ACCUVAR

KVAR based Controller for LT Capacitor Banks

USER MANUAL

TRINITY

User's Manual

ACCUVAR
KVAR BASED CONTROLLER FOR LT CAPACITOR BANKS

This document contains the latest technical information about ACCUVAR which is a microcontroller based KVAR controller for LT capacitor bank. The product, ACCUVAR is sophisticated electronic equipment and, the user is advised to read this User's Manual carefully before attempting to install or operate the equipment.

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Introduction:

Every Power distribution system requires reliable metering of various electrical parameters. From the electricity user's point of view, this is important for saving of electrical energy, where-ever possible. Not only should his distribution transformer be loaded optimally, but it should also operate at near unity power factor. The load imbalance on the three phases should be within reasonable limits. Thus, information like amount of loading imbalance, power factors at different times of the day, peak loading hour etc. can be of great help in planning usage of power and also implementing automatic switched capacitor systems to maintain power factor near unity. This is where ACCUVAR comes in. ACCUVAR is a KVAR based controller which controls capacitor banks optimally to achieve near unity power factor and also which measures/calculates various electrical parameters. ACCUVAR is meant for use in three phase four wire electrical system. It uses the three watt-meter method to calculate KVA, KW & KVAR.

ACCUVAR is based on a powerful micro-controller. The controller receives voltage & current signals and performs high speed measurement and calculations, typically finishing one complete measurement cycle in less than a second.

The unit displays all parameters locally on a 128 x 64 Display. The user-friendly keypad on the front makes programming the unit (for C.T. ratios etc.) very easy.

ACCUVAR is thus a very versatile controller and accurate information interface for the user.

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The Main Features Available in this Model

- 3P4W electrical system
- Three powers: KW, KVA and KVAR
- Three phase voltages (Vr, Vy & Vb) and currents(Ir, Iy, Ib)
- Auto phase sequence and polarity detection and correction
- Active energy (KWh) and apparent energy (KVAh)
- Capacitor CT sensing enable/disable selection
- CT ratio for both load current and capacitor current selectable
- PT ratio is site programmable
- Capacitor current (I cap)
- Phase-Wise PF, System PF and Average integrated PF
- Autosense/Manual types of KVAr control and the capacitor bank size of every stage display.
- Eight/twelve/fifteen stage relays controller with a one alarm selectable.
- Up to 15th Odd Harmonics and Total Harmonic Distortion (THD) for each Voltages and Currents

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Technical Specifications

Parameter		
Type	**Name**	**Statistics**
INPUT	Supply	Three Phase and Neutral of a 3P4W system
	Voltage	Direct Voltage Input : Up to 300V L-N Burden : 0.5VA
	Current	Secondary Current Input : 5A or 1A CT Ratio : Site Selectable Range of Reading : 5 - 5000A Burden : < 1.0VA Overload : 5A CT = 6A RMS Continuous : 1A CT = 1.2A RMS Continuous
	Power Supply	Self Powered from mains. Wide operating Voltage SMPS: 80 VAC - 480 VAC, 45-65 Hz.
OUTPUT	Relay	Switching Voltage : Max. 250 VAC Switching Power : Max. 1000W Expected Mechanical Life : $>10 \times 10^6$ switching operations. Expected Electrical Life : $>4 \times 10^6$ switching operations. @(Load = 200VA, Cos Ø = 0.5)

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Measurement

<table>
<tr><th colspan="3">Parameter</th></tr>
<tr><th>Type</th><th>Name</th><th>Statistics</th></tr>
<tr><td rowspan="4">True RMS Basic Parameters</td><td>Voltage
(Volts L-N: VRN, VYN, VBN)</td><td>Accuracy : 0.5% of Reading</td></tr>
<tr><td>Current
(Amps IR, IY, IB)</td><td>Accuracy : 0.25% of Reading</td></tr>
<tr><td>Capacitor Current</td><td>CT Ratio : Site Selectable
Accuracy : 1.0% of Reading</td></tr>
<tr><td>Line Frequency</td><td>45 to 65 Hz, Accuracy : 0.3% of Reading</td></tr>
<tr><td rowspan="4">Power</td><td>Active Power (P)</td><td>Accuracy : 1.0% of Reading (For IPFI>0.9)</td></tr>
<tr><td>Reactive Power (Q)</td><td>Accuracy : 1.5% of Reading
(Between 0.5 Lag to 0.8 Lead)</td></tr>
<tr><td>Apparent Power (S)</td><td>Accuracy : 1.0% of Reading</td></tr>
<tr><td>Power Factor</td><td>Accuracy : 1.0% of Reading (IPFI≥0.5)
Range of Reading : 0.05 to 1.00 Lag/Lead</td></tr>
<tr><td rowspan="3">Energy</td><td>Total Active Energy (KWh)</td><td>Range of Reading : 0 to 9999999.9 KWh
Accuracy : 1.0S as per IS13779.</td></tr>
<tr><td>Total Apparent Energy (KVAh)</td><td>Range of Reading : 0 to 9999999.9 KVAh
Accuracy : 1.0% of Reading</td></tr>
<tr><td>Total Reactive Energy (KVARh) (Lag & Lead)</td><td>Accuracy : 1.5% of Reading
Range of Reading : 0 to 9999999.9</td></tr>
<tr><td>Misc.</td><td>Cap. Bank KVAR</td><td></td></tr>
</table>

