E11 - DIGITAL INPUT ACTIVE ON ADDITIONAL TIME FOR OUT-OF-STEP OCCURRENCES CHECK (not programmable)

```
TA TLIM
eeeeeee
```

It shows the digital input programmed to activate the additional time TA on the TLIM time length.

The parameter **eeeeeeee** can show one of the following values:

DISABLED	none of the digital inputs has been programmed to activate an additional time delay
DIG1	digital input DIG1 activates the TA delay
DIG2	digital input DIG2 activates the TA delay
DIG3	digital input DIG3 activates the TA delay
DIG4	digital input DIG4 activates the TA delay
DIG5	digital input DIG5 activates the TA delay
DIG6	digital input DIG6 activates the TA delay

More than one digital input can activate the same additional time delay (e.g. DIG 1,3).

Please note that to activate the additional time delay at least one of the digital inputs should be programmed (ref. G1 ÷ G6 - paragraph 5.8).

5.6.2 Out-of-step function enabling thresholds

E12 - POSITIVE SEQUENCE MINIMUM CURRENT THRESHOLD (programmable)

```
I1<
x.xx In
```

Programming of the positive sequence minimum current threshold to enable the operation of the out-of-step protection.

x.xx threshold value expressed as nominal current (In)

The available settings of the threshold are listed in Table A.

E13 - NEGATIVE SEQUENCE OVERCURRENT THRESHOLD (programmable)

```
I2>
x.xx In
```

Programming of the negative sequence overcurrent threshold to disable the operation of the out-of-step protection.

x.xx threshold value expressed as nominal current (In)

The available settings of the threshold are listed in Table A.

E14 - NEGATIVE SEQUENCE OVERVOLTAGE THRESHOLD (programmable)

```
U2>
x.xx Un
```

Programming of the negative sequence overvoltage threshold to disable the operation of the out-of-step protection.

x.xx threshold value expressed as nominal voltage (Un)

The available settings of the threshold are listed in Table A.

E15 - RESIDUAL OVERCURRENT THRESHOLD (programmable)

```
Ir>
x.xx In
```

Programming of the residual overcurrent threshold to disable the operation of the out-of-step protection.

x.xx threshold value expressed as nominal current (In)

The available settings of the threshold are listed in Table A.

5.6.3 Voltage memory threshold

E16 - UNDERVOLTAGE THRESHOLD (programmable)

```
U<<
x.xx Un
```

Programming of the undervoltage threshold to activate the voltage memory function.

x.xx threshold value expressed as nominal voltage (Un)

The available settings of the threshold are listed in Table A.

E17 - VOLTAGE MEMORY LENGTH (programmable)

```
TMem
x.xx s
```

Programming of the length of the voltage memory function when activated by the threshold **U<<**.

x.xx time length (in seconds)

The available settings of the time length are listed in Table A.

5.7 Output relays programming (figure 3)

The session allows to program the activation of the output relays R1, R2, R3 or R4 on START or TRIP conditions of the out-of-step protection functionalities.

Equivalent information and set-up related to relay R1 is available for the relays R2, R3 and R4 just changing the relay identification.

F1 - OUTPUT RELAY R1 QUIESCENT STATUS (programmable)

```
R1
NORM xxx
```

Programming of the R1 relay status when no START or TRIP conditions are activated.

NORM OFF normally de-energized (energized status on activation)
NORM ON normally energized (de-energized status on activation)

F2 - F3 - RELAY ACTIVATION ON OUT-OF-STEP CONDITION (programmable)

Programming of the activation of the output relay when the maximum number of allowed out-of-step occurrences is exceeded (counter NZ1 or NZ2 exceeded) for ZONE 1 or ZONE 2 of the polygonal characteristic.

F2

```
R1   PZ1
xxxxxxxx
```

F3

```
R1   PZ2
xxxxxxxx
```

The parameter **xxxxxxxx** is selectable as the following:

START instantaneous output relay R1 activation when the power swing condition is detected
TRIP output relay R1 activation when the counter NZ1 or NZ2 is exceeded
NONE no activation related to the function

When the START selection is programmed, the output relay will be activated every time the impedance vector is inside the polygonal characteristic; this functionality is useful for test purposes.

F4 - RELAY ACTIVATION ON POWER SWING CONDITION (programmable)

```
R1 TSIGN
xxxxxxxx
```

Programming of the activation of the output relay when the power swing condition is detected the first time (the impedance vector enters in the polygonal characteristic) and the time delay **TLIM** starts.

The parameter **xxxxxxxx** is selectable as the following:

START instantaneous output relay R1 activation when the power swing condition is detected
NONE no activation related to the function

F5 - RELAY ACTIVATION ON OUT-OF-STEP FUNCTION ENABLED (programmable)

```
R1 DISAB
xxxxxxxx
```

Programming of the activation of the output relay when the out-of-step protection functionalities are disabled for the intervention of one of the thresholds **I1<**, **I2>**, **U2>** or **Ir>**

The parameter **xxxxxxxx** is selectable as the following:

START instantaneous output relay R1 activation when the out-of-step protection function is disabled
NONE no activation related to the function

F6 ÷ F8 - RELAY ACTIVATION ON DISABLING THRESHOLDS (programmable)

F6
```
R1  U2>
xxxxxxxx
```

F7
```
R1   I2>
xxxxxxxx
```

F8
```
R1   Ir>
xxxxxxxx
```

Programming of the activation of the output relay when one or more of the thresholds (**I1<**, **I2>**, **U2>** or **Ir>**) related to the out-of-step protection disabling function are exceeded.

