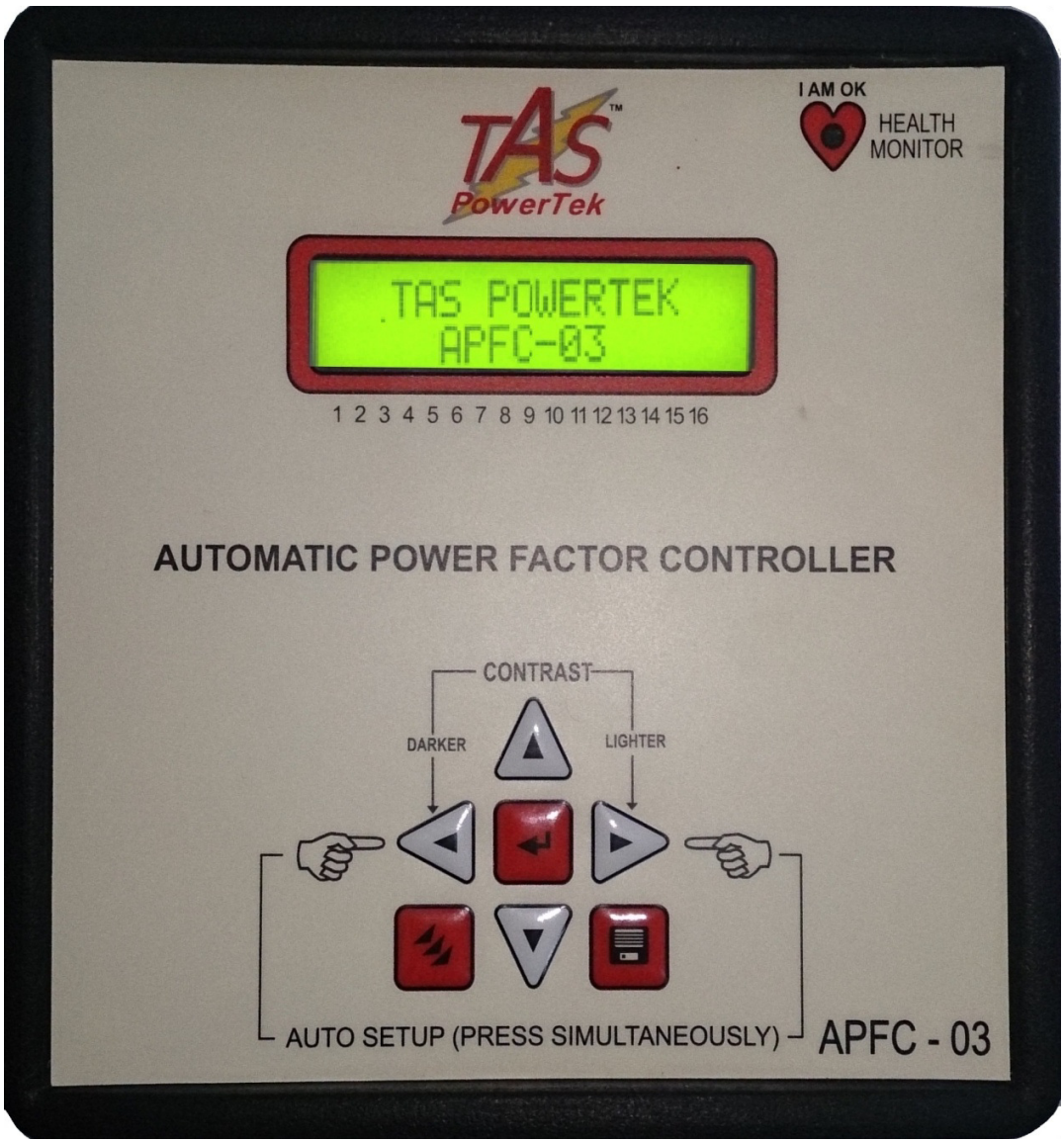
AUTOMATIC POWER FACTOR CONTROLLER

APFC-03



USER MANUAL

NOTE

These instructions do not purport to cover all details or variations in equipment, or 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 factory.

The contents of this User 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.

CAUTIONS:

1. There are High Voltages associated with this Unit. So, take appropriate precautions.
2. To be installed & commissioned by a technically qualified person only.
3. This Automatic Power Factor Controller (APFC) is to be used indoor only.
4. Make sure that the Capacitor Bank Discharge time set in the PF Controller matches with the actual Capacitor Bank discharge time.
5. This User Manual corresponds to the APFC-03Controller, Firmware Version 1.1.3

Because of continuous improvements carried out by TAS PowerTek in their Product's Features and Specifications, the Product as well as the Content of the User Manual is likely to get updated without any prior notice.

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

INDEX

Ordering Information

Product Specific Information Number (PSIN): Single-Load-Current-CT based Automatic Power Factor Controller; with wide voltage range Input **AC** Operating Aux. Input Supply.

APFC-03 / nn

nn Number of Relay N.O. Contacts Outputs, for Capacitor Banks Switching:

Standard Output Options are: 04, 08, 12, or 16.

(Similar APFC Unit is available with Current-Sourcing Transistor Outputs, as TPFC-03. The TPFC-03 Firmware is compatible for the high-speed PF Correction Applications with TAS or other Make high-speed Capacitor-Duty Thyristor Switches for Power Capacitor Banks Switching. Please contact TAS PowerTek, Nasik, India, for further details.)

Features:

1. Power Factor Controller for universal application, requires no settings and is self-configuring in basic mode of functioning.
2. Advanced Microcontroller based logic for measurements, monitoring, analysis and control. It is suitable for balanced 3-Phase Compensation by capacitor switching.
3. 16 Character, 2 Lines, alpha-numeric, dot matrix LCD display with LED back-light.
4. 7 keys, tactile keypad for user interaction.
5. Front panel flashing LED indication for PF Controller healthy (running) status.
6. Phase-to-Phase input voltage measurement with over-voltage transients protection.
7. Single-Phase load current CT secondary input, field selectable for 1Amp or 5Amp range.
8. 4 Models, as per Order Code, suitable for 4, 8, 12 or 16 Capacitor Banks control.
9. Independent, fast-blow fuse protection for control outputs relay commands, for banks 1 to 8 and 9 to 16.
10. Potential free, “normally-open” relay contact outputs for external contactor switching control.
11. Two auxiliary outputs, “normally-open” relay contacts for external interlocking.
12. THD% measurements of supply voltage and current. Odd harmonics up to 15th.
13. In “Expert” Mode facility of Un-equal bank size selection. Including user defined bank values in kVAr.
14. Capacitor Bank Step Protection features like
    - Over / Under Voltage at measurement input.
    - Harmonic overload, both for voltage and current.
    - Over-Temperature inside the APFC-03 Controller Unit.
    - Over / Under AC Mains Line Frequency.

15. DIN Standard 144 x 144 mm Plastic Cabinet for Panel-door flush-mounting. Rear side dimensions as 137 x 137 mm with recommended Panel door cut-out as 138 x 138 mm. Max. Depth of 76 mm on rear side of panel mounting door.

16. Three-Sides Closed Screw Terminals on the rear side suitable for fork type lugs providing easy field wiring connections.

17. Optional "Expert Configuration" allows Line-to-Neutral as voltage sensing input.

18. Use of SMPS which facilitates wide range Auxiliary Supply voltage, with externally accessible input auxiliary supply slow-blow fuse protection.

19. Most important and advanced feature is the "BASIC Configuration".

    Controller in Basic Configuration has the following features:
    - Automatic detection and usage of the optimum capacitor banks.
    - Fully automatic capacitor bank step value setting and self-adapting.
    - System parameters (voltage, current, active power, reactive power, apparent power, Maximum values of these parameters, kVAr value of every bank that are connected) are displayed in terms of percentage of it's rated 100% values.

Specifications:

1. Balanced 3-Phase Reactive Power Compensation because of 3-Phase Balanced Connected Power Capacitor Bank Steps.

2. Operating Auxiliary and Measurement voltage: 100V to 500V AC Line-to-Line value, and Supply frequency Nominal as 50 (+/-3) Hz or 60 (+/-3) Hz.

3. Active Power Measurements with 1.0 Class accuracy, Reactive Power Measurement with 2.0 Class accuracy for the recommended Measurement Voltage & Load Current phase inputs, as per the line diagram at the rear side of APFC controller.

4. Single-CT Load Current Input (from CT secondary): 1A or 5A, selectable at the rear terminal block.

5. Output Stages: Standard Models with 4, 8, 12 or 16 Outputs, as per Order Code.

6. Relay Output N.O. contact rating: Max: 250Vac, 0.5Amp, resistive / inductive load, continuous.

7. Operating Temperature Range: 0 to +55° C.

8. Storage Temperature Range: 0 to +65° C.

9. Relative Humidity Range: 10% to 95% (Non-condensing)

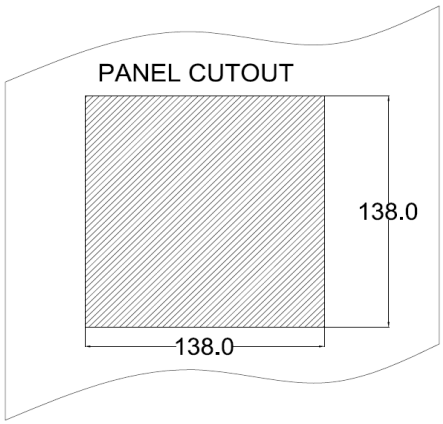
10. Un-packed Net Weight of the Unit: 650 grams.

MECHANICAL DIMENSIONS: Front Side: 152 x 152 mm, Rear Side: 137 x 137 mm.
Rear Depth: 76 mm, Panel Cut-out: 138 x 138 mm.

152 mm

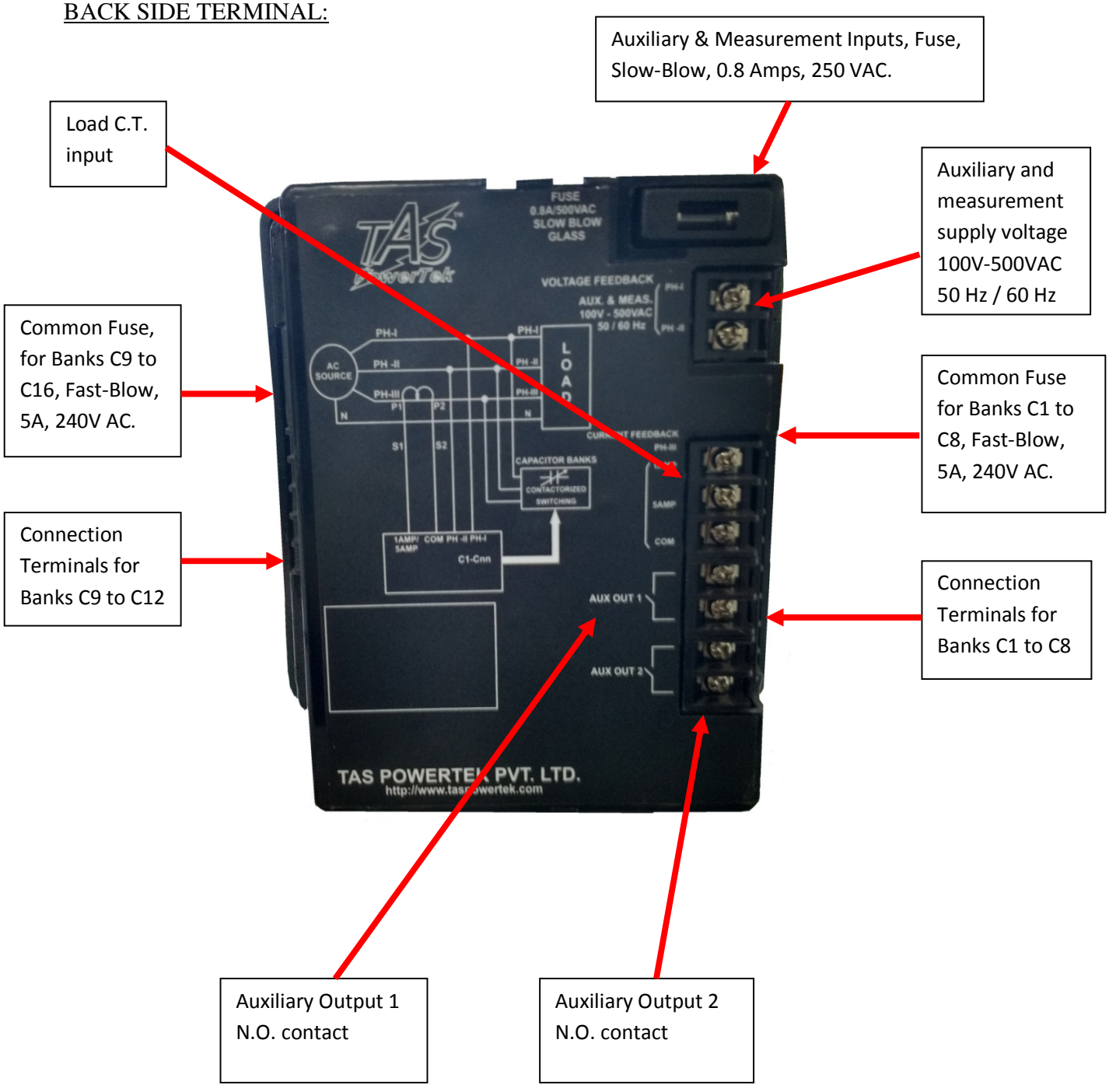
76 mm

52.5 mm



TERMINAL ARRANGEMENT & Connector Details:

BACK SIDE TERMINAL:



LEFT and RIGHT SIDE Terminal View:

Left side terminal Rear View

Right side terminal Rear View

INPUT AND OUTPUT CONNECTOR DETAILS:

1) *Auxiliary Supply and Measurement Supply:*

AC Auxiliary Supply and measurement supply have common terminals.

Terminals are marked with PH1 & PH2.

An Auxiliary supply is for powering the internal SMPS.

Measurement supply is for measuring the Phase-to-Phase voltage. (Also Phase-to-Neutral voltage, in case of EXPERT Configuration selected).

2)*Mains CT load current feedback Terminals:*

Terminals are marked with COM (Common), 5AMP & 1AMP. These terminals are connected to secondary winding of the external Mains current feedback CT. The rated secondary can be either nominal 5 Amp or 1 Amp AC.

CT secondary standards are 5 Amp and 1 Amp. In view of the same, the user can use the feedback CTs as per field installed CTs.

COM is the common terminal of CT (the other secondary winding than that of 5 Amp or 1 Amp winding).

Please refer to the terminal arrangement as shown in line diagram on the rear side of the controller.

3) On/Off Command Output Terminals:

Terminals marked with C1 ----- C*nn* and COM.

COM: This is the Common terminal. The voltage applied to this terminal would appear at the output terminals C*nn* if output relay for that "Step nn" is turned ON.

Cnn: These are the Capacitor Bank ON / OFF command terminals. When a specific capacitor bank is to be turned ON, it connects the internal relay switch to the COM terminal.

Normally, a phase voltage is applied to COM terminal. The C*nn* terminals are connected to actuation coils of the external Three-Phase Power Contactor. The other terminals of contactor actuation coil are connected to System Neutral, to use the Single-Phase, Maximum 240 V AC Operated Contactors.

Please refer the connection diagrams on the relevant pages in this manual, for the terminal connection details.

Note that the external Contactor Coil should be of maximum nominal 230V AC rating only.

Use of a 320 V, 20 mm Dia. MOV directly across the Contactor Coil is highly recommended to extend the Relay Contact Operational life as well as avoid EMI-EMC related issues.

In case, MOV are NOT immediately available, then, Series Connector Resistor-Capacitor Networks as "R-C" Snubbers are to be placed directly across EACH Contactor Coil.

This Resistor & Capacitor are to be connected in Series, by soldering the leads and to be covered in a Heat-Shrinkable Insulating Tube. No PCB is required for this assembly.

The Specifications for the R-C Components of the Snubbers required are:

1] Capacitor:
Capacitance Value = 0.1 micro-Farad (100 nano-Farad (nF)). Voltage Rating = 1000 Volts DC (1 kV DC), Leads Structure & Shape = Axial Leads, Cylindrical Shape.

2] Resistor:
Resistance Value = 330 Ohms (330 E), Resistance Value Tolerance +/- 5% of the nominal value of 330 Ohms.
Resistor Wattage = 1 Watt
Resistor Type = Axial Leads, CFR (Carbon Film Resistor).

3] Wires for Connection of RC Snubber to the Contactor:
One Square Millimeter, Reputed Make, 7 Centimeter Long.
The loose, flying-end of the Wires for the Contactor Connections, should have a Fork-Type Lug Soldered to the wire.

Note: The Resistor-Capacitor Assembly to be covered in appropriate size Heat-Shrinkable Tube and heat-shrunk.

Auxiliary Outputs (Two Channels):

These are marked as AUX OUT 1 and AUX OUT 2. These are provided for inter-locking with external Master Controllers such as PLC, Alarm Annunciation, or equivalent.

These are potential free Normally Open (N.O.) Contacts. Rating is 250V AC at 0.5 Amp resistive or inductive loads.

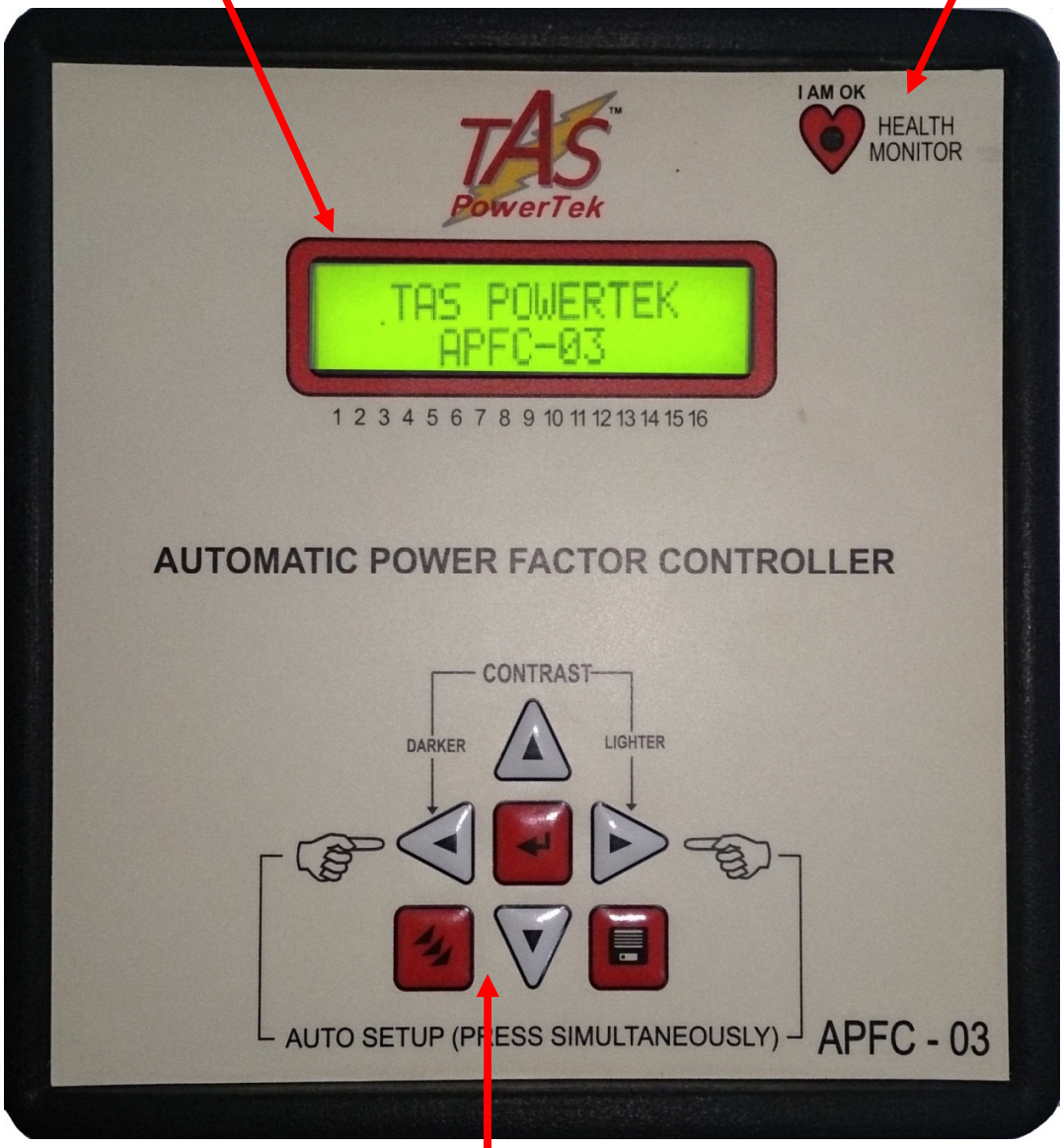
Auxiliary output is user programmable to become "Close" (N.C.) due to any of the following:

1. PF Controller tripping-off Capacitor Banks on any fault.
2. Over -Temperature (internal to APFC Unit), for switching-on external cooling fan connection for the APFC Panel.
3. Out of Banks (Insufficient Total Capacitive kVAr – not able to attain target PF).

FRONT PLATE INDICATIONS AND KEY-BOARD:

LCD DISPLAY

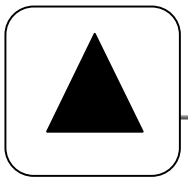
"I AM OK" LED



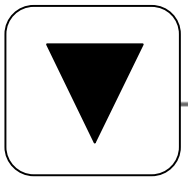
KEY-BOARD

KEY-PAD DESCRIPTION:

SOFT TOUCH KEY-PAD:

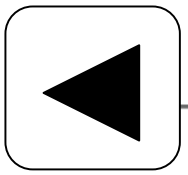


UP key. Used to scroll up the menu screen; increment values when entering numbers. Also used for changing the status of banks.



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

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



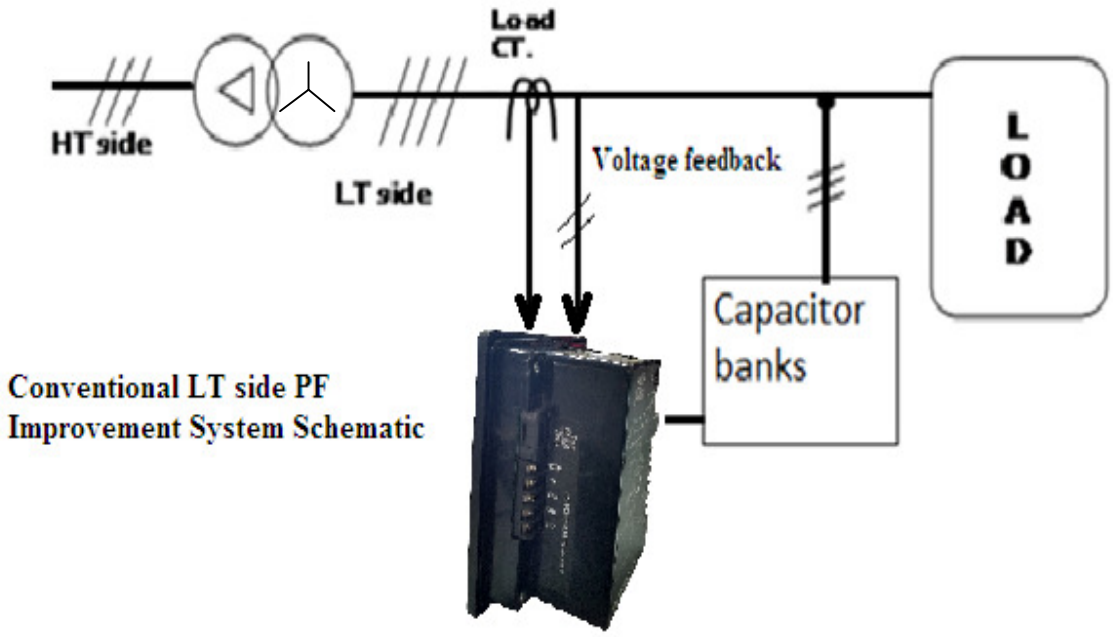
LEFT key. Used to shift the cursor to left; also used to decrease the contrast of LCD in default display screen mode.

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

MODE key. Used for selecting modes of operation and editing of parameters.

SAVE key. Used to save all the changes made in the Program mode menu.

INSTALLATION CONTROL SCHEMATIC:

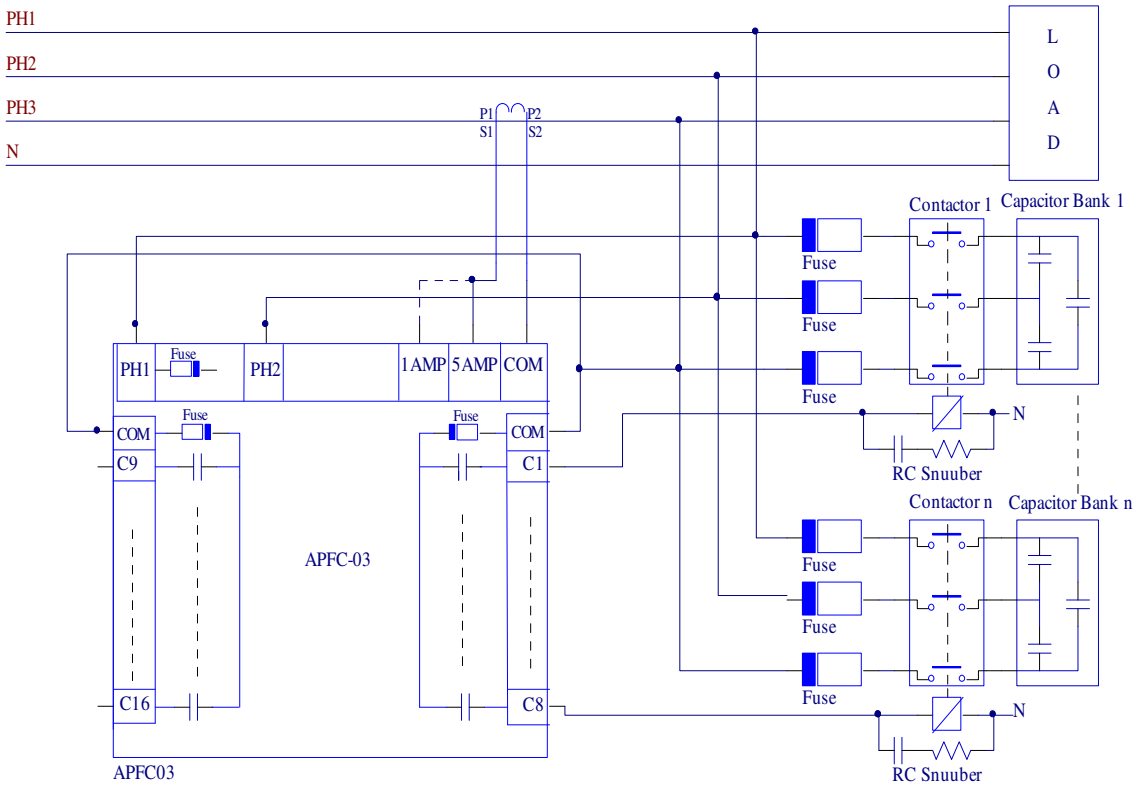


Conventional LT side PF Improvement System Schematic

- As per this scheme, the load Current sensing CT is put between the AC Power Source and the PF Correction Capacitor Banks and load. This is as per the diagram shown above. The positioning of the Load Current sensing CT in the Power Connection diagram is extremely important.
- The Measurement Voltage feedback is taken from the LT Bus System itself. Please note that the Measurement Voltage Feedback is to be taken from the point after the Load Current sensing C.T.
- This is the most common and conventional scheme.

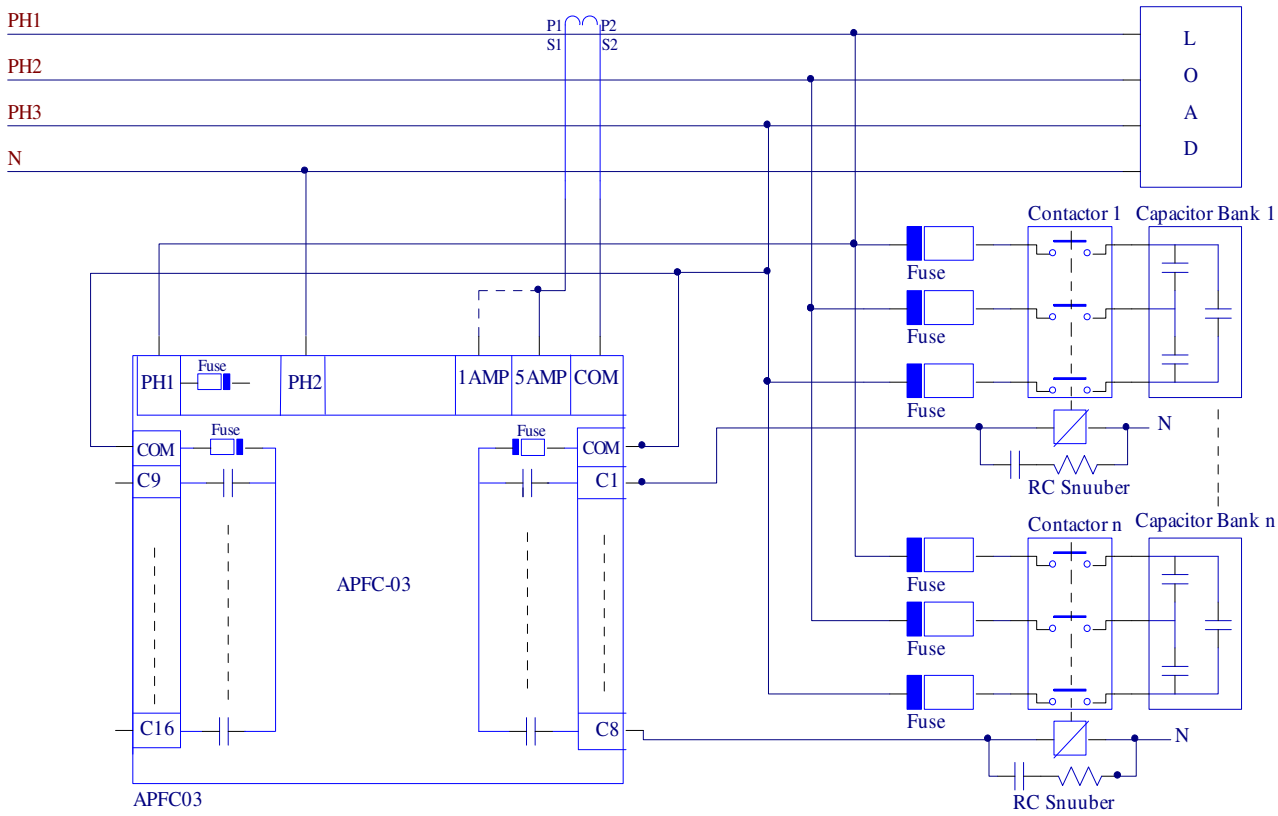
INSTALLATION CONTROL SCHEMATIC:

V & I Feedback control wiring: Typical schematic:



Quadrature Connection (Default for Basic Configuration)

Note: Use R-C Snubbers or appropriate MOVs across EACH Power Contactor Coil.



In-Phase (Same Phase for V & I) Connection (Can be selected in Expert Configuration)

Note: Use R-C Snubbers or appropriate MOVs across EACH Power Contactor Coil.

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

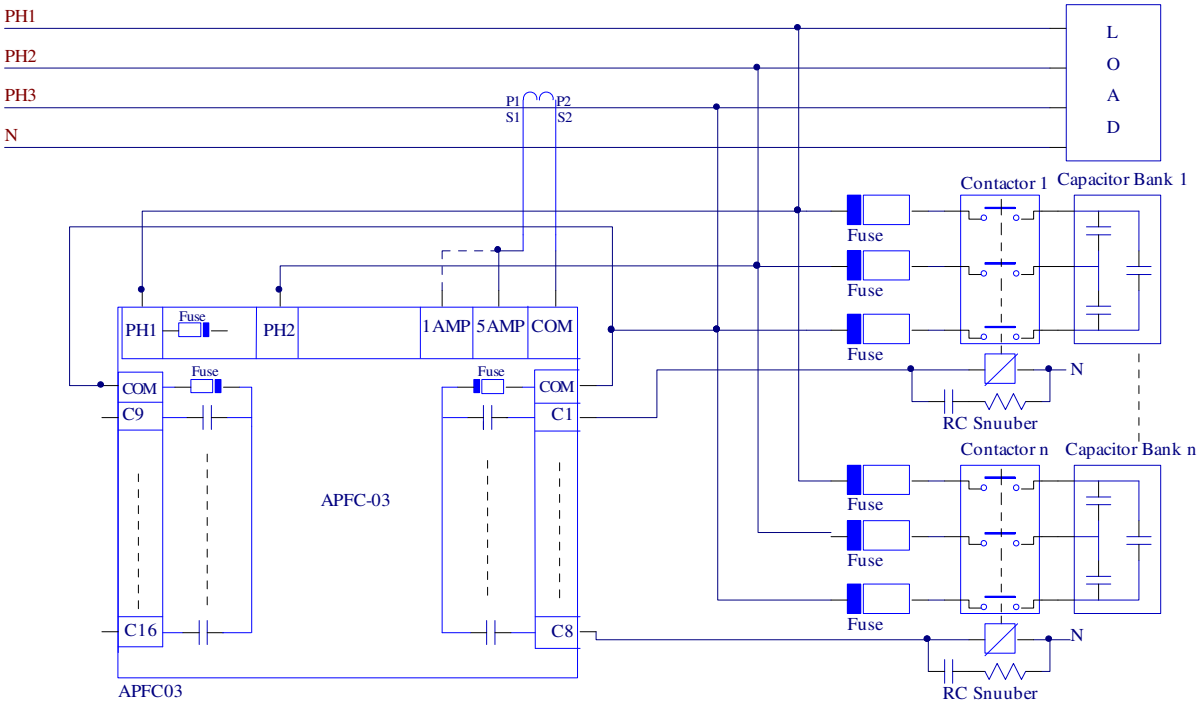
The In-Phase Mode Connection, one Phase and Neutral are used for voltage monitoring. The load current monitoring CT too is put in the same phase.

Note that Auto Synchronization feature or Manual synchronization feature can internally correct the connection errors by internal configuration and in case the Voltage or Current feedbacks are taken from other phases than shown in the diagram above, physical connections need not be changed. Please refer the further section on “Auto Synchronization” for detailed explanation.

INSTALLATION CONTROL SCHEMATIC (DETAILS):

Typical Scheme of APFC-03 with

Contactor switches:

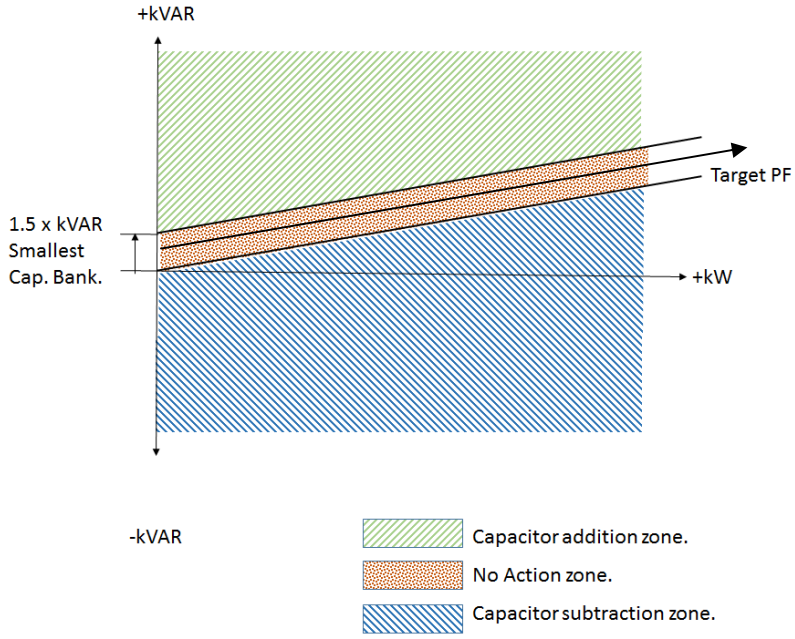


The above APFC connections are shown for Quadrature mode operation.

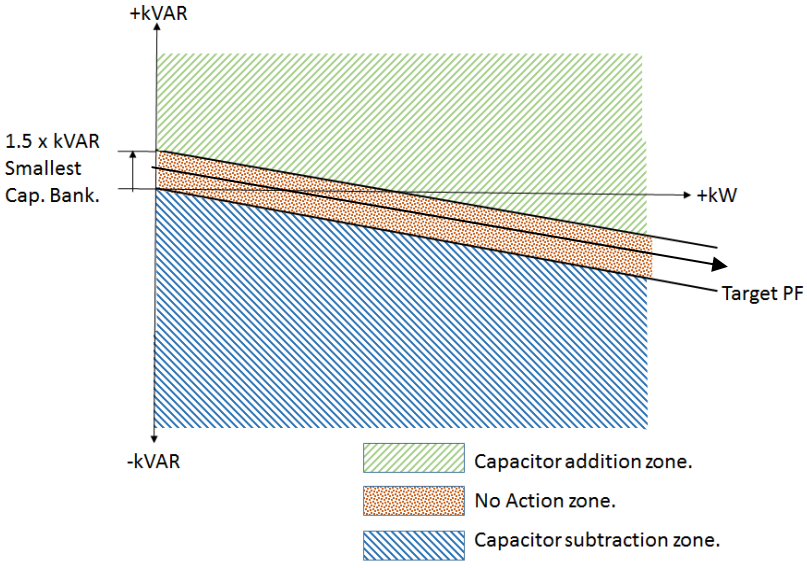
Note: Use R-C Snubbers or appropriate MOVs across EACH Power Contactor Coil.

PF CORRECTION TECHNIQUES

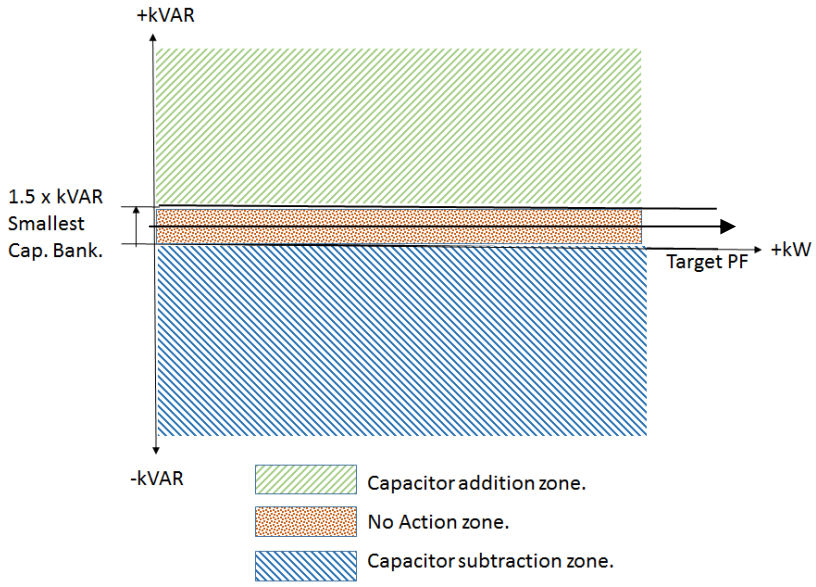
With Lagging (Inductive) Target Power Factor



With Leading (Capacitive) Target Power Factor



With Unity Target Power Factor



All the three conditions are specified in the diagram. One should take note of “No Action Zone” which is internally created to prevent hunting of the capacitor bank(s) that is, switching ON and OFF every correction cycle.

This PF Controller is designed for a single “TARGET P.F.”

“No Action Zone” is preset to minimum kVAr Capacitor Bank size equal to smallest bank kVAr * 1.5. This band is 50%-50% distributed around the Target PF line. This band size normally takes care of all the variations in supply voltage, frequency and harmonics changes, against the hunting of the Capacitor Banks.

FRONT LCD DISPLAY:

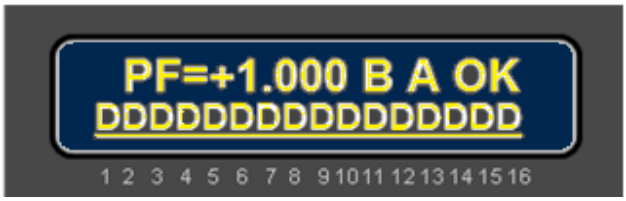
- Simultaneous pressing of left key  and right key  for a second, will put the APFC-03 in **auto-initialization** mode. Automatic synchronization will start. This feature is present in both "Expert" as well as for "Basic" configuration.
- On powering up the unit, there is power on discharge time given for the capacitors to discharge completely. However, if the user is sure that the capacitors are discharged, then on pressing the **left key** would allow the controller to come out of the discharge time and thus user need not wait for the discharge time to get complete and thus saves time.
- The contrast of the LCD can be adjusted by using the keys.  or 
  The left key will make the contrast darker and right key will make it lighter.
  Multiple continuous operations of these keys will achieve this.
- The front LCD Display under default condition displays the various parameter readings.
  There are number of screens that show the various parameters that are measured or derived. These various screens can be displayed by pressing the Scroll keys.
  Viz.

UP key - 

DOWN key - 

Power-up Display Screen. (Only for first 1 Second)

Then the Unit will display:



The above is the factory set default screen. The "PF=" part is to indicate that the value following that is "Power Factor". This indicates the PF that is sensed by the Unit near the load sensing Load Current CT position, i.e. the transformer / supply grid side.

The PF is with "+" OR "–" sign. **+ Sign indicates Power Factor is lagging and – sign indicates Power Factor is leading.** Refer Indian Standard IS 14697: 1999, for Direction and Sign of Active & Reactive Power, PF, Annex F (Clause 3.1.8), for interpretations for a Four-Quadrant Operation of PF Controller.

The next character indicates the "configuration", i.e., in which configuration the controller is operating. There are two configurations in which the controller can operate, viz., **B**asic Configuration indicated by a letter "**B**" OR the **E**xpert Configuration indicated by a letter "**E**".

The next character on the upper line of display shows the operational mode. There are two modes, viz. **A**uto mode indicated by a letter "**A**" and **M**anual mode indicated by a letter "**M**".

The last two characters on the upper line of display show the Health status of APFC-03. "**OK**" indicates that all conditions are fine for normal operation.

"I AM OK" (Health Monitor) LED flashing (Amber colour LED) indicates the Controller health status is Healthy.

This LED is located at the extreme, right-hand side, on the top of the front panel, enclosed by a heart shape as viewed by the user.

The last two characters represent the following status:

OK	Controller status is okay (Healthy)
OV	Over-Voltage Fault
UV	Under-Voltage Fault
VH	Voltage-Harmonics high Fault
IH	Current-Harmonics high Fault
OT	Over-Temperature (inside APFC Unit) Fault
OB	Out of Banks (Insufficient Total Capacitive kVAr)
OF	Over-Frequency Fault
UF	Under-Frequency Fault
AS	Auto-Synchronization is pending status.

The bottom line of the LCD display shows the Capacitor Bank status. The numbers 1 to 16 below the LCD display are for specific outputs (Capacitor Bank number that is controlled by APFC-03). The LCD display above this number indicates the status of that specific Relay Output / Capacitor Bank.

During Power Up, till the time all Banks are showing D status, the keyboard would not be operational. This is to ensure that at Power-Up, all the Capacitors Banks are allowed to be discharged.

Total blank indicates that the output is not used for control.

A small dash  indicates that Bank is connected but is in OFF state.

A symbol  indicates that bank is connected and it is in ON state.

A symbol  indicates that bank is declared as fixed bank and is ON.

A symbol  indicates that bank is declared faulty and is OFF.

A symbol  indicates that bank has just turned off and it is discharging.

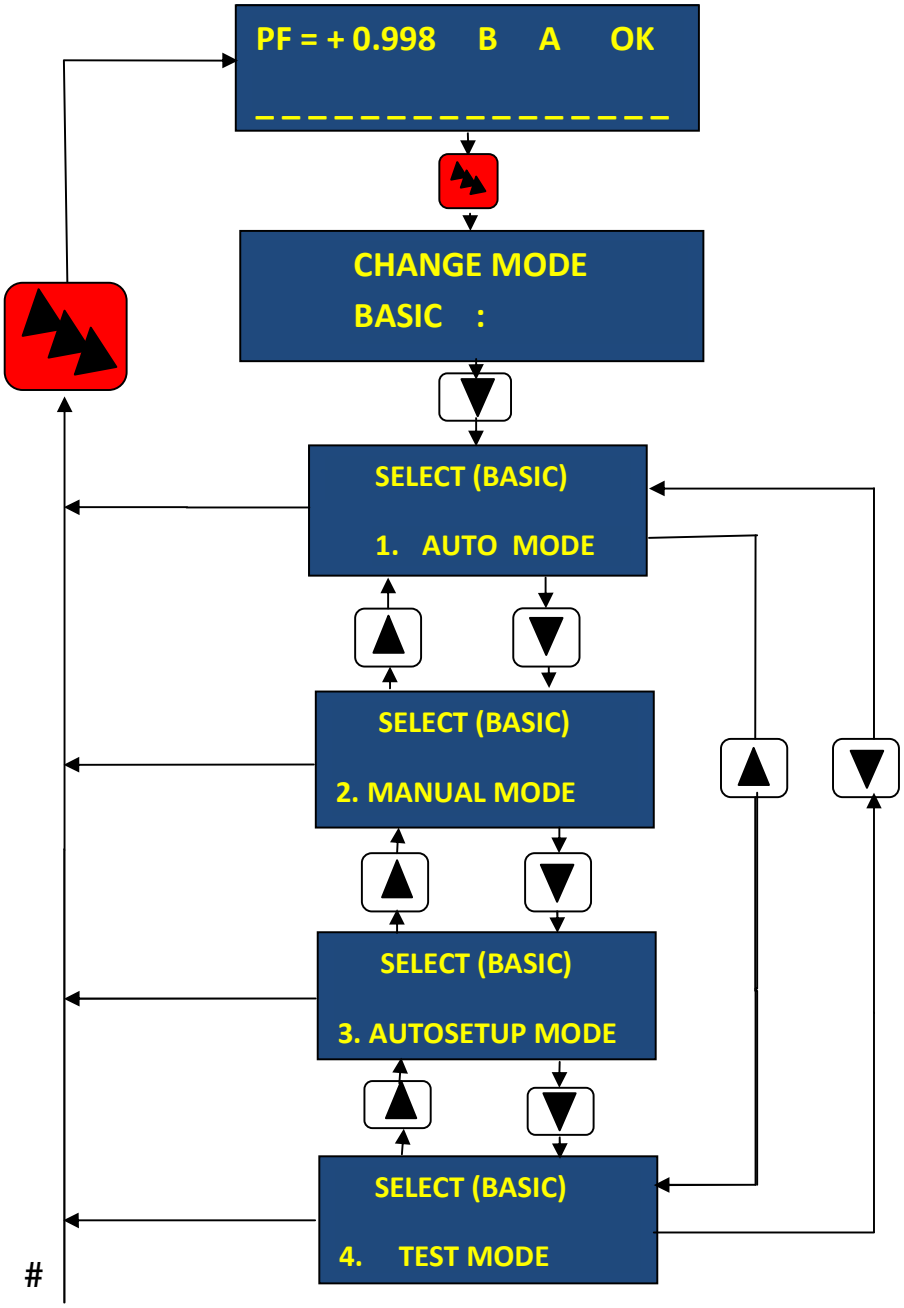
Menu Structure

1. *Basic Configuration menu*:

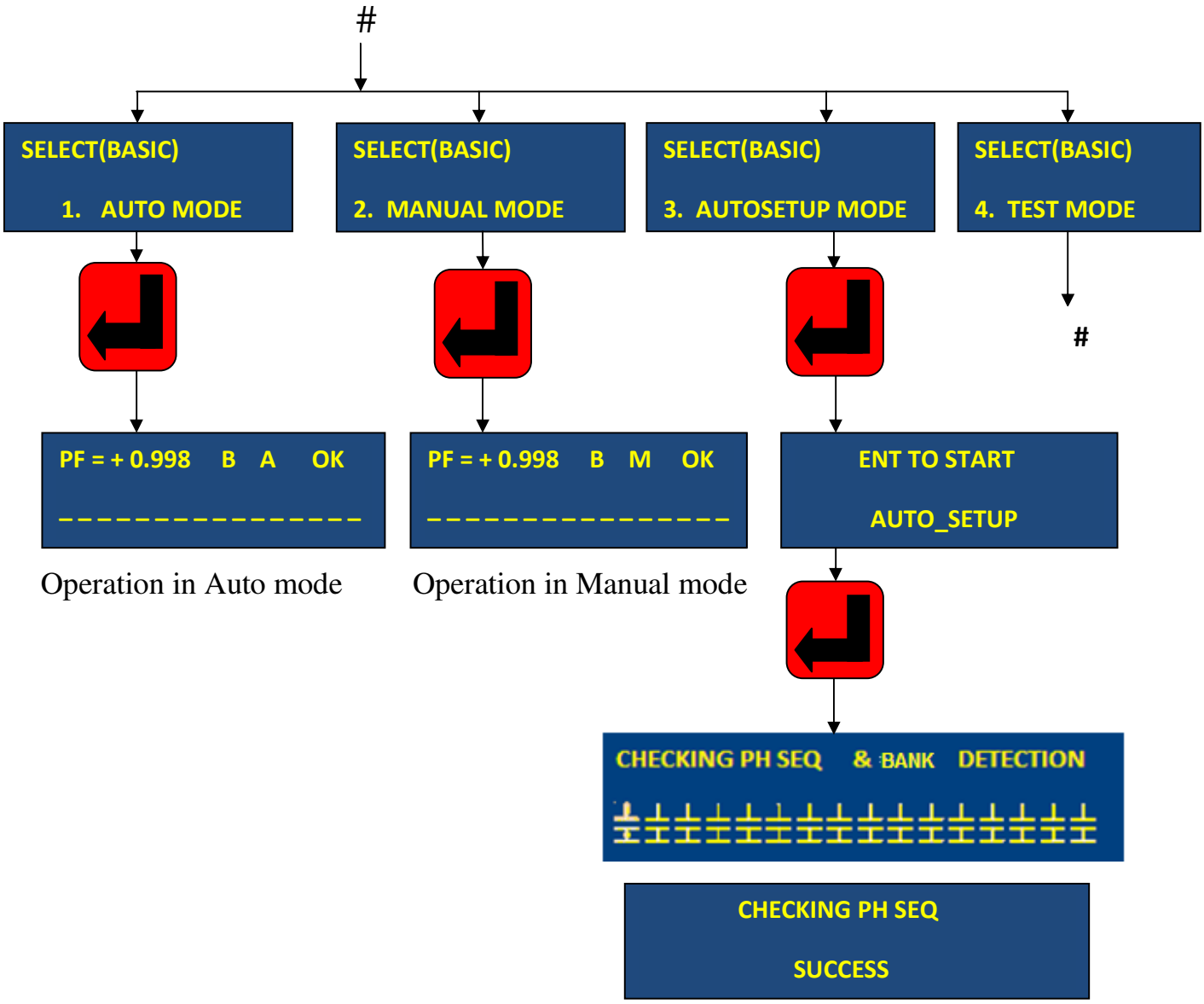
The basic configuration is default & user friendly configuration on which the controller operates. There is no parameter editing facility given to the user in this configuration. All the parameters like average values, maximum values & Step kVAr values are displayed in terms of (%) percentage of respective parameter.

This configuration can work only in Quadrature connection.

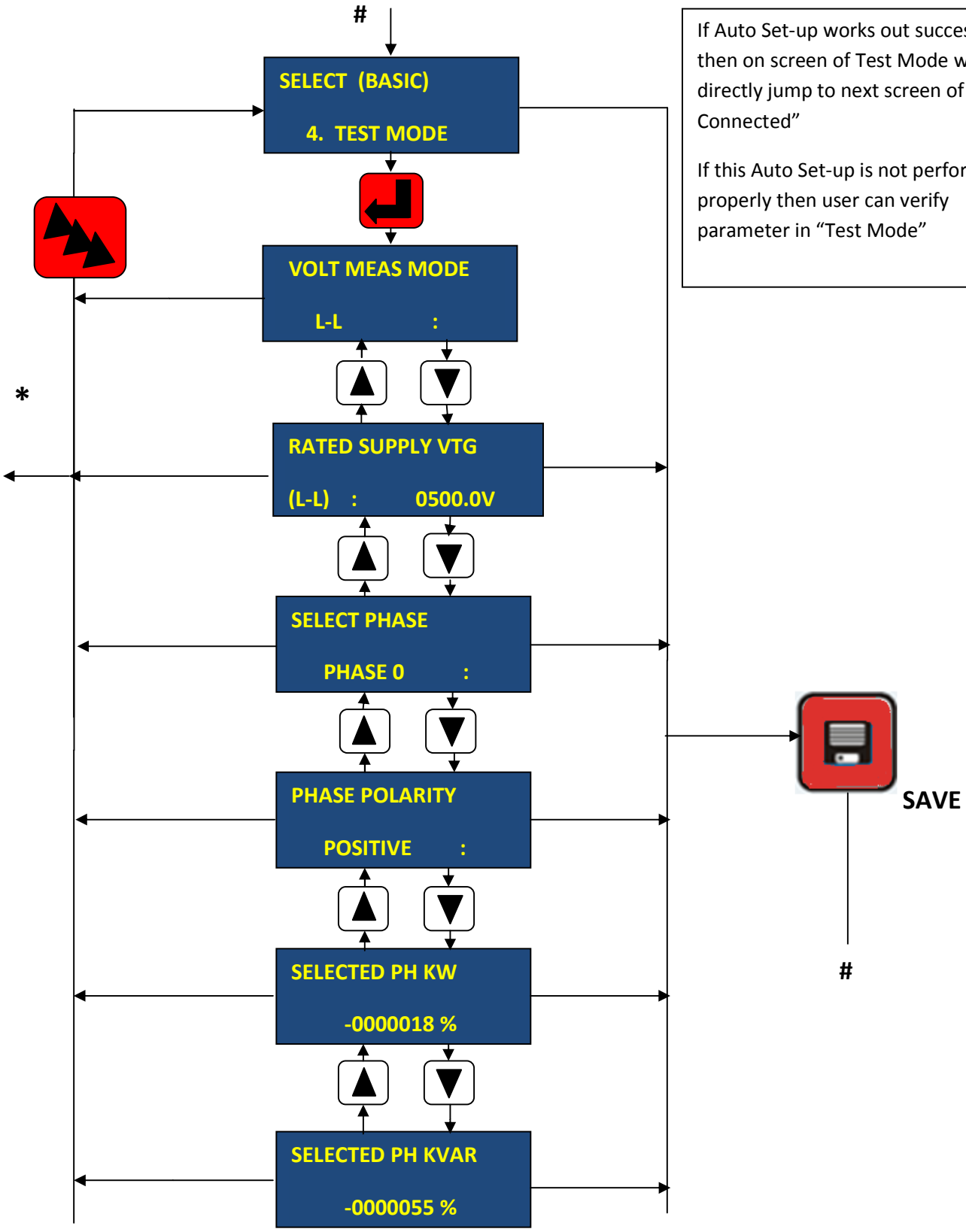
Following are the various screens that can be seen in the Basic mode.



#



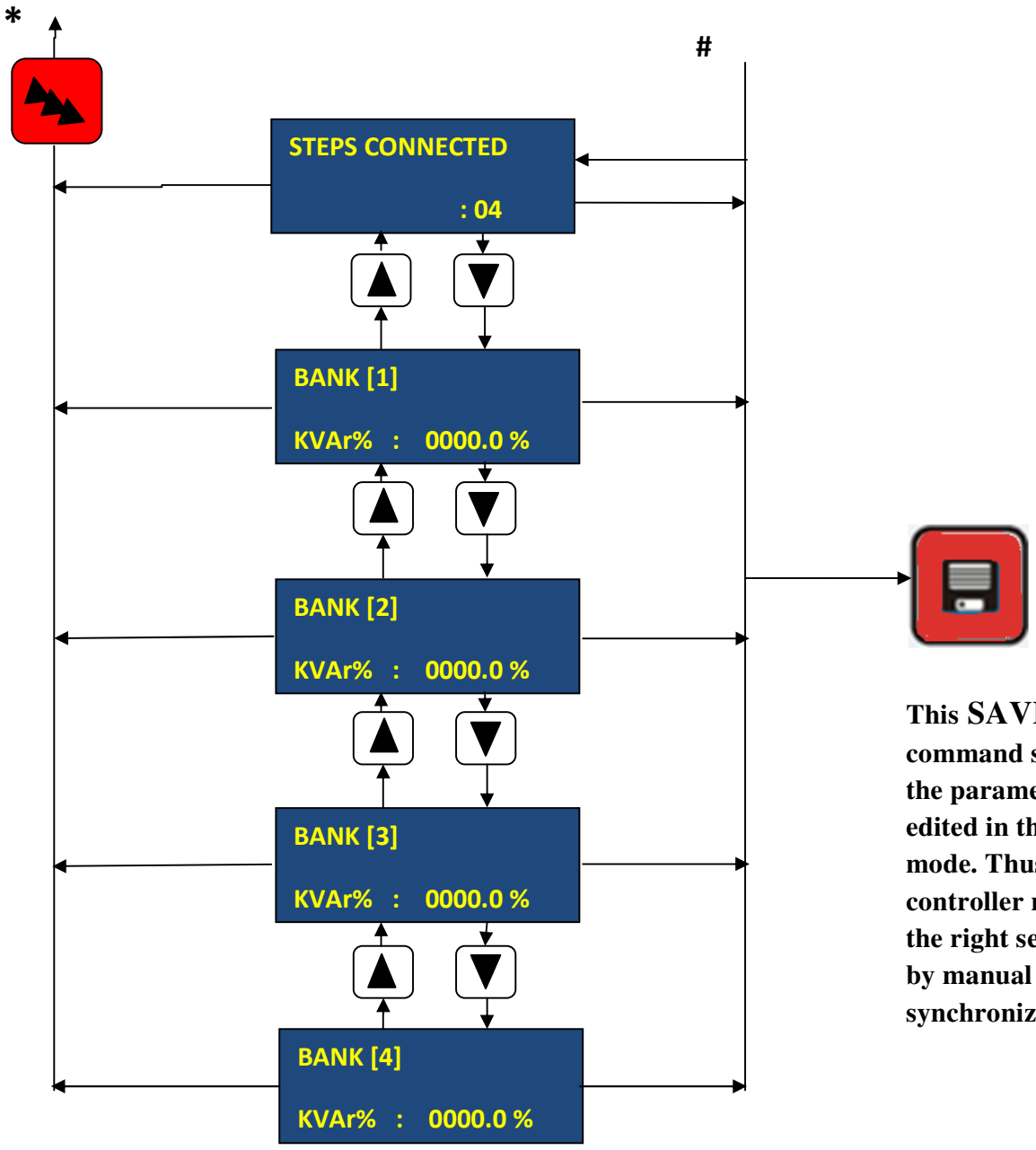
Auto synchronization and bank detection starts. After the success of auto synchronization, auto bank detection is done in basic mode. It may take some more iterations upto 7 nos. if it finds any bank not connected.The screens are as follows:



If Auto Set-up works out successfully then on screen of Test Mode will directly jump to next screen of "Step Connected"

If this Auto Set-up is not perform properly then user can verify parameter in "Test Mode"

"TEST Mode" is to facilitate the user to enter into manual synchronization, specifically if Auto-Synchronization shows a Failure. Entering into this mode, the first screen shows the mode of operation, that is, Line-to-Line for Basic Configuration. After that, the next screen is the selection of Phase. According to the selected phase, the user can see all the kW and kVAr values of the selected phase in terms of respective percentages.User can also choose the polarity option, in case CT polarity is physically reversed. Once, the user has completed editing, user has to press the "SAVE" key and the following screens would be displayed on the LCD display:

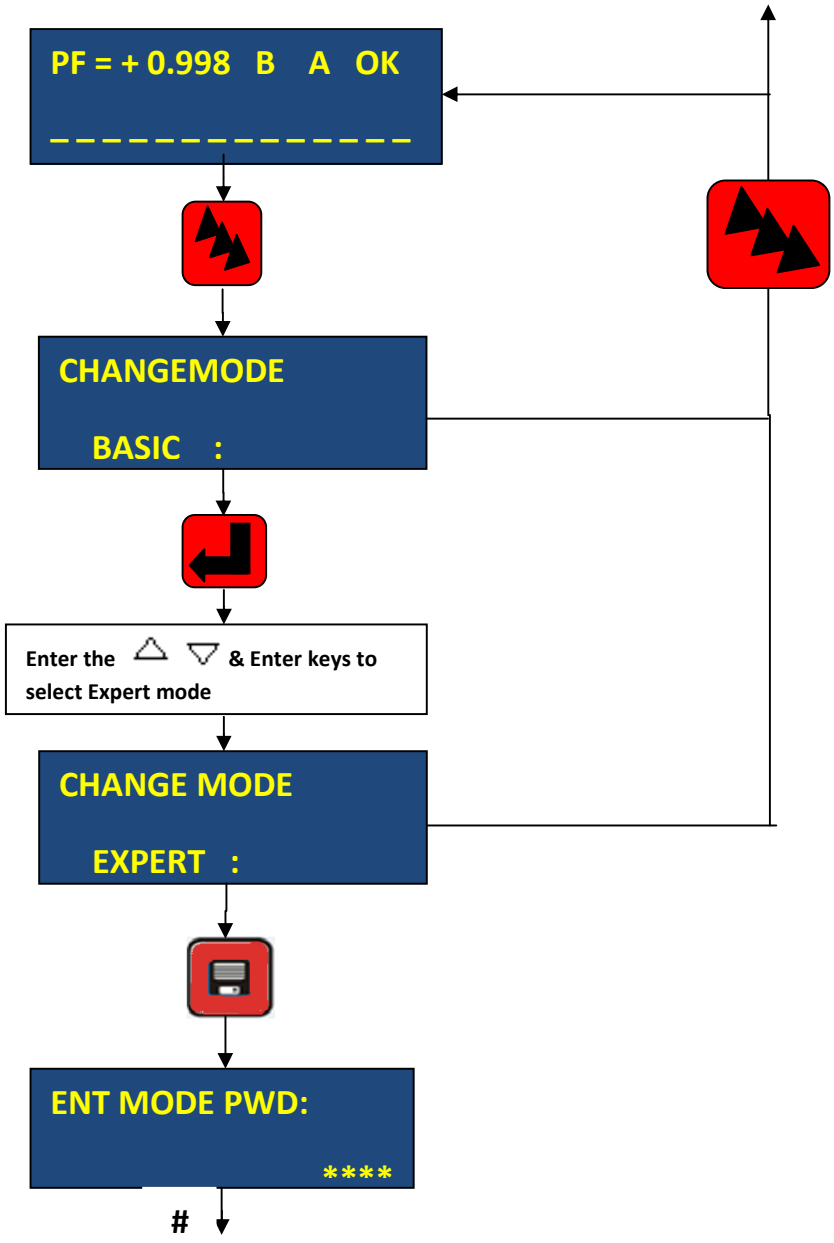


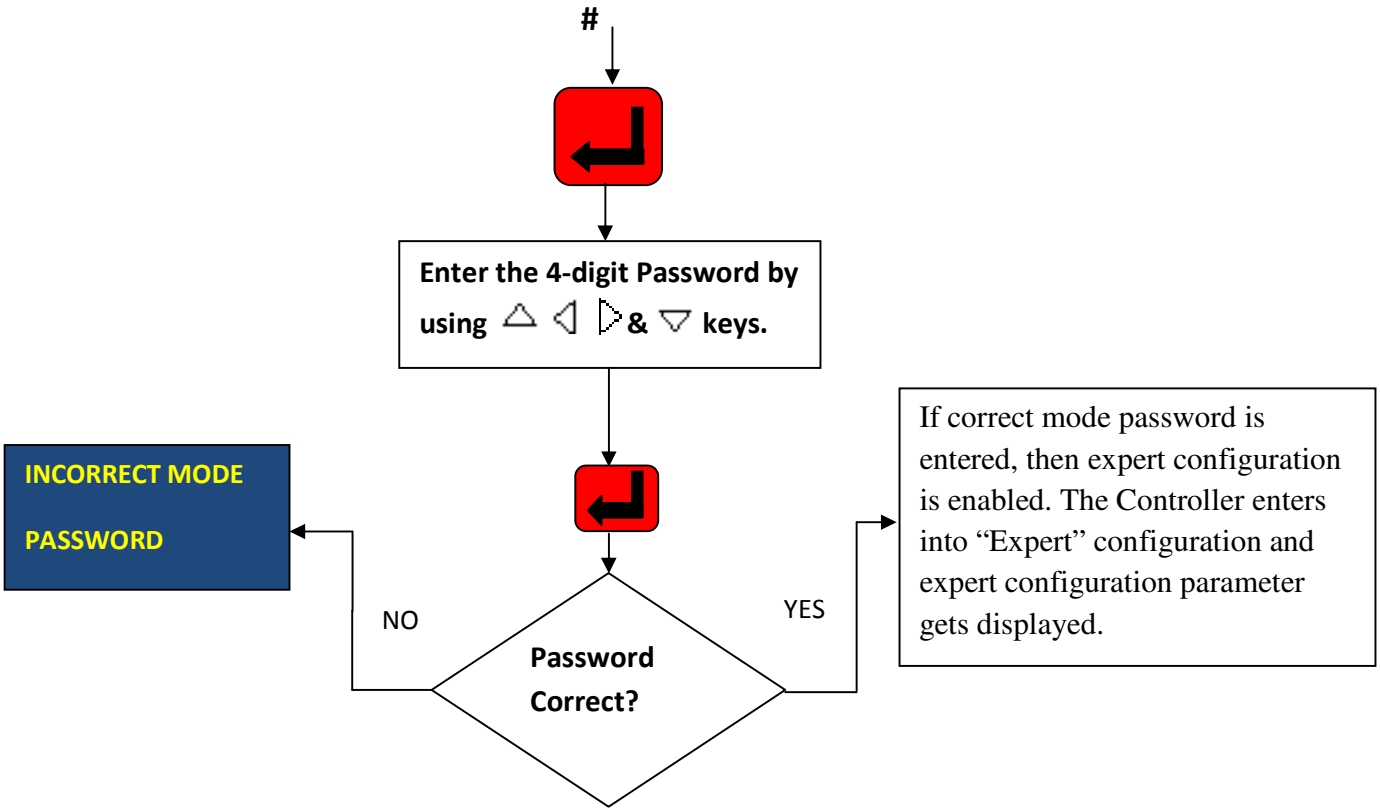
This SAVE command saves all the parameters edited in the TEST mode. Thus, the controller runs on the right sequence by manual synchronization.

If auto-synchronization was successful, then entering into TEST Mode will only show the second screen which is above, in which all the bank kVAr values are to be fed in the controller in terms of percentage. The % value would be % ratio of "Capacitor Bank kVAr at rated Volt" AND "Rated kVA of supply system". **Note that rated kVA in 3 phase system is "$\sqrt{3} * V_{L-L} *$ CT primary rated Amp".**

A. ***Changing configuration menu:*** *(From Basic to Expert configuration)*

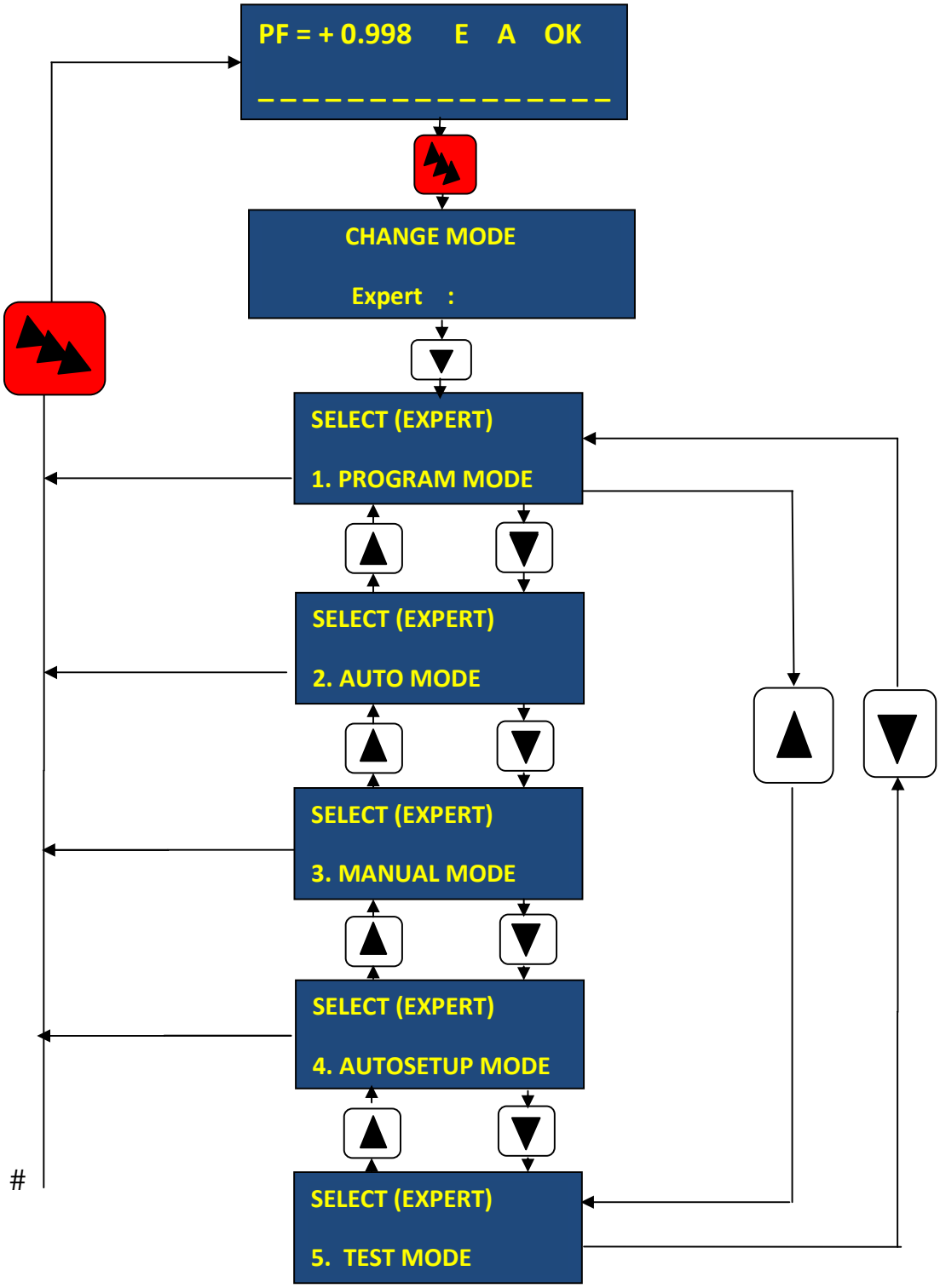
In "CHANGE MODE" screen, there are two configurations:
Expert = 1, Basic = 0. The default password for changing configuration is "0001".

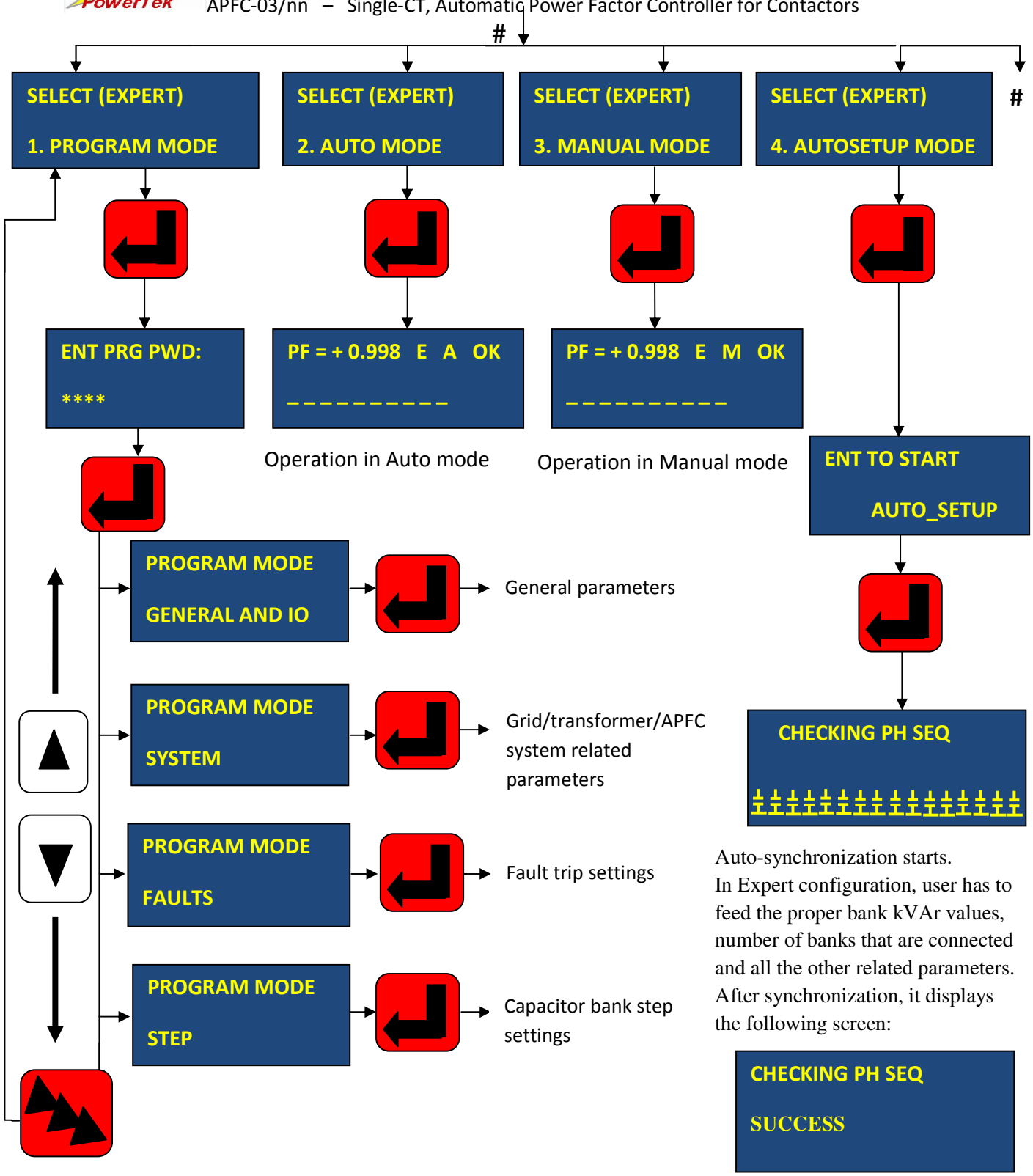



#
Enter the 4-digit Password by using △ ◁ ▷ & ▽ keys.
Password Correct?
NO
YES
INCORRECT MODE PASSWORD
If correct mode password is entered, then expert configuration is enabled. The Controller enters into "Expert" configuration and expert configuration parameter gets displayed.

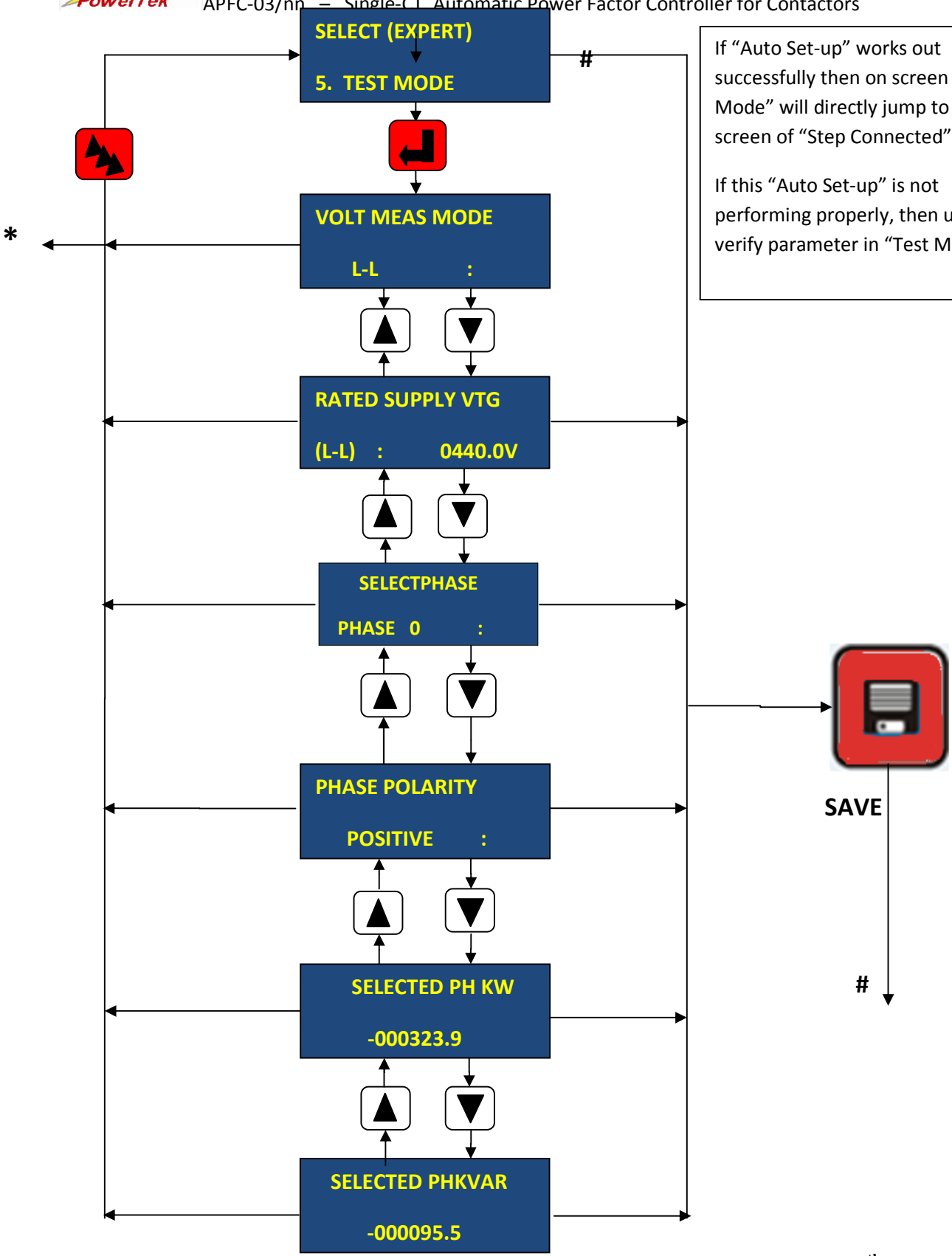
2. *Expert Configuration menu:*

In this menu, all the parameters are user settable. Only a technical person well conversant with electrical engineering and power factor correction should enter into this configuration. All the values of the parameters are displayed on the LCD Display in their absolute engineering units.





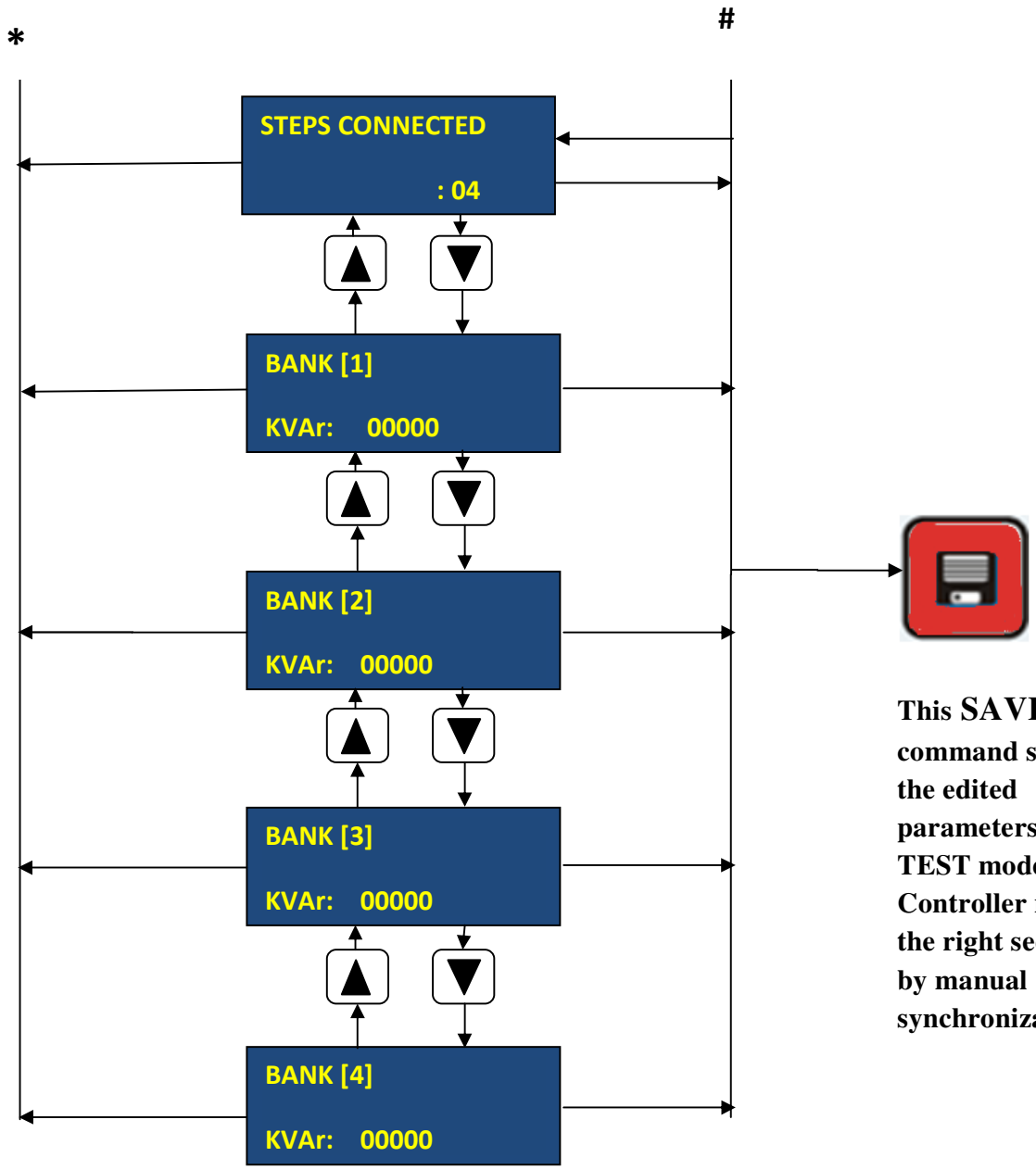
Auto-synchronization starts.
In Expert configuration, user has to feed the proper bank kVAr values, number of banks that are connected and all the other related parameters. After synchronization, it displays the following screen:



If "Auto Set-up" works out successfully then on screen of "Test Mode" will directly jump to next screen of "Step Connected".

If this "Auto Set-up" is not performing properly, then user can verify parameter in "Test Mode".

