ESTAmat® PFC
Mounting Instructions
MV1161

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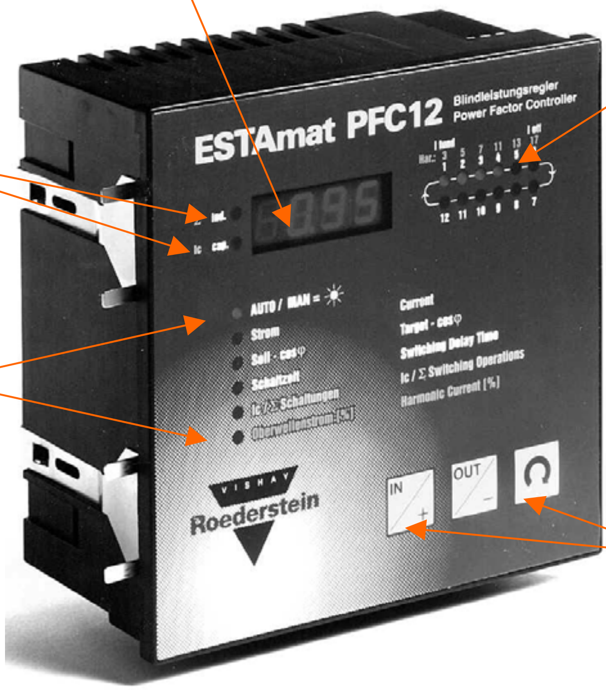
Front Panel Controls

Digital display
The four-digit display indicates actual values, faults, and the set parameters.

Step LEDs
The LEDs indicate the energized capacitor steps.
yellow lettering:
fundamental current **I fund** (LED**1**)
root-mean-square current **I eff** (LED **6**)
orange lettering:
display of harmonic current

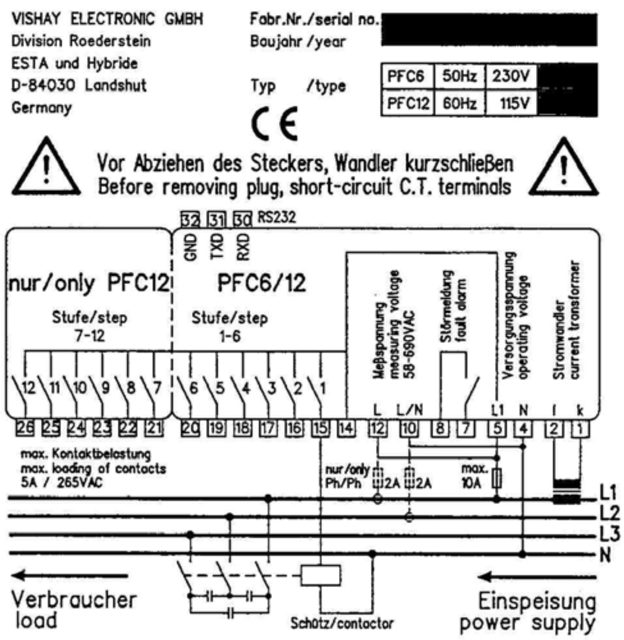
Trend LEDs
"**ind**" and "**cap**":
switching steps in or out.
green lettering:
Alternate display of step current "**Ic**"
number of switching operations "Σ"
(step LEDs 1 to 12)



LED indicators
Selected operating mode or parameter

Keyboard

Connection diagram
(Rear view of the controller)



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1. Concise Operating Instructions

1.1. Settings

The **ESTAmat PFC** Controller will be supplied with the following standard setting :

Supply voltage	: 230 VAC or 120 VAC
Measuring voltage connection	: phase to neutral
Frequency	: 50 Hz or 60 Hz
Type of initialization AU1	: fully automatic identification of - measuring voltage connection, - C.T. location and - output of the connected capacitor steps.

1.2. Mounting and connection of the **ESTAmat PFC** Controller

A cut-out of 138 by 138mm is required for mounting the Controller. The added springs for attachment shall be pushed into the slots at the device's rear until they have reached the switchboard and have locked in place.

Terminals	Connection
1	C.T. connection **k (S1)**, X/5 A or X/1 A
2	C.T. connection **l (S2)**, X/5 A or X/1 A
4	Mains connection **N**, 230 VAC or 120VAC
5	Mains connection **L1**, 230 VAC or 120VAC
7, 8	Potential-free alarm contact, normally open
10	Measuring voltage L or N
12	Measuring voltage L
15-20	Control terminals for contactors 1-6
21-26	Control terminals for contactors 7-12 (only PFC12)

In case of standard setting as per item 1.1 above, the measuring voltage can be connected to the mains supply, i.e. terminal 4 shall be bridged to terminal 10, and terminal 5 is to be bridged to terminal 12.

1.3. Start-up procedure

After the supply voltage has been applied to it, the **ESTAmat PFC Controller** starts a **self-test.** The following data will be displayed for about 2 seconds:

- The type of program e.g.: 1.2.1.
- The mode of initialization e.g.: AU1 *)
- The set target cosφ e.g.: 1.00
- The switching delay time e.g.: LoAd
- with AU1 the type of measuring voltage e.g.: L-0, must be changed to L-L by the operator, if the measuring voltage is to be connected between phase to phase. Refer to item 4.4. and 6.3.2.
- with AU2 and AU3
  the connection of measuring voltage e.g.: L1-0, must be adapted to a different connection of measuring voltage <u>and current transformer location</u> . Refer to item 4.4. and 6.3.3.

***) with AU3, the additional display of :**

- the switching program and number of engaged relay steps e.g.: IIII and with LED ●●●●●●
- the C/k-value e.g.: 0.025

Owing to the basic setting made at the factory, the **ESTAmat PFC Controller** changes into the fully automatic initialization AU1. This means that no further settings need to be made by the operator.

Prerequisite for starting the fully automatic initialization:

- The C.T. secondary current must be at least 25 mA.
- The current of the smallest capacitor connected must be at the C.T. secondary side in the range of 0.025 to 1.00 A.

Sequence of the fully automatic initialization :

Display	Function
AU1 -1- to -5- no	The Controller starts with step 1 and continues switching in steps until the location of the current transformer has been determined due to the changes in current. The trial runs are counted and evaluated. The C.T. location is determined only after 5 consecutive trial runs producing all the same result. The Controller starts at the meter reading -1- and stops, in the normal case, at -5- after 5 trial runs. In cases of unfavourable conditions of the mains supply, the value of the meter reading may reduce again. If the value -3- is not reached, either the setting AU2 or AU3 should be selected. Refer to item 6.3.1 in this case. Continuous changes of display between AU1 and no indicates that the Controller has already stored a connection value for the C.T. location. The Controller will start at AU2 after the re-switching blocking delay time has elapsed. Refer to item 4.4.1.3 for this. An activated blocking delay time for re-switching for one step is indicated by a flashing decimal point

Having identified the location of the current transformer, the current or output ratings of the capacitor steps will be determined.

Display	Function
AU2 2.1 to 2.3	Starting with step 1, the Controller switches in each **individual** step briefly, and switches it out again immediately. (PFC6 : 6 steps, PFC12: 12 steps). The procedure is repeated three times.

Normally, the **ESTAmat PFC Controller** terminates a successful initialization after approximately 5 minutes, and correctly determines the configuration of the plant, and indicates the actual power factor.

If one of the following symbols is on display, the following conditions may be the cause:

Display	Condition	Remedy
≡I	The measuring current is less than 25 mA.	Check C.T. electric circuit
≡O	The measuring current is in excess of 5.3A.	C.T. transformation ratio is too small
≡U	The measuring voltage is missing.	Check connection of Controller
≡AU1	**AU1** could not be carried out correctly. Possible causes: quick reversals of load, insufficient compensation output, load too low.	Set AU2. Refer to item 6.3.1.
≡AU2	**AU2** could not be carried out correctly. Possible causes: quick reversals of load, no switching of capacitor steps.	Set AU3. Refer to item 6.3.1.
SLE	The faults ≡AU1 or ≡AU2 have appeared five times in succession. This condition can be modified only upon fundamental change of load.	Set AU3. Refer to item 6.3.1.

