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NARACO Power Factor Controller

PFR5NRC_0006 / PFR5NRC_0014

Operation Manual

(Rev 4.0 / 2025)

Warranty Certificate

Warranty period of 24 months from the date of purchase, however no later than within 30 months from the dispatch date from manufacturer's warehouse, is provided for the instrument. Problems in the warranty period, evidently caused by poor workmanship, design or inconvenient material, will be repaired free of charge by the manufacturer or an authorized servicing organization.

The warranty becomes void even within the warranty period if the user makes unauthorized modifications or changes to the instrument, connects it to out-of-range quantities if the instrument is damaged in out-of-specs impacts or from improper handling or if it has been operated in conflict with the technical specifications.

Type of product: NARACO.....
Date of dispatch: .....

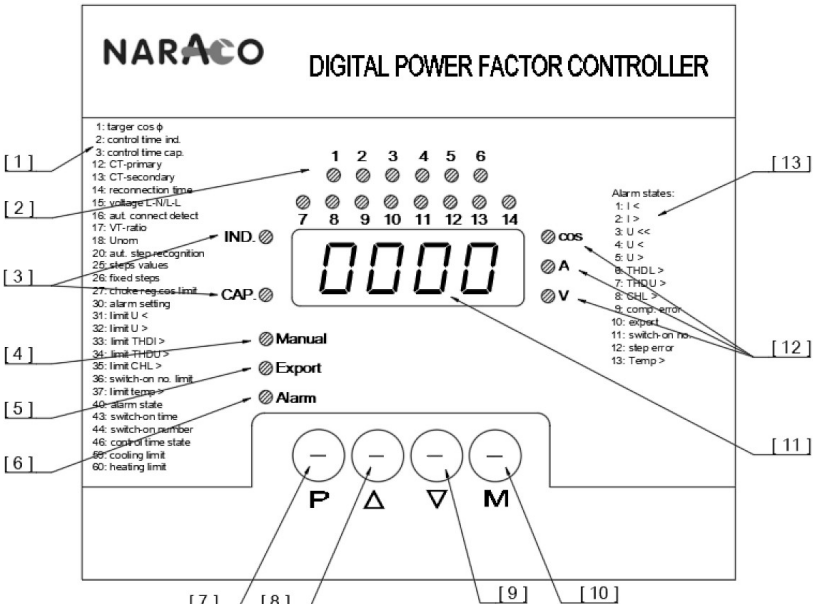
Serial number: .....
Final quality inspection: .....
Manufacturer's seal:

Date of purchase: .....

Supplier's seal:

1. *Controller Interface*

Figure 1.1: PFR5 controller interface



#	*Items*
[1]	*List of parameters*
[2]	*Steps status LED indication*
[3]	*Trend LED indication*
[4]	*Manual mode LED indication*
[5]	*Power export LED indication*
[6]	*Alarm LED indication*
[7]	*Button "PARAMETER"*

#	*Items*
[8]	*Button "UP"*
[9]	*Button "DOWN"*
[10]	*Button "MEASUREMENT"*
[11]	*Numeric display*
[12]	*Instantaneous measurement branch LED indication*
[13]	*List of alarm states*

2. Installation and Connection

2.1 Controller Dimension and Installation

Figure 2.1: Controller dimensions in millimeters

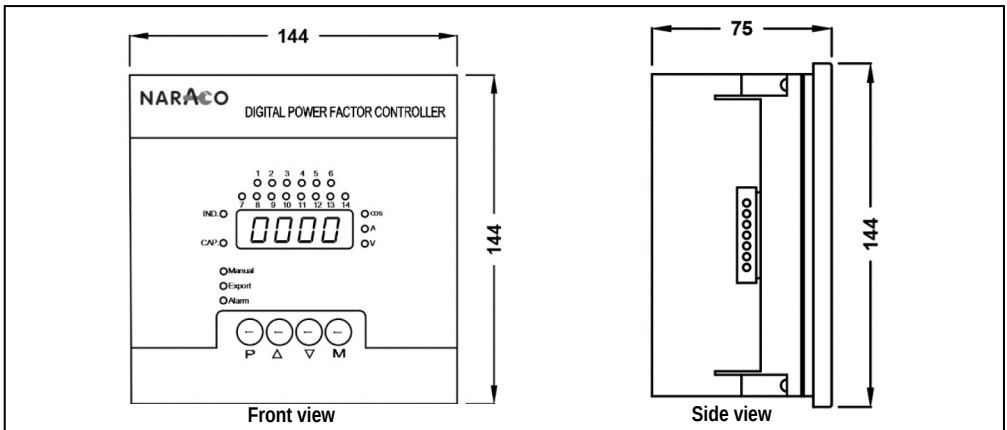
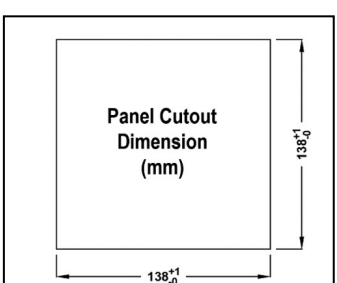
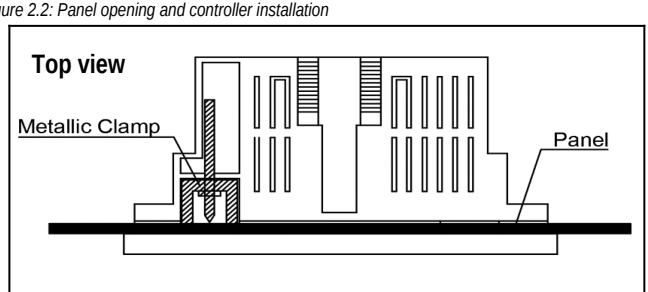


Figure 2.2: Panel opening and controller installation



Panel cutout dimension required for controller installation

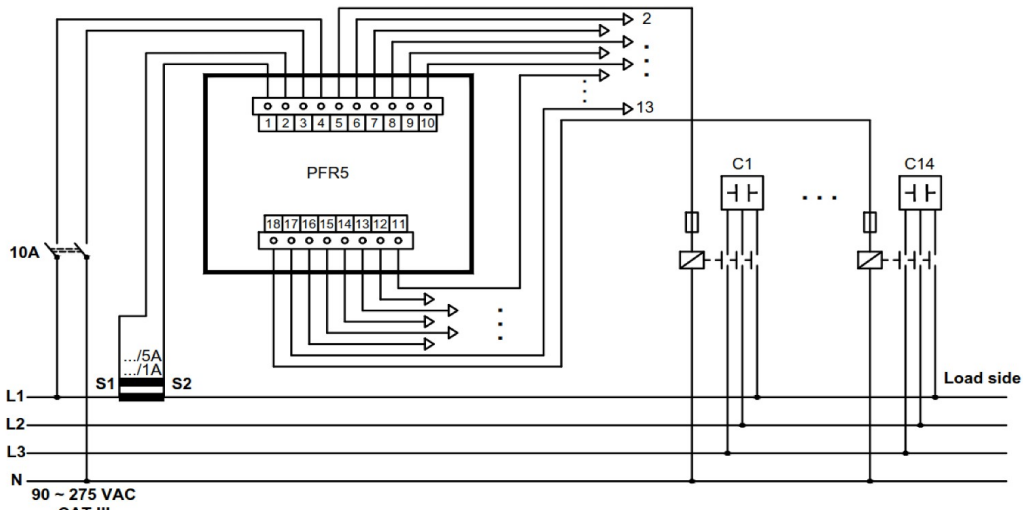


Please ensure the controller is inserted and fixed into panel opening, with metallic clamps at top and bottom of controller.