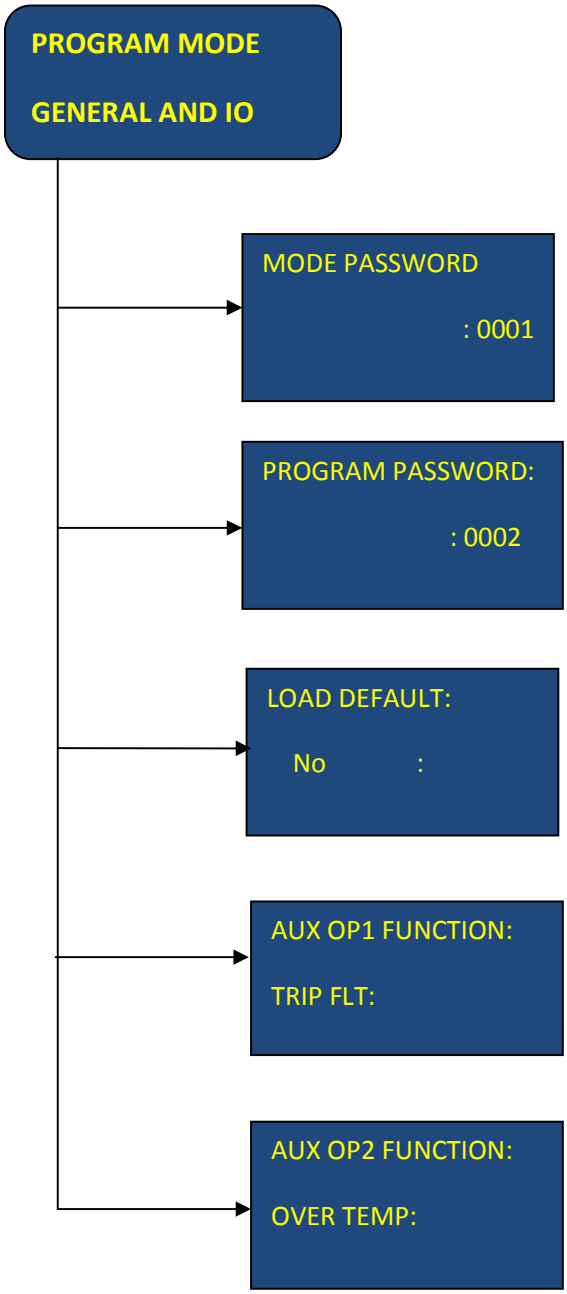
Entering in the "TEST Mode" of Expert Configuration menu allows the user to carry out synchronization manually. For this, first select the mode of operation, whether Line-to-Line (Quadrature) or Line-to-Neutral (In-Phase) Mode. After that, the next screen is the selection of Phase. According to the selected phase, the user can see all the kW and kVAr values of the selected phase for getting judgement of right selection of Phase sequence & polarity. After selection, Save key is to be pressed.



This SAVE command saves all the edited parameters in the TEST mode. Controller runs on the right sequence by manual synchronization.

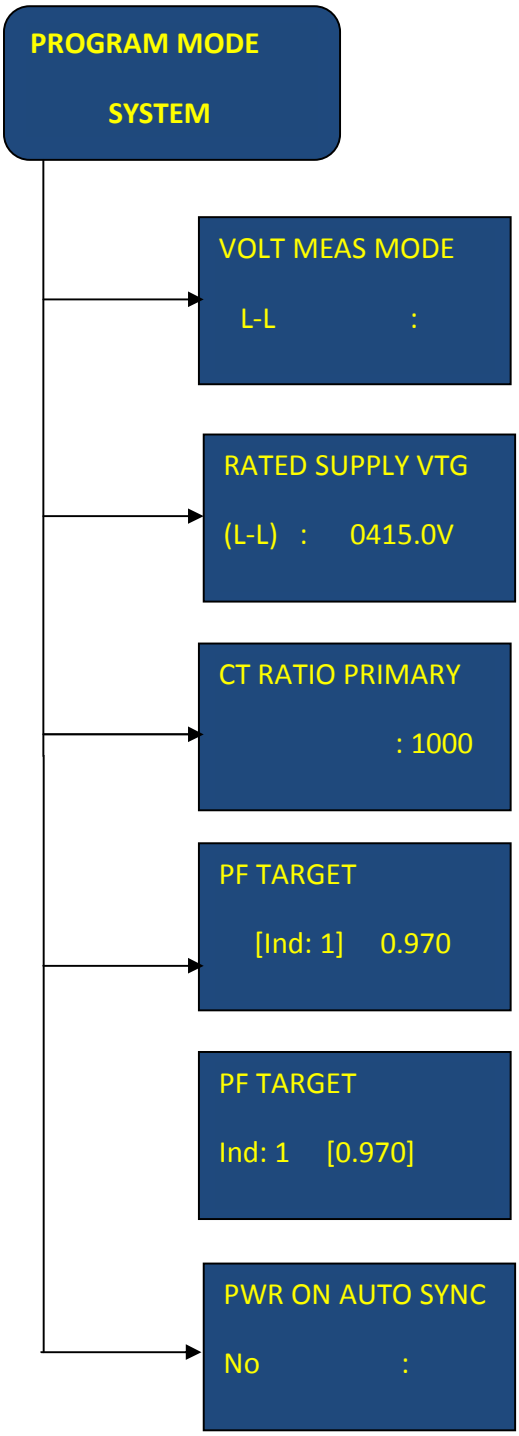
All the Capacitor Bank kVAr values are to be fed in the Controller in their absolute value. kW and kVAr values can be seen in their absolute engineering units on the LCD Display.

Editing the user defined parameters



- **MODE PASSWORD** is basically for changing the mode. The 4-digit number that can act as a pass-word can be changed by changing the value in this parameter.
- **PROGRAM PASSWORD** is for entering into the Program mode parameters in Expert mode menu. Only trained person should enter into this mode and edit the values. Program default password is 0002.
- **LOAD DEFAULT**: There are number of parameters that are loaded at the time of manufacturing. In case, if the user wishes to put these values, the **Load default** can be put to "Yes" and then "Save" command would put the all parameters as set while manufacturing.
- **AUX OP1 FUNCTION**: Program the auxiliary digital output to become NC due to any of the following choices: NONE, TRIP FLT, OVER TEMP, OUT OF BANK.
- **AUX OP2 FUNCTION**: Same as above (As aux. digital output 1 function).

  Note: The auxiliary digital output 1 and auxiliary digital output 2 functions are of auto reset types.



- **VOLT MEAS. MODE**: This is the system parameter that defines the controller's connections of operation (auxiliary supply to the controller). These are two types:
  Line-Line (Quadrature) and Line-Neutral (In-Phase)

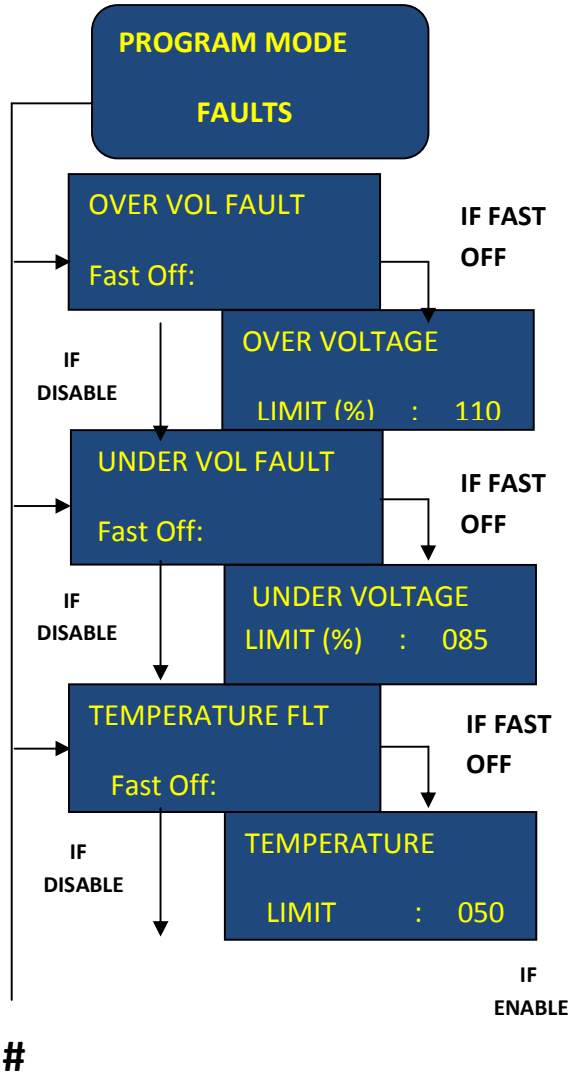
- **RATED SUPPLY VTG**: This is the system parameter that defines the Controller's nominal supply voltage. These are edited as per the Quadrature or In-Phase mode select:
  Line-Line (Quadrature) and Line-Neutral (In-Phase)

- **CT RATIO PRIMARY**: This parameter tells the controller about the primary current rating of the grid/transformer side connected CT.

- **PF TARGET**: User can set the target PF as Inductive: 1 or Capacitive: 0.

- **PF TARGET**: The exact value can be set here. User can set the value anywhere in between 0.700 to 1.000.

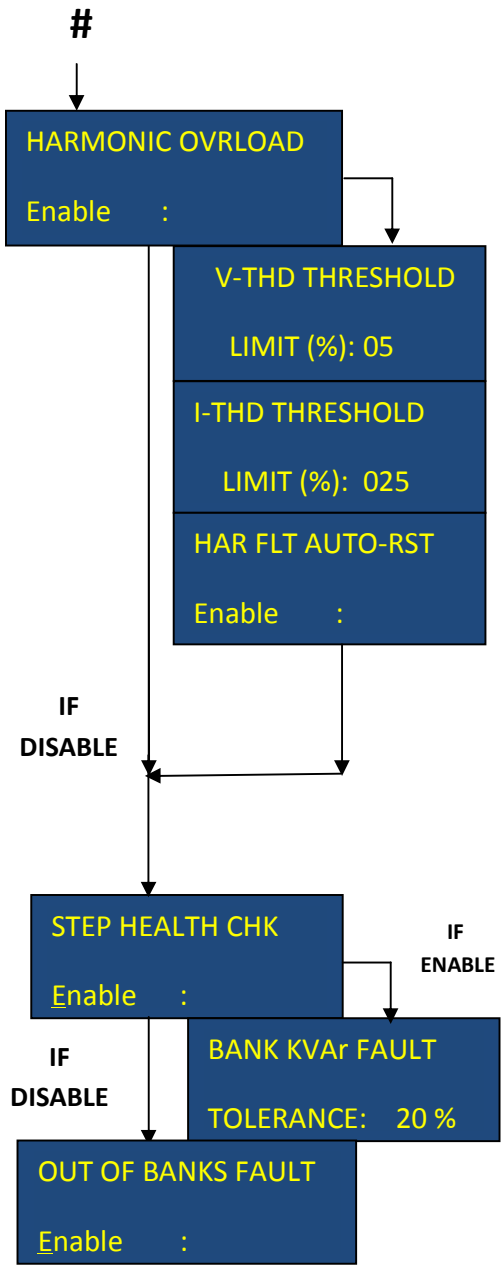
- **POWER-ON AUTO SYNCHRONIZATION**: Auto synchronization feature is enabled or disabled by choosing YES/ NO. If enabled, at every power ON, the Auto-Synchronization would get activated.



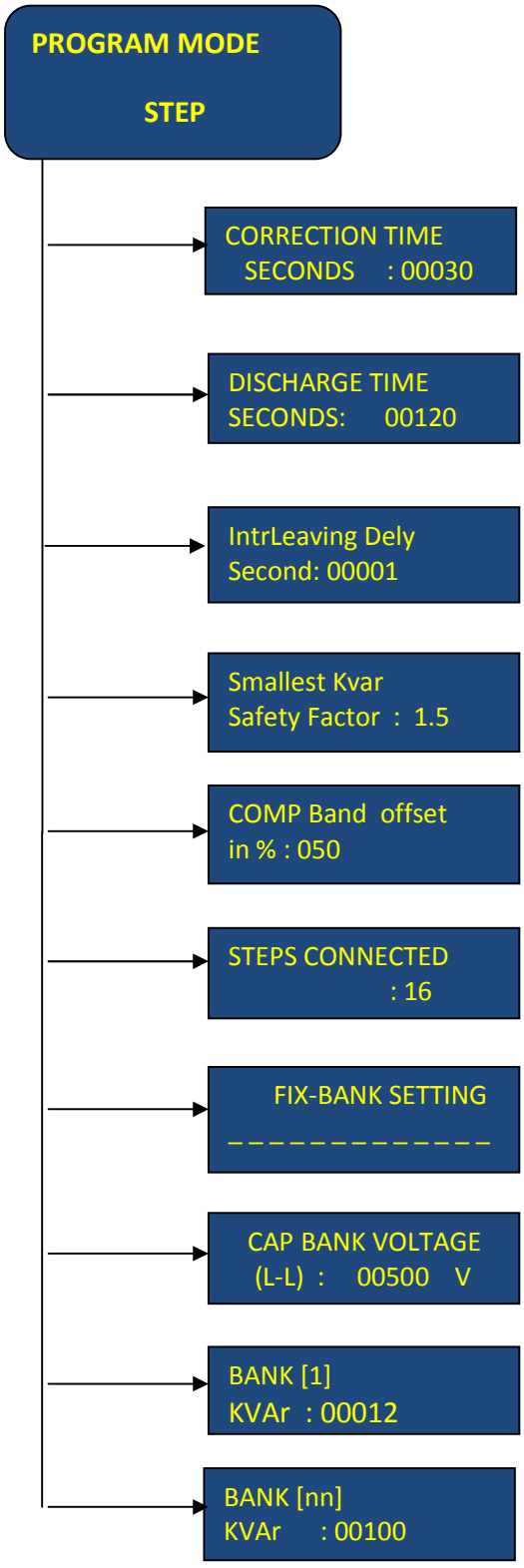
#

Fast Off Action: In this, all the banks that are switched ON, are tripped at one go.

- **OVER-VOLTAGE FAULT**: This would indicate the over voltage fault if "Fast Off" option is activated. It has two options: Disable and Fast off.
- **OVER-VOLTAGE LIMIT**: This screen would be visible only if the over voltage fault parameter is set to "Fast off". In this, user can set the limit in percentage and if the voltage exceeds this limit then "OV" fault would be indicated on the LCD display.
- **UNDER-VOLTAGE FAULT**: This would indicate the under voltage fault if "Fast Off" option is activated. It has two options: Disable and Fast off.
- **UNDER-VOLTAGE LIMIT**: This screen would be visible only if the under voltage fault parameter is set to "Fast off". In this, user can set the limit in percentage and if the voltage falls below this limit then "UV" fault would be indicated on the LCD Display.
- **TEMPERATURE FAULT**: This has two options: Disable and Fast Off.
- **TEMPERATURE LIMIT**: This screen would be visible only if the temperature fault parameter is set to "Fast Off". User can set the limit and if the APFC unit internal temperature exceeds this limit, "OT" fault would be indicated on the LCD and all the capacitor bank step shall be turned off.



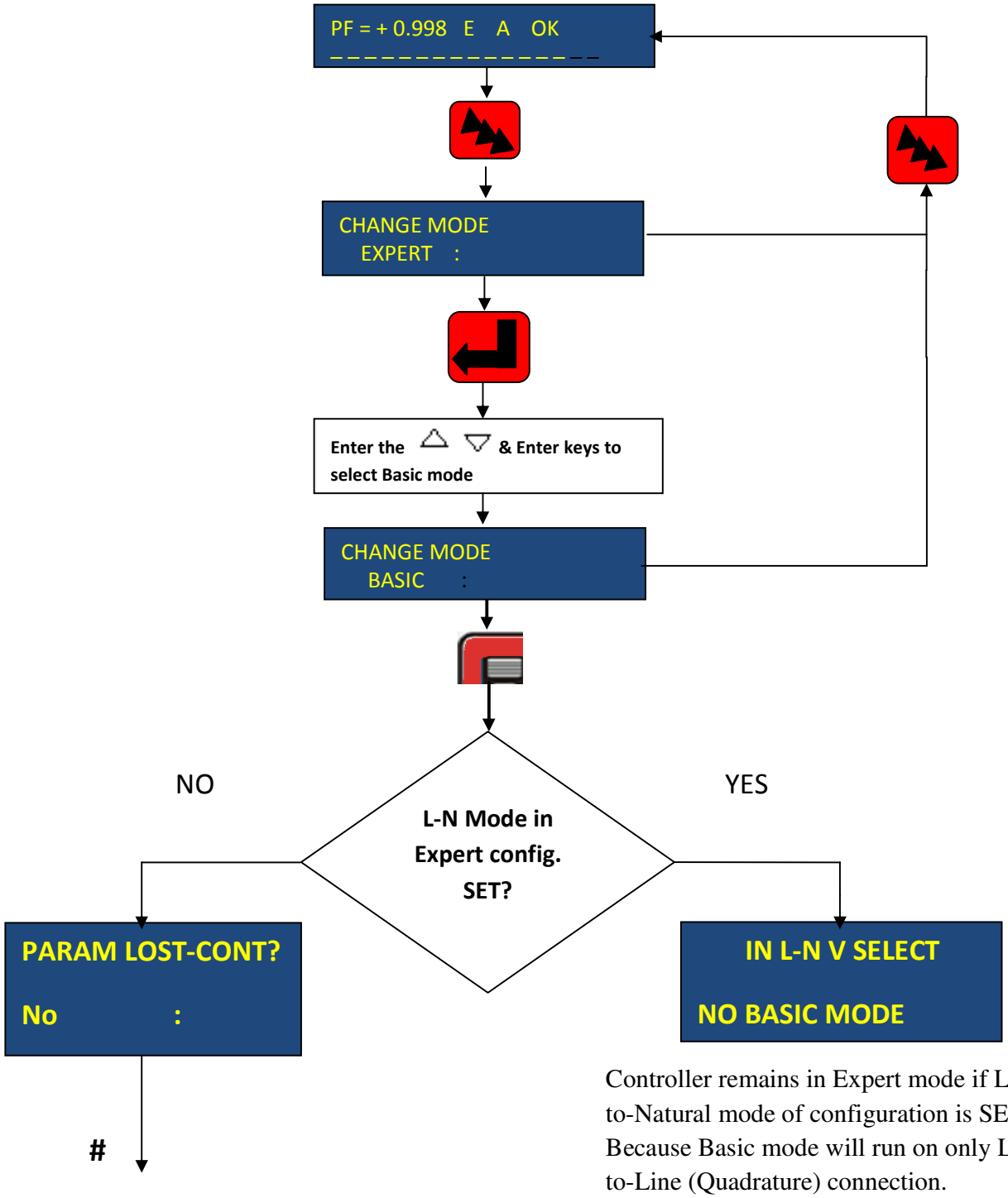
- **HARMONIC OVERLOAD**: This has two options: Disable and Enable. If this parameter is enabled, then only the below three screens would get displayed.
- **V-THD THRESHOLD**: Total voltage Harmonic Distortion limit can be set in this menu. User can set the limits in percentage. If the percentage value of total voltage harmonics distortion (V-THD) exceeds the set limit, then "VH" fault would be indicated on the LCD display.
- **I-THD THRESHOLD**: Total Current Harmonic Distortion limit can be set in this menu .User can set the limits in percentage. If the percentage value of total current harmonics distortion (I-THD) exceeds the set limit, then "IH" fault would be indicated on the LCD display.
- **HARMONIC FAULT AUTO RESET**: This has two options, namely Disable and Enable. If this screen is set for enabled, then after 180 seconds, the harmonic fault is auto reset after the Harmonic level falls below the limit.
- **STEP HEALTH CHECK**: APFC-03 carries out on line monitoring of the kVAr values of every step. This is when the capacitor bank step is put ON in the circuit. In case the set tolerance limit defined here is exceeded, then the specific bank is declared faulty. If step health check is enabled, then only its bank tolerance limit screen would be visible.
- **OUT OF BANKS FAULT**: This is only with 0= Disable and 1= Enable (Indicative option). If on 1, then Unit will indicate this fault as "OB" if PF is inductive beyond set target PF compensation range and all the healthy Capacitor Banks are in ON state, i.e. the total kVAr capacity of the Capacitor Bank steps is lesser the load kVAr requirement. **If this option is enabled, then only this fault can be assigned to auxiliary digital output 1 or auxiliary digital output 2, for indication to external system**.