A target factor of 1.00 is preset as standard.

2. General

2.1. ESTAmat PFC Controller– Application and Operation

The **ESTAmat PFC Controller** can be applied wherever automatic control of the power factor is required. All functions of the **ESTAmat PFC** are controlled by a microprocessor. A protective gear (watchdog) continously monitors the processor to guarantee its faultless operation. There are no internal time or date functions.

The measurable variables current and voltage are conducted across a 50/60Hz band-pass filter.Thus harmonics existing in the network cannot affect the measurement process. Both measurement entries are potential-free. The measuring voltage shall be in the range of 58V-690V and may be connected, at option, between phase to neutral or phase to phase. The current measuring range is 25mA to 5A, and there is no need to differentiate between X/1A or X/5A current transformer.

A measuring cycle lasts 0.5 seconds and comprises the measurement of values, the calculation of all required parameters, such as power factor, current, harmonic current, etc., and if necessary, the initialization of certain actions, e.g. switching the steps, activating alarm, etc.

2.2. Automatic identification of C.T. location and of capacitor step output

The **ESTAmat PFC Controller** is capable of determining by itself , during the start-up procedure, the location of the current transformer as well as the output rating of the connected capacitor steps by means of test switchings.

Three modes of initialization are possible:

- **Fully automatic initialization** AU1
  The **ESTAmat PFC Controller** identifies the location of the current transformer, the output and number of capacitor steps, and the switching program.
- **Semi-automatic initialization** AU2
  The **ESTAmat PFC Controller** identifies, upon presetting of the C.T. location, the output and number of capacitor steps, and the switching program.
- **Manual initialization** AU3
  The C.T. location, output and number of capacitor steps, and the switching program have to be set by the operator.

2.3. C/k value

The C/k-value is the pick-up value of the **ESTAmat PFC Controller**. The value represents the reactive current response threshold of the Controller in Ar (ampere reactive). In case the reactive current portion of the load exceeds the set C/k value, one of the two LEDs "**ind**" or "**cap**" will indicate the trend. The calculation of the C/k value is described under item 6.3.5.

2.4. 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 elements such as contactors and 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 are also applicable for the so-called hunting programs. With the switching sequence 1:2:2:2:2:2, for example, the "double-size" steps are likewise switched in circular switching sequence. The "single-size" step will then be used only for fine tuning. With the switching programs of equivalent hunting steps, e.g. 1:1:2:2:4, the hunting steps of same size (1:1 or 2:2) will also be switched alternately.

2.5. Optimized switching performance

The **ESTAmat PFC Controller** measures continuously the demand for reactive power and the variations of it and, due to the optimized switching performance, 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 **ESTAmat PFC Controller** will immediately switch in a step of 50 kvar instead of gradually switching in steps of 25kvar. This way, the number of switching operations is reduced, which results in an increased life expectancy of both the capacitors and the contactors.

2.6. Generator operation (4-quadrant operation)

The increasing use of renewable energy sources (e.g. wind, solar, biogas) and thermal regeneration, as also the application of emergency power supply systems, require that state-of-the-art power factor controllers operate trouble-free in case of a feed-back of active power into the general supply mains (generator operation). In both cases of energy supply and of energy feed-back, the **ESTAmat PFC Controller** can identify correctly the inductive reactive power and compensate it.

2.7. Switching delay time

The period between lighting-up of one of the light-emitting diodes (LED) ("**ind**","**cap**") and the switching in or out of capacitor steps is defined as switching delay time. The switching delay time can either be determined by the **ESTAmat PFC Controller** as a function of load, or preset by the operator.

2.8. Blocking delay time for re-switching

The period between switching out a certain capacitor step and the earliest possible re-switching in of the same step is defined as re-switching blocking delay. With the **ESTAmat PFC** Controller, this blocking delay for re-switching can be either 20, 60, 180 or 300 seconds. This period is necessary in order to allow the voltage existing at the capacitor after the switching-out to reduce to an acceptable level. The blocking delay for re-switching shall be selected in accordance with the existing discharging device. Switching-in shall be effected only when the residual voltage is less than 10% of the operating voltage.

2.9. Harmonic current - Root-mean-square current

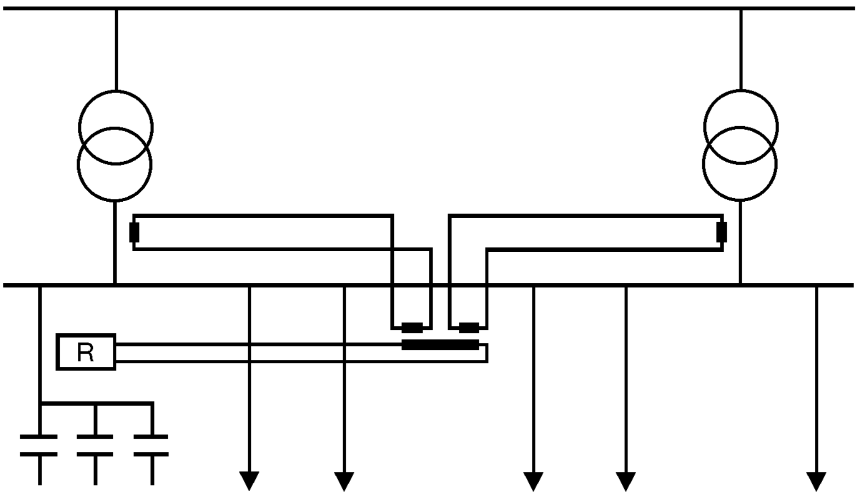
By means of the FFT-analysis (**F**ast-**F**ourier-**T**ransformation), the **ESTAmat PFC** Controller can determine harmonic currents of the 3rd, 5th, 7th, 11th, 13th, 17th and 19th harmonic. The presentation is in percentage with regard to the current of the basic frequency. The Controller displays the

percentage values up to the 17th harmonic. If harmonic generators exist and if the resonance frequency between the compensation equipment and the line transformer is on a typical harmonic frequency, the percentage part of this harmonic increases excessively. This may activate alarms by means of various limit-value profiles. This may be, for example, an audible or an optical signal via the alarm relay.
The root-mean-square current is determined by calculation on the basis of the current's curve shape. Non-linear consumers distort the sinusoidal shape of the current. Fundamental frequency current and root-mean-square current are of different values in case of harmonic load. The higher the portion of harmonic load the higher is the deviation between the values of the fundamental frequency current and of the root-mean-square current. A factor which is created from these two values is a parameter portraying the harmonic status, and can be determined by means of settable limit values to be used for the alarm.

2.10. Measurement of temperature

Via an internal temperature sensor the **ESTAmat PFC** Controller can permanently measure the ambient temperature. Although the sensor is installed within the device, the measuring can be carried out with sufficient precision because of the existing venting slots which allow sufficient air circulation. When the Controller is mounted into a switch cabinet, there is the possibility of monitoring the cabinet's internal termperature. By setting limit values, an alarm function can be activated.

