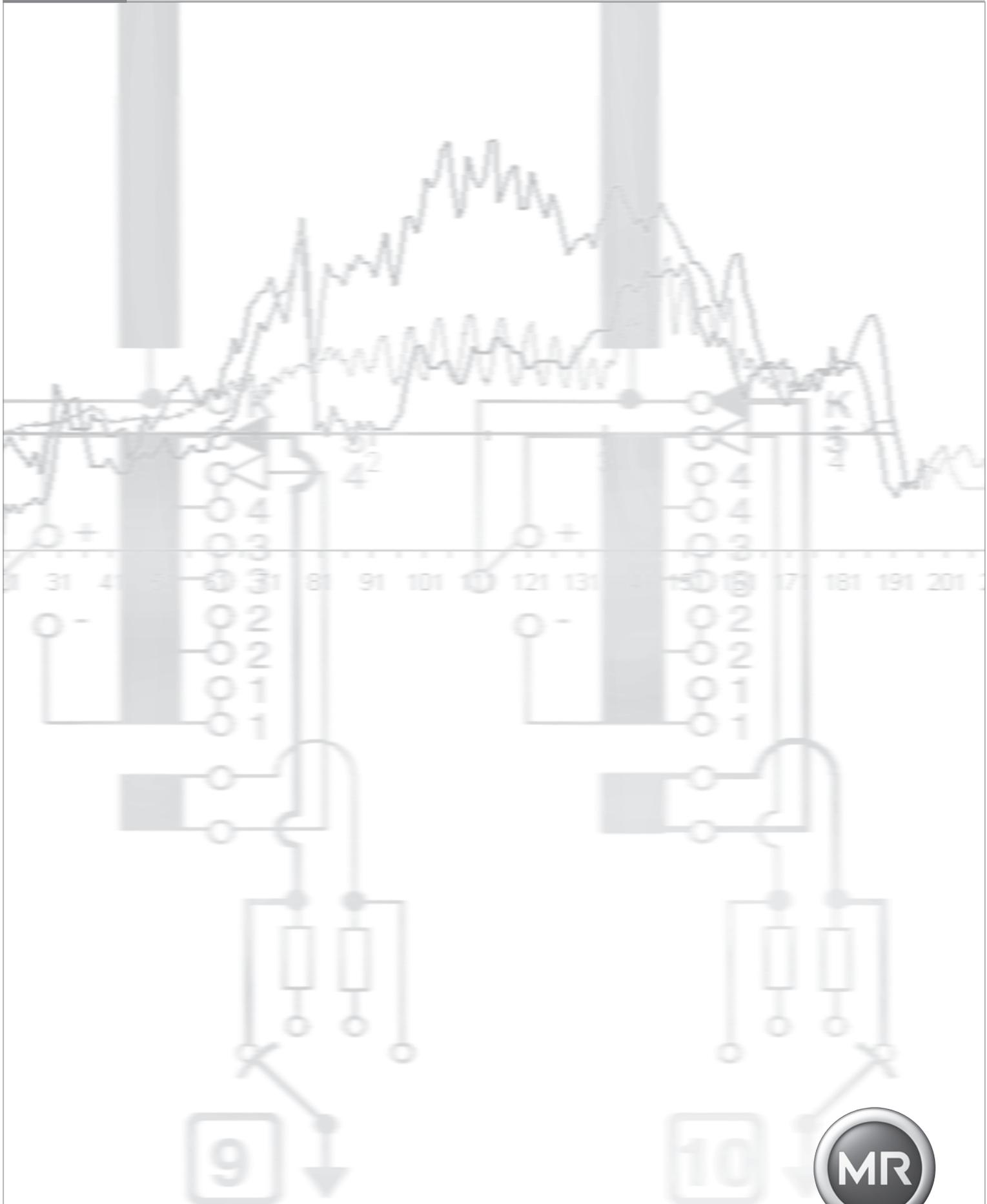


# Voltage Regulator TAPCON® 230

Operating Instructions BA 225/03



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### NOTE

Changes may have been made to a product after going to press with this documentation.

We expressly reserve the right to make changes to a product's technical data and design as well as changes to the scope of delivery.

In all cases, the information submitted and agreements concluded during processing of the quotation and order in question shall be binding.



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**NOTE**

A "PARAM?" message appearing in the first line of the display indicates a negative result of the parameter verification that may be caused by interference above the permissible electromagnetic compatibility limit (see information on standardisation and verification in section 2). In this case, voltage regulation is blocked for safety reasons. Check the settings in order to clear the blocking. Press and hold the "SELECT" key and press the "↑" or "↓" key for displaying the current settings (see section 3.2.1). Voltage regulation is reinstated once invalid settings have been corrected while cycling through the menu. The status LEDs and status relays are activated, and the display shows the current measurement readings.

# 1 General

## 1 General

### 1.1 Safety instructions

All personnel involved in installation, commissioning, maintenance or repair of this equipment must:

- be suitably qualified and
- strictly observe these operating instructions.

Improper operation or misuse can lead to

- serious or fatal injury,
- damage to the equipment and property of the user and
- a reduction in the efficiency of the equipment.

Safety instructions in this manual are presented in three different forms to emphasize important information.



#### WARNING

This information indicates particular danger to life and health. Disregarding such a warning can lead to serious or fatal injury.



#### CAUTION

This information indicates particular danger to the equipment or other property of the user. Serious or fatal injury cannot be excluded.



#### NOTE

These notes give important information on a certain subject.

### 1.2 Specified application

The electronic voltage regulator TAPCON® 230 serves for automatic control of transformers with a motor-driven on-load tap-changer. The motor-drive mechanism receives the corresponding control commands from the voltage regulator. With these commands, the on-load tap-changer moves to the next position and the transformer's voltage value is adapted to the preset desired voltage level.

To allow individual adaptation of the control system to the various field service conditions encountered, influencing variables such as time delay, bandwidth, and even line-dependent and load-dependent parameters can be programmed for compensation of voltage-dependent and/or current-dependent limits. As a special feature, the voltage regulator is also capable of controlling parallel transformer operation.



#### CAUTION

Installation, electrical connection and commissioning of the electronic voltage regulator may only be carried out by qualified, skilled personnel and only in accordance with these operating instructions.

It is the responsibility of the user to make sure that the electronic voltage regulator is used for the specific application only. For safety reasons, any unauthorized and improperly executed works, i. e. installation, modification, alteration of the equipment, electrical connection, or commissioning of the equipment, are forbidden without first consulting MR!

The trouble-free operation of the drive, the on-load tap-changer, and the transformer may be put at risk.



#### WARNING

All relevant fire protection regulations must be strictly observed.

## 1.3 Design and performance features of the TAPCON® 230

The electronic voltage regulator TAPCON® 230 is mounted in a protective housing with hinged cover and inspection window. The protective housing is suitable for both flush and projected panel mounting.

The front panel contains several function keys for setting the individual operating parameters.

Display of the operating status is achieved by a 4-line, 16-digit alphanumeric LC display and light emitting diodes.

The electronic voltage regulator is controlled by a micro-controller (see appendix, block/connection diagram). Besides a voltage transformer and a current transformer it contains optocoupler inputs with potential separation as well as potential-free output relay contacts.

Apart from the usual well-known, versatile and individual setting options for the MR control system, the TAPCON® 230 voltage regulator also offers the option of fast and easy parametering by introducing the innovative "Normset" function.

The term „Normset" function stands for an automatism which considerably simplifies the configuration of a voltage regulator. If the desired voltage level is entered while the „Normset" function is active, the voltage regulator will examine the given line/network conditions and proceed to perform an automatic adaptation of all further inputs (comprised in part of the pre-parametering and standard reference values) which used to be required for customary regulators (also refer to the standard configuration according to Sub-menu 2).

The parameters of the regulator can be set by means of a PC via the incorporated serial interface (RS232) integrated in the regulator; the appropriate PC software will be furnished by MR.

A load-dependent line-voltage drop, e. g. of a spur line leading from the transformer to the load, can be compensated either by line simulation (Line Drop Compensation) or by load-current dependent increase of the voltage level (Z compensation).

Trouble-free operation is ensured by the regulator's inherent undervoltage blocking, overcurrent blocking and overvoltage monitoring.

The functions of the TAPCON® 230 voltage regulator are just about fully compatible with those of the earlier generations of voltage regulators.

Parallel operation follows the principles of either minimum circulating reactive current or the Master/Follower principle.

Parallel control of two groups comprised of up to 8 users total is possible without the need for a supplementary device due to the utilization of a serial bus system.



### NOTE

When voltage regulation is effected by tap transformers and voltage regulators, it is assumed that a change of the tap position results in a significant voltage change. When generators feed the voltage level to be regulated, however, quite different conditions may result so that a correct regulation of the voltage cannot be guaranteed. In such cases MR should be consulted as early as the planning stage.

## 2 Technical Data

## 2 Technical Data

### Setting ranges

	Standard setting range	Standard step width
Desired voltage level 1	85 – 140 V	0.1 V steps
Desired voltage level 2	85 – 140 V	0.1 V steps
Desired voltage level 3	85 – 140 V	0.1 V steps
Bandwidth	$\pm 0.5 \dots \pm 9 \%$	0.1 %
Delay time T1	0 ... 180 s	1 s
Delay time T2	1 ... 10 s	1 s
Switching pulse duration	0.5 ... 10 s	0.5 s
LDC	Ur = 0 ... $\pm 25$ V Ux = 0 ... $\pm 25$ V	0.1 V 0.1 V
With optional Z compensation selection	Voltage rise 0...15 % Limitation 0...15 %	0.1 % 0.1 %
Undervoltage blocking	70 ... 99 %	1 %
Overvoltage detection with high speed return control	101 ... 130 % pulse signal 1.5 / 1.5 s	1 %
Overcurrent blocking	50 ... 210 %	5 %
Voltage transformer	0.1 ... 999,9 kV/100 V	
Current transformer	100 ... 5000 A/5/1/0.2 A	
Measuring circuit	Phase angle adjustable between current and voltage circuit: -30° 3-phase 0° 3-phase +30° 3-phase +90° 3-phase 0° 1-phase	



<b>Display</b>	<p>4-line, 16-digit LC display</p> <p>1 LED lamp (green) for signalling status</p> <p>1 LED lamp (red) each for signalling U&lt;, U&gt;, I&gt;</p> <p>1 LED lamp (green) for signalling ‚parallel operation active‘ status</p> <p>1 LED lamp (green) for signalling ‚Normset active‘ status</p>	
<b>Inputs and outputs</b>	<p>Input relays</p> <p>1x manual control mode</p> <p>1x automatic control mode</p> <p>1x group 1 parallel (optional)</p> <p>1x group 2 parallel (optional)</p> <p>1x high-speed circuit breaker of voltage limit monitoring indicator</p> <p>1 x analogue input of tapping position (optional) 4 - 20 mA; potentiometer</p> <p>1 x desired voltage level 2</p> <p>1 x desired voltage level 3</p>	<p>Output relays</p> <p>Rating of relay contacts:</p> <p>AC: 250 V 5 A</p> <p>DC: 30 V 5 A; 110 V 0.4 A; 220 V 0.3 A</p> <p>1 x raise</p> <p>1 x lower</p> <p>1 x automatic control mode</p> <p>1 x status</p> <p>1x group interrupt U&lt;, U&gt;, I&gt;</p> <p>1x monitoring (function monitoring)</p>
Voltage transformer	85 ... 140 V, measuring range 60 ... 185 V, r.m.s. value 40 ... 60 Hz, intrinsic consumption < 1 VA	
Current transformer	0.2 / 1 / 5 A, 40 ... 60 Hz, r.m.s. value intrinsic consumption < 1 VA, overload capacity 2x I <sub>n</sub> continuously, 100x I <sub>n</sub> /1 s	
Measuring errors	<p>Voltage measuring: &lt; 0.3 % ± 40 ppm/°C</p> <p>Current measuring: &lt; 0.5 % ± 40 ppm/°C</p>	
Serial interfaces	<p>1 x serial interface RS232 (COM1) for parametering via PC</p> <p>optionally</p> <p>1 x CAN bus for parallel operation</p> <p>1 x RS232 for parallel operation with digital MR parallel control unit SKB</p>	
<b>Power supply</b>	<p>115 V (+25 % - 35 %) 40 - 60 Hz, can be changed over either from the measuring voltage or by separate change-over in the factory to a supply voltage of 230 V</p> <p>Power consumption approx. 5.5 VA (at 115V, idle state)</p>	

## 2 Technical Data

**Protective housing** Steel-plate housing with inspection window for flush or projected panel mounting  
W x H x D: 216 x 326 x 137mm  
Degree of protection provided by enclosure: IP 44 according to IEC 60529  
Weight: approx. 5.4 kgs

**Temperature limits** Admissible ambient temperature for operation: -10 °C ... + 70 °C  
Admissible ambient temperature for storage and transport: -25 °C ... +80 °C

### Tests

#### Electrical safety

Protection class 1 in accordance with IEC 60536  
Protection rating IP44 in accordance with IEC 60529  
Degree of soiling 2 in accordance with IEC report 664-1  
Overvoltage category III in accordance with IEC report 664-1  
Fulfills IEC 60688

EN 61010-1	Safety provisions governing electrical measurement, control, regulation and laboratory equipment. Dielectric test with operating frequency of 2.5 kV/1 min
IEC 60255	Dielectric test with surge voltage, 5 kV, 1.2/50 µs
IEC 61000-4-2	Interference immunity tests (EMC): electrostatic discharge 4 kV / 8 kV
IEC 61000-4-3	Interference immunity tests (EMC): electromagnetic fields 10 V/m 80-1000 MHz
IEC 61000-4-4	Interference immunity tests (EMC): burst 1MHz, 4 kV
IEC 61000-4-5	Interference immunity, surge 2 kV
IEC 61000-4-6	HF interference immunity of leads: 10V, 150 kHz – 80 MHz
EN 61000-6-2	Immunity for industrial environments
EN 61000-6-4	Emission standards for industrial environments
VDE 0435	Short-time current and continuous rating of the current transformer inputs, 100 x In/1s and 2 x In/continuously
VDE 0100	Provisions governing the erection of electrical power installations featuring rated system voltages up to 1,000 V Grounding conductors, protective conductors, equipotential bonding conductors, arrangement of operating elements
VDE 0110	Provisions governing the rating of clearance in air and creepage distances in electrical equipment
IEC 60529	Determination of the degree of protection provided by enclosures: „Shock-hazard protection, protection against ingress of solid foreign bodies and protection against the ingress of water for electrical equipment“ Level IP44
IEC 60068	Basic environmental test procedures
IEC 60068-2-1	Cold test for heat-dissipating specimens, with slow temperature change rate -10°C / 20 hours
IEC 60068-2-2	Dry-heat test for heat-dissipating specimens, with slow temperature change rate +70 °C / 16 hours
IEC 60068-2-3	Humid heat, constant +40 °C / 93 % / 56 days
IEC 60068-2-30	Humid heat, cyclical (12 + 12 hours) + 55 °C / 93 % and + 25 °C / 95 % / 6 cycles
IEC 60068-2-31	Drops and topple, unpacked, 100 mm height
IEC 60068-2-32	Free fall, unpacked, 250 mm height
IEC 61000-4-8	Power frequency magnetic field immunity test
IEC 61000-4-11	Voltage dips, short interruptions and voltage variations immunity tests

## 3 Operation

### 3.1 Input and output of data; functions

The following instructions tell you how to call up the basic functions of the TAPCON® 230 voltage regulator and how to reset parameters.

