ESTAmat® MH
Mounting Instructions
MV1151

VISHAY ELECTRONIC GMBH - Geschäftsbereich ROEDERSTEIN, ESTA und Hybride
Hofmark-Aich-Str. 36 - Phone (49)-871/86-0 - Fax (49)-871/86 25 12 - D-84030 Landshut - Germany
www.vishay.com

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Front Panel Controls

<u>Trend LEDs</u>
The LEDs "ind" and "cap" switch on in case the Power Factor Controller is going to switch in additional steps or to switch out active steps

<u>Digital display</u>
The four-digit display indicates the computed actual values, faults, and the set parameters.

<u>Step indicators</u>
The LEDs indicate the energized capacitor steps.

<u>LED indicators:</u>
The selected operating mode or parameter lights up.

<u>Operational controls</u>
The control key >**IN/+**< increases the parameter of the selected mode, or switches in capacitor steps. The control key >**OUT/-**< reduces the indicated parameter, or switches out capacitor steps.
The desired mode/parameter can be selected by pressing the key .

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1. Concise Operating Instructions

1.1 Setting

Check whether both the supply voltage (230 V oder 120 V) and the frequency (50 Hz oder 60 Hz) correspond with the data on the rating plate on the rear side of the P.F. Controller!
Upon application of the supply voltage, the following data will be indicated one after the other, for two (2) seconds each:

seconds each:	Standard settings at time of delivery:
☑ the programme version	for instance "1.1.2"
☑ the set cosφ	1.00
☑ the switching programme	1:1:1: ...
☑ the number of steps	6 (with MH12: 12)
☑ the C/k value	0.025 A
☑ the switching delay time	'LoAd'
☑ the re-switching blocking delay time	20 seconds
☑ the locking	'off'

After this display, the P.F. Controller turns to automatic operation.
If the »ESTAmat MH« has been operated manually hitherto, the P.F. Controller will turn automatically to manual operation upon return of the voltage. Capacitor steps having previously been switched in, will likewise be re-switched in taking into account the re-switching blocking delay. This process can be aborted by pressing the key .
Modifications can be made as described under Item 6 (pages 7 f.).

The following data must of necessity be set in order to start up the P.F. Controller:
1. Switching programme: (refer to chapter 6.2 (page 8))

1:1:1:1:1 ... 1:2:2:2:2 ...
1:1:2:2:2 ... 1:2:3:3:3 ...
1:1:2:2:4 ... 1:2:3:4:4 ...
1:1:2:3:3 ... 1:2:3:6:6 ...
1:1:2:4:4 ... 1:2:4:4:4 ...
1:1:2:4:8 ... 1:2:4:8:8 ...

2. Number of steps:
Number of energized capacitors

3. C/ k values for 400 V:
(refer to chapter 6.3 (page 8)

C/k values for 400 V

C.T.	smallest capacitor step [kvar]											
	5	**10**	**12.5**	**15**	**16.7**	**20**	**25**	**30**	**40**	**50**	**60**	**100**	**150**
50:5	0.72	1.44	-	-	-	-	-	-	-	-	-	-	-
75:5	0.48	0.96	1.20	1.44	-	-	-	-	-	-	-	-	-
100:5	0.36	0.72	0.90	1.08	1.21	1.44	-	-	-	-	-	-	-
150:5	0.24	0.48	0.60	0.72	0.80	0.96	1.20	1.44	-	-	-	-	-
200:5	0.18	0.36	0.45	0.54	0.60	0.72	0.90	1.08	1.44	-	-	-	-
250:5	0.14	0.29	0.36	0.43	0.48	0.58	0.72	0.87	1.5	1.44	-	-	-
300:5	0.12	0.24	0.30	0.36	0.40	0.48	0.60	0.72	0.96	1.20	1.44	-	-
400:5	0.09	0.18	0.23	0.27	0.30	0.36	0.45	0.54	0.72	0.90	1.08	-	-
500:5	0.07	0.14	0.18	0.22	0.24	0.29	0.36	0.43	0.58	0.72	0.87	1.44	-
600:5	0.06	0.12	0.15	0.18	0.20	0.24	0.30	0.36	0.48	0.60	0.72	1.20	-
800:5	0.05	0.09	0,11	0.14	0.15	0.18	0.23	0.27	0.36	0.45	0.54	0.90	1.35
1000:5	0.04	0.07	0.09	0.11	0.12	0.14	0.18	0.22	0.29	0.36	0.43	0.72	1.08
2000:5	0.02	0.04	0.05	0.05	0.06	0.07	0.09	0.11	0.14	0.18	0.22	0.36	0.54
2500:5	-	0.03	0.04	0.04	0.05	0.07	0.07	0.09	0.12	0.14	0.17	0.29	0.43
3000:5	-	0.02	0.03	0.04	0.04	0.05	0.06	0.07	0.10	0.12	0.14	0.24	0.36
4000:5	-	0.02	0.02	0.03	0.03	0.04	0.05	0.05	0.07	0.09	0.11	0.18	0.27