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Miscellaneous

Parameter		
Type	**Name**	**Statistics**
Dimensions	Bezel	144 X 144 mm
	Panel Cutout	138 X 138 mm
	Depth of installation	55 mm
	Operating temp	10 ^{0}C to 50 ^{0}C
	Weight	0.82 Kgs (Approx.)
	Min. Operating Current	1% or 5% of CT primary for FIFO/SFIFO Mode

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Installation and Commissioning

To install and commission the unit, proceed the following instructions:

1. Push the unit into the Panel and mount it by using the clamps provided.
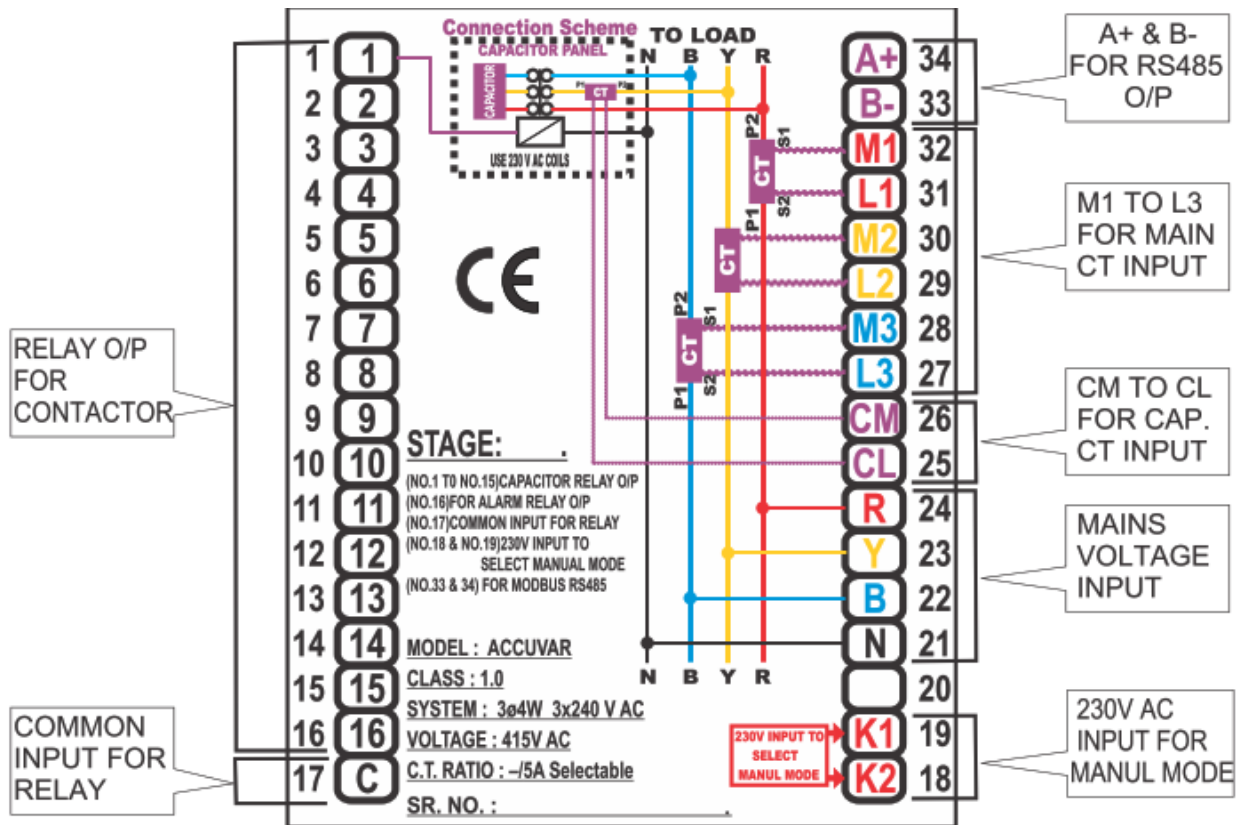
Back View (Connection Scheme) of the Unit

2. Connect the three phases with the phase sequence being R-Y-B to the terminals marked R, Y and B accordingly such as shown above Connection Scheme. Make sure that the three phases coming to the unit come through control fuses 1.0 Amp rating. This will protect the electronics inside from damage due to severe over voltages or phase faults in the system.