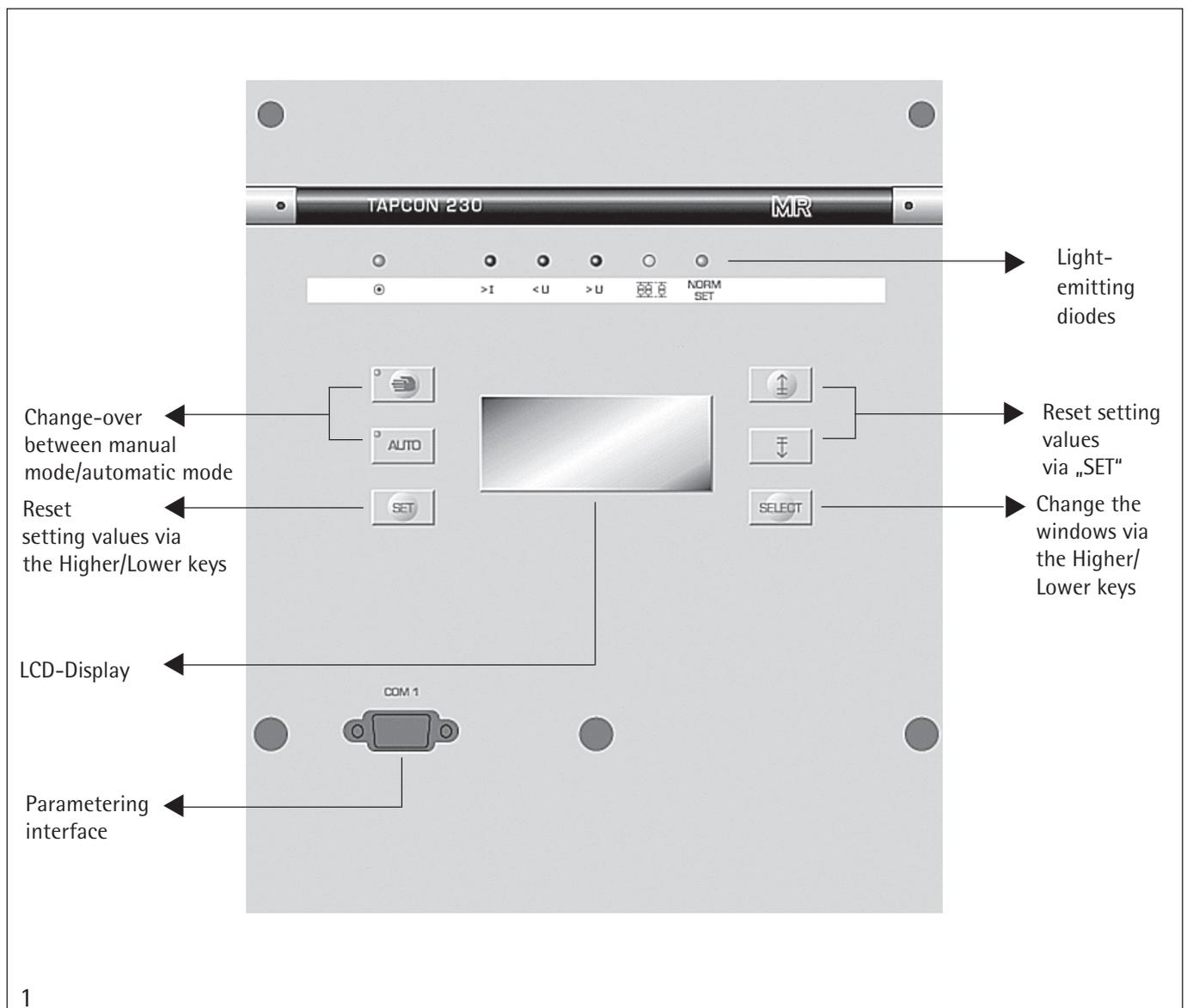
### 3.2 Description of the front panel (fig. 1)

Generally, the keys located at the front panel fall into two different basic groups.

- Operating keys
- Function keys for menu guidance

The LED's located in the front panel's upper area serve for signalling the following system statuses:

- Operating status display
- Overcurrent blocking
- Undervoltage blocking
- Overvoltage monitoring
- Parallel operation
- NORMSET



## 3 Operation

### 3.2.1 Display

The TAPCON® 230 contains a 4-line, 16-digit LC display. A distinction is made between the two following types of displays: Basic display and parametering display.

#### a) Basic display

In addition to the actual voltage level, the desired voltage level and the deviations the basic display indicates an additional measuring value in the 4th line during normal operation. Selection of this measuring value in the display window „SELECT 4<sup>th</sup> LINE“.

The following values are available:

- Current I
- Apparent power S
- Reactive power Q
- Active power P
- Phase angle PHI
- Power factor cos PHI
- Frequency f
- Status line
- Position, optional

ACTUAL VOLT. LEVEL	64.90 kV
DESIRED VOLT. LEVEL	66.00 kV
dU%	1.67 %
CURRENT I	253 A

#### b) Parametering display windows

The TAPCON® 230 contains parametering display windows which serve to display set parameters and allow the user to modify any previously set parameters to suit his specifications.

Generally, these windows are set up as follows:

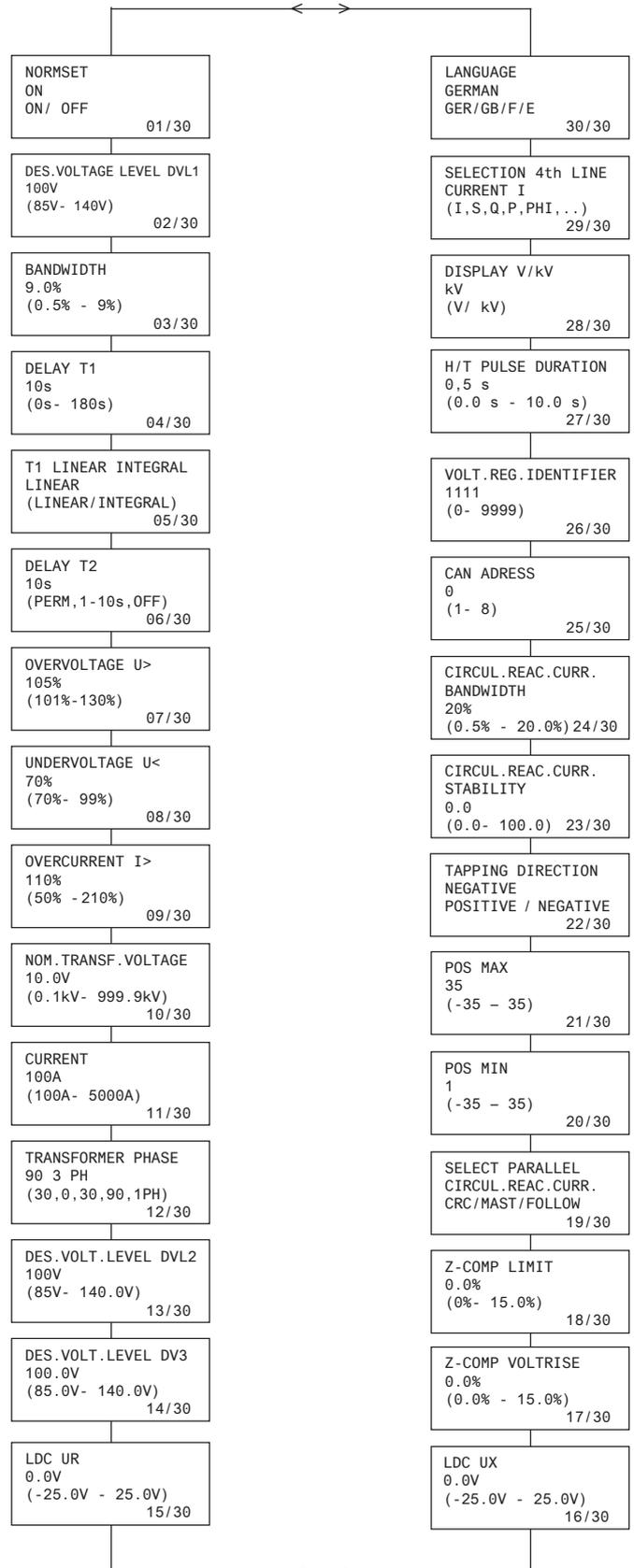
- 1st line: Title/designation of the parameter
- 2nd line: Set value
- 3rd line: Possible setting values and/or setting limits
- 4th line: Serial number of the display

DESIRED VOLT. LEVEL SW1	110V
(85V - 140V)	
	02/30

The displays are situated behind one another in a ring-shaped arrangement, as shown in the illustration to the right, and can be selected by operating the function keys SELECT and  . The display will remain visible for as long as the SELECT key is being pressed, plus an additional 10 seconds after the SELECT key was released. It is possible to move in both directions within the menu. As a result, display no. 30 of the basic display can be reached just as quickly as display no. 1.

The preset value can be altered within the setting values and/or setting limits by operating the SET and   function keys. Once the SET key is released, the new value will be set to 'active'.

For parametering purposes, please use the displays listed below, the functions of which are explained in detail in the following.



## 4 Parametering

### 4.1 Normset setting

```
NORMSET
ON
ON / OFF      01 / 30
```

The term „Normset“ function stands for an automatism which considerably simplifies the configuration of a voltage regulator. The only thing left to do for the operator when commissioning during the Normset mode is to enter the desired voltage level and subsequently take the device into operation.

All other parameters required for simple voltage regulation will be preassigned at the factory (e. g. bandwidth of  $\pm 1\%$ ). Should the actual value exit the set bandwidth, an appropriate switching operation will be initiated at the on-load tap-changer. The voltage change ensuing from the switching operation corresponds to the transformer's tap voltage and is checked for plausibility by the regulator, using the preset bandwidth. The bandwidth value is then optimised in accordance with the results gleaned from this check.

If the next system deviation occurs, the new bandwidth will be used as basis, which will be rechecked and readjusted, if necessary.

The time parameters are handled in the same way by the regulator, which ensures optimum self-adjustment of the regulator after only a few regulating sequences.

Should the marginal conditions change, the regulator will again optimise itself automatically.

It goes without saying that mains-specific and/or customer-specific settings such as LDC, parallel operation or position indication can still be done in the standard mode and will be taken into consideration during determination of the optimum parameters.



#### NOTE

The parameters for undervoltage/overvoltage and over-current are not set by the Normset function. These parameters have to be entered manually during commissioning/initiation.

### 4.2 Setting the desired voltage level 1

```
DES.VOLTAGE LEVEL DVL1
100V
(85V - 140V)      02 / 30
```

The setting of the desired voltage level refers either to the secondary or to the primary voltage side of the voltage transformer connected to the TAPCON® 230.

'V' stands for the secondary voltage which is indicated in Volt. 'kV' stands for the primary voltage which is indicated in Kilovolt. Press the SET and   function keys to set the desired voltage level.

### 4.3 Setting the bandwidth

```
BANDWIDTH
9.0%
(0.5% - 9%)      03 / 30
```

Set the bandwidth from  $\pm 0.5\%$  to  $\pm 9\%$  in steps of  $0.1\%$  by pressing the SET and   function keys. The transformer's step voltage must be known to ensure proper setting of this value.

$$B (\%) = \frac{\text{Control range } (\%)}{\text{No. of steps}} = \frac{\text{Control range } (\%)}{\text{No. of positions} - 1}$$

For increased regulating sensitivity it is also possible to set lower values, although it is highly inadvisable to go beneath  $60\%$  of the computed value. Higher values will cause a decrease in regulating sensitivity.

If the measuring-circuit voltage is altered far enough during operation to exceed the set bandwidth, the presignal will respond. An output pulse will be generated according to the set delay time.

If no compensation occurs for more than 15 min, the „function monitoring“ relay will respond (see connection diagram). The relay will not be reset until a shortfall of the bandwidth threshold has occurred.

Standard setting range:  $\pm 0.5 - \pm 9\%$

Standard step width:  $0.1\%$

## 4 Parametering

### 4.4 Setting the delay time T1 or T2 (DELAY 1/ DELAY 2) and pulse duration (option)

The delay time starts as soon as the deviation exceeds the set bandwidth limits above or below. At the same time the corresponding presignal arrow appears. If the deviation is still present after the delay time has elapsed, an output pulse is emitted. If the deviation returns to within bandwidth limits, then the current delay time is cancelled immediately.

