Automatic Power Factor Controller
for L.T. Applications

APFC-06/xx
xx =04/06/08/12 Relay Output Channels

User Manual

First Release Date: 16th April 2018.

Updated on: 17th February. 2022.

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 TAS 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.

Because of continuous improvements efforts by TAS in their Product's Features and Specifications, the Product as well as the content of the User Manual is likely to get updated.

Therefore, please always refer to the User Manual supplied to the customer along with the Product, at the time of product dispatch.

CAUTIONS:

- There are High Voltages associated with this Unit, so, take appropriate precautions.
- This Automatic Power Factor Controller (APFC) is for only in-door use.
- Make sure that the discharge time set in the controller matches with the capacitor bank discharge time.

This User Manual corresponds to the APFC-06/xx Controller, Firmware Version 2.1.1 Dated: 16th Feb. 2021.

Please always refer to the User Manual supplied to the customer along with the Product, at the time of product dispatch, or check from us or from our website.

A short-form User Guidelines Manual is being supplied with the TAS APFC-06 Unit for quick information and settings during field installation by the User.

Please refer to full version of the User Manual for more detailed understanding and use of our Automatic Power Factor Controllers. Check TAS website, www.taspowertek.com for the availability of the User Manual under appropriate sections / down-loads section.

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Features:

- 32-Bit ARM Cortex-Mx State-of-the-Art Technology Micro-Controller controlled Digital Signal Processing logic for measurements, monitoring, indication, alarming & controls.
- Power Measurements with Class-3 accuracy as IEC62053-pt21 & 23.
  Auto CT polarity check (user editable)
- Phase-to-Phase Measurement Voltage Feedback on independent Input Terminals.
- Single CT Supply (Load) Current Measurement Feedback on a Three-Terminal Side Connector at the Rear.
- Supply V, I, odd harmonic coefficients up to 15th Harmonic.
- Wide AC I/P Voltage Range measurement.
- Various modes for switching, viz.:
  - ✓ Un-equal (user defined)
  - ✓ C-Series (preset series)
  - ✓ E-Series (user defined)
- Output Capacitor Banks control:
  4 or 6 or 8 or 12 Banks, as per ordered Model.
- Auxiliary Digital Input (N.O. Contact) and Auxiliary Digital Output (Potential-Free N.O. Relay Contact, for external systems Interlocks, or Auxiliary Digital Output for APFC Panel Cooling Fan On / Off Control, if enabled.
- 16-Char. x 2-Lines, LCD Display with LED Back-light.
- DIN Standard 144mmX144mm Metal Cabinet for panel-door flush-mounting.
- Protections provided:
  - Over / Under supply voltage
  - Over current / under load (kW)
  - Over Temperature of APFC Unit
  - Capacitor Bank Step health-check

  All are user settable.

Specifications:

- Feed-back Voltage: 1-Ph, 2-wire (Phase-to-Phase), Nom. 415 Volts. (User Settable Range: 110 to 480 Vac, in step of 1 Volt).

- Supply Current Feedback (CT) I/P: Selectable Nom. 1 Amp or 5 Amp.

- Measurement Accuracy: Class 2.

- Auxiliary Operating Supply: 1-Ph, 2-wire (Phase-to- Neutral), Nominal 240 Volts, 50 Hz, or Nominal 120 Volts, 60 Hz.

- Feed-back Voltage and Mains AC Supply Frequency Range: 47 Hz to 53 Hz. (Nom. 50 Hz) or 57 Hz to 63 Hz (Nom. 60 Hz).

- P. F. Correction Cycle Time Range: User Selectable:1 Second to 600 Seconds, in step of 1 Second.

- Capacitor Bank Discharge Time Range: User Selectable:1 Second to 600 Seconds, in step of 1 Second.

- Output commands: 4 or 6 or 8 or 12 Relay N.O. Contacts Outputs. (Isolated 'N.O.' Relay Contacts of rating 5 Amp (Resistive Load) / 0.5Amp (Inductive Load)/ 230Vac, suitable for Three-Phase Capacitor-Duty Contactor Coils of nominal 230 Vac, 50 Hz).

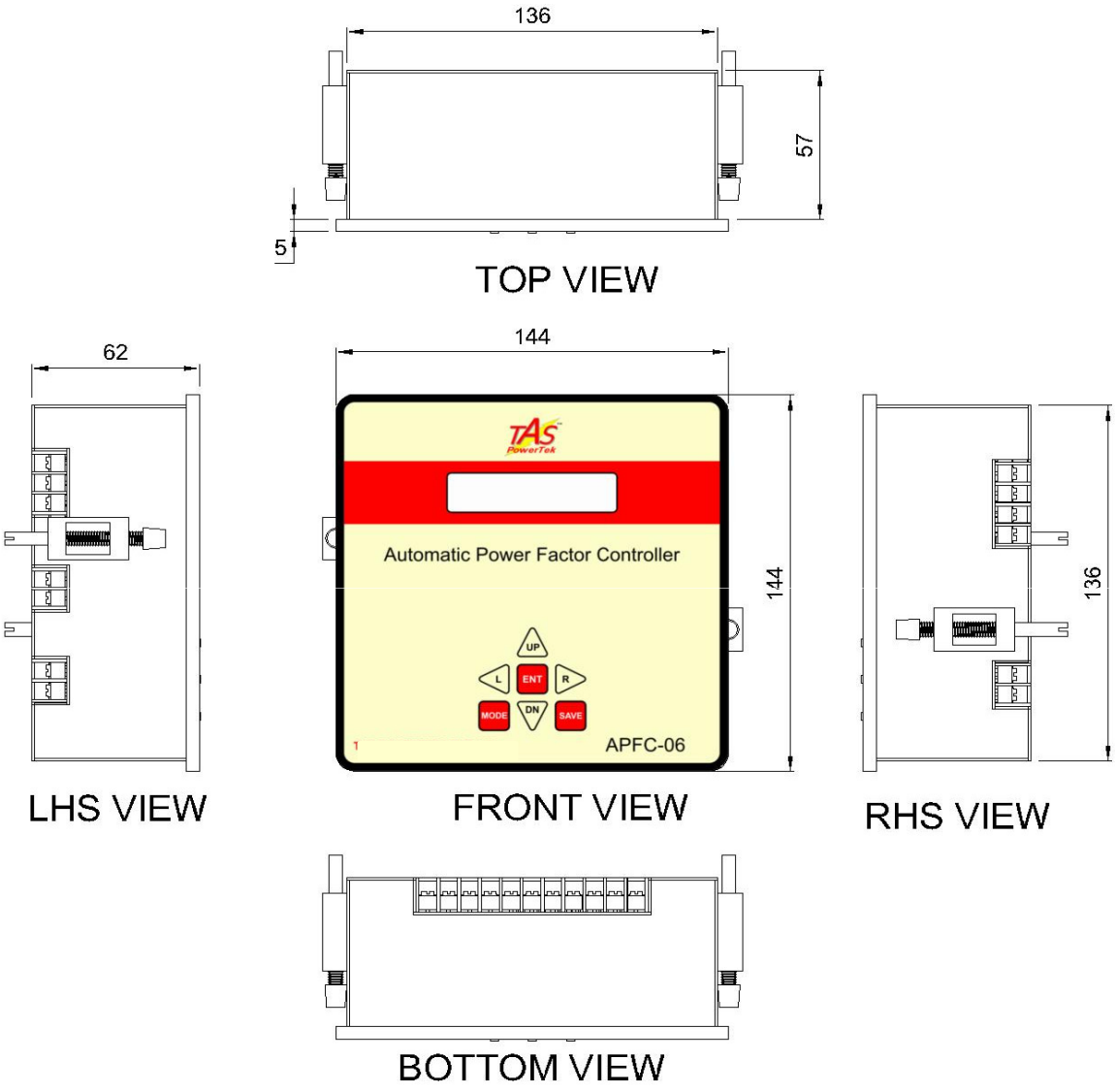
- Operating Temperature Range: +5°C. to +60°C.

- Class-2 power measurement accuracy operating temp. +5°C to +50°C

- Storage Temperature Range: -5°C to +65°C.

- Relative Humidity Range: 10% to 90% RH Non-Condensing.

Mechanical dimensions:

