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Power Factor Controllers

NOVAR-106/114
NOVAR-206/214

Firmware v. 2.1

Operating Manual

11/2005

CONTENTS

1. Description

1.1 Basic Functions

Novar reactive power controllers are fully automatic instruments that allow optimum control of reactive power compensation.

The instruments feature precise voltage and current measurement circuits and the digital processing of values measured provides high evaluation accuracy of both true root–mean–square and power factor values.

The instruments calculate fundamental harmonic component of active and reactive current with FFT algorithm. Voltage fundamental harmonic component is calculated in an analogous fashion thus providing accurate measurement and control even in conditions of distortion by higher harmonic components.

The voltage measurement circuit in Novar 106/114 is internally connected to power supply terminals of 230 V AC; it is isolated in Novar 206/214 allowing connection of voltage in the range from 100 to 690 V AC. The current measurement input is a general–purpose one for nominal value of a 1 A or 5 A metering current transformer's secondary winding. The measurement inputs can be connected to the controller in any combination, that is any phase or line voltage and any phase's current.

The instrument's installation is fully automatic. The controller automatically detects both the connection configuration and the value of each compensation section connected. Entering these parameters manually is also possible.

Control is provided in all four quadrants and its speed depends on both control deviation value and its polarization (overcompensation / undercompensation). Connecting and disconnecting power factor capacitors is carried out in such a way that achieving the optimum compensation condition is by a single control intervention at minimum number of sections connected. At the same time, the instrument chooses relay sections with regard to their even load and preferably connects those that have been disconnected for the longest time and the remanent charge of which is thus minimum.

Within the control process the instrument continually checks the relay compensation sections. If a section's outage or change in value is detected, the section is temporarily disabled for regulation under given setting. The section temporarily disabled is periodically tested and enabled for regulation again when possible.

The controllers ate designed for systems with nominal voltage frequency 50 or 60 Hz. Voltage signal dominant fundamental harmonic component is evaluated continuously since voltage is connected and using this information the controller determines the nominal frequency and adjusts its operation to it automatically

In measurement of current, harmonic component levels are evaluated of up to the 19^{th} order of magnitude. The total current harmonic distortion, THD, which can be viewed on a display, is calculated from these measurements' results while it is possible to preset the THD threshold level at which the controller disconnects all compensation sections thus preventing their damage. Besides that, the most adverse THD values, values of harmonic components selected and the minimum power factor values are recorded into the instrument's memory for subsequent analysis.

Besides the power factor capacitors, it is possible to connect power factor chokes (mains decompensation). Any output can be set as fixed.

The controllers come in two basic designs with different numbers of outputs: Novar 106/206 with six output relays and Novar 114/214 with fourteen output relays. The Novar 2xx controllers have, as opposed to the 1xx line, an additional voltage measurement input and a second tariff input.

Both types of controller have an Alarm relay output that can be set to signal non-standard conditions, such as undercurrent, overcurrent, measurement voltage failure, harmonic distortion preset threshold exceeded, overcompensation or undercompensation, section limit connection rate exceeded, section outage or back feeding condition.

All types of controllers can be ordered in a version extended with galvanic-isolated RS-232 or RS-485 communication interface. All values measured can be monitored and the controller's parameters set using a remote computer.

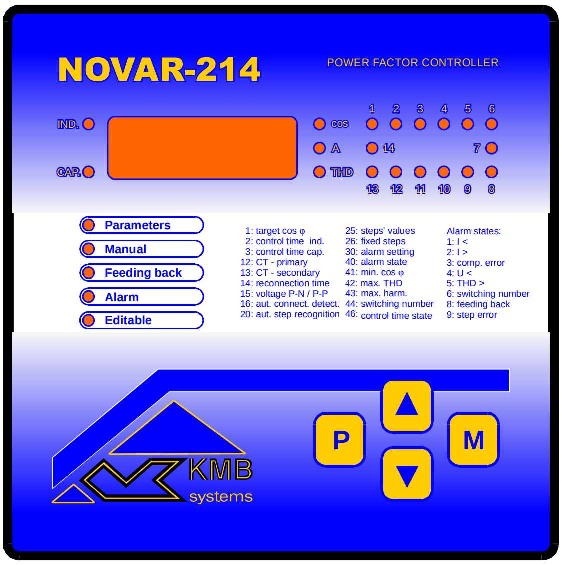
1.2 History of Versions

version	date of release	note
1.6	04/2000	- basic version
1.7	12/2000	- automatic 50 / 60 Hz switching over added - minimum measurement current value decreased to 0.01 A
1.8	04/2001	- THD and harmonic component measurement range extended - communication line selectable transfer rate introduced
1.9	01/2002	- optimized control algorithm - maximum number of power factor chokes increased to 10
2.0	01/2003	- Modbus-RTU communication protocol implementation - switch-on time of section monitoring function added
2.1	04/2005	- regulation time setting extension

1.3 Front Panel

The front panel consists of a numeric display, indication LEDs and a control keypad.

figure 1: front panel



1.4 Numeric Display

Information shown on the numeric display can be divided into 3 main data groups:

- instantaneous mains values measured, such as power factor, current, current THD, etc.
- controller parameters
- test and error messages

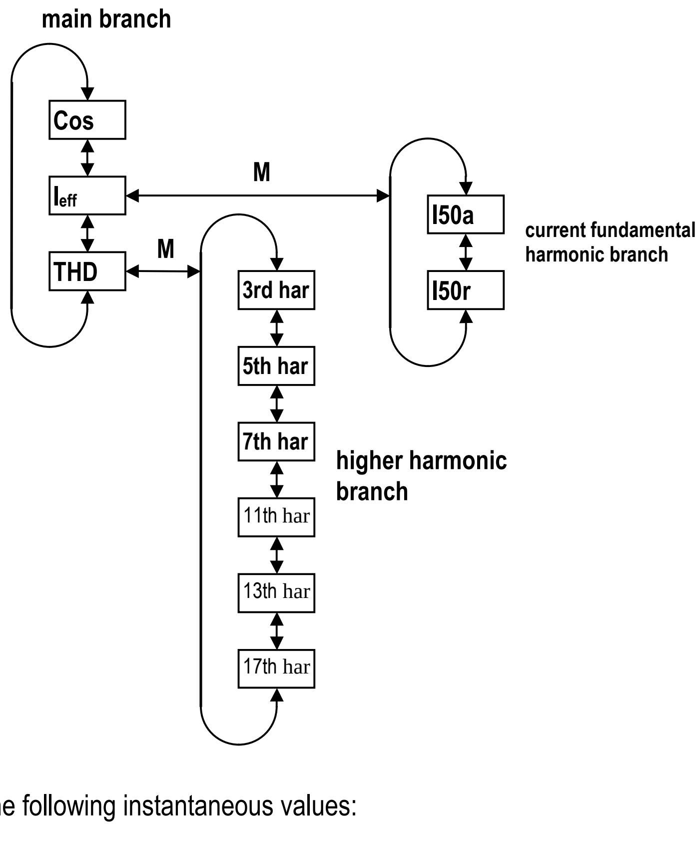
1.4.1 Instantaneous Measurement Values

The mode of displaying instantaneous values is the basic display mode which the controller enters on power-up. If you switch to parameter display mode, you can get back to instantaneous value display mode by pressing the ***M*** button (measurement).

The controller enters the instantaneous display mode automatically in about 30 seconds from the moment you stop pressing control keys (or in five minutes if control time is displayed – see description of parameter 46 further below).

One of LEDs, ***COS*** , ***A*** , ***THD,*** is always lit in the instantaneous display mode. These LEDs identify the value displayed. Instantaneous values displayed are organized in branches – see figure 2.

figure 2: instantaneous value display – structure



The main branch contains the following instantaneous values:

- ***COS*** – power factor. The value corresponds to instantaneous ratio of active component to total current fundamental harmonic value in the mains. A positive value means inductive power factor, negative means capacitive power factor.
- I_{eff} – current effective value in the mains (including higher harmonic components) in amperes.
- ***THD*** – level of current total harmonic distortion in the mains — this percent value is calculated from the measured curve using the FFT algorithm and it tells the ratio of content of current higher harmonic component up to the 19th harmonic to current

fundamental harmonic level. This value is only shown if the total mains load is at least 5 % of the nominal load (in accordance with metering current transformer's primary side nominal value).

You can switch between values displayed with the ↑, ↓ buttons.

If the I_{eff} value is displayed, you can switch to the current fundamental harmonic branch by pressing the ***M*** button (measurement). This branch contains two values:

- ***I50a*** – active component of current fundamental harmonic. This value in amperes is indicated on display with letter ***A*** (A for active)
- ***I50r*** – reactive component of current fundamental harmonic in amperes. Depending on its character it is indicated with letter ***L*** (inductive) or ***C*** (capacitive).

Note: names 150a and 150r are derived from the frequency of fundamental harmonic component, which is usually 50 Hz. In systems with nominal frequency 60 Hz, the fundamental harmonic component has frequency 60 Hz, of course.

You can again move up and down the branch using the ↑, ↓ buttons. To get back to the main branch of instantaneous values press button ***M***.

You can switch to the higher harmonic branch while a THD value is shown by pressing button ***M***. After pressing the button, the harmonic's number shows for a moment and then the value of this harmonic as percentage of the fundamental harmonic is displayed. The value is only displayed if the total load in the mains reaches at least 5 % of the nominal load (in accordance with metering current transformer's primary side nominal value).

You can switch between all selected harmonic components, 3rd, 5th, 7th, 11th, 13th, and 17th, by pressing the ↑, ↓. These harmonic components were selected since they represent the most usual cases of distortion and their values are usually the highest when compared with the others. To get back to the main branch of instantaneous values press button ***M*** again.

1.4.2 Controller Parameters

You can view controller parameters by pressing the ***P*** button (parameters). First the parameter number shows momentarily and then its value does. The parameter number flashes momentarily every five seconds for better orientation.

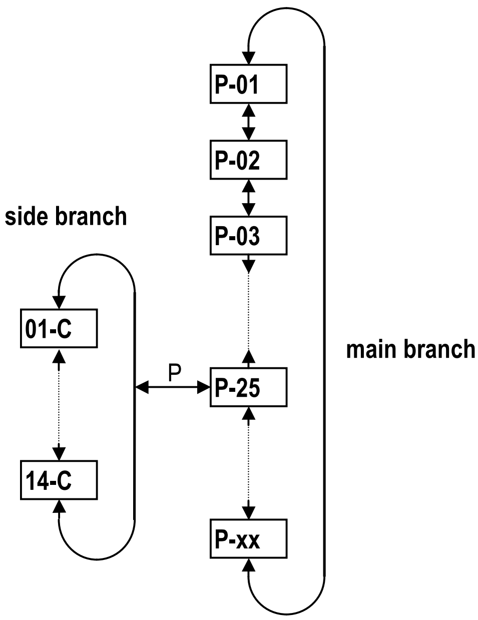
The ***Parameters*** LED is lit in the parameter display mode.

The parameters can be divided into three main groups:

- Parameters determining controller functions. These parameters can be set to direct the regulation process. There are power factor required, regulation period, reconnection delay time, etc.
- Parameters indicating controller's current state. This is a current state of alarm (parameter 40), error state (parameter 45), and regulation time state (parameter 46). These parameters' values are set by the controller and they are used to identify nonstandard or error conditions closely and monitor progress of the regulation process in detail.
- Parameters of mains and controller recorded in the process of regulation. These are extreme values measured in the mains (minimum power factor, maximum THD and current harmonic levels) on the one hand and number of connections of each compensation sections on the other hand. These values are set by the controller and the operator can only reset them.

