

Voltage Regulator TAPCON® 230 AVT

Installation and commissioning instructions



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We expressly reserve the right to make changes to the technical data, the design or the scope of delivery.

The information provided and the arrangements agreed during processing of the relevant quotations and orders are strictly binding.

The original operating instructions were drawn up in German.



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1 Introduction

This technical file contains important information for the safe and correct packaging, transport, storage, mounting and commissioning of the product.

It also includes safety instructions and general information about the product.

This technical file is intended solely for specially trained and authorized personnel.

1.1 Manufacturer

The voltage regulator is manufactured by:

Maschinenfabrik Reinhausen GmbH

Falkensteinstrasse 8

93059 Regensburg, Germany

Tel.: (+49) 9 41/40 90-0

Fax: (+49) 9 41/40 90-70 01

E-mail: sales@reinhausen.com

Further information on the voltage regulator and copies of this technical file are available from this address or on our website at www.tapcon230.com if required.

1.2 Subject to change without notice

The information contained in this technical file comprises the technical specifications released at the time of printing. Significant modifications will be included in a new edition of the user manual. The document and version numbers for this manual are shown in the footer.

1.3 Completeness

This technical file is incomplete without the supporting documents.



1.4 **Supporting documents**

The quick reference guide, the operating instructions and the accompanying connection diagrams also apply in addition to this technical file. All documents are part of the scope of delivery.

In addition, generally applicable statutory and other binding regulations in European and national legislation and the regulations for accident prevention and environmental protection in force in the country of use must be complied with.

1.5 **Safekeeping**

This technical file and all supporting documents must be kept ready to hand and accessible for future use at all times.

1.6 **Notation conventions**

This section contains an overview of the abbreviations, symbols and textual emphasis used.



1.6.1 Abbreviations used

Abbreviation	Definition
°C	Degrees Celcius
A	Ampere
AC	Alternating Current
B	Bandwidth
a/o	and/or
ca.	circa
CAN	Controller Area Network
CE	Conformité Européene
CI	Communication Interface
COM	Computer Object Model
CPU	Central Processing Unit
i.e.	that is
DC	Direct Current
DIN	Deutsches Institut für Normung (German Institute for Standardization)
DNP	Distributed Network Protocol
EMC	Electromagnetic compatibility
ESC	Escape
EUC	Energy utility company
GPI	General Purpose Input
GPO	General Purpose Output
R/L	Raise / lower
HCS	Hard Clad Silica Optical Fiber
Hz	Hertz
I	Current
IEC	International Electrotechnical Commission
IP	Internet Protocol
kg	Kilogram
kV	Kilovolt
LDC	Line-Drop Compesation
LED	Light Emitting Diode
OF	Fibre-optic cable
max.	maximum
MB	Megabyte
MHz	Megahertz

Table 1 Abbreviations used



Abbreviation	Definition
min.	minimum
MIO	Measurement input/output
mm	Millimetre
MMI	Man Machine Interface
ms	Millisecond
PIO	Parallel input/output
s	Second
SCADA	Supervisory Control and Data Acquisition
T	Time
TCP	Transmission Control Protocol
U	Voltage
e.g.	for example

Table 1 Abbreviations used

1.6.2 Hazard communication system

The warning notices in this technical file are structured as follows:

SIGNAL WORD	
	Danger
	Consequences
	▶ Action
	▶ Action

The following signal words are used:

Signal word	Hazard level	Consequence of failure to comply
Danger	Immediate threat of danger	Death or serious injury could occur
Warning	Possible threat of danger	Death or serious injury could occur
Attention	Possible dangerous situation	Minor or moderate injury may occur
Note	Possible dangerous situation	Material damage

Table 2 Signal words in safety instructions



Symbols are used to warn of dangers:

Symbol	Definition
	Danger
	Dangerous electrical voltage
	Fire hazard
	Danger of tipping

Table 3 Symbols used in warning notices

1.6.3 Information system

Information is designed to simplify and improve understanding of particular operational procedures. In this technical file it is laid out as follows:

	Important information.
---	------------------------



1.6.4 Instruction system

Instructions which consist of only a single process step are structured in this technical file as follows:

Aim of action

- ✓ Requirement (optional)
- ▶ Step 1 of 1
 - ↳ Result of step (optional)

Result of action (optional)

Instructions which consist of several process steps are structured in this technical file as follows:

Aim of action

- ✓ Requirement (optional)
- 1. Step 1
 - ↳ Result of step (optional)

2. Step 2

...

Result of action (optional)

1.6.5 Typographic conventions

The typographic conventions in this technical file are structured as follows:

Typographic conventions	Definition
...>...>...	Step of the procedure for software descriptions in the subsequent menu
UPPERCASE	Key labels e.g. "MENU key"

Table 4 Typographic conventions



2 Safety

2.1 General safety information

This technical file contains important information for the safe and correct packaging, transport, storage, mounting and commissioning of the product.