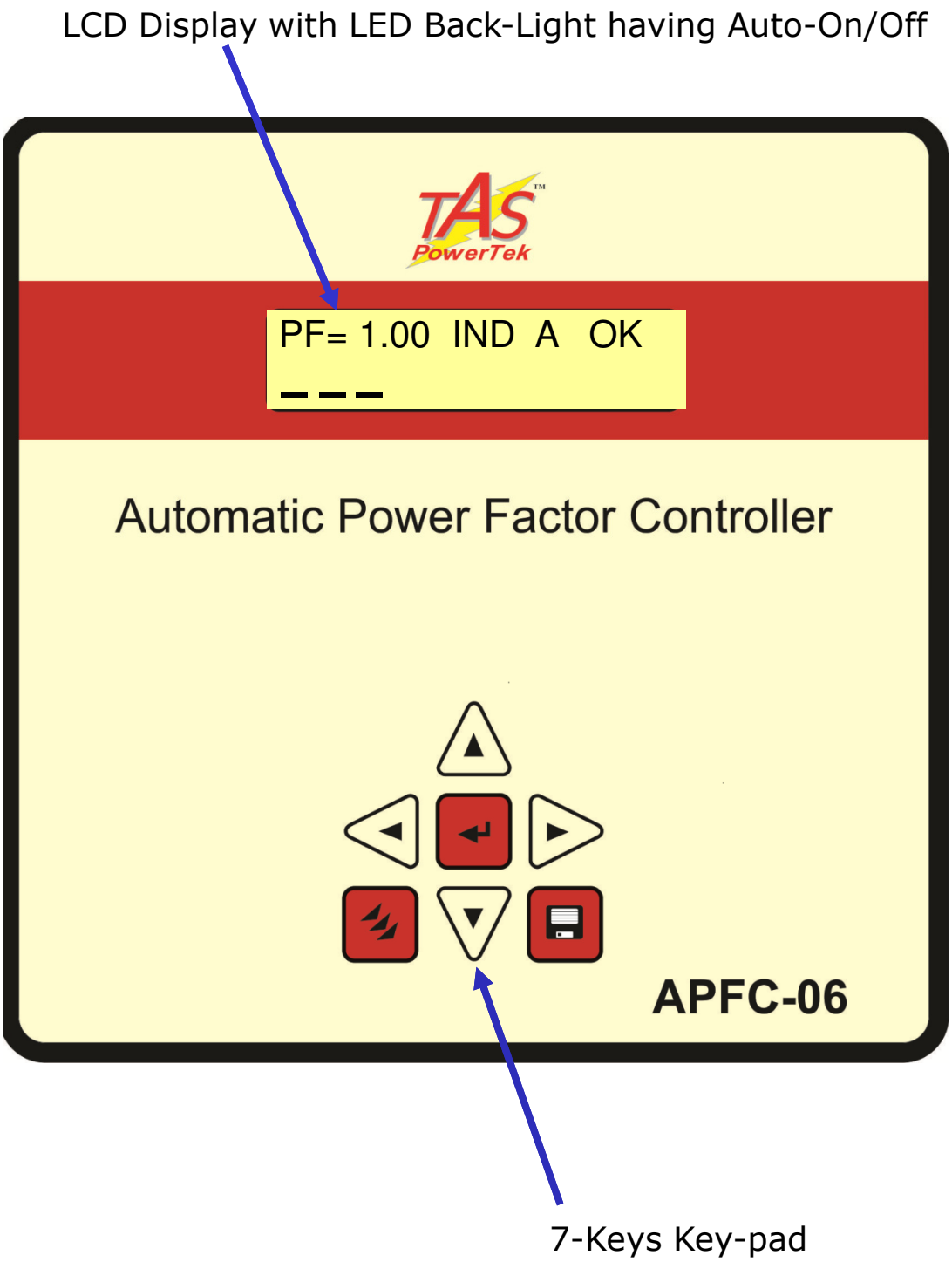


All Dimensions are in mm.

Recommended size for cutout on panel door: 138 mm x 138 mm.
Maximum weight: (with mounting clamps) = 0.8 kg approx.
Note: Low-Depth behind the APFC Panel Door, being a slim model!

Front fascia:

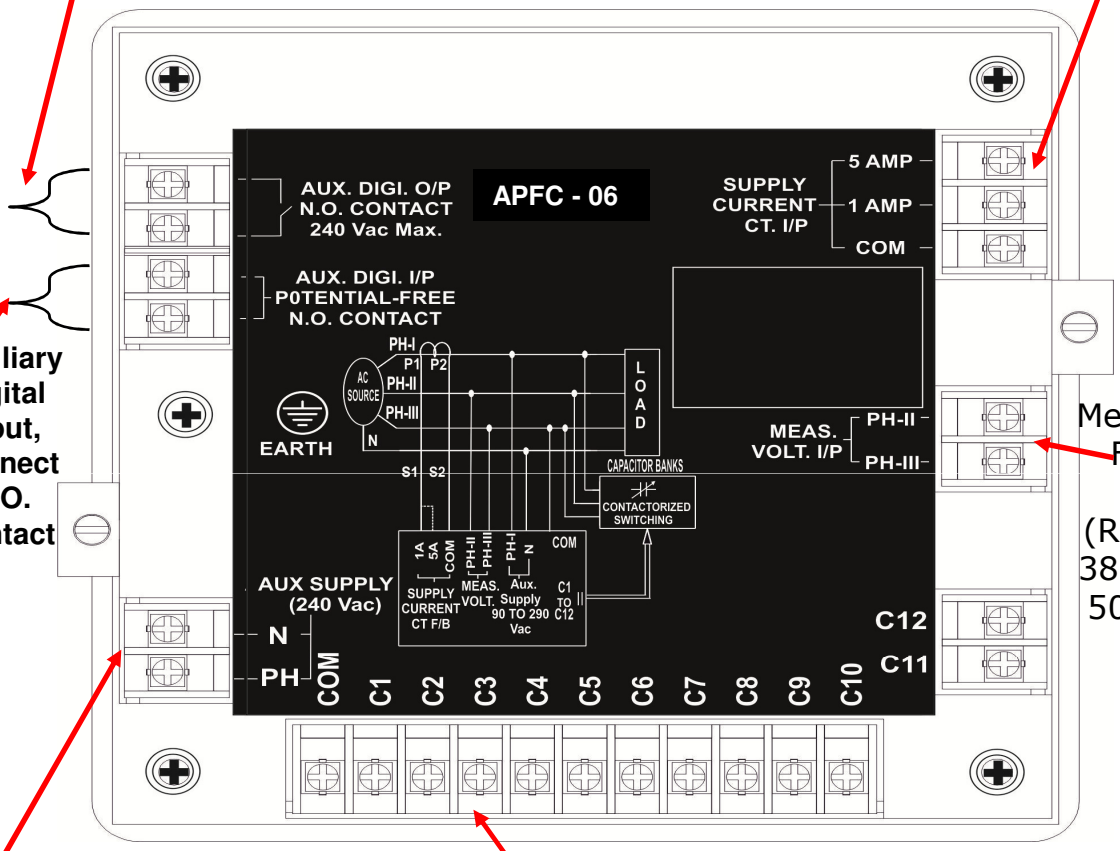
Keyboard, LCD Display



Rear side terminals

Auxiliary Digital Outputs – Potential-free, N.O. Relay Contact, Contact Rating: 5A (Resistive), 240Vac nominal

Supply current Feedback CT, User Selection of 1 Amp or 5 Amp Nominal & Common



Auxiliary Digital Input, Connect N.O. Contact

Measurement Feedback Voltage (Rated Nom. 380-485 Vac, 50 / 60 Hz).

Auxiliary Operating Voltage

(Rated Nom. 240 Vac, 50/60 Hz.)

Output terminals

Output commands to capacitor contactors.

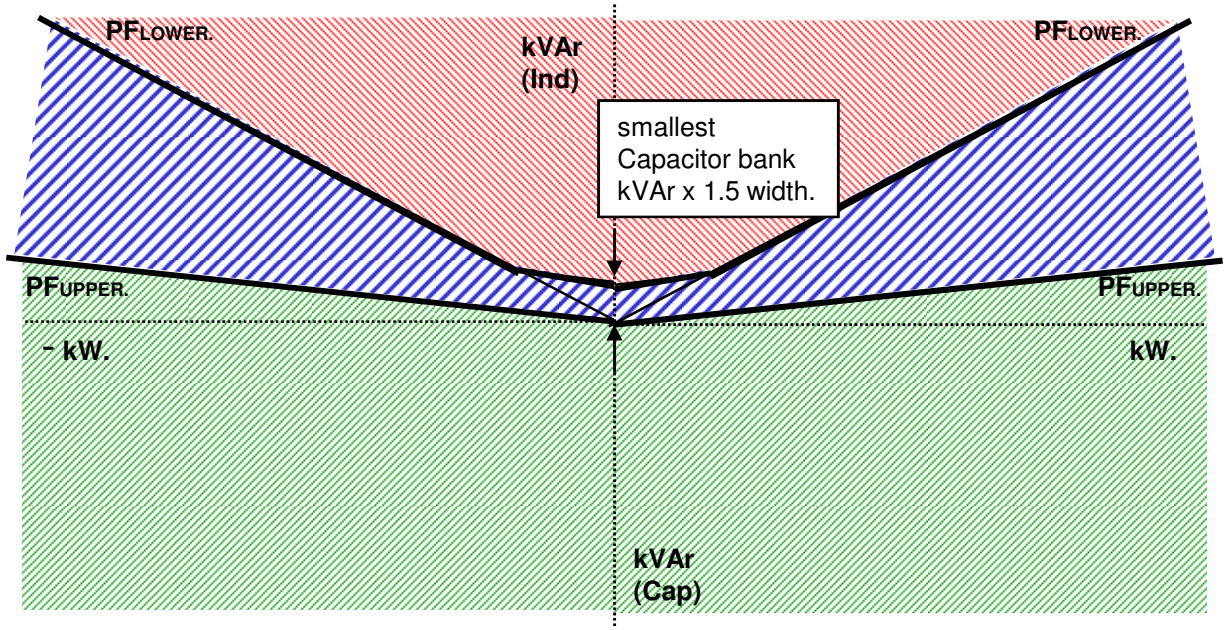
COM = common,

C1….C12 (C4 or C6 or C8) = potential free N.O. contact, 5 A (Resistive Load), 250 Vac.

Use Correct Size “U” Type, Insulated Fork Lugs for Field Wires Connections, suitable for 2.5 mm-Square wires. Suggested Make: Chetna Engg., F-57, Ambad MIDC, Nashik-422 010, India. Cat. No.: **CCFM-937, Serial No.: 835.** Or Direct Equivalent.

PF correction technique

Case-1: PF_{UPPER} & PF_{LOWER} both set as inductive:

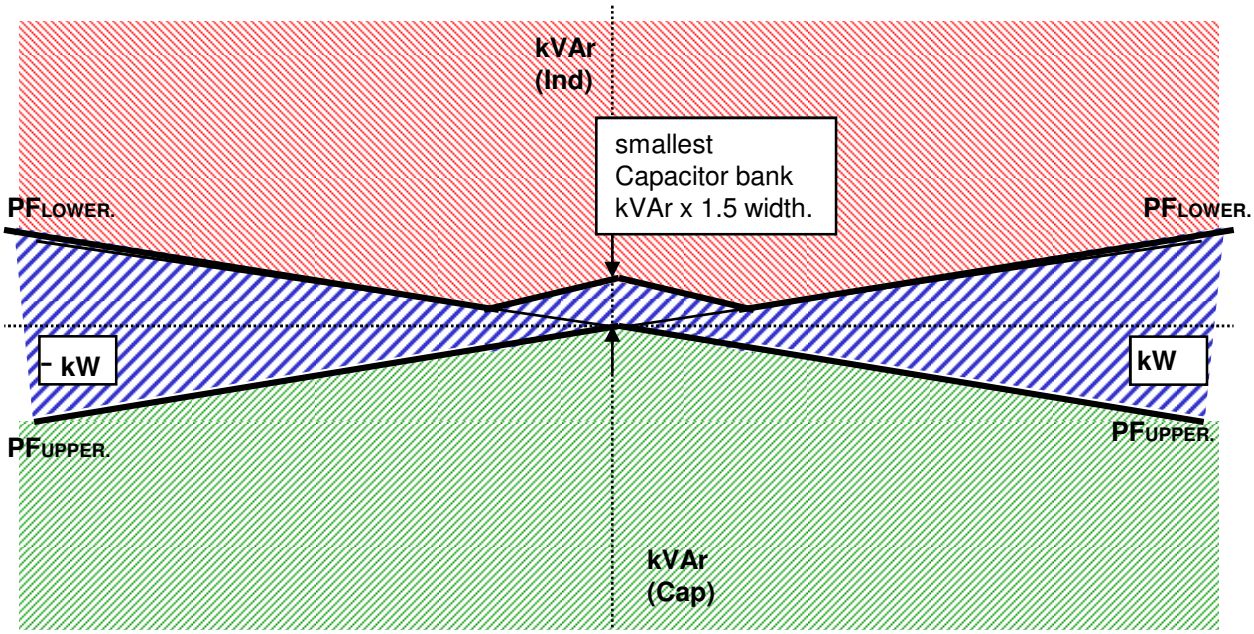


No change band.