#### Delay time T1

```
DELAY T1
10s
(0s - 180s)
04/30
```

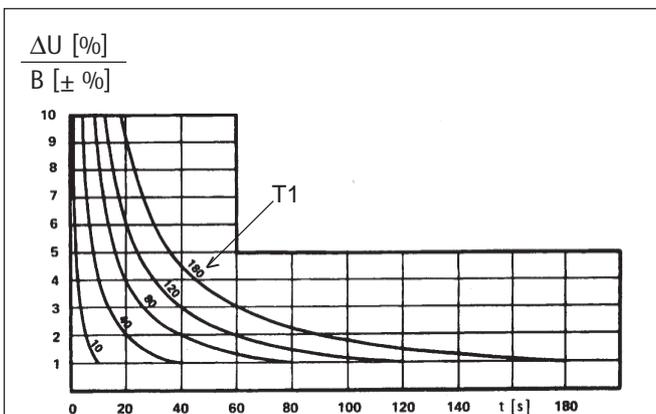
The delay time can be set from 0...180 s by pressing the SET and   function keys.

#### T1 Linear/integral

```
T1 LINEAR INTEGRAL
LINEAR
(LINEAR/INTEGRAL)
05/30
```

The delay time T1 can be set with linear or integral response. If a delay time with integral response „Int" is set, the delay time is automatically shortened according to the relation of actual system deviation to set bandwidth, down to a minimum of 1 s (**fig. 2**).

The desired time behavior can be set by pressing the SET and   function keys.



Delay of the delay time

$\Delta U/B$  – voltage change  $\Delta U$  in % of the desired value, in relation to the set bandwidth of  $B$  in  $\pm$  % of the desired value.

2

#### Delay time T2

```
DELAY T2
10s
(PERM, 1-10s, OFF)
06/30
```

The delay time T2 will become effective only if more than one tap change is required for reduction of the control deviation below the bandwidth limit. The set delay time T2 is then valid for all consecutive output pulses.

Set the delay time T2 for a range of 1.0 ... 10 s by pressing the SET and   function keys.

If the voltage regulator is set to PERM, it will emit a continuous signal. If it is set to OFF, the delay time T2 will be deactivated.

#### H/T Pulse duration (option)

```
H/T PULSE DURATION
0.5 s
(0.0 s - 10.0 s)
27/30
```

The value designated as "H/L pulse duration" is the time interval occurring between two pulses during high-speed return control. The adjusting range is between 0 and 10 s at an increment of 0.1 s each.

The value parameterised in "H/T pulse duration" is used both for the 'on' time and the 'off' time of a switching operation, i. e. for an adjusting value of "2 s", the relay will be switched on for 2 seconds, and then remains switched off for another 2 seconds. That way a new switching operation cannot be initiated until after 4 seconds.

Here, the make time is identified as "n → 1" or "1 → n", and the break time is identified as "MOTOR RUNNING" in the third display line.

### 4.5 Setting the overvoltage detection (U>) with automatic return control

```

OVERVOLTAGE U>
105%
(101%-130%)
07/30
    
```

The response threshold can be set from 101 % to 130 % of the desired voltage level in steps of 1 % by pressing the SET and   function keys.

In the event of an overvoltage detection response, the on-load tap-changer is operated by periodic pulses to the motor-drive until the overvoltage falls below the response threshold. The motor-drive is controlled by periodic pulses of 1.5 s through the "Lower" output relay while the set delay time re-mains inactive during this operation. At the same time the alarm signalling LED lamp "U>" responds and a signalling relay is energized (contacts 17/18/19) as long as overvoltage is present. If the voltage regulator regulates towards a higher voltage than the set limit U> due to an unfavourable parametering (e. g. too high LDC settings), it is prevented from exceeding the limit. This condition is signalled by the signalling relay for 'function monitoring', after 15 minutes.

### 4.6 Setting the undervoltage blocking (U<)

```

UNDERVOLTAGE U<
70%
(70%- 99%)
08/30
    
```

The response threshold for undervoltage blocking can be set from 70 % to 99 % of the desired voltage level in steps of 1 % by pressing the function keys Set and  .

Undervoltage blocking prevents tap change operations in the event of a network breakdown. The voltage regulator output pulses are blocked and the alarm signalling LED lamp "U<" and a signalling relay (contacts 17/18/19) respond when the measuring voltage falls below the set blocking value. After a delay time of approx. 10 s, the associated signalling relay is energized and remains that way. The signalling relay does not respond in case of a failure of the measuring-circuit voltage or supply voltage (< 30 V).

### 4.7 Setting the overcurrent blocking (I>)

```

OVERCURRENT I>
110%
(50% - 210%)
09/30
    
```

The overcurrent blocking response threshold can be set from 50 % to 210 % (of the rated current of the current transformer) in steps of 1 % by pressing the Set and   function keys. Overcurrent blocking prevents tap change operations in the presence of overload.

The voltage regulator output pulses are blocked and the alarm signalling LED lamp responds when the measured current exceeds the set blocking value. At the same time the corresponding signalling relay is energized and remains energized (contacts 17/18/19).

## 4 Parametering

### 4.8 Measuring transformers (VT, CT CONFIGURATION)

The transformation ratios and measuring set-ups of the voltage and current transformers used can be set in the corresponding display windows by pressing the SET and   function keys.

#### Rated transformer voltage

NOM. TRANSF. VOLTAGE  
10.0V  
(0.1kV- 999.9kV)  
10/30

Primary voltage of the voltage transformer in kV, in relation to 100 V secondary voltage.

#### Rated transformer current

CURRENT  
100A  
(100A- 5000A)  
11/30

Primary current of the current transformer in A.

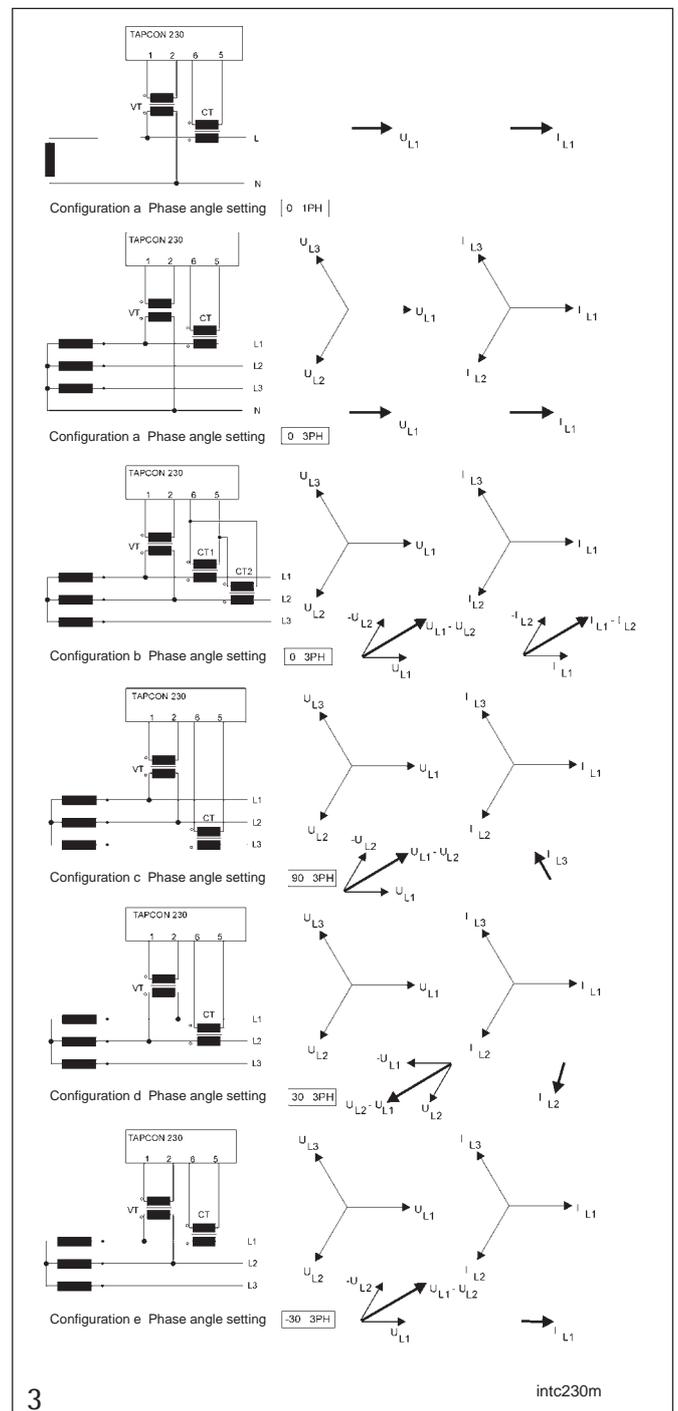
#### Transformer phase, measuring circuit

TRANSFORMER PHASE  
90 3 PH  
(30,0,30,90,1PH)  
12/30

Phase angle of the current/voltage transformer, see **fig. 3** for explanations.

Setting values for customary measuring circuits:

- 0° (for one-phase systems)
- 0° (for single-phase systems)
- 0° (for three-phase systems)
- 90° (for three-phase systems)
- 30° (for three-phase systems)
- 30° (for three-phase systems)



## 4 Parametering

### 4.9 Setting the desired voltage levels DVL2 and DVL3

```
DES. VOLT. LEVEL DVL2
100V
(85V - 140.0V)
13/30
```

```
DES. VOLT. LEVEL DV3
100.0V
(85.0V - 140.0V)
14/30
```

The voltage regulator TAPCON® 230 permits the preselection of three different desired voltage levels, each of which will be activated specifically in relation to the actuation of inputs 13 and 14.

No signal present at terminals 13 and 14 => Desired voltage level 1 is active  
 Presence of a signal at terminal 13 => Desired voltage level 2 is active  
 Presence of a signal at terminal 14 => Desired voltage level 3 is active

Setting the desired voltage levels 2 and 3 is identical to the setting procedure for the desired voltage level 1, i. e. by operating the function keys SET and .

### 4.10 Line compensation

The line compensation, i. e. the inclusion of the voltage drop of a line connected to the transformer in the regulating process, can be accomplished in two different ways.

#### Comparison between LDC and Z Compensation

##### Application of the vectorial compensation (LDC):

- requires knowledge of the exact line data
- permits a more accurate determination of the line voltage drops

##### Application of the Z compensation:

- can be used in the case of minor shifts of the phase angle  $\varphi$
- can be also used in meshed network applications.

### 4.10.1 Line Drop Compensation (LDC)



#### NOTE

For the correct setting of the LDC it is necessary to calculate the resistive and inductive line voltage drop in relation to the secondary side of the voltage transformer in V and the correct setting of the existing measuring transformer configuration according to paragraph 4.8.

#### Setting the resistive voltage drop UR

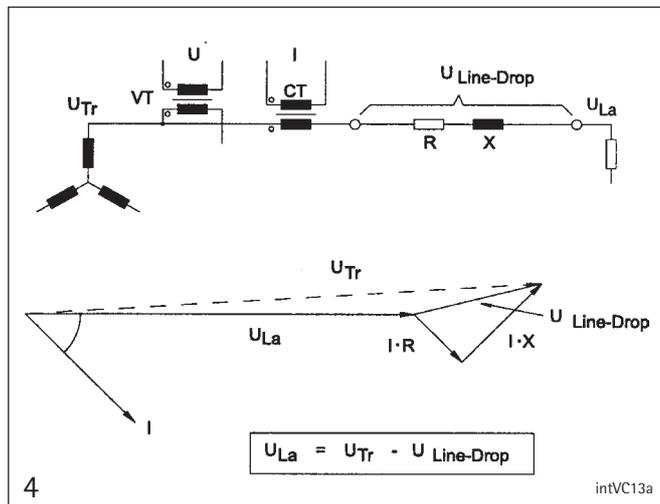
```
LDC UR
0.0V
(-25.0V - 25.0V)
15/30
```

The calculated resistive voltage drop is set in the LDC UR display by pressing the function keys SET and . The effect of the compensation can be reversed by 180° (minus sign preceding the setting). If no compensation is desired, then the value „0” is to be set (condition at the time of delivery).

#### Setting the inductive voltage drop Ux

```
LDC UX
0.0V
(-25.0V - 25.0V)
16/30
```

The calculated inductive voltage drop is set in the LDC Ux display by pressing the function keys SET and . The effect of the compensation can be reversed by 180° (minus sign preceding the setting). If no compensation is desired, then the value „0” is to be set (condition at the time of delivery).



## 4 Parametering

Calculation of the required setting values:

$$U_r = I_N \cdot \frac{R_{CT}}{R_{VT}} \cdot r \cdot L \text{ (V)}$$

$$U_x = I_N \cdot \frac{R_{CT}}{R_{VT}} \cdot x \cdot L \text{ (V)}$$

Where

$U_r$  = LDC setting for resistive line voltage drop in V

$U_x$  = LDC setting for inductive line voltage drop in V

$I_N$  = Rated current in A of the selected current transformer connection to the voltage regulator, i.e. 0.2 A or 1 A or 5 A

$R_{CT}$  = Current transformer ratio, e. g. 200 A / 5 A

$R_{VT}$  = Voltage transformer ratio, e. g.

$$\frac{30000 \text{ V} / \sqrt{3}}{100 \text{ V}}$$

$r$  = Ohmic resistance of line in  $\Omega$ / km per phase

$x$  = Inductive reactance of line in  $\Omega$  / km per phase

$L$  = Length of line in km

If the active voltage drops  $U_r$  and reactive voltage drops  $U_x$  are set correctly, then the line end voltage will remain constant regardless of load.

### 4.10.2 Z-Compensation

For correct setting of the parameters the voltage rise ( $\Delta U$ ) has to be calculated in consideration of the current.