The parameter **xxxxxxxx** is selectable as the following:

START instantaneous output relay R1 activation when the single threshold is exceeded
NONE no activation related to the function

The output relay will remain activated as far as the threshold is exceeded (out-of-step protection function disabled).

F9 ÷ F12 - RELAY ACTIVATION ON COUNTERS STATUS (programmable)

F9
```
R1 NZ1OR
xxxxxxxx
```

F10
```
R1 NZ1AO
xxxxxxxx
```

F11
```
R1 NZ2OR
xxxxxxx
```

F12
```
R1 NZ2AO
xxxxxxxx
```

Programming of the activation of the output relay when the **NZ1** counter (related to Zone 1 of the polygonal characteristic) or the **NZ2** counter (related to **Zone 2** of the polygonal characteristic) are different than zero (power swing condition detected); this functionality is useful for test purposes.

It is identified the clockwise or counter-clockwise impedance vector swing.

- NZ1OR clockwise impedance swing in Zone 1
- NZ1AO counter-clockwise impedance swing in Zone 1

- NZ2OR clockwise impedance swing in Zone 2
- NZ2AO counter-clockwise impedance swing in Zone 2

The parameter **xxxxxxxx** is selectable as the following:

START	instantaneous output relay R1 activation when the impedance swing is detected
NONE	no activation related to the function

The output relay will remain activated as far as the respective counters **NZ1** and **NZ2** are greater than zero (therefore for a maximum time length equals to **TLIM**, when both counters will be reset).

F13 - TEST OF OUTPUT RELAYS - R1

```
TEST  R1
xxxxxxxx
```

See paragraph 4.4

5.8 Digital inputs function programming (figure 4)

For each digital input one of the following functions are selectable:

- additional time on TLIM timer
- ON / OFF of one of the zones of the polygonal characteristic
- STATUS function (recording of measures on external command)
- pilot wire fault monitoring (only DIG2 monitors DIG1)

When the function of more than one digital input refers to a threshold, the priority will be the following:

a) OF selection (disabling function) has the priority on TA function (additional time)

b) the ALL selection (ALL the thresholds) has the priority on single threshold selection.

G1 - DIGITAL INPUT DIG1 SET-UP (programmable)

```
DIG1  cc
xxxxxxxx
```

Programming of the function related to digital input channel 1 (DIG1).

Parameter cc: programming of the condition that activates the function related to digital input DIG1; the condition is selectable between HI and LO.

Parameter xxxxxxx: programming of the function related to digital input DIG1; the following functions are selectable:

NONE	no functions active related to digital input DIG1
TA TLIM	additional time on TLIM timer
OF PZ1	ZONE1 disabled (NZ1 counter blocked)

OF PZ2	ZONE2 disabled (NZ2 counter blocked)
OF ALL	ZONE1 and ZONE2 disabled (NZ1 and NZ2 counters blocked)
STATUS	activation of status function (see paragraph 1.)

G2 - DIGITAL INPUT DIG2 SET-UP (programmable)

```
DIG2  cc
xxxxxxxx
```

Programming of the function related to digital input channel 2 (DIG2); the selections available are the same as presented for DIG1 (ref. G1) plus the following:

MONITOR	activation of pilot wire monitor function.

G3 ÷ G6 - DIGITAL INPUTS DIG3÷DIG6 SET-UP (programmable)

```
DIG3  cc
xxxxxxxx
```

Programming of the function related to digital input channel 3 (DIG3); the selections available are the same as presented for DIG1 (ref. G1).

5.9 Parameter values visualization (figure 4)

L1 - L2 - THRESHOLDS STATUS

The actual status of the thresholds related to **ZONE1** and **ZONE2** is displayed.

For each threshold are displayed the threshold identification and the threshold status; the status can show one of the following values:

ON	active threshold
OFF	disabled threshold (programmed OFF at ref. E1 - see par. 5.6.1)
OFF_DIG	threshold programmed active but disabled by a digital input actual status (ref. G1 ÷ G6 see par. 5.8)

Examples:

```
PZ1
ON
```

```
PZ2
OFF_DIG
```

M1 - M2 - OUTPUT RELAY STATUS

The actual status of each output relay is displayed; for each relay the following information is displayed:

- relay identification (R1, R2, R3, R4)
- relay status (ON - activated, OFF - non activated)

Note that ON/OFF do not necessary mean energized or de-energized (see ref. G1).

N1 ÷ N3 - DIGITAL INPUT STATUS

The actual status of each digital input is displayed.

For each digital input the following information is presented:

- digital input identification (DIG1, DIG2, DIG3, DIG4, DIG5, DIG6)
- digital input status (HI or LO)

P1 ÷ P15 - MEASUREMENT DISPLAY

The actual values of the measures and of the computed parameters are displayed; the following information is presented:

P1 ÷ P3	measured currents
P4 ÷ P6	measured voltages
P7	computed positive sequence current
P8	computed positive sequence voltage
P9	computed negative sequence current
P10	computed negative sequence voltage
P11	computed residual current

For each display it is presented the measure or parameter identifier and the value expressed as In or Un and primary value (A or V).