2.11. Summation current transformer

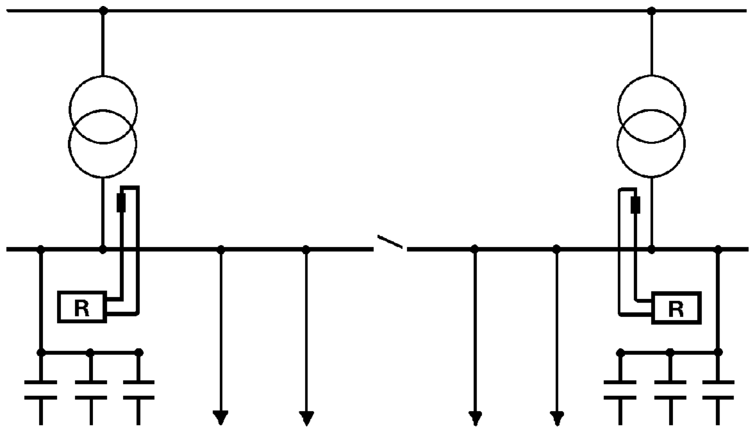


When several transformers supply one single L.V. bus bar, the individual currents shall be measured by means of current transformers and then added together via a summation current transformer. Special attention shall be given to the correct polarity because, otherwise, the current intensities of the individual transformers will subtract.

The calculation of the C/k-value is described under item 6.3.5. It is important to remember that the transformation ratios of the individual current transformers shall be added up.

k = k1 + k2 + k3 ... **k = ∑ C.T. transformation ratios**

2.12. Parallel operation



In case two network sections, each with independent power factor control equipment, are interconnected, the two power factor controllers influence each other, because the currents distribute across the two transformers. In such a case, to avoid hunting of the two power factor controllers, the C/k-values should be set differently. The result will be a so-called "lead-follow" - behavior because both controllers react at a different speed. The power factor controller with the lower C/k value is quicker in switching than the one with the higher C/k value.
The target cosφ values of both power factor controllers should be the same. If this is not the case, the power factor controller with the higher setting would try to switch in steps which the power factor controller with the lower setting would again switch out immediately. This would also result in an unacceptable hunting between the switch-in and switch-out operations.

2.13. Interface

The **ESTAmat PFC** is equipped with a serial interface **RS232**. By means of a computer, all relevant measuring values and Power Factor Controller data can be requested. Furthermore, all Power Factor Controller's parameters can be modified via a computer. The computer software and the connection cable **ESTAmat PFC** to the computer are available at option.

3. Connection of the **ESTAmat PFC Controller**

3.1. Terminals allocation

The power factor controller is connected by means of a 20-terminal plug. The **ESTAmat PFC12** is provided with an additional 6-terminal plug for the steps 7 to 12. The connections are shown at the rear of the power factor controller's casing.

Terminal allocation of the plug:

Terminals	Connection
1	C.T. connection **k (S1)**, X/5 A or X/1 A
2	C.T. connection **l (S2)**, X/5 A or X/1 A
4	supply connection **N**, 230 VAC
5	supply connection **L1**, 230 VAC
7, 8	potential-free fault alarm contact, normally open
10	measuring voltage L or N
12	measuring voltage L
15-20	control outputs for contactors 1-6
21-26	control outputs for contactors 7-12 (only PFC12)

3.2. General connection instructions

1. The power factor 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 5A, but the external fuse must not exceed the value of 10A.

3. Under normal circumstances, the measuring voltage is identical with the operating voltage, i.e. the terminals 4-10 and 5-12 shall be connected by means of bridging links. If measuring voltage and operating voltage are connected separately, the terminals 10 and 12 are each to be protected by a quick-acting fuse of 2 A.

4. All control contacts, except for the fault alarm contact (7 and 8), are bridged by a spark-quenching unit (RC element). The impedance of the RC element is 30 kΩ at 50 Hz.

5. When using capacitors with attached discharge resistors, the necessary time for discharging will be 60 or 180 seconds, which has to be observed for any switching-in of steps. The re-switching blocking delay time of the ESTAmat PFC must be set accordingly via parameter 7.

3.3. Connection instructions for current transformer

1. In case of an unbalanced load of the phases, the current transformer should be connected to the phase which is most highly loaded.

2. The current transformer shall be installed at a position which ensures that all the subsequent consumer current, including the capacitor current, will flow through it. Normally, this position is next to the feed-in transformer and on the load side of the tariff meter reading.

3. The connecting cable to the current transformer, with a maximum 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 or a current transformer of a higher rating shall be used.

4. When an already existing current transformer can be made use of, then all the current paths of the individual devices shall be connected in series with the **ESTAmat PFC Controller**. Attention should be paid that the rating of the current transformer be sufficient.

5. The primary current of the current transformer should coincide with the actual current consumption of the factory. If the current transformer is overdimensioned, the **ESTAmat PFC** Controller receives too small a measuring signal and, consequently, will work incorrectly or not at all, and will signalize the fault "undercurrent ≡I ".

6. The C/k value is set automatically by the **ESTAmat PFC Controller** in the initialization modes AU1 und AU2. Attention shall be paid, however, that the current of the smallest capacitor step at the transformer secondary is in the range of 0.025 up to a maximum 1.5 A.

7. In case of several supplies, a summation current transformer is required. In this case, it is **definitely** necessary that the terminals **k (S1)** and **l (S2)** of the individual current transformers be connected correctly.

Advice concerning the replacement of the P.F. Controller :

When working at the C.T. secondary circuit (e.g. removal of the ESTAmat PFC), attention should always be paid that the C.T. secondary terminals be short-circuited and remain so until the work is completed (e.g. re-installation of P.F. Controller).

4. Start-up procedure

In the following text, the keys to be activated are marked black..

Example: means that the key **IN** shall be pressed. The display **- - - -** symbolizes an identified keyboard operation, no further keyboard operation is necessary.

4.1. Visual control

Upon completion of the installation, all connections to the main 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 to confirm that they correspond with the relevant data given on the rating plate at the rear of the P.F. Controller!

230 VAC or 120 VAC? - 50 Hz or 60 Hz ?

4.3. Verification of set values

Upon application of the supply voltage, the display will show for 2 seconds respectively:

- type of program e.g.: 1.2.1.
- initialization mode e.g.: AU1 *)
- set target cosφ e.g.: 1.00
- switching delay time e.g.: LoAd
- with AU1 the type of measuring voltage e.g.: L-0, must be changed to L-L by the operator, if the measuring voltage is to be connected between phase to phase. Refer to item 4.4. and 6.3.2.
- with AU2 and AU3
  the connection of measuring voltage e.g.: L1-0, must be adapted to a different connection of measuring voltage <u>and current transformer location</u> . Refer to item 4.4. and 6.3.3.

***) with AU3, the additional display of :**

- the switching program and number of engaged relay steps e.g.: 1111
- the C/k value e.g.: 0.025

The **ESTAmat PFC** Controller is supplied with the following standard setting:

initialization mode	:	AU1
target cosφ	:	1.00
switching delay time	:	LoAd
blocking delay for re-switching	:	20
locking of the keyboard	:	no (not activated)

If the **ESTAmat PFC Controller** had been turned to manual operation, the P.F. Controller will automatically go back to manual operation upon return of the supply voltage. Then all capacitor steps which had before been switched in, observing the re-switching blocking delay, will be re-switched in again.

By pressing the key  this process can be aborted.

4.4. Initialization :

The P.F. Controller offers three modes of initialization:

- Fully automatic initialization AU1 (= standard setting)
  The **ESTAmat PFC** determines the location of the current transformer, the output and number of the capacitor steps, and the switching program. The operator must only set the measuring voltage mode phase to phase L-L or phase to neutral L-0 . (refer to 6.3.1 and 6.3.2).

- Semi-automatic initialization AU2
  The **ESTAmat PFC** Controller determines, after presetting the location of the current transformer, the output and number of the capacitor steps, and the switching program.

- Manual initialization AU3
  The operator has to set the location of the current transformer, the output and number of capacitor steps, and the switching program.

The P.F. Controller is supplied with the fully automatic initialization mode AU1 set, which is the normal application. The fully automatic initialization may not be successful in case of strong oscillations in the public mains. In such a case, the semi-automatic AU2 or the manual initialization AU3 can be applied. The initialization mode is stored as parameter -1- (item 6.3.1).