1.2 Start-up procedure

After the correct data have been set, a functional test shall be carried out. The desired cosφ is be set to 1.00 for this purpose. Provided that a sufficient number of inductive consumers are connected, the P.F. Controller will switch in an appropriate number of capacitor steps, upon its return to automatic operation.
When the desired power factor value 1.00 has been reached, the setting should be turned down to 0.85 inductive. The »ESTAmat MH« must now switch out enough capacitor steps in order to reach the new desired cosφ.
If the above-mentioned tests do not succeed, chapter 8 "Trouble shooting" should be consulted.

After completion of these tests, the desired cosφ shall be set with a suitable margin. If, for example, a cosφ value of 0.9 is demanded by the Electrical Power Supply Utility, the desired cosφ should be set to 0.92 or 0.95. When the apparent power is also billed, the desired cosφ should be set to 1.00..

Warnings:

- ☑ The correct coordination of both current and voltage is prerequisite for the trouble-free operation of the »ESTAmat MH«. The current transformer must be connected to the same phase from which the supply voltage is tapped. Normally, the current is connected to phase L1, while the voltage is tapped between phase L1 and the neutral conductor N.
- ☑ The current transformer shall be connected in such a way as to make sure that it can measure the current to all the consumers including that to the capacitors, i.e. next to the feed-in position.
- ☑ The C.T. transformation ratio should be adapted to the consumers' requirement. If too large a ratio has been chosen, the »ESTAmat MH« will receive an insufficient measuring signal and will, consequently, regulate unprecisely or not at all; in this case, the P.F. Controller will indicate the fault "power failure".

2. General

2.1 Functions and mode of operation

The microprocessor-controlled »ESTAmat MH« can be used whenever automatic control of the power factor is required. All functions of the »ESTAmat MH« are controlled by a microprocessor. A protective device (watchdog) permanently monitors the processor for trouble-free operation. The correct coordination of current and voltage is prerequisite for the trouble-free operation of the »ESTAmat MH«, because the measuring signals must both come from the same phase. Usually, the current is taken from phase L1, while the voltage is tapped between phase L1 and N. The capacitor steps are switched in the specified sequence by the 6 or the 12 relay contacts.
The output of the smallest capacitor step is the deciding factor in determining the number of steps of the power factor correction equipment.

2.2 Switching in circular sequence

Switching in circular sequence means that capacitors which have been switched in first, will also be switched out again first. Switching follows the FIFO principle: First-IN-First-OUT. If the switching-in follows the order 1-2-3-4-5, then also the switching-out of the capacitors will follow that same order 1-2-3-4-5.

The circular switching mode distributes the load uniformly on all contactors and thus on all capacitors. A further advantage of this mode is that a capacitor step, when switched out, has enough time for discharging before it is switched in again.

The advantages of the circular switching sequence also help avoiding the so-called hunting operations. With the switching sequence 1:2:2:2:2:2, for example, the "double-size" steps are switched in circular switching mode, and the "single-size" step is used only for fine tuning.

Thus the »ESTAmat MH«, with all the various switching programmes of different step sizes, offers the advantage of avoiding the continuous switching in and out of one oscillating step.

2.3 Voltage interruption

In case of an interruption of the mains voltage, all relay contacts in the P. F. Controller are switched out.
Upon return of the supply voltage, the capacitors are switched in again after the blocking delay for re-switching has elapsed. This ensures enough time for the capacitors to discharge and thus avois harmful switching-in in phase opposition to the mains voltage.