P12 ÷ P13	impedance values R, X expressed as % Zn
P14 ÷ P15	impedance values R, X expressed as secondary Ohm

5.10 Events (figure 4)

On the display are shown the memorized information related to the last 8 TRIP or STATUS events.

The 8 events are recorded and identified with a progressive number from 1 to 8; the more recent event shows a lower number.

Q1 - EVENT NUMBER

The index E1, E2 ... E8 identifies the memorized event.

The parameter **cccccccc** gives information on the kind of event and it can show one of the following values:

NONE	no event memorized
TRIP PZ1	event on trip out-of-step ZONA1
TRIP PZ2	event on trip out-of-step ZONA2
START	event on start condition timer TLIM
TLIM	event on end timer TLIM
STATUS	information recorded on external command
POWER ON	switch-on of the protection relay (auxiliary power)

For the events NONE and POWER ON no other information is presented: for the other events the following displays give more detailed information on the event.

The START event is registered when the impedance vector enter the first time in the polygonal characteristic and the timer **TLIM** is activated.

Q2 - Q3 - TRIP THRESHOLD PARAMETERS

The actual values of the **NZ1** and **NZ2** timers (number of out-of-step occurrences at event registration) in are shown.

Example:

Q2

```
E1   ACT
NZ1 = 2
```

Q3

```
E1   ACT
NZ2 = 3
```

Q4 - ACTIVATED OUTPUT RELAYS

```
E1 RELAY
nnnnnnn
```

It shows the list of the output relay activated by the threshold trip.

Examples:

```
E1 RELAY
1,3,4
```

```
E3 RELAY
1,4
```

When no output relays have been activated (no relays programmed to TRIP on the threshold) the following message will be displayed:

```
E1 RELAY
NONE
```

Q5 - TLIM TIMER VALUE

```
E1 T-Tot
www.ww s
```

It is shown the value of the timer TLIM at the event registration; the information will be shown only for the following events:

TRIP PZ1 event on trip out-of-step **ZONE1**
TRIP PZ2 event on trip out-of-step **ZONE2**

When the event is memorized on the external command (STATUS), the message N/A (Not Applicable) is shown instead of the number of seconds.

```
E1 T-Tot
  N/A
```

Q6 - DIGITAL CHANNELS RELATED TO THE MEMORIZED EVENT

```
E1 DIG
1, 3, 4
```

The list of the digital inputs related to the memorized event is displayed (STATUS function) command or additional time TA enabled - ref. par. 5.8).

If no digital inputs were activated, the message NONE is displayed.

Q7 - Q8 - MEASURED IMPEDANCE

It is shown the values R and X (in % of Zn) of the measured impedance at the event registration; the impedance is computed using the direct sequence voltage and current (direct sequence impedance).

Example:

Q7

```
E1 R1 Zn
 2.012 %
```

Q8

```
E1 X1 Zn
0.750 %
```

Q9 ÷ Q18 - MEMORIZED MEASURES ON EVENT

The values of the measures or computed parameters at the event are displayed; the values are expressed as relative terms (In, Un).

Q9	computed direct sequence current (I1)
Q10	computed direct sequence voltage (U1)
Q11	computed negative sequence current (I2)
Q12	computed negative sequence voltage (U2)
Q13 ÷ Q15	measured currents (Ia, Ib, Ic)
Q16 ÷ Q18	measured voltages (Ua, Ub, Uc)

Examples:

Q9

```
E3    I1
1.301 In
```

Q14

```
E3    U2
0.003 Un
```

Q20

```
E3    Uc
1.001 Un
```

Q19 ÷ Q24 - DIGITAL INPUTS STATUS ON EVENT

```
E1
DIG1 vv
```

```
E1
DIG2 vv
```

```
E1
DIG3 vv
```

```
E1
DIG4 vv
```

```
E1
DIG5 vv
```

```
E1
DIG6 vv
```

The status of the digital inputs at the event are displayed.

The parameter **vv** can assume the value HI or LO.

Q25 - Q26 - DATE AND TIME OF THE EVENT

E1 Date dd/mm/yy	E1 Time hh:mm:ss

The date and time of the event are showed

5.11 Trip counters (figure 4)

In this section are displayed the total and partial counters of the trip conditions related to the out-of-step protection intervention for each zone (**ZONE1** or **ZONE2** or **ZONE1+ZONE2**) and the numbers of programming sessions with the date and time of the last confirmed programming session.

The total counters, the number of confirmed programming sessions and the date and time of the last confirmed programming session are not modifiable or resettable; the information related to the last programming session are used to control unauthorized access.

The partial counter can be modified following the standard set-up procedure for parameters as described at paragraph 4.2; the partial counters are immediately modified in the memory (the recorded values are immediately resetted without the need of the programming confirmation).

R1 ÷ R6 - TRIP COUNTERS

PZ1+PZ2 P eeee	PZ1+PZ2 T eeee	PZ1 P eeee
PZ1 T eeee	PZ2 P eeee	PZ2 T eeee

Display of the partial (P) and total (T) counters of the TRIP condition related to each zone (PZ1 or PZ2) and globally (**ZONE1+ZONE2** referred to PZ1+PZ2).