- Natural air ventilation shall be provided inside the panel for heat dissipation.
- Heat generating devices are not recommended to be installed underneath the controller, otherwise the accuracy of temperature measurement may be affected.

2.2 Controller Wiring Connection

Figure 2.3: PFR5 controller wiring connection

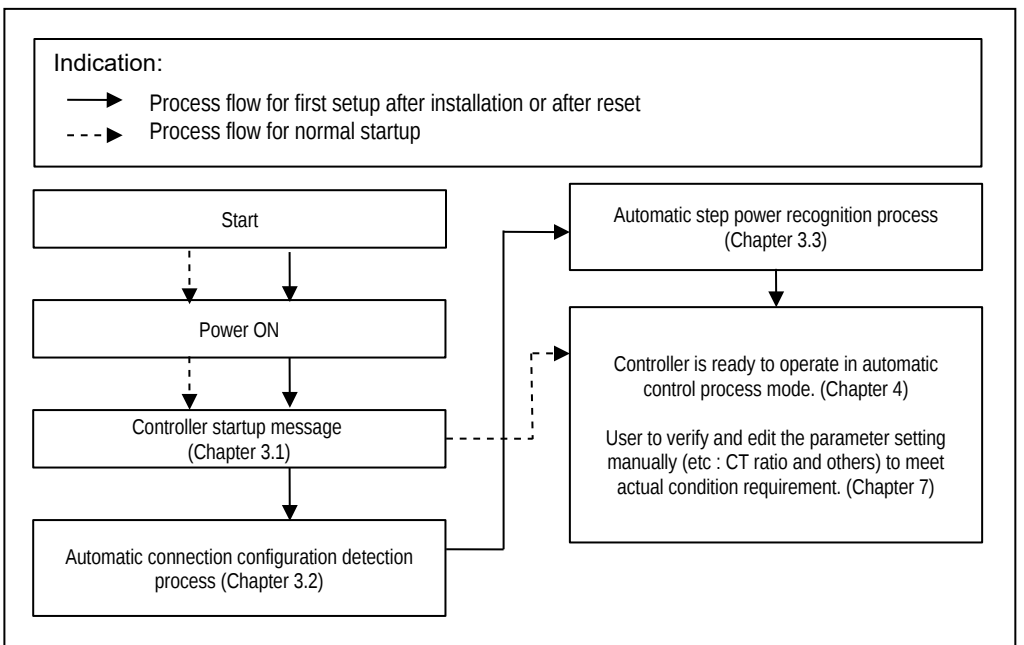


- Please check the controller technical specification required (Chapter 9) before installation.
- Connectors are attached at the back of controller for wiring connection.
- Cable size supported: 2.5 mm^2 max.
- Please apply a 10A disconnecting device at power input as overcurrent protection.
- Output relay common contact is internally connected to power supply terminal 4.
  Please ensure terminal 4 (L) and terminal 3 (N) is connected to L-N power supply of 90 ~ 275Vac.

3. Controller Operation

- For first startup after controller installation and controller reset, the controller performs full startup process flow to ensure basic setting such as connection configuration and step power are configured automatically.
- For normal power supply interruption startup, the controller skips the automatic connection configuration detection and automatic step power recognition process, as the settings have been saved during first startup.

Figure 3.1: PFR5 controller overall operation process flow



- To understand the text message shown on display → refer to Chapter 5.3 (Test and error message)
- To understand the LED indication → refer to Chapter 6 (LED indications)
- When alarm function is triggered → refer to Chapter 8.1 (Alarm status)
- To reset controller parameter → refer to Chapter 7.9 (Controller reset)

3.1 Startup Message

- During controller startup, text messages as below will be shown on display in sequence.

Table 3.1: Example of PFR5 controller startup message

Text message	Remarks
AHOY	
tESt	
P 1 14 or P006	Controller model (14 or 6 steps)
2.0	Controller firmware version (subjected to change)
I=5A or I= 1A	Current transformer secondary nominal value (5A or 1A)

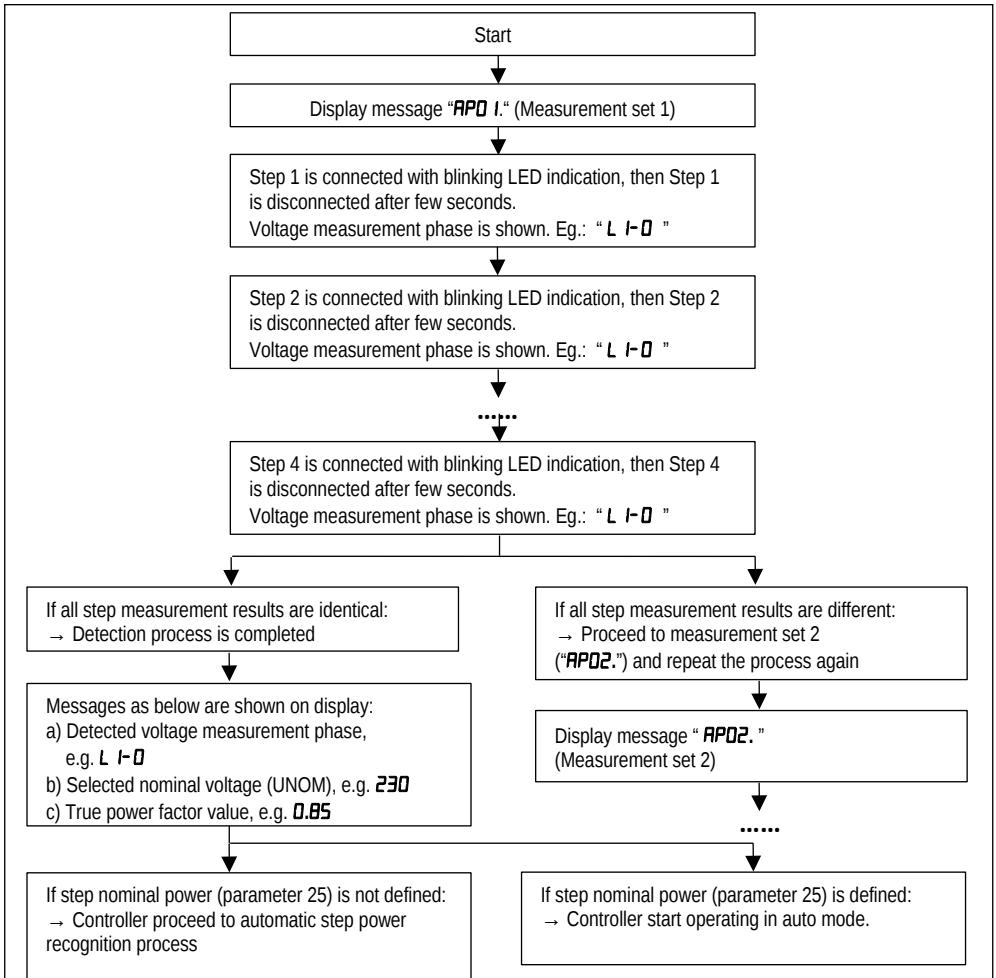
3.2 Automatic Connection Configuration Detection

- Purpose: To determine the voltage measurement phase connection and nominal voltage. The controller will take one set of measurement when step 1~4 is connected and disconnected consecutively.
- During the first setup after installation or reset, voltage measurement phase connection (parameter 16) is not defined.
  (See chapter 7.3 for more details on voltage measurement phase connection (parameter 16))
- Blinking text message "P=0" will be shown on display and automatic connection configuration detection process will be triggered.