- Read this technical file through carefully to familiarize yourself with the product.
- Particular attention should be paid to the information given in this chapter.

2.2 Appropriate use

The product and associated equipment and special tools supplied with it comply with the relevant legislation, regulations and standards, particularly health and safety requirements, applicable at the time of delivery.

If used as intended in compliance with the specified requirements and conditions in this technical file as well as the warning notices in this technical file and attached to the product, then the product does not present any hazards for persons, property or the environment. This applies during the entire lifespan, from delivery through installation and operation to disassembly and disposal.

The operational quality assurance system ensures a consistently high quality standard, particularly when it comes to observance of the health and safety requirements.

Use is considered to be appropriate if

- the product is operated according to the agreed delivery conditions and technical data, and
- the associated equipment and special tools supplied with it are used solely for the intended purpose and in accordance with the specifications of this technical file.
- the product is used only for the application specified in the order.

2.3 Inappropriate use

Use is considered to be inappropriate if the product is used other than as described in chapter 2.2.



Maschinenfabrik Reinhausen does not accept liability for damage from unauthorized or inappropriate changes to the product. Unauthorized changes to the product without consultation with Maschinenfabrik Reinhausen can lead to personal injury, material damage and operational faults.

2.4 Personnel qualification

The product is designed solely for use in electrical or energy systems and facilities operated by appropriately trained staff. This staff comprises people who are familiar with the installation, assembly, commissioning and operation of such products.

2.5 Operator duty of care

To prevent accidents, faults and damage as well as unacceptable adverse effects on the environment, those responsible for transport, installation, operation, maintenance and disposal of the product or parts of the product must ensure the following:

- All warning and hazard notices are complied with.
- Personnel are instructed regularly in all relevant aspects of operational safety, this technical file and particularly the safety instructions contained therein.
- Regulations and operating instructions for safe working as well as the relevant instructions for staff procedures in the case of accidents and fires are kept to hand at all times and displayed in the workplace where applicable.
- The product is only used in a sound operational condition and safety equipment in particular is checked regularly for operational reliability.
- Only replacement parts approved by the manufacturer are used.
- Comply with the specified operating conditions and requirements of the installation location.
- All necessary equipment and personal protective equipment for each activity is available.
- The prescribed maintenance intervals and the relevant regulations are complied with.
- Fitting, electrical connection and commissioning of the product may only be carried out by qualified and trained personnel in accordance with this technical file.
- The operator must ensure appropriate use of the product.



3 Product description

3.1 Description of functions

The voltage regulation of transformers with on-load tap-changers is an important subject for energy utility companies.

The completely redesigned voltage regulator handles both simple control tasks and the complex requirements of a modern monitoring and control device.

The TAPCON[®] 230 AVT voltage regulator constantly checks the actual value V_{Actual} (transformer output voltage) against a specified or load-dependent set value V_{Target} , which can be determined by the user.

The TAPCON[®] 230 AVT provides the control pulse for the transformer on-load tap-changer, depending on the deviation of the actual from the set value.

The on-load tap-changer switches if the voltage level falls below or exceeds the specified tolerance band B ($V_{\text{Target}} \pm B\%$). The minimum waiting time between two consecutive tap change operations is 60 s.

The voltage at the transformer is thus kept constant. Fluctuations within the permissible bandwidth have no influence on the control response or the tap change operation.

The voltage regulator parameters can be optimally adjusted to the line voltage behavior, so that a balanced control response with a minimum number of on-load tap changer operations is achieved.

Figure 1 shows an overview of voltage regulation using the TAPCON[®] 230 AVT.

