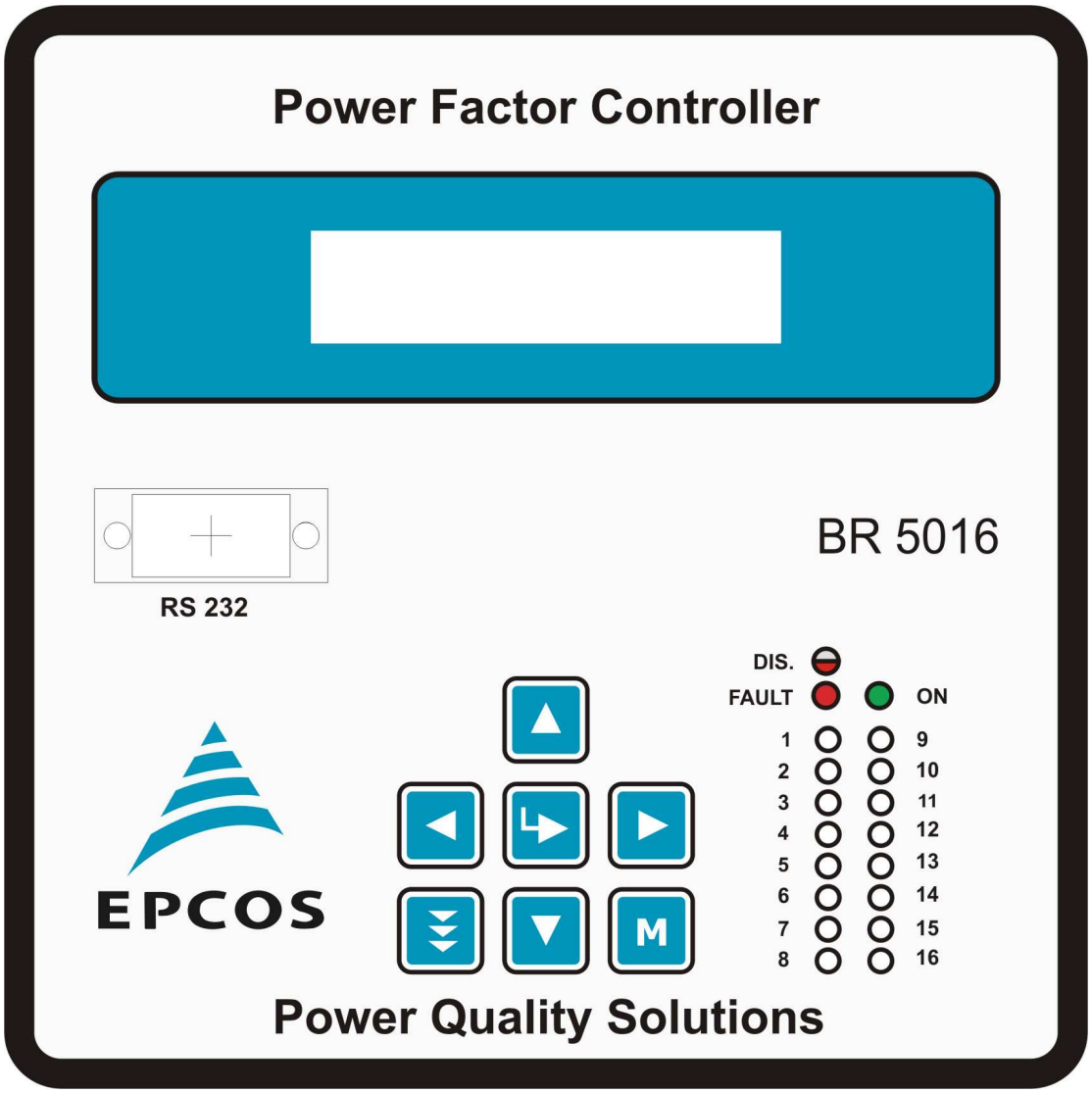
BR-5016
Operation Manual



PRELIMINARY DRAFT 1
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NOTE

These instructions do not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in connection with installation, operation or maintenance.

Should further information be desired or should particular problems arise which are not covered sufficiently for the purchasers purposes, the matter should be referred to our office.

The contents of this instruction Manual shall not become part of or modify any prior or existing agreement or relationship. Any statements contained herein do not create new warranties or modify the existing warranty.

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Unit PSIN number: (ordering information)

SPF-35 / nn / V_{fb} / I_L I_C / V_{aux} / Com / Add / Sw

nn: Defines the number of outputs. 04, 06, 08, 12, 14, 16.

V_{fb}: Feedback Voltage levels: 0, 1.
0 – 110Vac Line-Line value 3phase 3 wire.
1 – 415Vac Line-Line value 3phase 3 wire.

I_L: Load current feedback value: 1, 5.
1 – 1Amp.ac CT secondary.
5 – 5Amp.ac CT secondary.

I_C: Capacitor current feedback value: 1, 5.
1 – 1Amp.ac CT secondary.
5 – 5Amp.ac CT secondary.

V_{Aux}: Auxiliary Supply Voltage: 0, 1, 2, 3.
0 – 63.5Vac.
1 – 110Vac.
2 – 240Vac.
3 – 415Vac.

Com: Serial communication Features: R2, M3
R2 – RS-232 port with GSM protocol on 2nd port (backside).
M3 – RS-485 port with MODBUS on 2nd port (backside).
(Standard feature: RS-232 port with our protocol on front side).

Add: Additional feature for LCD display: L2, L4
L2 – LCD display with 2lines of 16 character.
L4 – LCD display with 4lines of 16 character.

Sw: PC side software: S1, S2, S3
S1 – PC side software to view logged data.
S2 – PC side software to view logged data and Billing Software.
S3 – PC side software to view data through GSM.
(For S3 please select M3 on **Com** port at backside).

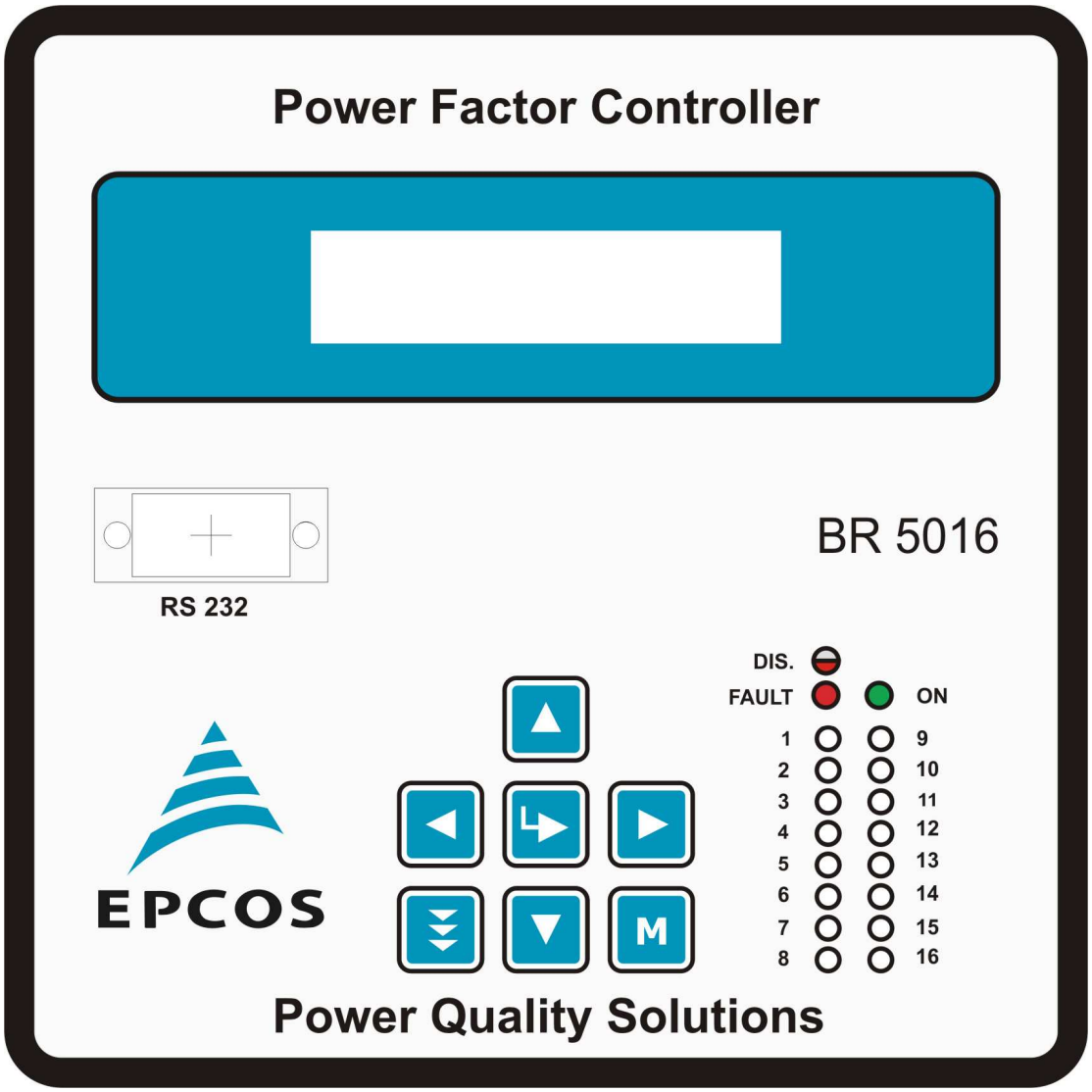
Features:

- Totally Micro-processor controlled Digital Signal processing logic for measurements.
- All measurements with 0.5 class accuracy.
- Automatic Synchronisation capable of giving the correct results for wrong connections at CT terminals (even wrong polarity of CTs).
- Load V,I and Cap. current THD measurement with odd harmonic coeff. upto 15^{th} harmonic. Neutral current analysis too.
- Various modes for switching, viz:
    - Binary
    - Un-equal (user defined)
    - C-Series (preset series)
    - E-Series (user defined)
- Up-to 16 output banks control.
- Capable of doing the kVAr measurements every cycle of the mains waveform.
- Optional GSM connectivity with battery backup arrangement.
- Standard 144 X 144 cabinet for panel door flush mounting.
- Serial communication through our standard protocols. In case of requirements with MODBUS connectivity, this can be provided on optional basis.
- One RS-232 communication port with our protocol is provided on front facia.
- Data logging of 2months data in the form of Hourly Records, Fault Records & Daily Records – recording all electrical values.
- One more optional serial communication port for RS-232 or RS-485 (half-duplex) communication can be provided on back side.
- Protections provided (user settable):
    - Over/under Voltage
    - Cap. Over/under current / THD.
    - Over/Under frequency
    - Over / Under load.
    - Load unbalance.
    - Over temperature.
    - Out of steps (only for indication).
    - NV-RAM battery down.