Table 3.2: Text message shown during automatic connection configuration detection process

Text message	Remarks
APOX	Indicates the set of measurement (1 to 7). Eg. APO 1 : means measurement set 1
LX-0 or 0-LX	Indicates the phase of voltage measurement connection respect to neutral. Eg. L 1-0 : means phase L1 to neutral

Figure 3.2: Automatic connection configuration detection process flow



- After completion of automatic connection configuration detection process, please check on recognized nominal voltage (parameter 18) and correct it manually if necessary.
- If automatic connection configuration detection failed, controller will be switched to idle mode and blinking text message " P-0 " will be shown.
- To re-trigger automatic connection configuration detection process:
    a) Update "----" (undefined) manually in parameter 16 to force trigger
    OR
    b) Wait for 15 minutes for auto trigger.
- It is necessary to set parameter 16 manually if automatic connection configuration detection process is not successful.
- Pre-condition to perform automatic connection configuration detection process.
    a) Controller must be in automatic operation modes
    b) Minimum value of voltage measurement (≥ 90V) is connected to controller
    c) Linear switching mode (parameter 21) is not selected
- Pre-condition for successful automatic connection configuration detection :
    a) No compensation choke is connected to steps 1 ~ 4
    b) At least two compensation capacitors are connected to step 1 ~ 4
- The automatic connection configuration detection process can be interrupted at any time by pressing P.

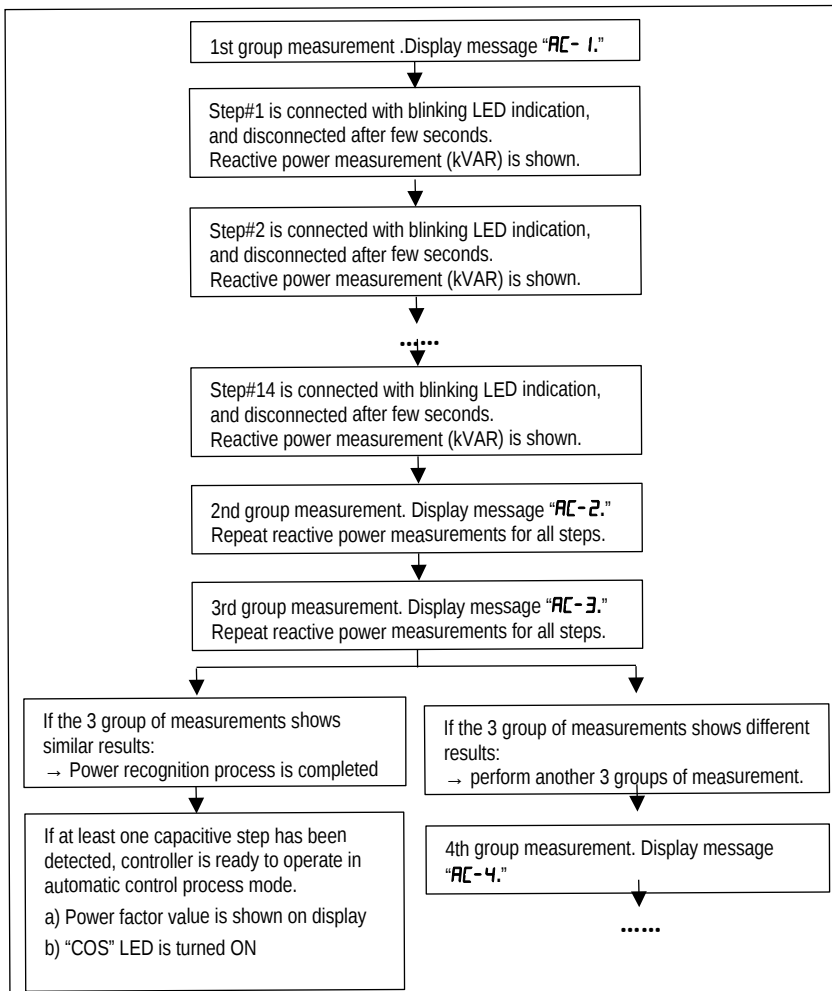
3.3 Automatic Step Power Recognition Process

- Purpose: To define the nominal power of each connected compensation step outputs. The controller will take three sets of measurement to determine reactive power value.

Table 3.3: Text message shown during automatic step power recognition process

Text message	Remarks
AC- X	Indicate the set of measurement (1 to 6). Eg. AC- 1 : means measurement set 1

Figure 3.3: Automatic step power recognition process flow

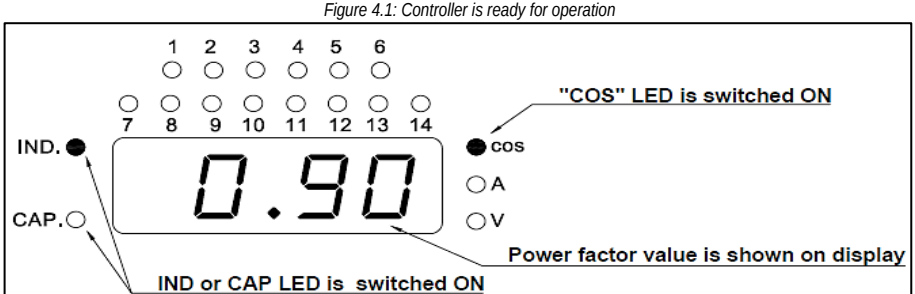


- If step power recognition is failed or none capacitive step is detected, controller will be switched to waiting mode and blinking message "C=0 " is shown.
- To re-trigger automatic connection configuration detection process:
  a) Update each compensation step power value in parameter 25 manually.
  OR
  b) Update value " A " in parameter 20 to force trigger.
  OR
  c) Wait 15 minutes for auto trigger.
- Pre-condition to perform automatic step power recognition process:
  a) Controller must be in automatic control modes
  b) Minimum value of voltage measurement (≥90V) is connected to controller
  c) Voltage measurement detection phase (parameter 16) is defined
  d) Linear switching mode (parameter 21) is not selected
- Pre-condition for successful automatic step power recognition process:
  a) Stability of supply network during step power measurement, when connecting or disconnecting a step.
  Lower the load in the supply network, higher accurate of the step recognition measurement.
- It is recommended to update CT ratio (parameters 12, 13) before starting of automatic step power recognition process.
- After completion of automatic step power recognition process, please check on recognized step power values (parameter 25).
- The automatic step power recognition process can be stopped at any time by pressing P.

4. Control Process Mode

- When controller is ready for operation, the indications as below are shown.

Figure 4.1: Controller is ready for operation



4.1 Automatic Control Process Mode

- The controller is running in automatic control process mode by default.
- Appropriate compensation steps will be connected/disconnected automatically, to improve the power factor of power system.
- To check the controller's response on a deviation change, steps manual switching can be done without stopping automatic intervention control process mode by:
    a) With M is pressed and hold, press ▲ or ▼ to connect/disconnect a step.
    (Except in linear switching mode, which is "first in last out order").
    Reconnection delay time is respected for connecting.

4.2 Controller Manual Control Mode

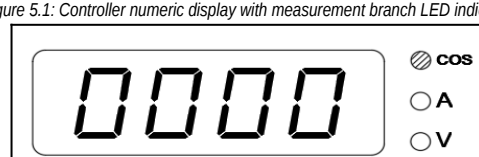
- The controller can be set to manual control mode to test the functionality of each compensation step.
- In manual mode, the controller remains in the output steps status before mode switching.
- The controller stops performing automatic intervention process until controller is switched back to automatic control process mode.
- To switch to manual control mode
    a) Press M and P simultaneously and hold for 5 sec until Manual LED starts flashing
    b) Press P to show corresponding output state
    Example 02-0 , which means step #2 is off (disconnected)
    03- 1 , which means step #3 is on (connected)
    c) Press ▲ or ▼ to change the outputs' states, respecting the reconnection delay time specified
    d) Press M and P simultaneously and hold for 5 sec to switch back to automatic control process mode.