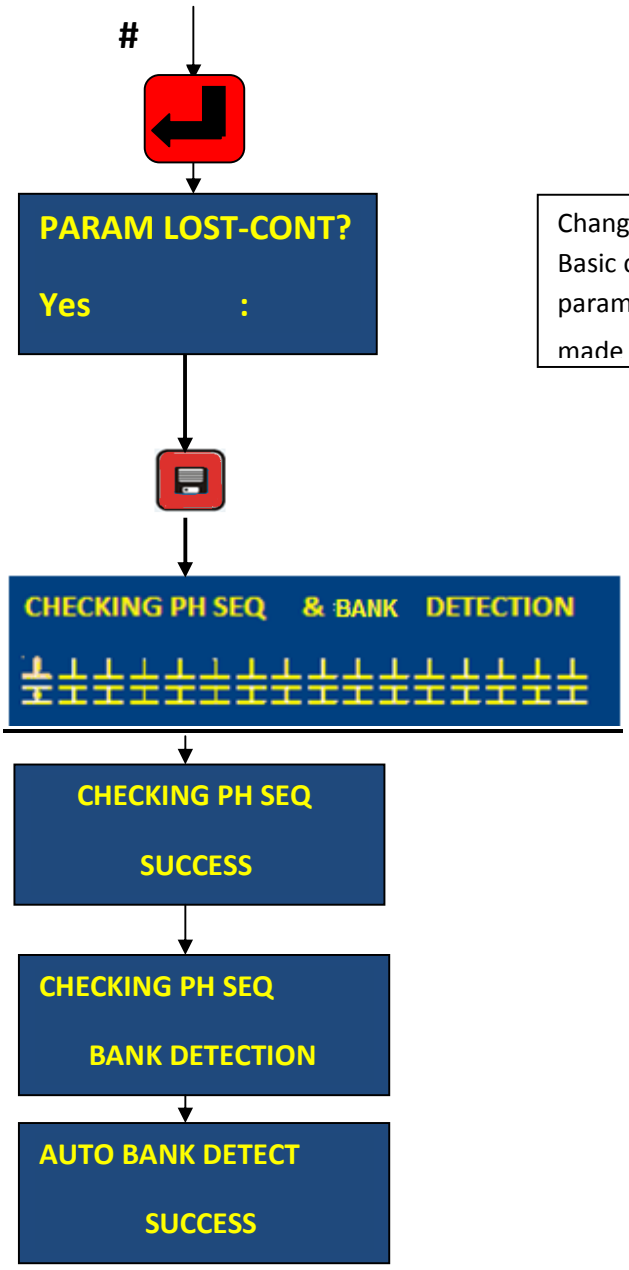
- **PF CORRECTION TIME**: Defined in seconds. This is the time between two consecutive kVAr compensations, i.e. time between change in load requirement & accordingly switching of capacitor bank(s). During this time in case any Key is pressed on the controller , the correction time is reset & again starts from zero.
- **DISCHARGE TIME**: Time defined here is the time in seconds for discharge of the Capacitor Banks to a level, so that they can be turned ON again at the end of discharge time.
- **INTERLEAVING TIME**: This is the switching time delay between two banks, switching one after other. For APFC-03, this parameter can be set from 1 to 9 second. Factory Default Setting is 1 second.
- **SMALLEST kVAr:** This multiplying factor defines the "no action zone" prohibiting the capacitor bank On/Off operation to avoid hunting. It can be set from 1.1 to 1.9. The factory default value is 1.5.
- **COMPENSATION BAND OFFSET:** This band is normally 50%-50% distributed around the Target PF line. This band size normally takes care of all the variations in supply voltage, frequency and harmonics changes, against the On-Off hunting of the Capacitor Banks. The band can be set from 0% to 100%. The factory default value is 50%.
- **STEPS CONNECTED**: Defines the number of total Capacitor Bank steps. Depending on PF system banks, this parameter is set.
- **FIX-BANK SETTING**: Defines the banks that are to be declared as fixed. These banks even in spite of over-compensation cannot be turned OFF. The banks can only be turned OFF under certain fault conditions.
- **CAP BANK VOLTAGE**: Defines the rated capacitor banks voltage at which the bank kVAr value is defined. It is indicated on the Capacitors as the rated voltage of Capacitor.
- **BANK kVAr [1….16]**: In APFC-03, every bank kVAr is to be defined at rated Voltage. APFC-03 has an in-built intelligent algorithm to select the best possible combination to suit the exact kVAr requirement for compensation.

B. Changing mode menu: (From Expert to Basic configuration)

In "CHANGE MODE" screen, there are two configurations: **E**xpert and **B**asic .



Controller remains in Expert mode if Line-to-Natural mode of configuration is SET, Because Basic mode will run on only Line-to-Line (Quadrature) connection.

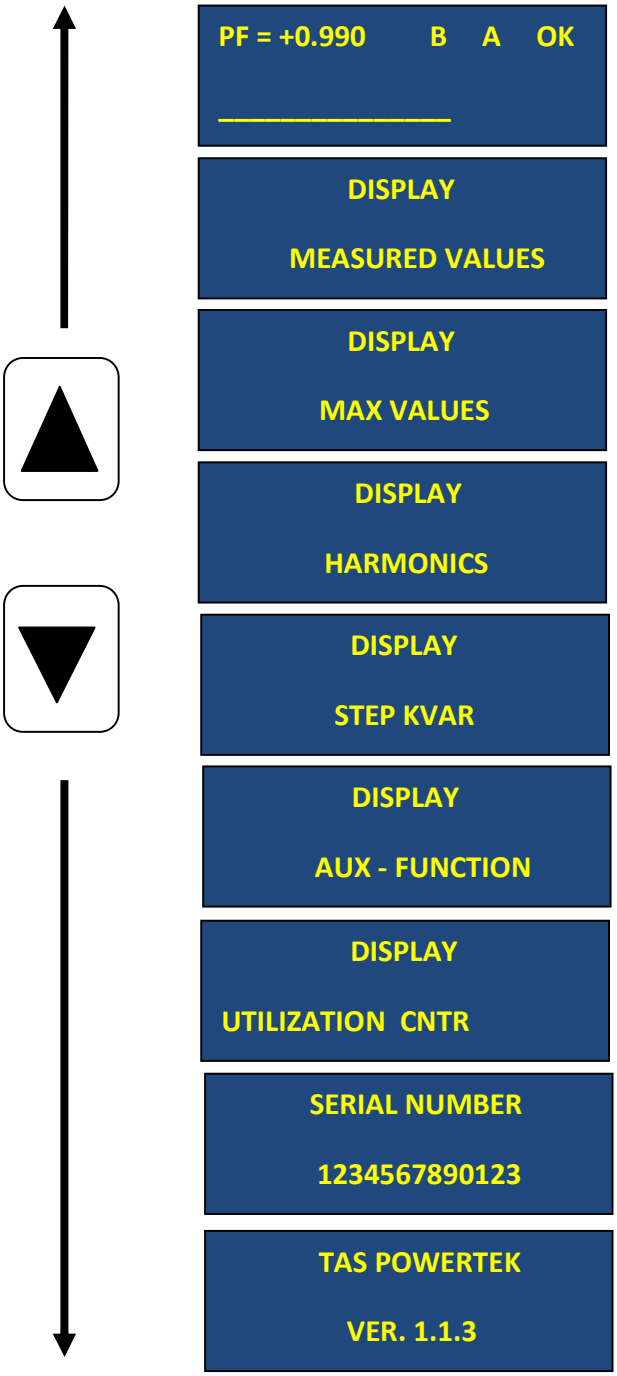


Changing from Expert configuration to Basic configuration would cause all the parameter settings on the controller made by user to be **lost.**

While changing the mode from "**Expert" to "Basic" mode**, a screen "PARAM LOST-CONT?" appears. This indicates that while entering into Basic mode from Expert mode, previous stored (edited) values of parameters in the Expert mode would be lost. If the user still wishes to continue to enter into the Basic mode, then one has to enter and press "Yes: 1" and press the "SAVE" key after which controller would in-corporate all the default parameter values and automatic synchronization would start. After it completes the automatic synchronization functionality, the controller enters into the "AUTO BANK DETECTION" feature which is a unique feature provided in APFC-03. In this, APFC-03 automatically detects all the physically connected capacitor banks without the requirement of user edited values as been done in the Expert mode menu.

Display of various parameters:

Values of various parameters can be viewed by the UP / DOWN key and then pressing the ENTER key. To exit a sub-menu, press MODE key.



- **MAIN SCREEN**: This is factory set default screen giving information on PF, functionality mode, operating mode and controller health status.
- **MEASURED VALUES:** give the measured values of the system parameters like V, I, kW, kVAr, kVA, C-kVAr and line frequency.
- **MAX VALUES**: gives the maximum values of V, I, kW, kVAr and kVA, detected after the last reset. This also has the facility of resetting the maximum values manually which would be the actual instantaneous values and not zero.
- **Display Harmonics / THD:** for voltage and current. Also displays odd harmonics up to 15th.
- **DISPLAY STEP kVAr:** the measured kVAr values of each connected capacitor bank step.
- **DISPLAY AUX FUN:** the APFC unit's internal temperature, status and selection of auxiliary digital outputs.
- **DISPLAY UTILIZATION CNTR:** the bank utilization counter, i.e. number of times the bank is utilized and also displays the clear bank counter to 0. This helps in proper maintenance of the 3-Phase Power Contactors.
- **DISPLAY SR NO:** the unique serial number of the particular APFC Unit.
- **DISPLAY UNIT DETAILS:** the name and version of software. The firmware version number may be different, dependent on date of design updates.

EXPERT mode will have all the values in absolute form whereas **B**ASIC mode will display the values (system parameters) in terms of percentage of the respective parameters.

Sub-menu for display of parameters in Expert configuration:

MEASURED VALUES	MAX VALUES	HARMONICS	STEP kVAr	DISPLAY AUX-FUNCTION	DISPLAY UTILIZATION CNTR
MEASURED VOLTAGE	MAX-VOLTAGE	V-THD-F	STEP[01]kVAr	AUX OP1: TRIP FLT	UTILIZATION CNTR
00415.0V(L-L)	0000.0 V	000.0%	0001.0	STATUS: 0	BANK[1]:0000000000
MEASURED CURRENT	MAX - CURRENT	I-THD-F	.	AUX OP2: OVR TEMP	.
1000.5A	0000.0 A	000.0%	.	STATUS: 0	.
ACTIVE POWER	MAX-KW		.	INT-TEMPERATURE	BANK[16]:0000000000
000000.0KW	0000.0 KW		.	28 Deg C	CLR BANK[1] CNTR
REACTIVE POWER	MAX-kVAr		STEP[16] kVAr		No :
000000.0 kVAr	0000.0 kVAr		0000.0		.
APPARENT POWER	MAX-KVA				.
000000.0kVA	0000.0 kVA				CLR BANK[16] CNTR
C-KVAR	RESET MAX-VALUES				No :
000000.0	No :				
FREQUENCY					
50.0Hz					

In Expert configuration, all the values are displayed in their absolute engineering units.

Auxiliary Function has two auxiliary digital outputs. It shows the type of the auxiliary digital output functionality that the user has selected and also LCD Displays its status.

0: Logic "Low" signal (Internal Relay contact is open, i.e., Relay is in OFF State).

1: Logic "High" signal (Internal Relay contact is closed, i.e., Relay is in ON State).

Sub-menu for display of parameters in Basic configuration:

MEASURED VALUES	MAX VALUES	HARMONICS	STEP kVAr	DISPLAY AUX-FUNCTION	DISPLAY UTILIZATION CNTR
MEASURED VOLTAGE	MAX-VOLTAGE	V-THD-F	STEP[01] kVAr	AUX OP1: TRIP FLT	UTILIZATION CNTR
00085.1 % (L-L)	0087.6 %	002.5 %	0001.0%	STATUS: 0	BANK[1]:0000000000
MEASURED CURRENT	MAX-CURRENT	I-THD-F	.	AUX OP2: OVR TEMP	.
0009.5%	0009.5 %	003.3 %	.	STATUS: 0	.
ACTIVE POWER	MAX -kW		.	INT-TEMPERATURE	BANK[16]:0000000000
000004.0%	0007.9%		.	28 Deg C	CLR BANK[1] CNTR
REACTIVE POWER	MAX_ kVAr		STEP[16]kVAr		No :
000006.4%	0006.4 %		0002.0%		.
APPARENT POWER	MAX kVA				.
000008.1 %	0008.2 %				CLR BANK[16] CNTR
C-KVAR	RESET MAX_ VALUES				No :
000.0 %	No :				
FREQUENCY					
50.0Hz					

Step kVAr is dependent on the number of banks connected, i.e. step kVAr of only those banks that are detected in the automatic bank detection functionality would be displayed.

Note: The line frequency parameter however, is not shown in percentage, but in absolute value in Hertz.

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.

V- Harmonics 03rd: 00.0 %
V - Harmonics 05th: 00.0%
V - Harmonics 07th: 00.0 %
V - Harmonics 09th: 00.0%
V - Harmonics 11th: 00.0 %
V- Harmonics 13th: 00.0 %
V - Harmonics 15th: 00.0 %

I - Harmonics 03rd: 00.0 %
I - Harmonics 05th: 00.0%
I - Harmonics 07th: 00.0 %
I - Harmonics 09th: 00.0%
I - Harmonics 11th: 00.0 %
I - Harmonics 13th: 00.0 %
I - Harmonics 15th: 00.0 %

Calculation in terms of percentage in Basic mode:

By Example:

Suppose the Line-to-Line voltage is 430V, CT used is 100A/5A, i.e. CT primary as 100 and total numbers of banks that are connected are 2. Both the Capacitor Banks kVAr values are 12 at 430 Vac each.

For Controller in Basic Configuration:

The rated nominal Line-to-Line voltage is 500V. The rated nominal CT primary is 5000.

Rated kVA**=**
Rated voltage (500) x Rated current (5000) x √3 / 1000 = 4330 is fixed.

Therefore the basic configuration will display the voltage, current and step kVAr values as follows:

Line voltage = (430 /500)* 100 = 86% (As the rated voltage in basic mode is **500 V-ac** which is the maximum operating controller voltage)

Load current = The 100% value considered is 5000Amp. As per the CT used, the calculation would display its corresponding percentage.

Thus, Bank % kVAr is calculated & then Displayed is as follows:

Bank kVAr at 500Vac is 12 x $(500/430)^2$ = 16.225 kVAr. (Normalization of Capacitor kVAr)
Used CT primary ratio is 5000: 100 i.e. ratio is "50".(Normalization of CT Primary Ratio).
Thus, effective kVAr of the Bank = 16.225 x 50 = 811.25 kVAr at 500V and with normalized CT ratio.