2.4 Optimized switching performance

The »ESTAmat MH« measures continuously the demand for reactive power and the variations of it, and always switches in or out the largest possible capacitor step. In case of, for example, a power factor correction equipment of 25 : 25: 50 : 50 : 50 kvar, the P.F. Controller will immediately switch in a step of 50 kvar instead of gradually switching in steps of 25 kvar. This way, the number of switching operations is reduced, which results in an increased life expectancy of both the capacitors and the contactors.

2.5 Generator operation (4-quadrant operation)

The increased use of regenerative energy sources, such as wind , solar , biogas, and steam power, as also the application of emergency power supply systems, require that up-to-date power factor Controllers operate trouble-free, also with generator operation. The »ESTAmat MH« recognizes the implicit energy reverse, i.e. the feed-back into the network, and continues compensating in direction of the consumer.

2.6 Blocking delay time for re-switching

The period between switching out a certain capacitor step and the earliest possible re-switching-in of this step is defined as ”re-switching blocking delay”. With the »ESTAmat MH«, this blocking delay for re-switching is 20, 60 or 180 seconds. The advantage is that, in case of quick load variations (e.g. cranes or elevators), the P.F. Controller will re-switch in a capacitor only after it has discharged to an acceptable low-voltage level.

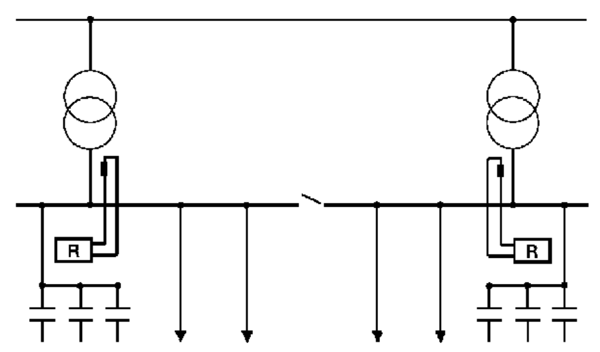
The re-switching blocking delay time of 20, 60 or 180 seconds is maintained even during manual operation.

During the blocking delay for re-switching of a capacitor step, the decimal point of the digital display flashes.

2.7 Parallel operation

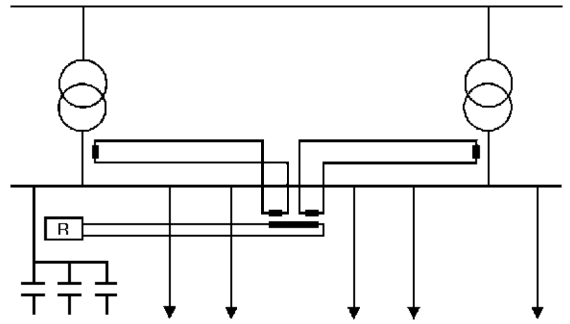
When two plants, each having independently a P.F. Controller, are interconnected, the two P.F. Controllers influence each other, because the two currents distribute across both transformers. To avoid hunting between the two Controllers, the C/k values should be set differently. In this way, a so-called "lead-follow" behaviour is realized, i.e. one Controller reacts slower than the other.

Parallel operation



plants connected in parallel

2.8 Summation current transformer



activation of Controller via summation current transformer

For Computing of the c/k value, refer to item 6.3.2

3. Connection

3.1 Connection of the »ESTAmat MH«

The P.F. Controller is connected by means of a socket connector (female) with screw-type contacts for external connection lines, plugged onto a plug connector (male); fixing of socket connector by means of two screws, with following identification:

terminals	connection
1	C.T. connection **k**, X/5 A or X/1 A
2	C.T. connection **l**, X/5 A or X/1 A
3	- (no assignment)
4	supply connection **N**, 230 VAC
5	supply connection **L1**, 230 VAC
6	- (no assignment)
7, 8	potential-free fault alarm contact, normally open
9 -14	control outputs for contactors 1-6
15 - 20	control outputs for contactors 7-12

3.2 General connection instructions

1. The P.F. Controller is internally protected by means of a fine-wire fuse 100 mA (glass tube fuse 5 x 20 mm). This fuse is not accessible from the outside.