Calculation of the required setting values:

$$\Delta U \text{ (%) } = 100 \cdot \frac{U_{Tr} - U_{Load}}{U_{Load}} \cdot \frac{I_N \cdot R_{CT}}{I}$$

$\Delta U$  = Setting of Z-Compensation in %

$U_{Tr}$  = Transformer voltage at current  $I$

$U_{La}$  = Line end voltage at current  $I$  and with the same service position of the tap-changer

$I$  = Load current in A

$I_N$  = Rated current in A of the selected current transformer connection to the voltage regulator, i. e. 0.2 A or 1 A or 5 A

$R_{CT}$  = Current transformer ratio, e. g. 200 A / 5 A

### Setting the voltage rise (VOLTRISE)

The calculated percentage of the voltage rise, referred to the desired voltage level, is set by pressing the function keys SET and  . If no compensation is desired, the value „0“ is to be set (link with →LIMIT).

```
Z-COMP VOLTRISE
0.0%
(0.0% - 15.0%)
17/30
```

### Setting the limitation for $\Delta U_{max}$ (LIMIT)

```
Z-COMP LIMIT
0.0%
(0% - 15.0%)
18/30
```

The value is set by pressing the function keys SET and  . If compensation is set to a certain value while avoidance of excessive transformer voltage rises (e. g. in case of an unusually high load) is desired, the limit values can be set to the desired voltage level.

If no compensation is desired, the value „0“ is to be set.

### 4.11 Analog remote position indication (option)

Optionally, the voltage regulator TAPCON® 230 is available with an analog control/activation of the remote position indication. This option requires an analog module.

The following analog values can be processed:

- 4 – 20 mA
- Potentiometer range with a minimum total resistance of 50  $\Omega$ , up to a maximum total resistance of 2 k $\Omega$ .

Press the SET and   function keys to set the respective minimum and maximum positions.

For POS MIN, please enter the position corresponding to e. g. 4mA; for POS MAX, please enter the position corresponding to e. g. 20mA.

The analog position indication will be included automatically if the TAPCON® 230 is equipped with the parallel operation option.

```
POS MIN
1
(-35 - 35)
20/30
```

```
POS MAX
35
(-35 - 35)
21/30
```

### 4.12 Voltage regulator identification

```
VOLT. REG. IDENTIFIER
1111
(0- 9999)                26/30
```

The voltage regulator contains a parametering interface to allow parametering via laptop. The required visualization software is included in the standard scope of delivery. The purpose of voltage regulator identifier is to assign a specific 'address' to the individual voltage regulator to permit specified operation via visualization software. A number ranging between 0 and 9999 can be entered to serve as a „name“ by operating the SET and   function keys.

### 4.13 Setting the unit to V or kV

```
DISPLAY V/kV
kV
(V/ kV)                28/30
```

The voltage regulator TAPCON® 230 allows the user to both display and enter the unit of the actual voltage level and the desired voltage level in the basic display as well as the parametering displays for the, desired voltage level 1, 2 and 3' in the primary voltage transformer unit kV. To that end it is indispensable that the rated voltage of the voltage transformer be entered as indicated under paragraph 4.8. Set the desired unit by operating the SET and   function keys.

### 4.14 Selection of the display in the 4<sup>th</sup> line of the display

```
SELECTION 4th LINE
CURRENT I
(I, S, Q, P, PHI, ...)
29/30
```

The basic display of the voltage regulator TAPCON® 230 shows an additional measuring value in the 4th line. This measuring value can be set individually by operating the SET and   function keys.

The following measuring values are available:

- Current I
- Apparent power S
- Reactive power Q
- Active power P
- Phase angle PHI
- Power factor cos PHI
- Frequency f
- Status line
- Position, optional

### 4.15 Language selection

```
LANGUAGE
GERMAN
GER/GB/F/E                30/30
```

The screen texts are available in two languages. Select the desired language by operating the SET and   function key.

### 5 Commissioning

#### 5.1 Installation

The voltage regulator is suitable for both flush and projected panel mounting (see dimension diagram). Be sure to install the device in an easily accessible place in the control room or in a switching cabinet attached to the transformer.

#### 5.2 Connection

The voltage regulator is to be connected in accordance with the wiring diagram (see Appendix).

When connecting the equipment, please pay attention to:

- the correct phase angle of the secondary terminals of current transformer and potential transformer
- correct connection of the output relays to the motor drive unit
- correct connection to earth of the housing.



#### WARNING

Take care to properly connect the voltage regulator and the housing to ground. Danger to life.

The voltage regulator is normally fed by the voltage transformer.



#### NOTES

When using an auxiliary voltage AC 115V, 50...60Hz, be sure to remove the links between terminals 1/3 and 2/4:

Connect the voltage transformer to terminals 1 and 2, and the auxiliary voltage to terminals 3 and 4 (see **fig. 5**).

The TAPCON® 230 is optionally available with a supply input of AC 230 V preset at the factory.

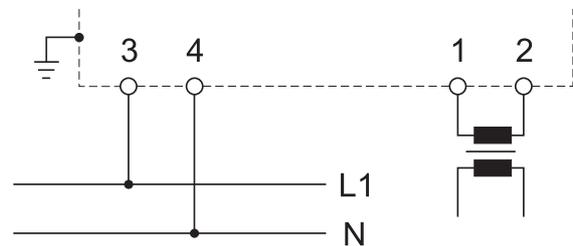


#### NOTE

The TAPCON® 230 was developed in accordance with the relevant EMC standards. The following instructions must be observed to ensure preservation of the EMC properties:

- Ensure correct connection to ground by means of the ground screw attached to the housing, wire section not less than 4mm<sup>2</sup>.
- Be sure to lead the individual power circuits (motor-drive control, inputs, outputs) in separate cables.
- Be sure to use only shielded cables for the parallel operation data links for the remote tap position indication of the motor-drive unit. The screenings at both line ends must be connected to ground via the grounding angle cable clamps at the housing included in the delivery (see **fig. 6**).

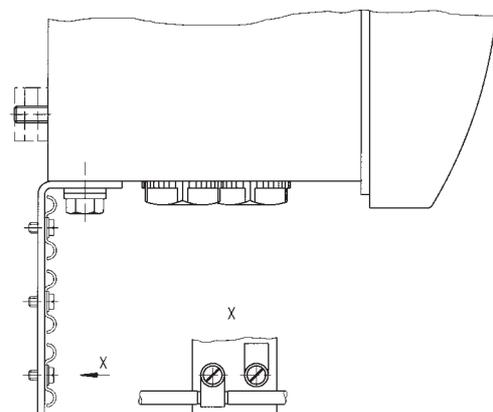
#### TAPCON® 230



Required connection for use of the auxiliary voltage

5

intVC18



6

ERD-ANL



### 5.3 Easy setting of operating modes with NORMSET

Prior to commissioning, be sure to check the entire circuitry and the measuring and operating voltage. To assess the working mode of the voltage regulator, the use of a registering device to record the regulator voltage (actual voltage level) is highly recommended.

The related transformer should be subject to normal load.

- a) Select the MANUAL operating mode at TAPCON® 230.
- b) Select the NORMSET function as indicated under 4.1.
- c) Set the Desired Voltage Level 1 as indicated under 4.2.

If you do not require a voltage display of the primary voltage in kV you may now proceed to initiate the regulator by operating the AUTO function key.

If you do require a voltage display in kV, however, please proceed as follows:

- d) Set the rated transformer voltage and the rated transformer current as indicated under 4.8.

If you wish to configure the TAPCON® 230 voltage regulator to suit your specific requirements, please proceed as indicated under 5.4.

### 5.4 Function tests; operational settings

Prior to commissioning, be sure to check the entire circuitry and the measuring and operating voltage. To assess the working mode of the voltage regulator, the use of a registering device to record the regulator voltage (actual voltage level) is highly recommended. The related transformer should be subject to normal load.

- a) Select the MANUAL operating mode at TAPCON® 230
- b) Set the transformation ratios of the transformers as specified under paragraph 4.8, as well as the measuring circuit.
- c) Let the measured actual voltage (= voltage from the voltage transformer) be indicated on the display of the voltage regulator.
- d) Let the current, power, and phase angle values be indicated on the display and compare these values with those from possibly existing service measuring instruments. If wrong signs are indicated, reverse the polarity of the current or voltage transformer.
- e) Set the desired voltage level. By manual control of the motor-drive, bring the on-load tap-changer to the service position so that the desired voltage level is obtained (see paragraph 5.5).

- f) Set the VOLTAGE LEVEL to this value.
- g) Set the bandwidth " $\Delta U$  max" to 1.0 %. In most cases the voltage regulator is now in a balanced state (no presignal LED lamp lights up). Otherwise change the desired voltage level in steps of 0.5 V until a balanced state is reached.
- h) Set the bandwidth " $\Delta U$  max" dependently of the step voltage (see paragraph 4.3).
- i) Set the delay time T1 to 20 s lin. as per paragraph 4.4; by manual control, move the on-load tap-changer towards "Raise" (arrow in the display right "-->") by one step, the presignal LED lamp for "Lower" (arrow in the display left "-->") must come on. Set the mode of operation to "AUTO"; 20 s after the presignal lamp lights up, the voltage regulator must control the on-load tap-changer back to its previous service position. The presignal LED lamp goes out. Set the mode of operation to "MANUAL". Repeat the control procedure towards "Lower".

Set the operating delay time T2 to 10 s. Set the mode of operation to "MANUAL". By manual control, move the on-load tap-changer towards "Raise" by two steps, the pre-signal LED lamp for "Lower" must come on.

Set the mode of operation to "AUTO", then 20 s after the presignal lamp has come on, the voltage regulator must automatically control the on-load tap-changer back to its previous service position by one step and after further 10 s by another step.

Set the delay times T1 and T2 to the desired value. If T2 is not utilized, the "OFF" setting will be required.

When putting the transformer into service, it is recommended to set the delay time T1 provisionally to 100 s. Depending on the existing operating conditions, you may want to determine the definitive setting only after some time of observation. For this purpose it is recommended to register the variation of the actual voltage and the number of tap change operations on a day-to-day basis. If an inverse response of the voltage regulator is desired, set an integral time response for the delay time 1. In this case the delay time is automatically shortened inversely proportional to the deviation.

## 5 Commissioning

- k) Set the response threshold for undervoltage blocking  $U <$  to 85 %. Set the mode of operation to "MANUAL" and set the existing voltage level, e. g. 110 V, to  $110 \text{ V} / 0.85 \approx 130 \text{ V}$ , so that the actual voltage now corresponds to the set percentage of the response threshold for the blocking value. The presignal LED lamp for "Raise" must light up. Set the mode of operation switch to "AUTO". After approx. 10 s the signalling relay "U <" must be energized, the signalling contact (Contacts 17/18/19) will open; the output relay "Raise" must **not** issue a control command. LED U < will now respond. Upon completion of this function test you may now set the desired response threshold for undervoltage blocking.
- l) Set the response threshold for overvoltage detection  $U >$  to 115 %. Set the mode of operation to "MANUAL", e. g.  $110 \text{ V} / 1.15 \approx 95 \text{ V}$  so that the actual voltage now corresponds to the set percentage of the response threshold for overvoltage detection. The presignal LED lamp for "Lower" must light up. Set the mode of operation to "AUTO".  
The output relay "Lower" must issue periodic control commands at 1.5 s intervals. The group signalling contact 17/18/19 will close/open. LED U > will now respond. Now set the desired response threshold for overvoltage detection to the initially desired voltage level.
- m) Set the response threshold for overcurrent blocking  $I >$ .  
A function check is not necessary.
- n) Setting the load drop LDC (as per paragraph 4.10.1). Set the mode of operation to "MANUAL".  
Settings for  $U_x = U_r = 0$ , no presignal LED lamp for Raise/Lower must light up.  
Setting of  $U_r = 20 \text{ V}$ ,  $U_x = 0 \text{ V}$ , the presignal LED lamp for "Raise" must light up.  
Setting of  $U_r = -20 \text{ V}$ ,  $U_x = 0 \text{ V}$ , the presignal LED lamp for "Lower" must light up (during this function check a minimum load current of 5 % of the rated current of the current transformer must flow.)  
If the presignals appear in opposite direction, change the polarity of the current transformer.  
The actually desired LDC can be set upon completion of the above settings.  
Set the mode of operation to AUTO.  
Check if the setting is correct by observing the voltage at the line end during service and with different loads. When the setting is correct the voltage at the line end will remain constant.
- o) Setting of Z Compensation (as per paragraph 4.10.2) as an alternative to LDC.  
Set the mode of operation to MANUAL.  
Set the voltage rise to 0, the voltage regulator is in a balanced state, no presignal LED lamp must light up.  
Set the voltage rise to 15 %, the presignal LED lamp for "Raise" must light up (during this functional check a load current of 10 % of the rated current of the current transformer must flow).  
The desired values for Z Compensation can be set upon completion of the above settings.  
Set the mode of operation to AUTO. Check if the setting is correct by observing the voltage at a specific point in the line and with different loads. When the setting is correct the voltage at the line end will remain constant.
- p) Set the DESIRED VOLTAGE LEVEL 2 to the desired value (refer to paragraph 4.9). Set the mode of operation to MANUAL and connect L+ to terminal 13. According to the set value for Desired Voltage Level 2, the presignal "Lower" or "Raise" must respond.  
Please proceed in the same manner for DESIRED VOLTAGE LEVEL 3 by connecting L+ to terminal 14 signalling relay for DESIRED VOLTAGE LEVEL 3. Set the mode of operation to AUTO.

### 5.5 Manual control of the on-load tap-changer

The manual control of the on-load tap-changer is possible if the buttons "hand" and lower resp. raise or direction "raise" resp. "lower" are pushed at same time.

### 6 Parallel operation without system topology (Option)

#### Parallel operation

The TAPCON® 230 permits controlled parallel operation of 8 transformers maximum, either in a busbar arrangement or in two groups.

Parallel operation management is achieved via the CAN bus.

