PFRNX POWER FACTOR REGULATOR

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THING TO SETUP AND VERIFY BEFORE RUN

1) Check CT Setup
   a) Make sure CT installs before capacitor bank and load.
   b) Make sure cable connect between secondary CT and PFRNX terrminal (No.34 and No.35) are connectted in correct polarity follows according to PFRNX connection diagram.
   c) Primary CT setting in PFRNX must set according to primary current ration _/5A.

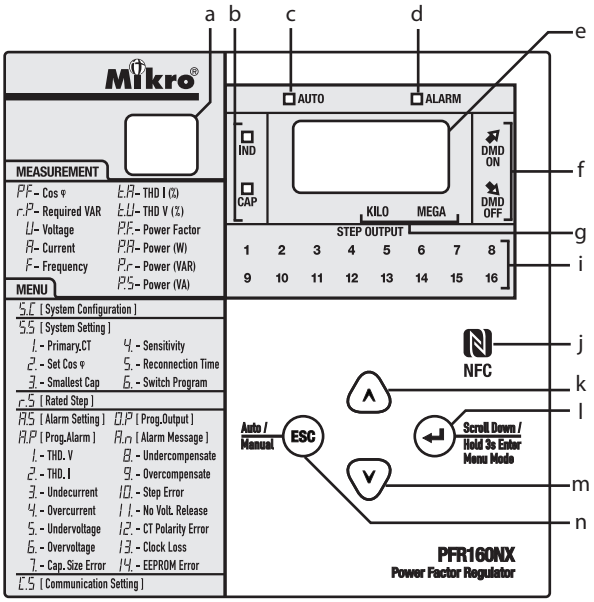
2) Check Voltage Setup
   a) If voltage sytem is measured by Phase to Phase system, then make sure voltage system setting set to [L-L]. Besides that, YELLOW voltage phase must connects to terminal block No.23, BLUE voltage phase must connects to No.20 and CT installs on RED phase line.
   b) If voltage sytem is measured by Phase to Neutral system, then make sure voltage system setting set to [L-N]. Besides that, RED voltage phase must connects to terminal block No.23, NEUTRAL voltage phase must connects to No.20 and CT installs on red phase line.
   c) If voltage frequency is run in 60Hz, the frequency system setting must set to [60], otherwise set to [50].

3) Check Step Output Setup
   a) For those steps are unused, encourage to set rate step setting in PFRNX to disable, so that will not cause step error alarm may be triggered.
   b) Make sure terminal block No.18 has connected to Live voltage.

4) Check Aux Power Setup
   a) Make sure voltage supplies to Aux in terminal block No.24 and No.25 are within 100VAC to 415VAC or 140VDC to 340VDC.

Power Factor Regulator User's Guide

A BRIED OVERVIEW



a - 2-digit numeric display [Mode Indicator]

b - CAP and IND indicators [CAP = Capacitive power factor, IND =Inductive power factor]

c - AUTO or MANUAL mode indicator [LED On = Auto, LED Off = Manual]

d - ALARM indicator [LED On = Alert from alarm message]

e - 3-digit numeric display [Display parameter value and alarm message]

f - DMD ON and DMD OFF indicators [DMD ON = Capacitor bank is required to switch On, DMD OFF = Capacitor bank is required to switch Off]

g - Prefix multipliers indicator [KILO = 10^3, MEGA = 10^6]

i - STEP Output Indicator [LED ON = Step output switch On, LED OFF = Step output switch Off]

j - NFC tag area [Tag mobile on this location for communication]

k - UP button

l - ENTER button

m- DOWN button

n - ESC button

1. General Description

The power factor regulator combines comprehensive operation with user-friendly control setting. It uses numerical techniques in computing the phase difference between the fundamental of current and voltage, thus precise power factor measurement is achieved even in presence of harmonics.

The power factor regulator is designed to optimize the control of reactive power compensation. Reactive power compensation is achieved by measuring continuously the reactive power of the system and then compensated by the switching of capacitor banks. The sensitivity setting optimizes the switching speed. With the built-in intelligent automatic switching program, the power factor regulator further improves the switching efficiency by reducing the number of switching operations required to achieve the desired power factor.