3. Connect the neutral wire to the terminal marked N.

4. Connect the two wires from the R-phase main CT to terminals marked M1 & L1 such that S1 from CT goes to M1 on the unit. Connect the two wires from the Y-phase main CT to terminals marked M2 & L2 such that S1 from CT goes to M2 on the unit. Connect the two wires from the B-phase main CT to terminals marked M3 & L3 such that S1 from CT goes to M3 on the unit.

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5. Connect the two wires from the Y-phase capacitor CT to terminals marked CM & CL such that S1 from CT goes to CM on the unit.

6. Switch on the three phases supply. Unit will power on from these three phases supply.

7. First of all, user should program the following parameters of the unit: CT RATIO FOR MAIN CTs, CT RATIO FOR CAPACITOR CTs, ALARM MODE. Refer Operational Details in the next section. The proper operation of the relay can commence only after these three parameters are defined.

8. Ensure that all capacitors are in the circuit i.e. all fuses link pushed in. Give Autosense (Refer Operational Details in the next section). ACCUVAR will first display 'AUTOSENSING' and as it switches on one bank at a time and also, displays the bank size of every stage. After AUTOSENSING is completed, the unit will Reset.

9. In case user did not connect proper voltage and current I/p as described in second point, Phase sequence detection will help. In order to detect proper phase sequence, the load current should have a value greater than zero. The unit will switch ON and OFF the bank selected by user in REF_BANK, in order to perform auto correct. If load is nonlinear or too many sudden changes occur in the load during this process, it may not be able to correct the connection. In this case, user must disable non linear load temporarily and repeat the process or can manually enter the phase sequence value. Make sure to connect three phase capacitor bank on selected REF_BANK number.

10. Now, the unit is ready for the control action after a 1 minute delay.
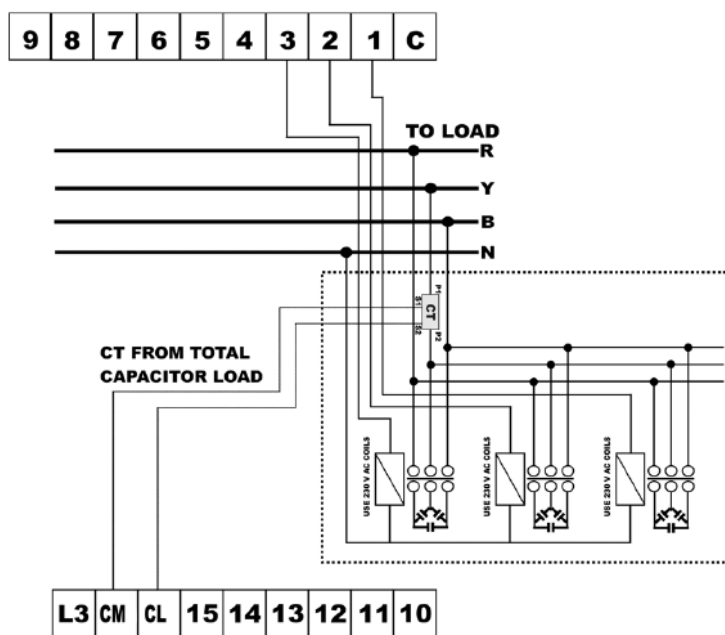

Capacitor Panel Connection Scheme

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Operational Details

The KVAR Based Controller for LT Capacitor Banks, ACCUVAR is a versatile meter, with all the features needed to implement a robust electrical load management system. It can be configured to suit most PF control needs and this is achieved by making as many parameters field programmable as possible.

There are basically two modes of operation in ACCUVAR:

1. Programming Mode
2. Run Mode

After supplying power (80 VAC - 480 VAC), the unit displays immediately power on display message and by default, the display comes into Run Mode such as shown below.
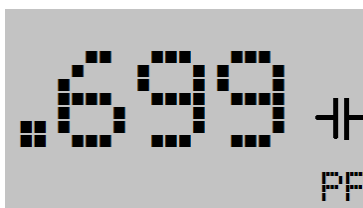
Now, the unit can be operated by using the following keypad provided for both the Programming Mode and Run Mode.