Activation of parallel operation is achieved via the status inputs, the terminals 41, 42 and 43. This way it can be determined in which group the associated transformer engaged in parallel operation is contained.

Parallel control is possible in two different ways:

Parallel operation according to the principle of „minimum circulating reactive current“

or

Parallel operation according to the principle of tap-change synchronicity (Master-Follower).

Selection of the desired parallel operation principle is effected via a menu point.

```
SELECT PARALLEL
CIRCUL. REAC. CURR.
CRC/MAST/FOLLOW
19/30
```

Select the menu point by operating the SELECT key and the keys and set the desired parallel operation principle by pressing the SET and function keys.

Connect the paralleling voltage regulators via the CAN bus interface in both cases (**fig. 7**). The voltage regulators engaged in parallel operation will signal the status at the terminals 38/39/40.

#### Menu → Standard → **CAN Address**

To permit regulator communication via CAN bus, each individual regulator needs a separate identifier.

Assign a number between 1 and 8 as address to each regulator by pressing the SET key and function keys.

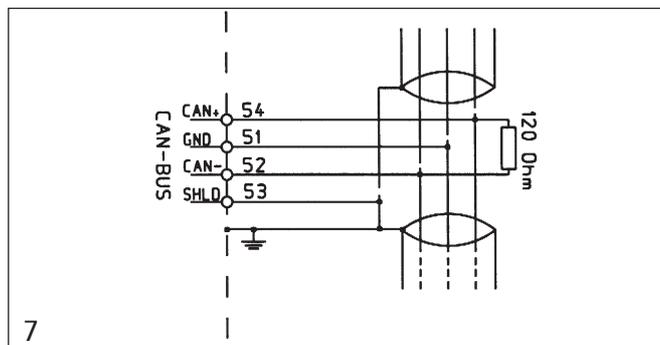
No parallel operation will be possible if the address is at zero (condition at the time of delivery).

```
CAN ADDRESS
0
(1 - 8)
25/30
```



#### NOTE

Please bear in mind that the CAN bus must be connected with a 120 ohm resistor at both ends (at the first and last regulator). The resistor is included in the scope of delivery.



Simultaneously press the „Higher“ key (arrow showing up) and the „Lower“ key (arrow showing down) in the measured-value display screen to change over into a display screen showing which of the devices are running in parallel in what group. Here is also where the CAN addresses of the voltage regulators are listed for each group.

Example: In the first group, the voltage regulators are running in parallel with the CAN addresses 1, 3, 5 and 6, whereas in the second group they are running in parallel with the CAN addresses 2 and 4.

```
GROUP 1
1, 2, 3, 5, 6
GROUP 2
2, 4
```

Example: In the first group, the voltage regulators are running in parallel with the CAN addresses 1, 2, 3, 4, 5, 6, 7 and 8. The second group is not being used.

```
GROUP 1
1, 2, 3, 4, 5, 6, 7, 8
GROUP 2
```

Example:

In the first group, the voltage regulators are running in parallel with the CAN addresses 1, 3, 5 and 6, whereas in the second group they are running in parallel with the CAN addresses 2 and 4. For one of the regulators, both group inputs have been activated. It can therefore be taken as a given fact that both busbars are connected together.

```
GROUP (1+2)
1, 2, 3, 4, 5, 6, 2, 4
```

If a voltage regulator is running individually while receiving the data of other voltage regulators, the voltage regulators engaged in parallel operation will be displayed as well.

If the voltage regulator is separated from the CAN bus while one parallel input is active, only the dedicated CAN address will be displayed in the group.

## 6 Parallel operation without system topology (Option)

Example:

If the CAN bus is disconnected, a "CAN BUS ERROR" will be displayed in the status line.

```
GROUP 1
1
GROUP 2
```

No voltage regulator will be displayed in the group either during individual operation with disconnected CAN bus or in the absence of Can telegrams during individual operation.

```
GROUP 1
GROUP 2
```

### 6.1 Parallel operation with "Minimum Circulating Reactive Current Method"

The circulating reactive current is computed from the transformer currents and their respective phase angles. For correction of the measuring circuit voltage, a voltage proportional to the circulating reactive current is applied to self-sufficiently operating regulators. This correction voltage can be either decreased or increased through adjustment of the "stability" (see paragraph 6.1.3).

If an inadmissibly high circulating reactive current is detected, all on-load tap-changers involved will be reset after only 10 s, regardless of the delay time preset at the regulator.

This method is suitable for transformers of comparable output and  $u_k$ , whether with uniform or with non-uniform step voltage. No information on tap position is required.

#### 6.1.1 System configuration, settings

Feed the additional connections/terminals to the regulators (see **fig. 8**).

#### 6.1.2 Setting the interference variable (CIRCUL. REAC. CURR. STABILITY)

```
CIRCUL. REAC. CURR.
STABILITY
0.0
(0.0- 100.0) 23/30
```

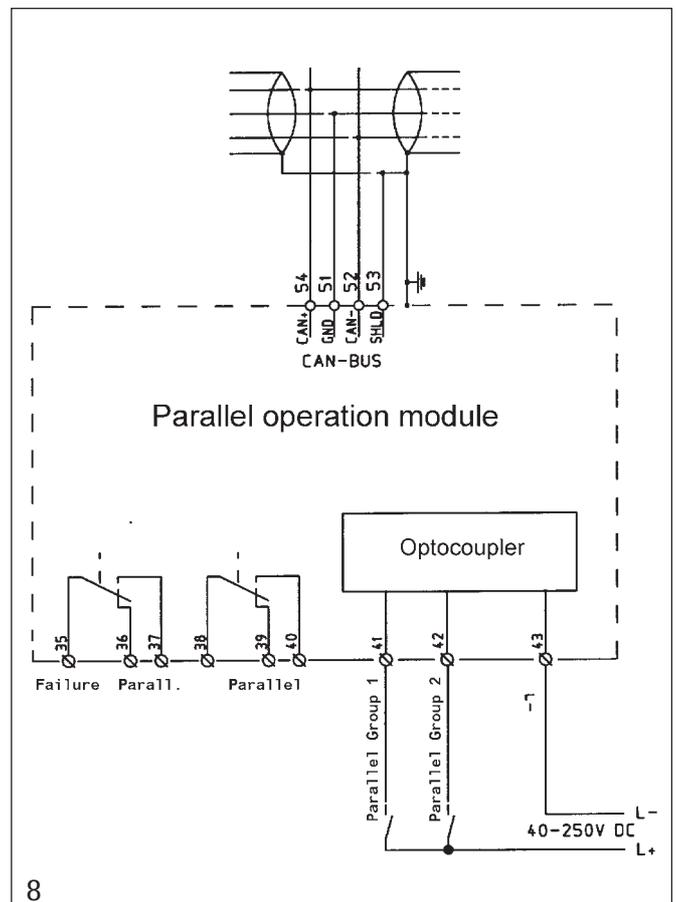
Operate the SELECT key and the   keys to select the menu point and press the SET and   function keys to set a stability value between 0 and 100. The stability value is a measure used for determining the effect of the circulating reactive current on the voltage regulator. If it is set to „0“,

no effects will occur. For a circulating reactive current equal to the rated current of the voltage transformer, a setting value of 10 would result in a voltage correction of 10 % in the voltage regulators.

#### 6.1.3 Setting the bandwidth for circulating reactive current (blocking threshold)

```
CIRCUL. REAC. CURR.
BANDWIDTH
20%
(0.5% - 20.0%) 24/30
```

Operate the SELECT key and the   keys to select the menu point and press the SET and   function keys to set the bandwidth from 0.5 to 20 % (in relation to the rated current of the voltage transformer). If the circulating reactive current exceeds the preset threshold value during parallel operation, the message „circulating reactive current“ will be displayed in the status line and after a period of 30 s the signalling relay contact (terminal 35/36/37) will respond. All voltage regulators engaged in parallel operation will be blocked.



### 6.1.4 Function tests, commissioning

#### 6.1.4.1 Preliminary settings



#### NOTE

The prerequisite for the proper functioning of parallel operation is the commissioning of the voltage regulators for individual operation.

The current transformer inputs must be connected and the transformer configuration must be parameterised correctly. The voltage regulators must be set to identical operating parameters for the desired voltage, bandwidth, time delay 1, and line compensation, if applicable (LDC or Z Compensation, respectively).

In all cases, set STABILITY to "0" and Blocking to "20".

During parallel operation, time delay 2 must never be set below 8 s!

All settings must be performed in the "Manual" operating mode.

#### 6.1.4.2 Setting the interference variable (CIRCUL. REAC. CURR. STABILITY)

Individually set both transformers to identical voltage with the on-load tap-changers so that both voltage regulators are in a balanced state (no presignal LED are lighting up, the indication of "dU %" must be as low as possible, i. e. lower than the preset bandwidth "dU max").

Now switch the transformers to parallel operation and enable parallel control (close contact at terminals 41 and 42, respectively).

The voltage regulators must continue to remain in a balanced state, the LED lamp "parallel operation" on the front panel is lighting up.

Raise one of the two transformers by one voltage step and lower the other of the two transformers by one voltage step. Both regulators must continue to remain in a balanced state.

Raise the setting value "CIRC.REAC.CURR.STABILITY" of both regulators in small steps starting with "0" until the corresponding presignals appear (the regulator of the transformer with the higher voltage step must show the tendency "lower" while the other transformer must show the tendency "raise"). Now add the setting values thus established and set the added-up value for both regulators.

Select the "Auto" operating mode for both voltage regulators. Both voltage regulators must control the on-load tap-changers back into their previous service positions. The presignals will go out.

If the previous service position cannot be achieved that way, the "CIRC.REAC.CURR. STABILITY" setting needs to be increased. If the on-load tap-changers are regulating out of sync ("pumping"), this setting needs to be reduced.

#### 6.1.4.3 Setting the circulating reactive current monitoring (CIRCUL. REAC. CURR. MON. BANDWIDTH)

Switch over one of the two voltage regulators to the "Manual" operating mode. Using the manual control, the associated motor drive must now be reset to "Raise" by the maximum admissible difference of the service positions between the parallel operating transformers (e. g. by 1 ... 2 steps).

Starting with the preset value of "20 %", reset the blocking towards a lower value in small steps until the message "Circulating reactive current" appears in the status line of the display (please wait 2 – 3 s between the individual steps).

The bandwidth threshold of the circulating reactive current monitoring is reached as soon as this message appears. The voltage regulators will block all further regulating actions and the signalling relay will respond (terminals 35/36/37). Now reset the blocking again towards a higher value until the message „circulating reactive current" disappears from the status line of the display.

Again switch the voltage regulator back to the "Auto" operating mode. The motor-drive will be automatically controlled back to the original service position.

Use the value established for the "Blocking" threshold to set it for all of the other regulators.

### 6.2 Parallel operation according to synchronized tap-change operation Master/Follower

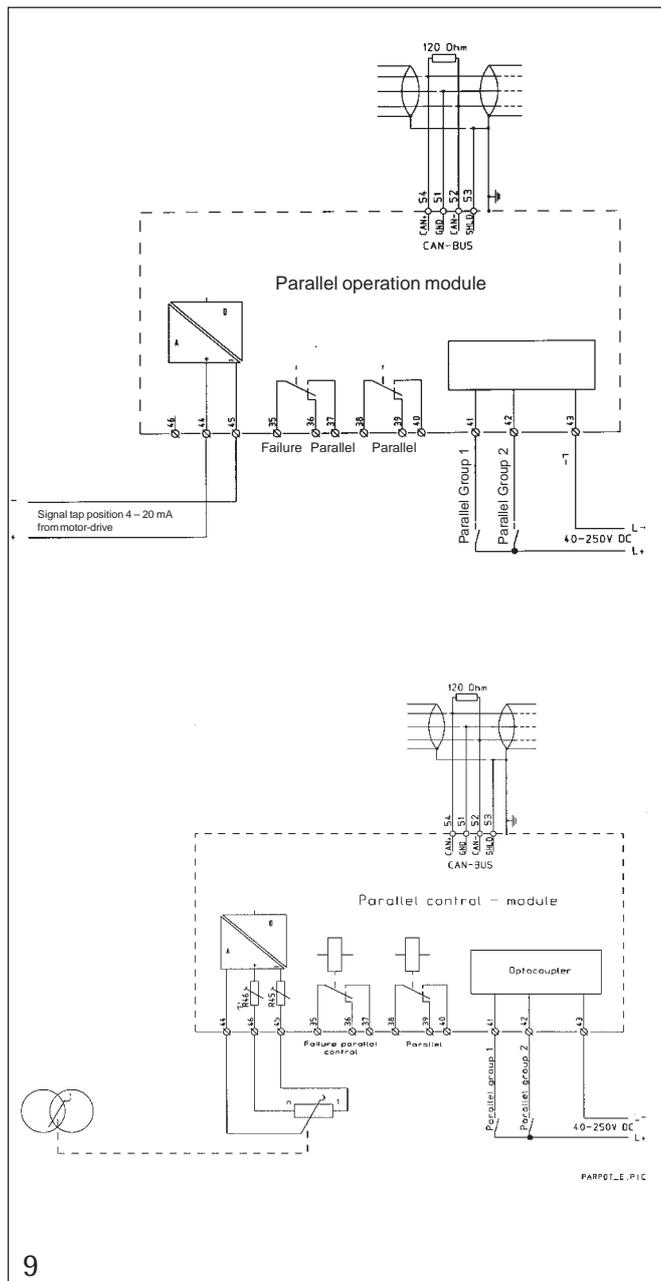
This method is suitable for transformers featuring an identical rated current, identical step voltage, and an identical number of service positions. The motor-drive must signal the tap-change position by means of a current of 4 ... 20 mA (with 4 mA corresponding to the lowest position and 20 mA corresponding to the highest position). Optionally the connection of a potentiometer contact range in the motor-drive is possible in lieu of the injected current.