Note: - Controller's parameters cannot be viewed or edited in the Manual mode
- Alarm actuation (parameter 30) is disabled in Manual mode

5. Numeric Display

- The data displayed on numeric display can be categorized into:
    a) Instantaneous measurement
    b) Controller parameters
    c) Test and error messages

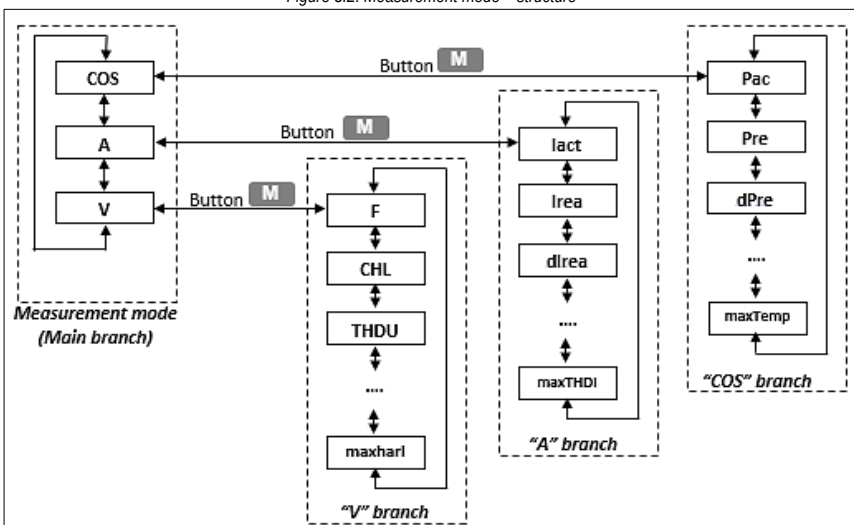
Figure 5.1: Controller numeric display with measurement branch LED indication



5.1 Instantaneous Measurement (Measurement Mode)

- Purpose : To display related instantaneous measurement values of branch: power (COS), current (A) or voltage (V)
- The lit LEDs of COS / A / V indicates the branch values which is being displayed on screen.
- Please refer to Appendix A for the list of branch measurement parameters.

Figure 5.2: Measurement mode – structure



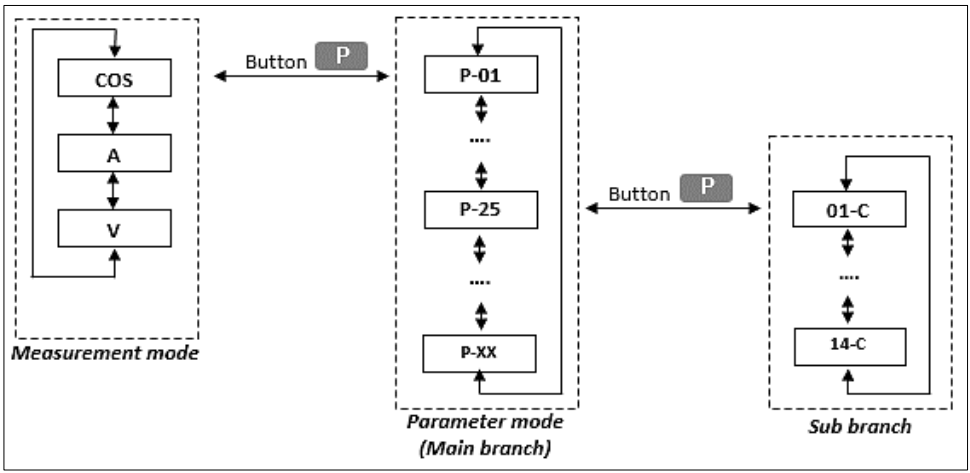
- To enter measurement mode :
  - a) Press ▲ , ▼ to switch between main branch COS, A and V.
  - b) Press M to enter its relevant branch.
  - c) Press ▲ , ▼ to browse all parameters in related branch.
  - d) Press M to return back to main branch.

Note: The controller returns to instantaneous measurement mode automatically after 30 seconds idle time.

5.2 Controller Parameters (Parameter Mode)

- Purpose: To display and edit the controller parameter settings.
- Please refer to Appendix B for the list of parameters and their default setting value.

Fig. 5.3: Parameter Display – Structure



- To enter parameter mode:
  a. Press P to show parameter P-01 and its setting value.
  b. Press ▲ , ▼ to view all parameters (P-01 to P-60)
  c. Press P to switch between parameter main branch and its sub branch.
     Sub branch parameters are indicated with a dash between the parameter number and value.
  d. Press M to back to the instantaneous measurement mode.

Note: - The controller returns to instantaneous measurement mode automatically after 30 seconds idle time.

5.3 Test and Error Messages

- Purpose: To prompt user on the controller current status with text message.

Table 5.1 : List of text messages

Message	Explanation	Comment
AHOY	Initial sequence after power up or initialization	Controller carries out self- diagnostics
tESt		
P 14 P006	Controller model type (14 steps or 6 steps)	
1.9	Controller firmware version	
I=5A	Current transformer secondary nominal value specified	Parameter 13
U=0	Voltage measurement not detected or its fundamental harmonic component lower than minimum value	Controller is in waiting mode
I=0	Current Measurement is not detected or lower than minimum value	Controller is in waiting mode
APnn	Automatic connection configuration detection process in progress (refer to Chapter 3.2)	Process can up to 1 to 7 steps
P=0	Automatic connection configuration detection process has failed and voltage measurement phase connection (parameter 16) has not been defined. (refer to Chapter 3.2)	Retrigger automatic connection configuration detection process by: a) Update parameter 16 manually OR b) wait for 15 minutes for auto trigger
AC-n	Automatic step power recognition process in progress (refer to Chapter 3.3)	Process can up to 3 or 6 steps
C=0	No capacitors have been successfully detected during automatic step power recognition process. OR Parameters 21 through 26 have not been set properly in manual step value specification mode (parameter 20 = "0") OR All capacitive steps have been automatically disabled because of error (parameter 25) or they are set as fixed (parameter 26) (refer to Chapter 3.3)	Retrigger automatic step power recognition process by: a) Update parameter 21~ 26 manually OR b) Wait for 15 minutes for auto trigger.

6. LED Indications

- Purpose: To prompt user on the controller current status with LED indication.

Table 6.1 : List of LED indications

Indication LEDs	Remarks
Output state indication	Indicates the current state of output relays. a) LED on : output relay is closed. b) LED off : output relay is opened. c) Flashing LED : awaiting for output connection after reconnection delay time.
Trend indication	Indicates the deviation of the instantaneous reactive power from optimum reactive power value. a) ***IND*** led : lagging (under-compensation) b) ***CAP*** led : leading (over-compensation) c) LED on : deviation is higher than 100% of reactive power of smallest capacitor. d) LED flashes : deviation is in range of 50 ~ 100% of reactive power of smallest capacitor. e) LED off : deviation is smaller than 50% of reactive power of smallest capacitor.
Indication of manual mode	Controller is in the manual mode.
Indication of back feed (Power Export)	Indicate the real power (Watt) transmission direction. a) LED off : power is flowing from power supply to appliance. b) LED on : power is flowing from appliance to power supply
Alarm Indication	Indicate the alarm relay's status. LED flashes: Alarm function is triggered by alarm states condition. *Please check on parameter 40 for triggered alarm status (Chapter 8.1)*

7. Controller Setup

- The controller's parameters are configured to default values when delivery.
- To achieve optimum compensation results, it is sometime necessary to change parameter values in correspondence with particular requirements

7.1 Parameter Editing – Parameter 00

- Function: To disabled/enabled parameter editing (avoid unauthorized parameter setting changes.)
  - a) Setting value " **Ed= 1** " :Editing mode is enabled (default setting).
  - b) Setting value " **Ed=0** " :Editing mode is disabled.
- To unlock the parameter editing mode:
  - a) Press **P** to display parameter " **P-01** "
  - b) Press **▲** to display parameter " **P-00** ", setting value " **Ed=0** ".
  - c) Press and hold **P** until the last character on the display starts flashing.
  - d) Press the following button press sequence: **▼**, **▲**, **▲**, **▼**.
    Only sequence of buttons pressed is important. Please ignore the number shown on display)
  - e) Press **P** to confirm. Editing mode is enabled and " **Ed= 1** " will be shown on display, if correct button press sequence is entered.

- To edit the parameter setting:
    a) Press P to display parameter "P-01".
    b) Press button ▲ or ▼ repeatedly to find the desired parameter for editing. (P-01 to P-60)
    c) Press and hold P until the displayed value starts flashing.
    d) Release P and set the desired value with ▲ or ▼.
    e) Press P to save the desired value.
    f) Press M to return to instantaneous measurement mode.

7.2 Second Tariff Setting Enable – Parameter 06

- Function : To allow controller to apply different set of control parameter in normal and power export condition.
- The control parameters are shown as below.

Table 7.1: Parameters of tariff setting

Parameter description	Tariff setting 1	Tariff setting 2
Target power factor	Parameter 1	Parameter 7
Control time when undercompensated	Parameter 2	Parameter 8
Control time when overcompensated	Parameter 3	Parameter 9
Control bandwidth	Parameter 4	Parameter 10

- By changing parameter 6 setting, tariff settings as below will be applied during power export condition.

Table 7.2: Second tariff setting enable – parameter 6

Parameter 6	Power flow from utility to load (normal condition)	Power flow from load to utility (power export condition)
0	Controller applies tariff setting **1**	Controller applies tariff setting **1**
E	Controller applies tariff setting **1**	Controller applies tariff setting **2**

7.3 Voltage Measurement Phase Connection – Parameter 16

- Function: To define the voltage measurement phase connection with respect to current measurement. It is automatic detected by the controller during automatic connection configuration detection process.
- By default, the controller assume the phase where CT connected is phase L1 (0°). The phase which is +120°, -120°out of the CT phase is considered as phase L2, L3.
- Example: If CT is connected to yellow phase, and controller voltage measurement is connected to blue phase
    a) Yellow phase is assumed as phase L1 (0°)
    b) Blue phase is assumed as phase L2 (+120°)
    c) Red phase is assumed as phase L3 (-120°)
    d) Voltage measurement phase connection (Parameter 16) will be detected as "L2-0".
    If CT is connected in opposite polarity, "0-L2" will be detected.

Table 7.3: Voltage measurement phase connection setting (parameter 16)

CT phase	Red			Yellow			Blue		
Voltage phase	Red	Yellow	Blue	Red	Yellow	Blue	Red	Yellow	Blue
Forward CT polarity	L1-0	L2-0	L3-0	L3-0	L1-0	L2-0	L2-0	L3-0	L1-0
Reversed CT polarity	0-L1	0-L2	0-L3	0-L3	0-L1	0-L2	0-L2	0-L3	0-L1

- If voltage measurement phase connection (parameter 16) is undefined ("----"), automatic connection configuration detection process will be triggered automatically. (Except linear switching mode (parameter 21) is set. In such case, it is necessary to set the voltage measurement phase connection manually.)

7.4 Step Configuration (Fixed Step/Alarm Relay/Fan/Heater) – Parameter 26

- Function: To configure a particular step as capacitive, inductive, and fixed (permanent connected /disconnected)
- Only the highest two steps can be configured to trigger :
  a) Alarm relay to trigger device such as buzzer
  b) Exhaust fan or heater (parameter 59 and 60 for temperature threshold limit)

Table 7.4: Step configuration

Parameter 26	Explanation	Remarks
05-C	Step #5 is a capacitive step	Applicable for all steps
05-L	Step #5 is a inductive step	
07-0	Step #7 is permanently disconnected (off)	
07- 1	Step #7 is permanently connected (on)	
14-A	Step #14 is configured as alarm relay. The alarm relay is **opened** if it is being triggered	Applicable for highest two steps only
14-A.	Step #14 is configured as alarm relay. The alarm relay is **closed** if it is being triggered	
14-F	Step #14 is configured as fan relay	
14-H	Step #14 is configured as heater relay	

7.5 Control Bandwidth (Anti-hunting) - Parameter 4 (Tariff Setting 1) / 10 (Tariff Setting 2)

- Function: To specify the control bandwidth of controller intervention process.
  The controller stops switching steps if the instantaneous power factor fall within target power factor + control bandwidth.
- The control bandwidth limit is adjustable in such a way of :
  Target power factor + control bandwidth of 0.000 ~ 0.040 max. (or ± 0.000 ~ 0.020 max.)
  Example: Target power factor is specified as 0.95 and control bandwidth of 0.040 is selected.
  Instantaneous power factor from range of 0.93 to 0.97 will be accepted and controller stops making further compensation.

7.6 Step Switching Program – Parameter 21

- Step switching program (parameter 21) is available only when the Automatic Step Power Recognition Process is disabled (parameter 20 = " 0 ").
- 12 type of step switching preset combinations are available in parameter 21 (see Table 7.5), which specifies the ratios of all capacitor step's values.

Table 7.5: 12 type of step switching preset combination

#	Step switching preset	combination	#	Step switching preset	combination
1	1111	*1:1:1:1:1*	*7*	1222	*1:2:2:2:2*
2	1122	*1:1:2:2:2*	*8*	1233	*1:2:3:3:3*
3	11224	*1:1:2:2:4*	*9*	1234	*1:2:3:4:4*
4	1123	*1:1:2:3:3*	*10*	1236	*1:2:3:6:6*
5	1124	*1:1:2:4:4*	*11*	1244	*1:2:4:4:4*
6	11248	*1:1:2:4:8*	*12*	1248	*1:2:4:8:8*

- The step switching program (parameter 21) is can be configured as below.

Table 7.6: Step switching program (parameter 21)

Parameter 21	Remarks
Any one of the switching preset combination (see table 8.2)	- Step switching method: auto select appropriate step according to load required - Capacitors must be connected to the controller's outputs in ascending order (lowest capacitive is connected to output 1). - Number of connected capacitors is update in parameter 23. - CT ratio (parameters 12, 13), UNOM nominal voltage (parameter 18), and VT ratio (parameter 17) are specified correctly to obtain actual smallest capacitor's nominal reading. - Ratios of all capacitor step's values are specified according to present combination selected.
"----" (undefined)	- Step switching method: auto select appropriate step according to load required, - When switching preset combination do not applicable to actual condition, it is required update the desire step value in parameter 25 manually.
" L "	- Step switching method: "first in last out" order Strongly recommend not to select linear switching mode at standard power factor compensation applications, otherwise quality of compensation process will be affected

7.7 Recorded Values Reset

- To erase the recorded measurement values(such as average, maximum, minimum value) as specified in chapter 5 :
  - a) Press M to enter measurement mode
  - b) Press ▲ or ▼ to select desired parameter.
  - c) Press M and hold it pressed until the displayed value starts flashing.
  - d) Release M , press ▲ or ▼ button change display to show CLr (= clear).
  - e) Press M to clear the value.

Note: - Clearing a value clears all the other values in its group and starts over their evaluation.