2. The rating of the external fuse is a function of the current consumption of the connected contactors. It should, however, be taken into account that an individual control contact may certainly be loaded with a maximum of 5 A, but the external fuse must not exceed the value of 10 A.
The total current should not be more than 10 A !

3. All control contacts, except for the fault alarm contact, are bridged by a spark-quenching unit (RC element). The impedance of the RC element is 30 kΩ at 50 Hz.

3.3 Connection instructions for current transformer

1. The correct coordination of current and voltage is prerequisite for the trouble-free operation of the »ESTAmat MH«. The current transformer shall be incorporated in the phase at which the supply voltage is tapped. Normally, the current transformer is connected to phase L1, and the voltage is tapped between phase L1 and N.

2. In case of unbalanced load of the phases, the current transformer should be incorporated into the phase which is most highly loaded.

3. The current transformer shall be installed at a spot where it is sure that all the subsequent consumer current, including the capacitor current, will flow through it. Normally, this is next to the feed-in transformer and behind the tariff meter reading.

4. The connecting cable to the current transformer, having a length of 10 m, should have a minimum conductor cross section of 2.5 mm². If the cable is longer than 10 m, a larger conductor cross section shall be used, or a current transformer of a higher rating shall be used.

5. When an already existing current transformer can be made use of, then all the current paths of the individual consumers shall be connected in series with the »ESTAmat MH« . Attention should be paid that the rating of the current transformer be sufficient.

6. The transformation ratio of the current transformer should coincide with the consumers' requirements. When the current transformer is overrated, the »ESTAmat MH« will receive too small a measuring signal and, consequently, will regulate unprecisely or not at all, and will signalize the fault "power failure".

Attention:
When handling the C.T. (e.g. when removing the »ESTAmat MH«), attention should be paid that the C.T. secondary terminals are first short-circuited.

4. Start-up procedure

4.1 Visual control

Upon completion of the installation, all connections to the mains circuit and the control-circuit terminals and the screws for fixing the socket connector are to be checked.

4.2 Verification of supply voltage

Operating voltage and frequency are to be checked whether they correspond with the relevant data given on the rating plate at the rear side of the P.F. Controller!
230 V or 115 V? - 50 Hz or 60 Hz ?

4.3 Verification of set values

Upon application of the supply voltage, the display will indicate the programme version (e.g. "1.1.2") and the standard values set for the desired cosφ, the mode of switching programme, the number of steps, the C/k value, and the switching delay time for two seconds each.
The »ESTAmat MH« will be supplied ex works with the following standard settings:

Desired cosφ:	**1.00**
Switching programme:	**1:1:1:1**
Number of steps:	**6 (MH12: 12)**
C/k value:	**0.025 A**
Switching delay:	**'LoAd'**
Re-switching blocking delay time:	**20 s**
Locking:	**not activated**

The following data will have to be carefully checked when putting the P.F. Controller into operation and, if necessary, adapted to the requirements of the specific type of power factor correction equipment:

- **Type of switching programme and number of steps**
- **C/k value**

Changes can be made as described under point 6.

Attention:
If the »ESTAmat MH« has hitherto been operated in manual operation, the P.F. Controller will automatically go back to 'manual' operation upon return of the voltage. Then all the capacitor steps which had before been switched in, observing the re-switching blocking delay, will be re-switched in. This process can be aborted by pressing the key Ω .

4.4 Start-up tests

For a functional test, it is recommended to set the desired cosφ to 1.00 . Upon return to the automatic operation mode, and with an adequate number of inductive consumers connected, an equivalent number of capacitor steps should now be switched in.

When cosφ has reached the value 1.00, the desired cosφ is to be set to 0.85 inductive. Now, the »ESTAmat MH« should switch out some capacitor steps in order to reach the new desired cosφ value.

Upon completion of these tests, the desired cosφ value for normal operation is to be reset.

If, for example, a cosφ value of 0.9 is demanded by the Electrical Power Supply Utility, the desired cosφ should be set in a range from 0.92 to 0.95. In areas where apparent power is billed, a desired cosφ value of 1.00 should be set.

4.5 Functional test without load

When the P.F. Controller is set to automatic operation mode, capacitor steps can be switched in or out by means of the keys "**IN/ +**" or "**OUT/ -**". The switching operations will be effected in accordance with the set switching programme.