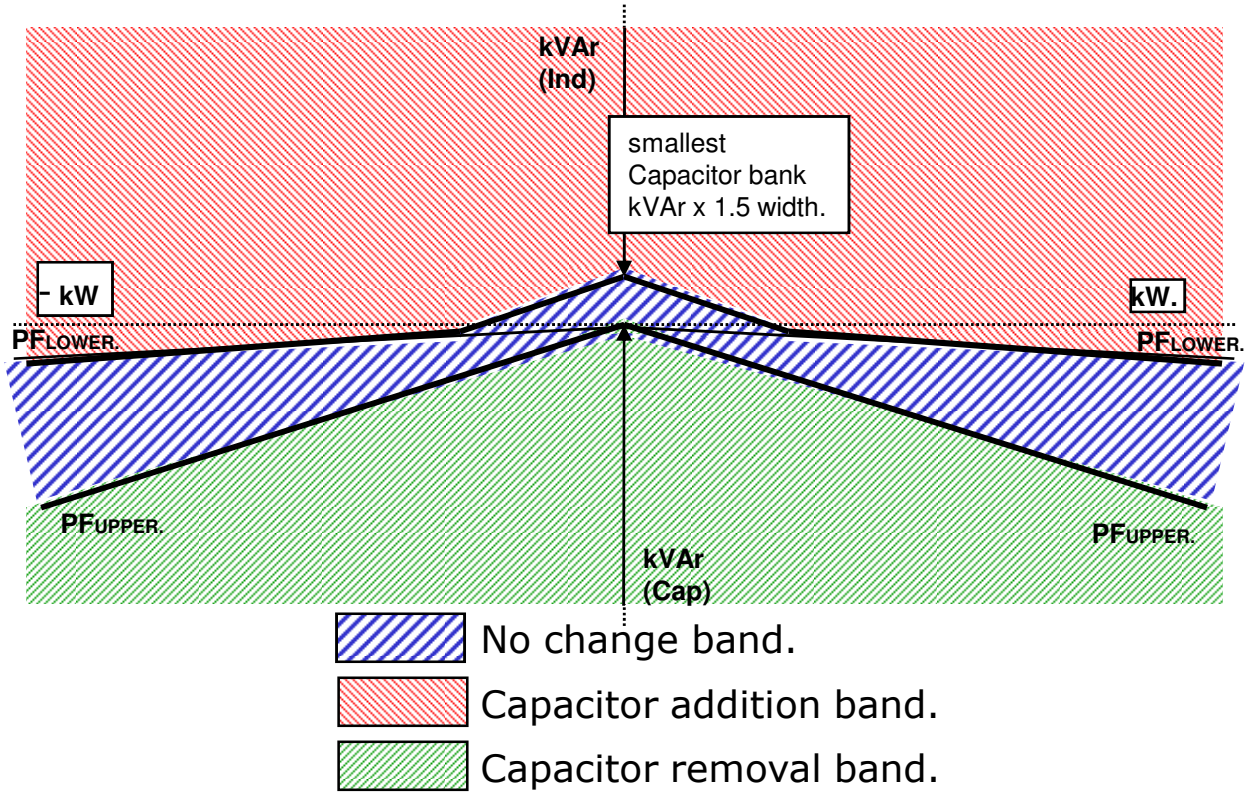
Capacitor addition band.

Capacitor removal band.

Case-2: PF_{UPPER} as Capacitive & PF_{LOWER} set as Inductive:



Case-3: PF_{UPPER} & $PF-_{LOWER}$ both set as Capacitive:

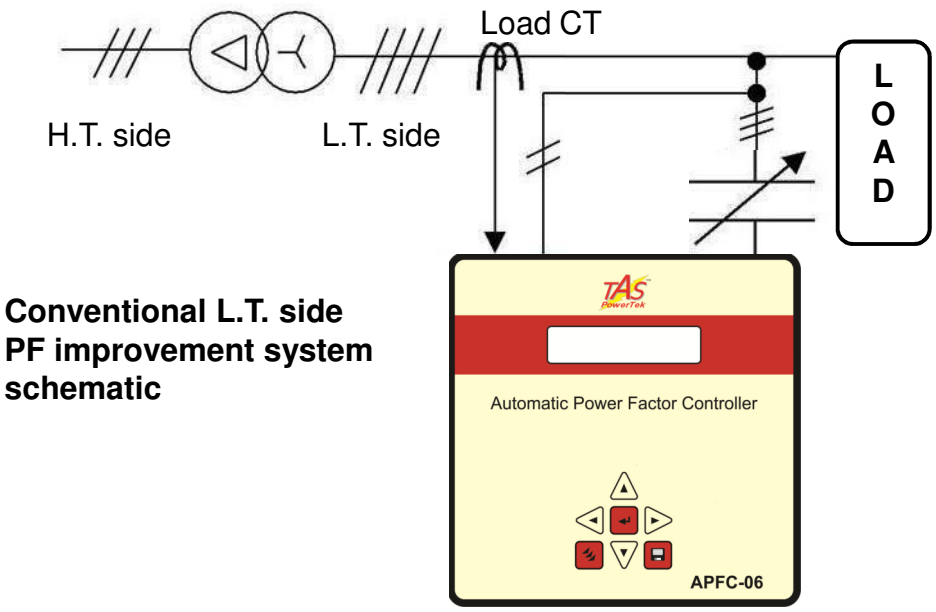


There are two PF set points to be set in APFC 06. The UPPER limit and the LOWER limit. APFC 06 ensures that PF-UPPER is never exceeded. Additionally, "No change band" to minimum kVAr band size equal to smallest bank kVAr x 1.5 ensures no hunting during the low kW loading.

APFC 06 is normally set for PF settings as per first two diagrams shown where PF LOWER is inductive. This philosophy helps to optimize 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 of the switched capacitors as well as the switching devices.

This methodology of kVAr compensation reduces the complex settings that are used by conventional PF relays. The settings like C/K ratio and kVAr offsets/shifts are eliminated which makes APFC 06 user friendly and thus easy to commission.

Typical wiring diagram for PF correction



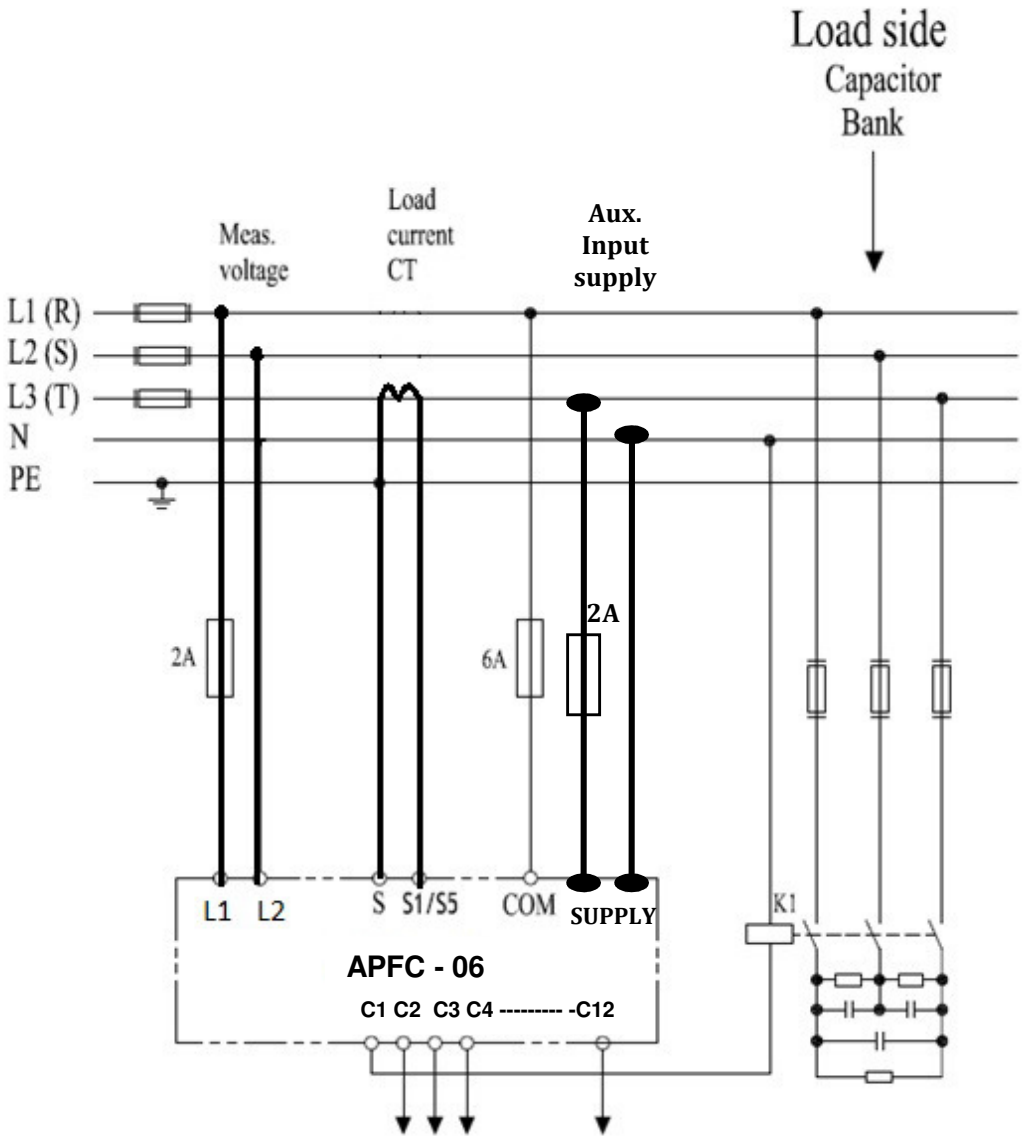
Conventional L.T. side PF improvement system schematic

As per this scheme, the Supply (Load) Current sensing CT is put between the source and the PF correction capacitor banks. This is as per diagram shown above. The voltage feedback is taken from the L.T. bus system itself.