How to change the initialization mode is described under items 6.2 and 6.3.1 .

4.4.1. Fully automatic initialization AU1

With this mode of initialization, the current transformer may be connected to any phase. Connection of both the current transformer **k/l (S1/S2)** and the measuring voltage is also at option. The mode of measuring voltage will have to be set either phase to phase L-L or phase to neutral L-0 (=standard setting). Refer to items 6.2 and 6.3.2.
When the supply voltage is applied, the setting values will be displayed as described under item 4.3.

The fully automatic initialization AU1 comprises :
- **part 1 : determination of current transformer location and**
- **part 2 : recording the currents of the capacitor steps**

4.4.1.1. Part 1 : Current transformer location

First of all, the set re-switching blocking delay is effective. During this time, AU1 is being displayed and a decimal point is flashing. When the display alternates between AU1 and no, it means that there is still stored a C.T. location of a previous application. Refer to item 4.4.1.3. If this is not the case, the **ESTAmat PFC Controller** switches capacitor steps in and out several times after the re-switching blocking delay has elapsed and subject to the mains conditions. The number of switching cycles carried out will be displayed after the last step has been switched out. This number may range between -0- and -5- . When the display shows the figure -5- , part 1 of the initialization is completed.

If a value of 2 or even less is displayed after several switching cycles have been carried out, it is recommended to set the semi-automatic initialization AU2 or the manual initialization AU3.

If wrong results are caused by load variations during the measuring period, the display will show ≡AU1 and the result of the measurement will be rejected. If due to special mains conditions, a clear determination of the connection mode during initialization is impossible, then five further trial runs will be made observing the re-switching blocking delay. After five abortive trial runs in succession displaying ≡AU1, the power factor controller switches into a stand-by position and will resume initialization only after the load conditions have fundamentally changed. The stand-by position is indicated by the letters SLE (Sleep).

Again in this case, the semi-automatic initialization AU2 or the manual initialization AU3 is recommended.

4.4.1.2. Part 2 : Determination of the current of capacitor steps

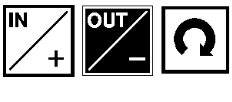
At first, the set re-switching blocking delay is effective. During this time, AU2 is displayed and a decimal point is flashing. For the determination of the currents of the capacitor steps, 6 (or 12) steps will be switched in and out, one after the other. This procedure will be repeated three times. The respective switching cycle is displayed as 2.1, 2.2 and 2.3. The measured reactive current changes will be stored as step currents. Upon completion of the initialization, the power factor controller changes into automatic operation mode and the actual power factor is displayed.

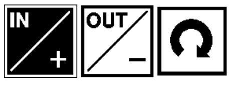
In case of a fault, e.g.: measuring voltage missing ≡U, measuring current insufficient ≡I or measuring current too large ≡O, the initialization will be interrupted. The elimination of the fault's cause will be detected by the power factor controller, and the initialization will automatically be re-started.

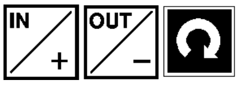
4.4.1.3. Memorizing the C.T. location with AU1

When the set target power factor has been reached for the first time during the automatic operation mode, the C.T. location will be stored permanently. If this is the case, there will appear in the display of the **ESTAmat PFC Controller**, directly after application of the supply voltage, alternatively AU1 and no during the period of the re-switching blocking delay. Thereafter, the **ESTAmat PFC Controller** performs part 2 AU2 (item 4.4.1.2).

A stored C.T. location can be erased by changing the alternating display AU1 and no into AU1 and YES.

This can be realized by means of the keys 

or 

The selected value is to be confirmed by pressing the key 

no : The **ESTAmat PFC Controller** takes over the stored C.T. location and starts with part 2 = determination of the currents of the capacitor steps.

YES : The **ESTAmat PFC Controller** erases the stored C.T. location and performs part 1 and part 2 of the initialization AU1

4.4.2. Semi-automatic initialization AU2

The semi-automatic initialization AU2 should be selected when the fully automatic initialization does not produce a satisfying result due to strong load changes. Attention will have to be paid to the fact that the phase connection of the measuring voltage has to be explicitly specified. Refer to items 6.2 and 6.3.2.

The initialization runs in accordance with part 2 of the initialization mode AU1 (item 4.4.1.2).

4.4.3. Manual Initialization AU3

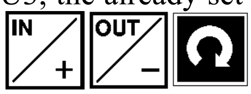
In case of manual initialization AU3, the operator must set:

- measuring voltage connection (parameter -3-, item 6.3.3.),
- the type of switching program (parameter -4-, item 6.3.4.),
- the C/k value (parameter -5-, item 6.3.5.) and
- the number of steps (parameter -6-, item 6.3.6.).

The procedure to set the parameters is described under item 6.2.

During the first start-up procedure, parameters -4- and -5- must be verified. For this, both parameters must be called-in and, if necessary, be modified in the setting menu. If this is not done ≡PAr will be displayed, and after a delay of 2 seconds, the controller will automatically change to the setting menu of the parameter concerned.
The step outputs will be determined by means of the C/k value, the number of switching steps and the switching program. No readjustment of the step outputs will occur while switching the capacitor steps during operation.

4.5. TEST MODE

During the start-up procedure of the controller, **if the measuring current ≡I, or the measuring voltage ≡U is missing**, a test mode can be activated to switch steps in the manual operating mode. During AU1 and AU2, the switching program of 1:1:1:1, the C/k value of 0.05 and the maximum number of switching steps are automatically preset. Only during AU3, the already set parameters (4, 5 and 6) will remain. The test mode is activated by means of the key 

.
Thereafter, the selected menu is displayed alternately with tESt. For deactivation of the test mode, the operating voltage of the controller must be disconnected. For example, this can be achieved by temporarily removing the control fuse of the capacitor bank.

5. Operating the **ESTAmat PFC** Controller- main menu

In the following text, the keys to be activated are marked black..

Example: 

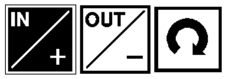
means that the key **IN** shall be pressed. The display **- - - -** symbolizes an identified keyboard operation, no further keyboard operation is necessary.

On the front plate of the ESTAmat PFC **Controller** six main menu points are laid out. Important control parameters, measuring values, and control characteristics can be enquired for or can be set by means of this main menu.

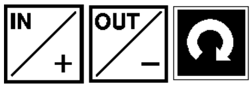
By means of the key 

the respective menu point can be engaged.

By means of the key 

the values can be reduced, or by the key 

they can be increased.

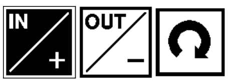
The selected value will be stored by pressing the key 

If one of the following menu points **current**, **target-cosφ**, **switching delay**, **Ic/Σ switching operations** or **harmonic current** is called upon, and no key is being operated for a period of 30 seconds, the **ESTAmat PFC Controller** switches to the **AUTO** mode.

5.1. Mode **AUTO** – automatic operating mode

In the automatic operating mode, the capacitors are automatically switched in or out depending on the demand for reactive power. The actual power factor is shown in the display. A minus in front of the power factor means that the power factor is capacitive.

For the purpose of testing, capacitors can be switched in or out manually at any time in the automatic operating mode.

By means of the key 

steps can be switched in.

By means of the key 

steps can be switched out.

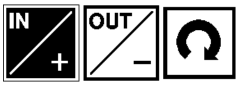
As long as the decimal point flashes in the display, the re-switching blocking delay is still effective. However, the operation of the key is stored and the capacitor step will be switched in after the re-switching blocking delay has elapsed.

5.2. Mode **MAN** - manual operating mode

The manual operating mode can be called upon from any other mode. When the **MAN** mode is set, the automatic operating mode is ineffective, i.e. no capacitor steps are switched.