5. Mode of Operation

5.1 Automatic operation

When set to automatic operation, the P.F. Controller switches in the capacitor steps as a function of the reactive power demand, the deviation of the cosφ value from the set desired value, and the C/k value automatically.

For test purposes, capacitors may be switched in or out manually, even with automatic operation mode, at any time:

Key **"OUT/-"**: switching-out of capacitors.
Key **"IN/+"**: switching-in of capacitors.

Attention:
As long as the decimal point flashes in the display, the re-switching blocking delay is active. However, the operation of the key will be memorized and the capacitor step will be switched in after the re-switching blocking delay time has elapsed.

5.2 Manual operation

For turning the P.F. Controller to manual operation, press the key Ω as long as is needed to blank the display (approx. 5 s). Only then the key may be released. Manual operation is indicated by the flashing of the LED 'auto'. During manual operation, capacitors can be switched in and out manually.

Key **"OUT/ -"**: switching-out capacitors.
Key **"IN/ +"**: switching-in capacitors.

The automatic control is not effective, i.e. the capacitors switched in remain permanently switched in.

Access to the manual operation mode is possible from any other mode. In order to leave the manual operation mode, briefly press the key Ω**.**

Attention:
If the P.F. Controller had been changed to manual operation, this operating mode remains effective even after a voltage interruption has taken place. The P.F. Controller returns automatically to manual operation mode after return of the voltage. Capacitors that had been switched in before the voltage interruption will be re-switched in taking into account the re-switching blocking delay.

By pressing the key Ω this process can be aborted.

As long as the decimal point flashes in the display, the re-switching blocking delay is effective. However, the operation of the key will be memorized and the capacitor step will be switched in after the re-switching blocking delay time has elapsed.

The keys "IN/ +" or "OUT/ -" are partly equipped with a repeat function. When activating these keys only briefly, the indicated parameter will be changed only by one step, while activating them longer will result in a gradual change at a rate of 0.5 s.

6. Settings and Display

For changing settings and displays push Ω

6.1 Actual and desired cosφ

Related to the mains frequency, electronic measuring input filters allow for a most precise display of the cosφ value, independent of the waveform of both current and voltage. This advantage is especially valuable for plants with above-average harmonic loads.
The display always shows the actual cosφ value. A minus sign in front of the power factor means that the latter is capacitive.

The desired cosφ value can be set in a range from 0.85 inductive to 0.95 capacitive:

Key **"OUT/-"**: reduces the desired cosφ
Key **"IN/+"**: increases the desired cosφ

When pressing simultaneously the keys **"OUT/ -"** and **"IN/ +"**, the desired cosφ goes back to the standard setting of "1.00".
The value displayed when leaving the setting mode for the desired cosφ will be memorized.

6.2 Switching programmes:

Before starting up the P.F. Controller, the following data will have to be carefully checked and, if necessary, re-adjusted:

a) Type of switching programme and number of steps
b) C/k value.

The switching programme is presented as a four-digit data (e.g. 1:1:1:1, 1:2:2:2, 1:2:4:4).
The activated output steps are indicated by means of step LEDs.

Initially, the actual switching programme is indicated in the display. Other switching programmes may be selected by means of the keys **"IN/+"** and **"OUT/-"** The display will signalize any changes made.

If there is no need for any changes, or when the correct switching programme has been set, the key Ω is to be pressed for confirmation.

The following switching programmes are feasible:

1.	**1:1:1:1:1 ...**	**7.**	**1:2:2:2:2 ...**
2.	**1:1:2:2:2 ...**	**8.**	**1:2:3:3:3 ...**
3.	**1:1:2:2:4 ...**	**9.**	**1:2:3:4:4 ...**
4.	**1:1:2:3:3 ...**	**10.**	**1:2:3:6:6 ...**
5.	**1:1:2:4:4 ...**	**11.**	**1:2:4:4:4 ...**
6.	**1:1:2:4:8 ...**	**12.**	**1:2:4:8:8 ...**

Then the number of steps, which may also be adjusted, is being displayed. The step LEDs indicate permanently the number of activated output steps. The number of steps can be changed by means of the keys **"IN/+"** and **"OUT/-"** . Any changes made are indicated by flashing step LEDs. If there is no need for any changes, or when the correct number of steps has already been selected, again the key Ω is to be pressed for confirmation.

Attention:
If another switching programme has been selected or if the number of steps has been changed, all switched-in capacitor steps will be switched out upon leaving the mode 'switching programme'.

6.3 C/k value

The C/k value is the tripping value of the power factor Controller. The value represents the Controller's reactive-current tripping threshold in Ampere-reactive. When the reactive current portion of the load exceeds the set C/k value, one of the two LEDs ("ind" or "cap") will indicate this condition.

The display always shows the actual C/k value.

Key **"OUT/-"**: reduces the C/k value
Key **"IN/+"**: increases the C/k value

The standard value of "0.025" for the C/k value will be set when pressing simultaneously the keys **"OUT/-"** and **"IN/+"** .

6.3.1 Computing and setting of the C/k value:

The C/k value can be changed within the range of 0.025 A to 1.5 A maximum by means of the keys **"IN/+"** and **"OUT/-"** . The C/k value is computed as follows:

$$C/k = \frac{Q}{1.73 \cdot U \cdot k}$$

Q = output of the smallest capacitor step, var
U = phase-to-phase voltage, volt
k = C.T. transformation ratio

Example:
Q = 25 kvar; U = 400 V; k = 1000:5 = 200;
C/k = 25 000 / (400V * 1.73 * 200) = 0.18 A

Attention:
When the C/k value has been changed, all switched-in capacitor steps will be switched-out when leaving the mode 'C/k value'.

6.3.2 Summation current transformer

When feeding in several transformers onto one low-voltage busbar, the currents of the transformers equipped with current transformer have to be measured and added up via a summation C.T.

Attention should be paid to correct polarity, because otherwise the currents of the individual current transformers will subtract.

The C/k value, with this configuration, is calculated as follows:

$$C/k = \frac{Q}{1.73 \cdot U \cdot k}$$

Q = output of the smallest capacitor step, var
U = phase-to-phase voltage, volt
k = $\sum$ of the C.T. transformation ratios

k = k1 + k2 + k3 ......

e.g.: 2 current transformers 600/5 , k = 120
k = 120 + 120 = 240

C/k value for 400 V

C/k values for 400 V													
C.T.	smallest capacitor step [kvar]												
	5	**10**	**12.5**	**15**	**16.7**	**20**	**25**	**30**	**40**	**50**	**60**	**100**	**150**
50:5	0.72	1.44	-	-	-	-	-	-	-	-	-	-	-
75:5	0.48	0.96	1.20	1.44	-	-	-	-	-	-	-	-	-
100:5	0.36	0.72	0.90	1.08	1.21	1.44	-	-	-	-	-	-	-
150:5	0.24	0.48	0.60	0.72	0.80	0.96	1.20	1.44	-	-	-	-	-
200:5	0.18	0.36	0.45	0.54	0.60	0.72	0.90	1.08	1.44	-	-	-	-
250:5	0.14	0.29	0.36	0.43	0.48	0.58	0.72	0.87	1.5	1.44	-	-	-
300:5	0.12	0.24	0.30	0.36	0.40	0.48	0.60	0.72	0.96	1.20	1.44	-	-
400:5	0.09	0.18	0.23	0.27	0.30	0.36	0.45	0.54	0.72	0.90	1.08	-	-
500:5	0.07	0.14	0.18	0.22	0.24	0.29	0.36	0.43	0.58	0.72	0.87	1.44	-
600:5	0.06	0.12	0.15	0.18	0.20	0.24	0.30	0.36	0.48	0.60	0.72	1.20	-
800:5	0.05	0.09	0,11	0.14	0.15	0.18	0.23	0.27	0.36	0.45	0.54	0.90	1.35
1000:5	0.04	0.07	0.09	0.11	0.12	0.14	0.18	0.22	0.29	0.36	0.43	0.72	1.08
2000:5	0.02	0.04	0.05	0.05	0.06	0.07	0.09	0.11	0.14	0.18	0.22	0.36	0.54
2500:5	-	0.03	0.04	0.04	0.05	0.07	0.07	0.09	0.12	0.14	0.17	0.29	0.43
3000:5	-	0.02	0.03	0.04	0.04	0.05	0.06	0.07	0.10	0.12	0.14	0.24	0.36
4000:5	-	0.02	0.02	0.03	0.03	0.04	0.05	0.05	0.07	0.09	0.11	0.18	0.27

6.4 Switching delay time:

The time between exceeding the hysteresis and starting the switching operation is defined as switching delay time. This transgression must be given permanently during the whole switching delay time. The switching delay time can be determined by the 'ESTAmat MH' as a function of the load or it may be specified by the user.