During parallel operation, actual voltage regulation is performed by one of the voltage regulators (Master function). The second voltage regulator (Follower) receives the tap-change position of the motor-drive from the first regulator, for comparison with the tap-change position of its own motor drive. If a difference is noted, the motor-drive in question will receive a suitable control pulse.

## 6 Parallel operation without system topology (Option)

### 6.2.1 System configuration, settings, transfer of the on-load tap-changer setting

Lead the additional connections/terminals (see **fig. 9**) to the regulators.



**Fig. 9**  
Feed the position signal in the form of a 4 ... 20 mA signal to the regulator at terminals 44-45 (see connection diagram).  
Feed the position signal from the potentiometer range to the terminals 44-45-46 (see connection diagram).

#### 6.2.1.1 Setting the tapping position range

POS MIN	0
(-35 - 35)	20/30

POS MAX	35
(-35 - 35)	21/30

Operate the SELECT key and the keys to select the menu point and set the respective lowest/highest tap positions between -35 and +35 by pressing the SET and keys. To perform a function check, set the deactivated transformer for all positions of the entire tap position range while checking the position indicator.

TAPPING DIRECTION	NEGATIVE
POSITIVE / NEGATIVE	22/30

Since a comparison of the tap positions of the transformers jointly engaged in parallel operation is performed during parallel operation in accordance with the principle of tap-change synchronicity (Master-Follower), it is imperative to maintain identical position designations for all of these transformers, and to ensure that the „higher“ and „lower“ signals will effect identical voltage changes in all the transformers.

If this is not the case, e. g. if the „Higher“ command (higher voltage) is not equal to a higher position, it is also possible to „turn the tap direction“ within the voltage regulator.

This function is activated/deactivated through operation of the SELECT key and the function keys.

When using a potentiometer contact range (see section 4.11), it is advisable to first calibrate the top and bottom operating positions, if needed. To that end, start by indicating the bottom (POS MIN) and top (POS MAX) operating positions via the parameter screens 20 and/or 21, as outlined above.

Then proceed to calibrate the operating positions as follows:

- Establish the connections in accordance with the corresponding attached connection diagram.
- Move the OLTC into the operating position "2".
- Set the R45 trimming resistor at the TAPCON® 230 so that the operating position "2" will appear in the TAPCON® 230's display.
- Move the OLTC to the operating position „n<sub>max</sub>-1" (e. g. to the operating position "32" out of a total of 33 possible OLTC operating positions).
- Set the R46 trimming resistor at the TAPCON® 230 so that the operating position "n<sub>max</sub>-1" will appear in the TAPCON® 230's display.
- Since the trimming resistor settings are capable of mutually influencing each other, the entire process should be double-checked for safety reasons by repeatedly making the OLTC approach the operating position "2" and checking the TAPCON® 230's display. Should it turn out that another calibration procedure is necessary, it is also advisable to recheck the operating position "n<sub>max</sub>-1" and to recalibrate it, if needed.



### NOTE

The trimming resistor R45 is located directly behind terminal 45 of the TAPCON® 230, whereas the trimming resistor R46 is located directly behind terminal 46, as shown on pages 30 and 31. Setting/trimming is done using the adjusting screws located on the visible side of the trimming resistor housing. Please note that due to TAPCON® 230's measuring-cycle time being fixed, the trimming resistors should be operated slowly to allow for an update of the current operating position on the TAPCON® 230's display.

### 6.2.1.2 Selecting the Master/Follower operation

```
SELECT PARALLEL
CIRCUL. REAC. CURR.
CRC/MAST/FOLLOW
19/30
```

Operate the SELECT key and the   keys to select the menu point and assign the respective regulator as a Master or a Follower by pressing the SET and   keys.

If both regulators were assigned as „Follower" or „Master" during parallel operation, the regulators will be blocked (see section 6.3 – Disturbances during parallel operation).

### 6.2.2 Function tests, commissioning and preliminary settings



### NOTE

The prerequisite for the proper functioning of parallel operation is the commissioning of the voltage regulators for individual operation.

The voltage regulators must be set to identical operating parameters for the desired voltage, bandwidth, time delay 1, and line compensation, if applicable.

The tap position indication at the regulators must function correctly.

Select the "MANUAL" operating mode at the voltage regulators.

Individually set all on-load tap-changers involved in parallel operation to identical voltage so that the voltage regulators are in a balanced state (no presignal appearing on the display).

Now switch the transformers to parallel operation and close the contacts at terminals 41 and 42, respectively. The voltage regulators must continue to remain in a balanced state and the LED lamps "Parallel" at the regulators must respond.

Switch the Follower voltage regulator to the "AUTO" operating mode.

Use the manual control to raise the MASTER regulating unit engaged in the "MANUAL" operating mode by one step; the follower regulator now has to automatically drag along the associated transformer to do the same.

During the short period while a tap position difference is present, the message "TAP DIFFERENCE" will appear in the status line of the display. If a follower regulator fails to drag along its associated transformer, regulating action will be blocked and a signalling relay will respond (terminals 35/36/37).

## 6 Parallel operation without system topology (Option)

### 6.3 Parallel operation with an existing parallel control unit SKB 30 to the principle of „minimum circulating reactive current“

In case of an extension of a plant, it is possible to add optional a communication module instead of the CAN-bus module on factory site in the voltage regulator TAPCON® 230 to work with an existing parallel control unit SKB 30. The wiring has to be done according to the schematics 71481900 resp. 71482000 (see appendix). The setting for parallel control has to be done according to operating instruction BA 117 on the parallel control unit SKB 30.



#### NOTE

If the communication module to SKB 30 is added, the parameters for parallel control are shown in the menus 19 ... 25 of the TAPCON® 230. Changes of the parameters made here are however without effect.

### 6.4 Disturbances during parallel operation

During parallel operation the following messages will be displayed in the status line:

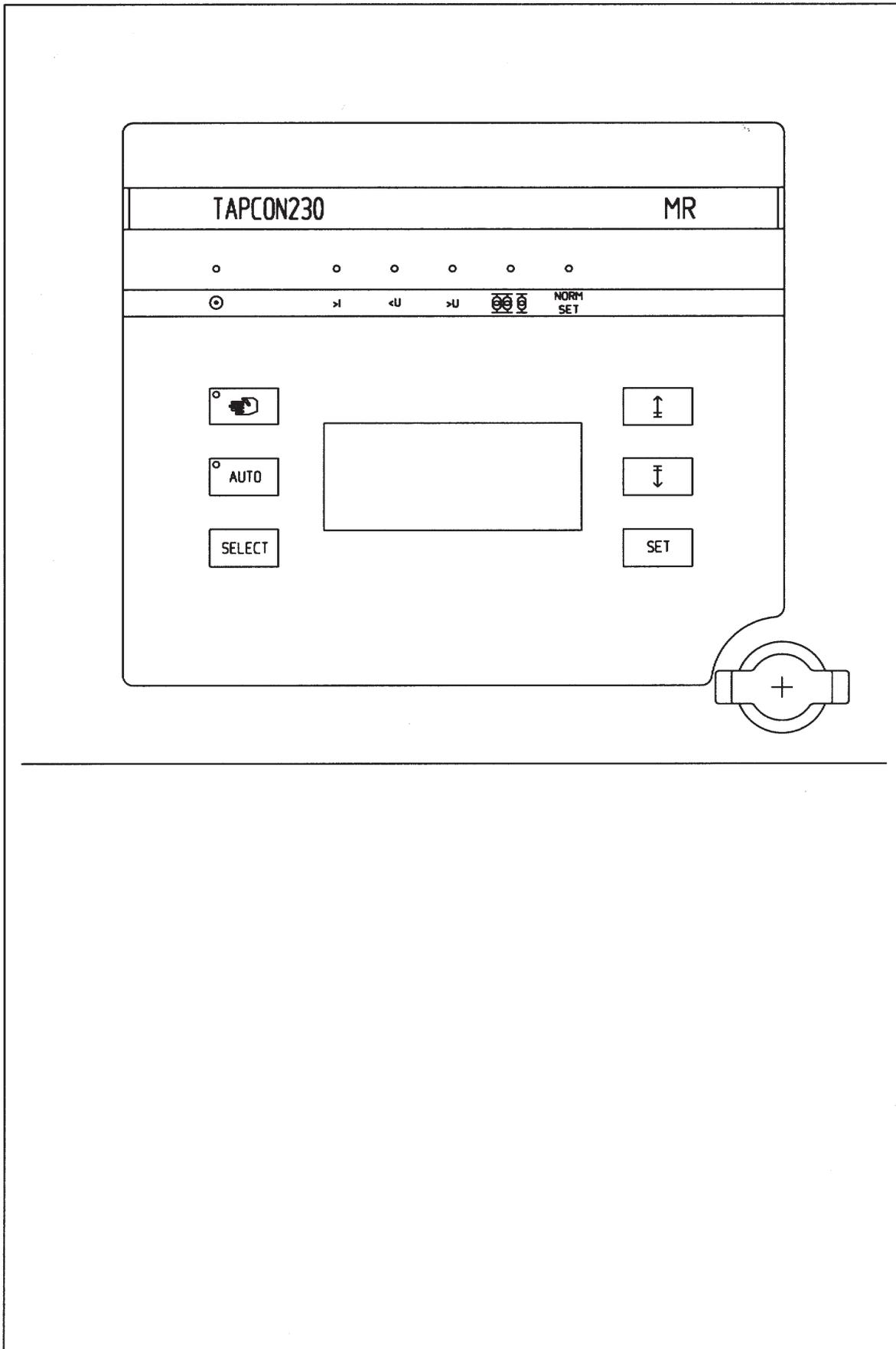
Message	Cause
CIRCULATING REACTIVE CURRENT	Circulat. reactive current was exceeded
TAP DIFFERENCE	Synchronism disturbance (tap difference $\leq 2$ steps)
>1 MASTER	More than one Master was selected
NO MASTER	No Master was selected
NO POSITION	Failure of position indication
DIFF. METHOD	Different methods of parallel operation were selected
DATA TRANSFER	Data transfer between the regulators was interrupted
CAN ADDRESS ERROR	Wrong CAN-Address set on the regulator

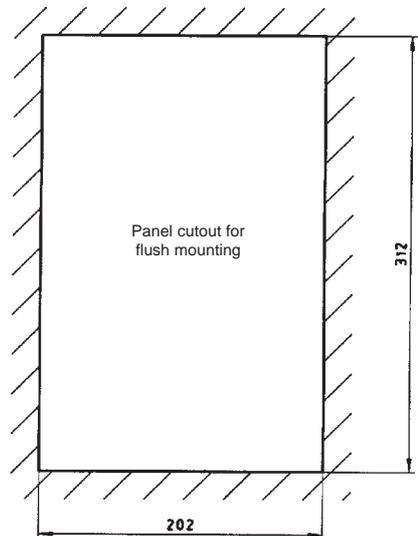
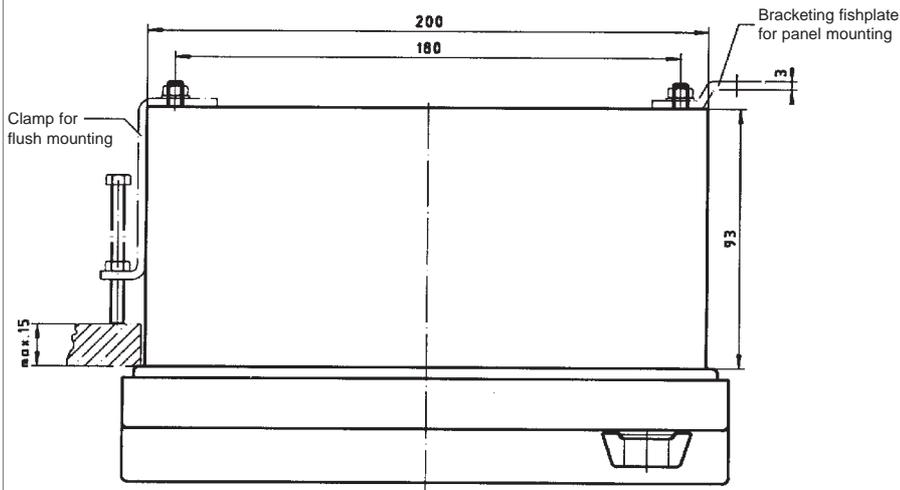
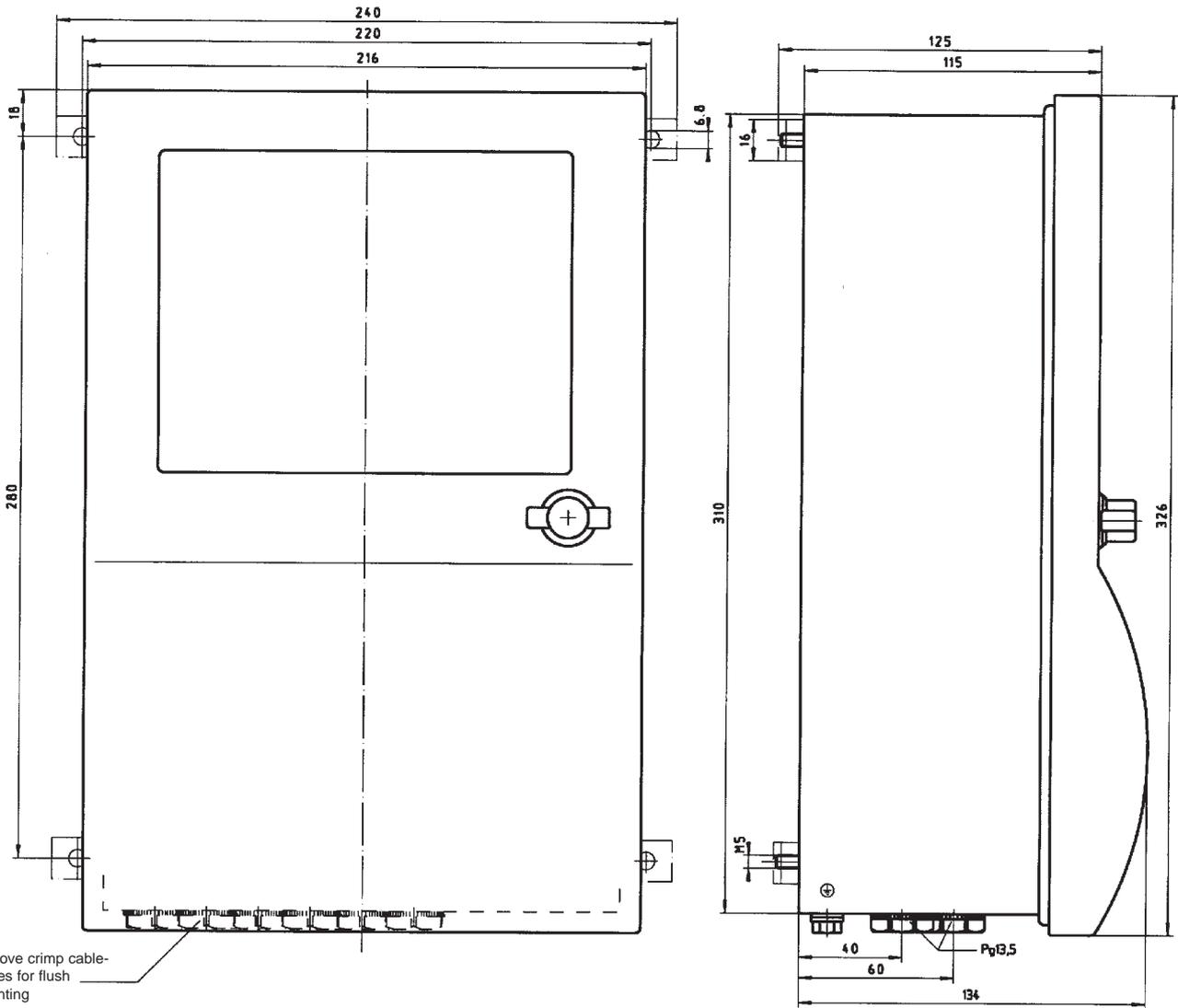
If any of the above disturbances occur, the regulators will be blocked.