In order to activate the **MAN** mode, one must keep pressing the key  until the display shows 8888 after about 5 seconds. Manual operation is manifested by the flashing of the LED **AUTO**.

In the **MAN** mode, capacitor steps can be switched in or out manually:

By pressing the key  steps can be switched in.

By pressing the key  steps can be switched out.

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

To de-activate the **MAN** mode, press key 

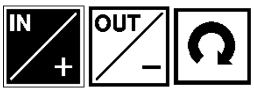
> The **MAN** mode remains active even after a voltage interruption has occurred. When the voltage has returned, the P. F. Controller goes back to **MAN** mode by itself. Capacitors which had been switched in before the voltage interruption occurred will be switched in again taking into account the re-switching blocking delay.

By pressing the key  this procedure can be stopped.

5.3. Mode current , yellow lettering

The apparent current in Ampere is displayed.

By means of the key  the root-mean-square value of the current and

by means of the key  the fundamental frequency current can be called upon.

This is displayed by means of the step LEDs **1** and **6** . The lettering **I fund** defines the fundamental frequency current, **I eff** the root-mean-square value of the current.

Ifund : current value of the mains frequency 50 or 60 Hz
Ieff : current value comprising the mains frequency plus the harmonic component.

The transformation ratio of the current transformer can be set by means of the parameter -18- . (Refer to item 6.3.18). This way, the actual primary C.T. current can be displayed.

The portion of harmonics will increase as a function of the increased deviation between root-mean-square current and fundamental frequency current.

5.4. Mode target cosφ

By means of the keys and the target power factor can be set in the range of 0.85 inductive (0.85) up to 0.95 capacitive (-0.95). A minus in front of the power factor means that the power factor is capacitive.

When pressing simultaneously the keys the standard setting 1.00 for the **target cos**φ is produced. The value shown when the setting mode for the **target cos**φ is left will be stored.

5.5. Mode switching delay time

The period between surpassing the hysteresis and starting the switching procedure is defined as switching delay time. The condition of surpassing must be given permanently during the determined switching delay time. The switching delay time can be determined by the **ESTAmat PFC Controller** as a function of load, or it can be fixed by the operator.

The following fixed switching delay times are possible: 10 , 30 , 60 , 120 , 180, 300 and 500 seconds.

Determination of the switching delay time as a function of load is activated when the display indicates LoAd . The switching delay time may range between 2 and 500 seconds.

By means of the key or the desired switching delay time or the function LoAd can be selected.

By pressing simultaneously the standard setting LoAd is produced.

The selected value is stored by means of the key and the menu indicator changes to the next menu.

By means of the parameters 8 and 9 (items 6.3.8 and 6.3.9), fixed switching delay times can be set separately for the switching-in and the switching-out of capacitors. In this case, the flashing LED **IND** signalizes a fixed presetting for the switching-in delay time while the flashing LED **CAP** indicates a fixed presetting for the switching-out delay time.

5.6. Mode Ic / Σ switchings, green lettering

In this mode the capacitor steps are examined. The capacitor current and the number of switching operations of the selected step are alternately displayed.

By means of the key or a step can be called upon.

The step LEDs 1 to 12 show for which step the values are being displayed. By means of the LEDs "Σ" and "Ic", the displayed value can be identified:

Ic = Current in Ampere of the selected capacitor step. The current is readjusted via the current transformer's transformation ratio which is set under parameter -18- .

Σ **switching operations** = Number of switching operations of the contactor of the selected capacitor step. The point symbolizes the thousandth place.

Range of switching cycles	Display
0 – 9999	8.888
10,000 - 99,999	88.88
100,000 –999,999	888.8

The capacitor contactors will have to be replaced after about 100,000 switching operations. A regular check is strongly recommended.

By pressing simultaneously the switching counter of the selected step can be reset.

5.7. Mode harmonic current [%] , orange lettering

By means of the FFT-type analysis (**F**ast-**F**ourier-**T**ransformation), the **ESTAmat PFC** Controller can determine harmonic currents of the 3rd, 5th, 7th, 11th, 13th, 17th and 19th harmonic. They are displayed in percentage of the current of the fundamental frequency. These percentage values are displayed up to the 17th harmonic. (**Har.: 3 5 7 11 13 17**)

By means of the key or a harmonic can be selected.

In the step display one can see which harmonic has been selected.

6. Parameter: setting and display

The parameter can be set in two different ways:

- at the Controller and
- with a PC via the serial interface of the Controller.

6.1. Parameter in the main menu

In the following text, the keys to be activated are marked black..

Example: means that the key **IN** shall be pressed. The display **- - - -** symbolizes an identified keyboard operation, no further keyboard operation is necessary.

The target power factor and the switching delay time can be modified directly by means of the main menu.

By means of the key the respective menu point can be selected.

The values can be reduced by means of the key or can be increased by means of the key

The selected value is stored via the key

6.2. Parameters in the setting menu

6.2.1. Setting menu - call-in

In a specific setting menu, another 19 parameters can be modified. This menu can be activated by **simultaneous** pressing of the keys

The keys must be kept pressed until the display shows the value 8888 after about 5 seconds. Thereafter, the parameter -1- and in alternation its actual occupancy, e.g.: AUI , is shown.

A parameter can be selected by pressing key or

6.2.2. Setting menu – Modifying the parameter

If the parameter is to be modified, press key The set value flashes in the display.

The value can be modified by pressing the keys or

The set value is stored via the key

Thereafter, the parameter is displayed in alternation with the modified value.

6.2.3. Setting menu – Completing and memorizing the parameter

By means of the keys or the parameter's number is to be modified until the display indicates donE . This display will appear at the moment when the number of the parameter changes from -1- to -19- or from -19- to -1- .

Thereafter, the key is to be pressed. The display SAFE flashes.

By means of the keys or the display can now be commutated between

SAFE , rSt and CAn The display continues flashing.

SAFE	=	The modified parameter values will be stored.
rSt	=	All parameters will be returned to their **RESET** values.
CAn	=	The menu is exited. Any modification will **not** be stored.

By pressing the key the selection will be confirmed. Thereafter, the Controller runs a new start-up of the program or, in case no significant parameters have been modified, it returns to the calling menu position.

A new start-up of the program without modification of the parameter will also be carried out if, after activating the setting menu, no key operation takes place for a period of 2 minutes.

6.3. Setting menu – Description of the parameter

In the setting menu, 19 parameters can be modified.

Number	Implication
-1-	Modes of initialization AU1, AU2 or AU3
-2-	Type of measuring voltage L-N or L-L, only to be set in case of AU1
-3-	Connection of measuring voltage, to be set in case of AU2 and AU3
-4-	Switching program, to be set in case of AU3
-5-	C/k value, to be set in case of AU3

-6-	Number of capacitor steps, to be set in case of AU3
-7-	Re-switching blocking delay time
-8-	Switching-in delay time
-9-	Switching-out delay time
-10-	Switching in circular or series mode
-11-	Number of fixed steps, settable only in case of circular switching mode.
-12-	Key operation blocked
-13-	Mode of functioning of the alarm relay
-14-	Release of steps switch-out
-15-	Temperature limit value
-16-	Limit values for the ratio between r.m.s. current and fundamental wave current (Ieff/Ifund)
-17-	Limit values for harmonic current
-18-	Transformation ratio of the C.T.
-19-	Waiting time for switching-out steps in case of undercurrent and of energy feed-back, if the respective function has been released via parameter 14 .

6.3.1. Parameter -1- : Modes of initialization

Three modes of initialization are possible:

Initialization mode	Display
Fully automatic	AU1
Semi-automatic	AU2
Manual	AU3

If rSt is selected (see page 20), AU1 is reset.

- Fully automatic initialization AU1
  The **ESTAmat PFC Controller** determines the current transformer location, the output and number of capacitor steps, and the switching program.

- Semi-automatic initialization AU2
  The **ESTAmat PFC Controller** determines, after the current transformer location has been set, the output and number of capacitor steps and the switching program.

- Manual initialization AU3
  The operator will have to set the current transformer location, the output and number of capacitor steps, and the switching program.

6.3.2. Parameter -2- : Type of measuring voltage

The type of measuring voltage determines whether the measuring voltage is connected between phase to phase or phase to neutral. Since this information is required only for the initialization mode **AU1,** this parameter will only be displayed in case AU1 has been selected.

Type of measuring voltage	Display
Phase / Neutral	L-0
Phase / Phase	L-L

If rSt is selected (see page 20), L-0 is reset.

6.3.3. Parameter -3- : Connection of measuring voltage

The connection of the measuring voltage needs to be indicated only in case of semi-automatic (= AU2) and manual initialization (= AU3). The table shows all the possible connection combinations to the terminals 12 and 10 of the **ESTAmat PFC Controller.**

Connection of measuring voltage	Setting value as a function of the C.T. location		
	L1	L2	L3
L1 – N	L1-0	L3-0	L2-0
L2 – N	L2-0	L1-0	L3-0
L3 – N	L3-0	L2-0	L1-0
N - L1	0-L1	0-L3	0-L2
N - L2	0-L2	0-L1	0-L3
N - L3	0-L3	0-L2	0-L1
L1 - L2	L1L2	L3L1	L2L3
L2 - L3	L2L3	L1L2	L3L1
L3 - L1	L3L1	L2L3	L1L2
L2 - L1	L2L1	L1L3	L3L2
L3 - L2	L3L2	L2L1	L1L3
L1 - L3	L1L3	L3L2	L2L1

If rSt is selected (see page 20), U-0 is reset.

The identifiers L1-N, L2-N, etc. indicate the connection of the measuring voltage. The setting value has to be read in the column which indicates the correct C.T. phase.

6.3.4. Parameter -4- : Type of switching program

The switching program has to be set only in case of the manual initialization mode (= AU3) . The figures indicate the relation between the various step outputs. For example, the switching program 1:2:4:4:4 reveals that step 2 is double the size of step 1. Step 3 and the following steps have four times the output of step 1 (e.g.: 50kvar : 100kvar : 200kvar : 200kvar ... etc.). The steps with equal output are regarded also as equal with regard to controlling (=circular steps) and can be switched in accordance with the principle of circular switching.

Switching program	Display
1:1:1:1:1	1111
1:1:2:2:2	1122
1:1:2:2:4	11224
1:1:2:3:3	1123
1:1:2:4:4	1124
1:1:2:4:8	11248
1:2:2:2:2	1222
1:2:3:3:3	1233
1:2:3:4:4	1234
1:2:3:6:6	1236
1:2:4:4:4	1244
1:2:4:8:8	1248

If rSt is selected (see page 20), 1111 is reset.

6.3.5. Parameter -5- : C/k value

The C/k value is the pick-up value of the **ESTAmat PFC Controller**. This value is the reactive current responding threshold of the Controller in reactive Ampere. If the reactive current portion of the load exceeds the set C/k value, this will be displayed by one of the two LEDs ("**ind**" or "**cap**").

The C/k value can be calculated as follows:

$$C/k = \frac{Q}{\sqrt{3} \cdot U \cdot k_{ct}}$$

Q = output of the smallest step [var]
U = phase conductor voltage (Phase-Phase) [V]
k_{ct} = C.T. transformation ratio

Example : Q=25kvar, U=400V, k_{ct}=1000:5 = 200
C/k = 25000var / (1.732 · 400V · 200) = **0.18A**

The setting range of the C/k value is 0.025A up to a maximum 1.5A. The maximum value is a function of the selected switching program. The C/k value has to be set only with the initialization mode AU3. Conditional on the minimum ***C/k$_{min}$*-value** of 0.025A and a specified C.T. transformation ratio, the smallest possible capacitor step **Q_{min}** can be calculated as follows:

$$Q_{\min} = \sqrt{3} \cdot U \cdot k_{ct} \cdot C/k_{\min}$$

U = phase conductor voltage (phase to phase) [V]
k_{ct} = C.T. transformation ratio
C/k_{min} = smallest C/k value (=0.025A)

Example: U=400V, k_{ct}=1000:5A
Q_{min} = 1.732 · 400V · 200 · 0.025A = 3.46kvar

Table with C/k values for 400V:

C/k values for 400 V													
current trans-former	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

If rSt is selected (see page 20), 0.05 is reset.

6.3.6. Parameter -6- : Number of switching steps

The number of the connected steps can be set by means of the LED step display. The setting range comprises 1-6 or12 steps respectively. The number of steps has to be set in case of initialization mode AU3. The minimum number of steps is determind by the switching program. In case the number of set steps is lower than the allowed minimum number of steps, the number of steps will be adjusted respectively.

If rSt is selected (see page 20), 6 (**PFC6**) or 12 (**PFC12**) is reset.

6.3.7. Parameter -7- : Blocking delay time for re-switching

The time between switching out a certain capacitor step and the earliest moment of switching it in again is defined as blocking delay time for re-switching. This time is required in order to reduce the voltage existing at the capacitor to an acceptable level. The re-switching blocking delay time will have to be selected in accordance with the existing discharge device. Switching-in must take place only after the residual voltage has fallen below 10% of the operating voltage. The standard setting of the blocking delay time is 20 seconds.

Re-switching blocking delay time	Display
20 sec	20
60 sec	60
180 sec	180
300 sec	300

If rSt is selected (see page 20), 20 is reset.

6.3.8. Parameter -8- : Switching-in delay time

The time for switching-in and switching-out can be set either processor-controlled as a function of load, or as fixed time presetting. It is also possible to set the switching-in time separately from the switching-out time. The setting range for the fixed time presetting is 2 to 500 seconds. This option is not effective in case of setting oFF , i.e. fixing of the switching delay time is carried out in accordance with the setting in the main menu.

If rSt is selected (see page 20), oFF is reset.

6.3.9. Parameter -9- : Switching-out delay time

As already mentioned in 6.3.8., the switching-out delay time can be set independently of the switching-in delay time. The setting range is likewise 2 to 500 seconds. This option is not effective in case of setting oFF , i.e.. fixing of the switching delay time is carried out in accordance with the setting in the main menu.

If rSt is selected (see page 20), oFF is reset.

6.3.10. Parameter -10- : Switching in circular or series mode

Steps of equal output can be switched in different sequence. In case of circular switching, the step which had been switched out for the longest time will be switched in, and the step which had been switched in for the longest time will be switched out. The advantage of this method is that there is equal switching stress and operating time for all steps. The series switching mode is applied where the compensation is assembled of filter circuits with different tuning frequencies and also when a certain switching sequence has to be maintained.

Switching sequence	Display
circular switching	[]
series switching	--

If rSt is selected (see page 20), [] is reset.

6.3.11. Parameter -11- : Fixed steps (<u>only in circular mode</u>)

A number of capacitor steps determined by the operator can be defined as fixed steps. These steps are switched in permanently upon application of the supply voltage to the **ESTAmat PFC** Controller and after the re-switching blocking delay time has elapsed. The desired number of fixed steps has to be set. The **ESTAmat PFC** Controller switches in the respective number of steps starting with the highest step digit. As a rule, all circular steps can be used as fixed steps. One cirular step, however, shall remain for the control operation. In case of series connections, no fixed steps can be defined. If the operating mode **MAN** is set, this parameter cannot be selected.

If rSt is selected (see page 20), oFF is reset.