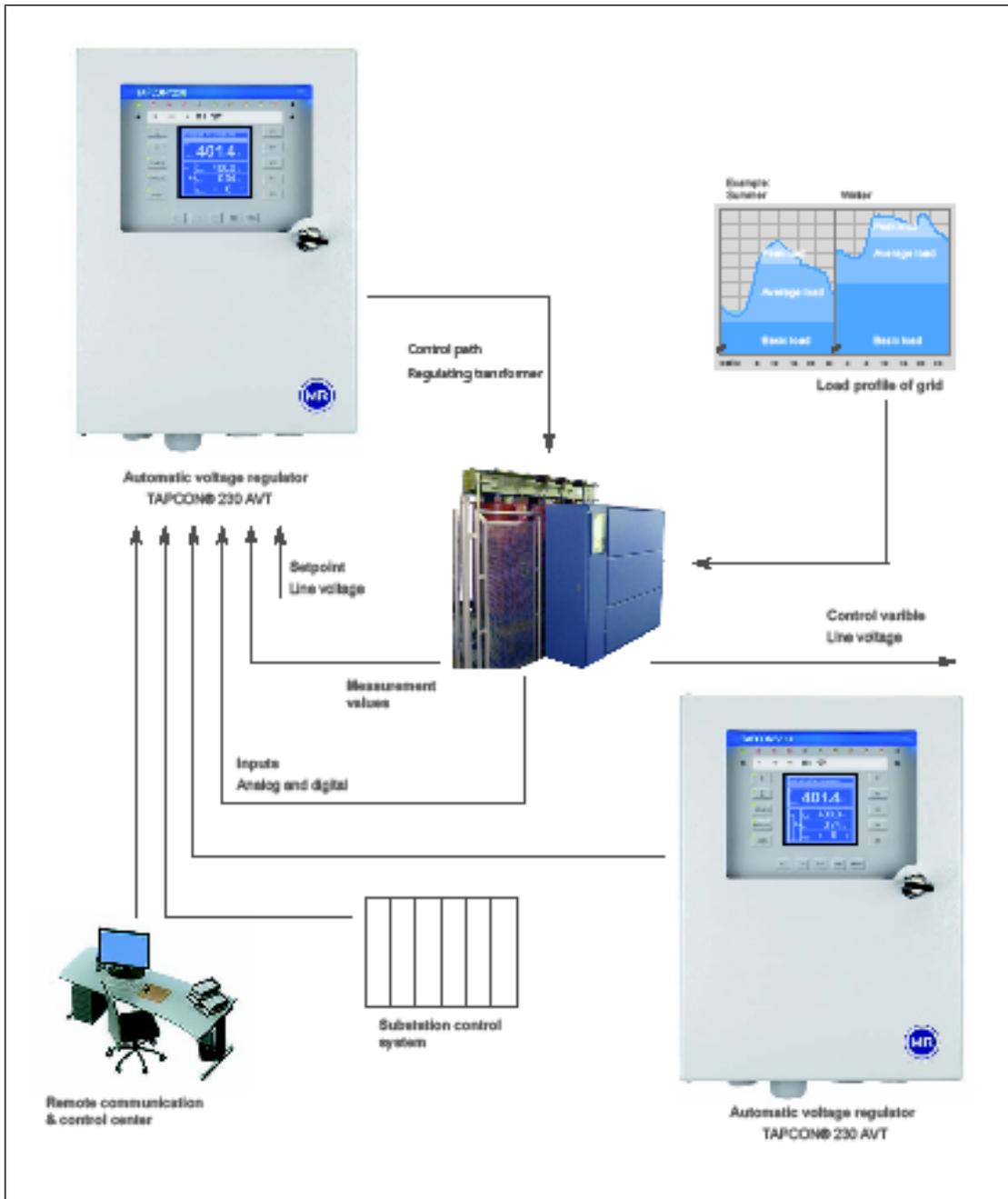


Figure 1 Overview of voltage regulation using the TAPCON® 230 AVT



3.2 Features TAPCON® 230 AVT

The TAPCON® 230 AVT handles the control of step transformers with proven reliability.

Apart from control tasks, the TAPCON® 230 AVT provides additional functions such as:

- Integrated protection functions:
 - Undervoltage and overcurrent blocking
 - Overvoltage detection with high-speed return
 - A defined minimum waiting time between two consecutive tap change operations of 60 s.
- Digital inputs and outputs can be individually programmed on-site by the user
- Additional indicators using LEDs external to the display for freely selectable functions
- Display of all measured values such as voltage, current, active power, apparent power or reactive power, $\cos \varphi$
- Cable connection using modern plug terminals
- Selection of 3 different set values
- Tap position input can be selected on site between
 - analog signal 4 - 20 mA
 - analog signal over resistor contact series
 - digital signal using BCD or Gray code
- Additional digital inputs and outputs which can be freely parameterized by the customer
- Parallel operation of up to 6 transformers in 2 groups using the methods
 - Master / Follower
 - Circulating reactive current minimization

The CAN bus ensures error-free data exchange between all TAPCON® devices with parallel operation over a distance of up to two kilometers.

The regulators automatically detect which transformers are in parallel operation without any supplementary equipment. By activating the binary inputs for Master/Follower/Independent or using the menu settings, the position of a transformer can be quickly selected with certainty.



3 Product description

For particularly demanding requirements the TAPCON® 230 AVT also provides connection to a superordinate control system with protocols as shown in **Table 5**. RS232 and RS485 are standard and freely selectable.