Press (PROG RUN) key for about five seconds continuously, to go from Run mode to Programming Mode. The first screen in this mode is:

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Programming Mode

In order to set all the field programmable parameters, the user has to press the keys such as, (PROG/RUN), (▲), (▼) And (ENTR) . Once the display is in Programming Mode,

Press key to set the values for the following parameters:

1. CT Ratio for load current

2. PT Ratio

3. Mode of control action FIFO, SFIFO, PID or VAR

4. Capacitor CT Ratio (If Enable)

5. Desired PF setting

6. Switching (Thyristor or Contactor)

7. Number of Capacitor bank stages

8. Meter Address

9. Baud rate

10. Alarm Mode

11. Alarm limit - PF setting below which alarm will operate

12. Alarm Delay - Delay after which alarm should operate

13. Switching Delay - Delay between two successive switching operation of Relay

14. Damp Factor for settling the sensitivity level for control action

15. Reference Bank number

16. Auto phase input sequence detection

17. phase input sequence setting for all three channels

18. Min bank

19. Auto sense of capacitors

20. Minimum Operating current for FIFO and SFIFO mode

21. PF value to switch OFF banks

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1. **Setting Main CT Primary, Main CT Secondary, PT Ratio and Mode of control action.**

In order to give actual voltage and current values in your system, Main CT Primary and Secondary as well as PT Ratio should be set. Main CT Primary can be select from 5 to 5000. main CT Secondary can be select 1 or 5. PT Ratio can be select from 1, 3.7727, 4.0, 6.2727, 30, 60, 100, 200, 300, 600 and 1200.

For PF correction, there are four types of Control Action such as VAR, PID, SFIFO and FIFO which are selectable at site. In case the control action is selected to VAR, Minimum Bank, Capacitor CT and AUTOSENSING become relevant as programmable parameters. However, these parameters are not applicable in case of FIFO or SFIFO mode control action.

To set above parameters, proceed as follows:

Once in Programming mode,

1. Set Arrow (>) to the desired parameters using ▲ and ▼ keys and press (ENTR) key. Now Arrow (>) starts blinking which means value of this parameter can be set now. Set desired value by using ▲ and ▼ keys and again press (ENTR) key to save its value.

```
MCT-PRI=500
MCT-SEC=5
PT-RATIO=1
CONTROL=VAR
```

2. If other parameters need to be changed, do so using similar method. Else, press (PROG/RUN) key for about four seconds continuously. The unit will restart and enter into run mode.

2. **Setting Capacitor CT Enable, Capacitor CT Primary and Secondary and Desired PF**

In VAR control action mode, using capacitor CT, proper Bank KVAR can be sensed. Capacitor CT Primary and Capacitor CT Secondary will be enable in case of CAP_CT_ENB is set to YES. Capacitor CT Primary can be set from 5 to 5000. Capacitor CT Secondary can be set to 1 or 5. The desired PF can be set to either LEAD or LAG according to user's requirement. In case of LAG, the PF could be set from 0.800 to 1.000. In case of LEAD, the PF could be setting from 1.800 to 1.999. e.g., the PF to be set for 0.998 LEAD should be set as 1.998.

To set above parameters, proceed as follows:

Once in Programming mode,

1. Set Arrow (>) to the desired parameters using ▲ and ▼ keys and press (ENTR) key. Now Arrow (>) starts blinking which means value of this parameter can be set now. Set desired value by using ▲ and ▼ keys and again press (ENTR) key to save its value.

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```
CAP-CT-ENB=YES
CCT-PRI=50
CCT-SEC=5
SET-PF=1.000
```

2. If other parameters need to be changed, do so using similar method. Else, press (PROG/RUN) key for about four seconds continuously. The unit will restart and enter into run mode.

3. **Setting Switching, Number stages, Meter Address and Baud rate**

Normal (Contactor) OR Fast (Thyristor) switching is Site selectable. ACCUVAR supports up to 15 capacitor bank stages. For user's system requirement, the number of active stages can be selected from 2 to 15. This is helpful in cases where the relay has been purchased for higher number of stages but presently, fewer stages have been actually connected. The Relay has RS485 port for external communication as an optional feature. ACCUVAR supports MODBUS-RTU protocol on RS485 port. Each device on RS485 bus should have unique address for proper functionality. Unit Address value is programmable from 1 to 255. The baud rate for communication is programmable between 9600 or 19200.

To set the desired PF above parameters,

Once in Programming mode,

1. Set Arrow (>) to the desired parameters using (▲) and (▼) keys and press (ENTR) key. Now Arrow (>) starts blinking which means value of this parameter can be set now. Set desired value by using (▲) and (▼) keys and again press (ENTR) key to save its value.