When the value exceed 9999 the counter starts again from 0000.

R7 ÷ R9 - TOTAL PROGRAMMING SESSIONS AND DATE/TIME OF THE LAST PROGRAMMING SESSION

TOT PRG eeee	DATE PRG dd/mm/yy	TIME PRG hh:mm:ss

Display of the number of confirmed programming sessions (from the factory set-up) and the date and time of the last confirmed programming session.

6 INSTALLATION

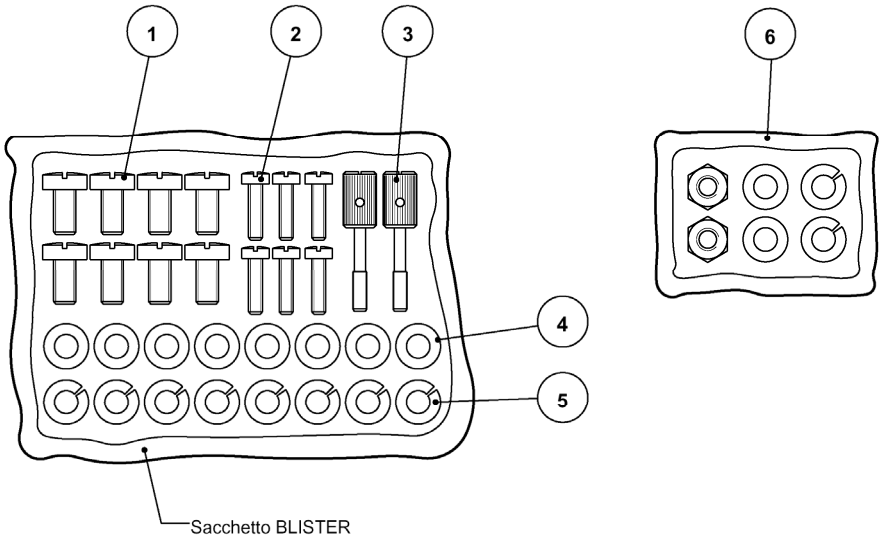
6.1 Supplied kit

RK VERSION - 19" rack installation (the proper rack is supplied by SEB

- protection relay module ZFP8N with 2 rear sockets
- transparent front panel with push-buttons
- transparent front panel without push-buttons
- blister with items 1-2-3-4-5

MR VERSION - mini-rack installation

- mini-rack
- protection relay module ZFP8N with 2 rear sockets
- transparent front panel with push-buttons
- transparent front panel without push-buttons
- blister with items 1-2-3-4-5



1) n° 8 screws to fix wire terminals of current circuits
2) n° 4 screws to fix the relay rear socket on the 19" rack (or on the mini rack) n° 2 screws to fix (optionally) the protection relay on the front of the 19" rack
3) n° 2 knobs to fix the transparent front panel
4) n° 8 washers to be used to fix wire terminals (current)
5) n° 8 growers to be used to fix wire terminals (current)

The knobs to fix the transparent front panel must be screwed through the panel the front panel itself; the operation will create a screw thread in the plastic material and the knobs will never be missed.

6.2 Cabling

For the terminal numbers on the rear sockets please refers to next figure.

Current circuits
It is suggested to terminate the current wiring using eyelet terminals.

Minimum suggested wire cross section: 2,5 mm^2

Voltage circuits
It is suggested to terminate the voltage wiring using plug terminals.

Minimum suggested wire cross section: 1,5 mm^2

With reference to the insertion diagram, the voltage input terminals must be selected as function of the programmed Un value.