Step [01] kVAr= (811.25 / 4330) * 100 = 18.7 % (As bank is of 12 kVAr at 430V and as per CT of 100 Amp is to be defined at 500Vac rated voltage and 5000 Amp CT).

However the banks less than 0.5% of Rated kVA of the system cannot be detected.

Rated kVA of the system depends upon the maximum voltage and CT ratio.

Auto and Manual operation modes:

This controller has two modes of operation, “Auto” and “Manual”.

Auto Operation:

On this screen, pressing “ENT” key would put the unit in Auto Operation. This mode would continue till alternate option mode is selected or unit is put in Power down condition.

This is the mode in which the unmanned operation of automatically putting the capacitor bank in the electrical network, one bank at a time, in and out of circuit is performed.

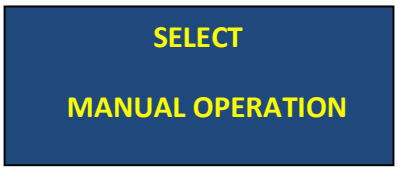
This mode should be normally selected with this controller, once the system is totally commissioned.

Here the kVAr compensation values are calculated by the controller and the closest equivalent capacitor combination is inserted in the system so that the PF is maintained within the desired level. This is as per the kW v/s kVAr graphs shown earlier in PF compensation part.

On the default display, the status of capacitor banks is seen. If any capacitor bank is sensed as faulty by this controller, it would mask the said bank and PF relay would search for new nearest value bank combination to maintain the target PF.

During the turn-on and turn-off of the capacitor banks, this controller does not turn them ON or OFF simultaneously. Between two successive capacitor switching operations, the delay of about 1 second is provided by this controller.

Manual Mode of Operation:



Pressing "ENT" button on this screen will put the controller in Manual mode. This mode will continue to run till it is purposefully changed or Power down. This mode is normally used to perform the operation like:

- Checking the capacitor banks by turning them ON/OFF.
- Resetting of faulty banks to healthy status.
- Declaring specific bank/banks faulty. Masking of the banks so that once auto mode is selected, these faulty declared banks would not be used.
- While commissioning, all the capacitor banks should be turned ON and should be checked regarding its healthy status.

For Declaring banks faulty or Resetting faulty banks:

In Manual mode default screen press "ENT". The cursor above bank 1 will start blinking.

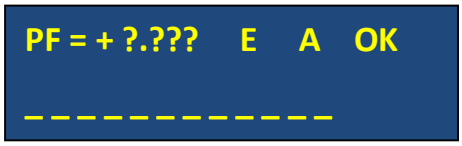
Use "left/right" keys to select the specific bank. Then use "down " key to declare the bank faulty. To reset the faulty bank, bring the blinking cursor to that bank and use "down" key to declare the bank as healthy.

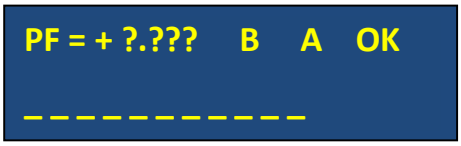
Once the specific banks are declared faulty or reset from faulty to a healthy status, press "ENT" key so that cursor stops blinking.

Note: As the primary objective of APFC is to control PF, it cannot be left in manual mode forever. Therefore, while the Unit is in manual mode and if no key is pressed for two minutes then the APFC will be automatically switched to AUTO mode of control by putting off all the capacitor bank steps first.

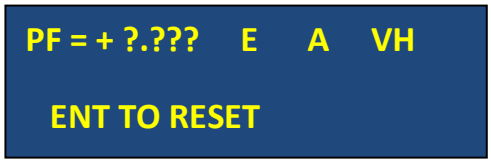
NOTES:

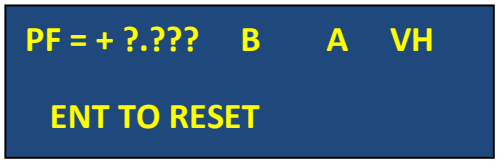
(1) If current CT connections are not connected to the APFC-03 Unit i.e. if no current is detected or the detected current is below 0.5% of rated load current, then, APFC-03 would show the following display on the LCD.

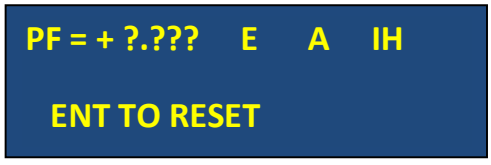


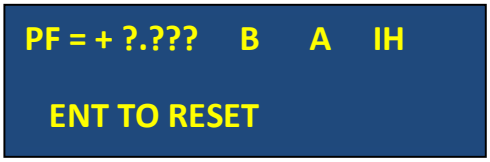


(2) If Harmonics overload fault is enabled and if the voltage or current THD exceeds the set limits, then APFC-03would flash the message "ENT TO (MANUAL) RESET" on the LCD display.









Pressing the Enter key, would reset the ***VH/IH*** fault even if voltage/current THD is above the set limit. The fault indication would continue till the respective THD is above the set limit. In case of THD above limit, all capacitor banks are switched off to protect them.

Auto Synchronization:

The **APFC-03** is an intelligent Micro-Controller based Automatic Power Factor Controller, for switching on or off capacitor bank steps, to maintain the Power Factor (PF) as close as possible to the target PF set.

For "*normal*" industrial loads and in the absence of any PF improvement, the load PF is inductive (lagging). The inductive reactive power is compensated by using capacitive reactive power with the right magnitude to bring the PF close to unity.

- The Quadrature scheme is possible only if the phase to phase voltage and the third phase load current feedback CT's are correctly wired to the PF controller. For example, the current of 'B' Phase must be connected to the current input channel when 'R-Y' voltage is connected to the voltage input channel. This should be with proper polarity, as per the wiring diagram shown in this user manual.
- However, if it is observed that in the field, during initial start-up itself or later during maintenance this proper phase relationships, phase to phase voltage and corresponding third phase current relationship gets disturbed due to wrong connections of CT or of Voltage. In such a situation, a PF controller without Auto Synchronization will not be able to do it's operation correctly. Or rather it's operation would be totally erratic and unpredictable.
- APFC-03 has an in-built intelligence, if enabled; it automatically detects the correct voltage phase sequence as well as current input channel, even though the proper connection order is not followed. It is even intelligent enough to detect the 'reverse' polarity of CT connections.
- Even though Auto-Synchronisation success probability is very high (almost 98%), in some cases where load fluctuations are extremely rapid or where system is highly under-loaded (current less than 5% of rated CT current), there is a possibility of Auto-Synchronisation failure. In such case, controller takes user to "TEST MODE" where User is expected to select right phase sequence, CT polarity and Capacitor bank sizing.

  If the operation is performed successfully, it is indicated on the LCD Display.

Disclaimer!

The accuracy specifications for the APFC are valid for the factory default 'Quadrature' mode of operation with voltage feedback from **R-Y phases** and load current feedback from **B phase**. Similarly, 'In-phase' mode is used then the factory default voltage feedback from **R-N phase** and supply current feedback from **R phase**.

In Any other alternate phase sequence, the controller will work because of auto synchronization facility. The accuracy specification may slightly degrade.

Auto Capacitor Bank Detection :

For individual Capacitor Bank kVAr and total number of Capacitor Banks**:**

- **APFC-03** has an intelligent algorithm that is "Auto Bank Detection" when it is set to operate in the basic mode.
- When the controller is set to operate in the basic mode, then it first incorporates all the load default parameters and starts auto synchronization. After detecting the correct phase, the controller goes in the "Auto bank detection" mode.
- In basic configuration, controller does not have any edited or saved parameter values in it, as it is there in the Expert configuration. Therefore in basic configuration, it does not have any information related to capacitor bank size, number of banks connected etc. In this case, the smartest feature that is provided in APFC-03 is the "**Auto bank detection**".
- When the APFC-03 enters into the auto bank detection mode, it displays "CHECKING PH SEQ" and "BANK DETECTION" message on the LCD. In this, it will switch ON the first bank and will switch OFF the same bank. This is done for all sixteen banks one by one. It detects the number of banks that are physically connected. Sometimes, controller would take some multiple attempts with same banks for sensing banks size accurately.
- Once, the bank detection logic is accomplished, a message "BANK DETECTION SUCCESS" is displayed on the LCD screen.
- However, the banks that are less than **0.5% of the rated kVA** of the system are declared as not connected bank (zero kVAr). Rated kVA of the system depends upon the maximum voltage and CT ratio.
- In case of success in the auto bank detection algorithm, the APFC-03detects the number of banks that are physically connected as well as the kVAr values of those banks are displayed in the "Step kVAr" menu. PF compensation is done based on the automatic bank size detection method.
- In basic configuration, user does not have to involve much with manual efforts but can look into all the parameters in a user friendly manner.

  Note: In Basic mode to work correctly, it is essential that the user connects all working banks starting from bank 1 in a consecutive manner without leaving any intermediate step unconnected.

Commissioning Instructions:

Commissioning guidelines- After the panel is powered up

(A) Basic Configuration:

Because the Basic Configuration expects that the wiring in the panel is done perfectly alright, it attempts to switch on and switch off the banks to find the necessary bank kVAr information as well as the total number of banks connected. It is the user responsibility to do thorough checks of the panel wiring before switching on the power. In Basic Configuration, since no user inputs are required, the controller should be put in "Auto-Setup" by pressing Left and Right arrow keys of front keyboard simultaneously for a period of 1 second.

(B) Expert Configuration:

1. All the MCB's / MCCB's for capacitor protection shall be kept in ***OFF*** position.
In case of fuses all the fuses in series with every capacitor bank shall be removed.
Connect the supply to the controller. Keep the load feedback CTs in shorted condition.

2. Turn On the supply to the panel and set various parameters as per the panel configuration. For using Expert mode, it is essential to understand the meaning of every parameter and then put the appropriate values in them. Wrong values entered can give the incorrect performance of the panel.

3. Once the parameterization is completed then put the APFC-03 in Manual mode to check every bank Contactor is operational from APFC-03. This can be carried out by keeping the control supply to contactor coils ON. By checking that ON command from APFC-03 is reaching the specific Contactor, by observing their respective ON / OFF operations.

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

5. Put APFC-03 back in Manual mode and turn ON/Off the individual bank. Use Current measurement clamp-on meter (ac current measurement) to check that current in all the three phases of the corresponding bank are OK. It should be approximate 1.4 times the kVAr capacity of the capacitor bank step.

6. Keep all the banks in off mode. Remove the shorting of Load feedback CT. In case kW value is seen as negative, it means CT is with wrong polarity. Correct the polarity with proper physical connection. Put the APFC-03 in Automatic mode.

Note: Observe the panel performance for a period of about 2 Hours after the commissioning.

Fault finding Guidelines and Trouble-shooting procedures

Fault finding guidelines:

Fault Type	Probable Reason	Action to Take
Unit Does not turn ON LCD is blank with no Backlight	• Input supply is not coming • Input side fuses blown	• Check the input supply to restore • Check all fuse in the unit for OK
If any capacitor bank or selected banks could not turn on immediately after Power on Unit.	• This is perfectly OK when correction time delay is set, which causes unit to turn ON outputs only after delay is finished. • However if the user is sure that the capacitors are discharged completely and does not want to wait for the discharge time then user can press the "**Left key**" and come out of the discharge time.	• As this is normal operation, it does not need to take any specific action. Unit will start performing normally after the stipulated time delay.
APFC-03 does not indicate the improved PF, even though Capacitor Banks are Turn ON	• Check that Load CT & connect it in correct phase on mains source side. • Check if CT secondary terminal selected is 5Amp or 1Amp and check if it is wrongly wired.	• Correct the wiring as per the scheme requirements and the CT positioning or run Auto-synchronization.
Contactor(s) controlled by this unit is / are not turning ON/OFF even if front LCD indication shows it correctly	• Control wiring to contactor is open circuit • Internal fuse at relay stage blown off due to some momentary short circuit in control.	• Check the continuity for any open circuit • Replace the externally accessible fuse(s) of the unit. While replacing fuse make sure about the proper type and rating

Parameter Settings:

Parameter	Min	Max	Default
General IO			
Mode password (Basic or Expert)	0000	9999	0001
Program password (Only for Expert configuration)	0000	9999	0002
Load default (Yes/No)	-	-	No
Aux OP 1: NONE TRIP FLT OVER TEMP OUT OF BANK	-	-	TRIP FLT
Aux OP 2: NONE TRIP FLT OVER TEMP OUT OF BANK	-	-	OVER TEMP
System			
Voltage meas. Mode (L-N/L-L)	-	-	L-L
Rated Supply Voltage (L-L) (L-N)	110 110	500 288.5	415 240
CT ratio	1	6500	1000
PF Target (Ind / Cap)	-	-	Ind
PF Target	0.700	0.999	0.999
Power-on auto sync (Yes/No)	-	-	No
Faults			
Over voltage fault (Fast OFF /Disable)	-	-	Fast OFF
Over voltage limit (%)	105	125	110
Under voltage fault (Fast OFF: /Disable:)	-	-	Fast OFF
Under voltage limit (%)	70	95	85
Temperature fault (Fast OFF /Disable)	-	-	Fast OFF
Temperature limit (Deg Celsius)	50	65	60
Harmonic overload(Enable /Disable)	-	-	Enable
V-THD threshold limit (%)	1	20	5
I-THD threshold limit (%)	3	150	25
Harmonic Fault Reset(Enable/Disable)			Enable
Step health check(Enable/Disable)	-	-	Disable
Bank kVAr fault tolerance (% of rated)	3	50	20
Out of BANK (Enable / Disable)	-	-	Enable

Step			
Correction time (seconds)	1	1200	00120
Discharge time (seconds)	1	1200	00060
IntrLeavingDely (seconds)	1	9	00001
Smallest KVAR safety Factor	1.1	1.9	1.5
Compensation Band Offset in %	000	100	050
Steps connected	1	16	16
Fix bank setting	-	-	-
CAP Bank Voltage (L-L)	110	600	00440
Bank kVAr[1] …. [16]	1	65535	-

FAULT	**FAULT ACTION**
Over Voltage (OV)	Fast OFF (All banks simultaneously off)
Under Voltage (UV)	Fast OFF (All banks simultaneously off)
Over Temperature (OT)	Fast OFF (All banks simultaneously off)
Over Frequency (OF)	Normal banks + Fixed banks OFF, one bank off at a time
Under Frequency (UF)	Normal banks + Fixed banks OFF, one bank off at a time
Voltage Harmonics (VH)	Normal banks + Fixed banks OFF, one bank off at a time
Current Harmonics (IH)	Normal banks + Fixed banks OFF, one bank off at a time
Out of Bank (OB)	Due to insufficient Capacitor. Banks, requirement of KVAr is not satisfied

Action of Fast-off during fault means all banks are simultaneously turned off. For others only one bank is turned off at a time.

The “Auto synchronization pending (AS)” fault is seen on the LCD display if any of the system faults like, OV, UV, VH or IH exists and the user enters into auto initialization mode. This status fault indications would continue to exist until the above mentioned faults (if all faults) are cleared. After the fault gets cleared, the Controller would start auto-synchronization on its own.

Note: The Measurement Voltage Feedback Potential Transformer (PT) ratio is internally set as 1:1 (primary: secondary).

Field Commissioning & Set-up Records for the Specific Project Site Use:

Parameter	As on date	As on date	As on date
General IO			
Mode password			
Program password			
Load default (Yes/No)			
Aux OP 1: NONE TRIP FLT OVER TEMP OUT OF BANK			
Aux OP 2: NONE TRIP FLT OVER TEMP OUT OF BANK			
System			
Voltage meas. Mode (L-N/L-L)			
Rated Supply Vtg (L-L) / (L-N)			
CT ratio Primary			
PF Target (Ind /Cap)			
PF Target			
Power-on auto sync (Yes/No)			
Fault			
Over voltage fault (FastOFF/Disable)			
Over voltage limit (%)			
Under voltage fault (FastOFF /Disable)			
Under voltage limit (%)			
Temperature fault (FastOFF/Disable)			
Temperature limit (%)			
Harmonic overload(Enable/Disable)			
V-THD threshold limit (%)			
I-THD threshold limit (%)			
Harmonic Fault Auto Reset(Enable/Disable)			
Step health check(Enable/Disable)			
Bank kVAr fault tolerance			
Out of Banks FLT (Enable/Disable)			

Step	As on Date	As on Date	As on Date
Correction time (seconds)			
Discharge time (seconds)			
IntrLeavingDely:			
Smallest KVAR safety Factor			
Compensation Band Offset in %			
Steps connected			
Fix bank setting			
CAP Bank Voltage (L-L)			
Bank kVAr [1]			
Bank kVAr [2]			
Bank kVAr [3]			
Bank kVAr [4]			
Bank kVAr [5]			
Bank kVAr [6]			
Bank kVAr [7]			
Bank kVAr [8]			
Bank kVAr [9]			
Bank kVAr [10]			
Bank kVAr [11]			
Bank kVAr [12]			
Bank kVAr [13]			
Bank kVAr [14]			
Bank kVAr [15]			
Bank kVAr [16]			

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