The parameters are organized by ordinal number in the main branch – see figure 3. Some of the parameters (parameter 25 – sectional current, 26 – fixed sections, 30 – alarm setting, 40 – state of alarm, 43 – maximum harmonic values, 44 – number of sections connected) are located on side branches for easier navigation. You can switch to a side branch with selected parameters by pressing button ***P*** (parameters) and switch back to the main branch in the same way. Side branch parameter displayed can be identified from a dash between the parameter number and value. For example: in the main branch, while showing parameter 26 (fixed sections), you will se *01 C* (section 1 is regulating capacitive); if you want to display conditions of the other sections, you need to switch display to the side branch by pressing button ***P***; the display will change to *01-C* and now you can move up and down through all sections' values on the side branch. Pressing button ***P*** again returns display to the main branch (the dash disappears).

figure 3: parameter display – structure



When viewing parameters, the ***Editable*** LED indicates if the parameter being displayed can be edited — if it is lit, the parameter value can be changed; if it is dark, the parameter value can not be changed — either a parameter completely locked for changes by operator (such as parameter 40 – state of alarm) is displayed or the edit mode is protected by password.

Pressing button ***M*** (measurement) returns to the instantaneous value display mode. The controller gets back to this mode automatically in about 30 seconds from the last press of button.

Exception: In the ***Manual*** mode the parameter values can not be viewed. Instantaneous output values are displayed on pressing button ***P*** (parameters) — see description further below.

1.4.3 Test and Error Messages

In the instantaneous value display mode a test or error message pops up in place of an instantaneous power factor value in some situations. Each message are described further below in more detail. In these situations, when the value shown does not represent instantaneous power factor, the ***COS*** LED flashes.

1.5 Indication LEDs

Besides the numeric display and adjacent LEDs, ***COS*** , ***A*** , ***THD*** , ***Parameters*** and ***Editable***, the front panel has some more indication LEDs.

1.5.1 Output State Indications

The array of LEDs at the top right part of the front panel show the current state of output relays. Each LED is assigned a number from 1 to 6, or from 1 to 14, and if lit they indicate closed contacts of corresponding output relay.

If a LED is flashing, it means the controller wants to switch on the output, but it has to wait for the delay time to elapse. The corresponding output relay is open and it will be closed as soon as the reconnection delay time has elapsed.

An exception is the power-up display test to check correct operation of all display elements. In this test the display shows ***TEST*** and all indication LEDs go on and off one by one. All output relays stay open while the test is running.

1.5.2 Trend Indication

These LEDs show the magnitude of deviation of the true instantaneous reactive power in the mains from optimum reactive power value which would correspond to the set value of required power factor.

If the deviation is smaller than a half of the reactive power value of the smallest capacitor, both LEDs are dark. If the deviation is greater than a half of, but smaller than, the reactive power value of the smallest capacitor, the corresponding LED flashes — if lagging (undercompensation), the ***IND*** LED flashes; if leading (overcompensation), the ***CAP*** LED flashes. If the deviation exceeds the value of the smallest capacitor, the corresponding LED is permanently lit.

Exceptions to these LEDs' meanings are the following situations:

- measurement U and I method of connection is not defined (parameter 16)
- process of automatic connection detection is in progress
- process of automatic detection of sections' currents is in progress

If the method of connection is not defined, both LEDs flash; they are dark in the other two situations.

1.5.3 Indication of Manual Mode

Flashing ***Manual*** LED indicates that the controller is in the manual mode. The controller's regulating function is disabled.

If this LED is dark and display is in the ***Measurement*** mode (that is the ***Parameters*** LED is dark), the controller is in its standard regulating mode or it is carrying out automatic connection detection or automatic detection of output currents.

1.5.4 Indication of Back Feeding

If the controller knows of the method of connection (measurement voltage and current), that is if the process of automatic connection detection has been completed successfully or the method of connection has been entered manually, the ***Feeding Back*** LED indicates the power transmission direction. If it is dark, the power is flowing from the assumed power supply to the appliance. If the LED is lit, the power is flowing in the opposite direction.

1.5.5 Alarm Indication

The controller features a signalling ***Alarm*** relay. This relay's operation can be set as described further below. The ***Alarm*** LED indicates this relay's condition, that is if the ***Alarm*** *relay's output contact is closed, the LED flashes.*

2. Installation

2.1 Mechanical

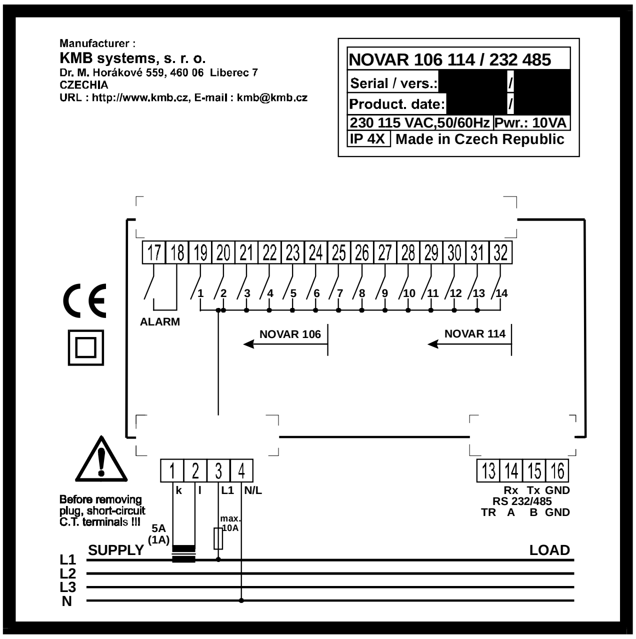
The instrument is built in a plastic box to be mounted in a switchboard panel. The installation opening dimensions are to be 138 x 138 mm. The instrument's position is fixed through enclosed locks.

2.2 Connection

To connect the controller there are connectors with screw-on terminals in the back wall. Configuration of signals on these connectors is illustrated in figure 4 and figure 5.

Examples of controller connections are shown in a separate chapter.

figure 4: Novar-114 controller – connectors



Maxim cross section area of connection wires is 2.5 square millimeters.

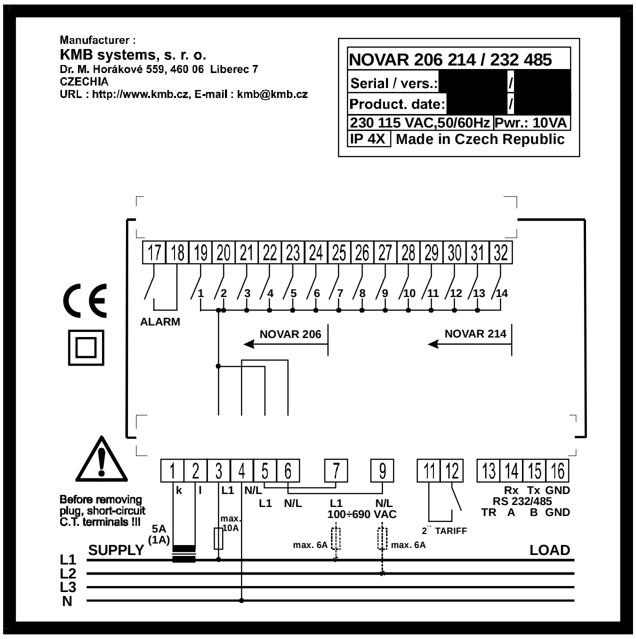
2.2.1 Power Supply

The controller requires supply voltage at nominal value 230 or 115 V AC (according the device type), 50/60Hz, for its operation while the power requirement is maximum 10 VA. The supply voltage connects to terminals 3 (***L1***) and 4 (***N/L***). Controller's power supply is one-pole protected with a T0.1L or T0.2L fuse, respectively.

The 2xx line controllers have power supply terminals 3 a (***L1***) and 4 (***N/L***) internally connected to terminals 5 (***L1***) and 6 (***N/L***) which can be utilized for connecting the power supply voltage to measurement voltage input (terminals 7 – ***L1*** and 9 – ***N/L***).

Power supply terminal 3 (***L1***) is internally connected to the common pole of output relays. It is necessary to dimension the power supply protection considering output circuit breakers' power as well.

figure 5: Novar-214 controller – connectors



Since the instrument does not have its own power switch, you must include a disconnecting device in the power supply circuit (switch — see installation diagram). It must be located right at the instrument and easily accessible by the operator. The disconnecting device must be marked as such. A circuit breaker for nominal current of 10 amp makes a suitable disconnecting device, its function and positions, however, must be clearly marked (symbols “0” and “I” in accordance with EN 610 10–1).

2.2.2 Measurement Voltage

2.2.2.1 1xx Line Controllers

The power supply voltage is used as measurement voltage in 1xx line controllers and it is not thus necessary (or possible) to connect measurement voltage independently.

2.2.2.2 2xx Line Controllers

The 2xx Line Controllers feature a general-purpose, galvanic-isolated voltage measurement input. It allows to connect measurement voltage in the range of nominal values from 100 to 690 V AC of either phase or line voltage. In basic connection phase L1 goes to terminal ***L1*** (7) and neutral wire to terminal ***L2/N*** (9). The voltage signal (or dominant harmonic component) nominal frequency can be 50 or 60 Hz.

The measurement voltage must be protected externally. If the measurement voltage is identical with power supply voltage, they can share a circuit breaker. Otherwise each voltage branch must be protected with fuses or circuit breakers of nominal value 1 to 6 A.

2.2.3 Measurement Current

Metering current transformer outputs connect to terminals 1 (***k***) and 2 (***l***). A metering current transformer of nominal output current 5 or 1 A can be used – the metering current transformer’s nominal secondary winding current value must be entered when setting up the instrument for its proper operation (parameter 13 – see further below). The connector features a screw lock to prevent accidental pull-out.

2.2.4 Error Indication

The instrument has an auxiliary Alarm relay to indicate nonstandard conditions. This relay's contact goes to terminals 17 and 18. It can be loaded with current 4 A at 250 V AC.

2.2.5 Output Relays

The instrument has 6 or 14 output relays (depending on type of controller). The relays' contacts go to terminals 19 through 32. Relays' common contacts are internally connected to power supply terminal 3 (***L1***) — when an output relay contact closes, power supply voltage appears at the corresponding output terminal.

The relays' output contacts are wired with varistors. They can be loaded with current 4 A at 250 V AC.

In installation there may be a need to test function of each regulation section by manual connection and disconnection — this can be done in the ***Manual*** mode or using *manual intervention in regulation process* (see further below).

2.2.6 Second Tariff Function Selection

In some situations it may be suitable to operate the controller with two different settings, for example depending on load characteristics in different daily or weekly zones. To select the setting desired, there is the second tariff input.

This input is not galvanic-isolated from the controller's internal circuitry and that is why it is necessary for the relay, switch or optocoupler driving the input to be located as close to the controller as possible (optimally in the same cabinet) to minimize the lead length (maximum about 2 to 3 meters). The input is connected to terminals 11 and 12. The input's internal power supply voltage is 12 V DC, switching current about 5 mA.

If the second tariff active device is a transistor (NPN) or optocoupler, it is necessary to observe the connection polarity – transistor or optocoupler collector to go to terminal **+** (11) and emitter to terminal **–** (12).

When the input is open, the controller operates with the basic tariff setting, when it is closed (if the second tariff function is enabled – see further below), it operates with the second tariff setting.

Only 2xx line controllers feature the second tariff selection input.

2.2.7 Communication Interface

The controllers can be equipped with galvanically isolated communication interface in compliance with RS-232 or RS-485 standard for remote setting and regulation process monitoring.

2.2.7.1 RS-232 Communication Interface

The communication link uses an additional four-pole connector on the rear panel (terminals 14, 15, 16). The signals are assigned as shown in table 1.

table 1: local communication line signal configuration

signal	terminal
RxD, receive data	14
TxD, transmit data	15
GND/C, communication line ground	16

The communication interface complies with CCITT V.28 (RS-232) recommendations, that is ± 12 V with minimum internal impedance load 3 kΩ. Signals in accordance with CCITT V.24 are used, that 102 (common wire), 103 (transmission data) and 104 (reception data).

The interface can be used to connect one controller to a remote computer. Communication cable maximum length is about 30 meters (shielded cable, such as 3 x AWG24, recommended).

2.2.7.2 RS-485 Communication Interface

Signal-to-pin configuration for RS-485 type line is shown in table 2.

table 2: local communication line signal configuration

signal	terminal
TR	13
DATA A	14
DATA B	15
GND/C	16

The interface allows connecting up to 32 instruments at a distance up to about 1 kilometer. Recommended cable is shielded twisted metallic double pair.