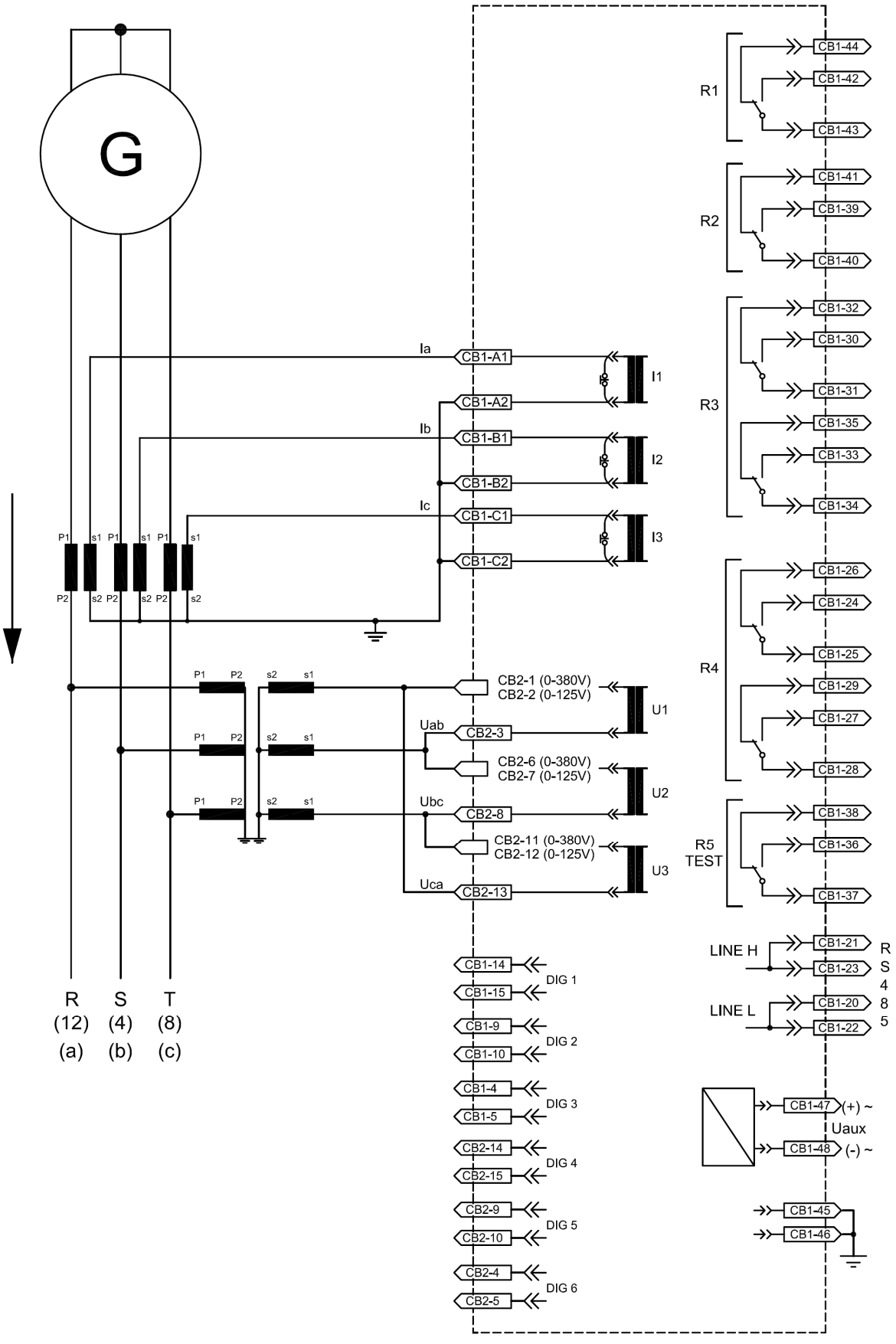


Figure 7 – Insertion

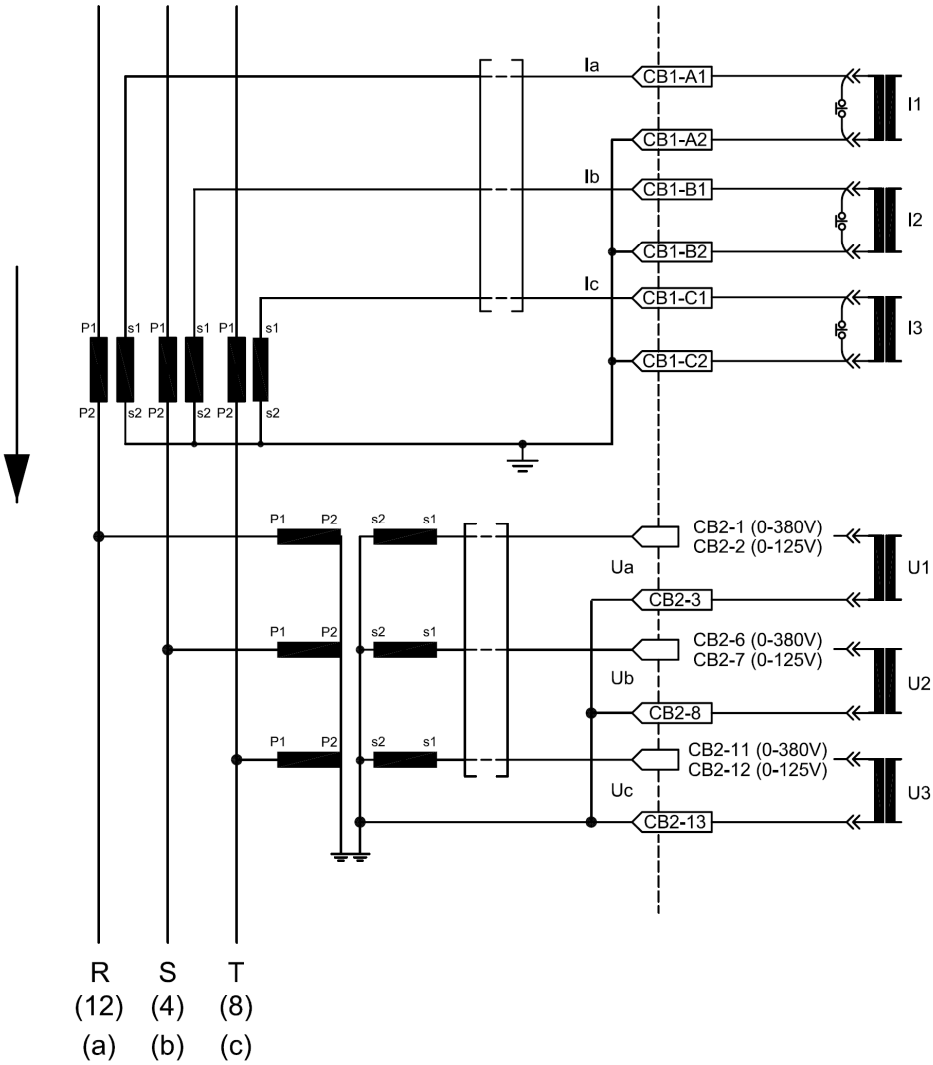