Specifications:

- Feed-back Voltage: 3ph, 3wire, 110/415Volt (+20%/-40%).
- Current input : 1A/5A for load and capacitor feed-back.
- Measurement Accuracy:1% (Dynamic range 10).
- Auxiliary Supply: For selected range +20% to –40%.
  (63.5/110/240/415Volt, 1 phase)
- Correction time:
  Selectable in seconds from 1sec. to 250sec.
- Output commands: Max. 16 outputs.
  (Isolated 'NO' contacts of rating 5Amp ac / 250Vac).
- RS-232 baud rate selectable upto 38.4kBPS.
- Operating temperature: 0 to 70^{o}C.
- 0.5class measurement Operating temperature: 0 to 50^{o}C.
- Storage temperature: -10 to +75^{o}C.
- Humidity: 0 to 98%.
- Supply frequency: 45Hz to 55Hz.

Mechanical Dimensions:



Recommended size for cutout on panel door is 138 X 138.

All Dimensions given are in mm.

Maximum weight: (with clamps and terminals) = 2.5kg.

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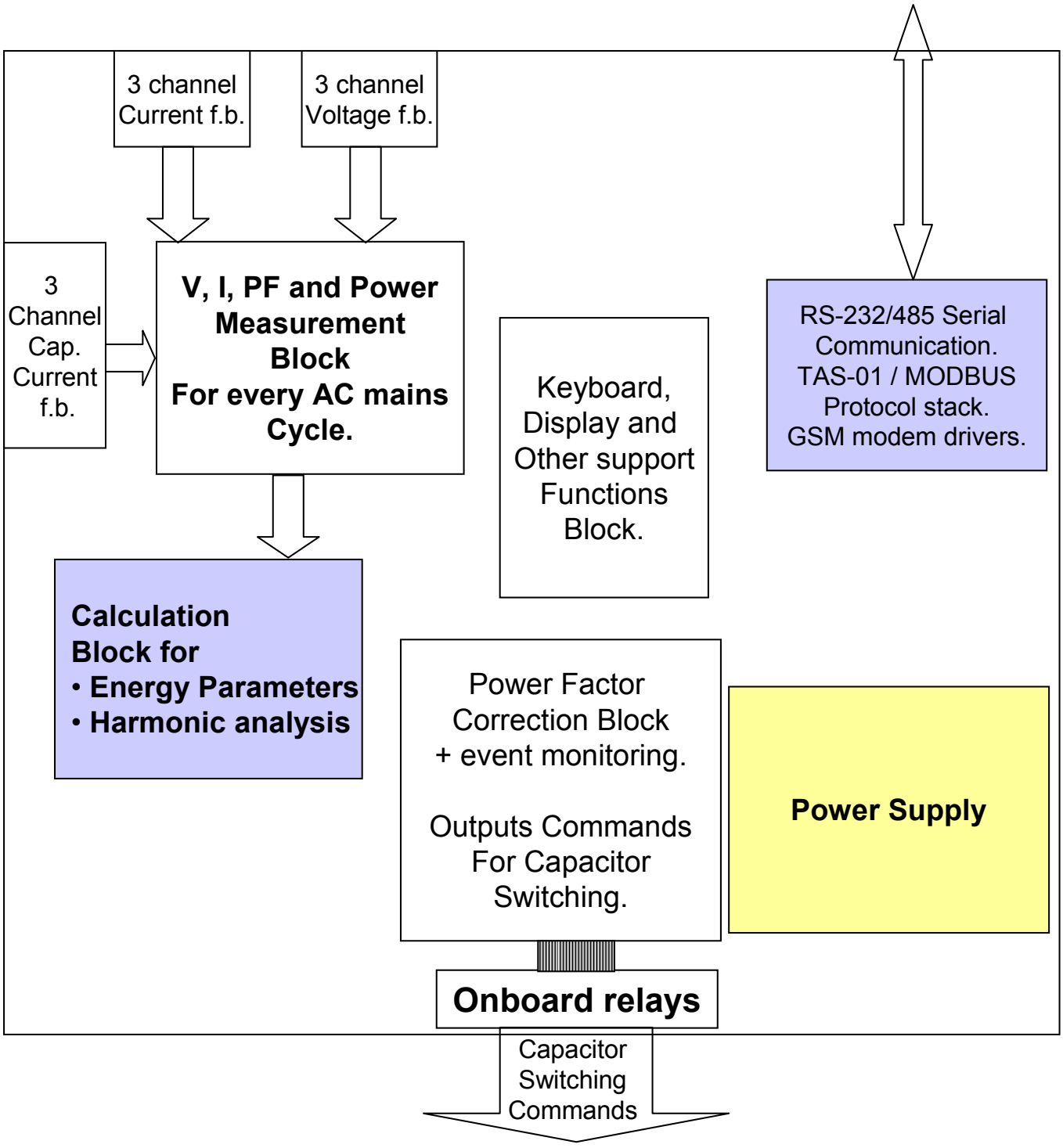
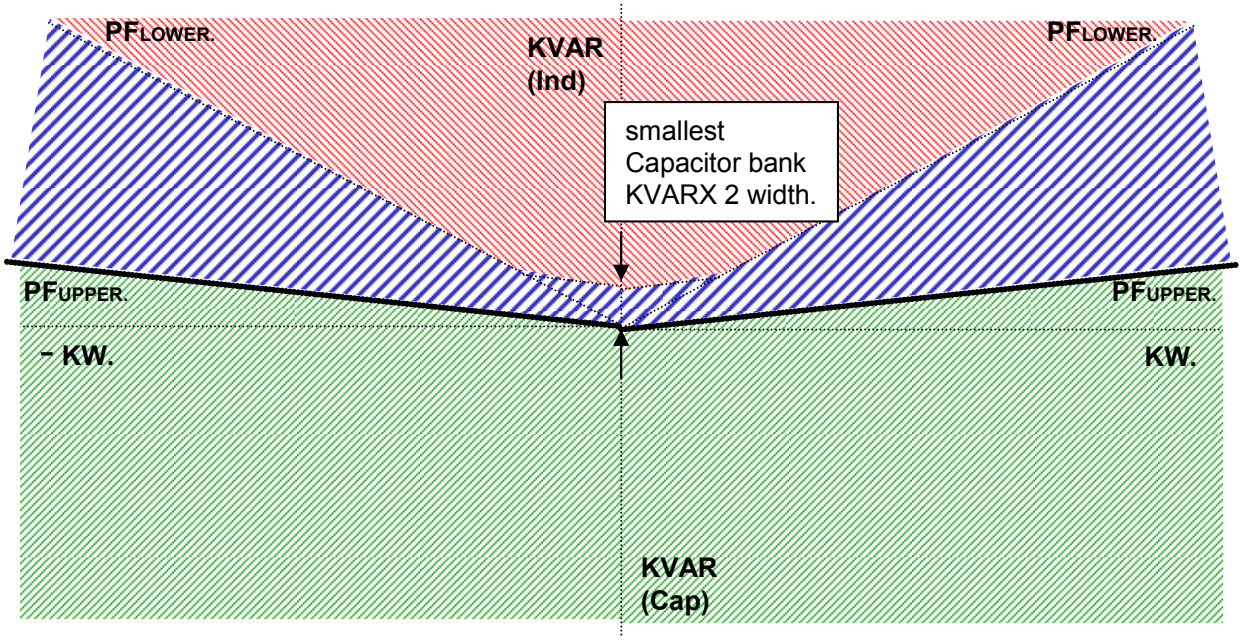
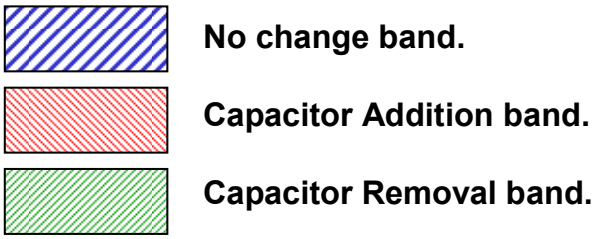
Functional Block Diagram:



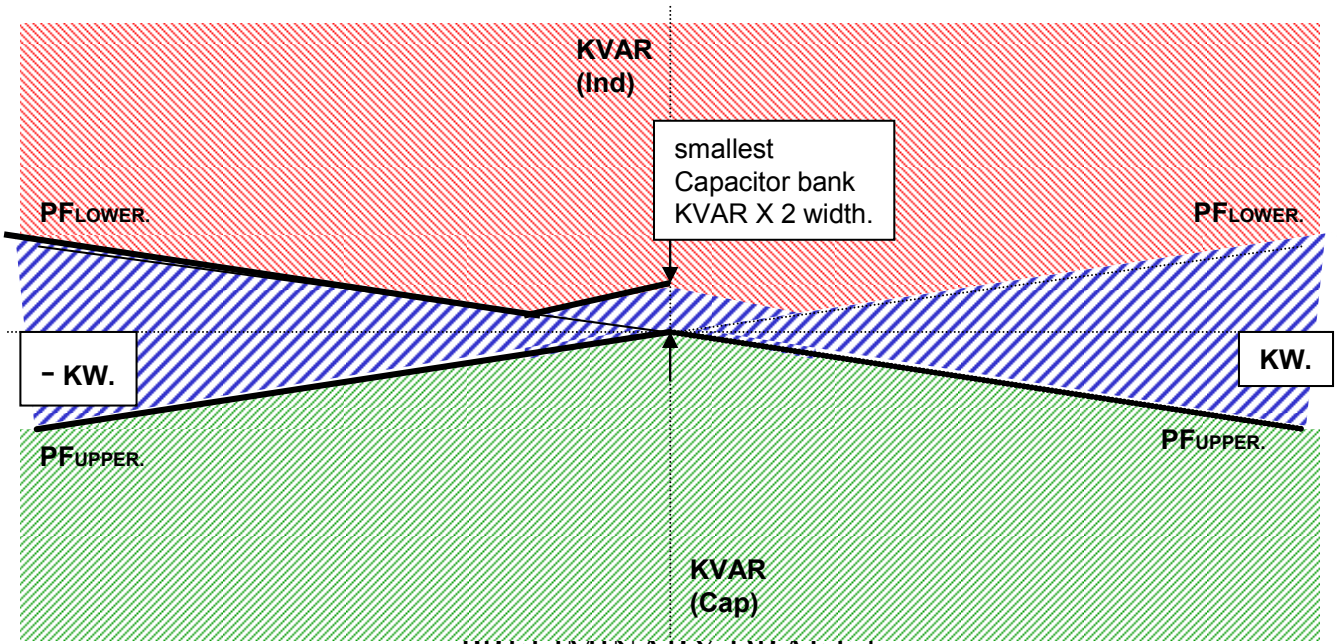
PF correction technique:

PF$_{UPPER}$ & PF$_{LOWER}$ both set as inductive:

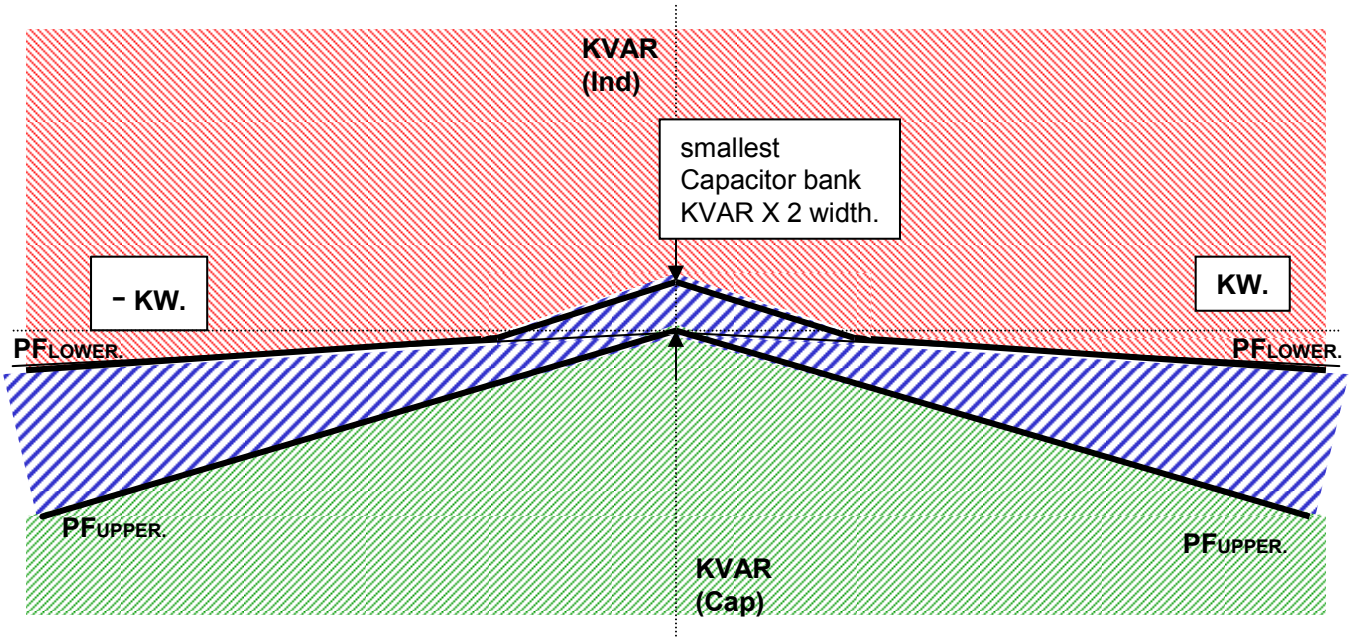




PF$_{UPPER}$ as Capacitive & PF$_{LOWER}$ as inductive:



PF$_{UPPER}$ & PF$_{LOWER}$ as Capacitive:



No change band.

Capacitor Addition band.

Capacitor Removal band.

All the three conditions specified in the diagram, the four quadrant operation is achieved if “Auto-Synchronisation” is not activated. If this feature is activated, the relay works with only kW +ve two quadrants. Thus, with 4 quadrant operations requirements, Auto-Synchronisation should be kept off. Typical example of 4 quadrant operation is with “Co-Generation Plants” and “Wind-Power Generation”. But with most conventional consumer applications, only +ve KW is seen, where the Auto Synchronisation feature can be kept ON.

It can be seen that there are two PF set points to be set in the relay. The Upper and the Lower. The relay ensures that PF$_{UPPER}$ is never exceeded. Additionally, “No change band” to minimum KVAR band size equal to smallest bank KVAR X 2 ensures no hunting during the low KW loading.

The relay is normally set for PF settings as per first two diagrams shown where PF$_{LOWER}$ is inductive. This philosophy helps to optimise the system maximum KVAR to be used as well as reduces the number of switching operations during higher loading conditions. This ensures better life expectancies to the switched capacitors as well as to the switching devices.

This methodology of KVAR compensation reduces the complex settings that are used by conventional PF relays. The settings like CT ratio and KVAR offsets/ shifts are eliminated which makes the relay user friendly and thus easy to commission.

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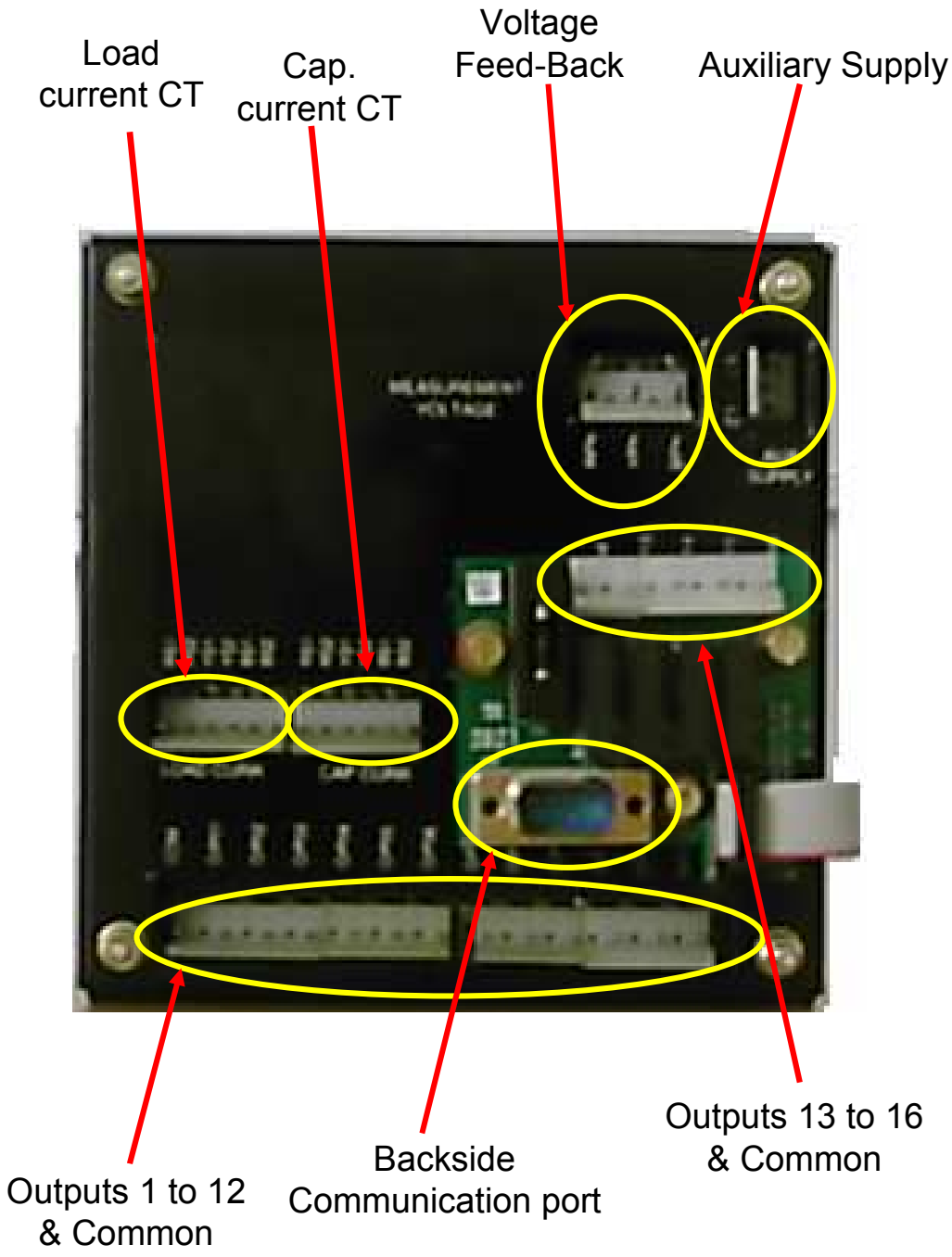
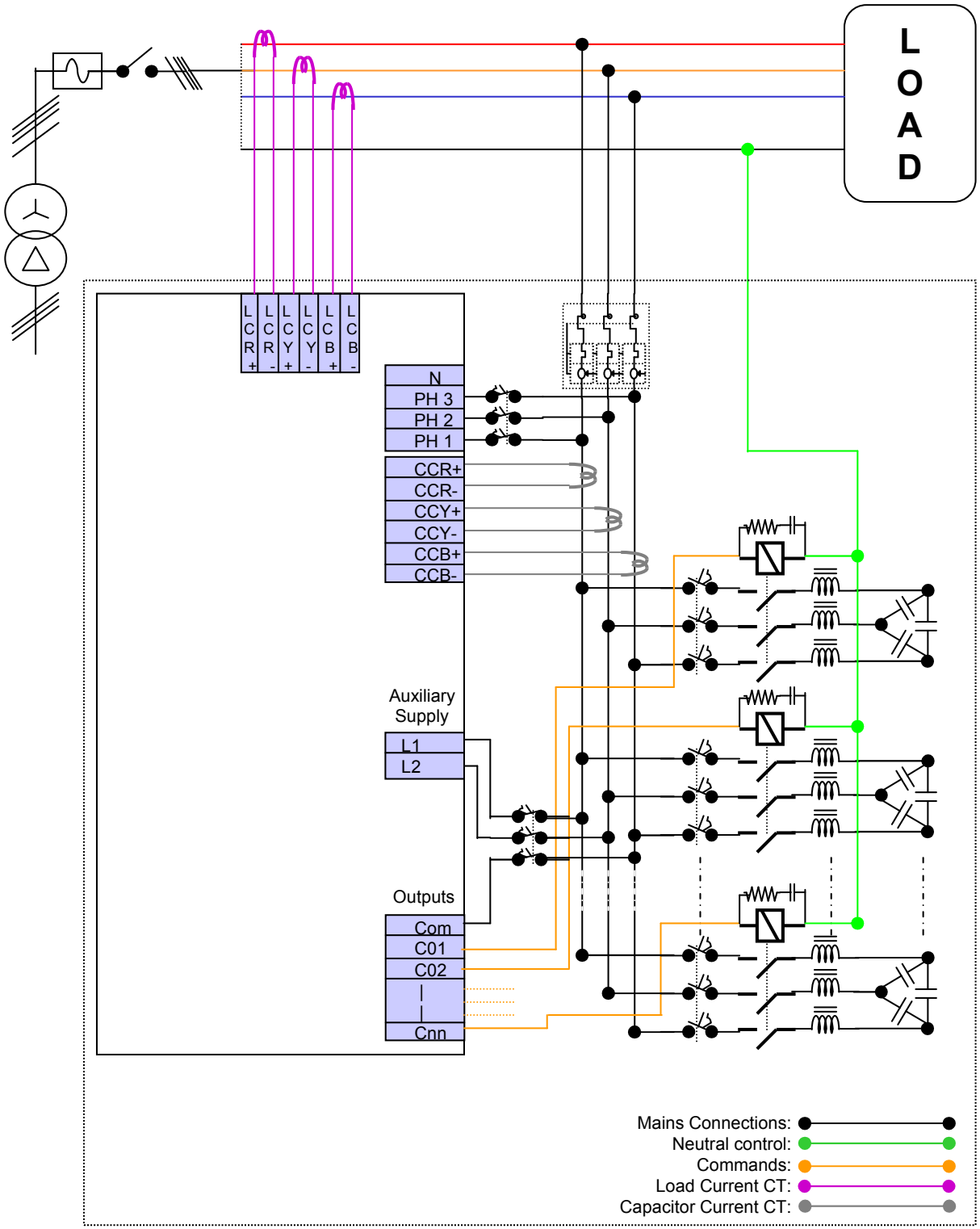
Back Side terminals:



Front side communication:

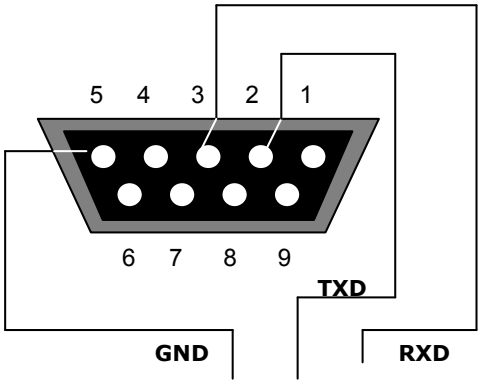
Front side communication port with RS-232 with our protocol.

Typical wiring with PF correction system.



Communication port diagram.

RS-232 serial communication 9 pin D connector:
(RS-485 is available only if separately ordered)



RS-232 cable connection Details:

PIN NO	PC side Connection	CONNECTION	SPF-35
1	NC		
2	RXD		TXD
3	TXD		RXD
4			
5	GND		GND
6			
7			
8			
9	NC		

Communication Terminals: The relay has two serial communication ports. One is on front D type connector and another is on the back side of the controller. By default, only front terminal is given and is active for communication. The default is RS-232.
The back side port is optional and is provided in case of external GSM modem is to be fixed to it. Alternately, it can also be used for SCADA communication.

Default Display:

First line of display indicates the PF value, inductive / capacitive PF, mode of operation and fault / OK status:

"PF = 1.00" indicates the overall PF of the system.
"IND" or "CAP" indicates if this PF is inductive or capacitive respectively.
"A" or "M" indicates the Auto and Manual mode of operation respectively.
"OK" (blinking) indicates status of the system, healthy or faulty.

Second line of display indicates the status of each capacitor bank by symbols. The status is also shown by LEDs for each step:

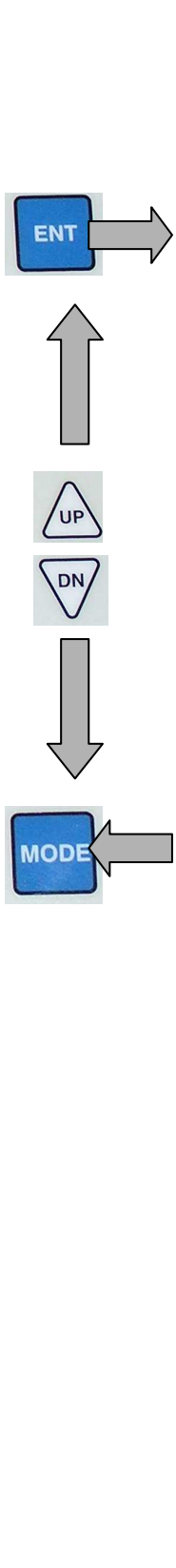
- Symbol indicates that the bank is on state.
- Symbol indicates that the bank is in off state.
- Symbol indicates that bank is declared as fixed bank and is on state.
- Symbol indicates that bank is declared faulty and not available for use.
- Symbol indicates that this output stage is not used in System.
- Symbol indicates that this output is in discharge mode (blinking red LED).

Default Screen Example:

Meaning of this screen:
Power Factor at Load sensing CT is 0.98 'IND' Inductive. ('CAP' defines Capacitive).
Unit is operating in 'A' Auto mode. ('M' defines Manual mode)
Total number of banks that are operational are eight.
Bank no.1 is declared as fixed and is in ON condition.
Bank no.2, 3 and 7 are in ON condition.
Bank no.4 and 6 are in OFF condition.
Bank no.5 is declared as faulty.
Bank no.8 is in discharging state.

Display of Various Parameters:

Values of various parameters can be viewed by using the UP / DN keys and then pressing ENT key. To exit a sub-menu press MODE.



This is factory set default display screen giving information on PF, mode and bank status.

Overall values gives the overall system parameters like PF, freq, kW, KVA, KVAR, av. V & I etc.

Per Phase RMS values for the instantaneous parameters like V, I, cap. Current and Neutral current.

Power parameter gives per phase values of PF, KW, KVA, KVAR and Capacitive KVAR.

Gives overall energy parameters like KWH, Inductive & Capacitive KVARH, KVAH and C-KVARH.

This gives per phase V, I, Neutral current & Capacitor per phase current THD as well as odd harmonics coefficients up-to 15^{th}.

Gives the values of KVAR that is measured for every output step.

Auxiliary functions like Internal Temperature.

Displays Date and Time that is set on internal RTC.

Displays the version of software.

Sub-Menus for Display Parameters:

Overall Values
Average Voltage 00440.1V (L-L)
Average Current 1000.5 A
Activer Power 000440.0KW
Reactive Power 000010.0 KVAr
Apparent Power 000442.0 KVA
Cap-Current 0009.6 A
C-KVAR 000006.1
Load Side PF 0.998 IND
Load Side KVAR 000016.1
Load Side KVA 000438.1
Frequency 50.0 Hz

Per Phase RMS
R-Phase Voltage 00415.0 V
Y-Phase Voltage 00415.0 V
B-Phase Voltage 00415.0 V
R-Phase Current 1000.0 A
Y-Phase Current 1000.0 A
B-Phase Current 1000.0 A
Neutral Current 0001.0 A
R-Phase Cap Cur 0009.5 A
Y-Phase Cap Cur 0009.0 A
B-Phase Cap Cur 0009.9 A

Power
R-Phase PF 1.000 IND
Y-Phase PF 1.000 IND
B-Phase PF 1.000 IND
R-Phase KW 000250.0
Y-Phase KW 000254.0
B-Phase KW 000256.0
R-Phase KVAR 000005.7
Y-Phase KVAR 000006.7
B-Phase KVAR 000005.2
R-Phase KVA 000254.0
Y-Phase KVA 000256.0
B-Phase KVA 000258.0
R-Phase CKVAR 000002.3
Y-Phase CKVAR 000003.1
B-Phase CKVAR 000002.4

Energy
KWH 000000000.0
IND RVARH 000000000.0
CAP KVARH 000000000.0
KVAH 000000000.0
C-KVARH 000000000.0

Harmonics
Vr-THD-(R/F) 000.0 %
Vy-THD-(R/F) 000.0 %
Vb-THD-(R/F) 000.0 %
Ir-THD-(R/F) 000.0 %
Iy-THD-(R/F) 000.0 %
Ib-THD-(R/F) 000.0 %
In-THD-(R/F) 000.0 %
CCr-THD-(R/F) 000.0 %
CCy-THD-(R/F) 000.0 %
CCb-THD-(R/F) 000.0 %

Step KVAR
Step[1] KVAr 0010.0
Step[2] KVAr 0010.0
Step[3] KVAr 0010.0
Step[4] KVAr 0010.0
Step[5] KVAr 0010.0
Step[6] KVAr 0020.0
Step[7] KVAr 0020.0
Step[8] KVAr 0020.0
Step[9] KVAr 0020.0
Step[10] KVAr 0020.0

Step[11] KVAr 0020.0
Step[12] KVAr 0020.0
Step[13] KVAr 0020.0
Step[14] KVAr 0020.0
Step[15] KVAr 0020.0
Step[16] KVAr 0020.0

Aux-Function
INT-Temperature 00 Deg C

continued..

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continued..

Harmonic data of various current & voltage parameters can be viewed by pressing ENT on the respective parameter screen of the Harmonics menu. Following are the sub-menus giving the harmonic data of voltage, current & capacitor current for each phase.

V Harmonics

Vr-THD-(R/F) 3rd: 00.0 %	Vy-THD-(R/F) 3rd: 00.0 %	Vb-THD-(R/F) 3rd: 00.0 %
Vr-THD-(R/F) 5th: 00.0 %	Vy-THD-(R/F) 5th: 00.0 %	Vb-THD-(R/F) 5th: 00.0 %
Vr-THD-(R/F) 7th: 00.0 %	Vy-THD-(R/F) 7th: 00.0 %	Vb-THD-(R/F) 7th: 00.0 %
Vr-THD-(R/F) 9th: 00.0 %	Vy-THD-(R/F) 9th: 00.0 %	Vb-THD-(R/F) 9th: 00.0 %
Vr-THD-(R/F) 11th: 00.0 %	Vy-THD-(R/F) 11th: 00.0 %	Vb-THD-(R/F) 11th: 00.0 %
Vr-THD-(R/F) 13th: 00.0 %	Vy-THD-(R/F) 13th: 00.0 %	Vb-THD-(R/F) 13th: 00.0 %
Vr-THD-(R/F) 15th: 00.0 %	Vy-THD-(R/F) 15th: 00.0 %	Vb-THD-(R/F) 15th: 00.0 %

I Harmonics

Ir-THD-(R/F) 3rd: 00.0 %	Iy-THD-(R/F) 3rd: 00.0 %	Ib-THD-(R/F) 3rd: 00.0 %	In-THD-(R/F) 3rd: 00.0 %
Ir-THD-(R/F) 5th: 00.0 %	Iy-THD-(R/F) 5th: 00.0 %	Ib-THD-(R/F) 5th: 00.0 %	In-THD-(R/F) 5th: 00.0 %
Ir-THD-(R/F) 7th: 00.0 %	Iy-THD-(R/F) 7th: 00.0 %	Ib-THD-(R/F) 7th: 00.0 %	In-THD-(R/F) 7th: 00.0 %
Ir-THD-(R/F) 9th: 00.0 %	Iy-THD-(R/F) 9th: 00.0 %	Ib-THD-(R/F) 9th: 00.0 %	In-THD-(R/F) 9th: 00.0 %
Ir-THD-(R/F) 11th: 00.0 %	Iy-THD-(R/F) 11th: 00.0 %	Ib-THD-(R/F) 11th: 00.0 %	In-THD-(R/F) 11th: 00.0 %
Ir-THD-(R/F) 13th: 00.0 %	Iy-THD-(R/F) 13th: 00.0 %	Ib-THD-(R/F) 13th: 00.0 %	In-THD-(R/F) 13th: 00.0 %
Ir-THD-(R/F) 15th: 00.0 %	Iy-THD-(R/F) 15th: 00.0 %	Ib-THD-(R/F) 15th: 00.0 %	In-THD-(R/F) 15th: 00.0 %

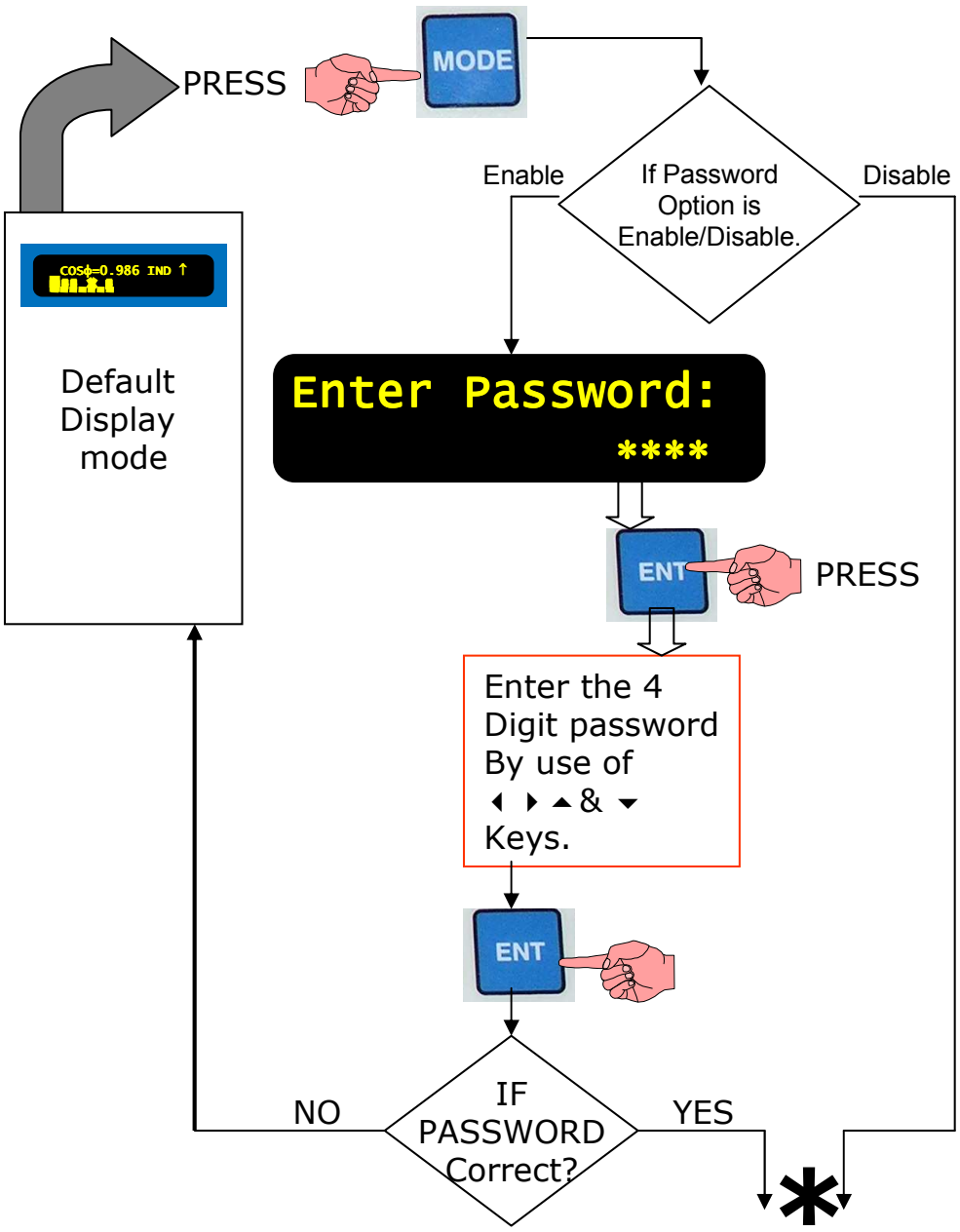
continued..

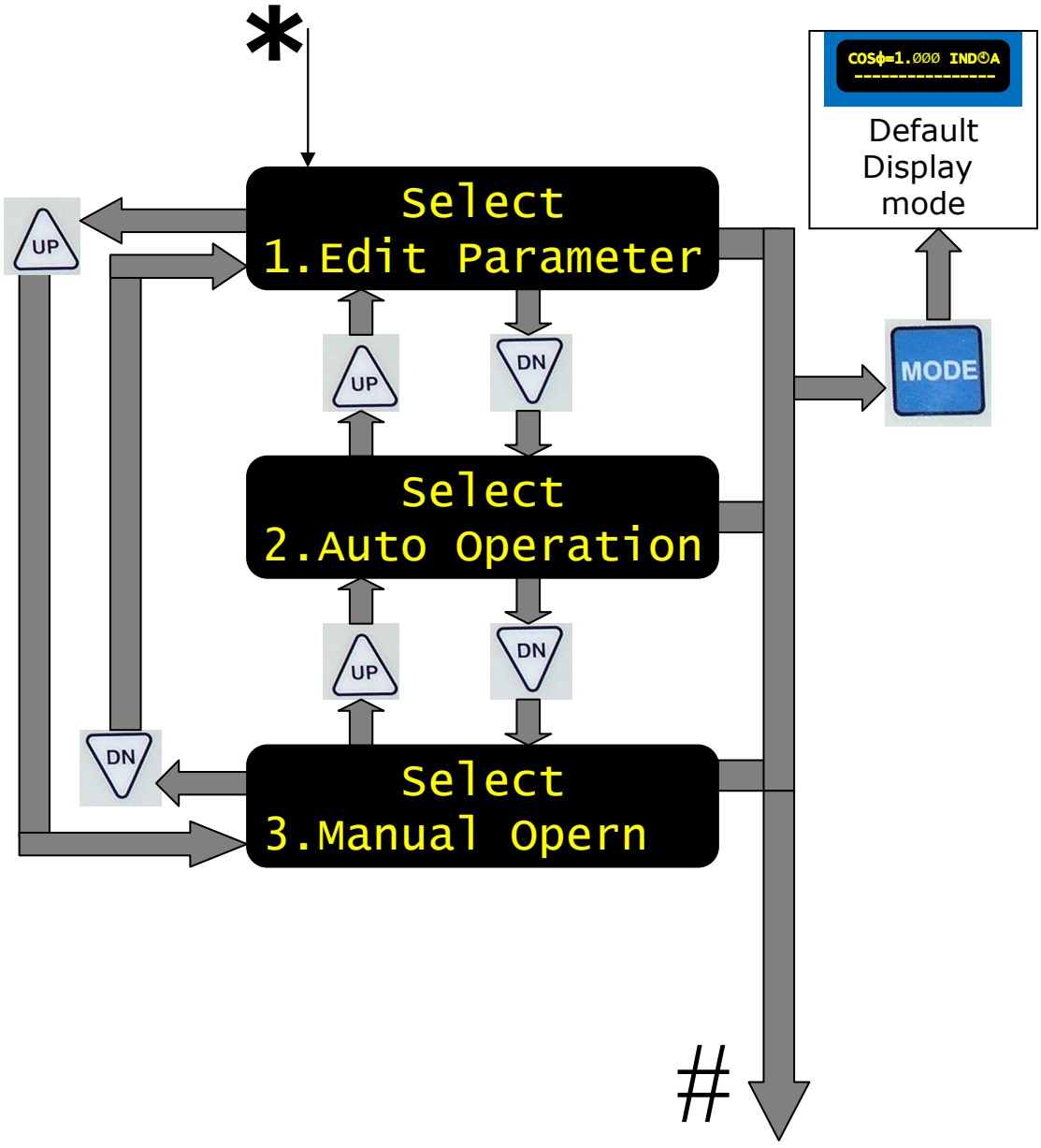
continued..

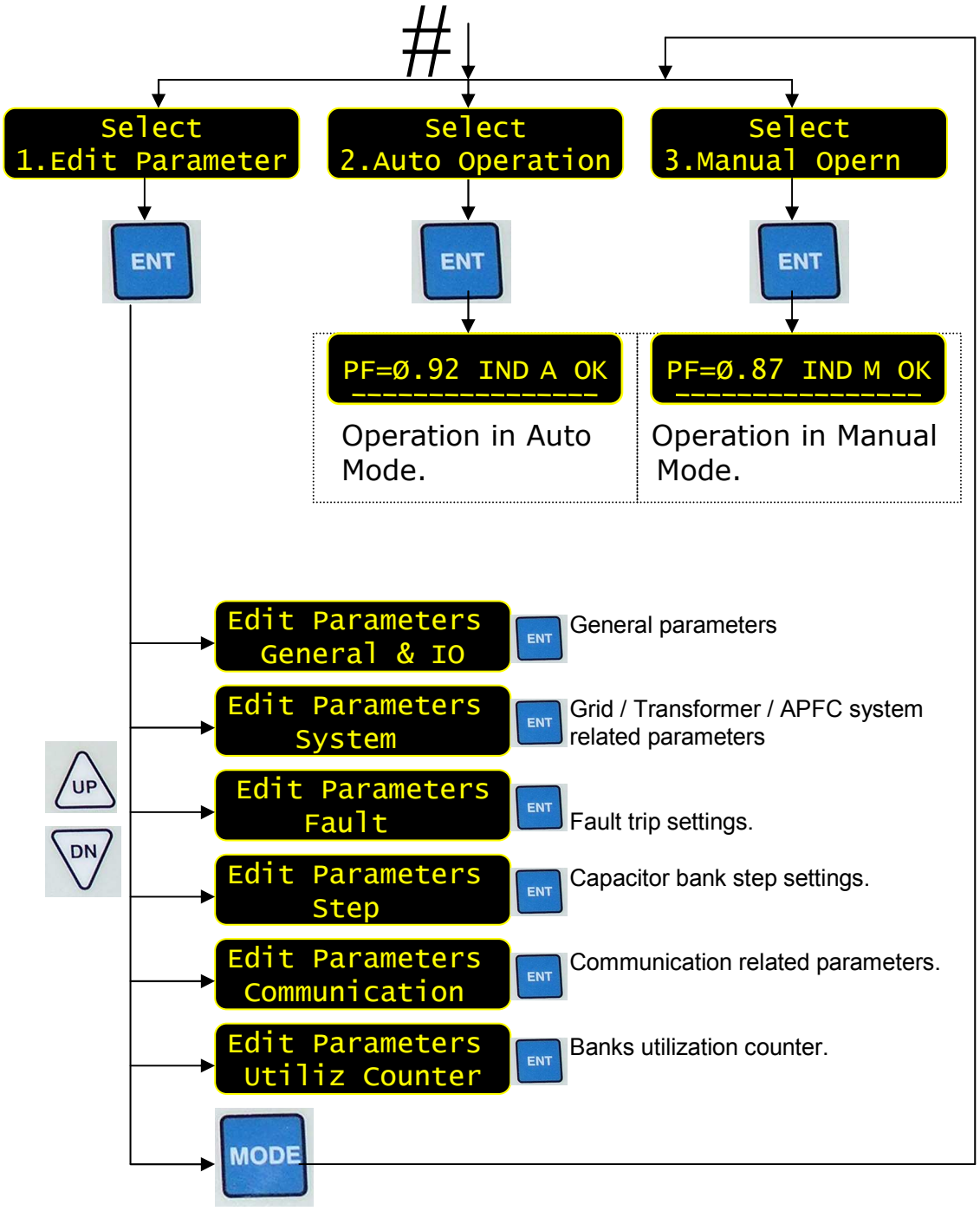
CC Harmonics

CCr-THD-(R/F) 3rd: 00.0 %	CCy-THD-(R/F) 3rd: 00.0 %	CCb-THD-(R/F) 3rd: 00.0 %
CCr-THD-(R/F) 5th: 00.0 %	CCy-THD-(R/F) 5th: 00.0 %	CCb-THD-(R/F) 5th: 00.0 %
CCr-THD-(R/F) 7th: 00.0 %	CCy-THD-(R/F) 7th: 00.0 %	CCb-THD-(R/F) 7th: 00.0 %
CCr-THD-(R/F) 9th: 00.0 %	CCy-THD-(R/F) 9th: 00.0 %	CCb-THD-(R/F) 9th: 00.0 %
CCr-THD-(R/F) 11th: 00.0 %	CCy-THD-(R/F) 11th: 00.0 %	CCb-THD-(R/F) 11th: 00.0 %
CCr-THD-(R/F) 13th: 00.0 %	CCy-THD-(R/F) 13th: 00.0 %	CCb-THD-(R/F) 13th: 00.0 %
CCr-THD-(R/F) 15th: 00.0 %	CCy-THD-(R/F) 15th: 00.0 %	CCb-THD-(R/F) 15th: 00.0 %

Method for Keyboard/Display usage.
Flow chart for entering into different modes:




*
COSϕ=1.000 IND⏲A
Default
Display
mode
Select
1.Edit Parameter
UP
UP
DN
MODE
Select
2.Auto Operation
UP
DN
DN
Select
3.Manual Opern
#


#
Select
1.Edit Parameter
Select
2.Auto Operation
Select
3.Manual Opern
ENT
ENT
ENT
PF=Ø.92 IND A OK
PF=Ø.87 IND M OK
Operation in Auto Mode.
Operation in Manual Mode.
Edit Parameters General & IO
General parameters
Edit Parameters System
Grid / Transformer / APFC system related parameters
Edit Parameters Fault
Fault trip settings.
Edit Parameters Step
Capacitor bank step settings.
Edit Parameters Communication
Communication related parameters.
Edit Parameters Utiliz Counter
Banks utilization counter.
UP
DN
MODE

Keyboard / Display Operations:

Mode Selection:

Press “MODE”.
Enter Password (If enabled) by using ◄ ► ▲ ▼ keys then press “ENT”.
Using ▲ ▼ keys, select the Mode for
• EDIT PARAMETERS
• AUTO OPERATION
• MANUAL OPERATION
Then press “ENT” to enter the specific mode.

Edit Parameters: For carrying out the system settings.

Auto Operation: For functioning of the relay in automatic compensation.

Manual Operation:
Pressing “ENT” button on this screen will put the relay in Manual mode. This mode would continue to run till it is purposefully changed or Power down.

This mode is normally used to perform the Operation like:
•Resetting of faulty banks to healthy status.
•Checking the Capacitor banks by turning them ON/OFF.
•Declaring specific bank/s faulty. Masking of the banks so that once auto mode is selected, these faulty declared banks would not be used.

For Declaring banks faulty or Resetting faulty banks:
In manual mode default screen press “ENT”.
The cursor above bank 1 will start blinking. Use ◄ ► keys to select the specific bank. Then use ▼ key to declare the bank faulty.
To reset the faulty bank, bring the blinking cursor to that bank and use ▼ key again to declare the bank as healthy.
Once the specific banks are declared faulty or reset from faulty to a healthy status, press “ENT” key so that cursor stops blinking.
For saving the status on permanent basis (so that even after Power down, the status is unchanged), press “SAVE” key. After this save command, the unit will jump back to default mode. (Default as auto or manual is set in edit parameters)

For Testing banks with manual On / Off commands:
Press “ENT”, the cursor will start blinking. Use ◄ ► keys to select the specific bank/s that are healthy and use ▲ key to turn On and use ▼ key to turn Off the capacitor banks. To come out of Manual On/Off edit mode, press “ENT” key so that cursor stops blinking.

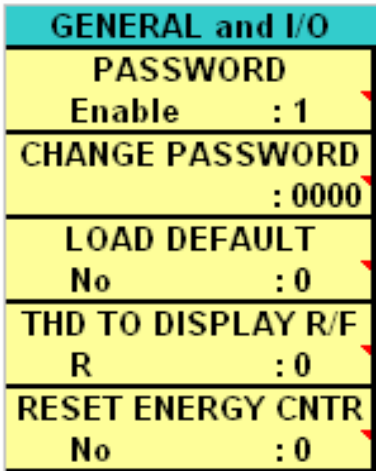
Edit Parameters:

In this mode, the various system settings can be carried out.
To do the same,
Using ▲▼ keys, select the type of Parameters to be edited.
The types are

- **General & IO** : For General settings.
- **System** : For Mains/Generator related system settings
- **Fault** : Fault settings.
- **Step** : Capacitor Banks step settings.
- **Communication** : Communication parameters.
- **Utilization Counter** : Bank operations utilization counters.

After selecting the type, press "ENT" to enter the sub-menus of that specific type.
The details of these Sub-menus for every type is given further.
You can edit all these sub-menu settings by using "ENT", ▲, ▼, ◀, ▶ keys. Coming out of sub-menu is by "MODE" key once.
To store the edited Parameters permanently, press "SAVE" when either in Edit Parameters type or sub-menu areas.
To, come out of EDIT Parameters without saving the changes, press "MODE" key again.
(Note that in Edit Parameters area, if no keys are pressed for more than a minute, the default display screen comes on and the changes done till that time are discarded).

Here are the Details of Various types of Parameters:



General:

Password: Value: 0 / 1
0-Disable 1-Enable
Enable / Disable Password
Change Password: Set new value of password (4 digit).
The factory default Password is '0001'.
Load Default: Value: 0 / 1
0-No 1-Yes
Load all default parameters.
THD to Display: 0=R-THD & 1=F-THD
Select the type of THD to be displayed for V, I and CC
Reset Energy Counter: Value: 0 / 1
0-No 1-Yes
Resets the Energy Counters.

SYSTEM
Meas. Voltage 440 V
EXT-PT Ratio 0001.0 : 1
CUR CT PRIMARY Mains: 1000
CUR CT PRIMARY Gener: 0500
CAP CUR CT PRIMARY 1000
PF UPPER LIMIT MAINS [CAP] 0.998
PF LOWER LIMIT MAINS [IND] 0.998
PF UPPER LIMIT GENR [CAP] 0.998
PF LOWER LIMIT GENR [IND] 0.998
Mains / Generator 0: Mains
Phase Auto Sync. 1: Yes
Auto Sync. Flt Tol (%) : 20
Reset Phase Auto Sync. 0: No

COMMUNICATION
UNIT ID :0000
BAUD RATE 9600 : 1
TIME 01:58:40
DATE 01/01/04
INITIALIZE RTC No : 0
CLEAR NVRAM No : 0
GMS SERVICE PROVIDER 9890012345
SMS RECEIVER NO 9890585734

System:

- Measured Voltage:
  This is a factory set parameter and is only available for viewing. As this parameter is dependent on the hardware configuration, user is not allowed to change it.
- Ext-PT ratio: This is by default set to 0001.0:1, but in case the external PT is used, this ratio can be set.
  Limits: Lower: 0000.1 Upper: 6000.0
- Cur CT Primary: (Mains & Generator): The feedback source current for mains and Generator (if used with summation CTs). Limits: Lower: 0001 Upper: 9999.
- Capacitor Current CT Primary: The feedback Capacitor current. Limits: Lower: 0001 Upper: 9999.
- Power Factor Limits: SPF-35 has two set points sets. One is for Mains and another is for Generator. For every set, the limits can be set as Upper PF and Lower PF. Due to these settings, the characteristics for PF compensation are already defined earlier in this manual. The PF limits can be set up-to third decimal and can even be set as inductive or capacitive.
- Mains / Generator: This parameter defines weather unit should consider the
  set-points defined in Mains or in Generator.
  0 – Mains 1 – Generator.
- Phase Auto Synchronisation: Auto Synchronisation feature is enabled or disabled.
  0 – Disable. 1 – Enable.
- Auto Synchronisation Fault: Unit if put in auto-synchronisation, carries out some Power parameter checks. In this process, the tolerance of these parameters is defined here. If this tolerance is exceeded then unit declares failure of Auto-synchronisation. In this condition, unit stops compensating the PF correction.
- Reset Phase Auto Synchronisation: If auto-synchronisation fault is detected, by 1 – Yes parameterising, unit can start normal PF correction.

Communication:

- Unit ID: Value: 0000 to 9999. Default value 0001.
  Defines the 4 digit unit ID used for serial communication on RS-232 our protocol.
- Baud Rate: selectable.
  0 – 4800bps, 1 – 9600bps, 2 – 19200bps, 3 – 38400bps, 4 – 57600bps.
- Time: Defines the time setting.
- Date: Defines the date setting.
- Initialize RTC: 0 – No, 1 – Yes.
  Defining Yes initializes RTC (real time clock) to the above specified values. (This is after pressing SAVE command).
- Clear NVRAM: 0 – No, 1 – Yes.
  Defining Yes clears NVRAM (in real time clock) in SPF-35. This will also clear Energy counters, this is generally used to clear NVRAM Checksum fault (This is after pressing SAVE command).
- GSM Service Provider: GSM service provider number is is to be given. It is normally a 10digit number.
- SMS Receiver No: This defines the number to where the SMS communication is to be sent. Normally it's a Master control unit Receiver Number.

PRELIMINARY DRAFT 1
UNDER
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FAULT	
OVER VOLTAGE FLT DISABLE	: 0
OVER VOLTAGE LIMIT	: 115 %
OVER VOLTAGE RESUME	: 110 %
UNDER VOLTAGE FLT DISABLE	: 0
UNDER VOLTAGE LIMIT	: 085 %
UNDER VOLTAGE RESUME	: 090 %
OVER LOAD FLT DISABLE	: 0
OVER LOAD LIMIT	: 130 %
OVER LOAD RESUME	: 125 %
UNDER LOAD FLT DISABLE	: 0
UNDER LOAD LIMIT	: 020 %
UNDER LOAD RESUME	: 025 %

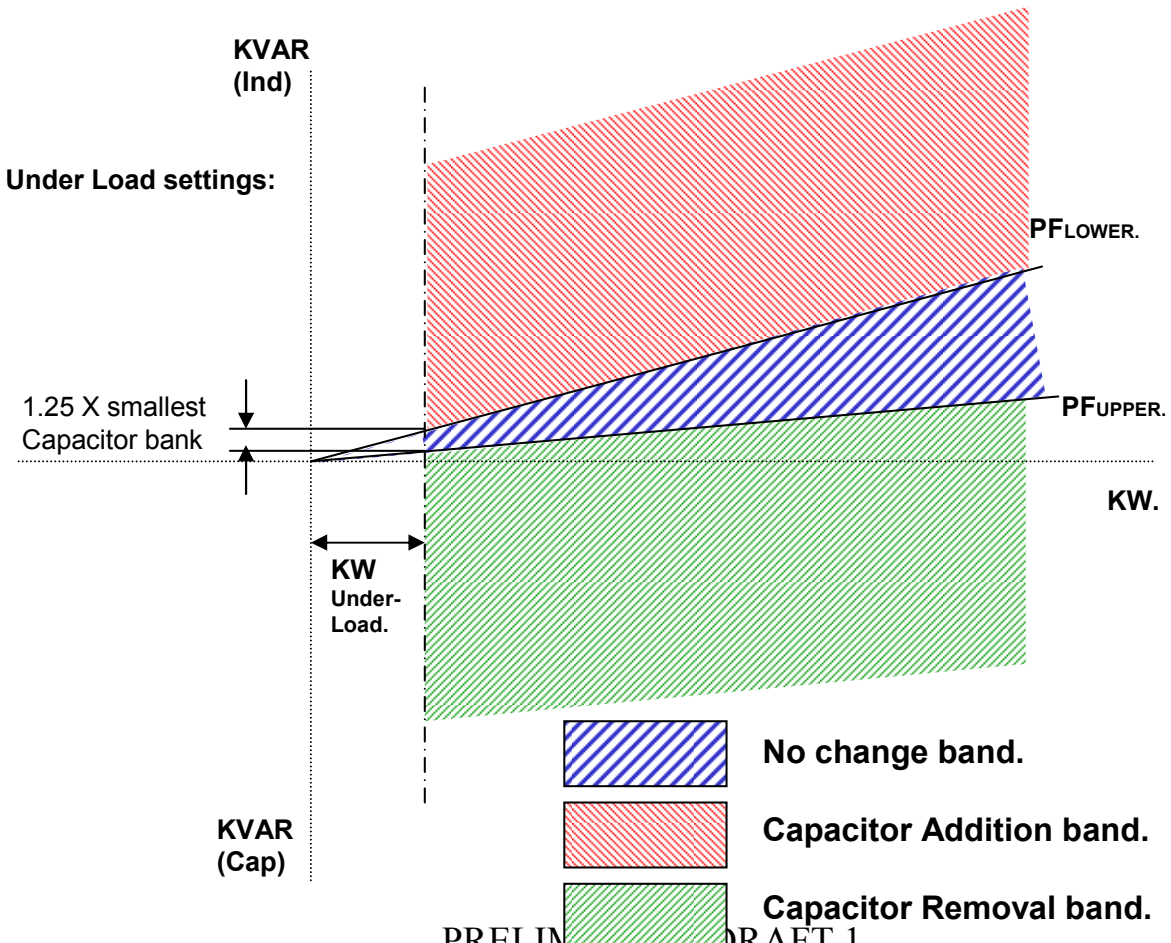
Fault:

For most of the types of faults defined here, the options available are as hereunder:

0=Disable
1=Indicative :Only Flash a Fault Message/& store in Flash
2=Off Step (Switch off Non Fixed Steps one by one)
3=Off Fixed Step Also (Switch off All Steps one by one)
4=Fast Off Step (Switch off all Steps in one shot)

For all the faults, there are normally two limits are defined. One is detection limit and another Resume limit. Detection limit if exceeded by the parameter would mean the action as defined by parameter in type of fault. (as given here-above). Resume limit defines the parameter value below which the fault is deactivated.

- Over Voltage: As name suggests, its for Over-Voltage conditions.
- Under Voltage: For Under-Voltage conditions.
- Over Load: If SPF-35 detects the supply system is overloaded, then it is sometimes recommended to remove the capacitors out of circuit to reduce the fault current levels. Under such circumstances this parameter is set. Alternately, it can be set to Indicative.
- Under Load fault: The values here are set as % of Maximum rated KW. This is useful in case of fixed banks are put in circuit to take care of no load compensation. Value for this Under-Load KW can be calculated as shown here-under.



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For PF_{UPPER} Inductive and PF_{LOWER} Inductive :

$$\textbf{Under-Load KW value setting} = \frac{\textbf{1.25 X Smallest bank KVAR.}}{[\tan\{\cos^{-1}(PF_{LOWER})\} - \tan\{\cos^{-1}(PF_{UPPER})\}]}$$

For PF_{UPPER} Capacitive and PF_{LOWER} Inductive :

$$\textbf{Under-Load KW value setting} = \frac{\textbf{1.25 X Smallest bank KVAR.}}{[\tan\{\cos^{-1}(PF_{UPPER})\} + \tan\{\cos^{-1}(PF_{LOWER})\}]}$$

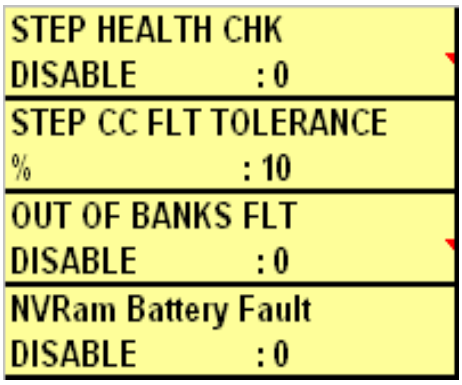
For PF_{UPPER} Capacitive and PF_{LOWER} Capacitive:

$$\textbf{Under-Load KW value setting} = \frac{\textbf{1.25 X Smallest bank KVAR.}}{[\tan\{\cos^{-1}(PF_{UPPER})\} - \tan\{\cos^{-1}(PF_{LOWER})\}]}$$

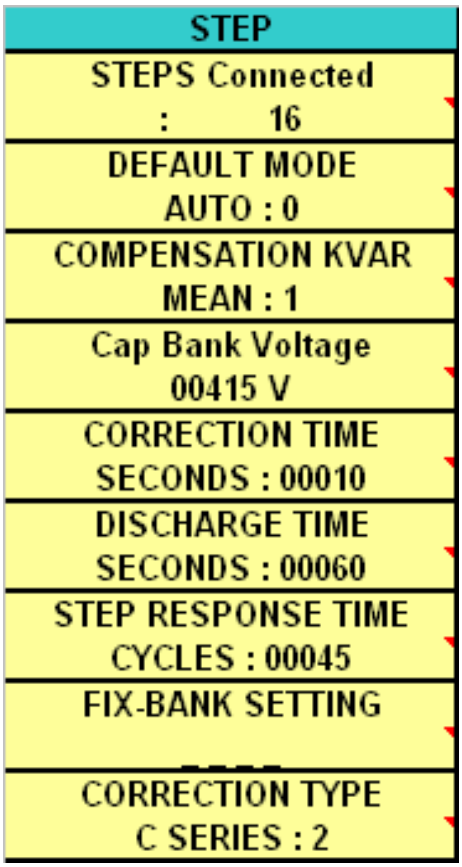
LOAD UNBALANCE FLT DISABLE : 0
LOAD UNBALANCE LIMIT : 020 %
OVER CC FLT DISABLE : 0
OVER CC LIMIT : 130 %
OVER CC RESUME : 125 %
OVER CC AUTO RESTART DISABLE : 0
AUTO RESTART TIME Seconds : 0060
UNDER CC FLT DISABLE : 0
UNDER CC LIMIT : 095 %
UNDER CC RESUME : 097 %
INT TEMPERATURE FLT DISABLE : 0
INT TEMPERATURE Lower Limit : 50 DegC
INT TEMPERATURE Upper Limit : 60 DegC
CC THD FLT DISABLE : 0
CC THD LIMIT : 010 %
CC THD RESUME : 008 %

- Load Unbalance Fault: The limits defined here are in % of maximum of the three phase source current compared with the minimum of three phase source current.
- Over Capacitor Current Fault: If put in indicative mode, it works as normal Limit and Resume operation. If put in any tripping modes, the capacitors are out of circuit. Under this case for restart, Auto-Restart "Enable" needs to be set along with Auto-Restart time. Note that with Auto-Restart feature enabled and Capacitor taking over-current even after restart may put system in hunting mode.
- Under Capacitor Current Fault: This fault can be only in two options. 0 - Disable and 1 – Indicative. This fault is not for tripping the capacitor banks. Thus, here there is no need for Auto-Restart and unit work with Normal Limit & Resume settings.
- Internal Temperature Fault: Units monitors the temperature inside the relay housing. This temperature can go up either due to ambient temperature in the APFC panel has gone up beyond limit or if some component failure in the relay hardware itself. Upper limit is for tripping and lower limit is for normal operation (resume).
- Capacitor Current THD: Capacitors are vulnerable to harmonics. The unit can sense the THD value of the capacitor current and in case of THD exceeding can give this fault.

LIMINARY DRAFT 1
- UNDER
FINALISATION



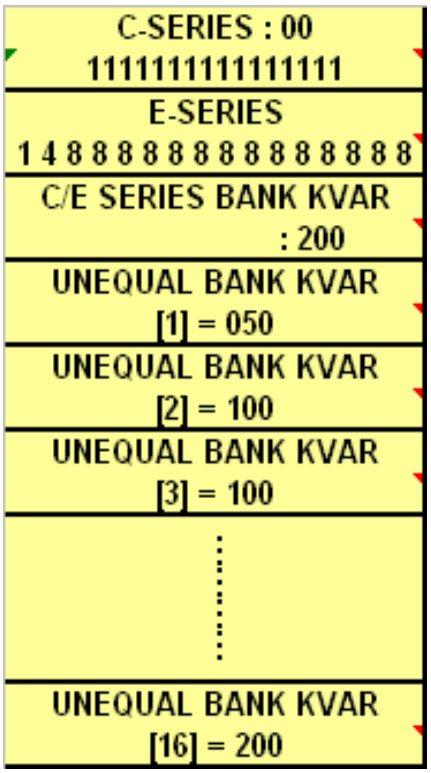
- Step Health Check: SPF-35 carries out on line monitoring of the kVAr values of every step. This is when the step is put in the circuit. In case the tolerance limit defined here is exceeded, that specific bank is declared faulty.
- Out of Banks Fault: This is only with 0 – Disable and 1 – Indicative options. If on 1, then unit will indicate this fault if: "Two consecutive correction cycles, PF is more inductive than Lower PF set point and all the healthy capacitor banks are in ON state.
- NV-Ram Battery Fault: For internal NV-RAM and RTC, a small battery is provided inside the relay. The health of this battery is checked by the relay on regular basis. If it is found un-healthy, if this parameter is enabled will give the indication and will stop data-logging operation (as it may write error prone data).



Step:

- Steps Connected: Defines the number of steps operational. Depending on PF system banks, this parameter is set.
- Default Mode: 0: Auto and 1: Manual. This parameter defines the mode during Power up. (Default is 0: Auto)
- Compensation KVAR: 0:Instantaneous & 1:Mean. Defines the method for KVAR compensation. If it should be instant at which the compensation is made or it is mean of KVAR that is required from previous compensation to present compensation.
- Capacitor Bank Voltage: Capacitor bank voltage line to line value is defined here. i.e. it defines the Voltage value at the defined KVAR.
- Correction Time: Defined in seconds. This is the Time between two consecutive KVAR compensations.
- Discharge Time: Time defined here is the time for discharge of the capacitors to a level, so that they can be turned ON again.
- Step Response Time: Defines the time after which the KVAR of any step should be measured when the step turns on .
- Fix-Bank Setting: Defines the banks that are to be declared as fixed. These banks even in spite of overcompensation cannot be turned OFF. The banks can only be turned OFF under fault conditions. (if settings in fault are defined).
- Correction Type: The can have bank configurations that are defined by four various methods. 0=Binary, 1=Unequal, 2=C Series, 3=E Series. Binary is in ratio of 1:2:4:8:16---. Un-equal is used with banks not having definite ratio. C series is predefined Control Series. The standard ratios are preloaded in the relay that can be selected here. E series is User defined Control Series. The bank ratios that are not defined in C series can be defined here. Digits can be 1,2,-- 9,A,B,C,D,E,F. i.e. the ratio can be maximum 1:F i.e. 1:15.

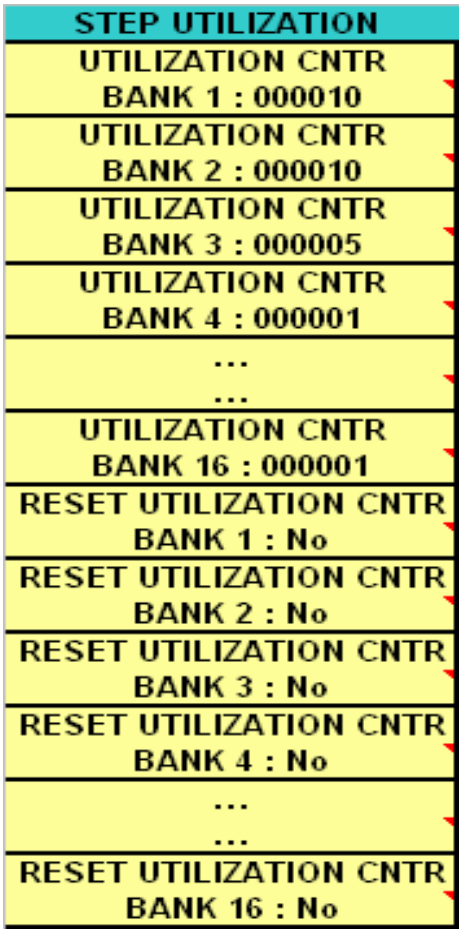
PRELIMINARY DRAFT 1
- UNDER
FINALISATION



- C Series: Various control series (C Series) can be selected

00: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1.	10: 1 1 2 2 2 4 4 4 4 4 4 4 4 4 4 4.
01: 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2.	11: 1 1 2 2 4 4 4 4 4 4 4 4 4 4 4 4.
02: 1 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3.	12: 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2.
03: 1 2 3 4 4 4 4 4 4 4 4 4 4 4 4 4.	13: 1 1 2 3 3 3 3 3 3 3 3 3 3 3 3 3.
04: 1 2 4 4 4 4 4 4 4 4 4 4 4 4 4 4.	14: 1 1 2 4 4 4 4 4 4 4 4 4 4 4 4 4.
05: 1 2 3 6 6 6 6 6 6 6 6 6 6 6 6 6.	15: 1 1 2 4 8 8 8 8 8 8 8 8 8 8 8 8.
06: 1 2 4 8 8 8 8 8 8 8 8 8 8 8 8 8.	16: 1 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3.
07: 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2.	17: 1 2 3 4 4 8 8 8 8 8 8 8 8 8 8 8.
08: 1 1 1 1 1 6 6 6 6 6 6 6 6 6 6 6.	18: 1 2 2 4 4 4 4 4 4 4 4 4 4 4 4 4.
09: 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2.	19: 1 2 2 2 4 4 4 4 4 4 4 4 4 4 4 4.

- E-Series: As explained earlier, this series is the user defined series. Digits can be adjusted from 1 to F i.e. 1 to 15.
- C/E/Bin Series Bank KVAR: The KVAR defined here is the capacitor bank KVAR of the smallest bank i.e. the value defined by digit '1' in C series, E series or Binary.
- Unequal Bank KVAR [1….16]: If unequal KVAR bank configuration is used, these parameters are to be defined for every bank KVAR (at defined Capacitor Bank Voltage). The relay has a in built intelligent algorithm to select the best possible combination to suit the exact KVAR requirement for compensation.



Utilization Counter:

- Utilization cntr: Bank nn: This gives the number of On/Off operations of the "nn"th bank.
- Reset Utilization Counter: Bank nn: Options are "Yes" and "No"
  Declaring specific bank no with Yes and pressing save command will reset the specific bank utilization counter to zero. This is normally done in case the specific bank is replaced with the new one.

Commissioning Instructions :

before panel is powered up for the first time.

1. Panel Wiring Check

Ensure that all connections in the panel is tightened properly and there are no loose connections. Also ensure that the wiring is done as per the wiring diagram.

2. Power Wiring Check

Ensure that the power cables are connected properly from the Panel I/C to the feeder I/C or the transformer bushings. The connection has to be after the Load Feed back CT looking from the Transformer side.

Ensure that the Bus Bars and/or Lugs are clean and free of Dust, Corrosion or Oxidation on the contact sides so that good electrical connection is maintained. The surface area should be flat so as to get maximum contact area.

If required Clean the Bus Bars and/ or Lugs by rubbing it with Polish Paper to remove the oxidation layer. Provide contact paste in between the contacts surfaces.
Not performing this, can result in to a weaker source point for Capacitor charging during Step on and this can generate undesirable Noise which can hamper the performance of equipments installed in the capacitor panel.

3. Load Feed Back CT connection.

Ensure that the load feed back CT connections are done properly. Confirm that correct phase CT is connected with the correct phase input terminals. (Even though auto sync is capable of taking care of wrong CT polarities or CT position interchanging, but then on display, the Phase readings may be seen to be interchanged. (May be R-phase reading would be seen in B-phase and vice-versa.

CT connections to be done carefully so as to ensure that the wire does not get open and there is no loose connection.

Loose connection’s or open CT secondary can result in to very high voltages getting developed in the circuit which can damage the CT and also produce high levels of noise in the system.

Commissioning Instructions:

After the panel is powered up.

1. Remove the fuses/switch off MCBs/MCCBs in series with every capacitor bank. Connect the supply to the relay. Keep the load feedback and capacitor current feedback in shorted condition.

2. Turn On the supply to the panel and set Date/time and various other parameters as per the panel configuration. Its important to understand the meaning of every parameter from the instructions given before and then put the appropriate values in them. Wrong values entered can give the wrong performance of the panel. Keep Auto-Synchronisation in Disabled state.

3. Once the parameterisation is complete, put the relay in Manual mode to check every bank command is transmitted to the switch. This can be observed by turning ON the contactor coil supply MCB on. The corresponding output should be checked for physical turn ON / OFF of the contactor.

4. Once all the contactors are seen to be getting the correct commands, switch off the supply to the panel and replace all the fuses (or turn on MCBs/MCCBs if they are provided instead of fuses). Turn on the panel.

5. Put the relay back in Manual mode and turn ON/Off the individual steps. Use tong tester (ac current measurement) to check that current in all the three phase of the corresponding bank are OK. In case of any bank not able to give the desired current, check for capacitor bank healthiness or power circuits.

6. Keep all the banks in off mode. Remove the short of Load feedback CT. In case KW value is seen as –ve for any phase, CT is with wrong polarity. Either select “Auto-synchronisation” in Enable mode or change CT polarity.

7. Remove the capacitor feedback CT short. Now turn ON the capacitor banks one by one and observe that capacitor current increases as per the rating of the steps on capacitor Current display. Turn ON all the banks to see that almost full rated current flows through the capacitors.

8. Switch OFF all the banks manually and put the relay in Automatic mode. Switch Off the supply to panel and put it ON. If auto-synchronisation is enabled, the relay will first turn ON all the capacitor banks and turn them off. This is one of the routine steps for auto-synchronisation during power up. In case of message of “Auto-Synchronisation Failure”, the relay will go in “No compensation”. In case of such failures (normally seen with very high fluctuating loads only), manual synchronisation is mandatory by physically checking the CT connections and polarity.

   Observe the panel performance for a period of about 2hrs after the commissioning.

Fault Finding Guidelines :

Fault Type	Probable Reason	Action to be Taken
Unit Does not turn ON.	•Input auxiliary supply not coming. •Input side fuses blown	•Check the input supply to restore •Check fuses in the unit for OK.
Unit does not turn On any capacitors even if PF is below Lower PF limit.	•If auto-sync failure message is there at Power On. • The load KW is too low. •Control connections from RLY module to contactor coils are not proper.	• Load may be highly fluctuating so need of manual synchronisation only. • This is OK condition. •Check control supply and connections from RLY to contactors.
"BF" flashing indication. *OR* "NV RAM Checksum error" display. *OR* Corruption of date & time.	In all these three conditions, the battery needs to be checked. • Internal Ni-Cd 3.2Vdc battery used for RTC and NV RAM must be drained down.	• Replace this battery in consultancy with our trained personnel.
Some Capacitor banks are declared as faulty even if they are checked to be OK.	•Individual step health monitoring is enabled and tolerance limits set are too stringent. • Capacitor current THD factor is continuously fluctuating.	•Set the tolerance limits for individual steps monitoring as relaxed. • With continuously fluctuating THD of Capacitor current and higher level of THD can cause some errors in individual step KVAR measurement. Under this condition, best is to keep this feature disabled.

PRELIMINARY DRAFT - UNDER FINALISATION

Fault Finding Guidelines (continued):

Fault Type	Probable Reason	Action to be Taken
Serial Communication is not working.	• Baud rate selection is not proper. • Unit ID is not set properly. • Serial communication cable connections are not proper.	• Select proper baud rate. • Set the unit ID correctly. • Check the serial cable continuity as per the connections given earlier in this manual.
Data logging is not taking place.	• If Battery Health monitoring is enabled and battery is weak. Possibility of battery unhealthy message being displayed. •Improper settings in PC software and/or PC	• Change the battery by help of our authorised person. •Ensure proper settings in date/time format of PC, and settings in the PC S/W are correct
Relay resets occasionally on turning OFF of any contactor.	• The contactor supply phase may be the same as used for the relay auxiliary supply. • RC snubbers/ free wheeling diodes are not put with contactor coils.	• Use the different phase for control supply of contactors and for the relay supply • Usage of RC snubbers / free wheeling diodes is mandatory.