RS-485 line requires impedance termination of the final nodes by installing terminating resistors for communication distances of a few tens of meters and longer. Terminating resistors matching the cable's wave impedance are connected between terminals 14 and 15 (DATA A and DATA B). The instrument has built-in terminating resistor of 330 ohms. It is connected between DATA B-signal (terminal 15) and TR-terminal (13) inside the instrument. To install the resistor, simply connect terminals DATA A (14) and TR (13) with each other.

If the communication cable is hundreds of meters long or in environment with electromagnetic noise it is suitable to use a shielded cable. The shielding connects to terminal 16 (GND/C) and to the PE (protection earth) wire at one end of the cable.

3. Putting in Operation

3.1 First Use

The controller comes preset to default values as shown in table 3.

On power-up a display test runs first. The display momentarily shows

- type of controller (e.g. *N214*)
- firmware version (e.g. *2.0*)
- type of measurement voltage set (*U=PN* or *U=PP*)
- current metering transformer secondary winding nominal value set (*I=5A* or *I=1A*)

If the measurement voltage connection is correct and the measurement current is sufficient (that is the current metering transformer current is higher than 0.01 A), the automatic connection detection process starts.

If no measurement voltage is detected, *U=0* will flash on the display, if too low measurement current is detected, *I=0* will .

3.2 Automatic Connection Detection Process

The controller's default measurement voltage and current connection parameters are set as follows:

- type of measurement voltage set to phase voltage (parameter 15)
- method of connection of U and I not defined (parameter 16)

If the method of connection is not defined, the controller can not evaluate instantaneous power factor and this condition is indicated by both trend LEDs flashing simultaneously. In such a case the controller carries out automatic connection detection.

For the controller to be able to carry out this process of automatic connection detection, the following conditions must be met:

- controller operation is not disabled (i.e. the ***Manual*** LED is dark)
- controller is in regulation mode, i.e. the numeric display mode is ***Measurement*** and the ***Parameters*** LED is dark
- measurement voltage is connected
- measurement current is sufficient

If meeting these conditions, the controller starts the automatic connection detection process.

The process may have up to seven steps. The controller makes four measuring attempts in each step in which it consecutively connects and disconnects sections 1 through 4. It at the same time assumes that power factor capacitors are connected to at least two of the sections (no power factor chokes may be connected to section 1 through 4). The two following messages are shown one after another in each measurement attempt on the numerical display:

1. step number in format *APXX* (**A**utomatic **P**hase detection, x... attempt number)
2. attempt result, e.g. *L1-0* (see table 4 of connection methods)

If the controller measures identical values repeatedly in each attempt, it considers the connection detected and quits carrying out further steps. If the measurement results are different from each other in a particular step, the controller carries out another measurement step.

The following conditions must be met for successful connection detection:

- type of measurement voltage is set correctly (phase or line – parameters 15)
- at least two power factor capacitors are connected to sections 1 through 4 and no power factor choke is connected to these sections

Type of connection detected is shown on the numeric display for a moment after successful completion of the automatic connection detection process, the true power factor value in the mains, and thereafter the instrument starts the regulation process or it starts the section recognition process (see further below).

If the automatic connection detection process is not completed successfully, the numeric display shows flashing *P = 0*. It is, in such a case, necessary to enter the connection type manually or to re-enter ---- (= not defined) in editing parameter 16 and thus restart the automatic connection detection process. Otherwise the controller changes over to a waiting mode and it repeats the automatic connection detection process in 15 minutes automatically.

The automatic connection detection process can be interrupted any time by switching the numeric display mode to ***Parameters***, that is by pressing button ***P***. The automatic connection detection process will start again from scratch on return to instantaneous value display mode.

3.3 Automatic Sectional Current Recognition Process

The controllers come as standard with enabled function of automatic sectional current detection (parameter 20 set to 1). At this setting the controller carries out the automatic sectional current detection process on **every** controller power-up (connection of power supply voltage). The process can also be started without interrupting the power supply voltage connection, by editing parameter 20 to value 1 or by controller initialization (see further below).

For the controller to be able to start the process of automatic sectional current detection, the following conditions must be met:

- controller operation is not disabled (i.e. the ***Manual*** LED is dark)
- controller is in regulation mode, i.e. the numeric display mode is ***Measurement*** and the ***Parameters*** LED is dark
- measurement voltage is connected
- measurement current is sufficient
- connection mode of measurement U and I is defined (parameter 16)

If these conditions are met, the controller starts the automatic sectional current detection process.

The process may have three or six steps. The controller consecutively connects and disconnects each output in each step (that is 6 outputs for Novar-106/206 and 14 for Novar-114/214). While doing that it measures the effect of connection and disconnection on total reactive current in the mains. From the values measured the current of each section is determined.

The following messages are shown one after another in each measurement attempt on the numeric display:

1. step number in format ***AC–x*** (x... step number)
2. sectional current measured in amperes; if the metering current transformer turns ratio has been entered (parameters 12 and 13), sectional current in the mains is shown (that is the metering current transformer primary current); if the metering current transformer primary side (parameter 12) is not defined, sectional current in the metering current transformer's secondary winding is shown

If the controller does not succeed in determining a section's value, it does not show it. This condition occurs if reactive current value in the mains fluctuates considerably due to changes in load.

After carrying out three steps, evaluation is carried out. If each measurement in the steps carried out provide sufficiently stable results, the detection process is completed. Otherwise the controller carries out three more steps. It puts an interval of approximately 30 seconds between each three steps.

A requirement for successful detection of current in each section is sufficiently stable condition of the mains – while connecting or disconnecting a section, the reactive load current must not change by a value which is comparable with, or even greater than, the reactive current vale of the section under test. Otherwise the measurement result is unsuccessful.

On successful completion of automatic section recognition process the controller checks whether at least one capacitive section has been detected and if so, it starts regulation. Otherwise the controller goes to the waiting mode and after 15 minutes it starts the automatic sectional current recognition process again.

Each section value recognized can be checked in side parameter branch 25. A positive current value means a capacitive section, negative value means inductive section. If the value could not be recognized, " ----" is shown. Each value recognized can be edited manually.

Recommendation :

> *After checking values recognized it is recommended at this phase to switch parameter 20 to 0 (AC-0). If switching automatic recognition process off, contingent unsuccessful results of recognition process after accidental power supply drop-out (due to great load and reactive current fluctuations after power recovery) will be avoided.*

If the automatic sectional current recognition process can not be completed successfully or none of the sections recognized is capacitive, flashing *C=0* is shown on the numeric display and the ***Alarm*** signal is activated at the same time. In such a case it is necessary to enter each section's value manually (see description further below) or by editing parameter 20 enter value *1* (= carry out automatic recognition) and thus force another start of the automatic sectional current recognition process.

The automatic sectional current recognition process can be stopped any time by switching the display mode to ***Parameters***, that is by pressing the appropriate button. On return to the instantaneous value display mode the automatic sectional current recognition process will be started from the beginning again.

4. Operation

4.1 Setup

To achieve optimum regulation in accordance with character of the load regulated the controller has a number of parameters that govern its operation. table 5 shows a list of the parameters. The following chapters describe each parameter, its meaning and how it can be edited.

4.1.1 Parameter Editing

The controller's parameters are set to default values, which are shown in table 3, when shipped.

To achieve optimum regulation results, it is sometime necessary to change some of the values in correspondence with particular requirements; in the other situations it is at least necessary to enter the measurement voltage type (phase or line) and the metering current transformer nominal secondary value (5 A or 1 A) in installation.

To prevent unqualified operation, controller parameter editing can be disabled in which case it requires entering password prior to editing (see further below). If parameter editing is enabled, you should proceed as follows:

1. Switch controller to parameter display mode by pressing button ***P***.
2. Find parameter you want to edit by pressing the ↑, ↓ buttons repeatedly.
3. Press button ***P*** (parameters) and hold it down until the display starts flashing.
4. Release button ***P*** and set the value desired with the ↑, ↓ buttons. Some values can be incremented or decremented continuously by holding down the ↑ or ↓ button.
5. When the value desired has been reached, press button ***P***. The value set will be saved in the controller's memory, the display stops flashing and editing is thus complete.

4.1.1.1 Enable / Disable Parameter Editing

When shipped, the controller is in the enabled status, that is the parameters can be edited freely on power supply voltage connection without prior password entry. After being put in operation parameter editing can be disabled to protect the controller against unauthorized changes in operation this way.

To see if editing is disabled or enabled check parameter 00. It can contain the following:

PA=- .... password not yet entered, parameter editing disabled

PA=Y .... password entered correctly, parameters can be edited

The edit enable / disable status is saved in the controller even after power outage.

If the password has not been entered correctly, the instrument's parameters can not be changed. Password is entered in a similar way to that of controller parameter editing:

1. Switch controller to parameter display mode by pressing button ***P*** (controller must not be in the ***Manual*** mode) and display parameter 00.
2. Press button ***P*** (parameters) and hold it down until the last character on the display starts flashing. A digit between 0 and 9 will be shown on the last digit position. As an example you can imagine 5 is displayed so the display shows PA=5 with the 5 flashing.

3. Press the following sequence: ↓, ↑, ↑, ↓. If 5 was shown as the last display digit, it would change to 4, 5, 6, 5 so the same value is shown at the end as at he beginning.

4. Press button **P**. The display will show PA = Y, indicating correct password entry and enabled parameter editing.

The digit shown while entering the password is random generated by the controller and it is not important for password correctness (it is there only to confuse). Only the sequence of buttons pressed is important.

After correct password entry, parameter edit mode is enabled until it gets disabled by the operator. The parameter edit enable or disable conditioned is retained in the instrument even on power off.

Parameter edit disable mode is switched to on (intentional) pressing buttons different from the correct password entry sequence.

4.1.2 Parameter 01/07 – Target Power Factor

The value of target power factor for tariff 1 (parameter 01) or tariff 2 (parameter 07) can be set in the range from 0.80 lag to 0.80 lead.

4.1.3 Parameter 02/08 – Regulation Time within Undercompensation

The value for tariff 1 (parameter 02) or tariff 2 (parameter 08) can be set in range from 5 seconds to 20 minutes : 0.05 - 0.10 - 0.15 - 0.20 - 0.30 -1.0 - 2.0 - 3.0 - 5.0 - 10.0 - 20.0 (value in front of decimal point specifies minutes, the one behind decimal point specifies seconds). The value set determines the frequency of regulation interventions under the following conditions:

- instantaneous power factor is more inductive than the one required – undercompensated
- the difference between reactive current instantaneous value in the mains and optimum value, which corresponds to the power factor required setting (= control deviation), is just equal to the smallest capacitive section current (C/k)

If the parameter value is set to say 3.0 and the above mentioned conditions are met in the mains, the controller calculates optimum compensation and carries out regulation intervention every 3 minutes.

The time mentioned gets shorter in proportion to the instantaneous control deviation. If regulation time without preceding character "L" is set, it gets shorter as square of control deviation over the smallest capacitive section value (C/k). If the regulation time with preceding character "L" is set, it gets shorter proportionally as the ratio ("L" = Linear, causes slower reaction to great deviations). Rising control deviation can decrease this value down to the minimum regulation time of 5 seconds.

On the contrary, if the control deviation is smaller than the smallest capacitive section current (C/k), regulation time gets twice as long. If the control deviation falls further under half of the smallest capacitive section current value (C/k), no regulation intervention takes place.

4.1.4 Parameter 03/09 – Regulation Time within Overcompensation

The value for tariff 1 (parameter 03) or for tariff 2 (parameter 9) determines frequency of the frequency of regulation interventions, very much like in parameter 02/08 described above. There is a difference though: it only applies if the instantaneous power factor is more capacitive than that required, that is it is overcompensated.

