NOVAR 300

Capacitor Controller for Power Factor Correction

Operation & Maintenance Manual

NOVAR_CM

Issue: March 2005

CONTENTS

1. INTRODUCTION

There is a warning symbol on the equipment, an exclamation mark within a triangle. This warns the user to refer to the operation and maintenance manual before commissioning, installing or operating the equipment.

WARNINGS

1. Installation, commissioning and maintenance should only be carried out by suitably qualified personnel.
2. Terminations exposed during installation, commissioning and maintenance may present a hazard unless the equipment is electrically isolated.
3. The equipment should only be operated as intended e.g. with the covers in place, and within the specified electrical and environmental limits.

1.1 APPLICATION

Many power utilities world wide apply financial penalties to industrial consumers of electrical energy when inductive loads are connected. The established solution for compensating inductive loads is to apply power factor correction (PFC) by switching capacitors on to the system. To optimise the operation of PFC, and realise maximum benefits and cost savings, a means of controlling the capacitor switching is necessary.

NOVAR 300 works by continuously measuring the system's kvar component and then switching the optimum quantity of capacitor compensation in, or out, to achieve the desired power factor.

NOVAR 300 uses true rms measuring techniques together with appropriate mathematical calculations in preference to mean sensing and zero crossing detection which has proved inaccurate on systems with distorted waveforms.

The NOVAR 300 should be connected to the system as shown in the appropriate diagrams (Figures 1 and 2).

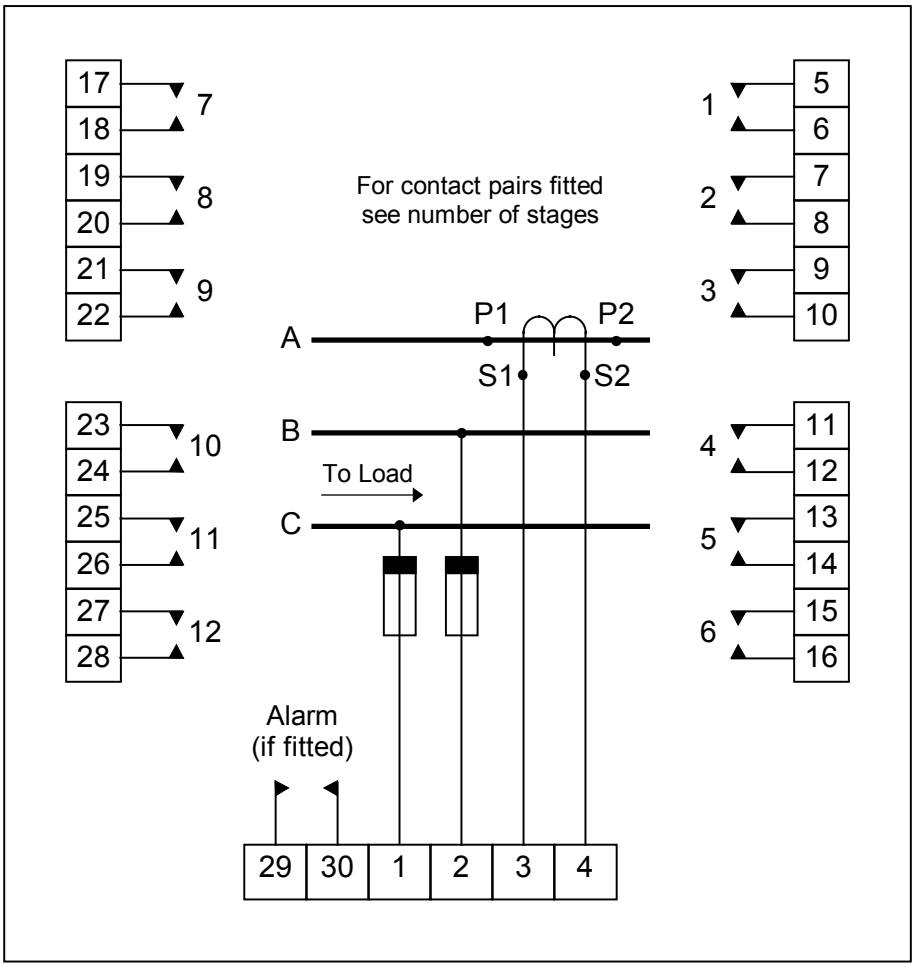


FIGURE 1 - Wiring diagram for volt free contacts

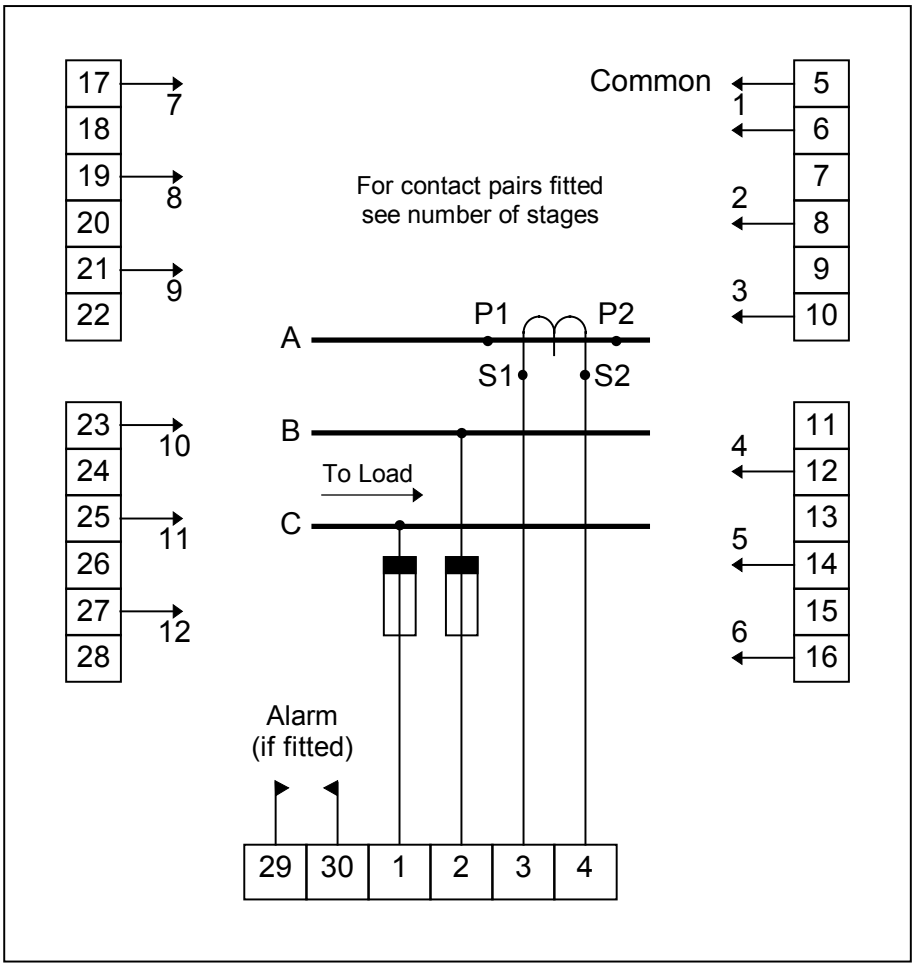


FIGURE 2 - Wiring diagram for common contacts

1.2 DESCRIPTION AND OPERATION

Multi-stage controllers are available in standard units of 6 and 12 stages. These provide up to 12 pairs of "volt-free" contacts.

The following switches are mounted on the controller front panel :

* An auto/manual control (upper button)

* A directional control marked +, 0, - (lower button)

* A ten-way programme selector switch

Depressing the auto/manual switch causes the Controller to enter MANUAL mode as indicated by the LED adjacent to the switch. Capacitor stages can be switched 'in' by pressing the directional control button once. Pressing this button once more places the Controller in the MANUAL 'off' position and no further stages will be switched 'in' or 'out'. Pressing this button once more will result in capacitor stages being removed until pressed again. the three LED's associated with this button will, at all times, indicate the operational mode.

When capacitors are being connected, a LED associated with the inductive (IND) control lights. As they are being disconnected, a LED associated with the capacitive (CAP) control lights.

The ten-way selector switch is used to select:

* The time interval between steps

* The sequence in which the stages are connected

* The limit which determines the number of steps taken in the sequence selected.

These are detailed in section 3.3.

2. TECHNICAL SPECIFICATION

2.1 RATINGS, OPERATING RANGES & FEATURES

Voltage Rating (Vn)
110 V, 120 V, 415 V, 480 V.
Others available in range 63.5 V to 500 V max.

Current Rating (In)
1 A or 5 A. Others available in the range 0.5 A to 5 A max.

Input Connections
IA, VBC, or IB, VCA or IC, VAB
IR, VYB, or IY, VBR or IB, VRY,
IR, VST, or IS, VTR or IT, VRS.

Line Current Transformers
Class 1, 5 VA

Operating Ranges

Voltage	85 ... 110 % Vn
Current	0...120 % In
Frequency	50/60 Hz
Humidity	0...93 % +2 % -3 % Relative (non-condensing)

Temperature Range
Storage: -40... 80° C
Operating: -10... 55° C

Settings
c/k 0.03...1.00
cos phi 0.80...1.00...0.95 leading

Overload Ratings
1.5 x Vn for 10 seconds
2 x In continuously
20 x In for 3 seconds

Isolation
The controllers will withstand:
2 kV rms, 50/60 Hz for 1 minute between:
- all terminals to case
- current terminals to all others
- voltage terminals to all others
- output contact pairs (Volt Free versions)

Impulse Voltage Test
The controller will withstand:
5 kV 1.2/50 us, 0.5J, to BS923 and IEC 255-22-1 between:
- all terminals and case
- current input terminals
- voltage input terminals
- output contacts (open)
- any pair of independent circuits

Output and Alarm contact rating
Make 1250 VA, 500 V a.c. resistive
Carry 5 A a.c.
Break 5 A a.c.
Type: one normally open

2.1 RATINGS, OPERATING RANGES & FEATURES (cont.)

No-volt release

All output contacts are disabled within 15 ms. After the supply voltage is restored, normal operation is resumed, and the outputs are energised in sequence after the appropriate safety lockout time has elapsed.

Burdens

Current circuit: 0.2 VA at In
Voltage circuit: 9 VA (6 stages energised)
15 VA (12 stages energised)

Net weight

All models: 1.5 kg

Terminals

Barrier type: M3.5
Plug-in wire size: 1...2.5 mm^2 (18...14 AWG)

Switching style

Rotational or linear (see Figure 3). Selected at time of order. Rotational switching evens the contactor wear (for the largest step size only) and generally reduces the system response time. It is implemented for all sequences on NOVAR 300, if requested.

Intelligent switching

If twice the minimum capacitor size (or more) is required, then the NOVAR will switch in a double step. This applies for all sequences. For sequence 00 (1:1:1:1), the second capacitor will be connected after an additional delay of two seconds.

Limit selection

Up to 12 plus alarm output. The maximum possible for any configuration is determined by the number of relays fitted and the selected sequence. If the selected value is too high, the unit will automatically override it to the highest allowable value.

Safety lockout

The time required to safely discharge a capacitor can be set to any of 8 different values. The NOVAR will not allow any capacitor to be re-energised until this time has elapsed.

Providing that the safety lockout time has passed, the capacitor can be called after one fifth of the programmed time. It is not possible to override this lockout time.

2.1 RATINGS, OPERATING RANGES & FEATURES (cont.)

Exit from manual

The AUTO/MAN button allows the user to switch between automatic and manual operating mode as required.

To safeguard against leaving a system indefinitely in manual mode, an automatic exit has been included. This will return the operating mode from manual to automatic five minutes plus the selected safety lockout time after the last manual mode operation. Relevant manual mode operations are pressing the lower button and operation of an output relay.

Models without the automatic exit from manual are available.

Alarm output

Signals failure to meet target cos φ
See also Self Test

Self Test

At reset and every ten minutes in operation, the NOVAR executes an internal hardware check for correct functioning. During this process, the model number will be displayed.

If the unit fails this self test, the IND and CAP LEDs are toggled and the alarm relay (if fitted) is also “flashed “ in time with this.

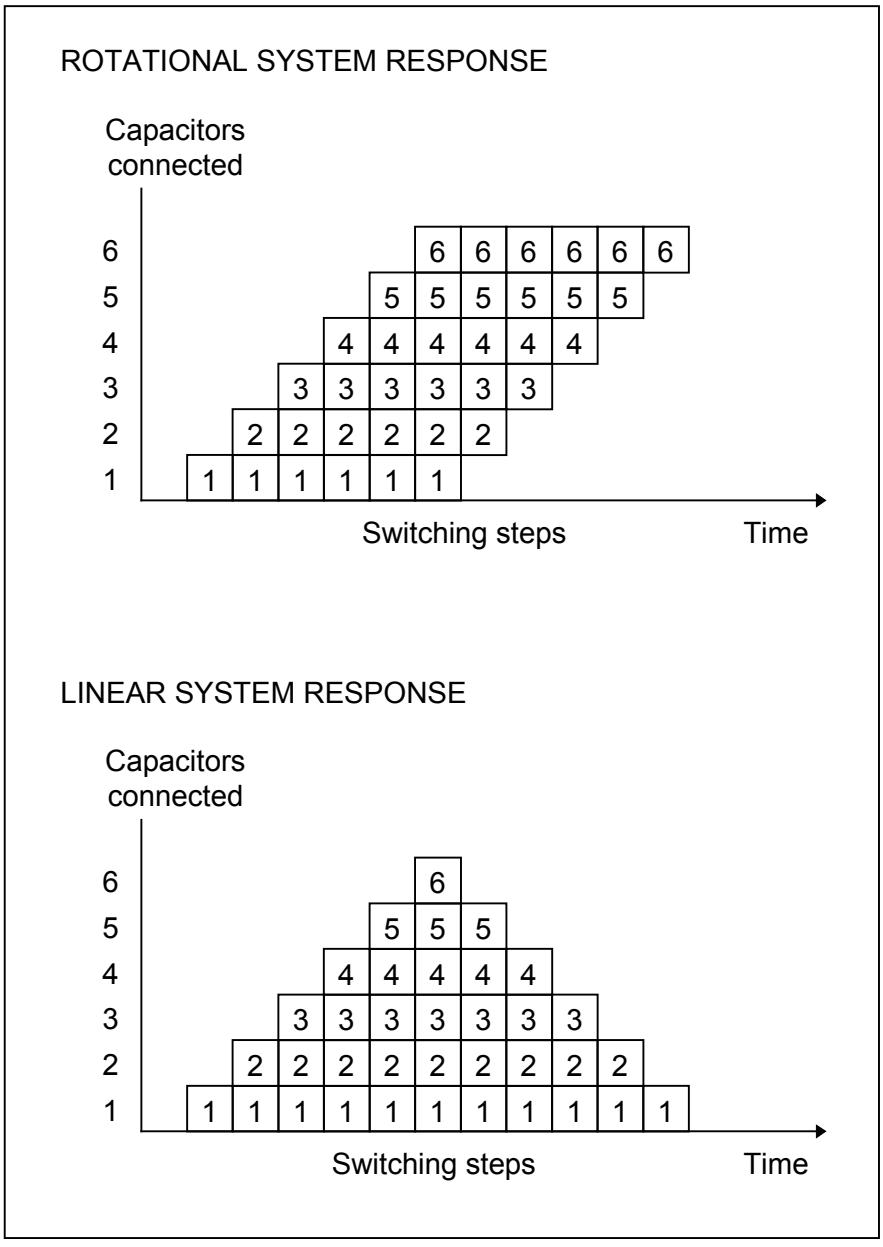


FIGURE 3 - Rotational/linear capacitor switching

2.2 ELECTROMAGNETIC COMPATIBILITY (EMC)

Phenomenon	Standard	Limits Met and Claimed
Conducted Emissions	EN50081-1 1992	EN55022:1987[C] Class B (Table II)
Radiated Emissions	EN50081-1 1992	EN55022:1987[R] Class B (Table IV)
Electrostatic Discharge	prEN50082-2 1991 (IEC 801-2)	8 kV air discharge, prEN50082-2: 9.1.2 4 kV contact discharge, Informative Annex: 1.1.4
Fast Transients	prEN50082-2 1991 (IEC 801-4)	2 kV Input AC power ports (direct)-prEN50082-2:9.5.1 4 kV Output ports (cap. clamp)- prEN50082-2: 9.5.1
Radiated Immunity	prEN50082-2 1991 (IEC 801-3)	10 V/m (*modulated 80% A.M., 1 kHz) 26 MHz to 1000 MHz. prEN50082-2: 9.1.1 and * Informative Annex 1.1.2
Conducted Immunity	prEN50082-2 1991 (IEC 801-6)	10 V rms (modulated 80% A.M., 1kHz) 150 kHz to 29 MHz
Burst Test	IEC255-22-1 1988	1 MHz burst disturbance test Class III 2.5 kV common mode, 1 kV differential mode

[C] - Conducted Emissions Limits: (to EN55022:1987 Class B)
0.15 MHz to 0.5 MHz ,66-56 dBµV Q-P,56-46 dBµV Ave., limits decrease linearly with log frequency.
0.5 MHz to 5 MHz, 56 dBµV Q-P, 46 dBµV Ave.
5 MHz to 30 MHz, 60 dBµV Q-P, 50 dBµV Ave.

[R] - Radiated Emissions Limits: (to EN55022:1987 Class B)
30 MHz to 230 MHz, 30 dBµV/m (at 10m).
230 MHz to 1000 MHz, 37 dBµV/m (at 10m).

2.3 EUROPEAN LOW VOLTAGE DIRECTIVE (LVD)

Designed to IEC1010-1 requirements.

WARNING

The circuit boards are susceptible to electrostatic discharge (ESD) and appropriate ESD protection should be taken to avoid damage, when handling or adjusting these. The 8 kV ESD susceptibility rating applies with the front label fitted.

3. COMMISSIONING

WARNINGS

1 Installation, commissioning and maintenance should only be carried out by suitably qualified personnel.

2 Terminations exposed during installation, commissioning and maintenance may present a hazard unless the equipment is electrically isolated.

3 The equipment should only be operated as intended e.g. with the covers in place, and within the specified electrical and environmental limits.

4 No capacitor controller is suitable for the isolation of system voltage from capacitor banks for the purpose of maintenance etc. Some NOVAR units are specially programmed to not return to 'auto' mode from 'manual'. These units will still reset to 'auto' on loss of volts and so are still unsuitable for capacitor bank isolation.

Before connection of the NOVAR into a customer's system, ensure that the safety lockout time programmed into the NOVAR is equal to or greater than that required for safe discharge of system capacitors. Unless this has been specified on ordering, the NOVAR will be set to 60 seconds. If the system requires a greater time this must be set before powering up the NOVAR.

3.1 SYSTEM CONNECTIONS

Refer to Figures 1 and 2.

The NOVAR power factor controllers employ solid state circuitry for the measurement of vars. The vars determination is directionally sensitive. Voltage and current supplies to the controllers must be mutually at 90 degrees when the system is at unity power factor.

On a three phase supply, the required phase shift is obtained by connecting the controller current input to a current transformer in one phase, and connecting the voltage input across the remaining two phases. Any phase can be used for the current input if the correct phase relationship exists between current and voltage.

The following combinations are possible :

CT in Phase			**Voltage Connections (across phases)**		
A	(R)	(R)	BC	(ST)	(YB)
B	(S)	(Y)	CA	(TR)	(BR)
C	(T)	(B)	AB	(RS)	(RY)

Connections between the controller and the capacitor contactors are also shown in Figures 1 and 2.

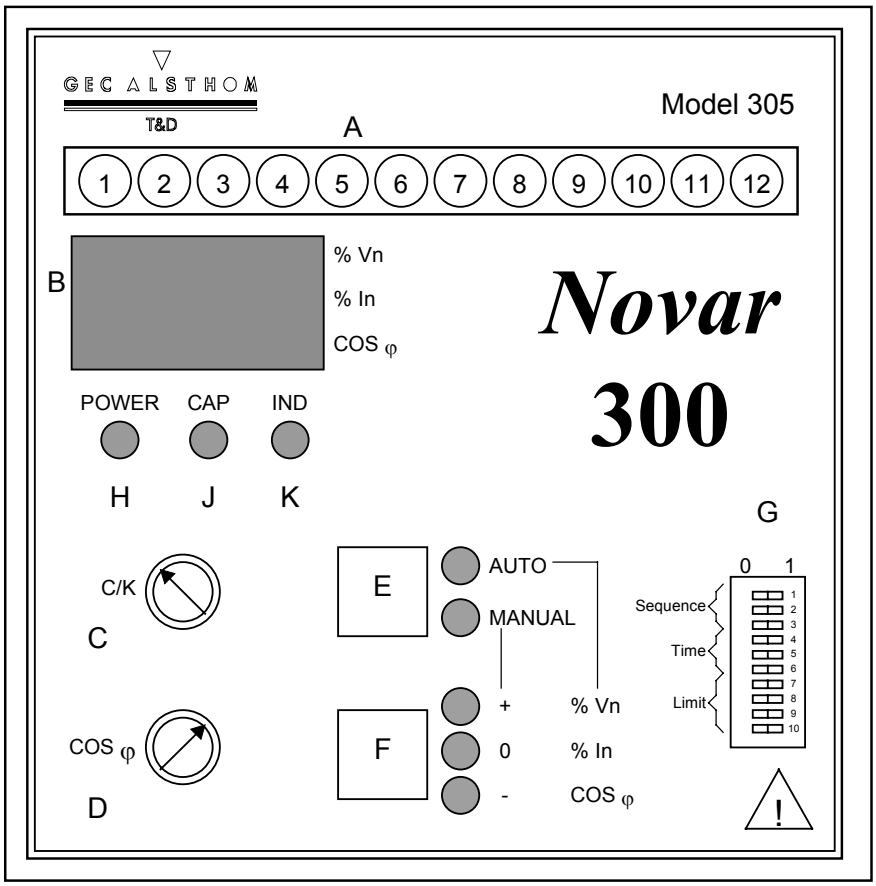
3.2 USER ADJUSTMENTS

The following user adjustments are available and should be set during commissioning. Refer to also to Figure 4.

Parameter	Fascia Key	Means of Selection
Sequence	G	DIL switch *
Time	G	DIL switch *
Limit	G	DIL switch *
C/k	C	Potentiometer
cos φ	D	Potentiometer

Warning

Due to the presence of electrostatic sensitive devices on the printed circuit board, care must be taken to effectively earth oneself before commencing commissioning. The recommended method is to use a standard wrist strap that is connected to earth.



Fascia Key

A - Secret-until-lit display of energised stages
B - High definition liquid crystal display
C - C/K setting
D - COS φ setting
E - Dual mode button: auto/manual
F - Dual mode button: capacitor switching (man) and display selection (auto)
G - DIL switch (sequence, time and limit setting)
H - Power on indication LED
J - Switching in progress, circuit is capacitive
K - Switching in progress, circuit is inductive

FIGURE 4 - NOVAR indication and user adjustments

3.3 SETTING OF DUAL-IN-LINE SWITCH

Settings of sequence, lockout time and stage limit should be set prior to powering up the NOVAR. When a controller leaves the factory, the DIL switch will be pre-set to the following default values, regardless of model type, unless specified on the order. Refer to Figure 5.

SEQUENCE = 1:1:1:1:1 . . .
TIME = 60 seconds
LIMIT = the number of stages of the controller, i.e., for 6 stages limit equals 6.

If these settings are suitable for the user's application, this section may be ignored.

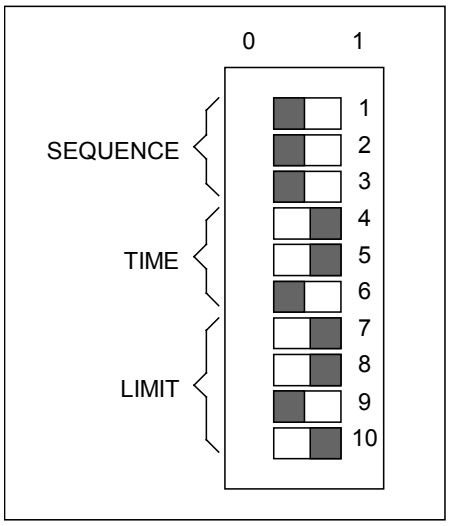


FIGURE 5 - DIL switch factory default settings

3.3.1 Sequence

The settings of this switch determine the controller's sequence, safety lockout time and limit of switching.

Note: The settings can only be altered on-site on the NOVAR 305 models.

Unless otherwise requested, the NOVAR will have a sequence setting of 1:1:1:1 (sequence 0), a safety lockout time of 60 seconds and a limit equal to the number of stages supplied with the unit.

Eight sequence settings are available. The sequence controls the number of steps taken for a desired number of capacitor stages. For instance, sequence 00 is used for capacitors which are all the same size. Alternatively, sequence 07 is used where each of the first four steps is progressively twice the size of the previous step (a ratio of 1:2:4:8).

The correct switch setting should be selected using table 1 as a guide. In the expanded display mode the setting can be checked by pressing the lower push-button once more (a digit 5, representing the letter S will appear in digit position 4 of the display).

Table 1 - Sequence settings

Sequence Number	Sequence	Switches 1	2	3	Max no. of steps per controller — Number of Stages 1	3	6	9	12
00	1:1:1:1:1 etc	0	0	0	1	3	6	9	12
01	1:1:2:2:2 etc	1	0	0	1	4	10	16	22
02	1:2:2:2:2 etc	0	1	0	1	5	11	17	23
03	1:2:3:3:3 etc	1	1	0	1	6	15	24	33
04	1:2:3:4:4 etc	0	0	1	1	6	18	30	30
05	1:2:4:4:4 etc	1	0	1	1	7	19	31	31
06	1:2:3:6:6 etc	0	1	1	1	6	24	30	30
07	1:2:4:8:8 etc	1	1	1	1	7	31	31	31

3.3.2 Safety Lockout Time

Proper selection of switching time delay is a function of the electrical system and capacitor voltage rating. Usually, as a guide, the time interval must be larger than the discharge time of the capacitor being switched. This time required for discharge is known as the safety lockout time. The dual-in-line switch should be set to the desired time by reference to Table 2. In expanded display mode, the setting selected can be checked by pressing the lower push button once more (a ‘t’ symbol will appear in digit 4 of the display).

Table 2 - Lockout time settings

Safety Lockout Time (Seconds)	Switches 4	5	6
10	0	0	0
20	1	0	0
30	0	1	0
60	1	1	0
180	0	0	1
300	1	0	1
480	0	1	1
600	1	1	1

3.3.3 Stage Limit

The number of stages switched can be limited to anywhere between 1 and 12. A limit function prevents unused stages being switched where no capacitors are present. Table 3 shows, for each sequence selected, the switch positions necessary to achieve the desired stage limit. This selected stage limit will equate to a finite number of steps depending on the sequence chosen. In expanded display mode, the limit selected can be checked by pressing the lower push button once more (an 'L' will appear in the fourth display digit).

Note: The limit is the number of capacitors connected to the NOVAR and must be set correctly. If the limit is set higher than the number of capacitors connected then the system response will be slowed down.

Table 3 - Limit settings

Stage Limit	1	2	3	4	5	6	7	8	9	10	11	12
Switch number	7 8 9 10	7 8 9 10	7 8 9 10	7 8 9 10	7 8 9 10	7 8 9 10	7 8 9 10	7 8 9 10	7 8 9 10	7 8 9 10	7 8 9 10	7 8 9 10
Switch setting	1 0 0 0	0 1 0 0	1 1 0 0	0 0 1 0	1 0 1 0	0 1 1 0	1 1 1 0	0 0 0 1	1 0 0 1	0 1 0 1	1 1 0 1	0 0 1 1
Sequence number	**Maximum number of steps**											
00	1	2	3	4	5	6	7	8	9	10	11	12
01	1	2	4	6	8	10	12	14	16	18	20	22
02	1	3	5	7	9	11	13	15	17	19	21	23
03	1	3	6	9	12	15	18	21	24	27	30	33
04	1	3	6	10	14	18	22	26	30	-	-	-
05	1	3	7	11	15	19	23	27	31	-	-	-
06	1	3	6	12	18	24	30	-	-	-	-	-
07	1	3	7	15	23	31	-	-	-	-	-	-

3.4 SETTING OF C/K VALUE

The c/k potentiometer should be set according to the following equation;

$$C/k = \left[\frac{\text{Smallest Capacitor Step Size in vars}}{\sqrt{3} \times V \times I} \right] \times 5$$

where: V = nominal primary system voltage
I = primary rating of the current transformer

This is indicated on the display by the small c symbol in the upper part of digit 4 if the expanded display mode is selected on models having displays.

3.4.1 Examples of Calculation and C/K Settings

Example 1

A 25 kvar capacitor operating on a 415 V, 3 phase supply, is controlled by a single stage controller operating via a 200/5 CT but without a VT.

C = 25,000 vars, V = 415 V, I = 200 A

$$C/k = \frac{25{,}000 \times 5}{\sqrt{3} \times 415 \times 200} = 0.87$$

The NOVAR 300 is scaled to give a deadband of 150 % nominal capacitor size.
(i.e. NOVAR 300 will switch capacitors in circuit when the input lagging vars exceed three quarters of a capacitor step size . NOVAR 300 will switch capacitors out of circuit when the input leading vars exceed three quarters of a capacitor step size .)
The value of C/K can be directly entered into the unit.

Example 2

A multi-stage unit controls a 6 stage capacitor bank. Each stage is rated at 100 kvar. The voltage is 415 V and the CT is 1000/5. There is no VT.

C = 100,000 vars, V = 415 V, I = 1,000 A

$$C/k = \frac{100{,}000 \times 5}{\sqrt{3} \times 415 \times 1{,}000} = 0.70$$

As above, this value can be directly entered into the unit.

Example 3

A multi-stage unit controls a six stage capacitor bank. Each stage is rated at 100 kvar. The VT is 3.3 kV/110 V and the CT ratio is 500/5.

C = 100,000 vars, V = 3 300 V, I = 500 A

$$C/k = \frac{100{,}000 \times 5}{\sqrt{3} \times 3{,}300 \times 500} = 0.17$$

As above, this value can be directly entered into the unit.

NB: The NOVAR 300 calculation has been formulated in such a way that it will work for any value of secondary amps and volts which can be used with the unit. However, if the nominal secondary amps used is other than 5 amps, the value represented by the scalings on the c/k potentiometer will no longer be the actual capacitor starting current in amps. This makes no difference to the operation of the unit.The NOVAR 300 ratings must match the secondary rating of any CT and VT used.

3.5 SETTING OF TARGET COS PHI

This is set using the potentiometer, labelled "cos φ", located on the front panel.

To make use of the expanded display mode, the lower push-button should be pressed once more .The display will now indicate the potentiometer setting and a large C in the fourth digit of the display.

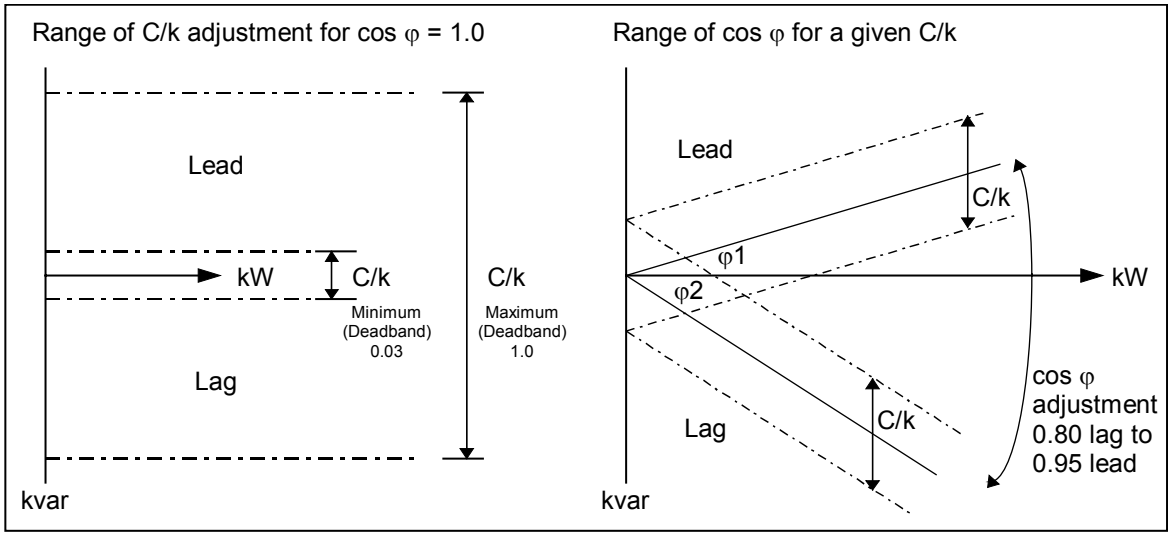


FIGURE 6 - Ranges for C/k and cos φ settings

3.6 CONNECTION ERRORS

NOVAR 300 gives a certain amount of information to assist with connection. There are six possible ways in which it is possible to connect a system. Of these six, only one is correct. For three of the others, NOVAR 300 will give indication of a connection error as follows.

At system unity power factor, the NOVAR 300 error mode is looking for a phase angle of 90° between amps and volts. As a system can in theory be operating anywhere within a band of 90° either side of this, the error mode looks for its inputs to be within this band.

Refer to Figure 4 for vector diagrams showing the correct and incorrect connections.

The correct connection (a)

Input is I_A with V_{BC}.

For this case, the NOVAR will go straight into AUTO mode.

The most common connection error is that of a reversed CT (b). In this case the NOVAR will display 270° for a system at unity power factor.

If V_{BA} is selected instead of V_{BC} (c) then the NOVAR will display 150°.

If V_{CA} is selected instead of V_{BC} (d) then the NOVAR will display 210°.

The above values will change if the system is not at unity power factor (e.g. if the system is at 40° lagging then a CT reversal would appear as 230°).

Because V_{AB} or V_{AC} are within the above stated bands, then the NOVAR is not able to distinguish between these and a system working at the relevant power factor.

If V_{AB} is selected (e) then the NOVAR will display a cos φ of 0.5 leading corresponding to an angle of 60° leading.

If V_{AC} is selected (f) then the NOVAR will display a cos φ of 0.5 lagging corresponding to an angle of 60° lagging.

3.7 USE OF EXPANDED DISPLAY

Once it is known that the NOVAR is connected into the system correctly, it is necessary to set up the working parameters of the unit.

If a display model is being used, then it enables more accurate settings if expanded display mode is now entered. This is achieved by pressing the lower push button for more than 5 seconds.

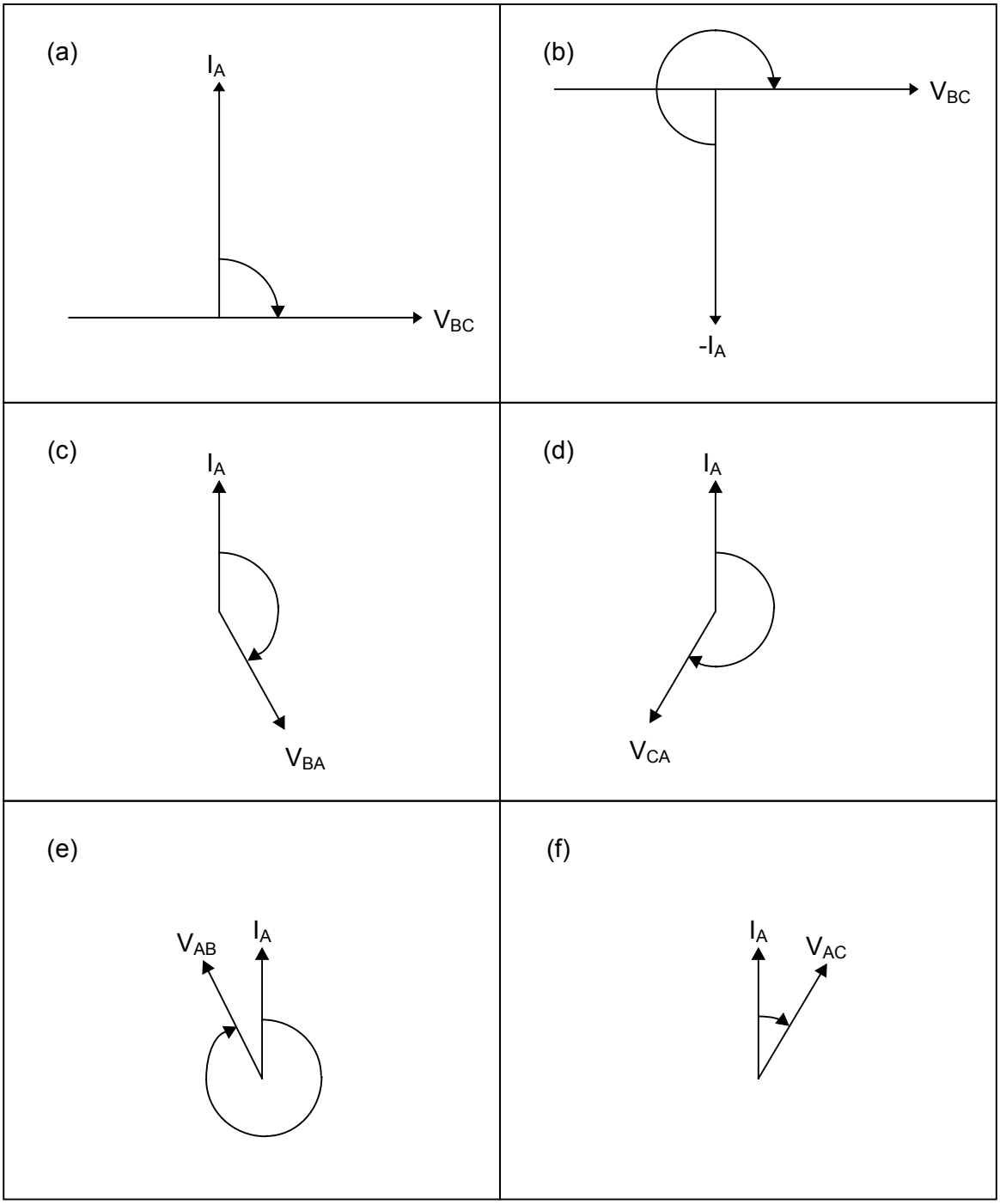


FIGURE 7 - System vector diagrams

4. FAULT FINDING AND TEST PROCEDURES

4.1 FAULT FINDING

When power is first applied to a NOVAR it examines both its own circuitry and the system into which it has been connected. If it finds any faults in either situation, it will signify this as follows.

4.1.1 Connection error

See section 3.6

4.1.2 Low system voltage

If the system voltage is below nominal working range, the NOVAR will perform a voltage reset. A line of four dashes will appear across the centre of the display for a few seconds and the unit will then reset.

4.1.3 System current errors

If the system current is below 10 percent of nominal, the NOVAR will display a line of dashes across the bottom of the display instead of cos phi. Apart from this, the unit will continue to operate normally. This will also be the display if the CT circuit is not connected.

If the system current is above 120 percent of nominal, the NOVAR will display 'A-HI'.

4.1.4 Incompatible settings

There are various situations where the NOVAR will appear not to be working properly. These are, in fact, caused by incompatibilities in DIL switch settings, c/k and/or target cos phi settings or an incomplete knowledge of how a particular NOVAR is programmed:

4.1.4.1 If sequence 4 or 5 is selected, it will not be possible under any circumstances to set the limit above 9. The same applies for sequences 6 and 7, the appropriate limits being 7 and 6 respectively.

4.1.4.2 If the limit is set to 1 then the sequence will automatically be set to 0 as any other sequence would be meaningless. Similarly, if the limit is set to 2 then the sequence can not be set higher than 2.

4.1.4.3 The NOVAR power factor controller is a device designed to reduce the lagging vars present in a system. Because of this, the system power factor is not necessarily a good measure of whether the unit should be changing the state of its outputs. As an example, it is possible to have an extremely poor power factor with low current as well. In this case, although the power factor is poor, the actual reactive power present may still be very low.

4.1.5 Factory programmed settings

There are two factors which are programmed into the NOVAR during test. The NOVAR is only able to operate as indicated on its label in regards to these:

- rotational or linear switching (test assist mode always works rotationally)
- manual mode automatic exit enabled or disabled

4.1.6 Input magnitude errors and transients

So long as both voltage and current inputs remain within the converter range specified in section 4.0, the NOVAR will continue to operate, even if rms values lie outside of the ranges specified in section 2 (excluding low voltage reset). However, if either the voltage or current input exceeds the converter limits specified in section 1.1, the NOVAR will be disabled from performing any further capacitor changes. This situation will occur for example very high or peaky voltage or currents, or for any interference which the NOVAR is not able to filter out by other means. When the inputs return to within their permitted limits, the NOVAR will continue to function as normal.

4.1.7 Internal NOVAR hardware fault

The IND and CAP LEDs will flash alternately and the alarm relay (if fitted) will toggle on and off. This is a very slow toggle, the on time for each LED being about two seconds.

4.1.8 Perceived software fault

The intelligence of the NOVAR 300 range of controllers is based around a highly integrated micro-controller. This system includes a software watchdog - a piece of hardware built into the processor to ensure that it cannot operate in any way which is not allowed. This system will reset the micro-controller, and therefore the NOVAR, if it is not regularly informed that all is well.

The NOVAR indicates that this is the case by either displaying CAL on its display or by alternating between this and its sign-on display whilst flashing the IND LED briefly.

NB This is not an indication of a software error in the NOVAR - it is impossible for a NOVAR to be despatched unless its software is correct. If either of these situations does occur, there will be some cause not caught by the above specific error traps (e.g. voltage < 50 %) If either of these situations occur, please contact our applications department for further advice.

4.1.9 Capacitors permanently connected

If the CAP light continues to flash after the automatically controlled capacitors are 'switched out', check for capacitors which have been permanently connected.

4.1.10 Hunting

This symptom must not be confused with switching caused by rapid fluctuations of the load. If the control scale settings are too close, a point in the load level may be reached where the introduction of another capacitor will make the total load LEAD marginally more than the CAP setting. The capacitor will then be disconnected after the selected relay operation time, causing the total load to LAG more than the IND setting. If the factory load remains steady, the sequence will be repeated after the selected safety lockout time. The regularity of switching is an indication of hunting. This can be rectified by increasing the control scale settings marginally.

On systems liable to high voltages, it may be necessary to set the control scales at higher settings than would otherwise be required at the nominal voltage. This is because the kvar rating of the capacitors is proportional to the square of the line voltage.

4.2 TEST PROCEDURES

4.2.1 Test equipment

This equipment should be capable of supplying a single phase voltage and a current which is in phase with this voltage, both of which should be adjustable. The supply should be of adequate rating to meet the voltage input and to supply up to a minimum of 50% of the full scale current rating of the controller.

The current and voltage inputs to the controller should be monitored using a watt-meter of 0.5% accuracy class or better. The accuracy of the switching levels can be checked by reading the single phase input power to the controller at the point when the CAP or IND light is lit for about half of the time.

For accurate readings, a stabilised voltage and current supply is preferred.

The switching time can be changed if the DIL switch is accessible. However, if this is done, it must be changed back to the correct time for the capacitors being used before being installed in a panel. The fastest time (10 second safety lockout, giving a relay operation time of 2 seconds) is with all three time switches set to '0'.

4.2.2 Test sequences

WARNING : IF INPUT CURRENT IS TAKEN FROM A CT, THE TRANSFORMER SECONDARY SHOULD BE SHORT-CIRCUITED BEFORE THE CONTROLLER INPUTS ARE DISCONNECTED.

4.2.2.1 Connect the test voltage source to the controller inputs with the neutral connected to terminal 1 and the live to terminal 2.

4.2.2.2 Increase the voltage to the rated value for the controller.

4.2.2.3 Set the target Cos Phi control to 1.00

4.2.2.4 Set the c/k control to .5

4.2.2.5 Check that the IND and CAP LEDs are not flashing and that all stage indication LEDs are off.

4.2.2.6 Connect the current source to the controller inputs with the neutral connected to terminal 4 and the live to terminal 3.

4.2.2.7 Increase the current slowly from zero .

4.2.2.8 Check that the IND LED begins flashing within the rated accuracy limits of the controller at 10% of the rated full scale current input.

After the selected relay operation time (i.e. one fifth of safety lockout time, providing that safety lockout time has elapsed), the first stage indicator LED should switch on.

4.2.2.9 Allow the controller to count up to its top limit.

4.2.2.10 Check that all of the output relays are now switched on.

4.2.2.11 Reduce the current to zero:

both the IND LED and the CAP LED should now be extinguished.

4.2.2.12 Reverse the input current connections, (see WARNING note above)

Increase the current from zero slowly. The CAP LED should flash when the 10% input level is exceeded. The controller should now start to count down.

4.2.2.13 The setting of the c/k potentiometer should be checked at several different levels by noting the inputs required to exceed the CAP and IND trip levels.

4.2.2.14 If it is required to check operation of the Target Cos Phi potentiometer as well as the c/k potentiometer, it will be necessary to use a test system with phase angle adjustment. The centre point of the IND and CAP deadband should be seen to move by the angle represented by the target cos phi selected.

5. SERVICING

WARNINGS

1. The circuit boards are susceptible to electrostatic discharge (ESD) and appropriate ESD protection should be taken to avoid damage, when handling or adjusting these. The 8 kV ESD susceptibility rating in the Technical Specification only applies with the front cover fitted.

2. Servicing, adjustment and inspection should only be carried out by suitably qualified personnel who are fully aware of the potentially hazardous conditions that can exist.

5.1 OUT OF SERVICE

When in storage retain the original packing, or seal the unit in a plastic bag.

The power supply circuit includes an electrolytic capacitor. During extended storage this should be reformed every four years. Reforming is carried out as follows:

5.1.1 Connect a variable ac voltage source to the voltage supply input terminals of the controller.

5.1.2 Set the source to zero voltage and switch on.

5.1.3 Slowly increase the voltage from zero to the rated value. Ideally the process should extend over a period of five minutes.

5.2 IN SERVICE

Under normal operating conditions, the controller requires little attention. During routine servicing and inspection of the associated equipment, the device should be inspected to normal standards for this class of equipment. For example, remove dust and check all connections for tightness after the power has been disconnected.

If a fault in the controller is suspected, it is recommended that the complete unit is replaced. Because of the complexity of a device such as a NOVAR and the fact that it does contain calibration variables particular to its hardware on leaving the factory, any hardware changes subsequent to this will almost certainly lead to a loss in performance.

If it is required to attempt an investigation and/ or repair it must be noted that ESD protection such as wrist straps must be used.

5.3 FITTING OF LOCKABLE FRONT COVER

If at some point after purchase, it is decided to add a lockable front cover, either for means of security or for the higher IP rating thus obtained, the cover may be applied as follows. NB the unit will need to be removed if it has already been installed and the surfaces to be glued must be clean and dry.

5.3.1 Remove the lockable cover, its 2 keys and the tube of glue supplied from their packaging.

5.3.2 Apply a thin line of adhesive to the bottom of the inside lip at the rear of the lockable cover.

5.3.3 Remove the standard cover from the front of the NOVAR and place the lockable cover over the front of the NOVAR, with the hinge placed towards the left of the NOVAR. Press together firmly.

5.3.4 Open the lockable cover door and wipe away any excess adhesive with a clean dry cloth.

5.3.5 Stand the NOVAR unit with the lockable cover face down on a clean, soft surface and leave to cure for approximately thirty minutes.

6. CIRCUIT DESCRIPTION

Figure 6 shows a block diagram of the Controller. This comprises two printed circuit boards with plugs and sockets providing all the board interconnections. There are two versions of the 'Relay' PCB circuit. One for volt-free contact versions and the other for common contact units. These differ only in the connection of the relay output contacts.

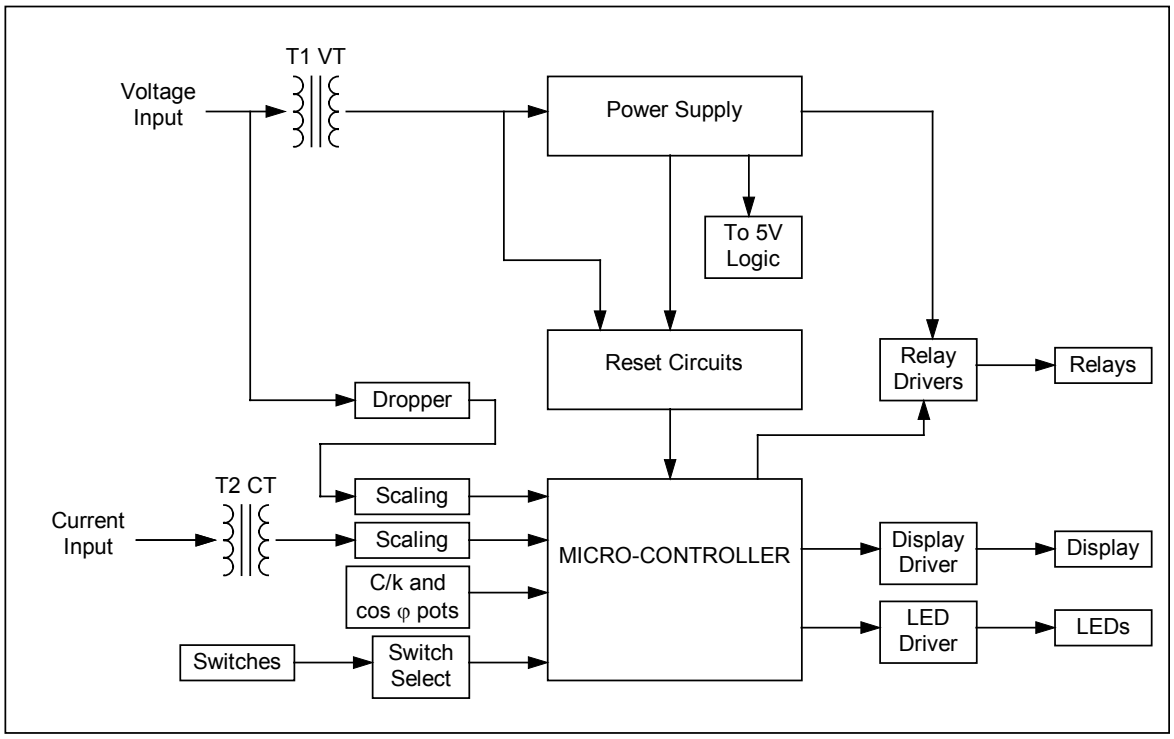


FIGURE 8 - NOVAR 300 Block diagram