This type of scheme is used when user is interested in maintaining the healthy Power factor on secondary side of the transformer.

Control wiring diagram :

Quadrature Mode Connection : Use any two phases for voltage monitoring and use the third phase for the current monitoring.



R-C Snubber across contactor coil:

It is **recommended** to install R-C Snubber across the 110-240 V AC Rated Contactor Coil, for APFC-06 relay contacts reliability and operational reliability.

The recommended values for the Series Connected Resistor & Capacitor (R & C) Components are: R =330 Ohm, +/- 5%, 1 Watt, CFR Type. C = 0.1 micro-farad / 1000 V DC.

Front fascia:

LCD screen, LED indications

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.

Last two characters represent one of the following status:

OK	Flashing - Controller status is OK
OV	Over Voltage (As Sensed)
UV	Under Voltage (As Sensed)
OF	Over Frequency (As Sensed)
UF	Under Frequency (As Sensed)

OL	Over Load (Current) (As Sensed)
UL	Under Load (kW) (As Calculated)
OT	Over Internal Temp. (As Sensed)
VA	Voltage Absent (As Sensed)
ZC	Supply Current zero

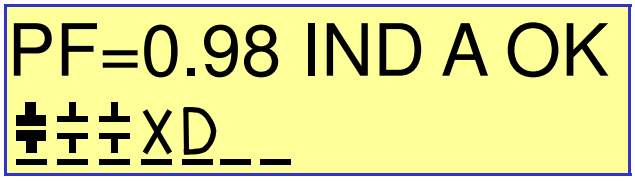
Second line indicates the status of each capacitor bank by symbols. Following table gives the description of symbols.

Symbol	Description
±	bank is in ON state.
–	bank is in OFF state.
±	bank is declared as FIXED & is in ON state.
X	bank is declared FAULTY & not available for use
	output stage is not used in the system. (blank)
D	bank is in DISCHARGE mode

Front fascia:

LCD Display Screen

Example of a typical LCD display screen is show below:



Meaning of this screen contents:
Total no. of banks connected is seven.
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 nos. 2 and 3 are in ON condition.
Bank no. 4 is declared as faulty.
Bank no. 5 is in discharging state.
Bank nos.6 and 7 are in off state. Ready to be switched on.
Bank (output) no. 8 is not used / not connected.

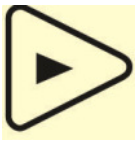
Front fascia:

Keyboard

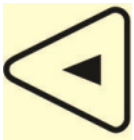
Keyboard with soft touch keys are provided on the front facia of the controller. The various keys are:

▲ key. Used to scroll up the menu screen; increment values when entering numbers. Also used for changing the status of banks.

▼ key. Used to scroll down the menu screen; decrement values when entering numbers. Also use to change status of bank.



► key. Used to shift the cursor to right; also used to increase the contrast of LCD in default display screen mode.



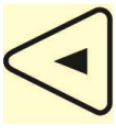
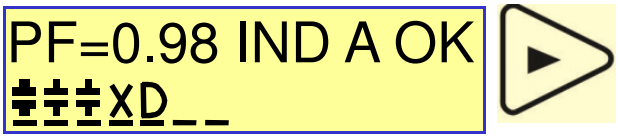
◄ key. Used to shift the cursor to left; also used to decrease the contrast of LCD in default display screen mode.

↵ key. Used for entering a submenu or for setting up values.

Triple▼ key. Used for selecting modes of operation and editing of parameters

■(memory) key. Used to save all changes made in Edit Parameters menu.

LCD Display Contrast Adjustment (View)

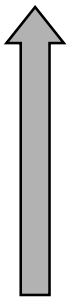
Lighter view  PF=0.98 IND A OK  **Darker view**

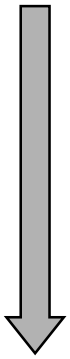
Multiple strokes of Left or Right key on default screen can adjust the display contrast.

For retaining the contrast, after adjustment, press the “Save” key 

Display of various parameters

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





PF=0.98 IND A OK 	This is factory set default display screen giving information on PF, mode, bank & controller status.
Display Overall Values	Overall values gives the average values of system parameters – V, I, PF & Line Frequency.
Display Power	Displays values of kW, kVAr, kVA
Display Harmonics	Displays values of THD for V, I, odd-harmonics up-to 15th order.
Display Step KVAr	Displays the measured kVAr value of each connected output step.
Display Aux-Function	Displays the internal (cabinet) temperature.
TAS POWERTEK Ver. 2.1.1	Displays the Firmware version in APFC Controller. This can change as and when found necessary. Therefore, always refer to the latest one and with corresponding User Manual.

Sub-menu for display of parameters

Overall Values
Mains Voltage 00415.6V(L-L)
Mains Current 00002.5 A
Power Factor 0.998 IND
Frequency 50.1 Hz

Power
KW 000250.0
KVAR 000005.7
KVA 000254.0

Harmonics
V-THD -F OO3.7%
V Harmonics O3rd: O2.7%
V Harmonics O5th: OO.8%
V Harmonics O7th: O1.2%
V Harmonics O9th: OO.3%
V Harmonics 11th: OO.5%
V Harmonics 13th: OO.3%
V Harmonics 15th: OO.2%

Harmonics
I-THD -F OOO.O%
I Harmonics O3rd: OO.O%
I Harmonics O5th: OO.O%
I Harmonics O7th: OO.O%
I Harmonics O9th: OO.O%
I Harmonics 11th: OO.O%
I Harmonics 13th: OO.O%
I Harmonics 15th: OO.O%

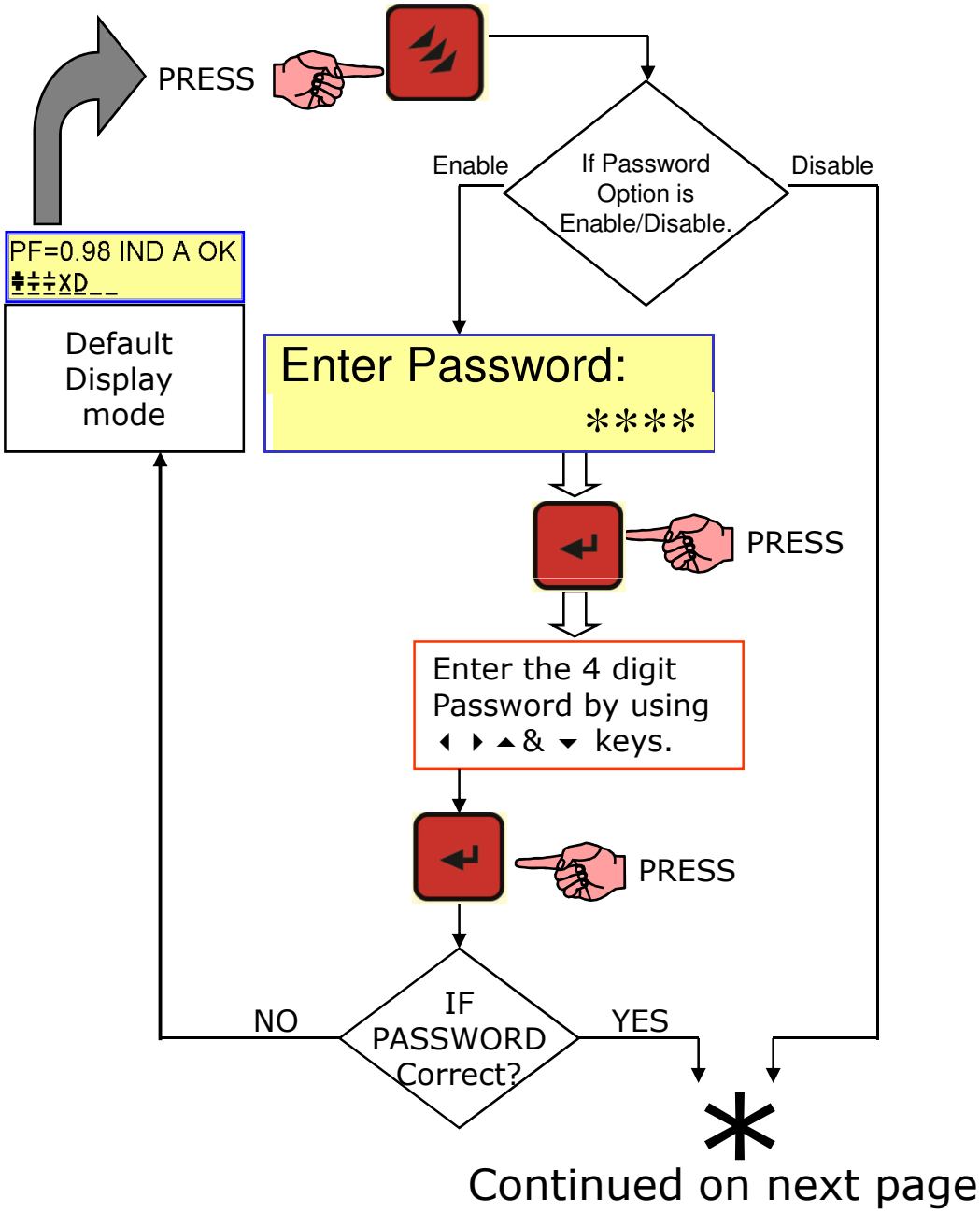
Step KVAR
Step [1] KVAr 0001.0
Step [2] KVAr 0002.0
Step [3] KVAr 0004.0
Step [4] KVAr 0005.0