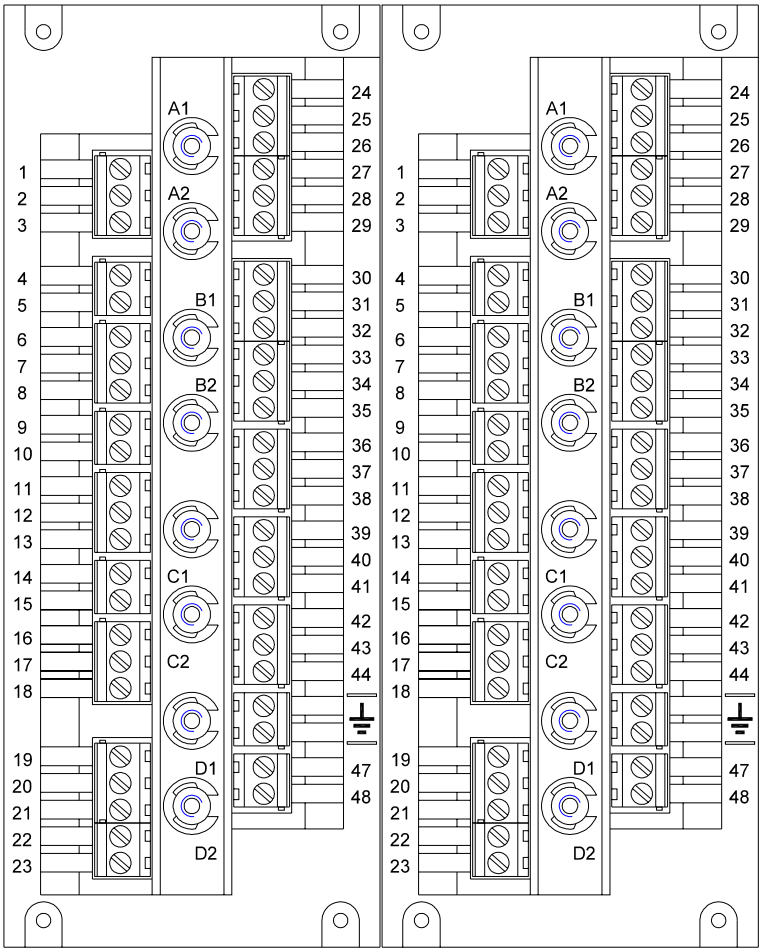
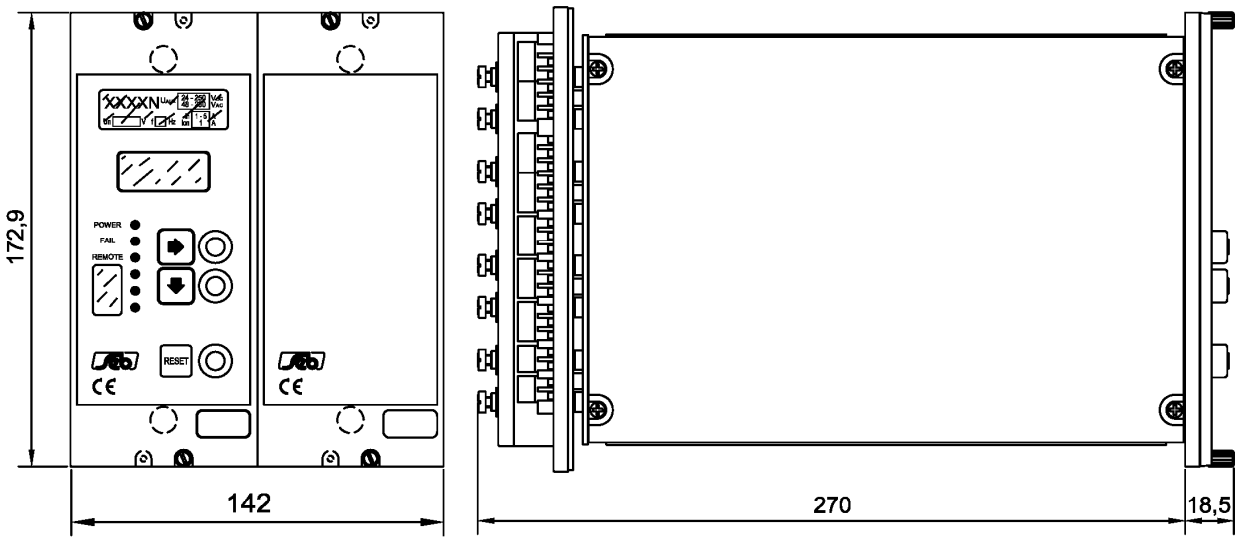
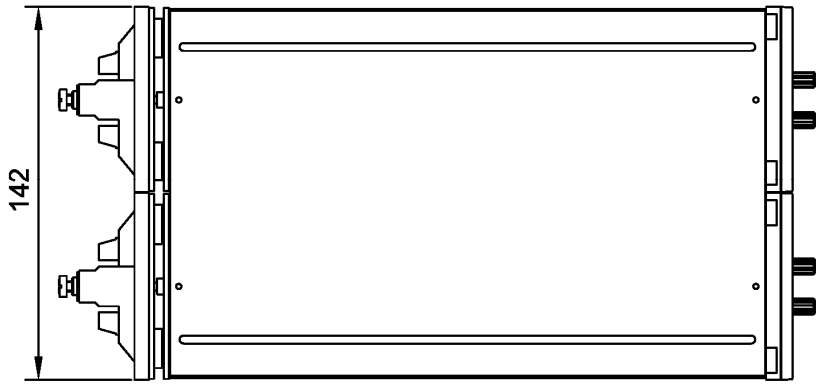