The regulation time's effect in proportion to control deviation magnitude is the same as with parameter 02/08 described above.

table 3: Controller Parameters

#	meaning	setting range	step	default	note
0	edit enabled (password)	- (no) / Y(yes)	-	Y	see Enable / Disable Parameter Editing
1	target power factor (tariff 1)	0.80 lag to 0.80 lead	0.01	0.98 lag	
2	regulation time when undercompensated (tariff 1)	5,10,15, 20, 30, 60, 120, 180, 300, 600, 1200 seconds	-	180	without "L" : square decreasing with "L" : linear decreasing
3	regulation time when overcompensated (tariff 1)	5,10,15, 20, 30, 60, 120, 180, 300, 600, 1200 seconds	-	30	without "L" : square decreasing with "L" : linear decreasing
6	tariff 2 evaluation	0 (no) - 1 (yes)	-	0 (no)	2xx line controllers only
7	target power factor (tariff 2)	0.80 lag to 0.90 lead	0.01	0.98 lag	not shown unless tariff 2 evaluation enabled
8	regulation time when undercompensated (tariff 2)	5,10,15, 20, 30, 60, 120, 180, 300, 600, 1200 seconds	-	180	not shown unless tariff 2 evaluation enabled
9	regulation time when overcompensated (tariff 2)	5,10,15, 20, 30, 60, 120, 180, 300, 600, 1200 seconds	-	30	not shown unless tariff 2 evaluation enabled
12	metering current transformer primary side nominal value	5 ÷ 9950 A	5	none	
13	metering current transformer secondary side nominal value	1 A ÷ 5 A	-	5	
14	reconnection delay time	5,10, 20, 30, 60, 120, 300, 600, 1200 seconds	-	20	
15	measurement voltage type – phase-neutral or phase-phase	PN - PP	-	PN	This parameter's correct setting is essential for automatic connection detection process.
16	method of connection of U and I	6 combinations	-	none	see parameter description
20	automatic sectional current recognition	0 (no) - 1 (yes)	-	1 (yes)	Automatic sectional current detection takes place on switching this parameter from 0 to 1 or on controller power-up while value 1 is set here.
21	connecting program	12 typical combinations	-	none	0 means individual section setting. Not shown if automatic section recognition is enabled.
22	smallest capacitor current (C/k value calculated for metering current transformer primary side)	(0.01 ÷ 2 A) x metering current transformer ratio	0.01	none	Value on metering current transformer's primary side – if its primary nominal value has not been entered, secondary side current is shown. Not shown if automatic section recognition is enabled.
23	number of capacitors	1 ÷ 6 (1 ÷ 14)	-	6 (14)	Not shown if automatic section recognition is enabled.
25	sectional current	(0.01 ÷ 8 A) x metering current transformer ratio	0.01	none	positive for capacitive sections (lead), negative for chokes (lag)
26	fixed sections	regulated / 0 / 1	-	all regulated	
27	limit power factor for regulation by choke	0.80 lag to 0.80 lead	0.01	none	No regulation by chokes takes place unless this parameter is specified.
30	alarm setting	0 / indication only / actuation only / indication and actuation	-	indication and actuation from undercurrent, voltage signal absence or section error	list of conditions: 1... undercurrent 2... overcurrent 3... compensation error 4... voltage signal absence 5... harmonic distortion 6... number of connections exceeded 8... feeding back condition 9... section error
31	THD limit (for alarm)	0.5 ÷ 300 %	0.5	20	not shown unless alarm from THD limit set
32	limit number of switching operations (alarm)	10,000 ÷ 2,000,000	10,000	1,000,000	not shown unless alarm from limit number of switching operations set
33	instrument address	1 ÷ 255	1	1	not shown in instrument without remote communication interface
34	communication rate	600 ÷ 9,600 Bd	-	9,600	not shown in instrument without remote communication interface
35	communication protocol	KMB(P0) / Modbus-RTU(P1)	-	KMB(P0)	not shown in instrument without remote communication interface
40	alarm instantaneous condition				Indicates current state of alarm.
41	minimum power factor recorded				in operation from load 10 % up
42	maximum THD recorded				in operation from load 10 % up
43	maximum value of harmonic components (3rd, 5th, 7th, 11th, 13th, 17th)				in operation from load 10 % up
44	number of section connections (in thousands)				display range 0.001 to 9999
45	instrument failure condition				
46	regulation time instantaneous condition				time until next regulation intervention in seconds
47	section switch-on time (in thousands of hours)				display range 0.001 to 130

4.1.5 Parameter 06 – Tariff 2 Operation

Novar 209/214 controllers allow changing the above described basic regulation parameters while regulation is in progress, triggered by external signal (relay contact). They have a tariff 2 request input for this operation, to which an insulated contact or optocoupler can be connected.

Parameter 6 in these controllers specifies if a tariff 2 request is to be processed or not. By default the controller is set to ignore tariff 2 requests, that is parameter 6 is set to 0 and only parameters 1 through 3 of the parameters described above are applied; parameters 7 through 9 are not significant in such a case so they are not shown.

If you set the parameter to *1*, the controller will start evaluating tariff 2 requests and, depending on the input's instantaneous condition, use parameters 1 through 3 or 7 through 9. The parameter's value is then *T2 = 1.* The decimal point after the last character then indicates whether tariff 2 request is just active. If it is dark, tariff 2 request is not active and only parameters for tariff 1 apply. On the opposite, lit decimal point indicates active tariff 2 request and the controller uses parameters set for tariff 2.

The 1xx line controllers do not feature tariff 2 operation so they do not display parameter 6.

4.1.6 Parameters 12,13 – Metering Current Transformer Ratio

You can set metering current transformer nominal primary value in amperes using parameter 12. The setting range is from 5 to 9,950.

This parameter (12) is not defined (---- shown) by default. With this setting, all values that are current-related, that is measured values of instantaneous effective, active and reactive currents and further the C/k value (parameter 22) and currents in each section (parameter 25), are shown in the magnitude to which they are transformed at the metering current transformer secondary side. The parameter's value set does not affect the controller's regulation operation, it only affects displayed values that are related to current.

Parameter 13 selects metering current transformer nominal secondary current. You can choose from 5A and 1A. **Warning!!! Unlike parameter 12, this parameter must be set correctly for controller's proper operation!** The controller determines whether the current input is overloaded evaluating this parameter and instantaneous current value. The controller may stop operation undesirably or, contrariwise, this operation disablement will not work when it should (see description of parameter 30, alarm from overcurrent).

Parameter 13 setting will be kept even on controller *initialisation* (see description further below).

4.1.7 Parameter 14 – Reconnection Delay Time

It is used to ensure sufficient discharge of a capacitive section prior to reconnection. It can be set in range 5 seconds to 20 minutes to one of the values 0.05 - 0.10 – 0.20 – 0.30 – 1.0 – 2.0 – 5.0 – 10.0 – 20.0. Format is the same as at parameters 2,8.

4.1.8 Parameters 15,16 – Measurement Voltage Type and Connection

Parameter 15 determines if the measurement voltage connected is phase (phase-neutral, *U = P N*, default value) or line (phase-phase, *U = P P*). If the measurement voltage is connected at the power supply transformer's side opposite to measurement current connection, the connection type value must be set in accordance with transformer type – see description in a separate chapter further below.

Connection type parameter must definitely be set correctly in installation, even if automatic connection detection process is assumed to take place. Otherwise the power factor measured will be evaluated with errors!

The connection type parameter (15) value set will be kept even on controller *initialisation* (see description further below).

Parameter 16 determines the method of measurement voltage connection with respect to measurement current, that is between which phases or neutral wire the measurement voltage is connected. It is assumed that the metering current transformer is in phase 1 and its orientation (terminals k, l) corresponds to real orientation supply–appliance. The method of connection is specified as one of six combinations as in table 4.

table 4: measurement voltage connection

phase measurement voltage U=PN		line measurement voltage U=PP	
#	connection	#	connection
1	L1-0	1	L1-L2
2	L2-0	2	L2-L3
3	L3-0	3	L3-L1
4	0-L1	4	L2-L1
5	0-L2	5	L3-L2
6	0-L3	6	L1-L3

Notes:

- It is assumed that the metering current transformer is in phase 1 and its orientation (terminals k, l) corresponds to real orientation supply–appliance.
- The method of connection is shown as x–y where x represents the phase connected to controller's terminal ***L1*** and y represents the phase connected to controller's terminal ***N/L*** (0 represents the neutral wire).

If the connection method value is entered as not specified (---- value), the automatic connection detection process is started. If the type of connection (phase or line, parameter 15) is changed, the method of connection (parameter 16) is automatically set to undefined value.

4.1.8.1 Setting Type of Connection if Measuring at Power Supply Transformer's Opposite Sides

If the measurement current signal is from the power supply transformer's side opposite to measurement voltage signal side, the transformer's hour angle is conclusive for correct parameter 15 setting. This value specifies the angle between voltage vectors of corresponding phases at primary and secondary windings. The hour angle can be in the range from 0 to 11, corresponding to phase angles from 0 to 330 degrees (in steps by thirty degrees).

Provided the measurement voltage signal is connected **in accordance** with the type of transformer (that is phase measurement voltage is connected to controller with wye connection or line measurement voltage with delta connection), it is necessary to set **phase** type of connection with **even** hour angle value and **line** type of connection with **odd** hour angle value.

If the measurement voltage signal is connected **in contradiction** with the type of transformer, the opposite rule applies: **line** connection with **even** hour angle or **phase** connection with **odd** hour angle.

Determining parameter 15 explained on practical examples:

Example 1:

Compensation should be done in consumption supplied via a **Dy1** transformer while line measurement voltage will be taken from its primary side (D stands for delta connection) and measurement current signal from a metering current transformer at the power supply transformer's secondary side (y stands for wye connection).

determining type of connection (parameter 15):

1. The transformer's primary side is delta-connected and line primary voltage will be connected to the controller (usually via a metering voltage transformer with nominal output voltage 100 V AC) — this means the measurement voltage will be connected **in accordance** with the type of transformer.
2. Since the measurement voltage is connected **in accordance** with the type of transformer and the transformer's hour angle (1) is **odd**, you set the method of measurement voltage connection to **line**. (If the hour angle was even or if the measurement voltage was not connected in accordance with the type of transformer, you would set phase connection).

Example 2:

Compensation should be done in consumption supplied via a **Yy6** transformer while line measurement voltage will be taken from its secondary side (y stands for wye connection) and measurement current signal from a metering current transformer at the power supply transformer's primary side (Y stands for wye connection again).

determining type of connection (parameter 15):

1. The transformer's secondary side is wye-connected, but line secondary voltage will be connected to the controller — this means the measurement voltage will be connected **in contradiction** with the type of transformer.
2. The measurement voltage is connected **in contradiction** with the type of transformer and the transformer's hour angle (6) is **even**, so you set parameter 15 to **line**. (If the measurement voltage was connected in accordance with the type of transformer, you would set phase connection).

If in doubt with correctness of determining the type of connection, experimental validation is convenient: after automatic connection detection you can usually compare the power factor value shown by the controller with information on billing electricity meter (ratio of revolutions of active and reactive electricity meters). If in discrepancy, you have to set type of connection to the opposite value and repeat the validation process.

4.1.9 Parameter 20 – Automatic Sectional Current Recognition

The controllers are shipped with default setting of enabled automatic sectional current recognition (parameter 20 set to 1, ***AC=1***). With this setting the controller carries out the automatic sectional current recognition process **always** on controller power-up (introduction of power supply voltage).

The process can also be started without interrupting power supply voltage, by editing parameter 20 to value 1 or by controller initialisation (see further below).

If automatic section detection is set, it makes no sense to set parameters 21 through 24, therefore these parameters are not shown.

Automatic sectional current recognition can be disabled by setting parameter 20 to ***0***. In such a case sections' values must be entered using parameters 21 through 24.

4.1.10 Parameters 21, 22 – Switching Program and Smallest Capacitor Value (I_{MIN}, or C/k)

If automatic sectional current recognition is disabled, you can enter the value of each section using these parameters.

Parameter 21 specifies the switching program which determines the ratio of values of individual capacitive sections. One of preset combinations can be selected as shown in table 5.