Usage of the capacitor bank is evenly distributed by the intelligent switching algorithm. This ensures uniform ageing of the capacitors and the contactors used.

The four-quadrant operation feature allows the power factor regulator to operate correctly in the case of active power feed beck to the mains where regenerative power sources are used.

Harmonic current in the system can be harmful to the capacitor bank. This power factor regulator is capable of measuring the total harmonic distortion (THD) in the system and trigger an alarm if the THD level is higher than the pre-set value. Other alarms include under/over compenstate alarm, under/over current alarm and under/over voltage alarm.

Mobile app has been provided for user convenient to monitor parameter or configure setting through NFC. User also able to communicate with power factor regulator through RS485 Modbus RTU protocol by install NX-M1 module on power factor regulator.

2. Measurement

[PF] Cosφ

The numeric display shows displacement power factor of the system.

3-digit numeric (e)	LED		Description
	IND (b)	CAP (b)	
"---"	Off	Off	The load current or voltage is below operating range. Current must be above 1% of rate current [_/5A] and voltage must be above 50 Vac.
"x.xx"	On	Off	The system is having inductive power factor.
"x.xx"	Off	On	The system is having capactive power factor.
"- .xx"	On	Off	Re-generative condition is detected where the energy flow is reversed in inductive power factor.
"- .xx"	Off	On	Re-generative condition is detected export active power in capactive power factor.

x = 0 - 9 numeric digit

[r.P] Required VAR

The numeric display shows required or excessive capacitive reactive power [VAR] to achieve target power factor at measured voltage system.

[U] Voltage

The numeric display shows the true-rms value of voltage measurement. Power factor regulator is able to control the voltage system measures in Line to Neutral or Line to Line.

[A] Current

The numeric display shows the true-rms value of primary current. Primary ratio current must be set according to the external 5A current transformer ratio.

[F] Frequency

The numeric display shows the frequency measurement of the voltage system.

[t.A] Current THD / [t.U] Voltage THD

The numeric display shows the total harmonic distortion of the current or voltage as according to the formula below:

$$THD = \sqrt{\frac{\sum_{n=2}^{\infty} i_n^2}{i_1^2}}$$

i_n = nth order harmonic current or voltage rms

i_1 = Fundamental current or voltage rms

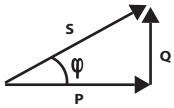
This measurement is possible only if the total load is at least 5% of the rated load.

[P.F.] Power Factor

The numeric display shows power factor of the system.

[P.A] Active Power / [P.R] Reactive power / [P.S] Apparent power

The numeric display shows active power, reactive power or apparent power of the load.



S = apparent power [VA]
Q = reactive power [VAR]
P = active power [W]

3. MENU

[S.C] System Configuration

S.C	Parameter	Setting Range
1	Rate Voltage	**[L- N]** Line to Neatural **[L - L]** Line to Line
2	Rate Frequency	**[50]** Rate frequency set to 50Hz **[60]** Rate frequency set to 60Hz ***{PFR will auto trace line frequency while THD voltage lower than 20%}***
3	System Coupling	**[ALN]** Standalone unit **[CTL]** Master unit **[SLU]** Slave unit
4	Input Control	**[YES]** Master and Slave activation control by Digital Input **[NO]** Master and Slave function operate immediately

**Master and Slave function only available while NX-M1 module is attached.*

[S.S] System Setting

[1] Primary.CT

Primary current transformer ratio (_/5A). This parameter must be set according to the external 5A current transformer ratio.

{Make sure Primary CT setting must be set, otherwise PFRNX will not run in normal condition.}

[2] Set Cos φ

The target power factor required when the system is under automatic mode. The power factor regulator will switch the capacitors in or out in order to achieve the set value.

[3] Smallest Cap

This setting is used to set the switching hysteresis according to smallest size capacitors used. With automatic selection **[Atc]**, the reactive power compensation is achieved without manually setting smallest cap. The PFR will measure and evaluate all steps available when necesssary and smallest cap value is then computed.