Figure 8 – Insertion

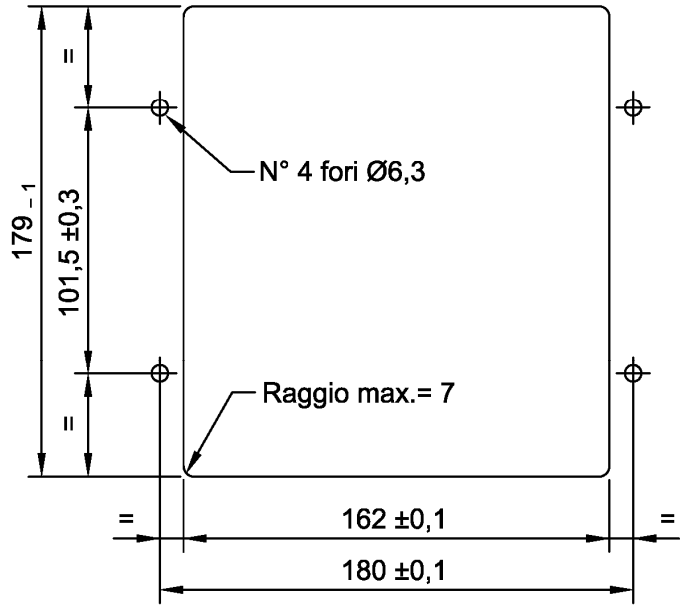


Terminal inputs position - REAR VIEW - Figure 9





Dimensioni
meccaniche
Case outlines



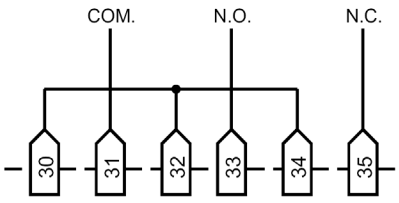
Dima montaggio da incasso
Flush mounting panel cut - out

Dimensioni frontali mini-rack per incasso
Mini-rack front sizes (flush mounting)
198.2 x 177 (4U) mm.

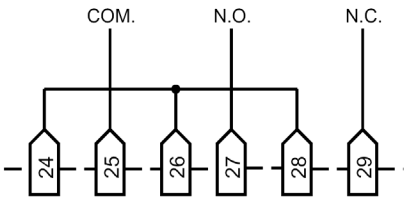
6.3 Relays R3 and R4 - Signaling / Command set-up

The protection relay is supplied with R3 and R4 relays configured as SIGNALING RELAYS, with 2 change-over output contacts with breaking capability equals to 0.2 A at 110 Vdc, L/R = 40 ms, 100000 operations.

Each R3 and R4 relay can be configured as COMMAND RELAY with 1 change-over output contact with breaking capability equals to 0.5 A at 110 Vdc, L/R = 40 ms, 100000 operations.
The new configuration is obtained with the following cabling:



R3



R4

6.4 RS485 serial communication port

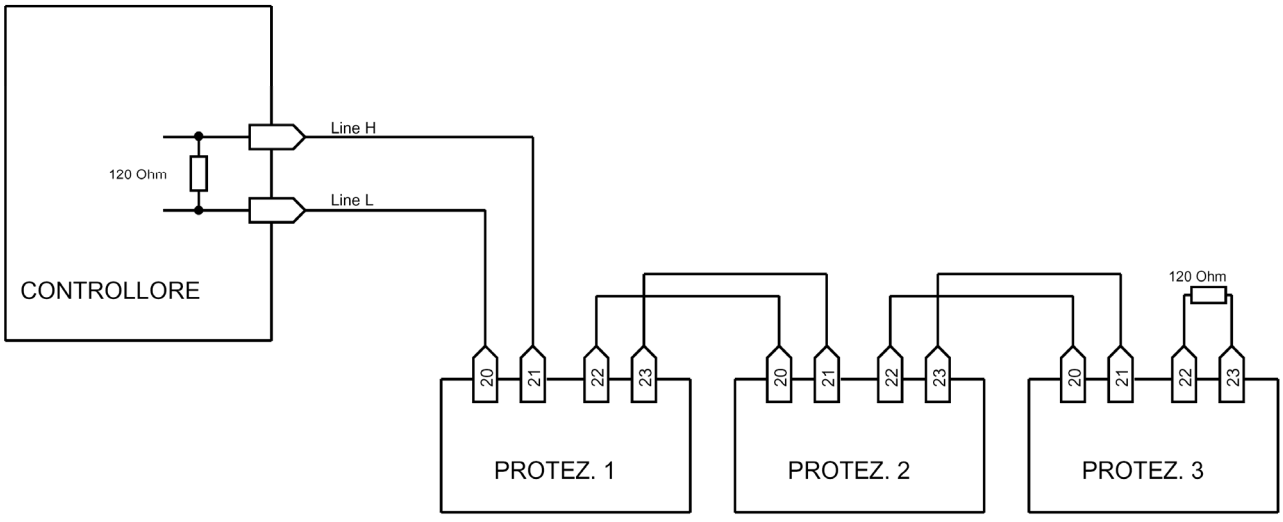
The digital protection relay ZFP8N presents an insulated serial interface RS485 half-duplex that allow the multi-drop connection up to 31 protection units. There are available 2 selectable communication protocols (ref. B2, par. 5.3).