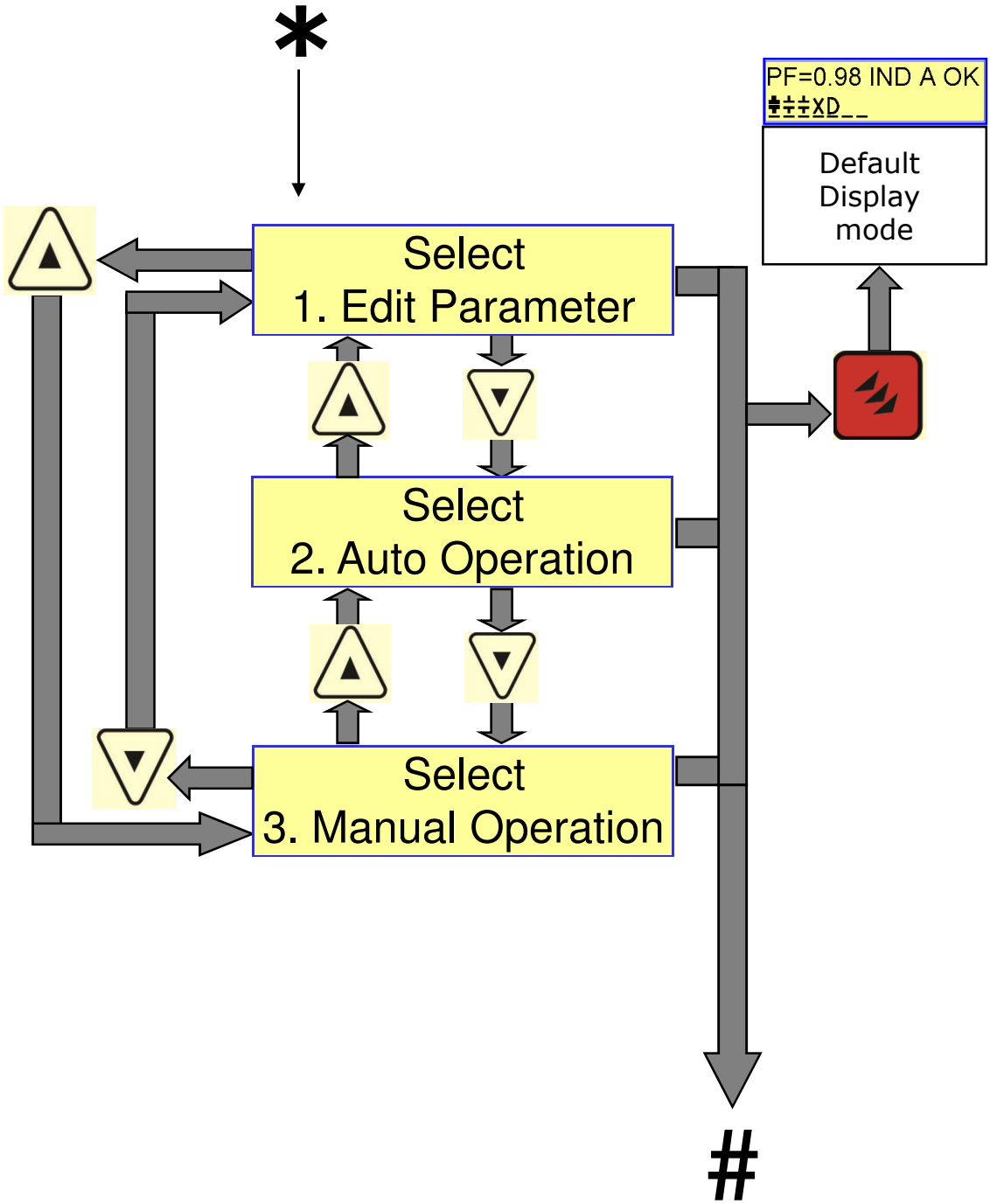
Step [12] KVAr 0090.0

Aux - Function
INT-Temperature 31 Deg C

Method for keyboard / display usage

Flowchart for entering into different modes:





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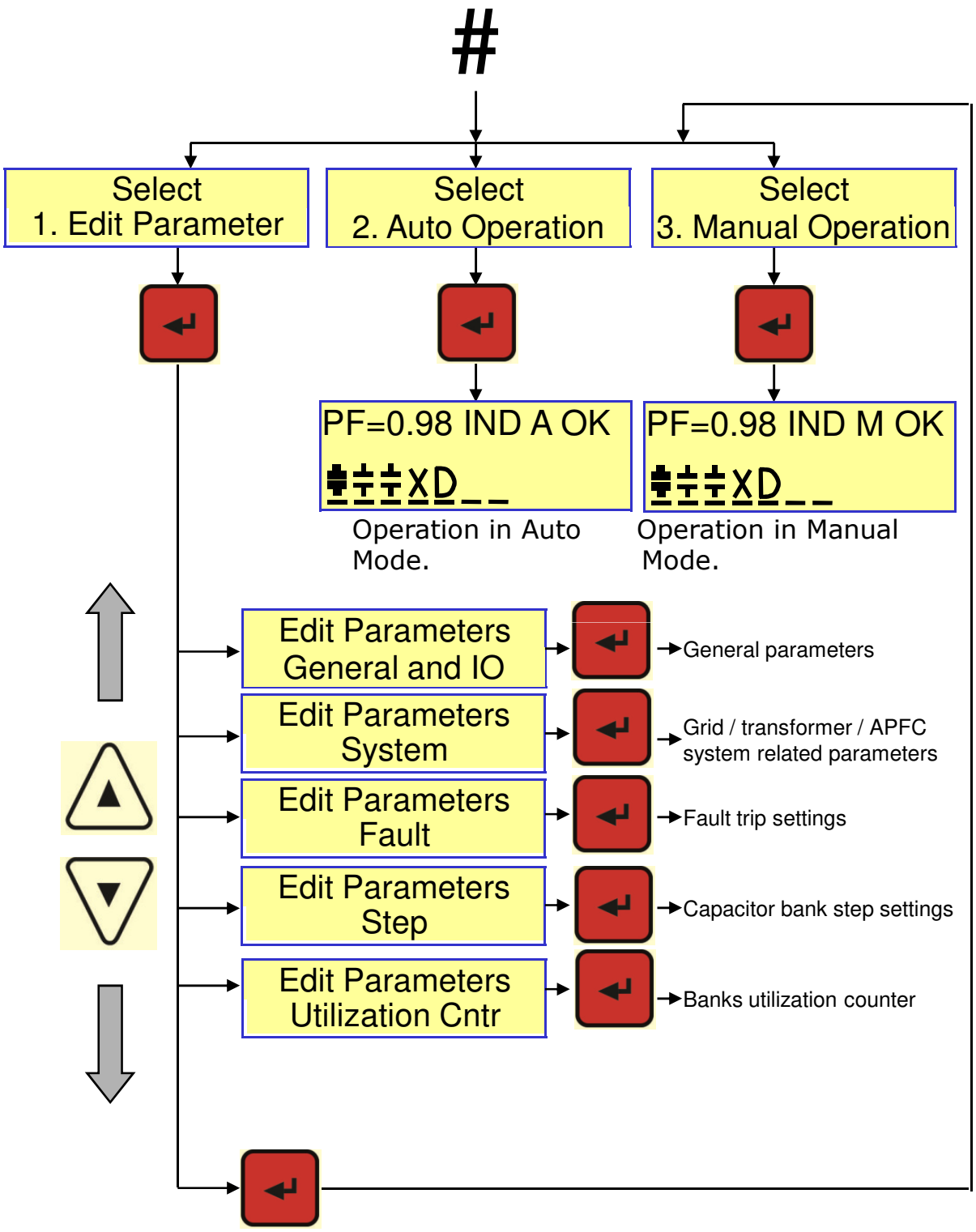

#
Select
1. Edit Parameter
Select
2. Auto Operation
Select
3. Manual Operation
PF=0.98 IND A OK
PF=0.98 IND M OK
Operation in Auto Mode.
Operation in Manual Mode.
Edit Parameters General and IO
General parameters
Edit Parameters System
Grid / transformer / APFC system related parameters
Edit Parameters Fault
Fault trip settings
Edit Parameters Step
Capacitor bank step settings
Edit Parameters Utilization Cntr
Banks utilization counter

Keyboard / Display operations

Mode Selection

There are two modes of operation (Manual and Auto) and one mode for APFC system entry (Edit Parameters).
Press the Triple▼(Mode/Program) key. Enter password (if enabled) by using ◄►▲▼ keys. Press ↵. Now using ▲▼ keys, select the Mode of operation:

- **AUTO OPERATION**
- **MANUAL OPERATION**
- **EDIT PARAMETERS**

Then press ENTER to enter the specific mode.

Auto Operation:
For functioning in automatic power factor correction mode.

Manual Operation:
Pressing ↵ button on this screen will put APFC-06 in Manual mode. This mode would continue to run till it is purposefully changed or power down occurs.

This mode is normally used to perform the operations 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 PF correction.

For Declaring banks faulty or Resetting faulty banks:
In manual mode default screen press ENTER key.
The cursor above bank 1 will start blinking. Use ◄► keys to select the specific bank. Then use ▼key to declare it faulty.
To reset the faulty bank, bring the blinking cursor to that bank and use ▼ key again to declare that bank as healthy.
After any of these operations press ↵ key so that cursor stops blinking. To save the status on permanent basis (so that even after Power down, the status is unchanged), press ■ (memory) key. After saving the settings, the unit will jump back to default mode. (Default as Auto or Manual is set in Edit Parameters).

…continued.

For Testing banks with manual ON / OFF commands:
Press ENTER key, 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 that capacitor banks.
To come out of Manual ON/OFF edit mode, press ↵ key so that cursor stops blinking.

Edit Parameters:
This mode is used to carry out system settings. In this mode various system settings can be carried out. To do the same, use the ▲▼ keys and select the type of parameters to be edited. The types of parameters that can be edited are:

General & IO : For general settings.
System : For APFC system settings.
Fault : Fault settings.
Step : Capacitor bank step settings.
Utilization counter: Bank operations utilization counters.