[4] Sensitivity

This parameter set the speed of the switching. A larger sensitivity value will result in slower switching speed and conversely. A smaller sensivitity value will result in a faster switching speed. this sensitivity applies to both switching on and switching off of the capacitor.

Example : if smallest step Q_{1st} = 15 kVAR and Sensitivity = 60s/step

Reactive power required to achieve set power factor, Q_{rq} = 15kVAR
Step required to achieve targer power factor = Q_{rq}/Q_{1st}
= 15 kVAR/ 15kVAR = 1 Step
Reaction time = 60/1 = 60 sec

[5] Reconnection Time

This is the safety lockout time which is used to prohibit the reconnection of the same capacitor step before it is fully discharged. This parameter is usually set larger than the discharge time of the largest capacitor size in used.

[6] Switch Program

This setting allows the selection of one of the four available switching algorithms.

a) Manual switching **[n-A]**
The capacitor steps are controlled manually by the "UP" or "DOWN" button. The "UP" button will connect the capacitor step and "DOWN" button will disconnect the capacitor step. Steps are swtiched in a rotational manner based on first-in-first-out basis.

b) Rotational switching **[rot]**
This switching program is similar to the manual switching method and it is based on rotational first-in-first-out sequence. Unlike the manual switching program, the option will automatically switch in and out the capacitors according to target power factor, sensitivity and reconnection time settings.

c) Automatic switching **[Aut]**
This automatic switching program uses intelligent switching sequence. The step switching sequence is not fixed and the program automatically select the most apporiate steps to switch in or out in order to achieve shortest reaction time with minimum number of steps. For equal ageing of the capacitor and contractors, the program will select the least used step to be switched in if there are two equally rated steps.
Under this switching program, the power factor regulator automatically detects the CT polarity power up. Once this polarity reference is fixed, any subsequent re-generative power condition detected will cause all the capcitor steps to be disconnected.

d) Four-quadrant switching **[Fqr]**
This switching program is similar to the automatic switching program **[Aut]** except that this switching program allows the power factor regulator to operate correctly under both import power and export power (re-generative) conditions. Under export power condition, the active power is fed back to the supply mains by other energy sources such as standby genset etc. If this option is selected, the installer must ensure that the CT polarity is correctly wired because the automatic CT polarity correction detection feature is disabled.

The "AUTO" LED indicator (c) on the power factor regulator light off when the switching program is set to Manual switching **[n-A]**. For Rotational **[rot]**, Automatic **[Aut]** and Four-quadrant **[Fqr]** switching programs, the "AUTO" LED indicator (c) on the regulator lights up. Under normal operating condition, the step indicators indicate the ON/OFF status of every step. A steady ON light indicates the particular step is switched in.

S.S	Parameter	Setting Range
1	Primary.CT	5 - 8000
2	Set Cosφ	0.8 IND - 0.8 CAP
3	Smallest Cap	500 - 1.5x10^6/AtC
4	Sensitivity	5s - 300s/step
5	Reconnection Time	5 -240s
6	Switch Program	[n-A], [rot], [Aut] or [Fqr]

[r.S] Rated Step

Every step in the power factor regulator is programmable except Step 1. Step 1 is fixed as "1" and it is the smallest capacitor step used. All other steps were programmed as multiple of Step 1.
Example:
If the configuration of capacitors used, starting from Step 1, is 10kvar, 10kvar, 20kvar, 20kvar, 30kvar, 30kvar, 60kvar & 60kvar, then the rated steps are 1,1,2,2,3,3,6,6.

Unless all steps are fully used, the unused steps should be set as "0". The last step can be programmed as alarm/fan output by setting the step to "ALA" /"FAn". When the last output is programmed as alarm output, second last output can be programmed as fan output.

If the auto smallest cap is enabled, the PFR will carry out the automatic rated step measurement. Therefore, all steps are not programmable except alarm/fan output.