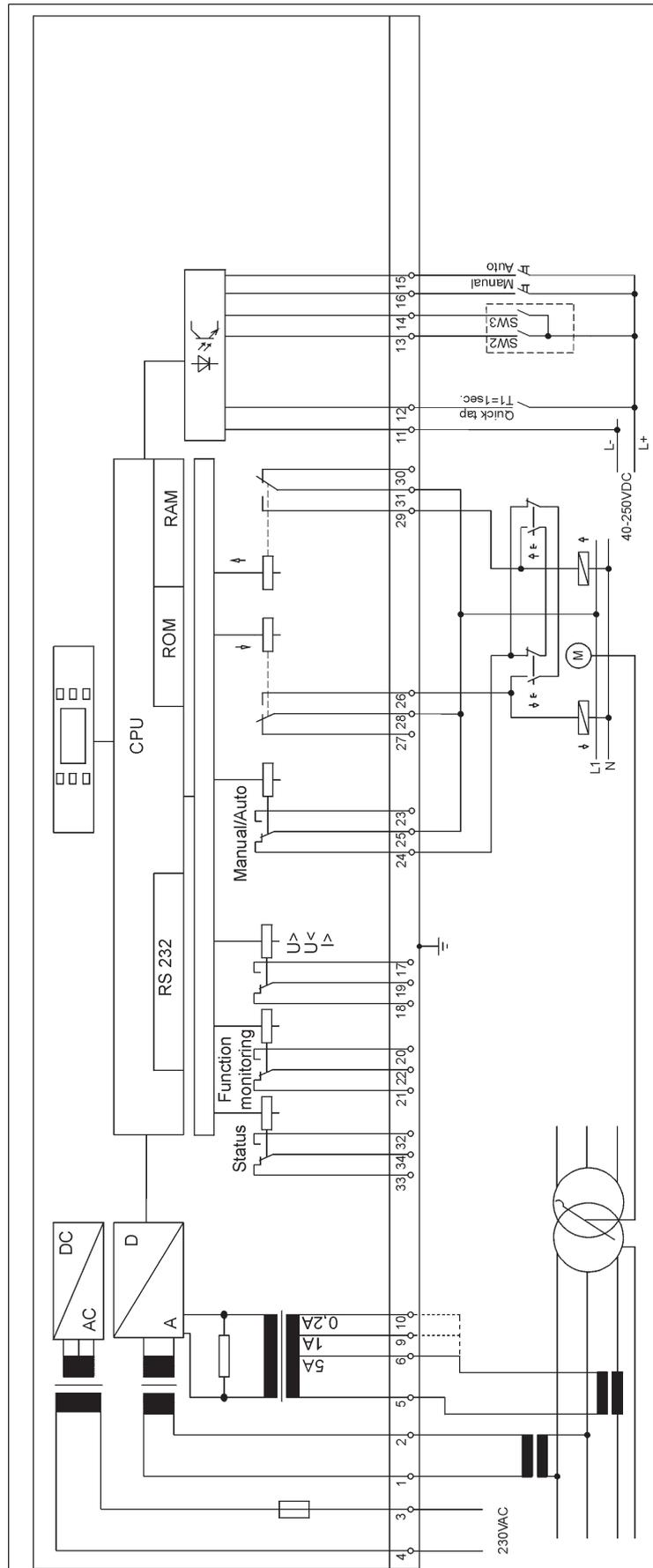
## 7 Appendix

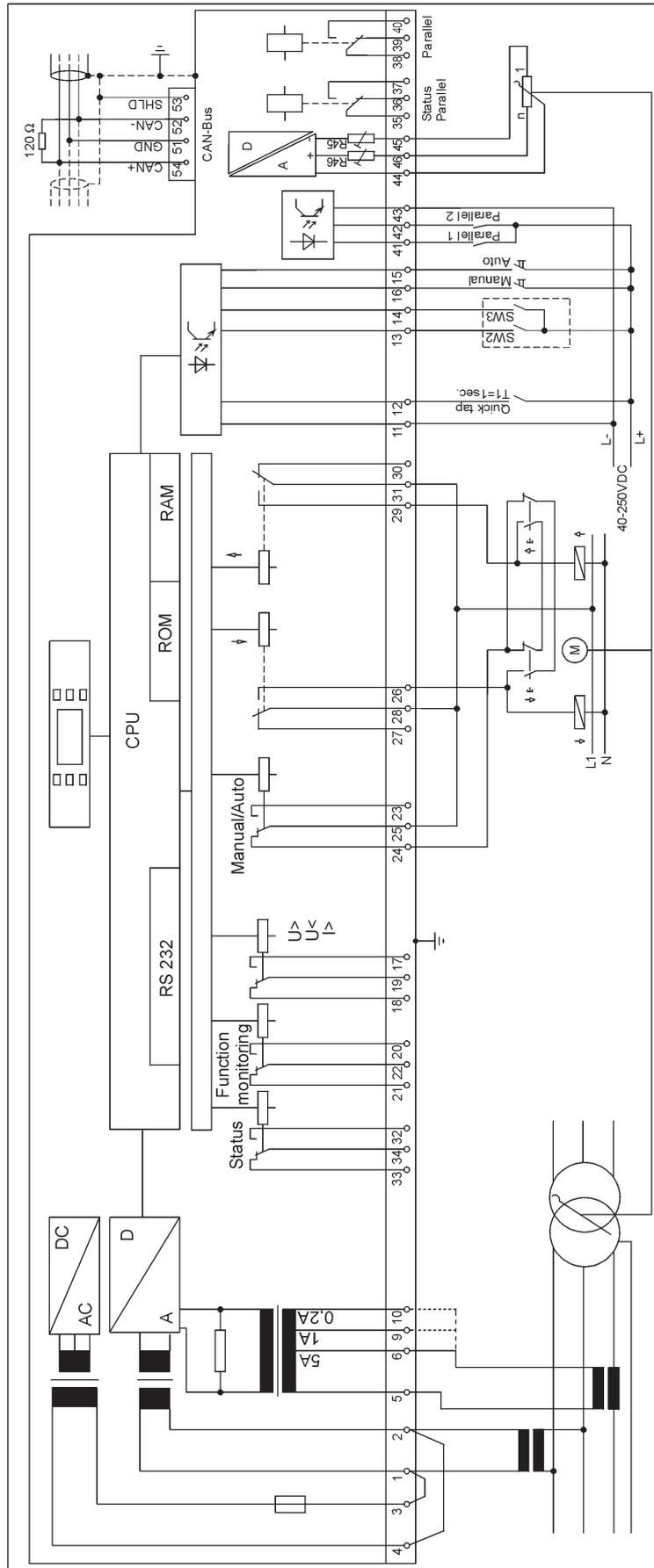
Front view .....	TC230_1
Control panel set-up and mounting .....	899564
Block/connection diagram – standard 115 V .....	TC230_714824xx
Block/connection diagram – Standard 230 V .....	TC230_714823xx
Block/connection diagram, 115 V, parallel operation option; analog input for position indication 0 - x Ohm .....	TC230_714826xx
Block/connection diagram, 230 V, parallel operation option; analog input for position indication 0 - x Ohm .....	TC230_714825xx
Block/connection diagram, 115 V, parallel operation option; analog input for position indication 4 - 20 mA .....	TC230_714828xx
Block/connection diagram, 230 V, parallel operation option; analog input for position indication 4 - 20 mA .....	TC230_714827xx
Block/connection diagram, 115 V, parallel operation option with SKB 30 .....	TC230_714830xx
Block/connection diagram, 230 V, parallel operation option with SKB 30 .....	TC230_714829xx
Block/connection diagram, connection example for motor-drive ED, 230 V / 400 V .....	TC230_Connect.