After selecting the type, press ↵ to enter the sub-menu 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 the ↵, ▲, ▼, ◄ and ► keys.
To come out of the sub-menu press Triple▼ key once.
To store the edited parameters permanently, press ■(memory) when you are either in the Edit Parameters or any sub-menu area.
To come out of Edit Parameters without saving the changes press Triple▼ key again.

Note: In the Edit Parameters mode, if no keys are pressed for more than 5 Minutes, the default display screen comes on and the changes done in edit parameters mode till that time are discarded.

General & IO

PASSWORD Enable : 1
CHANGE PASSWORD : 0001
LOAD DEFAULT No : 0
THD TO DISPLAY F-THD : 1
UNIT ID . :0000
AUX I/P FUNCTION None : 0
AUX 0/P FUNCTION None : 0

Password: Enable or disable password.
Value: 0=Disable, 1=Enable.
Change Password: Set new value of password (4 digit). Factory default password is "0000"
Load Default: Loads factory set default parameters. 0=No, 1=Yes.
THD to Display: Type of THD to be displayed for V, I.
UNIT ID : APFC System / Panel ID no. can be set .
AUX IP FUNCTION : Set an action through auxiliary input as per following – None : 0, O/P En Di (output enable disable):1, Reset Bank Flt :2.
AUX OP FUNCTION :Program the auxiliary output to become NC due to any of the following – None :0, TripFlt:1, Sys Flt :2 , Out Of Step :3., Fan On-Off:4.

Note: Total Harmonic Distortion (THD) can be distinguished as THDF (for "fundamental"), and THDR (for "Root Mean Square"). THDR cannot exceed 100%. At low distortion levels, the difference between the two calculation methods is negligible. For instance, a signal with THDF of 10% has a very similar THDR of 9.95%. However, at higher distortion levels the discrepancy becomes large. For instance, a signal with THDF 266% has a THDR of 94%.

System

Meas. Voltage : 415
CUR CT Primary Mains : 1000
PF Up Lim : Mains [Ind :1] 0.999
PF Up Lim: Mains Ind : 1 [0.999]
PF Low Lim: Mains [Ind :1] 0.970
PF Low Lim: Mains Ind :1 [0.970]
Freq 50 or 60 Hz 0 : 50 Hz

Measurement Voltage: Settable voltage from 110 V to 480 V, in step of 1 Vac. Factory Default = Nom. 415 V.

Cur CT Primary (Mains): Load Current Feedback C.T. primary current , Limits: Lower: 0001 Upper: 6500.

Power Factor Limits: APFC-06 has one set point for Mains. Upper & Lower limits can be defined as Upper PF and Lower PF. PF limits can be set as inductive or capacitive.

Freq 50 or 60 Hz: User can select supply frequency 50 Hz or 60 Hz according to measurement (feedback) supply. The Over / Under Frequency limits are automatic.

CT Polarity Chk Disable : 0

CT Polarity: This feature detects CT polarity and accordingly Active Power Sign is changed. If it is enabled, APFC controller work in two-quadrant mode, by way of internally considering Active Power (kW) as always "Positive". Disabled Mode is for four-quadrant mode where sign of kW can be +Ve or -Ve.

Fault

Over voltage flt Off Step : 2
Over voltage Limit (%) :115
Over voltage Resume (%) :110
Under voltage flt Off Step : 2
Under voltage Limit (%) :074
Under voltage Resume (%) :078
Over load flt Disable : 0
Over load Limit (%) :130
Over load Resume (%) :125
Under load KW Flt Off Step : 2
Under load Limit (%) :020
Under load Resume (%) :025

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

0=Disable

1=Indicate (Display a Fault Message & or 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)

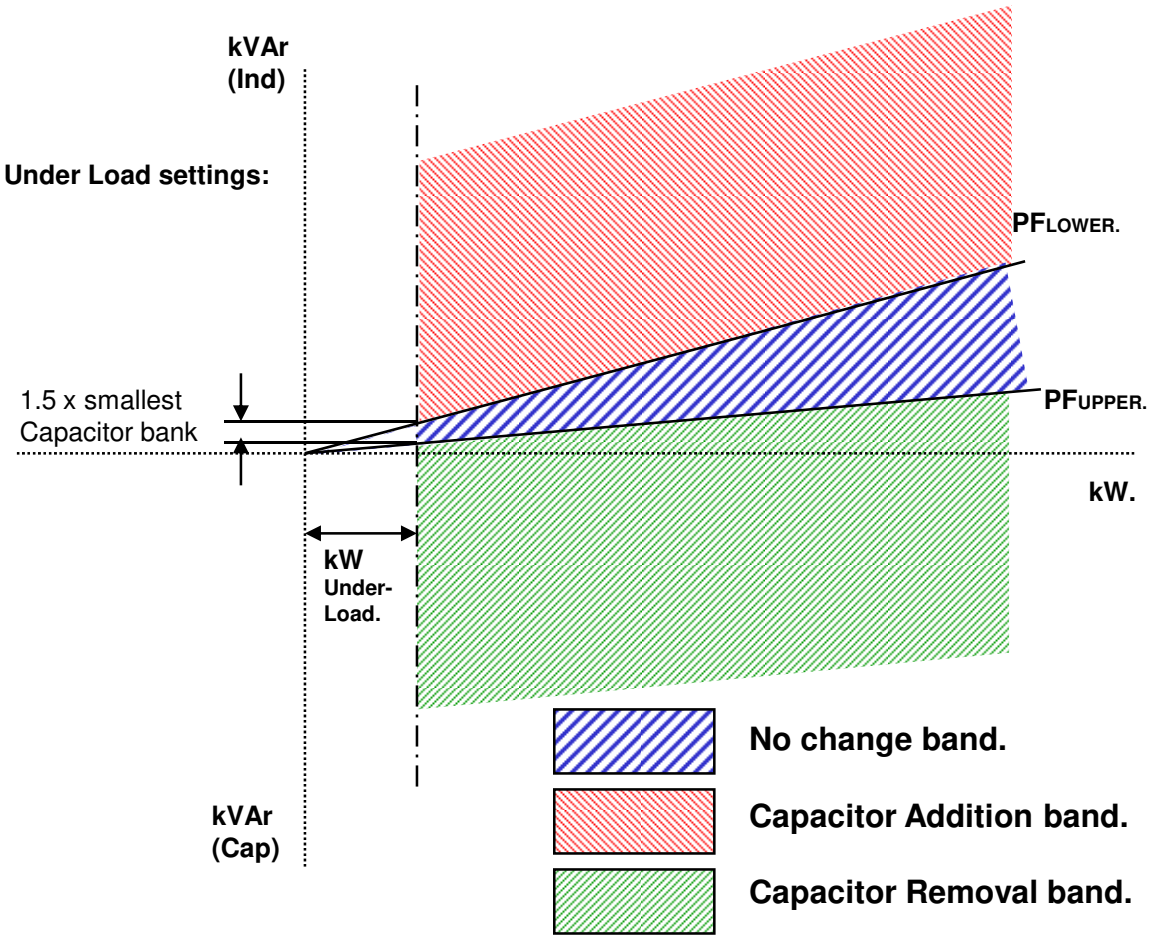
For all the faults, normally two limits are defined. One is Detection Limit and another Resume Limit. Detection Limit if exceeded by the parameter would mean the action as defined by parameter in type of fault (as given here-above). Resume Limit defines the parameter value below which the fault is deactivated.

• Over Voltage: As name suggests, its for Over-Voltage conditions.

• Under Voltage: For Under-Voltage conditions.

• Over Load: If APFC06 detects the supply system is overloaded (Amps%), then it is sometimes recommended to keep the capacitors in the circuit so as to maintain reduced Load current due to switched ON capacitor banks . Under such circumstances this parameter is set to Indicative.

• Under Load fault: The values here are set as % of Maximum rated kW. This is useful in case of banks are put in circuit to take care of no load compensation. Value for this Under-Load kW can be calculated as shown as per the following.



For PF$_{UPPER}$ Inductive and PF$_{LOWER}$ Inductive :

$$\textbf{Under-Load kW value setting} = \frac{\textbf{1.5 x Smallest Capacitor Bank kVAr.}}{[\tan\{\cos^{-1}(PF_{LOWER})\} - \tan\{\cos^{-1}(PF_{UPPER})\}]}$$

For PF$_{UPPER}$ Capacitive and PF$_{LOWER}$ Inductive :

$$\textbf{Under-Load kW value setting} = \frac{\textbf{1.5 x Smallest Capacitor Bank kVAr.}}{[\tan\{\cos^{-1}(PF_{UPPER})\} + \tan\{\cos^{-1}(PF_{LOWER})\}]}$$

For PF$_{UPPER}$ Capacitive and PF$_{LOWER}$ Capacitive:

$$\textbf{Under-Load kW value setting} = \frac{\textbf{1.5 x Smallest Capacitor Bank kVAr.}}{[\tan\{\cos^{-1}(PF_{UPPER})\} - \tan\{\cos^{-1}(PF_{LOWER})\}]}$$

Int Temperature Flt
Disable :0
Temperature
Resume : 55 Deg C
Temperature
Limit : 65 Deg C

▪Internal Temperature Fault: Unit monitors the temperature inside the APFC 06 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 APFC 06 hardware itself. Upper limit is for tripping and lower limit is for normal operation (resume).

Step Health Chk
Disable : 0
Bank KVAR Fault
Tolerance (%) :25
Bank KW Fault
Tolerance (%) :10

• Step Health Check: APFC 06 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 measured value exceeds the set tolerance limit defined here , that specific bank is declared faulty.

• Bank kVAr Fault Tolerance : For step health check , the Capacitor bank step kVAr tolerance limit is defined here.

• Bank kW fault tolerance : Online Capacitor kVAr value is calculated with the help of Load kW , Load kVAr. In case there is constant rapid variation in load , hence under such condition it is recommended to keep step health check disabled. The bank kW fault tolerance limit is the allowed variation in Load kW to detect the capacitor step kVAr values .

FAN O/P ACTION
Disable :0
FAN ON TEMPER.
Limit : 50
FAN OFF TEMPER.
Limit : 40

• FAN O/P ACTION: User can make APFC Panel Cooling Fan On or Off by enabling fan o/p action enable. To use this auxiliary digital o/p, function should be selected for fan o/p.