The capacitors must be connected to the controller's outputs in the order corresponding to the switching program selected so that the smallest value capacitor is at output 1. The number of capacitors connected must be entered in parameter 23. If this number is greater than 5, the controller assumes that values of sections 6 and higher are equal to section 5 value.

If none of the preset combinations corresponds to the arrangement required, any value of each section can be entered by editing parameter 25. In such a case the switching program parameter (21) is automatically set to undefined value **---**, which indicates *individual switching program*. In this case parameter 22 misses its purpose so it is not shown.

table 5: switching program

#	combination	displayed	#	combination	displayed
1	1:1:1:1:1	1111	7	1:2:2:2:2	1222
2	1:1:2:2:2	1122	8	1:2:3:3:3	1233
3	1:1:2:2:4	11224	9	1:2:3:4:4	1234
4	1:1:2:3:3	1123	10	1:2:3:6:6	1236
5	1:1:2:4:4	1124	11	1:2:4:4:4	1244
6	1:1:2:4:8	11248	12	1:2:4:8:8	1248

If the switching program is set to one of the values shown in table 5, you still have to enter the smallest capacitor current, I_{MIN} (corresponding the value 1, parameter 22). This value is displayed in amperes and is either equal to the capacitor's real current in the mains (if the current transformer's nominal primary value has been specified) or equal to current at the current transformer's secondary side (in the other case) – then the value is what is generally knows as C/k constant.

You can determine the smallest capacitor's current using the formula

$I_{MIN} = Q_{MIN} / (1,73 \times U_L)$ [A, VAr, V]

I_{MIN}...... smallest section's current in amperes

Q_{MIN}..... smallest section's power in volt-amperes reactive

U_L........ line voltage in volts (for example 400 V)

The following table shows currents for most used compensation capacitors:

table 6: capacitor's current (for U_L = 400V)

Q [kVAr]	2	3.15	4	5	6.25	8	10	12.5
I [A]	2.9	4.6	5.8	7.2	9.0	11.6	14.5	18.1
Q [kVAr]	15	20	25	30	40	50	60	100
I [A]	21.7	28.9	36.1	43.4	57.8	72.3	86.7	144.5

If the metering current transformer's nominal primary value has not been specified, it is necessary to enter the C/k value rather than the smallest capacitor current. You can obtain this value as a ratio of the smallest capacitor current and the metering current transformer ratio. C/k value can be set in the range between 0.01 and 2 A.

If the metering current transformer's nominal primary value has been specified, the smallest capacitor current is to be entered, I_{MIN} (equal to C/k value multiplied by metering current transformer ratio).

4.1.11 Parameter 23 – Number of Capacitors

If entering capacitors' currents manually using the switching program and smallest capacitor current (parameters 21, 22), it is also necessary to enter the number of capacitors connected – parameter 23. The value can be set within a range 1 through the controller's number of outputs, which is 6 for Novar 106/206 and 14 for Novar 114/214.

If using a smaller number of capacitors than the type of controller allows, it is necessary to connect the capacitors to outputs starting with output 1 (that is the unconnected outputs will be those with the highest ordinal numbers).

If the controller outputs are not all used for capacitor connections, the unused outputs can be used for connecting compensation chokes. The controller assumes that the chokes are connected from the lowest free output up (that is starting with the section following the last capacitor output connected).

These chokes' currents can be entered in parameter 25, for each choke separately (careful, a choke's current must be entered as a negative value – positive currents are considered capacitive sections by the controller!)

4.1.12 Parameter 25 – Compensation Sections' Currents

Current of each compensation output can be edited in the side branch of this parameter if necessary.

The currents are shown in amperes. They are equal to either real current of the compensation section (capacitor or choke) in the mains (if the metering current transformer's nominal primary value has been specified) or the metering current transformer's secondary value (in the other case). Capacitive sections are shown as positive, inductive sections as negative. If a section's current is not known (for example because of successful completion of the automatic section recognition process), the ---- value is shown. In such a case, as well as in the case of section current zero value, the controller does not use the corresponding regulation output.

The controller is shipped with default setting of automatic section recognition enabled (parameter 20 set to 1). The automatic sectional current recognition process is started on introducing the power supply voltage and after it has finished you can check or edit the recognized currents in the side branch of parameter 25.

Each sectional current can be changed even if they have been entered manually using the switching program and smallest capacitor current (parameters 21, 22).

If a section's value is shown with a flashing decimal point, it means:

- decimal point flashing **slowly** (about once a second), the section has not been accurized yet – see description of the mechanism to accurize sections in a relevant chapter further below
- decimal point flashing **fast** (about three times a second), the section has been disabled and the controller is not using it – see description of the mechanism to section disablement in a relevant chapter further below

4.1.13 Parameter 26 – Fixed Sections

Any controller output can be set as fixed. In such a case the output is permanently connected or disconnected and the controller does not use it for regulation. A fixed output **remains in a prespecified condition** (that is connected or disconnected) with the following exceptions:

- the controller is switched to the ***Manual*** mode
- a selected nonstandard condition occurs while the alarm's corresponding actuation function has been set (for details see alarm description further below)

A fixed section (one set as permanently connected) is **only** disconnected if alarm from exceeding the THD limit has been enabled and THD does exceed this limit for a specified time (for details see description of alarm functions further below).

By default all controller's outputs are set as regulating, not fixed. In such a case they are shown for example as follows:

01-C.... output 1 is regulating and it is a capacitive section (capacitor)

12-L.... output 12 is regulating and it is an inductive section (choke)

Each section's value can be set to 1 or 0 — in that case 01-1 or 01-0, respectively, is shown and the corresponding output becomes a fixed one – it will be permanently connected or disconnected.

4.1.14 Parameter 27 – Limit Power Factor for Regulation by Choke

This parameter specifies power factor value at which the controller starts using, besides capacitive sections, inductive compensation section for regulation as well – chokes (if available).

If the power factor measured is more inductive (current more lagging) than the value set in this parameter, the controller uses only capacitive sections (capacitors) for regulating compensation.

If the power factor in the mains changes so that it is more capacitive (current more leading) than the limit value for regulation by choke, the controller starts using combination of capacitive and inductive compensation sections for regulation.

By default this parameter's value is set as undefined (-.--- shown) in a shipped controller or after its initialization. In such a case the controller does not use chokes that are available (such sections are permanently disconnected) and it does not even detect available chokes in the automatic section detection process.

Regulation by inductive sections is described in more detail in an appropriate chapter further below.

4.1.15 Parameter 30 – Alarm Setting

Novar line controllers feature two alarm type functions that are independent of each other:

- alarm indication function
- alarm actuation function

4.1.15.1 Alarm Indication Function

In order to indicate nonstandard regulation conditions the instruments feature an ***Alarm*** LED on the front panel and an Alarm relay nonpotential contact accessible at a connector on the rear panel.

Indication of a nonstandard condition occurrence shows as flashing ***Alarm*** LED and closed Alarm relay contact. In standard condition this LED is dark and the relay contact open.

table 7: Alarm – indication

#	condition	description	minimum delay of activation / deact.
1	**undercurrent**	current at metering current transformer's secondary under minimum measurement current	5 / 5 seconds
2	overcurrent	current at metering current transformer's secondary over nominal value setting (5 A / 1 A)	5 / 5 seconds
3	compensation error	power factor out of range 0.9lag ÷ 1.00 – working from load 10 % up	15 / 7.5 minutes
4	**voltage failure**	measurement voltage not detected	5 / 5 seconds
5	harmonic distortion	THD limit setting exceeded – working from load 10 % up	5 / 2.5 minutes
6	number of switching operations exceeded	number of connecting and disconnecting a section has exceeded a limit setting	immediately
8	feeding back	power flow from appliance to source detected	5 / 2.5 minutes
9	**section error**	permanently wrong section value detected in regulation (usually section failure)	5 connections + 5 disconnections

Note: Bold type conditions above are set by default.

Nonstandard condition mentioned above, at which alarm should be indicated, can be specified in the side branch of parameter 30. Any of the eight conditions shown in table 7 can start the alarm indication.

Alarm indication from any nonstandard condition can be selected by editing such a condition in the side branch of parameter 30. The settings can take 4 different values:

1. *01-0* ... condition 1 (undercurrent) is not signalled (neither does it trigger actuation – see description further below)
2. *01-5* ... condition 1 (undercurrent) is signalled (but it does not trigger actuation)
3. *01-A* ... condition 1 (undercurrent) is not signalled (but it triggers actuation)
4. *01-2* ... condition 1 (undercurrent) is signalled (and it triggers actuation)

Alarm signalling can be set for any other condition in the same manner as shown for condition 1 in the above example. For some conditions alarm actuation can be specified besides indication (see description further below).

Alarm indication can be triggered by one or a combination of some conditions set. Alarm indication will start after the condition lasts continuously for the time specified in table 8 as 1st value ; 2nd value (behind „/") defines elapse time to stop alarm indication after the condition would disappear. The condition that has triggered alarm indication can then be checked in alarm status (in the side branch of parameter 40).

Unlike the alarm actuation function described below, the alarm indication function setting has no effect on the instrument's regulation process.

Besides conditions mentioned above, alarm indication will also be triggered by a condition when at least one nonzero capacitive section has not been specified (when entering sectional currents manually) or identified (in automatic section detection process). In this condition flashing C=0 is shown on the numeric display.

4.1.15.2 Alarm Actuation Function

Independently of the alarm indication function you can set alarm actuation function for some of the nonstandard conditions. Actuation means intervention in the regulation process, especially interruption of controller's operation, usually with subsequent disconnection of regulation sections. See list of actuations in table 9.

table 9: Alarm – actuation

#	condition	description	minimum delay of activation / deact.	actuation
1	**undercurrent**	current at metering current transformer's secondary under minimum measurement current	10 / 5 seconds	disconnection of all sections except fixed ones
4	**voltage failure**	measurement voltage not detected	5 / 5 seconds	disconnection of all sections except fixed ones
5	harmonic distortion	THD limit setting exceeded – working from load 10 % up	5 / 2.5 minutes	disconnection of all output (including fixed ones)
8	feeding back	power flow from appliance to source detected	5 / 2.5 minutes	disconnection of all sections except fixed ones
9	**section error**	permanently wrong section value detected in regulation (usually section failure)	5 connections + 5 disconnections	section disablement (see description in chapter below)

Note: Bold type conditions above are set by default.

If you require that the controller respond to occurrence of an above nonstandard condition with an actuation shown, you have to set the condition of choice in the side branch of parameter 30 to A or 2 (see previous chapter).

Conditions not shown in this table do not trigger any actuations, hence they can not be set this way either.

4.1.16 Parameters 31, 32 – Current Total Harmonic Distortion Limit and Number of Switching Operations Limit for Alarm Indication or Actuation

If alarm indication or actuation function is set from condition 5 (current harmonic distortion) or from condition 6 (number of switching operations exceeded), you also have to specify the THD limit level or limit number of connections and disconnection of a section from which the indication or actuation should be triggered.

The current THD (total harmonic distortion, parameter 31) is shown as percentage and it can be set in the range from 0.5 to 300 %.

Number of switching operations limit (parameter 32) is shown as thousands of switching operations and it can be set in the range from 10 thousand to 2 million switching operations.

If neither indication nor actuation function from either of the two conditions has been set, the corresponding limit value is not shown.

4.1.17 Parameters 33, 34, 35 – Instrument Address, Communication Rate and Communication Protocol

These parameters are only important in instruments featuring remote communication interface. They are not shown in other instruments.

When setting up remote communication you have to set the instrument's address (parameter 33) to one of the values from 1 to 253 (addresses 0, 254, and 255 are dedicated to special functions – do not use). If a number of instruments are connected to the communication line, each instrument must have a different address.

The communication rate (parameter 34) can be set to one of the values: 600, 1200, 2400, 4800, 9600 Bd.

Standard communication program uses proprietary communication protocol „KMB". The protocol is set as standard at parameter 35 as *P 0*. For easier implementation to user applications, the Modbus-RTU protocol can be used as well. The protocol can be set as *P 1N* / *P 1E* / *P 1O* (non parity / even parity / odd parity). Detailed description of both protocols is available at manufacturer on request.