7.8 Inductive Compensation – Parameter 27

- Function: To enable inductive compensation if choke(s) is(are) connected.
- By default, inductive compensation is disabled in parameter 27 (choke limit power factor = "**----**" undefined).
- The controller support compensation for both chokes and capacitors, or only chokes are connected.
  In such cases, power of the minimum capacitor or the minimum choke, whichever is less, is considered to be the C/kMIN value which determines sensitivity of the power factor control.
- Chokes are recommended to be connected to outputs 5 and higher. (Output 1~4 are reserved for capacitive steps and will be measured for automatic connection configuration detection)
  Otherwise, automatic connection detection process will be disabled and parameter 16 (voltage measurement phase connection) must be updated manually.
- Reactive power values of the chokes can be detected through automatic step power recognition process, if parameter 27 (choke limit power factor) is defined.
- Unlike capacitors, reactive power values of chokes are displayed negative in parameter 25 (with the minus sign)

Table 7.7: Choke compensation method

Parameter 27	
"**----**" (undefined)	- Choke compensation is disabled.
0.80L ~ 0.80C	- When PF is more capacitive than this specified value, the controller disconnect all capacitors (if connected) - If PF still capacitive, the controller connects chokes to improve PF to inductive, and next further fine-tuned by connecting appropriate capacitors (if any.

- If parameter 27 (choke limit power factor) is defined, a inductive step will be switched on in situation as below:
  - a) All capacitive steps are disconnected, but the power factor is still capacitive than target PF value.
  - b) This condition lasted for 5 times of overcompensation control time (Parameter 3).
    Hence, inductive compensation will take 5 times longer time than capacitive compensation.
  - c) No large undercompensation occur after choke connected.

7.9 Controller Reset

- To reset the controller parameter settings:
  a) Press M, P and ▼ simultaneously and hold for about 6 seconds
  b) Controller will first disconnect all steps and initialize the controller setting.
     Since parameter 16 value is not defined, it will start the automatic connection configuration detection process.
- All parameters can be reset to default value except :
  a) Current transformer secondary nominal value (parameter 13)
  b) Counters of connection time and switching operations (parameters 43, 44)

7.10 Step Value Accurizing

- To improve the accuracy of step power measurement, the controller continue measures and evaluates the average step power value after completed automatic step power recognition.
  a) The controller records all the power values after completion of automatic step power recognition process and tags them as “imprecise” value (slow flashing decimal point in step power, parameter 25)
  b) The controller continuous measures and evaluates the average step power value for 100 values.
     Latest step measurement values are updated into record and tagged as “precise” value and the controller stops further accurizing process
- If the step values are updated manually (using the switching program and smallest capacitor power or by editing step value in parameter 25), accurizing process will not be performed for both capacitive and inductive (if present) steps.
- If the controller detects a repeated measurement differences of a compensation capacitor to measurement in the automatic section power recognition process, and the difference is not in order of magnitude (that is in the interval from a half to double value) from the value recorded in the controller, the accurizing process for the particular step will be performed.

7.11 Faulty Step Indication and Disablement

- If switching a step does not repeatedly result in relevant changes to reactive power in the power system (or different from the recorded capacitor value), the controller tags the particular step as faulty. (fast flashing (about three times a second) decimal point in the step value display in the side branch of parameter 25)
- If relevant alarm actuation is set, the faulty step will be disabled temporarily. Otherwise, the faulty step will be included for compensation as normal.
- A step that has been temporarily disabled is periodically (about every five days) checked by including it in compensation for one switching operation. If relevant response detected when the faulty step is connected, the step will be included back in the control process. Hence a repaired step is automatically included in compensation.
- If the controller does not put a disabled step back to compensation automatically, please perform action as below.
  a) Controller initialization.
     OR
  b) Editing the step value in parameter 25
     OR
  c) Trigger automatic step power recognition process

- Faulty step indication and disablement can only be applicable for capacitive steps, not for choke sections (if present).

7.12 Capacitor Harmonic Load Factor (CHL)

- Capacitor Harmonic Load factor (CHL) expresses the capacitor total load caused by current. It can be used as an indication to protect the capacitors from overload condition.
- Unnecessary voltage harmonic distortion can be generated due to capacitor current overload. This will reduce to the capacitor service life span.
- The capacitor harmonic load factor is defined as below:

$$CHL = \frac{1}{U_{NOM}} \sqrt{\sum_{i=1}^{N} i * Ui^2} * 100 \quad [\%]$$

Where :

CHL	capacitor harmonic load factor	[%]
I	order of harmonic	[-]
Ui	voltage of i^{th} harmonic component	[V]
U_{NOM}	nominal voltage	[V]

- This factor value is calculated respecting to each voltage harmonic component value and order distribution of harmonic components across spectrum.

  Examples of CHL factor values for selected voltage harmonic distribution scenarios, are shown in table below.

Table 7.8: Examples of CHL factor values for selected distributions of voltage harmonic components (assume $U_1 = U_{nom}$).

Example	Voltage harmonic component respecting to fundamental component : U_i / U_1 [%]									CHL [%]
	3rd	5th	7th	9th	11th	13th	15th	17th	19th	
1	2.5	3.5	2.5	1.0	2.0	1.5	0.8	1.0	0.5	110
2	3.5	4.5	3.5	1.2	2.5	2.0	1.0	1.5	1.0	118
*3	5.0	6.0	5.0	1.5	3.5	3.0	0.5	2.0	1.5	133

* Example 3 shows the voltage harmonic distortion limits as specified in EN 50160 and the calculated CHL value is 133%.

8. Alarm Trigger Setting

8.1 Alarm Status – Parameter 40

- When alarm function is triggered by certain alarm states condition, alarm LED is blinking.
- Please check on Parameter 40 for the alarm triggered details:
  - a) Press P to show parameter "P-01"
  - b) Press ▼ repeatedly until parameters "P-40" is shown
  - c) Press P enter its sub branch and parameter "01-0" is shown
  - d) Press ▲ or ▼ repeatedly to check all parameter.

    Parameter with value " 1 " means the related alarm states condition is triggered

    Example : 02 - 1 (02 = alarm states condition #2 "overcurrent", 1 = triggered)
  - e) Press M to back to the instantaneous measurement mode.

Note: - The list of alarm states condition can be referred from the controller interface or Appendix C.

8.2 Alarm Indication and Alarm Actuation Configuration – Parameter 30

- Each of the alarm states conditions(refer to Appendix C) can be set to alarm indication and actuation in parameter 30.
  - a) Alarm indication: Alarm LED blinks when alarm triggered conditions occurred.
    (Please check on parameter 40 for indication conditions.)
  - b) Alarm actuation: Disconnect compensation steps when alarm triggered conditions occurred.

Table 8.1: Alarm setting (Parameter 30)

#	Parameter 30 setting	Alarm indication	Alarm actuation
1	0	Disable	Disable
2	5	Enable	Disable
3	A	Disable	Enable
4	2	Enable	Enable

Example : 01-2
01 = alarm state condition 1(undercurrent)
2 = alarm indication and actuation are enabled

8.3 Alarm Trigger Threshold Limit – Parameter 31 ~ 37

- Purpose - To define the threshold limit of alarm states conditions
- These parameters will not be shown in parameter mode unless alarm function is setup.

Table 8.2: Alarm Threshold Limits

#	Alarm states conditions	Parameter number	Limit setup range	Default value
4	Undervoltage	31	50 ~ 100 % of U_{NOM} (parameter 18)	80%
5	Overvoltage	32	100 ~ 200 % of U_{NOM} (parameter 18)	110%
6	THDI >	33	1 ~ 300 %	20%
7	THDU >	34	1 ~ 300 %	10%
8	CHL >	35	80 ~ 300 %	130%
11	Number of switching operations exceeded	36	(10 ~ 2000) * thousands of switching operations	1000
13	Overheated	37	20 ~ 60 °C	48 °C

9. Maintenance, Service

NARACO power factor controller does not require any maintenance. For reliable operation you only have to comply with the operating conditions specified and prevent mechanical damage to the instrument.