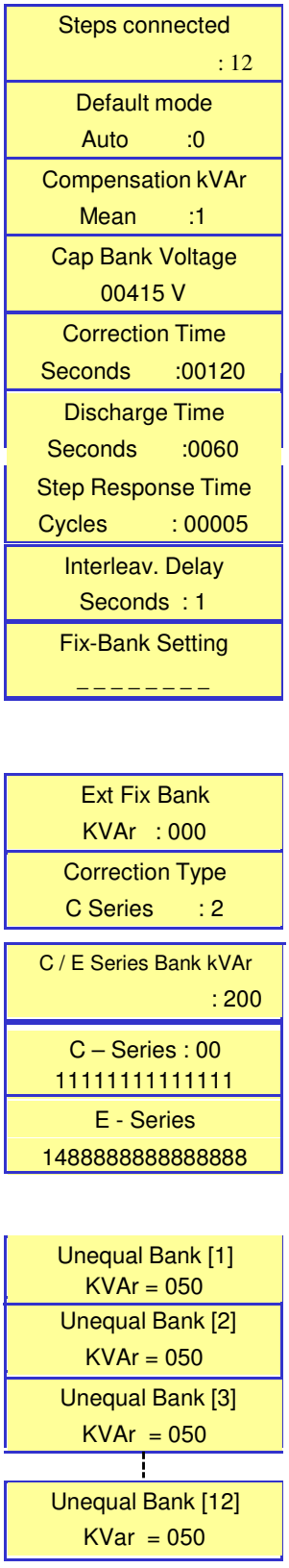
• Fan on & Off action temperature limit is settable. Please note this is based on internal microcontroller temperature. So, it may be possible to have some deviation between actual APFC Panel internal Temperature & APFC controller's Micro-Controller Temperature.

PF AUX. O/P ACTION
Disable :0
PF ALARM SET
Limit : 0.90
PF ALARM RESUME.
Limit : 0.95

•PF O/P ACTION: In case the PF detected on supply system to be way below the acceptable limit, if the alarm is to be sounded, this action can be enabled.

•PF ALARM SET and RESUME Limits can be set in the given subsequent screens.

Capacitor Bank Steps:



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 .

•Interleaving Delay: Interleaving delay is settable.

• 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).

•C/E Series Bank kVAr: The kVAr defined here is the capacitor bank kVAr of the smallest bank i.e. this capacitor step kVAr value is defined by digit '1' in C series, E series or Binary. Screen appears only on C or E.

• Ext Fix Bank kVAr: The kVAr value defined here is any fix capacitor bank kVAr which is connected externally to the APFC System & has not been included in internal defined Bank Step configuration of the APFC system.

• Correction Type: APFC 06 can have bank configurations that are defined by four various methods. 1=Unequal, 2=C Series, 3=E Series.

Un-equal is used with banks not having definite ratio.

C series is predefined Control Series. The standard ratios are preloaded in APFC 06 that can be selected here.

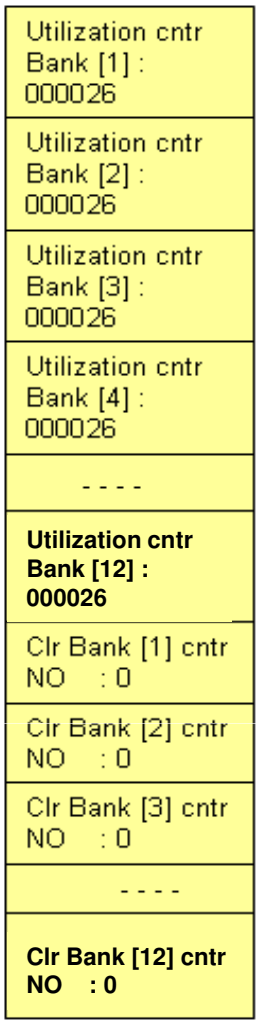
E series is User defined Control Series. The bank ratios that are not defined in C series can be defined here. Digits can be 1,2,-- 9,

• 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.
01: 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2.
02: 1 2 3 3 3 3 3 3 3 3 3 3 3 3 3.
03: 1 2 3 4 4 4 4 4 4 4 4 4 4 4 4.
04: 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.
06: 1 2 4 8 8 8 8 8 8 8 8 8 8 8 8.
07: 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2.
08: 1 1 1 1 1 6 6 6 6 6 6 6 6 6 6.
09: 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2.

• 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.

• Unequal Bank kVAr [1….12]: If unequal kVAr bank configuration is used, these parameters are to be defined for every bank kVAr (at defined Capacitor Bank Voltage). APFC 06 has a in built intelligent algorithm to select the best possible combination to suit the exact kVAr requirement for compensation.

Utilization Cntr (Counters):



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 into a weaker source point for Capacitor charging during Step on and this can generate undesirable Noise which can hamper the performance of equipment 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.

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

After panel is powered up

1. Remove the fuses/switch off MCBs/MCCBs which are in series with every capacitor bank. Connect supply to the **APFC-06** . Keep the load feedback current feedback in shorted condition.

2. Turn ON the supply to the panel and set the various parameters as per the panel configuration. It is 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.

3. Once the parameterization is complete, put the APFC 06 in Manual mode to check every bank command is transmitted to the control 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 APFC 06 back in Manual mode and turn ON/OFF the individual steps. Use Tong tester (ac current measurement) to check that current in all three phase of the corresponding bank are OK. In case any bank is not giving the desired current, check for capacitor bank healthiness or power circuits.

6. Keep all the banks in off mode. Remove the short of Supply (Load) feedback CT. In case kW value is seen as –Ve, CT is with wrong polarity as applicable for four-quadrant operation mode. However, in two-quadrant-mode, kW is always treated as +Ve.

7. 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 APFC 06 in Automatic mode. Switch Off the supply to panel and put it ON. APFC 06 will turn ON/OFF the capacitor banks as per Load KVAR requirement to maintain the set target PF.

Observe panel performance for about 2 hours after commissioning.

Troubleshooting procedure

Nature of Fault	Probable Reason	Action to be taken
Unit does not turn ON.	•Input auxiliary supply not coming. •Input side fuse (external)blown	•Check the input supply & restore. •Check input side fuses (external) OK.
Unit does not turn ON any capacitors even if PF is below Lower PF limit.	The load kW is too low. • Control connections from bank outputs to contactor coils are not proper.	• This is OK condition . •Check control supply and connections from Bank outputs to contactors coils.
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. • Load kW & THD factor is continuously fluctuating.	•Set the tolerance limits for individual steps monitoring appropriately. • With continuously fluctuating Load kW & THD can cause some errors in individual step kVAr measurement. Under this condition, best is to keep this feature disabled.
APFC-06 resets occasionally on turning OFF of any contactor.	• The contactor supply phase may be the same as used for **APFC 06** auxiliary supply. • R-C Snubbers are not put in parallel with contactor coils.	• Use different phases for control supply of contactors and for **APFC 06** supply. • Usage of R-C Snubbers are strongly recommended.
APFC-06 Functioning	• Verify EACH User Settable Parameter is right as per Panel Design. Check with commissioning records.	• Set again the Parameter(s) which did not match the design & save all settings again.

EDIT PARAMETERS : MINIMUM , MAXIMUM AND DEFAULT VALUES

PARAMETER	MIN	MAX	INCREMENT / DECREMENT STEP SIZE	FACTORY DEFAULT
GENERAL and IO				
1] Password (Enable: 1/ Disable: 0)	0	1	1	1
2] Change Password	0000	9999	1	0001
3] Load Default (Yes: 1/ No: 0)	0	1	1	0
4] THD to display (F-THD: 1/R-THD: 0)	0	1	1	1
5] Unit ID (0000)	0000	9999	1	0000
6]Aux I/P FUNCTION (None ; 0 , O/P En Di : 1, Reset Bank Flt : 2)	None	Reset Bank flt	-	None
7]Aux O/P FUNCTION (None : 0 , Trip Flt : 1 , Sys Flt : 2 , Out Of Bank : 3)	None	Out of Banks	-	None
SYSTEM				
1] Meas. Voltage	110	480	1	415
2] EXT-PT ratio	0000.1	5999.0	1	0001.0:1
3] Current CT primary (Mains)	1	6500	1	1000
4] PF Upper limit: Mains ([Ind: 1/ Cap: 0] , 0.999)	0	1	1	[Ind: 1]
5] PF Upper Limit: Mains (Ind: 1/ Cap: 0 [0.999])	0.100	0.999	0.001	[0.980]
6] PF Low limit: Mains ([Ind: 1/ Cap: 0] , 0.970)	0	1	1	[Ind: 1]
7] PF Low Limit: Mains (Ind: 1/ Cap: 0 [0.970])	0.100	0.999	0.001	[0.970]
8] Measurement Supply (Voltage Feedback) Frequency: 50 or 60 Hz 0: 50 Hz, 1: 60 Hz	0	1	1	50 Hz
9] CT Polarity Check (0: Disabled & 1: Enabled)	0	1	1	Disabled

EDIT PARAMETERS : MINIMUM , MAXIMUM AND DEFAULT VALUES

PARAMETER	MIN	MAX	INCREMENT / DECREMENT STEP SIZE	FACTORY DEFAULT
FAULTS				
1] Over Voltage Fault Disable: 0 Indicate: 1 Off Step: 2 Off Fixed : 3 Fast Off : 4	0	4	1	0
2] Over Voltage Limit (%)	Set Resume Limit	149	1	115
3] Over Voltage Resume (%)	100	Set Limit	1	110
4] Under Voltage Fault Disable: 0 Indicate: 1 Off Step: 2 Off Fixed : 3 Fast Off : 4	0	4	1	0
5] Under Voltage Limit (%)	0	Set Resume Limit	1	074
6] Under Voltage Resume (%)	Set Limit	99	1	078
7] Over Load Fault (**Amps%**) Disable: 0 Indicate: 1 Off Step: 2 Off Fixed : 3 Fast Off : 4	0	4	1	0
8] Over Load Limit (Amps%)	Set Resume Limit	149	1	130
9] Over Load Resume (Amps%)	100	Set Limit	1	125
10] Under Load **kW** Fault Disable: 0 Indicate: 1 Off Step: 2 Off Fixed : 3 Fast Off : 4	0	4	1	0
11] Under Load Limit (kW%)	0	Set Resume Limit	1	020
12] Under Load Resume (kW%)	Set Limit	99	1	025