R.S	Rate Step	Setting Range
1	Step1	Only can set as 1
2 ⋮ 14	Step2 ⋮ Step14	0, 1, 2, 3, 4, 5, 6, 8, 12, 16
15	Step15	0, 1, 2, 3, 4, 5, 6, 8, 12, 16, Fan
16	Step16	0, 1, 2, 3, 4, 5, 6, 8, 12, 16, ALA, FAn

* 0 - Disable

Fan Output [FAn]

When the fan output is selected, the output will be energized with any capacitor bank switched ON. Step 15 can be set to [Fan] when only step 16 set to **[ALA]**.

Alarm Output [ALA]

Alarm conditions detected by the power factor regulator are indicated by "ALARM" LED indicator **(d)**. If Step 16 set as **[ALA]**, step 16 contact and LED **(i)** will switch On while alarm is activated. The alarm indications are automatically reset to normal once the alarm conditions are restored.
To view the alarm message, user needs to goto Alarm Message menu **[A.n]**. The number shows on the 2 digit numeric display **(a)** are the alarm condition follows according to table 1 in page 3.

Example:

2 digit numeric (a) **3 digit numeric (e)**

The 2 digit numeric display **(a)** describes alarm is undervoltage condition. The 3 digit numeric display **(e)** shows the voltage value in 65 Volts.

[A.S] Alarm Setting

The alarm conditions for THD voltage, THD current, undercurrent, overcurrent, undervoltage and overvoltage and frequency error able to be set follow according to the table 1 in page 3.

[O.P] Programmable Alarm

The PFR can be programmed to disable or enable the detection of the alarm conditions according to the table 1 in page 3.

[A.P] Programmable Output

The PRF can be programmed to disable or enable which alarm conditions not to have activity on the step 16 contact, only if step 16 contact set as alarm output **[ALA].**

[C.S] Communication Setting

Cummunication through RS485 RTU protocol available only if NX-M1 module installs on the PRF.

C.S	Parameter	Setting Range
1	Communication?	Yes or No
2	Remote Set?	Yes or No
3	Comm. Address	1 - 255
4	Baudrate	2400, 4800, 9600, 19200 or 38400
5	Parity	Odd, Even or None
6	Stop Bits	1 bit or 2 bits

4. Descripstion of Alarm Parameters

A.S/ O.P/ A.P/ A.n	Parameter	Alarm Setting Range	Delay Time		Alarm/ Output Programmable Setting
			Activate	Deactivate	
1	THD Voltage	10% - 20%	5 mins	2.5 mins	On/Off
2	THD Current	20% - 300%	5 mins	2.5 mins	On/Off
3	Undercurrent	1.0% - 3.0%	10s	5s	On/Off
4	Overcurrent	110% - 140%	2 mins	1 min	On/Off
5	Undervoltage	90V - 395V	0.1s	5s	On/Off
6	Overvoltage	132V - 500V	15 mins	7.5 mins	On/Off
7	Cap Size Error	-	15 mins	0s	On/Off
8	Undercompensate	-	15 mins	7.5 mins	On/Off
9	Overcompensate	-	15 mins	7.5 mins	On/Off
10	Step Error	-	0s	1 week	On/Off
11	No Voltage Release	-	0.1s	0s	On/Off
12	CT Polarity Error	-	10s	5s	On/Off
13	Clock Loss	-	0s	0s	On/Off
14	EEPROM Error	-	0s	0s	On/Off
15	Step On Timer	1000 - 25500 hours	0s	0s	On/Off
16	Step On Counter	1000 - 25500	0s	0s	On/Off

Table 1: Description of number on 2 digit numeric display and parameter settings

1) THD Voltage - Total harmonic distortion for voltage threshold has been exceeded.
2) THD Current - Total harmonic distortion for current threshold has been exceeded. All steps disconnected if alarm triggers.
3) Undercurrent - Current lower than setting value of 5A rated current. Value displays on 3 digit numeric **(e)** is percentage *[%]* unit.
4) Overcurrent - Current excess setting value of 5A rated current. Value displays on 3 digit numeric **(e)** is percentage *[%]* unit.
5) Undervoltage - Voltage lower than setting value. Value displays on 3 digit numeric **(e)** is voltage *[V]* unit.
6) Overvoltage - Voltage exceed setting value. Value displays on 3 digit numeric **(e)** is voltage *[V]* unit.
7) Cap Size Error - Controller cannot reach the set cosφ due to no suitable step available. [UnS] or [OVS] shows on 3 digit numeric **(e)** if alarm triggers in smallest cap size oversized condition or no suitable step condition respectively.
8) Undercompensate - All capacitors are connected and the power factor lower than set cos φ. [Uco] shows on 3 digit numeric **(e)** if alarm triggers in this condition.
9) Overcompensate - All capacitors are disconnected and the power factor higher than set power factor. [Oco] shows on 3 digit numeric **(e)** if alarm triggers in this condition.
10) Step Error - PFR detects capacitor step may be having problem, only if smallest cap set to auto. [E.xx] shows on 3 digit numeric **(e)** if alarm triggers in this condition.
11) No Voltage Release - All steps disconnected if alarm triggers. Value displays on 3 digit numeric **(e)** is voltage *[V]* unit.
12) CT Polarity Error - PFR detects CT connection wrong polarity. [ECt] shows on 3 digit numeric **(e)** if alarm triggers in this condition.
13) Clock Loss - [CLo] shows on 3 digit numeric **(e)** if alarm triggers in this conndition. *Clock only available when NX-M1 attaches with PFR.
14) EEprom Error - [EEP] shows on 3 digit numeris **(e)** if alarm triggers in this condition. ***{Contact manufacturer If alarm trigger in this condition}***
15) Step On Timer - [t.xx] shows on 3 digit numeric **(e)** if alarm triggers in this conndition.
16) Step On Counter - [n.xx] shows on 3 digit numeris **(e)** if alarm triggers in this condition.

* Step on timer alarm and step on counter alarm only available when NX-M1 attaches with PFR. These alarms setting only can set through communication.

*xx - Step number

5. Automatic CT Polarity Detection

During the power on start-up process, the PFR, if programmed under Rotational or Automatic switch program, detects the CT polarity and correct it internally if the CT polarity is reversed. If the PFR is set for Four-quadrant switch program, this feature is disabled.

6. Programming Lock

The PFR is equipped with a programming lock to prevent inadvertent changes to the control parameters. If locked, all the control parameters can only be viewed at and cannot be changed without unlocking it first.

To lock or unlock, first ensure that the display is on the power factor display mode **[PF]**, then press and hold "ENTER" and "DOWN" buttons until the 3 digit numeric display **(e)** flashes **[LOC]** or **[CLr]**. **[LOC]** indicates the PFR is locked and **[CLr]** indicates the regulator is unlocked.

7. NFC Communication

PFR provides NFC communication convenient for user to read parameter values or to change setting through mobile. Below shows guide on how to operate NFC:

1) Download app from http://itmikro.com/Contents/view/20, and then install to mobile.
2) Open the app, and then tag the mobile nfc close to the PFR nfc tag area **(j)**. ***{Make sure NFC is available on mobile and NFC mode is turn On}***

8. NX-M1 Module

Clock and RS485 protocol communication only available if NX-M1 install on PFR. Without NX-M1, time of action are not recorded in event, fault and rate step records.

9. Application of Master and Slave PFR

{*Below usage only available if NX-M1 module is attached with PFR}

Application 1 : Link two PFRs together to increase the number of step contact. The connection setup between both PFR is shown in the diagram 1.

Programming :

	Master	Slave
System ID	Ctr	SLU
Input Control	No	No
Address	1	1

Application 2 : Refering to the diagram 2, both PFRs operate independent while coupling is open. When PFRs detect coupler is closed, both PFRs will switch to master and slave operation. The number of step eventually will be increased. The example of usage is shown in the diagram 2.