In the event of the product's breakdown, you have to return it to the supplier at their address.

Supplier :

Manufacturer :
NARACO COMPANY LIMITED
VILLA NO.17 RESIDENTIAL AREA IN, VINH HOANG,
VINH HUNG WARD HOANG MAI DIST,
HANOI VIETNAM

The product must be packed properly to prevent damage in transit. Description of the problem or its symptoms must be sent along with the product. If warranty repair is claimed, the warranty certificate must be sent in too. If after- warranty repair is requested, a written order must be included.

10. *Technical Specifications*

Table 9.1: PFR5 Controller Parameters

	Parameters	PFR5NRC_0006	PFR5NRC_0014
Adjustable Parameters	Power Factor Desired	0.80 Inductive - 0.80 Capacitive	
	Connection Time	5 - 1200 Seconds	
	Reconnection Delay Time	5 - 1200 Seconds	
	Operation Mode	Automatic Mode, Manual Mode	
Ranges And Accuracy	Power Supply And Voltage Measurement	90 - 275 VAC; 43 – 67 Hz; 7VA	
	Voltage Measurement Accuracy	+/-1% Of Range, +/- 1 Digit	
	Measuring Voltage Loss Response Time	≤ 20 ms	
	Measurement Current	0.02 - 7 A	
	Current Input Serial Impedance	< 10 mΩ	
	Current Measurement Accuracy Range 0.5 – 7A Range 0.02 - 0.5 A	 +/- 0.02A, +/- 1 Digit +/- 0.002A, +/- 1 Digit	
	Maximum Phase Angle Error (Power Factor And Powers Measurement)	+/-1° At I > 3 % of range; otherwise +/-3°	
	Voltage And Current Harmonic Measurement	up to 19th harmonic	
	Harmonic Component And THD Measurement Accuracy	±5 %, ± 1 Digit (For U, I > 10 % of range)	
	Temperature Measurement Range And Accuracy	-30 - +60 °C, ± 5 °C	
	Number Of Output Relays	6	14
	Output Relay Load Rating	250 VAC / 5 A	
	Installation Category / Level Of Pollution	in Compliance with Standard EN 61010-1, III-2	
Operating Condition	Operating Temperature	-40° - +60°C	
	Relative Humidity	5 - 100 %	
Output	Expected electrical life	100,000 operations at rated current	
	Expected mechanical life	2 x 10^6 operations	
Electromagnetic Compatibility, EMC	Noise Suppression Level	In Compliance With Standards: EN 50081-2, EN 55011 Class A, EN 55022 Class A	
	Immunity	In Compliance With Standards: EN 61000-4-2 Ed.2:2009, EN 61000-4-3 Ed.3:2006+A1+A2, EN 61000-4-4 Ed.3:2013, EN 61000-4-5 Ed.3:2015, EN 61000-4-6 Ed.4:2014, EN 61000-4-11 Ed.2:2005	
	Emission	In Compliance With Standards: EN 55011 Ed.3:2010 Class A, EN 55022 Ed.3:2011 Class A	
Physical	Enclosure	IP40 (IP54 option)	
	Dimensions Front Panel Built-In Depth Installation Cutout	 144 x 144 mm 75 mm 138^{+1} x 138^{+1} mm	
	Mass	max. 0.7 kg	

11. Appendix A : List of Measurement Parameters for Branch Power (COS),Current (A) and Voltage (V)

"*COS*" Branch

- Indicates the instantaneous power measurement in three-phase values (single-phase power values multiplied by three).
- Positive value= inductive power factor;
  Negative value= capacitive power factor.

Table 10.1: List of measurement parameters – "COS" Branch

Abbrev.	Symbol	Quantity	Unit
Pac	PAC	Instantaneous value of fundamental harmonic active power (**P**ower **ac**tive).	kW / MW *
Pre	PrE	Instantaneous value of fundamental harmonic reactive power (**P**ower **re**active).	kvar / Mvar *
dPre	dPrE	Value difference between instantaneous fundamental harmonic reactive power and target power factor (**D**elta **P**ower **re**active).	kvar / Mvar *
Temp	°C / °F	Instantaneous value of temperature (in the distribution board cabinet, at the controller). In degrees Celsius or Fahrenheit, as specified in parameter 58.	°C or °F
Acos	ACOS	Average power factor over the time specified in parameter 56 (**A**verage **cos**)	-
mincos	nCOS	Minimum power factor in the power system recorded since last clear. The evaluation duration is specified in parameter 56	-
APac	APAC	Average fundamental harmonic active power in the power system over the time specified in parameter 56 (**A**verage **P**ower **ac**tive)	kW / MW *
maxPac	⁻PAC	Maximum fundamental harmonic active power recorded since last clear. The evaluation duration is specified in parameter 57 (**M**aximum **P**ower **ac**tive)	kW / MW *
APre	APrE	Average fundamental harmonic reactive power in the power system over the time specified in parameter 56 (**A**verage **P**ower **ac**tive)	kvar / Mvar *
maxPre	⁻PrE	Maximum fundamental harmonic reactive power recorded since last clear. The eval. duration is specified in parameter 57 (**M**aximum **P**ower **re**active)	kvar / Mvar *
maxdPre	⁻dPr	Value difference between maximum fundamental harmonic reactive power and target power factor in the power system recorded since last clear. The eval. duration is specified in parameter 57 (**M**aximum **D**elta **P**ower **re**active)	kvar / Mvar *
maxTemp	°C / °F	Maximum temperature recorded since last clear. The evaluation is based on temperature one-minute moving averages (**M**aximum **Temp**erature).	°C or °F

* ... in kW-, kvar- units as default; flashing decimal point indicates value in MW, Mvar

"*A*" Branch

- Indicates the instantaneous value of effective current in the power systems (including higher harmonic components).
- Measurement unit: - A (by default)
  - kA (when flashing decimal point is shown in measurement)

Table 10.2 : List of measurement parameters – "A" branch

Abbrev.	Symbol	Quantity	Unit
Iact	ACt	Instantaneous value of active current fundamental harmonic component (**act**ive).	A / kA
Irea	rEA	Instantaneous value of reactive current fundamental harmonic component (**rea**ctive): ***L*** indicates inductive, ***C*** indicates capacitive.	A / kA
dIrea	drEA	Value difference between instantaneous reactive current fundamental harmonic component and target power factor in the power system (**D**elta **rea**ctive).	A / kA
THDI	tHd	Instantaneous value of **T**otal **H**armonic **D**istortion **C**urrent up to 19th harmonic (ratio of current harmonic components to fundamental harmonic) It is only evaluated if total power load is at least 5% of nominal load caused by current transformer primary side value (parameter 12)	%
3.-19.har	H3÷ 19	Instantaneous value of current harmonic component level from 3rd ~19th harmonic	%
maxTHDI	mtHd	Maximum THDI value recorded since last clear. The evaluation is based on THDI one-minute moving averages.	%

"*V*" Branch

- Indicates the instantaneous value of effective voltage in the power system (including higher harmonic components).
- Measurement unit: - volts (by default)
  - kilovolts (If voltage measurement is connected though a voltage transformer)