The values set will be kept even on controller's *initialization* (see description further below).

4.1.18 Parameter 40 – Alarm Status

If indication function from a nonstandard condition is set (see description of parameter 30 – alarm setting), you can view alarm current status in the side branch of parameter 40.

Indication can be triggered by any of the nine conditions shown in table 7. Parameter 40 is used for detailed identification of condition that has triggered alarm indication. Alarm indication function has been triggered by those conditions whose value is *1*.

4.1.19 Parameters 41, 42, 43 – Extreme Mains Parameters Recorded

In order to monitor and analyse the regulation process, the controller records the following extreme mains parameters:

- minimum power factor (parameter 41)
- maximum level of total harmonic distortion (parameter 42)
- maximum level of selected harmonic components (3^{rd}, 5^{th}, 7^{th}, 11^{th}, 13^{th}, 17^{th} – side branch of parameter 43)

These values are not specified in a controller when shipped so when viewing the parameters you will se ----. After the regulation process has started, the controller monitors the levels of the above mentioned quantities and if they reach a level which is lower or higher than a level so far recorded and such a condition holds for at least 1 minute, it will overwrite the last recorded extreme value with the newly measured value.

The controller carries this monitoring out only while the regulation process is in progress and while a condition is met of the total load in the mains at least 10 % of the nominal load (in accordance with the metering current transformer's nominal primary value). If load is low, the values of the above mentioned quantities can neither be measured precisely, nor are they important.

Each extreme level recorded can be reset by editing it.

4.1.20 Parameter 44 – Number of Section Connections and Disconnections

In the side branch of this parameter you can check the number of switching operations for each section. The number is shown in thousands. If the number of switching operations is low, the value is shown with a decimal point so that you can view it at accuracy down to units, tens or hundreds of switching operations.

The number of section connections and disconnections is kept in the controller's nonbacked up memory and stored in backed up memory about every eight hours where it is maintained even on power supply outage. The number of switching operations from the last eight–hour interval is lost on voltage failure or controller initialisation.

If a section's circuit breaker is replaced, the relevant output's switching operation counter can be reset by editing it.

4.1.21 Parameter 45 – Type of Controller Error

The controller carries out self-diagnostics in regular intervals during regulation. You can check the diagnostics' results in this parameter.

It shows ***E–00*** in errorless condition. If the value is nonzero, the controller has identified an error. Such a condition does not necessarily mean the controller is out of operation — in such a case the controller supplier must be contacted and told about the value of the type of error shown. Using this value a specialist will then decide about the method of solving the problem.

4.1.22 Parameter 46 – Regulation Time

When optimising controller parameter settings, it is sometimes required to monitor regulation time in detail. You can view the regulation time's current value in this parameter – it is shown in seconds as countdown to the next regulation intervention.

For monitoring the regulation time to make sense, the regulation function must not be halted — therefore the regulation function is enabled while viewing this very parameter. Another difference while viewing this parameter is automatic jump back to display of values measured; this automatic jump takes only place after viewing the regulation time for about 5 minutes from the last button pressing (it takes place as soon as after about 30 seconds while viewing any other parameters).

4.1.23 Parameter 47 – Number of Section Switch-On Time

In the side branch of this parameter you can check the time that each section was switched-on since last value clearing. The number is shown in thousands of hours. If the number of switch-on time is low, you can view it at accuracy down to units of hours. Maximum value is 130 thousands.

The value of section switch-on time is kept in the controller's nonbacked up memory and stored in backed up memory about every eight hours where it is maintained even on power supply outage. The switch-on time from the last eight–hour interval is lost on voltage failure or controller initialisation.

If a section's capacitor is replaced the relevant output's switch-on time counter can be reset by editing it.

4.2 Section Value Accurization

If the controller is set to automatic sectional current detection, it will carry out the automatic detection process after every power supply outage or initialisation.

After successful completion of the automatic recognition process it records all the currents measured and start regulation process. All currents measured are tagged as "not yet precise". A sections the value of which is not yet precise can be identified by **slowly** flashing decimal point (as opposed to fast flashing decimal point to identify a disabled section – see description further below).

The controller measures the sections continually within the regulation process as they are connected and disconnected. It evaluates the average value measured for each not-yet-precise section and, when having received about 100 values, it rewrites the original section value, which was obtained in automatic detection, with it. At the same time it tags the section as "precise" and stops further accurization of this section.

This way possible inaccuracies in automatic detection are removed.

If the sections' values are set manually (using the switching program and smallest capacitor current or by editing section value in parameter 25), no subsequent accurization takes place. Neither is accurization of choke sections, if present, carried out.

If automatic sectional current detection is enabled, the accurization process can be automatically started anytime during the regulation process as well. If the controller detects that a compensation capacitor has repeatedly been showing a value different from that measured in automatic detection and the difference is not in order of magnitude (that is in the interval from a half to double value) from the value recorded in the controller, the accurization process for such a section will start. Thus effects of changes in compensation capacitor values, for example as a consequence of the forming process after installation or due to aging etc., can be eliminated.

4.3 Faulty Section Indication and Disablement

In the alarm setting (parameter 30) you can choose alarm indication or actuation function from faulty section detection (section error).

If at least one of these functions has been set, the controller continually checks reactive current changes in the mains during the regulation process as the sections are connected and disconnected and compares them with each section's current recorded. If connecting and disconnecting a section does not repeatedly result in adequate change in reactive current in the mains (or change in reactive current measured is very different from the capacitor's value recorded), the controller tags such a section as faulty and, if a relevant alarm actuation function has been set, it will disable the section and stop using it in further regulation temporarily.

Alarm indication function can be used for section disablement indication (see description of parameter 30). If alarm actuation function is not set, the controller will only tag the faulty section, trigger alarm indication, but will keep using the section in regulation. A particular faulty section can be identified by **fast** flashing (about three times a second) decimal point in the section value display in the side branch of parameter 25 (as opposed to slowly flashing decimal point identifying not-yet-precise section – see description in chapter above).

A section that has been temporarily disabled is periodically, about every five days, checked by including it in regulation for one switching operation. If the controller detects a relevant response in the mains (within adequate allowance) to connecting the section, it will include the section in the regulation process again and, if automatic section detection is set, it will run accurization process for it too. This way, for example, a repaired section is automatically included in regulation (after replacing section fuse, for instance).

If the controller does not put a disabled section back to regulation automatically, such reinclusion in the regulation process will take place in the following situations:

- power supply interruption or controller initialisation (see description further below)
- editing the section's value or one of parameters 21 through 23 (switching program, smallest capacitor value, number of capacitors).
- automatic sectional current detection process

Faulty section indication and disablement can only be set for capacitive sections – choke sections, if present, are not checked.

4.4 Regulation by Choke

The instrument allows connecting chokes for mains decompensation.

Regulation by choke is conditioned by regulation by choke power factor limit value setting (parameter 27) within a range from 0.8 lag to 0.8 lead. If this parameter is not defined (-.-- shown), regulation by choke does not take place (if chokes are available at some of the outputs, these outputs are permanently disconnected).

If regulation by choke power factor limit value is set to a valid setting, a choke is connected in the following situation:

- controller has disconnected all capacitive sections
- power factor is still more capacitive (leading) than that required and also more capacitive than the regulation by choke power factor limit value set
- this condition has lasted for five times longer than the overcompensation regulation time (parameters 3, 9)
- a choke is available at least at one output and it has such a value that after its connection it will be possible to regulate the power factor to desired value using a combination of capacitive sections, that is large undercompensation will not occur after its connection

If a number of chokes are available for the controller, the most suitable one, depending on their values, is connected, and another one is connected if the above described situation lasts for another five times longer than overcompensation regulation time set.

If a combination of chokes are connected and undercompensation occurs, such a number of chokes are disconnected after a normal undercompensation regulation time has elapsed (parameters 2, 8), which prevents overcompensation.

Decompensation chokes can be connected to outputs 5 and higher. Outputs 1 through 4 are dedicated to capacitive sections only, since the controller uses these outputs in the automatic connection detection process.

The automatic section detection process can also be used for determining values of chokes connected, by the regulation by choke limit power factor (parameter 27) must be set to a valid value prior to this. If this parameters has not been defined (-.-- shown), connected chokes will not be detected.

After controller initialisation parameter 27 is not defined so regulation by choke is disabled by default.

4.5 Regulation Interruption

If the controller is in the regulation mode (not in the ***Manual*** mode), one of the values measured, ***COS***, ***A*** *(I_{eff})*, ***THD***, is shown on the numeric display and the controller carries out regulation process based on the values measured and parameter settings.

If you switch to parameter display by pressing button ***P***, the regulation process will be interrupted. Output relays will stay in the state they were at the moment of switching the display mode. The controller assumes the operator wants to check or change some of the parameters and it does not change the state of outputs until this is finished (provided no nonstandard conditions, such as measurement voltage failure, have occurred, of course). At the moment the operator switches back to correspondent display mode by pressing button ***M*** (measurement), the instrument continues the regulation process.

If the operator did not switch back to the ***Measurement*** display mode, the controller would switch to the mode automatically in about thirty seconds from the last button being pressed.

An exception is showing regulation time (parameter 46) – in this case the regulation interrupted will resume for operator to be able to check control process operation. Automatic switch to the instantaneous values display will occur after about 5 minutes.

Analogously to regulation interruption, automatic connection or sectional current detection process will be interrupted by the above mentioned procedure if in progress. It, however, starts over from the beginning again when resumed.

4.6 Manual Mode

When installing or testing the controller it may sometimes be required to check the function of each compensation section or it is necessary to put the automatic regulation process out of operation for a longer time.

In such situations you can switch the controller to a mode in which it only carries out measurements and displays the values. You can switch to this mode by pressing buttons ***M*** and ***P*** and holding them down simultaneously for about 6 seconds (until the ***Manual*** LED starts flashing). You can switch back to the regulation mode analogously.

You **can not** view or edit the controller's parameters in the ***Manual*** mode – you can only switch on or off each controller's output.

On switching the regulator to the ***Manual*** mode, the outputs stay in the state they were in during the regulation process before switching over the modes. You can then change the states of the outputs manually – after pressing button ***P*** the state of a correspondent output is shown (for example *01–0*, which means output 1 is off – contacts open) and you can move through them using buttons ↑, ↓ and edit them analogously with the instruments' parameters. The outputs' states change while being edited while respecting the reconnection delay time set.

If the controller is in the ***Manual*** mode and there is a measurement voltage failure, the ***Manual*** mode is resumed on power recovery. At this all outputs that were on before the failure get switched on one by one again (the states of outputs are remembered).

4.7 Manual Intervention in Regulation Process

In order to be able to check the controller's response to a regulation deviation change it is possible to connect or disconnect a section by operator's manual intervention, not only in the ***Manual*** mode but also within the regulation process.

While holding button ***M*** pressed down you can connect or disconnect section using buttons ↑ and ↓ and watch the controller's response to the change of condition. Each button press connects or disconnects one regulation section, always the one with the smallest value. Reconnection delay time is respected when connecting.

If the controller is left in the regulation mode, it will carry out evaluation and regulation intervention after the regulation time has elapsed thus putting the unbalanced conditions in the mains back to a compensated state.

4.8 Controller Initialisation

In some situations it may be necessary to put the controller back in its default setting in which it is shipped. You can do this using controller *initialisation*. After initialisation has been run, the initial test starts too, that means the controller carries out all the operations as if the power supply voltage is introduced.

The controller's parameters are set to the values shown as default in table 3 on initialisation, except the following parameters:

- metering current transformer nominal secondary value (13)
- type of measurement voltage (phase or line, 15)
- instrument address and communication rate in instruments with communication interface (33, 34)

These parameters remain unchanged in the values set before initialisation.

Values of parameters 41 (minimum power factor recorded), 42 (maximum THD recorded), and 43 (maxim harmonic values) will be set as undefined on initialisation. The counter of switching operations (parameter 44) is not affected by initialisation.