Programming :

	Master	Slave
System ID	Ctr	SLU
Input Control	Yes	Yes
Address	1	1

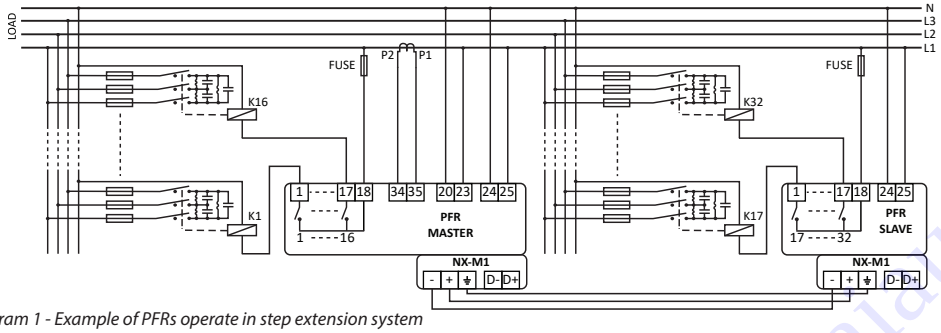


Diagram 1 - Example of PFRs operate in step extension system

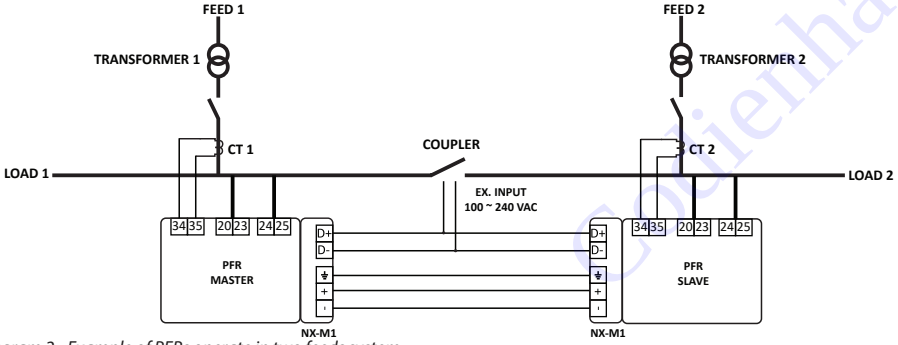


Diagram 2 - Example of PFRs operate in two feeds system

10. Shortcut to Manual Switch Program

User able to change switch program from auto mode to manual mode by press and hold "ESC" button for 3 seconds. The AUTO indicator light **(c)** eventually will turn off. User can press "UP" button to turn On capacitor step or press "DOWN" to turn Off capacitor step.

Capacitor step only will turn On after the countdown of step achieves reconnection time. The step output indicator **(i)** will flash and DMD ON indicator **(f)** will turn On while the step is waiting for reconnection time.

Manual mode will automatically change back according to system setting switch program after 1 hour if there is no button pressed.

11. Intelligent Capacitor Step Selection

PFR will look for capacitor step that has less activity to switch On or more activity to switch Off while more than one capacitor step are having same rate VAR value if switch program set to automatic switching or four-quadrant switching. This function only will operate after PFR affirms on the smallest cap value.

12. Step On Timer and Step On Counter

PFR will record down the step operating hour and counter. These features only can be read through NFC app or RS485 communication if NX-M1 module is attached with PFR. Besides that, user able to set step on timer alarm or step on counter alarm as a service alert.

User also can reset the step on timer record or step on counter record through NFC app or RS485 communication.

13. Harmonic

PFR measures harmonic up to 15 orders. User able to retrieve harmonic measurement through NFC app or RS485 communication.