When the STANDARD SEB communication protocol is selected, the transmission speed is automatically selected between 300 to 9600 bauds and the protocol is ASCII-HEX.

When the MODBUS communication protocol is selected, the transmission speed can be programmed between 300 to 9600 bauds (ref. B3, par. 5.3).

To integrate the protection relay in control systems, the documentation related to the protocol is freely available on request.

It is suggested to use a shielded twisted pair AWG22; terminal 19 (not connected internally) can be used for shields connections.



It is suggested to terminate the serial line with a resistance 120 Ω, 1/4 W.

7 TECHNICAL DATA

Measuring inputs	
Rated phase current (In)	1 A / 5 A programmable
Thermal withstand continuously	4 In
Thermal withstand for 1 s	100 In
Rated voltage (Un) programmable	57.73 - 63.50 - 72.16 - 100 - 110 V - 125 - 190 - 220 - 230 - 380 - 400 V
Thermal withstand continuously	2 Un
Thermal withstand for 1 s	2 Un
Rated frequency	50 / 60 Hz
Primary CT's current	10 ÷ 19999 A
Primary VT's voltage	1000 ÷ 999999 V
Output contacts ratings	
Number of relays (note 1)	4 + 1
Rated current	5 A
Rated voltage	250 V
Contact configuration	change over
Breaking capability (note 2)	
- tripping relays (R1, R2)	0.5 A
- signaling relays (R3, R4, R5) (note 3)	0.2 A
Mechanical life	> 10^6
Digital inputs	
Number of inputs	6
External control voltage	as Uaux
Typical current (sink)	2 mA
Data transmission	
Standard	RS-485 half duplex
Communication protocol	Mod-BUS - ASCII
Transmission speed	300 - 9600 bauds selectable
Optional	fibre optic module
Auxiliary supply	
Range	24 ÷ 320 Vdc ± 20% 48 ÷ 230 Vac ± 20%
Frequency (Vac)	47 ÷ 63 Hz
Burdens (min/max)	5 / 10 W
Environmental conditions	
Operation	- 10 / +60 °C
Transport and storage	- 25 / +80 °C
Relative humidity (without condensation)	< 95%
Protection degree for flush mounting (mini rack)	IP 31
Weight	3.5 kg

Note 1) The additional relay R5 is controlled by self-test program
Note 2) Breaking capability at 110 Vdc, L/R 40 ms, 100.000 operations
Note 3) The output contacts of R3 and R4 relays can be configured as signaling or tripping relays

8 TABLES

Table A

Polygonal characteristic parameters (see figure 1)		**Setting** (as % of Zn=Un/In)	**Resolution**
ZG	impedance generator direction	0.1 ÷ 150.0 %	0.1 %
ZT	impedance transformer direction	0.1 ÷ 150.0 %	0.1 %
ZS	additional impedance network direction	0.0 ÷ 150.0 %	0.1 %
ZA	rectangle half-width	0.2 ÷ 150.0 %	0.1 %
ANG	angle φ	60° ÷ 90°	1°
Time delays and thresholds		**Setting**	**Resolution**
NZ1	Maximum number of permitted out-of-step occurrences in **ZONE 1**	1 ÷ 9	1
NZ2	Maximum number of permitted out-of-step occurrences in **ZONE 2**	1 ÷ 9	1
TLIM	Time delay to check out-of-step occurrences **ZONE 1** and **ZONE 2**	0.20 ÷ 99.99 s	0.01 s
TSIGN	Activation time of the output relay signaling the first out-of-step condition	0.02 ÷ 99.99 s	0.01 s
I1<	Positive sequence minimum current threshold	0.10 ÷ 5.00 In	0.01 In
I2>	Negative sequence overcurrent threshold	0.05 ÷ 1.00 In	0.01 In
U2>	Negative sequence overvoltage threshold	0.05 ÷ 1.00 Un	0.01 Un
Ir>	Residual overcurrent threshold	0.10 ÷ 1.00 In	0.01 In
U<<	Undervoltage threshold for voltage memory function	0.05 ÷ 1.00 Un	0.01 Un
TMem	Voltage memory time length	0.04 ÷ 1.00 s	0.01 s

SEB DIVISIONE ELETTRONICA E SISTEMI - UFFICIO COMMERCIALE
Via Fratelli Ceirano, 19 - 10024 MONCALIERI (TO)
tel. +39 011 6474893 - **fax** +39 011 0432996
web: www.seb-barlassina.it
mail to: servizio-clienti@seb-barlassina.it