You can start the controller initialisation by pressing buttons ***M***, ***P***, and ↓ simultaneously and holding them down for about 6 seconds. The controller will first disconnect all sections connected and run the initial test – that is when you can release the buttons. Then it will carry out initialisation itself and since parameter 16 value is not defined, it will start the automatic connection detection process.

Warning!!! The ***Manual*** mode is terminated on initialisation if active!!! The controller is always set to the regulation mode after initialisation!!!

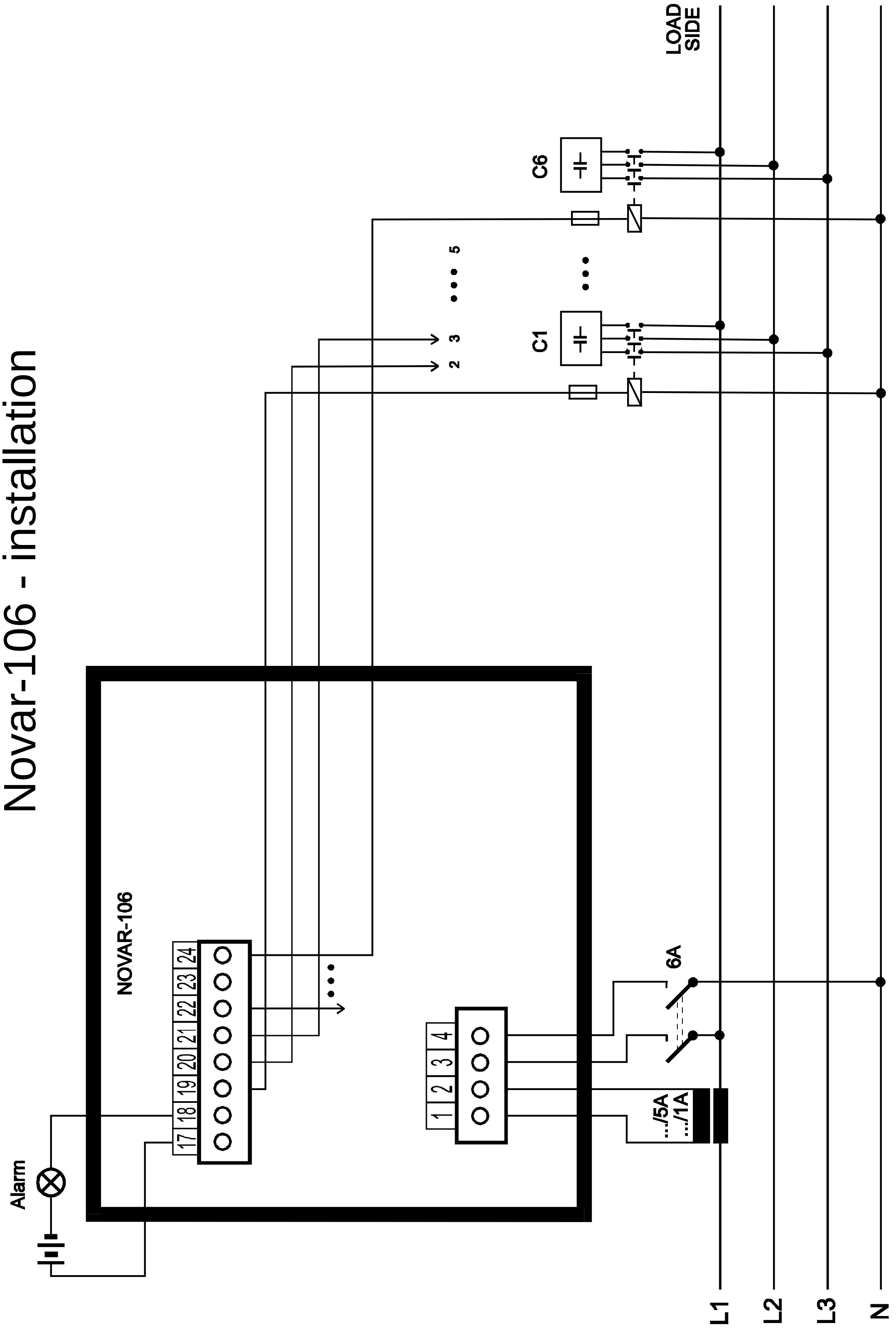
4.9 Summary of Text Messages

In the measurement value display mode a text message may appear in some situations instead of the instantaneous power factor value. table 10 shows a list of these messages.

table 10: summary of text messages

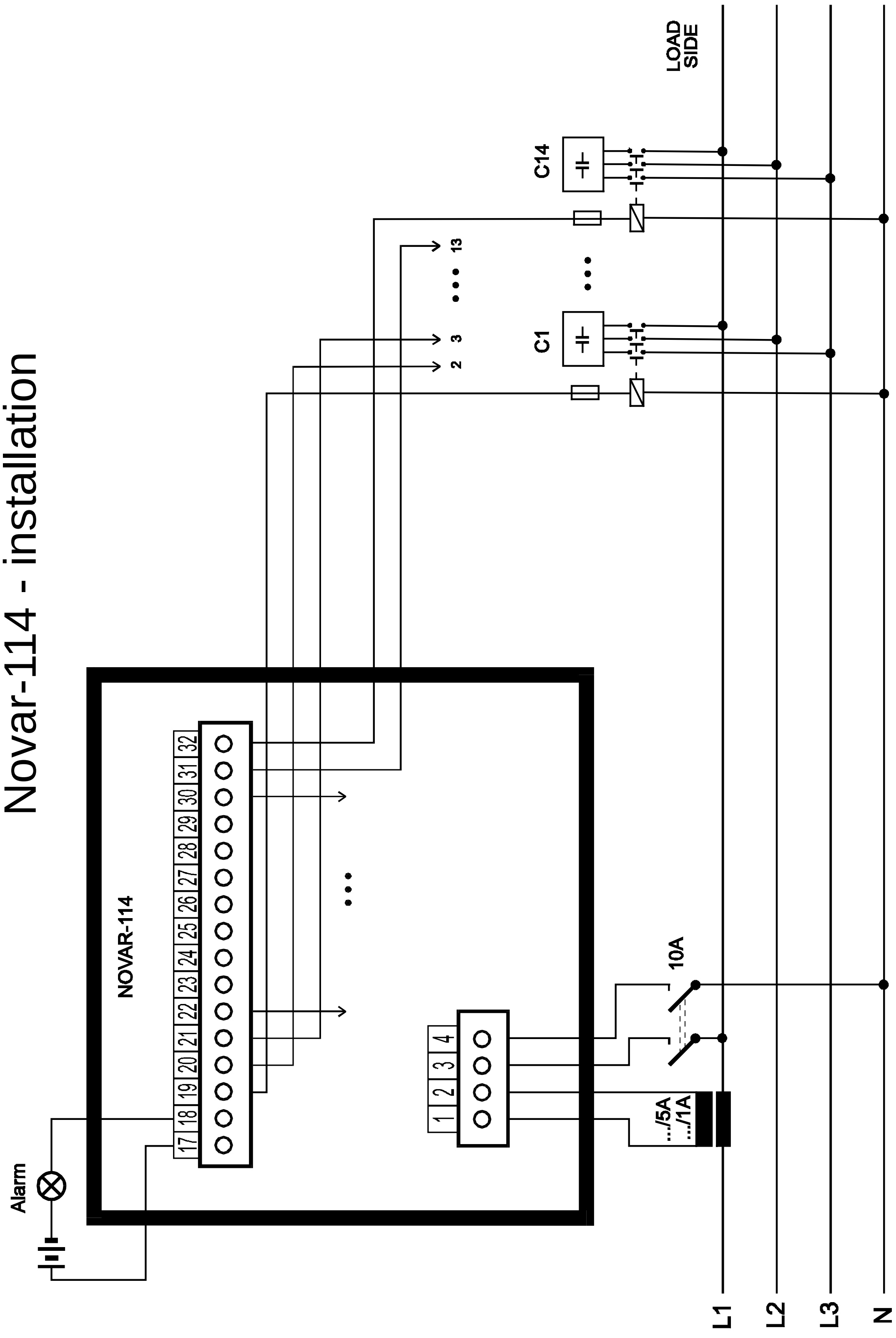
message	meaning	comment
AHOY TEST N206 2.0 U=PN I=5A	initial sequence after power up or initialization - type of controller - firmware version - measurement voltage type set (phase, phase-neutral) - metering current transformer nominal secondary value set	controller carries out self-diagnostics
U=0	measurement voltage not present or its fundamental harmonic component lower than minimum value	controller in waiting mode
I=0	measurement current absent or lower than minimum value	controller in waiting mode
APXX	automatic connection detection process in progress	process can have 1 to 7 steps
P=0	automatic connection detection process has failed and method of connection of measurement voltage and current (parameter 16) is not defined	automatic connection detection process will run again in about 15 minutes automatically or parameter 16 value can be entered manually
AC-X	automatic sectional current recognition process in progress	process can have 3 or 6 steps; about 30-second dwell after three steps
C=0	no capacitors have been successfully detected in automatic section recognition process or, in manual section value specification mode (parameter 20), parameters 21 through 26 have not been set properly or all capacitive sections have been automatically disabled because of error (parameter 25) or they are set as fixed (parameter 26)	if automatic section recognition process is set, it will be automatically repeated in about 15 minutes or you can set values of parameters 21 through 26 manually