```
SWITCH=THYR.
STAGE=2
UNIT ADDR=5
BAUD RATE=9600
```

2. If other parameters need to be changed, do so using similar method. Else, press (PROG/RUN) key for about four seconds continuously. The unit will restart and enter into run mode.

4. **Setting operation type, Alarm Mode, Alarm Limit and Alarm Delay**

If you have Solar panel installation at your site, select Solar else select Normal mode for proper control action. The relay has an inbuilt alarm mode. In case, the relay ordered is of 8 stage, selecting the alarm mode as NO will keep it as 8 Stage relay. The Control action will cover 8 Relays. If, however, you have selected alarm mode other than NO, the relay will effectively become 8+1ALARM stage relay and the 16th stage will be used as an alarm Contact.

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Thus, in a fifteen-stage relay, alarm mode NO means a 15 stage Relay, while alarm mode other than NO will make it as 15 stage Relay, with 16th stage used as an alarm contact. There are two additional parameters which need to programmed. i.e. Alarm Limit and Alarm Delay. In Alarm mode, if the selected parameter remains below/above the Alarm Limit, continuously for Alarm Delay time, the alarm relay will become ON. The hooter connected to this stage can be silenced by pressing any key. Alarm Mode can be set on PF, I_THD, V_THD or NO. Alarm mode PF will cause alarm when PF remains below the limit. For alarm mode I_THD or V_THD, alarm will occur when the THD values for current/voltage are above the programmed ALARM LIMIT. The Alarm Limit is programmable from 0.800 to 0.999 for PF Mode. same can be set between 10 to 80% of V_THD & I_THD. The sign of PF is not considered. Alarm Delay value can be set from 20 to 180 seconds.

To set the above parameters, proceed the following instructions:

Once in the programming mode,

1. Set Arrow (>) to the desired parameters using ▲ and ▼ keys and press (ENTR) key. Now Arrow (>) starts blinking which means value of this parameter can be set now. Set desired value by using ▲ and ▼ keys and again press (ENTR) key to save its value.

```
OPER.=NORMAL
ALRM MODE=PF
ALRM LMT=0.800
ALRM DLY=20
```

2. If other parameters need to be changed, do so using similar method. Else, press (PROG/RUN) key for about four seconds continuously. The unit will restart and enter into run mode.

5. Setting Switch Delay, Damp, Reference Bank number and Auto Phase Input Detection

Switch Delay is one type of digital dead band. In fast switching mode Value can be set from 1 to 10 and in normal switching mode value can be set from 40 to 120. The Damp value should be set from 5 to 20 in normal switching mode and 1 to 10 in fast switching mode so as to slow down the response of the control algorithm. Setting a higher value of DAMP will slow down the response of the relay to transient jumps in system KVAR values. The unit will switch ON and OFF the bank number selected by user in REF_BANK, in order to detect phase sequence of inputs.

NOTE: Make sure to connect three phase capacitor bank on selected REF_BANK number. Auto phase input detection can use to detect phase sequence error and correct all values according to detection. In order that this feature works, the load current should have a value

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greater than zero. The unit will switch ON and OFF the bank selected by user in REF_BANK, in order to perform auto correct. If load is nonlinear or too many sudden changes occur in the load during this process, it may not be able to correct the connection. In this case, user must disable non linear load temporarily and repeat the process or can manually enter the phase sequence value.

To change the above parameters, proceed the following instructions:

Once in the programming mode,

1. Set Arrow (>) to the desired parameters using ▲ and ▼ keys and press (ENTR) key. Now Arrow (>) starts blinking which means value of this parameter can be set now. Set desired value by using ▲ and ▼ keys and again press (ENTR) key to save its value.

```
SWITCH DLY=60
DAMP=10
REF-BANK=1
CHECK-SEQ.?YES
```

2. If other parameters need to be changed, do so using similar method. Else, press (PROG RUN) key for about four seconds continuously. The unit will restart and enter into run mode.

6. Setting phase Input sequence for all channels and Minimum Bank

If phase Inputs are not connected at proper voltage and current terminals, user can manually set it for all three channels. For example, if voltage and current of R phase are connected to terminal marked R and M3/L3 respectively, user have to set CH1_SEQ to M3/L3. Min.Bank (Minimum Bank) value can be set either to 100% or 75%. In VAR and PID mode, Accuvar will take control action if it finds that the needed KVAR is larger than the smallest bank connected. e.g. if it finds that in order to achieve the desired PF, the system needs to add/remove 8 KVAR, but the smallest bank connected to the system is 10 KVAR, it will not switch, if the MIN BANK is set to 100%. If however it is set to 75%, it will take switching action. (because 75% of 10KVAR is 7.5KVAR).

To change the above parameters, proceed the following instructions:

Once in the programming mode,

1. Set Arrow (>) to the desired parameters using ▲ and ▼ keys and press (ENTR) key. Now Arrow (>) starts blinking which means value of this parameter can be set now. Set desired value by using ▲ and ▼ keys and again press (ENTR) key to save its value.

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```
CH1-SEQ=M1/L1
CH2-SEQ=M2/L2
CH3-SEQ=M3/L3
MIN.BANK=100%
```

2. If other parameters need to be changed, do so using similar method. Else, press ⓟⓡⓞⓖ/ⓡⓤⓝ key for about four seconds continuously. The unit will restart and enter into run mode.

7. Auto Sense, Setting Minimum operating Current and PF Value to Switch OFF Banks

When the Auto Sense is set to YES, the unit switches on all relays one by one. The bank sizes will also display as they get sensed one by one and the user therefore must be patient and wait for about 4 to 5 minutes while the autosense is in progress. This process is vital for the smooth operation of the relay. Once all capacitor banks have been sensed, the relay will restart for control action and also display the parameters one by one.

Minimum operating current is used to set minimum current required to start control action in FIFO and SFIFO mode. If this parameter is set to "Sensitive" it will do control action until current goes below 1% of Main CT Primary. If this parameter is set to "Normal" it will do control action until current goes below 5% of Main CT Primary.

Offset_PF can be used to switch OFF banks in FIFO and SFIFO mode. If target PF is set on Lag side it will switch OFF banks if PF goes below 0.980 lead. If Target PF set on the lead side, it will switch OFF banks when PF goes below this parameters value. Value of "OFF_SET" parameter can be set from 1.780 to (Target_PF-0.02).

To change the above parameters, proceed the following instructions:

Once in the programming mode,

1. Set Arrow (>) to the desired parameters using (▲)and (▼) keys and press (ENTR) key. Now Arrow (>) starts blinking which means value of this parameter can be set now. Set desired value by using (▲) and (▼) keys and again press (ENTR) key to save its value.
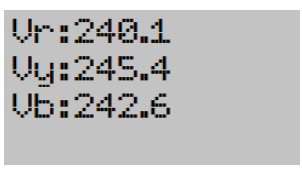
```
AUTO SENSE?YES
M-OPR=NORMAL
OFF-SET=1.780
```
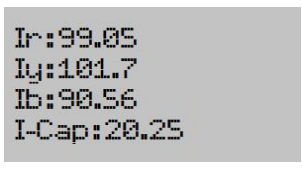
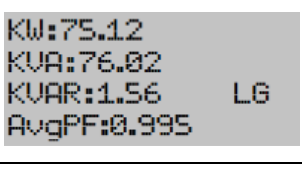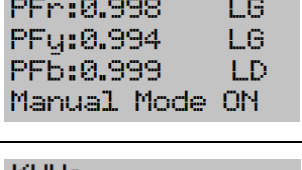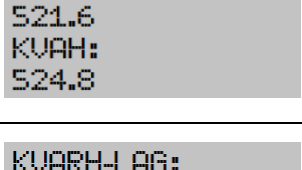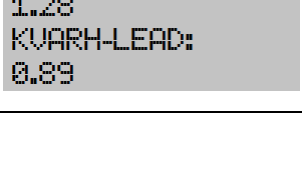2. If other parameters need to be changed, do so using similar method. Else, press ⓟⓡⓞⓖ/ⓡⓤⓝ key for about four seconds continuously. The unit will restart and enter into run mode.

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Run Mode

In the run mode, the various parameters calculated by the ACCUVAR are displayed on different pages on a 128 x 64 Display.

1. Screen Displays

Press ⬆ Or ⬇ keys on Run Mode so as to receive the following displays:

Display	Descriptions
.699 ⊣⊢ PF	This page shows system PF value. It will show inductor and capacitor symbols for Lag and Lead respectively.
Vr:240.1 Vy:245.4 Vb:242.6	This page shows voltages of R, Y and B phase.
Ir:99.05 Iy:101.7 Ib:90.56 I-Cap:20.25	This page shows currents of R, Y, B and capacitor. If value is less than 100, it will show 2 decimal digits else it will show 1 decimal digits.
KW:75.12 KVA:76.02 KVAR:1.56 LG AvgPF:0.995	This page shows System KW, KVA, KVAR (With LG/LD indication) and Average PF since last reset of energy or average PF.
PFr:0.998 LG PFy:0.994 LG PFb:0.999 LD Manual Mode ON	This page shows individual PF of R, Y and B phase with LG/LD indication. It will also display " Manual Mode ON" if user has apply AC voltage on K1 and K2 terminal.
KWH: 521.6 KVAH: 524.8	This page shows KWH and KVAH. If value is less than 100, it will show 2 decimal digits else it will show 1 decimal digits.
KVARH-LAG: 1.28 KVARH-LEAD: 0.89	This page shows KVARH of LAG and LEAD individual. If value is less than 100, it will show 2 decimal digits else it will show 1 decimal digits.

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Vr Hrm[%]	9th	3.0
3rd 2.1	11th	0.6
5th 0.5	13th	1.1
7th 1.5	15th	0.3

This page shows up to 15th Odd harmonics value of R phase volts.

Ir Hrm[%]	9th	1.5
3rd 1.2	11th	0.6
5th 0.3	13th	1.1
7th 0.5	15th	0.9

This page shows up to 15th Odd harmonics value of R phase current.

Vy Hrm[%]	9th	0.5
3rd 3.3	11th	0.6
5th 0.3	13th	1.1
7th 3.0	15th	0.9

This page shows up to 15th Odd harmonics value of Y phase volts.

Iy Hrm[%]	9th	1.5
3rd 1.2	11th	2.6
5th 0.9	13th	1.1
7th 0.8	15th	1.1

This page shows up to 15th Odd harmonics value of Y phase current.

Vb Hrm[%]	9th	1.5
3rd 1.2	11th	0.6
5th 0.3	13th	1.1
7th 0.5	15th	0.9

This page shows up to 15th Odd harmonics value of B phase volts.

Ib Hrm[%]	9th	1.6
3rd 4.9	11th	0.7
5th 2.9	13th	1.1
7th 0.8	15th	0.6

This page shows up to 15th Odd harmonics value of B phase current.

THD[%]			
Vr	15.1	Ir	12.1
Vy	9.2	Iy	10.8
Vb	10.1	Ib	9.6

This page shows Total harmonic distortion (THD) of volts and current for R, Y and B phase.

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2. Resetting Average PF

The integrated average PF can be reset by pressing ⬆ key in Run Mode for about 5 seconds continuously. This integrated average PF is basically the ratio of KWh & KVAh energy consumption since last reset of energy or Average PF value. After reset the value will go to 1.00.

3. Freezing and unfreezing the AutoScroll

The Run Mode displays will always auto scroll by default with an interval of about 5 to 6 seconds. Each display can be frozen or unfrozen by pressing (ENTR) key and also be moved up and down by pressing ⬆ and ⬇ keys. When the display is frozen at one page, the display will show a 'F' in the lower right corner of display.

Control Outputs

The relays are protected by snubbers against fast voltage transients which occur when inductive loads are switched off and therefore, the following points should be taken care when using these relay contacts:

- Use 230V AC coils only in the contactors. DO NOT use 440V AC coils.
- DO NOT switch small loads like electronic Hooters, small relays with 230V AC coils etc., directly from the relay contact of ACCUVAR. If done so, the small leakage current from the snubbers will not allow these loads to be switched off fully. The electronic hooters thus will give a low hum continuously, and the small relays will switch on but not switch off.
- Use these relay contacts to switch an Auxiliary contactor and put the load on the contactor contacts.

For correct operation, various points in the system need attention and unless these are correctly set up, proper operation cannot be expected.

These points are noted in section (A) and (B) such as subsequent sections deal with operational checks, setting up and trouble shotting.

System Considerations:

The Relay senses the total resultant power factor of the system and switches the Capacitors through the appropriate control gear in the panel so as to correct the power factor to the required level.

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To enable the Relay to measure the power factor correctly:

a. The R, Y, B voltage connections must be correct.

b. The voltage must be nearest (10% plus or minus) to the specified voltage for the Relay.

c. The control circuits of the panel, on which the Relay is mounted, are equally important. Using the built in Manual control is the easiest way to implement the system. It is also the most economical and trouble free. If user wishes to use external Manual Control, pay careful attention to signal flow. Push-buttons must be used for the contactors to enable automatic cutoff in the event of a power failure. Do provide isolating contacts for each contactor, otherwise the control can lock out in Auto, by feedback over the Manual Bus.

(A). Troubleshooting

The ACCUVAR is robust electronic equipment and must be handled with all the care merited by it. It is quite rugged and will withstand a few hard knocks, but this cannot make up for the deficiency in system design.

Repairs at site are not recommended because at most this can only be a patch work, and sustained reliability is difficult to achieve with a site repaired Relay. This section on Troubleshooting therefore deals with fault finding in the system and to establish whether the Relay is defective or whether it is a system problem. If the fault is seen to lie entirely with the Relay, it will have to be sent to factory for repairs.

System faults can be classified into three categories:

• Those related to the basic configuration of the system.
• Those related to the errors and mistakes in the implementation of the system design
• Those related to the faults in the actual equipment

a. Faults related to the actual system design:

The most common faults are:
External Manual Control not implemented properly,
>   Here many designers provide a 'Starter-relay' configuration for the manual control, and just bring the connection from the relay contact to the contactor.

There are two problems with this:

i. Timing function is not provided from Manual control.

ii. The scheme does not work in Auto ode. The remedy is to examine the drawings and make changes at site. The temporary remedy is to change the relay mode to Manual, and use the panel manually. The better alternative is to change the control wiring to incorporate suitable isolating contacts, timers etc. to make a proper system.

Faults related to the external cabling

Only two cables originate in the panel: the Power Incomer to the panel and the CT connections.

The power flow from the source (such as the main transformer) to the capacitor panel as well as to the entire load must be through the bus on which the CTs are mounted. It is best to provide separate CTs for the Relay to avoid problems.

b. Faults Related to the actual site conditions:

These faults occur when the actual site conditions are different from those assumed by the designer of the system. These faults relate to the location of the load feeders on the busbar, buscouplers, and connections from transformers etc. The locations of the CTs are the most important factor as far as the Relay is concerned.

Another problem frequently encountered is that of insufficient load on the power system. This might occur because the Plant has not been commissioned fully, or because the system allows for future expansion. In either case the actual current through the CT is very low compared to the rating of the CT.

In such conditions, the relay, (specially, if there are no small banks in the capacitor panel) will not take any control action at all. However, the transformer losses will cause the monthly average PF to show up as very poor. The remedy is to connect a small bank directly (independent of the automatic control scheme) for compensating transformer losses.

c. Faults related to the actual equipment:

These relate to the defects in the connected equipment. Again, an exhaustive list is beyond the scope of this document. A few are listed below:

Blown fuses, shorted CT, shorted voltage connections, switches that do not make contact, open connections etc. Check everything - before, during and after commissioning and you will be rewarded with a finely tuned system which will give you years of trouble-free service.

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(B). Troubleshooting Guide

(Read carefully section (A). Troubleshooting as before)

1. Relay is dead. Check that the specified voltages are available at the voltage terminals of the Relay. Do not check with a neon tester. Use a multi-meter and check physically the voltages available at the R-Y, Y-B and B-R terminals. If the voltages are available and the Relay is dead,
the Relay in all probability is defective. Please send it back for repairs.

2. Relay does not indicate expected power factor. Your wiring is wrong. Change around the wires leading to the R,Y,B voltage terminals of the Relay. There are six combinations, and only one of them is correct. Try all six. Also check that your expected power factor estimate is reasonably correct.

3. Relay switches the capacitors on, but the power factor does not improve.

   The source of this fault could be:
   - The CTs are located only on the Load bus, and capacitor current is not passing through the CTs. Change the location of the CTs to the true main Incomer.

   - The capacitors are all defective. This seemingly unlikely fault has occurred at many sites. Measure the current in each lead of each capacitor as it switches on, to check. This would also reveal if all the fuses of all the capacitors have blown.

4. Relay switches on all the capacitors, the power factor improves, but does not reach the set value. At the extreme is the possibility that the total installed KVAR is too low. In this case, the Relay switches on all the capacitors but the power factor does not improve to the set value. Check if the capacitors are healthy. Remedy is to add capacitors and add stages. This may need total reconfiguration of the panel wiring.

5. Relay switches on the contactors but does not switch them off, though indication on the Relay is correct. All contactors switch off simultaneously when the last switch off occurs. Your external Manual Control is not configured correctly. The contactors are latching up through their holding contacts. Extensive rewiring is required to remedy this fault. This is also possible if 440 VAC coils have been used.

6. Relay is on but PF meter indicates 1.0 always. The current through the Relay is inadequate.

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P.O No.: …………………………………………………………………...

Customer: …………………………………………………………………

Sr. No.: ……………………………………………………………….....

Routine and function tests conducted to relevant standards and our Specifications/Literature/O & M Manual. Traceability: tested against "MTE" Standard Model PRS1.3 having basic accuracy of 0.05% traceable upto International Standards derived using appropriate ratio techniques.

Result of Test: ……………………………………………………………

Remarks: …………………………………………………………………...

Test engineer: ……………………………………………………………

Date: …………………………………………………………..............

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