The following switching delay times can be specified:
fixed: **10, 30, 60, 120, 180, 300 and 500 s.**
As a function of the load, the following switching delay times occur:
automatic: **2 - 500 s.**
The display shows the actual switching delay time.

Key **"OUT/-"**: reduce the switching delay time
Key **"IN/+":** increase the switching delay time

A standard switching delay time is set to "**LoAd**" when pressing simultaneously the keys **"OUT/-"** and **"IN/+"** .

A load-controlled determination of the switching delay time is activated when the digital display indicates 'LoAd'. The load-controlled determination of the switching delay time is to be given preference, because **in most cases this achieves an optimal result.**

6.5 C.T. secondary current

Display of the C.T. secondary current in Ampere
No setting required.

6.6 Re-switching blocking delay time and locking of settings (programme version 1.1.2)

The set desired values, such as target power factor, type of switching programme, number of switching steps, C/k value, and the switching delay time, can be locked and thus protected against unauthorized operation.
The re-switching blocking delay time can be set to 20, 60, or 180 seconds.

6.6.1 The parameters

Parameter	Value	Implication
-01-	on off	locking active locking inactive
-02-	20,60,180	re-switching blocking delay in seconds
Stop/End	-	end setting menu

6.6.2 Activating the setting menu:

If the re-switching blocking delay time is to be changed, or if the locking is to be activated/deactivated, a special setting menu has to be addressed. To achieve this, the three keys **IN/+**, **OUT/-**, and Ω will have to continue being pressed simultaneously until all segments of the display are lit (displaying '8888'). Releasing the keys, the parameter **-01-** appears in the display alternating with the indication of its actual condition. The numbers for the parameters are always indicated with a hyphen (e.g. **-01-**; **-02-**). The condition of the parameter is indicated in figures (e.g. **20**, **60**, **180**) or in words (e.g. **on**, **off**).

6.6.3 Selecting a parameter:

In the mode of the alternating display of a parameter and its value, one can switch over to another parameter by pressing the keys **IN/+** or **OUT/-**.

6.6.4 Modifying the parameter condition:

The condition (=value) of a parameter can be modified by addressing the desired parameter number (refer to item 6.6.3 above) and then pressing key Ω. Thereafter, the actual value of the parameter flashes and can be increased or decreased by means of the keys **IN/+** and **OUT/-**. By means of the key Ω, the displayed value will be confirmed. The value will be permanently stored. Thereafter, the display alternates, as described under item 6.6.2 above, the parameter and its value.

6.6.5 Quitting the setting menu:

The setting menu can be quitted when applying the keys **IN/+** or **OUT/-,** as described under item 6.6.3 above, to effect the display "'Stop" / "End". Then the setting mode can be quitted by pressing key Ω .The setting mode will also be quitted when no key is pressed within a delay of 2 minutes.

<u>Important advice:</u>
At the time of delivery from the factory, the re-switching blocking delay time is set to 20 seconds, and locking is not activated.
If the display shows 'SAFE' while modifying the target settings, this means that locking has been activated.

Attention:

If there is no manual resetting to automatic operation, the change to automatic operation will take place automatically after a delay of 30 s (starting from the last pressing of a key).
This also applies for points 6.1 - 6.4.

7. Fault alarm

Faults are signalised by the two control LEDs ("ind" and "cap") and by a symbol in the display. The fault alarm is indicated only as long as the fault persists. An acknowledgment is not necessary.

7.1 Measuring current too low

Condition: Measuring current is less than 25 mA for 2 s at least.
Alarm: Control LEDs are flashing.
Fault symbol "≡I" on the display.
Capacitors will be switched out after the fault alarm has gone on for more than 5 minutes.

7.2 Measuring current too high

Condition: Measuring current is higher than 5.3 A for 2 s at least.
Alarm: Control LEDs are flashing.
Fault symbol "≡O" on the display.