6.3.12. Parameter -12- : Locking of keyboard operation

The parameters of the main menu, e.g.: target power factor, switching time, etc. and the manual operating mode MAN, can be protected against unauthorized adjustment by locking the keyboard. Locking is activated, when the display indicates ≡LoC .

Keyboard operation	Display
not locked	no
locked	YES

If rSt is selected (see page 20), no is reset.

6.3.13. Parameter -13- : Functioning of the alarm relay

During normal and trouble-free operation, the alarm relay is operative. The contact is open. In case of faults and of a breakdown of the supply voltage, the contact closes. The fault situation to which the alarm relay shall react can be selected by means of parameter 13.

Alarm signals							
≡t	≡hAr	≡IEF	≡C	≡U	≡0	≡I	Display
			X				0
						X	1
					X		2
				X			3
		X					4
	X						5
X							6
				X	X	X	7
					X	X	8
X	X	X					9
X	X	X			X		10
X	X	X	X	X	X	X	11

X = Alarm relay reacts to this fault situation.
The different types of fault are described in the survey matrix under item 7.
If rSt is selected (see page 20), 0 is reset.

6.3.14. Parameter -14- : Switching out the capacitor steps in case of alarm

Capacitor steps can be switched out when certain alarm signals are given. The fault alarm which shall cause a switch-out can be selected by means of parameter 14. The specific kind of fault alarm determines the switch-out behavior. The numbers **1**- **3** indicate the priorities.

1 = the capacitor steps will be switched out immediately without time delay.
2 = the capacitor steps will be switched out after a time delay which can be modified (parameter 19)
3 = steps will continue being switched out until the fault alarm has disappeared.

Due to the switching-out of capacitor steps, it may be that the set power factor cannot be maintained. This may cause reactive power costs.

Fault alarms					
≡IEF	≡t	≡E	≡U	≡I	**Display**
					oFF
			1		1
			1	2	2
		2	1		3
	3		1		4
3			1		5
		2	1	2	6
3		2	1		7
3	3		1		8
3	3	2	1		9
3	3		1	2	10
3	3	2	1	2	11

If rSt is selected (see page 20), 2 is reset.

6.3.15. Parameter -15- : Permitted maximum temperature

By means of an internal sensor, the **ESTAmat PFC** Controller can measure the ambient temperature. When the preset maximum temperature is exceeded, the display of the fault alarm ≡t alternates with the display of the actual power factor.

Advice: If for parameter -13- (function of the alarm relay) the value 6 has been selected, a cabinet ventilator can be switched in via the alarm relay.

Permitted max. temperature	Display
not active	oFF
35°	35
40°	40
45°	45
50°	50
55°	55

If rSt is selected (see page 20), oFF is reset.

6.3.16. Parameter -16- :Current factor RMS current/fundamental frequency current

This factor indicates the relation between fundamental frequency current (50Hz or 60Hz) and root-mean-square current. The higher this factor the greater is the portion of harmonic waves. This way, the harmonic situation can be evaluated. Factors between 1.05 and 2.00 can be set. The step width is 0.05. If the factor is exceeded, the fault alarm ≡IEF will be given after a time delay of 5 minutes. With the setting oFF , this function is switched out.

If rSt is selected (see page 20), oFF is reset.

6.3.17. Parameter -17- : Maximum permissible values for the harmonic current

For the harmonic portions of the 3rd; 5th; 7th; 11th; 13th; 17th and 19th harmonic, 10 maximum value profiles in percentage can be set. When at least one harmonic wave exceeds its set maximum value for a period of 5 minutes, the fault alarm ≡hAr is triggered.

Maximum permissible value of harmonic in % of the fundamental frequency current							
3rd	**5th**	**7th**	**11th**	**13th**	**17th**	**19th**	**Display**
not activated							oFF
10	10	7	5	4	3	3	1
15	15	12	8	6	5	4	2
20	20	14	9	8	6	5	3
25	25	18	11	10	7	7	4
30	30	21	14	12	9	8	5
35	35	25	16	13	10	9	6
40	40	29	18	15	12	11	7
45	45	32	20	17	13	12	8
50	50	36	23	19	15	13	9

If rSt is selected (see page 20), oFF is reset.

6.3.18. Parameter -18- : C.T. transformation ratio *k*

The current transformer transformation ratio ***k*** can be set by means of parameter 18. The displayed current values and C/k values will be respectively multiplied by the set factor. Factors between 1 and 8000 can be selected. This is possible in all the initialization modes.
If rSt is selected (see page 20), 1 is reset.

6.3.19. Parameter -19- : Time delay for switching out steps in case of ≡I and ≡E

If fault alarm is given as a consequence of undercurrent ≡I and energy feed-back ≡E , capacitor steps can be switched out after the set waiting delay has elapsed. The switch-out function has to be released via parameter 14. Waiting delays between 30 and 500 seconds can be set.
Step width is 10 seconds (range of 30 – 200), 20 seconds (range of 200 – 300) and 50 seconds (range of 300 – 500).
If rSt is selected (see page 20), 500 is reset.

7. Fault elimination

7.1 Operation and fault display

Symbol	Type	Description	Reaction of ESTAmat PFC	Fault elimination
≡I	failure of current	measuring current is below 25mA	capacitor steps will be switched out after a set delay has elapsed if the function is activated.	- measuring current too low, C.T. may be too large. - connection to C.T. may have broken. - in case of internal current generation, the C.T. current may be zero if internal consumption and generator output are about the same, and the target power factor is set to 1.00.
≡O	overcurrent	measuring current exceeds 5.3A	none	- measuring current exceeds 5.3A because the C.T. may be too small.
≡C	under-compensation	the actual power factor is permanently below 0.9 lagging for 15 minutes at least	none	- compensation output may be too small and the set target power factor cannot be reached. - capacitors do not carry any current because either the step-fuses are defective or the contactors are not connected.
≡U	measuring voltage fault	measuring voltage is missing	capacitor steps are switched out without delay	- possibly the control-fuses are defective
≡t	excess temperature	ambient temperature has exceeded the set limit	capacitor steps are switched out after a certain delay, if the function is activated	- internal temperature in the cubicle is too high. - check cubicle ventilation - check ventilation filters for clogging - capacitors or chokes may be overloaded due to harmonic currents
-1- to -5-	progress of AU1	the figures 1 to 5 indicate the progress of AU1. AU1 is completed when figure 5 is reached	none	- **No fault display!** - when figures 1 to 4 alternate with =AUI, the Controller tries to initialize under difficult load conditions. If this is the case, it is recommended to change to **AU2.**
2.1 to 2.3	progress of AU2	the figures 2.1 to 2.3 indicate the progress of AU2	none	- **No fault display!**

Symbol	Type	Description	Reaction of ESTAmat PFC	Fault elimination
≡AU1	fault during initialization mode AU1	AU1 could not be completed without faults	five trial runs are made	- Controller cannot determine the C.T. location easily owing to the quick load changes
≡AU2	fault during initialization mode AU2	AU2 could not be completed without faults	five trial runs are made	- Controller cannot determine the C.T. location easily owing to the quick load changes
≡SLE	stand by mode SLEEP	AU1 and AU2 have appeared five times in succession. This condition is changed only upon fundamental change of load	none	- automatic initialization is not possible due to the actual load condition. Upon change of the line conditions, the Controller tries again an initialization. It is recommended to change to AU3
≡E	feeding back of energy	the display appears when capacitor steps shall be switched out in case of feeding back of energy	capacitor steps are switched out after a certain delay, if the function is activated	- **No fault function!**
≡IEF	current rms value	the relation between rms value and fundamental frequency value of the current has exceeded a specified limit	capacitor steps will be switched out one by one after five minutes, if the function is activated	- due to harmonic currents, the rms current may clearly differ from the fundamental frequency current. The increased harmonic current may lead to overloading of the capacitors. Dangerous resonance conditions can be **temporarily** avoided by switching out capacitor steps. **However, the harmonic current situation will have to be examined.**
≡hAr	harmonic current	a specified percentage of a harmonic has been exceeded	none	- dangerous resonance conditions can be **temporarily** avoided by switching out capacitor steps. **However, the harmonic current situation will have to be examined.**
≡PAr	parameter control	by the first start-up procedure, the parameters **-4-** and **-5-** must be verified.	after a delay of 2 seconds, the controller will automatically change to the setting menu of the parameter concerned.	- **No fault function!**