Table 10.3 : List of measurement parameter – "V" Branch

Abbrev.	Symbol	Quantity	Unit
F	F	Instantaneous value of voltage fundamental harmonic component frequency.	Hz
CHL	CHL	Instantaneous value of Capacitor Harmonic Load factor.	%
THDU	tHd	Instantaneous value of **T**otal **H**armonic **D**istortion **V**oltage up to 19th harmonic (ratio of voltage higher harmonic components to fundamental harmonic)	%
3.- 9.har	H3÷19	Instantaneous value of harmonic component voltage	%
maxCHL	mCHL	Maximum CHL value recorded since last clear. The evaluation is based on CHL one-minute moving averages.	%
maxTHDU	mtHd	Maximum THDU value recorded since last clear. The evaluation is based on THDU one-minute moving averages.	%
3. - 19. maxharI	mH-3 ÷ 19	Maximum value of voltage harmonic component recorded since last clear. The evaluation is based on harmonic component one-minute moving averages.	%

12. Appendix B: List of Parameters and Their Default Values

No	Name	Range	Default	Comment
0	Parameter edit enable/disable	0 / 1	1	"**Ed=1**": editing mode is enable "**Ed=0**": editing mode is disable
1	Target power factor (tariff 1)	0.80 L - 0.80 C	0.98 L	Apply for normal operation
2	Control time when undercompensated (tariff 1)	5 sec - 20 min	3 min	Determine the frequency of control intervention in undercompensation condition. Without "L": control time reduction by squared proportional to C/kmin With"L": linear control time reduction.
3	Control time when overcompensated (tariff 1)	5 sec - 20 min	30 sec	Determine the frequency of control intervention in overcompensation condition. Without "L": control time reduction by squared proportion C/kmin With "L": linear control time reduction
4	Control bandwidth	0.000 - 0.040	0.010	Refer to chapter 8.3
6	Tariff 2 enable/disable	0 – E	0	Apply for active power export mode "0" : Tariff 1 is used for power export "E" : Tariff 2 is used for power export
7 - 10	Similar to parameter 1 - 5, but for tariff 2	same as parameter No. 1 - 4	-	not shown unless tariff 2 enabled (parameter 6)
12	Current transformer primary side nominal value	5 - 9950 A	undefined	
13	Current transformer secondary side nominal value	1 A - 5 A	5	Correct setting required for controller operation.
14	Reconnection delay time	5 sec - 20 min	60 sec	Specifies time required to ensure sufficient discharge of capacitor before reconnection
16	Voltage measurement phase connection	6 combinations	undefined	Displayed as x-y. x : phase connected to terminal 4 y : phase connected to terminal 3 (0 = neutral line)
17	VT turns ratio	no VT or 10 - 5000	--- (no VT)	
18	System nominal voltage U_{NOM}	50 - 750 V x VT ratio	230	Auto detected by controller in automatic connection detection process
20	Automatic step power recognition process	A(auto) – 0 (no) - 1(yes)	A	Refer to chapter 3.3 "A" = auto run if step nominal power (parameter 25) is not defined "0" = disable "1" = auto run on each controller startup regardless to step nominal power(parameter 25) definition
21	Switching program, linear switching mode	12 combinations or „L"	undefined	not shown if automatic step recognition process enabled
22	Smallest capacitor nominal power (C/kmin)	(0.007 - 1.3 kvar) x CT ratio x VT ratio	undefined	not shown if automatic step recognition process enabled
23	Number of capacitors	1 – 14	6 / 14	not shown if automatic step recognition process enabled

No	Name	Range	Default	Comment
25	Step nominal power	(0.001 - 5.5 kvar) xCT ratio x VT ratio	undefined	Corresponds to U_{NOM}. Positive for caps (lead), negative for chokes (lag), "----" means undefined
26	Fixed steps	regulated / 0 / 1 / F/ H / A / A.	all regulated	The highest 2 step can be set to switch cooling(F),heating(H),alarm (A / A.)
27	Power factor limit for compensation by choke	0.80 L - 0.80 C	undefined	No compensation by chokes unless this parameter specified.
30	Alarm setting	Off (0) / indication only(5) / actuation only (A)/ indication and actuation (2)	undercurrent, voltage loss and step error indication & actuation	1 ... undercurrent 2 ... overcurrent 3 ... voltage loss 4 ... undervoltage 5 ... overvoltage 6 ... THDI > 7 ... THDU > 8 ... CHL > 9 ... comp. error 10 ... export 11 ... no. of connections 12 ... step error 13 ... overheated 14 ... ext. alarm
31 - 37	Alarm thresholds: undervoltage, overvoltage, THDI, THDU, CHL, number of connections and temperature	-	-	not displayed if the alarm not set up
40	Alarm instantaneous condition			Indicates current state of alarm.
43	Step connection time			in thousands of hours
44	Number of step connections			in thousands
45	Instrument failure condition			
46	Instant. Condition of control time			Time remaining until next control intervention [sec]
55	Power system frequency	A (auto) – 50 Hz – 60 Hz	A (auto)	
56	Average value eval. Duration size	1 min - 7 days	7 days	applies to Acos, APac, APre
57	Min/max value eval. Duration size	1 min - 7 days	15 min	for mincos,maxPac, maxPre, maxdPre
58	Celsius/Fahrenheit temp. Mode	°C – °F	°C	
59	Cooling enable threshold	+10 - +60 °C	+40 °C	not displayed if cooling not set
60	Heating enable threshold	-30 - +10 °C	-5 °C	not displayed if heating not set

13. Appendix C: List of Alarm Indication and Actuation

			Alarm indication	Alarm actuation	
#	Alarm state conditions	Description	Time required to trigger/stop alarm	Time required to trigger/stop alarm	Actuation action
1	**Undercurrent**	Current at current transformer's secondary side is below minimum measurement requirement	5 / 5 sec	10 / 5 sec	disconnect all step except fixed ones
2	Overcurrent	Current at current transformer's secondary side is 120% exceeded of its nominal value setting (6 A / 1.2A)	Immediately	N/A	
3	**Voltage failure**	Voltage measurement value is not detected / too low (< 90 Veff)	5 / 5 sec	immediately / 5 sec	disconnect all step
4	Undervoltage	Voltage 1 min. moving average value is lower than the specified undervoltage threshold (parameter 31)	Max. 1 min	Max. 1 min	disconnect all step
5	Overvoltage	Voltage 1 min. moving average value is higher than the specified overvoltage threshold (parameter 32)	Max. 1 min	Max. 1 minute	disconnect all step
6	THDI >	THDI 1 min. moving average value is higher than the specified THDI threshold (parameter 33); works on loads 5% and higher	Max. 1 min	Max. 1 min	disconnect all step
7	THDU >	THDU 1 min. moving average value is higher than the specified THDU threshold (parameter 34)	Max. 1 min	Max. 1 min	disconnect all step
8	CHL >	CHL 1 min. moving average value is higher than the specified CHL threshold (parameter 35)	Max. 1 min	Max. 1 min	disconnect all step
9	Compensation error	Power factor 15 mins. moving average value is not within range of 0.9L to 1.00; works on loads 5% and higher	Max. 15 mins	N/A	
10	Export	Negative active power 1 min. moving average value is detected (flow of power from appliance to source)	Max. 1 min	Max. 1 min	disconnect all step except fixed ones
11	Number of switching operations exceeded	Number of step connection & disconnection has exceeded the limit setting	Immediately	5 connections +5 disconnections	N/A
12	**Step error**	Permanently wrong step value is detected in compensation (usually step failure)	5 connections + 5 disconnections	N/A	step disablement (see chapter 6.4)
13	Overheated	Temperature 1 min. moving average value is higher than the temperature threshold specified (parameter 37)	Max. 1 min	Max. 1 min	disconnect all step

Note: Nonstandard operation conditions shown above in **bold** type are set by default.