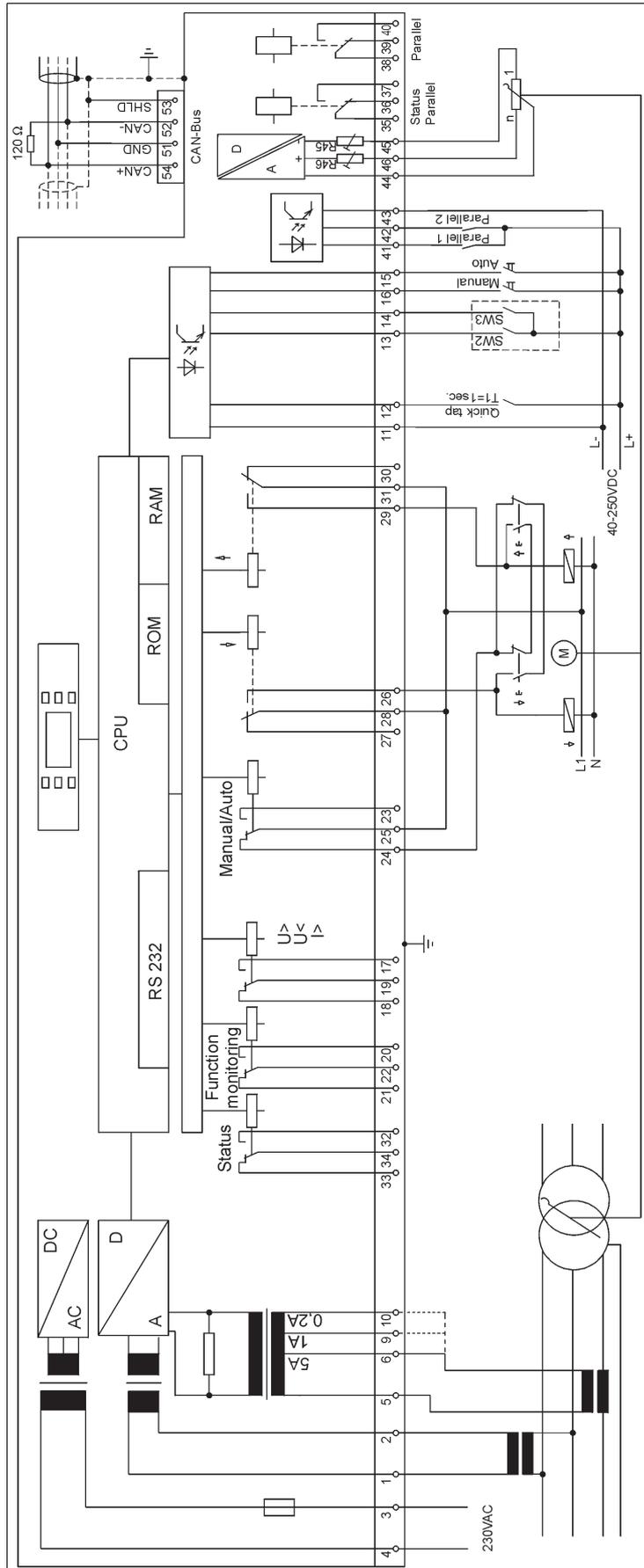


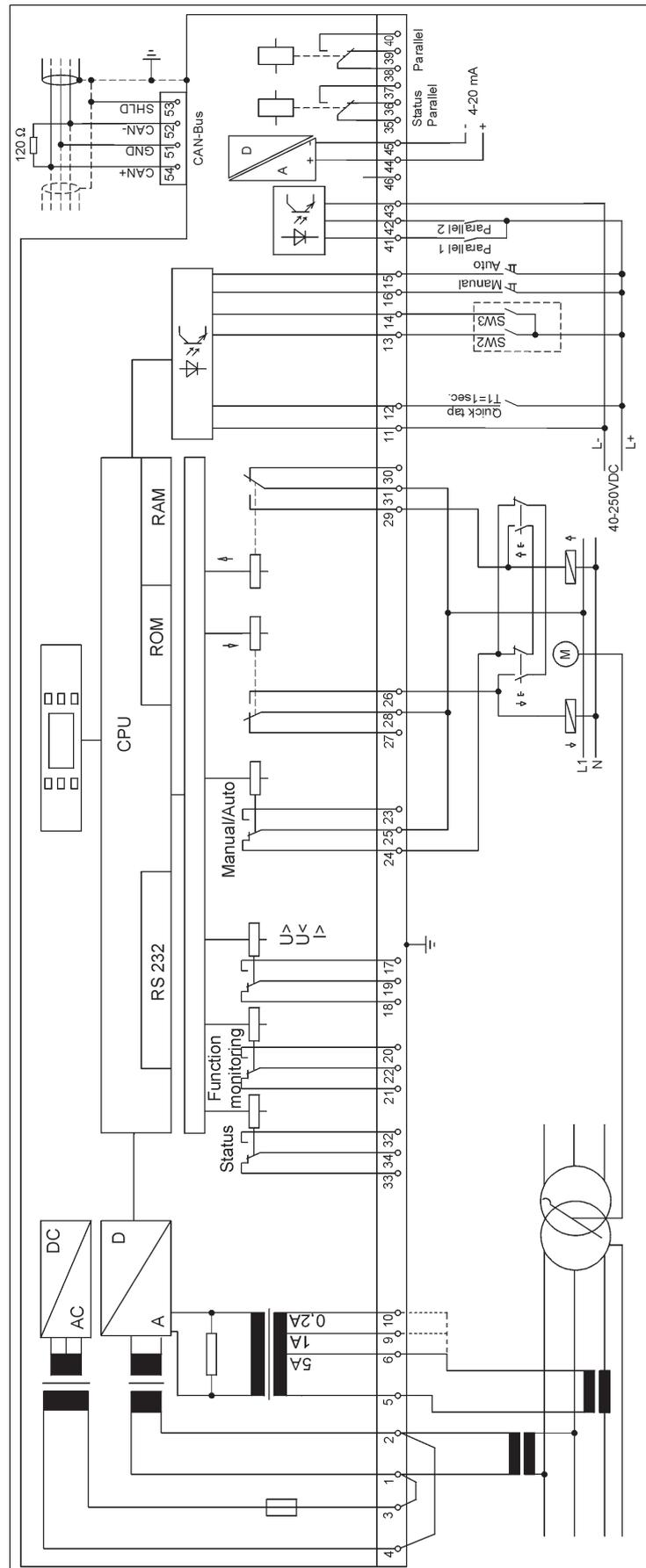


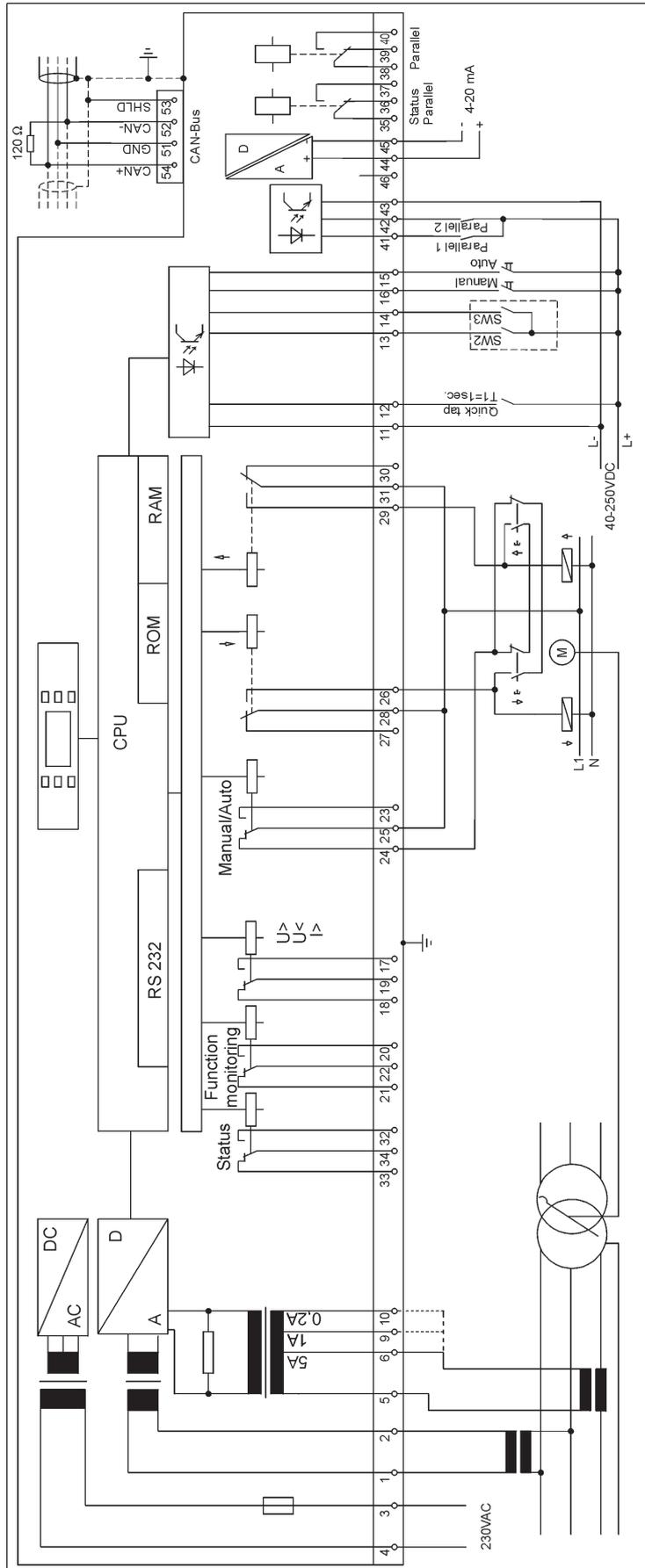




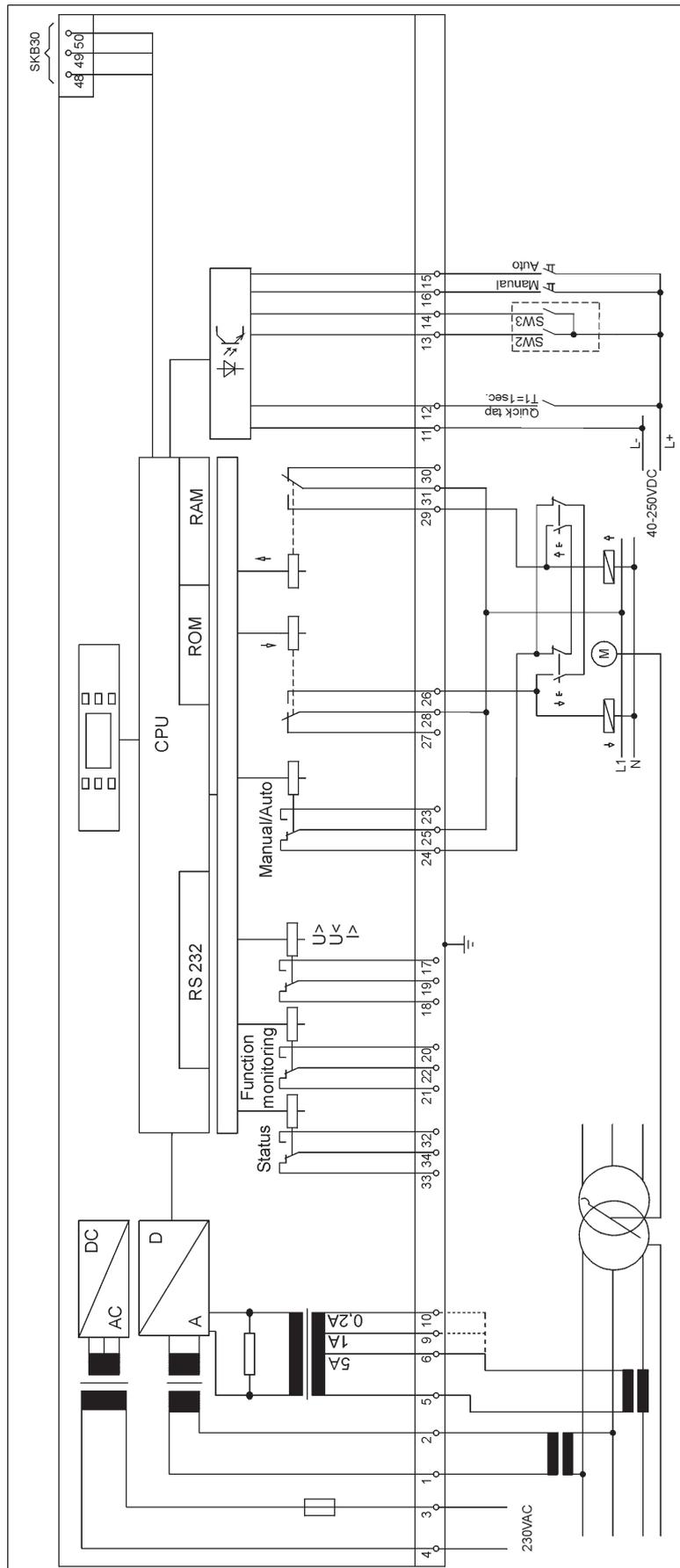


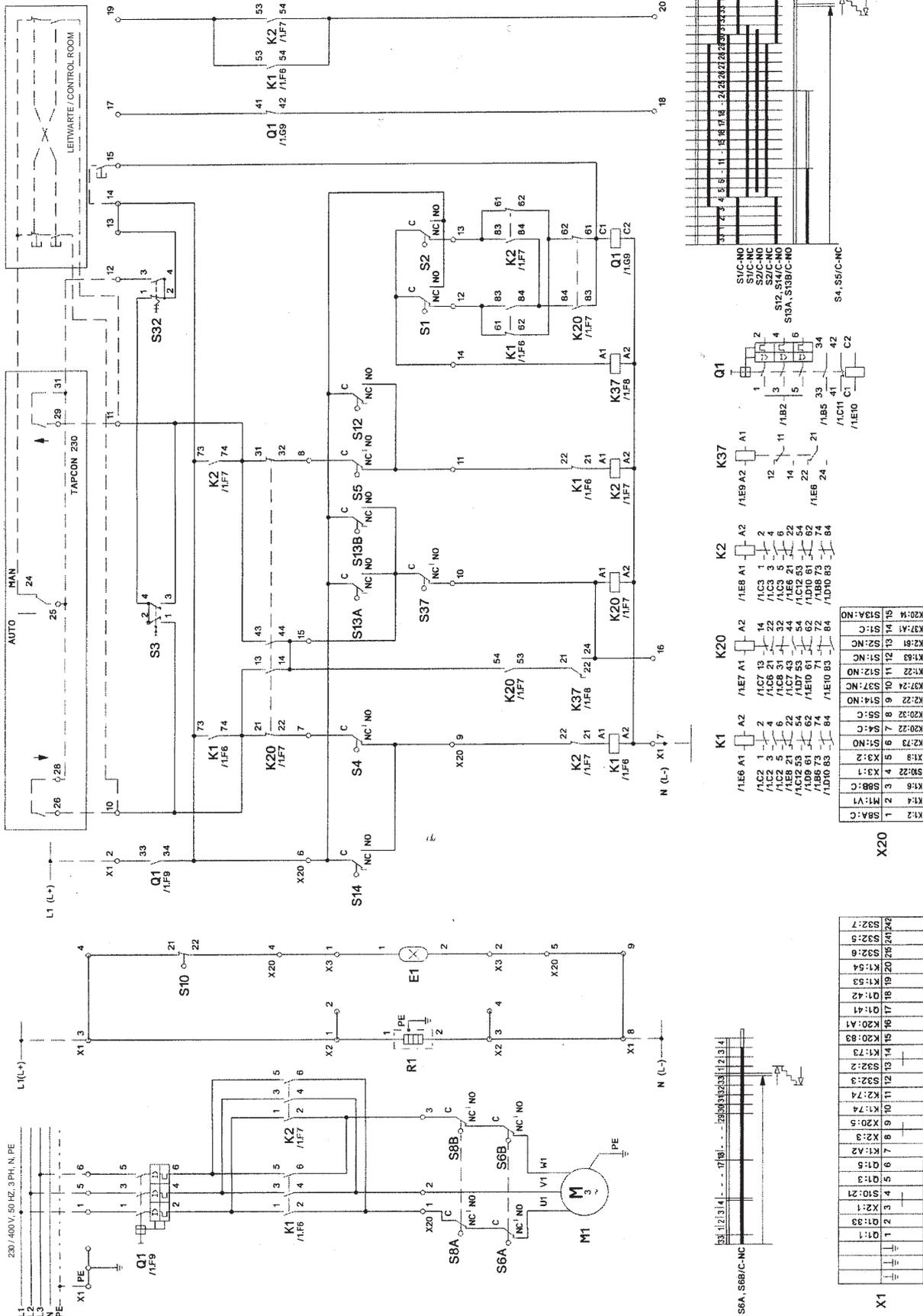






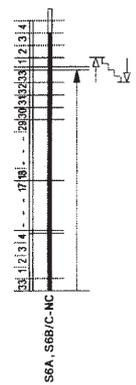






**X1**

1	Q1
2	Q1
3	Q1
4	Q1
5	Q1
6	Q1
7	Q1
8	Q1
9	Q1
10	Q1
11	Q1
12	Q1
13	Q1
14	Q1
15	Q1
16	Q1
17	Q1
18	Q1
19	Q1
20	Q1
21	Q1
22	Q1
23	Q1
24	Q1
25	Q1
26	Q1
27	Q1
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43	Q1
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47	Q1
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85	Q1
86	Q1
87	Q1
88	Q1
89	Q1
90	Q1
91	Q1
92	Q1
93	Q1
94	Q1
95	Q1
96	Q1
97	Q1
98	Q1
99	Q1
100	Q1



**X20**

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5	K1
6	K1
7	K1
8	K1
9	K1
10	K1
11	K1
12	K1
13	K1
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97	K1
98	K1
99	K1
100	K1