7.3 Under-compensation

Condition: The desired power factor continuously remains smaller than 0.9 inductive for 15 minutes at least.
Alarm: Control LEDs are flashing.
Display of actual power factor.
Alarm contact closes after 15 minutes.

7.4 Alarm relay

The fault alarm relay is an additional means of monitoring correct operation. When a plant is not sufficiently compensated for more than 15 minutes continuously, this condition will be signalized via the fault alarm relay. The condition of compensation having become insufficient or other faults will be perceived in time and can thus be eliminated. The potential-free contact of the alarm relay is closed when there is no supply voltage, or when the fault alarm indicates under-compensation.

8. Trouble shooting

Fault	Possible causes
Display remains blank.	- Supply voltage is not present. - Fuse has blown. The applied supply voltage may have been too high.
Fault "≡I"	- Measuring current is below 25 mA, C.T. may be too large. - Connection to the current transformer may have broken. - When the in-house generated electricity is used to meet the proper demand, which is approximately the same as the generated power, and the target power factor is set to 1.00, then the current of the C.T. will be very close to "zero". Consequently, the current will be below the measurement limit.
Fault "≡O"	- Measuring current exceeds 5.3 A, C.T. may be too small.
Fault "EPR" or "EEPR"	- A severe internal hardware failure has occured. The 'ESTAmat MH' shall be returned to the factory for checking and possible repair
P.F. Controller does not react to changes in load; display shows actual power factor, and LED "auto" flashes.	- The P.F. Controller has been changed to "man". Revert to "auto" mode by pressing the key Ω.
LEDs "ind" and "cap" are flashing, and all capacitor steps are switched in.	- The compensation output of the capacitor bank is insufficient so the desired power factor cannot be reached. - The capacitors do not receive current anymore, the HRC fuses may be faulty.
Controller is hunting.	- C/k value is too low.
Controller displays a capacitive power factor while inductive load is present, and no capacitor steps are switched in.	- k/l terminal mixed up.
The desired cosφ value is not reached and yet the Controller has stopped switching-in further steps.	- C.T. measuring current and voltage not in same phase.
Controller does not react to changes in load; LEDs "ind" and "cap" remain blank.	- The C.T.s connected to the summation current transformer have not been correctly polarized and, consequently, cancel each other instead of adding up; C.T. secondary current is to be checked. - C/k value set wrongly. - Step output is too large for this kind of application.

9. Technical Data

9.1 Measuring circuit

Precision:	category 1
Filter at input:	each measuring circuit is provided with a band-pass filter
Measuring frequency:	50 Hz (optional 60 Hz)
Measuring voltage:	interrnally connected with the supply voltage
Measuring current range:	25 mA -5 A
Measuring current consumption:	1 VA
Measuring current overloading:	20 % maximum permanent
Measuring current C.T.:	x/5 A or x/1 A, category 1

9.2 Control circuit

Number of steps:	6 or 12 steps
Switching delay time:	2-500 s as a function of reactive load, or specific setting possible (10, 30, 60, 120, 180, 300, 500 s)
Re-switching blocking delay time:	20, 60, 180 s
Fault alarm for:	Interruption of voltage, or overcurrent in measuring circuit and under-compensation
Alarm contact for:	Loss of supply voltage and under-compensation
Loading capacity of contacts:	5 A/ 265 VAC; the relay contacts of the steps are bridged with an anti-interference capacitor 47 nF.

9.3 Electrical data

Operating voltage:	230 VAC±15 %, 50Hz (60Hz and/or 115 VAC at option)
Power input:	8 W maximum
Fuse:	100 mA slow-blow type. 5 x 20 mm, incorporated in the apparatus
Connection:	14-way (MH12: 20-way) push-on terminal strip with screw-type contacts, fixing of connector by means of two screws.
External fuse:	10 A maximum

9.4 Mechanical details

Front plate:	142 x 142 mm
Panel cut-out:	138 x 138 mm
Depth:	approx. 65 mm
Weight:	0.65 kg maximum
Design:	to EN 50178, protective class II, and EN 61010-1, CE - Certification: EN50081-2, EN61000-6-2
Type of protection:	IP 40
Operating ambient temperature:	-25 to +60 degrees Celsius

10. Connection diagram

Rear view of P.F. Controller