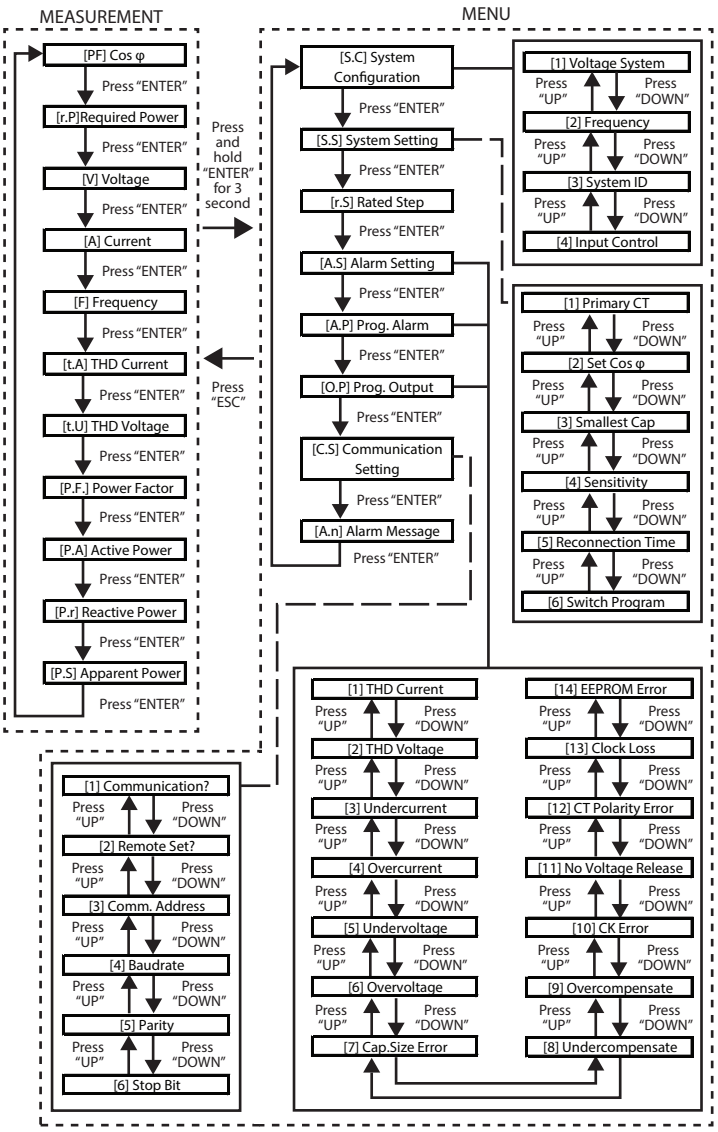
14. Reset to Factory Default

To reset all programmable parameters to factory default, first power off the PFR. Press the "UP" and "DOWN" buttons simultaneously while turning ON the PFR and holds itfor more than 3 seconds. The 3 digit numeric display **(e)** shows **[dEF]** 2 seconds.

Menu	Parameter	Default Setting
System Configuration **[S.C]**	Voltage system	L-N
	Frequency	50Hz
	System ID	ALN
	Input Control	No
System Setting **[S.S]**	Primary CT	5A
	Set Cosφ	0.98 IND
	Smallest Cap	Atc
	Sensitivity	45s/step
	Reconnection Time	30s
	Switch Program	Aut
Rate step **[R.S]**	Rate1 - Rate16	1
Alarm Setting **[A.S]**	THD Voltage	20%
	THD Current	50%
	Undercurrent	1.0%
	Overcurrent	110%
	Undervoltage	90V
	Overvoltage	500V
Programmable Alarm **[A.P]**	All parameters	On
Programmable Output **[O.P]**	All parameters	On
Communication Setting **[C.S]**	Communication?	Yes
	Remote Set?	Yes
	Communication Address	1
	Baudrate	9600
	Parity	Even
	Stop Bits	1 bit
--	Step On Timer	5000 hours
--	Step On Counter	5000

15. Guide on Controlling PFR

Below shows how to read next parameter displays and enter menu mode.



Example 2 : How to set Primary CT ratio setting to 500A

Step 1 : Goto **[S.S]** System Setting

Step 2 : Make sure 2 digit numeric display (a) flashs **[S.S]** and **[1]**, if not press "UP" or "DOWN" until display flash **[S.S]** and **[1].**

Step 3 : Press "UP" and "DOWN" simultaneously until value on 3 digit numeric display (e) blinks.

Step 4 : Press "UP" or "DOWN" until the value reach 500.

Step 5 : Press "UP and "DOWN" simultaneously to save setting.

Example 3 : How to temporally change switch program from auto mode to manual mode

Step 1 : At the Measurement page, press and hold "ESC" for 3 seconds until AUTO LED **(c)** light off.

Step 2 : Press "UP" to connect capacitor step or press "DOWN" to disconnect the capacitor step.

Step 3 : Press and hold "ESC" until AUTO LED **(c)** light on, switch program back to auto

Example 4 : How to read mutliple alarm messages when undervoltage and undercurrent alert.

Step 1 : Goto **[A.n]** Alarm message, 2 digit numeric display **(a)** flashes between **[A.n]** and **[5]**. If the value on 3 digit numeric display **(e)** shows 50. {The message shows PFR is in undervoltage condition at 50 V AC}

Step 2 : Press "DOWN" goto next alarm message. 2 digit numeric display **(a)** flashes between **[A.n]** and **[3]**. If the value on 3 digit numeric display **(e)** shows 1.5. {The message shows PFR is in undercurrent condition at 1.5% of primary rated current}

* Alarm message **[A.n]** can refer to table 1 in page 3.

16. Technical Data

Auxiliary Supply

Rated voltage	: 100 ~ 415 VAC or 140 ~ 340 VDC
Operating voltage	: 85 ~ 450 VAC or 110 ~ 370 VDC
Rated frequency	: 50 or 60 Hz
Operating frequency	: 45 ~ 65 Hz
Power consumption	: 10 VA max

Current Input

Rated current, In	: 5 A
Operating Limits	: 0.05 A ~ 10 A (Secondary current)
Accuracy	: ±3% or 20mA secondary current whichever greater
Rated frequency	: 50 or 60 Hz
Burden	: <0.3VA at In

Voltage Input

Operating Limits	: 5 V ~ 600 V
Accuracy	: ±3% or 1V whichever is greater
Rated frequency	: 50 or 60 Hz

Relay Output

Numbers of outputs	: 8 / 12 / 16 (PFR80NX / PRF120NX / PRF160NX)
Contact arrangement	: NO contact type
Rated capacity	: 5 A 250 VAC (COSφ = 1)
Max current for the commom terminals	:12 A continous

Mechanical

Mounting	: Panel mounting
Dimension (h x w x l)	: 145mm x 145mm x 78mm
Approximate weight	: 0.8kg
Enclosure Protection	: IP54 at panel : IP20 at body

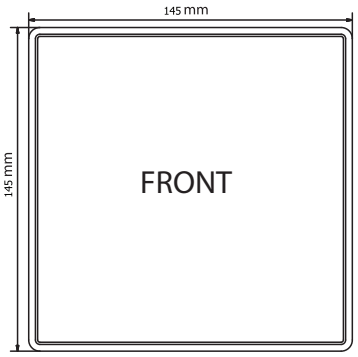
Environment Conditions

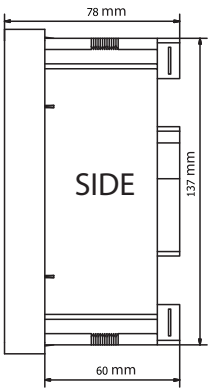
Overvoltage Class	: III
Temperature	: -5 ºC ~ +55 ºC
Humidity	: 56 days at 93% RH and 40 ºC non-condensing
Pollution Degree	: II
Altitude	: 2000m

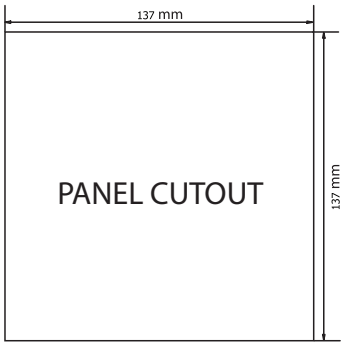
EMC

Electrical Fast Transient	: IEC61000-4-4 Level IV
Surge	: IEC61000-4-5 Level IV
Conducted Immunity	: IEC61000-4-6 Level III
Radiated Immunity	: IEC61000-4-3 Level III
Conducted and Radiated Emission	: EN55011

17. Case Dimensions







18. Typical Connection Diagram

Diagram 3 - PFR live-netural voltage system connection diagram