Symbol	Type	Description	Reaction of ESTAmat PFC	Fault elimination
≡coS	Switching out of capacitor steps	alarm ≡IEF or ≡t is given and switching out of capacitor steps is activated.	after the given alarm and with a 5 minutes delay, steps will continue being switched out. **Attention: to achieve this, the controller will reduce the set target power factor!**	- **No fault function!,** refer to ≡IEF and ≡t
≡LoC	keyboard is locked	the keyboard is locked by means of parameter 12	none	- **No fault function!,** refer to item 6.3.12
dAEr	data memory defective	during checks of the internal memory, a fault occurred	Controller is defective	- return Controller to factory for repair
EPr	memory defective	during checks of the program memory, a fault occurred	Controller is defective	- return Controller to factory for repair

7.2 General faults

Fault display	Cause
Display remains blank.	- supply voltage is missing. - equipment fuse is defective. Possibly the applied supply voltage is too high.
Controller does not react to changes; display shows actual cos φ and LED **'AUTO'** flashes.	- Controller has been changed to '**MAN**', press key to revert to automatic operation.
Controller is hunting.	- C/k value is too low (only with **AU3** mode)
Controller displays a capacitive power factor while inductive load is present, and no capacitor steps are switched in.	- C.T. connection **k/l (S1/S2)** is mixed up (only with **AU3** mode)
The set target power factor is reached but does not coincide with the actual power factor of the plant.	- a wrong measuring voltage connection is set in mode **AU2** or **AU3.**
The displayed current does not coincide with the actual current.	- the current transformers connected to the summation current transformer are wrongly 'poled'.Terminals **k/l (S1/S2)** are mixed up, i.e. the currents are not added up but subtracted. - the current measuring path of the Controller is connected in parallel with other measuring equipment; current measuring paths should be connected in series. - A wrong setting of the C.T. transformation ratio k (parameter 18) was made.
Upon switching it in, the Controller starts with initialization mode **AU2** and, after this mode is completed, operates incorrectly.	- Controller is set to **AU1** and uses wrongly memorized data. Possibly the Controller had been applied in another plant before, wiring of measuring connections were changed, or a fault occurred with mode **AU1**. - refer to items 6.0 and 6.3 'setting menu' in order to select the initialization mode new.

8. Technical Data

8.1. Measuring circuit

Voltage range	:	58 V to 690 V, stepless
Current range	:	25 mA to 5 A
Frequency	:	50 Hz (60 Hz upon request)
Input filter	:	each measuring circuit is provided with a band-pass filter
Voltage connection	:	phase to phase or phase to neutral
Current power input	:	1 VA maximum
Galvanic separation	:	potential-free connection with both measuring circuits
Current continuous overloading	:	20% maximum
Current transformer	:	x/5A or x/1A, category 1
Precision U-I	:	1%
Precision harmonic current	:	The accuracy of harmonic current measurement is better than 90 %.

8.2. Control circuit

Number of steps	:	6 or 12 steps
Switching delay time	:	a function of reactive load (2 to 500 seconds) or, settable to 10, 30, 60, 120, 180, 300, 500 seconds
Re-switching blocking delay time	:	settable to 20, 60, 180, 300 seconds
Relay contact load-bearing capacity	:	5A/265VAC, the contact is bridged with a 47 nF anti-interference capacitor

8.3. Monitoring

Watchdog	:	monitoring correct function of the processor
Temperature	:	monitoring ambient temperature
Alarm relay	:	can be programmed with various alarm functions
Display	:	showing symbols for the various types of faults
Harmonic current	:	alarm signal
No-voltage release	:	all capacitor steps will be switched out immediately upon interruption of supply voltage. Switching-in can take place only after the re-switching blocking delay has elapsed.

8.4. Electrical connection

Operating voltage	:	230VAC ±15%, 50Hz (60Hz and/or 120VAC upon request)
Power input	:	8W maximum
Instrument fuse	:	100mA tr. 5 x 20 mm, inside the device
Connection	:	via 20-poles (PFC12: an additional 6-poles) multipoint connectors, 2.5 mm², rigid or flexible cable
Interface	:	RS232, 3-poles multipoint connector

8.5. Mechanical details

Front panel	:	142 x 142 mm
Panel cut-out	:	138 x 138 mm
Depth	:	approximately 70 mm
Weight	:	0.65 kg maximum (PFC12)
Design	:	to EN 50178, protective class II, and EN 61010-1, EN50081-2, EN61000-6-2 CE
Type of protection	:	IP 40 with multipoint connector mounted (IP 55 upon request; but only for the frontside protected by a lockable Controller cover, when controller is mounted in the cubicle door)
Ambient operating temperature	:	-25°C up to +60°C
Position of installation	:	at option

9. Flow Diagram: Parameters in the setting menu

-1- Modes of initialization

AU1	AU2	AU3

-2-
Type of measuring voltage
L-0 or L-L

-3- Connection of measuring voltage
(Setting value as a function of the C.T. phase)

Connection of measuring voltage	Connection of measuring voltage
L1 – N	L1 – N
...	...
L1 - L3	L1 - L3

-4- Type of switching program

1:1:1:1:1
...
1:2:4:8:8

-5- C/k value

-6- Number of switching steps

-7- Re-switching blocking delay time	Display
20 sec	20
60 sec	60
180 sec	180
300 sec	300

-8- Switching-in delay time
LoAd or fixed time presetting is 2 to 500 seconds
(oFF: carried out according to the setting in the main menu)

-9- Switching-out delay time
LoAd or fixed time presetting is 2 to 500 seconds
(oFF: carried out according to the setting in the main menu)

-10- Switching in circular or series mode

Switching sequence	Display
circular switching	[]
series switching	--

-11- Fixed steps (only in circular mode)

-12- Locking of keyboard operation (≡LoC)

Keyboard operation	Display
not locked	no
locked	YES

-13- Functioning of the alarm relay

Alarm signals							Display
≡t	≡hAr	≡IEF	≡C	≡U	≡0	≡I	
			X				0
						X	1
					X		2
				X			3
		X					4
	X						5
X							6
				X	X	X	7
					X	X	8
X	X	X					9
X	X	X			X		10
X	X	X	X	X	X	X	11

-14- Switching out the capacitor steps in case of alarm

1 = the capacitor steps will be switched out immediately without time delay.

2 = the capacitor steps will be switched out after a time delay which can be modified (parameter -19-)

3 = steps will continue being switched out until the fault alarm has disappeared.

For table with relation between fault alarm and switch-out behavior, refer to item 6.3.14.

-15- Permitted maximum temperature

Permitted max. temperature	Display
not active	oFF
35°	35
40°	40
45°	45
50°	50
55°	55

-16- Current factor RMS current/fundamental frequency current

Factors between 1.05 and 2.00 can be set. The step width is 0.05.

-17- Maximum permissible values for the harmonic current

Maximum permissible value of harmonic in % of the fundamental frequency current							Display
3rd	5th	7th	11th	13th	17th	19th	

-18- C.T. transformation ratio *k*

Factors between 1 and 8000 can be selected.

-19- Time delay for switching out steps in case of ≡I and ≡E

The switch-out function has to be released via parameter -14-

Waiting delays between 30 and 500 seconds can be set.