EDIT PARAMETERS : MINIMUM , MAXIMUM AND DEFAULT VALUES

PARAMETER	MIN	MAX	INCREMENT / DECREMENT STEP SIZE	FACTORY DEFAULT
FAULTS				
13] Temperature Fault (Internal to APFC Unit) Disable: 0 Indicate: 1 Off Step: 2 Off Fixed : 3 Fast Off : 4	0	4	1	0
14] Temperature Resume (Deg. C)	0	Set Upper Limit	1	55
15] Temperature Limit (Trip) (Deg. C.)	Set Lower Limit	99	1	65
16] Step Health Check (Enable: 1/ Disable: 0)	0	1	1	0
17] Bank kVAr Fault Tolerance	0	60	1	10
18] Bank kW Fault Tolerance	0	60	1	10
19] FAN O/P ACTION (Enable: 1/ Disable: 0)	0	1	1	0
20] FAN ON TEMPER. Action, Degree C.	0	100	1	> = +40
21] FAN OFF TEMPER. Action, Degree C.	0	100	1	= < +30
22] PF Aux. O/P ACT.	0	1	1	0
23] PF Alarm Set	0.85	0.97	0.01	0.90
24] PF Alarm Resume	0.90	0.99	0.01	0.95

EDIT PARAMETERS : MINIMUM , MAXIMUM AND DEFAULT VALUES

PARAMETER	MIN	MAX	STEP SIZE	FACTORY DEFAULT
STEPS				
1] Steps Connected, as per ordered Model	01	04 / 06 / 08 / 12	1	As per Ordered.
2] Default Mode (Auto: 0/ Manual:1)	0	1	1	0
3] Compensation kVAr (Instant: 0/ Mean: 1)	0	1	1	1
4] Cap Bank Voltage (L-L)	100	65530	1	415 V
5] Correction Time (Seconds)	1	600	1	120
6] Discharge Time (Seconds)	1	600	1	60
7] Step Response Cycles		45		45
8] Interleaving Delay (Seconds)	1	9	1	1
9] Fix-bank Setting				
10] Bin/C/E Series Bank kVAr	1	250	1	020
11] Ext Fix Bank kVAr	000	999	1	000
12] Correction Type Binary: 0 Un-Equal: 1 C-series: 2 E-Series: 3	0	3	1	2
13] C-Series (Selectable from 0 to 9)	0	9	1	00
14] E-Series				11111222
15] Unequal Bank [1] kVAr	0001	250	1	001
16] Unequal Bank [2] kVAr	0001	250	1	002
17] Unequal Bank [3] kVAr	0001	250	1	004
18] Unequal Bank [4] kVAr	0001	250	1	005
19] Unequal Bank [5] kVAr	0001	250	1	010
‘ ---------				
‘ ---------				
26] Unequal Bank [12] kVAr	0001	250	1	050

EDIT PARAMETERS : MINIMUM , MAXIMUM AND DEFAULT VALUES

PARAMETER	MIN	MAX	STEP SIZE	FACTORY DEFAULT
UTILIZATION COUNTERS				
1] Utilization counter Bank [1] (not editable)	000000	999999	1	
2] Utilization counter Bank [2] (not editable)	000000	999999	1	
3] Utilization counter Bank [3] (not editable)	000000	999999	1	
4] Utilization counter Bank [4] (not editable)	000000	999999	1	
5] Utilization counter Bank [5] (not editable)	000000	999999	1	
‘ _____				
‘ _____				
12] Utilization counter Bank [12] (not editable)	000000	999999	1	
13] Clear Bank [1] Counter (Yes: 1/ No: 0)	0	1	1	0
14] Clear Bank [2] Counter (Yes: 1/ No: 0)	0	1	1	0
15] Clear Bank [3] Counter (Yes: 1/ No: 0)	0	1	1	0
16] Clear Bank [4] Counter (Yes: 1/ No: 0)	0	1	1	0
‘ _____				
‘ _____				
‘ _____				
24] Clear Bank [12] Counter (Yes: 1/ No: 0)	0	1	1	0

Blank Forms for Field User Entries
FORM - I

PARAMETER	As On Date	As On Date	As On Date	As On Date
GENERAL and IO				
1] Password (Enable: 1/ Disable: 0)				
2] Change Password				
3] Load Default (Yes: 1/ No: 0)				
4] THD to display (F-THD: 1/R-THD: 0)				
5] Unit ID (0000)				
6]Aux I/P FUNCTION (None ; 0 , O/P En Di : 1, Reset Bank Flt : 2				
7]Aux O/P FUNCTION (None : 0 , Trip Flt : 1 , Sys Flt : 2 , Out Of Bank : 3)				
SYSTEM				
1] Meas. Voltage				
2] EXT-PT ratio (Cancelled in this version)				
3] Current CT primary (Mains)				
4] PF Upper limit: Mains ([Ind: 1/ Cap: 0] , 0.999)				
5] PF Upper Limit: Mains (Ind: 1/ Cap: 0 [0.999])				
6] PF Low limit: Mains ([Ind: 1/ Cap: 0] , 0.970)				
7] PF Low Limit: Mains (Ind: 1/ Cap: 0 [0.970])				
8] Freq 50 or 60 Hz 0: 50 Hz, 1: 60 Hz				
9] CT Polarity Chk (0: Disable & 1: Enable)				

Blank Forms for Field User Entries

FORM - I

PARAMETER	As On Date	As On Date	As On Date	As On Date
FAULTS				
1] Over Voltage Fault Disable: 0 Indicate: 1 Off Step: 2 Off Fixed : 3 Fast Off : 4				
2] Over Voltage Limit (%)				
3] Over Voltage Resume (%)				
4] Under Voltage Fault Disable: 0 Indicate: 1 Off Step: 2 Off Fixed : 3 Fast Off : 4				
5] Under Voltage Limit (%)				
6] Under Voltage Resume (%)				
7] Over Load Fault (**Amps**) Disable: 0 Indicate: 1 Off Step: 2 Off Fixed : 3 Fast Off : 4				
8] Over Load Limit (%)				
9] Over Load Resume (%)				
10] Under Load **kW** Fault Disable: 0 Indicate: 1 Off Step: 2 Off Fixed : 3 Fast Off : 4				
11] Under Load Limit (%)				
12] Under Load Resume (%)				

Blank Forms for Field User Entries

FORM - I

PARAMETER	As On Date	As On Date	As On Date	As On Date
FAULTS				
13] Temperature Fault Disable: 0 Indicate: 1 Off Step: 2 Off Fixed : 3 Fast Off : 4				
14] Temperature Resume				
15] Temperature Limit				
16] Step Health Check (Enable: 1/ Disable: 0)				
17] Bank kVAr Fault Tolerance				
18] Bank kW Fault Tolerance				
19] FAN O/P ACTION (Enable: 1/ Disable: 0)				
20] FAN ON TEMPER. Action, Degree C.				
21] FAN OFF TEMPER. Action, Degree C.				
22] PF Aux. O/P ACT.				
23] PF Alarm Set				
24] PF Alarm Resume				

Blank Forms for Field User Entries FORM - I

PARAMETER	As On Date	As On Date	As On Date	As On Date
STEPS				
1] Steps Connected				
2] Default Mode (Auto: 0/ Manual:1)				
3] Compensation kVAr (Instant: 0/ Mean: 1)				
4] Cap Bank Voltage (L-L)				
5] Correction Time (Seconds)				
6] Discharge Time (Seconds)				
7] Step Response Cycles				
8] Interleaving Delay (Seconds)				
9] Fix-bank Setting				
10] Bin/C/E Series Bank kVAr				
11] Ext Fix Bank kVAr				
12] Correction Type Binary: 0 Un-Equal: 1 C-series: 2 E-Series: 3				
13] C-Series (Selectable from 00 to19)				
14] E-Series				
15] Unequal Bank [1] kVAr				
16] Unequal Bank [2] kVAr				
17] Unequal Bank [3] kVAr				
18] Unequal Bank [4] kVAr				
19] Unequal Bank [5] kVAr				
20] Unequal Bank [6] kVAr				
21] Unequal Bank [7] kVAr				
22] Unequal Bank [8] kVAr				
23] Unequal Bank [9] kVAr				
24] Unequal Bank [10] kVAr				
25] Unequal Bank [11] kVAr				
26] Unequal Bank [12] kVAr				

Blank Forms for Field User Entries

FORM - I

PARAMETER	As On Date	As On Date	As On Date	As On Date
UTILIZATION COUNTERS				
1] Utilization counter Bank [1] (not editable)				
2] Utilization counter Bank [2] (not editable)				
3] Utilization counter Bank [3] (not editable)				
4] Utilization counter Bank [4] (not editable)				
5] Utilization counter Bank [5] (not editable)				
6] Utilization counter Bank [6] (not editable)				
7] Utilization counter Bank [7] (not editable)				
8] Utilization counter Bank [8] (not editable)				
9] Utilization counter Bank [9] (not editable)				
10] Utilization counter Bank [8] (not editable)				
11] Utilization counter Bank [8] (not editable)				
12] Utilization counter Bank [8] (not editable)				
13] Clear Bank [1] Counter (Yes: 1/ No: 0)				
14] Clear Bank [2] Counter (Yes: 1/ No: 0)				
15] Clear Bank [3] Counter (Yes: 1/ No: 0)				
16] Clear Bank [4] Counter (Yes: 1/ No: 0)				
17] Clear Bank [5] Counter (Yes: 1/ No: 0)				
18] Clear Bank [6] Counter (Yes: 1/ No: 0)				
19] Clear Bank [7] Counter (Yes: 1/ No: 0)				
20] Clear Bank [8] Counter (Yes: 1/ No: 0)				
21] Clear Bank [9] Counter (Yes: 1/ No: 0)				
22] Clear Bank [10] Counter (Yes: 1/ No: 0)				
23] Clear Bank [11] Counter (Yes: 1/ No: 0)				
24] Clear Bank [12] Counter (Yes: 1/ No: 0)				

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