5. Wiring Examples

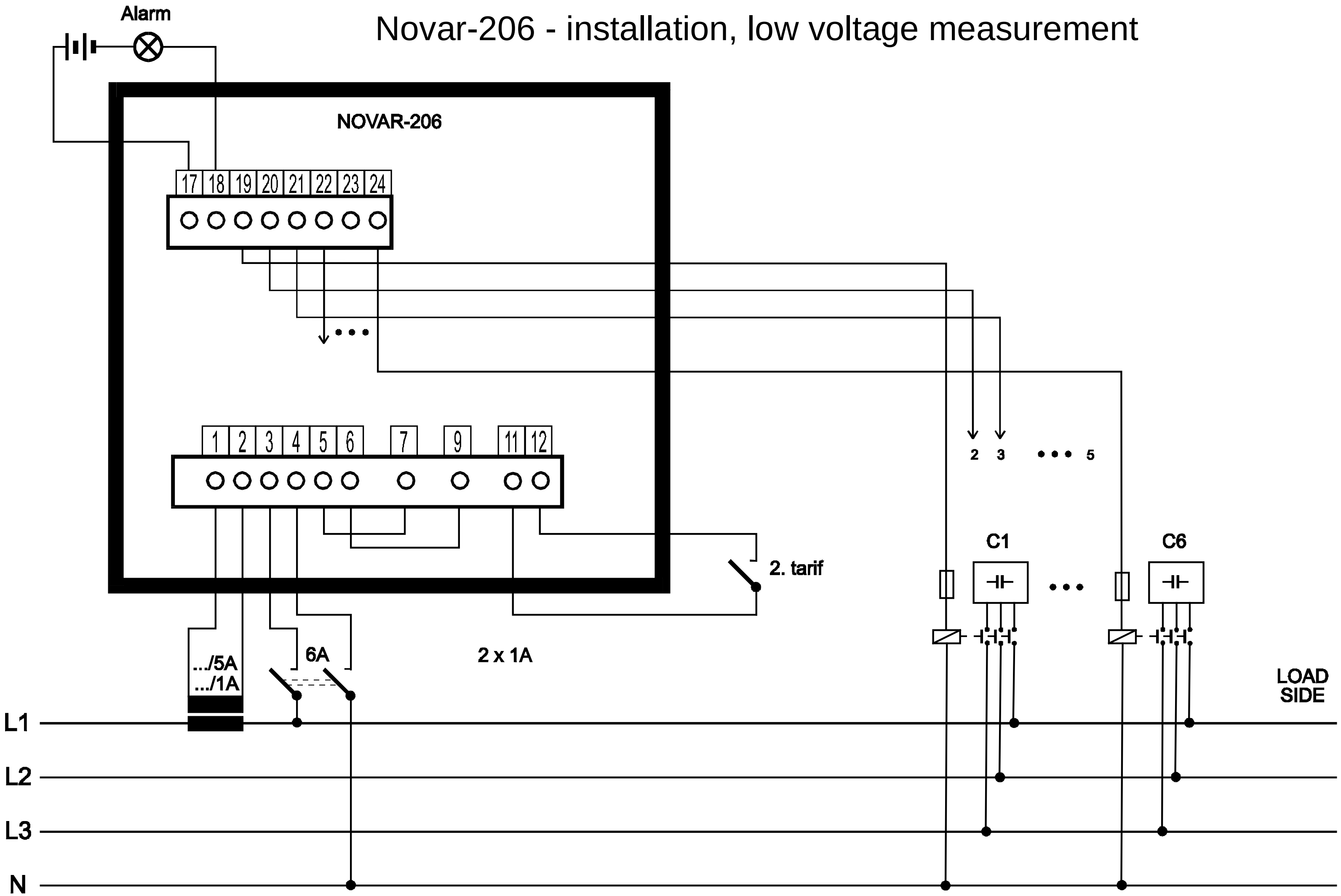


Novar-106 - installation

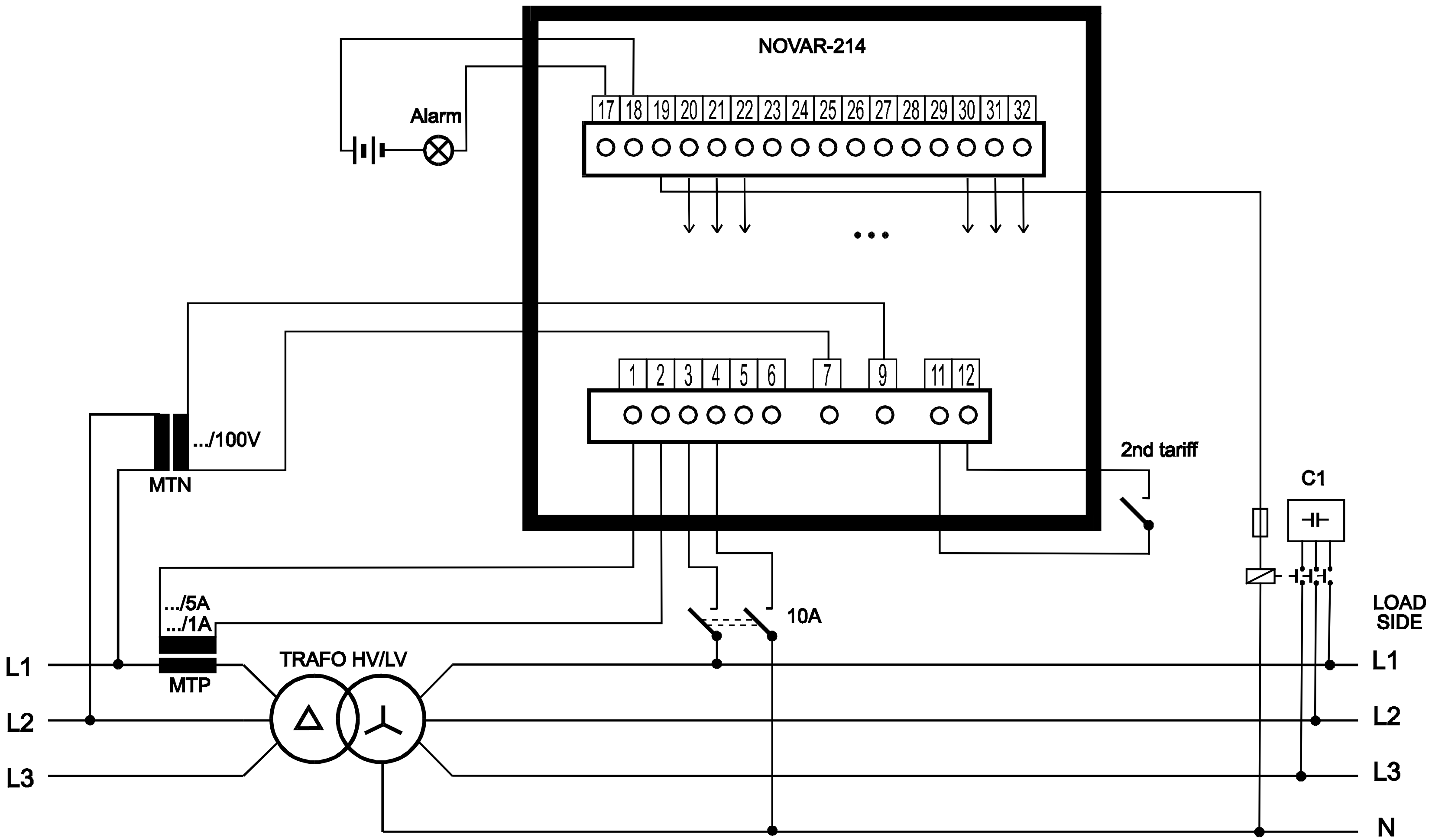
Novar-114 - installation



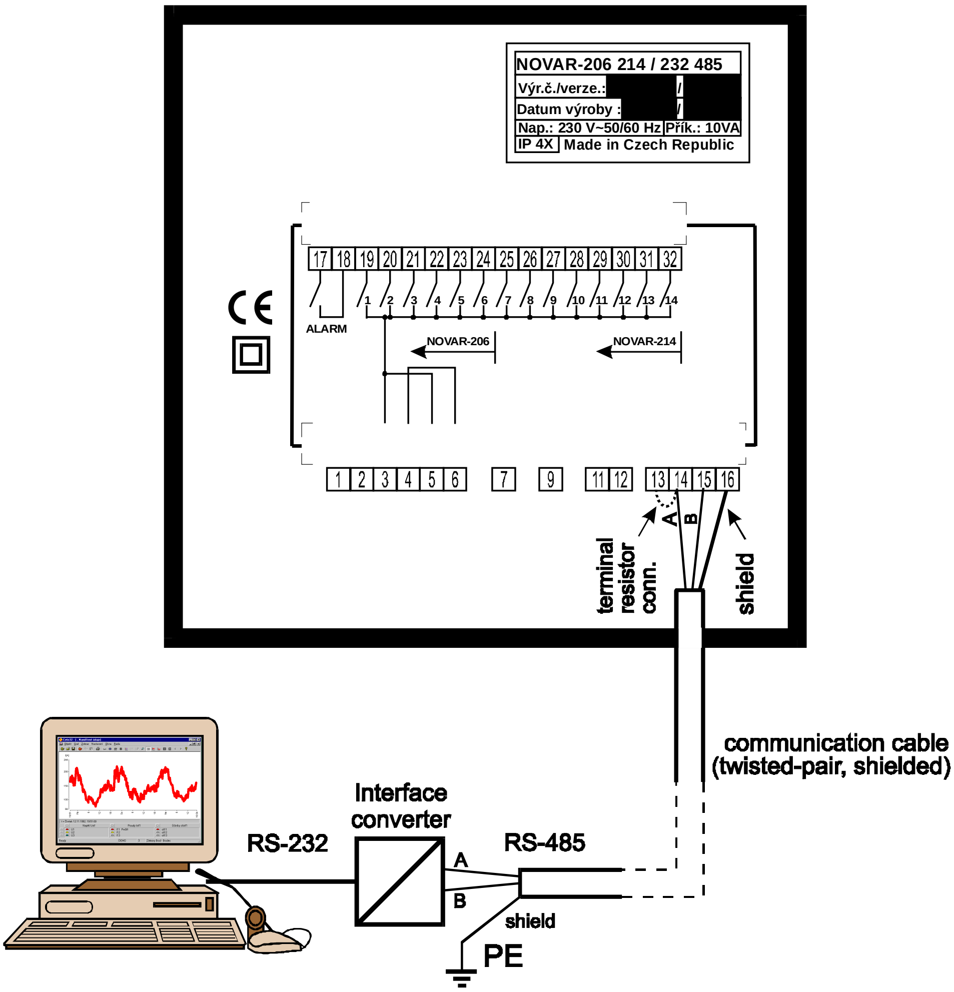
Novar-206 - installation, low voltage measurement



Novar-214 - installation, high voltage measurement



Novar - RS-485 communication link connection



6. Technical Specifications:

adjustable parameters

target power factor	0.80 lag to 0.80 lead
switching time (maximum value, depends on regulation deviation)	5 to 1,200 seconds
delay time on reconnection	5 to 1,200 seconds
smallest capacitor current (C/k value calculated for metering current transformer primary side)	(0.01 ÷ 2 A) x metering current transformer ratio
regulation by choke limit power factor	0.80 lag to 0.80 lead
method of setting compensation section values	automatic or manual
method of setting method of connection	automatic or manual

inputs–outputs

measurement voltage (galvanic-isolated)	100 to 690 V AC +10 / –20 %, 50 / 60 Hz
voltage input impedance	> 200 kΩ
measurement current (galvanic-isolated)	0.01 to 7.5 A
current input serial impedance	< 10 mΩ
current measurement accuracy (effective value and 1st harmonic)	± 1 % ± 0.01 A
current harmonic component and THD measurement accuracy	± 10 %
number of output relays	6 or 14
output relay load capacity	250 V AC / 4 A
alarm relay load capacity	250 V AC / 4 A
second metering rate input (galvanic-connected, for insulated contact or optocoupler connection)	12V DC / 10 mA
power supply	230 or 115 V AC +10 / – 20 %, 50/60 Hz
input power	maximum 10 VA
insulation strength (t = 1 minute)	
1. between instrument's internal circuitry and power supply, measurement voltage, and measurement current inputs	5,250 V DC
2. between internal circuitry and outputs	3,250 V DC
3. between instrument's internal circuitry and remote communication input/output	720 V DC
installation overvoltage category	II as specified in EN 61010-1

remote communication

interface	RS-232 / RS-485, galvanic-isolated
transmission rate	9,600 Baud
maximum number of instruments on one communication line	1 / 32
maximum distance between two nodes	30 m / 1,200 m

operating conditions

operating environment	class C1 as specified in IEC 654-1
operating temperature	–40° ÷ +60° C
relative humidity	5 to 100 %

EMC

emission	EN 50081-2 EN 55011, class A EN 55022 , class A (not for home use)
immunity	EN 61000-6-2
emission & immunity	EN 61326-1

physical features

sealing: - front panel - rear panel	 IP40 (or IP54) IP 20
dimensions:	
- front panel	144 x 144 mm
- installation depth	80 mm
- installation panel cutout	138 x 138 mm
mass	maximum 1.0 kg

7. MAINTENANCE, TROUBLESHOOTING

Novar line power factor controllers do not require any maintenance within their operation. For reliable operation you only have to comply with the operating conditions specified and prevent mechanical damage to the instrument.

The controller's power supply is one-pole protected with a mains fuse rated T0.1A (230 VAC type) or T0.2A (115 VAC type). The fuse is only accessible after back disassembly and only the controller supplier's qualified personnel may thus carry out this action.

In case of the product's breakdown, you have to return it to the supplier at their address.

supplier:

manufacturer:

KMB systems, s.r.o.

559 Dr. M. Horákové

460 06, Liberec 7

Czech Republic

website: www.kmb.cz

The product must be packed properly to prevent damage in transit. Description of the problem or its symptoms must be sent along with the product. If warranty repair is claimed, the warranty certificate must be sent in too. If repair beyond warranty is required, a written order must be included.

Warranty Certificate

Warranty period of 24 months from the date of purchase, maximum 30 months from the date of dispatch from manufacturer's warehouse however, is provided for the instrument. Problems in the warranty period, provably because of faulty workmanship, design or inconvenient material, will be repaired free of charge by the manufacturer or an authorized servicing organization.

The warranty ceases even within the warranty period if the user makes unauthorized modifications or changes to the instrument, connects it to out-of-range quantities, if the instrument got damaged in out-of-specs falls or by improper handling or if it has been operated in contradiction with the technical specifications presented.

type of product: **NOVAR**............................

serial number ....

date of dispatch: ....

final quality inspection: ....

manufacturer's seal:

date of purchase: ....

supplier's seal: