

# USER'S MANUAL

## ACCUVAR

### *KVAR BASED CONTROLLER FOR LT CAPACITOR BANKS*

This document contains the latest technical information about ACCUVAR which is a micro-controller based Power Meter. The unit is tested against latest "MTE" Standard Model PRS400.3 having basic accuracy of 0.02%, traceable upto International Standards derived using appropriate ratio techniques.

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 L.T. electrical system. It uses the three watt-meter method to calculate KVA, KW & KVAR.

ACCUVAR is based on a powerful 8-bit micro-controller operating at 16 MHz. The controller receives voltage & current signals which are fully isolated 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 16X1 STN LCD. The user-friendly membrane 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.

The Main Features Available in this Model

- 3P4W LT electrical system
- Three powers: KW, KVA and KVAR
- Three phase voltages( $V_r$ ,  $V_y$  &  $V_b$ ) and currents( $I_r$ ,  $I_y$ ,  $I_b$ )
- Active energy (KWh) and apparent energy (KVAh)
- CT ratio for both load current and capacitor current selectable
- Capacitor current ( $I_{cap}$ )
- 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.



ACCUVAR

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 (To be specified at the time of Ordering) 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, 50-60 Hz.
OUTPUT	Relay	Switching Voltage : Max. 250 VAC Switching Power : Max. 1000W Expected Mechanical Life: >10 x 10 <sup>6</sup> switching operations. Expected Electrical Life : >4 x 10 <sup>6</sup> switching operations. @(Load = 200VA, Cosφ = 0.5)

Measurement

Parameter		
Type	Name	Statistics
True RMS Basic Parameters	Voltage (Volts L-N: VRN, VYN, VBN)	Accuracy : 0.5% of Reading
	Current (Amps IR, IY, IB)	Accuracy : 0.25% of Reading
	Capacitor Current	CT Ratio : Site Selectable Accuracy : 1.0% of Reading
	Line Frequency	45 to 55 Hz, Accuracy : 0.3% of Reading
Power	Active Power (P)	Accuracy : 1.5% of Reading (For IPFI>0.9)
	Reactive Power (Q)	Accuracy : 2.0% of Reading (Between 0.5 Lag to 0.8 Lead)
	Apparent Power (S)	Accuracy : 1.0% of Reading
	Power Factor	Accuracy : 1.0% of Reading (IPFI≥0.5) Range of Reading : 0.05 to 1.00 Lag/Lead
Energy	Total Active Energy (KWh)	Range of Reading : 0 to 9999999.9 KWh Accuracy : 1.0S as per IS13779.
	Total Apparent Energy (KVAh)	Range of Reading : 0 to 9999999.9 KVAh Accuracy : 1.0% of Reading
Misc.	Cap. Bank KVAR	

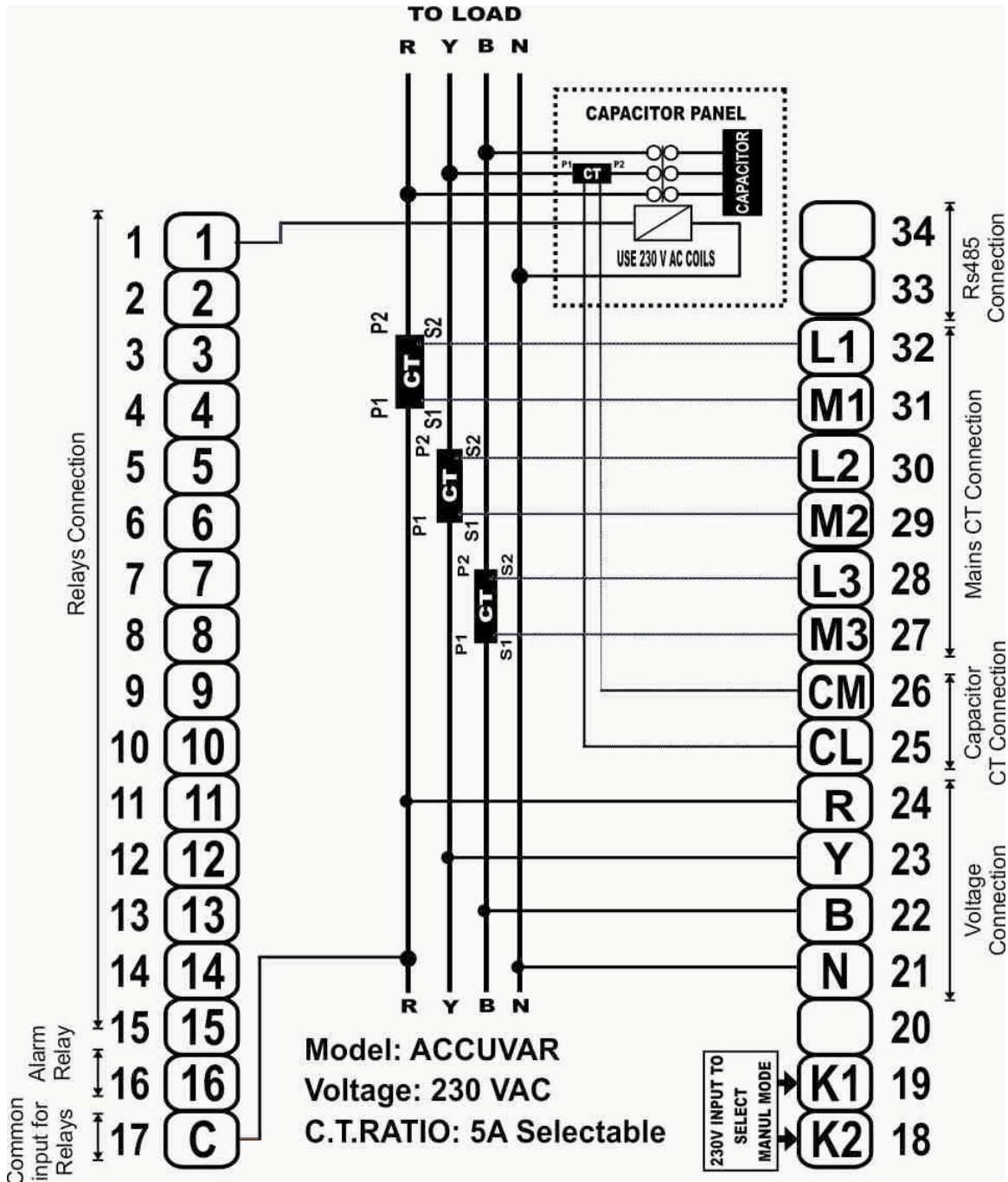
Miscellaneous

Parameter		
Type	Name	Statistics
Dimensions	Bezel	144 X 144 mm
	Panel Cutout	138 X 138 mm
	Depth of installation	55 mm
	Operating temp	10°C to 50°C
	Weight	0.554 Kgs (Approx.)
	Min. Operating Current	1% of CT primary

## Installation and Commissioning

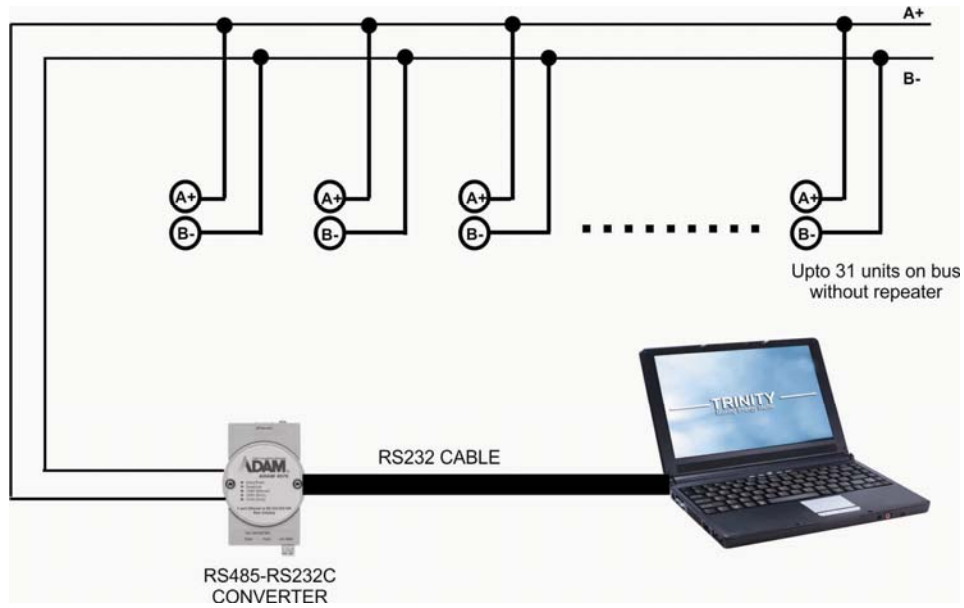
To install and commission the unit, proceed the following instructions:

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.
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 as well as auxiliary supply. Unit will power on from these three phases supply and prompt such as TRINITY ESPL for about 2 to 3 seconds.
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 (YES OR NO). 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 return to Run Mode, displaying KVAh.
9. Now, the unit is ready for the control action after a 2 minutes delay.



RS485 Connection

### 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 and communication needs and, is also achieved by making as many parameters field programmable, as possible.

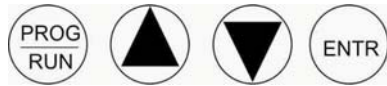
There are basically two modes of operation in ACCUVAR:

1. Programming Mode
2. Run Mode






After supplying power (80 VAC - 480 VAC), the unit displays immediately power receiving information, “---TRINITY ESPL---” on LCD screen 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 such as shown below.



## Programming Mode



In order to operate for all the field programmable parameters, it is easy for user interface by pressing the keys such as , ,  and . Once the display is in Programming Mode, press  key to move into the following programmable parameters:

1. CT ratio for load currents
2. CT ratio for capacitor currents
3. Desired PF setting
4. Operation mode
5. Unit Address
6. Baud Rate
7. Alarm Mode - Yes / No
8. Alarm limit. - PF setting below which alarm will operate
9. Alarm Delay - Delay after which the alarm should operate
10. Switching delay - delay between two successive switching operations of relay
11. Damp factor for setting the sensitivity level for control action
12. Minimum Bank-75% or 100%
13. Auto Sense for capacitors.

### 1. Setting CT Ratio for Load Current





In order to give actual current values for CT operated meter, the CT Ratio between the primary and secondary current should be set accordingly. The CT Ratio can be set from 5A to 5000A.

To set CT Ratio for Load Current, proceed the following instructions:

1. In Run Mode, press  for about 5 seconds continuously. The display will prompt such as `PROG MODE PRESS▲`.
2. Press  key to enter into Load Current (MAIN CTR) and the display will therefore prompt such as shown below.





MAIN CTR=525

3. Press  key. Immediately, “P” starts blinking which also indicates that the parameter can now be set. Set the MAIN CTR by pressing  and  keys until the desired value is received and then, press  key to confirm the value.
4. Now, the unit will restart and return into Run Mode.

## 2. Setting CT Ratio for Capacitor Current





In case of VAR/PID control action, the capacitor CT Ratio should be set for autosense of capacitor banks. The CT Ratio of capacitor current is settable from 5A to 5000 A.

To set CT Ratio for Capacitor Current, proceed the following instructions:

1. In Run Mode, press  for about 5 seconds continuously. The display will prompt such as PROG MODE PRESS<sup>^</sup>.
2. Press  key two times to enter into Capacitor Current Ratio (CAP CTR) and the display will therefore prompt such as shown below.





CAP CTR=550

3. Press  key. Immediately, “P” starts blinking which also indicates that the parameter can now be set. Set the CAP CTR by pressing  and  keys until the desired value is received and then, press  key to confirm the value.
4. Now, the unit will restart and return into Run mode.

## 3. Setting the Desired PF





The desired PF can be set to either Lead or Lag side according to your requirement. In case, your desired PF is 0.999 LEAD, the PF value must be set to 1.999. In case of your desired PF is 0.999 LAG, the PF value must be set to 0.999 only.

To set PF value, proceed the following instructions:

1. In Run Mode, press  for about 5 seconds continuously. The display will prompt such as PROG MODE PRESS<sup>^</sup>.
2. Press  key three times to enter into SET PF and the display will therefore prompt such as shown below.





SET PF=0.998

3. Press  key. Immediately, “P” starts blinking which also indicates that the parameter can now be set. Set PF by pressing  and  keys until the desired value is received and then, press  key to confirm the value.
4. Now, the unit will restart and return into Run mode.

#### 4. Setting the Mode of Control Action





For PF correction, there are four types Control Action such as **FIFO**, **VAR** and **PID** which are also settable at site. In case of Lagging PF, FIFO mode should be selected. In case of Leading PF, VAR or PID modes can be selected. Hence, the selection of Manual mode will not be taken any action.

To set the Mode of Control Action, proceed the following instructions:

1. In Run Mode, press  for about 5 seconds continuously. The display will prompt such as `PROG MODE PRESS^`.
2. Press  key four times to enter into control MODE and the display will therefore prompt such as shown below.





MODE=VAR

3. Press  key. Immediately, “P” starts blinking which also indicates that the parameter can now be set. Set PF by pressing  and  keys until the desired value is received and then, press  key to confirm the value.
4. Now, the unit will restart and return into Run mode.

#### 5. Setting Unit Address and Baud Rate



The unit supports RS485 port for the communication of all the parameters using the address map. However, the unit address should be set to communicate in between the unit and host with the same address. The unit address is settable from 1 to 255. Hence, unit has also an option for selecting the baud rate which can give you faster for downloading the data accordingly. This baud rate can be selected to either 9600 or 19200.


To set for both Unit Address and Baud Rate, proceed the following instructions.

1. In Run Mode, press  for about 5 seconds continuously. The display will prompt such as `PROG MODE PRESS^`.
2. Press  key five times to enter into UNIT ADDRESS and the display will therefore prompt such as shown below.








UNIT ADDR=2

3. Press  key. Immediately, “P” starts blinking which also indicates that the parameter can now be set. Set UNIT ADDRESS by pressing  and

▼ keys until the desired value is received and then, press  key to confirm the value.

4. Press  key to enter into BAUD RATE such as shown below.



BAUD RATE=9600

5. Select BAUD RATE by pressing  and  keys and then, press  key to confirm the selection. If the setting is completed, press  key for about 5 seconds to return into Run Mode. Otherwise, press  key to set for next parameter such as previous setting.





## 6. Setting Alarm Mode

The relay has inbuilt alarm mode. In case, the Alarm Mode is set to YES for a 8 stage relays, the 7 stage relays will work for control action whereas the 8th relay will work for Alarm contact only. Likewise, for 10 (or 15) stage relays, the 9 (or 14) stage relays will work for control action whereas the 10th (or 15th) relay will work for Alarm contact. The Alarm Mode will therefore occur two types of parameters in two consecutive programmable parameters such as *Alarm Limit* and *Alarm Delay*. Hence, the Alarm Mode is set to NO; all 8 or 10 or 15 stage relays will work for Control Action accordingly.

To set Alarm Mode, proceed the following instructions:

1. In Run Mode, press  for about 5 seconds continuously. The display will prompt such as PROG MODE PRESS<sup>▲</sup>.
2. Press  key seven times to enter into ALARM MODE and the display will therefore prompt such as shown below.



ALARM MODE=YES

3. Press  key. Immediately, “P” starts blinking which also indicates that the parameter can now be set. Set ALARM MODE to YES by pressing  and  keys and then, press  key to confirm the value.
4. Now, the unit will restart and return into Run mode.

## 7. Setting Alarm Limit and Alarm Delay






The Alarm Limit is programmable from 0.800 to 0.999 for which the Alarm can be generated. Hence, The Alarm delay is settable from 20 seconds to 180 seconds for which the Alarm can be activated or deactivated in a particular time period.

To set Alarm Limit and Alarm Delay, proceed the following instructions:

1. In Run Mode, press  for about 5 seconds continuously. The display will prompt such as PROG MODE PRESS<sup>▲</sup>.
2. Press  key eight times to enter into ALARM LIMIT and the display will therefore prompt such as shown below.








ALARM LMT=0.998

3. Press  key. Immediately, “P” starts blinking which also indicates that the parameter can now be set. Set PF by pressing  and  keys until the desired value is received and then, press  key to confirm the value.
4. Press  key to enter into ALARM DELAY such as shown below.





ALARM DLY=30

5. Set ALARM DELAY by pressing  and  keys and then, press  key to confirm the setting. If the setting is completed, press  key for about 5 seconds to return into Run Mode. Otherwise, press  key to set for next parameter such as previous setting.

## 8. Setting the Switch Delay



This is one type of digital dead band.

To set Switch Delay, proceed the following instructions:

1. In Run Mode, press  for about 5 seconds continuously. The display will prompt such as PROG MODE PRESS<sup>▲</sup>.
2. Press  key ten times to enter into SWITCH DELAY and the display will therefore prompt such as shown below.



SWITCH DLY=40

3. Press  key. Immediately, “P” starts blinking which also indicates that the parameter can now be set. Set SWITCH DELAY by pressing  and


▼ keys and then, press  key to confirm the value.


4. Now, the unit will restart and return into Run mode.

### 9. Setting Damp Factor for Sensitivity of Control Action

The Damp should be set from 1 to 10 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.





To set Switch DAMP, proceed the following instructions:

1. In Run Mode, press  for about 5 seconds continuously. The display will prompt such as `PROG MODE PRESS▲`.

2. Press  key ten times to enter into DAMP and the display will therefore prompt such as shown below.



DAMP=10


3. Press  key. Immediately, “P” starts blinking which also indicates that the parameter can now be set. Set DAMP by pressing  and  keys and then, press  key to confirm the value.


4. Now, the unit will restart and return into Run mode.

### 10. Selecting Minimum Bank







The Minimum Bank can be set to either 100% or 75% to bring the system PF into unity. If Minimum Bank is set to 100%, the unit will take control action when the need  $KVAR \geq$  Minimum Bank value of VAR. Example, if need  $KVAR \geq 25$  KVAR LAG and Minimum Bank is 25 KVAR, the relay will switch the minimum Bank on. The relay will switch the Minimum Bank off when the system  $KVAR \geq 25$  KVAR LEAD. Similarly, if the Minimum Bank is set to 75%, the relay will switch on or off with 75% LAG of the Minimum Bank value of 25 KVAR (i.e., Need  $KVAR$  of  $18.75 \geq 75\%$  of 25 VAR).

To set MINIMUM BANK, proceed the following instructions:

1. In Run Mode, press  for about 5 seconds continuously. The display will prompt such as `PROG MODE PRESS▲`.

2. Press  key twelve times to enter into MIN. BANK and the display will therefore prompt such as shown below.




MIN. BANK=75 %

3. Press  key. Immediately, "P" starts blinking which also indicates that the parameter can now be set. Set MIN. BANK by pressing  and  keys and then, press  key to confirm the value.
4. If the setting is completed, press  key for about 5 seconds to return into Run Mode. Otherwise, press  key to set for next parameter such as previous setting.





### 11. Performing Auto Sense of Capacitor Bank Sizes

In case, 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 could be sensed, the relay will restart for control action and also display the parameters one by one.

To set AUTONSENSE, proceed the following instructions:

1. In Run Mode, press  for about 5 seconds continuously. The display will prompt such as PROG MODE PRESS.
2. Press  key thirteen times to enter into AUTONSENSE and the display will therefore prompt such as shown below.

AUTONSENSE=YES

3. Press  key. Immediately, "P" starts blinking which also indicates that the parameter can now be set. Set AUTONSENSE by pressing  and  keys and then, press  key to confirm the value.
4. Now, the unit will restart and return into Run mode.

## Run Mode

In the run mode, the various parameters calculated by the ACCUVAR are displayed on different pages on a 16 X 1 backlit LC Display. There are thirteen parameters in a different thirteen displays which shows both the system values and the set values. Now the displays can be altered and analyzed one by one.

### Screen Displays

Press ▲ or ▼ keys on Run Mode so as to receive the following displays:

Displays	Descriptions
KVAH=125	The first display shows Apparent energy.
VR=241. 2	The second display shows voltage in R-phase.
VY=238. 2	The third display shows voltage in Y-phase.
VB=240. 6	The fourth display shows voltage in B-phase.
IR=360. 4	The fifth display shows current in R-phase.
IY=376. 4	The sixth display shows current in Y-phase.
IB=384. 3	The seventh display shows current in B-phase.
Icap=34. 4	The eight display shows current passing through capacitor.

KWH=21.4

The ninth display shows Active energy.

0.942 LG (0.944)

The tenth display shows the system PF to LEAD side and the integrated average PF within the bracket.

KVA=243.3

The eleventh display shows Apparent power.

KW=229.0

The twelfth display shows Active power.

KVAR=81.9 LG

The thirteen display shows system Reactive power with leading PF.

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#### Resetting Average PF

The integrated average PF whose parameter has been shown in 10th display can be reset by pressing ▲ key on Run Mode for about 5 seconds continuously. Such integrated average PF is basically the ratio of KWh & KVAh energy consumption. After reset the value will alter into 1.00.

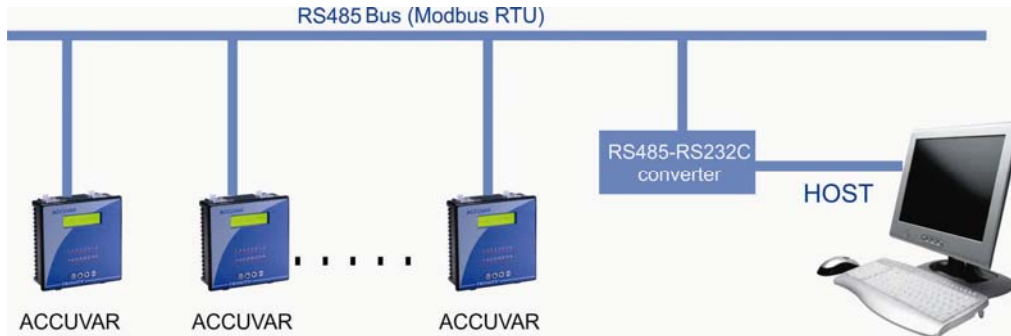
#### Freezing and unfreezing the AutoScroll

The Run Mode displays will always autscroll by default which starts displaying KVAh with an interval for about 5 to 6 seconds to each parameter on a cyclic basis. Each display can be frozen or unfrozen by pressing **ENTR** key and also be moved up and down by pressing ▲ and ▼ keys. In case of freeze mode, the display will stay with a blinking F.

#### Auto/Manual Mode of Operation

By default, the unit is in auto control action and can be operated as Manual Mode supplying power 150 VAC-230 VAC externally to the marked K1 and K2 on the unit itself. Once power is supplied for manual operation, the unit will start blinking "N" which shows that the operation is in Manual mode. Hence, some of the capacitor bank may be on. Immediately, the capacitor will be switched off. In this, manual mode there will be no control action.

## Communication



The industrial standard RS-485 communication port option is also available in ACCUVAR. This option makes it possible for a user to select ACCUVAR to provide power and energy information into a variety of existing or new control systems and communication networks such as EMS/PLS/SCADA.

### **Modbus RTU on RS485 Port**

In order to download live data for the various system parameters, user can use RS485 connecting to a SCADA or EMS software. ACCUVAR supports an RS485 port with MODBUS-RTU protocol. The station ID for every meter is site selectable. The data which can be read using MODBUS query # 3 (Read Holding Registers) is provided in an address map, with the applicable multiplication factors, vide **Appendix**.

Communication line parameters: 9600/19200/8/N/1.

The register map is described in Appendix. All addresses are in decimal whose parameters are unsigned long. If illegal address is sent in query or host, try to read more than 32 bytes of data in one query exception message is generated. The parameters name, address and multiplication factor are also mentioned.

Reserved values are for future uses which are transmitted as zeroes. Please refer to the address map for the various parameters in **Appendix**.

<b>3000-3019</b>	<b>3030-3049</b>	<b>3060-3079</b>	<b>3090-3109</b>	<b>MF</b>
3000-KVA	3030-KWh	3060-	3090-Avg.PF(X1000)	X100
3002-KW	3032-KVAh	3062-	3092-	X100
3004-KVAR	3034-	3064-	3094-	X100
3006-Sys.PF	3036-	3066-	3096-	X1000
3008-	3038	3068-	3098-	X100
3010-	3040-Vr	3070-Vy	3100-Vb	X100
3012-lcap	3042-lr	3072-ly	3102-lb	X100

## DEFINING MULTIPLICATION FACTOR

- For providing resolution, all parameters except PT are multiplied with 100 before transmitting. Thus if the KVA value is 278.99, it is sent out as 27899. PF has MF of 1000, instead of 100. Thus, a PF value of 0.987 is sent as 987.
- If an attempt is made to read some address other than the valid addresses, the exception response is sent.

## EXCEPTION CODE

In the event that the query from the HOST has no communication error, but there is some error in specifying the address of registers to be read, the meter returns an exception message. The format of the exception message will be such as table below:

Unit Address	0X83	Exception code	CRC	CRC
--------------	------	----------------	-----	-----

**Exception Code can have only one value, 02:** if the address is not a valid, start address or host has requested more than 32 bytes of data, this code is returned.

### 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 shooting.

#### **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.

#### **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 mode. 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 equipments:**

These relate to the defects in the connected equipments. 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.

(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:

- a. 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.
- b. 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 re-configuration 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.

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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