	RS232	RS485	ETHERNET
MODBUS ASCII	X	X	
MODBUS RTU	X	X	X

Table 5 Interfaces available for control system communication



Further information on the TAPCON® 230 AVT is available on our web site at:
www.tapcon230.com



3.3 Scope of delivery

The following items are included in the delivery:

Scope of delivery
Voltage Regulator TAPCON® 230 AVT
Control panel bracket pre-mounted on housing
2 x mounting bracket for wall mounting
Covering strip for door
Allen key, wrench 3
Key for door
Folder with all device documentation
Quick reference guide DIN A6 in pocket in the regulator door
Optional
DIN rail clip

Table 6 Scope of delivery

Please note:

1. Check the delivery for completeness against the dispatch documents.
2. Store components in a dry place before installation.



The functional range of the product is dependent on the equipment ordered or the version and not the content of this technical file.

3.4 Hardware description

The TAPCON® 230 AVT is presented in a flat housing only 135 mm deep and can be secured to any wall without taking up space.

There is also the option for flush panel or DIN rail mounting.

An LCD graphic display, LEDs and function keys are integrated in the front panel of the TAPCON® 230 AVT.



The device is controlled by a microcontroller and includes isolated optocoupler inputs and floating output relay contacts in addition to the voltage and current transformers (Figure 2).

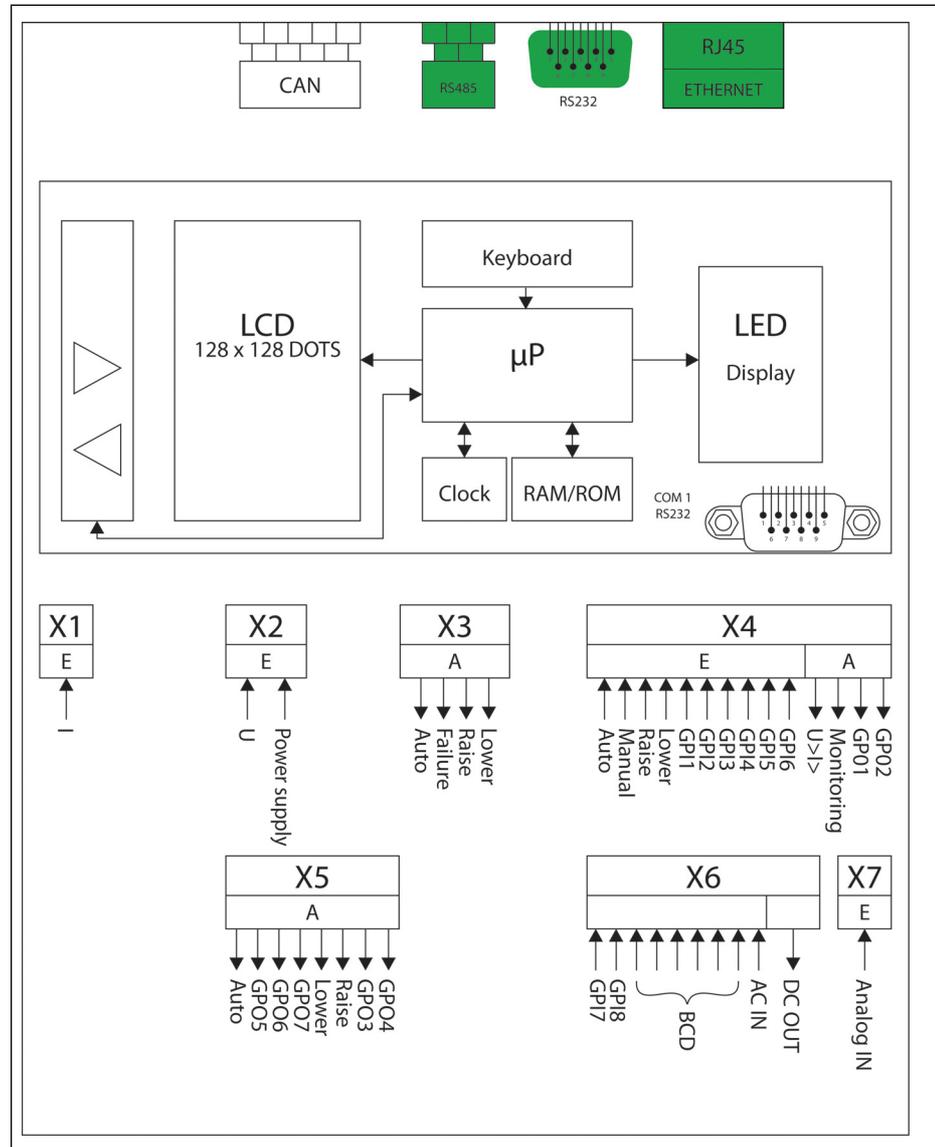


Figure 2 Block diagram for TAPCON® 230 AVT*

The TAPCON® 230 AVT can be parameterized with a PC via a COM 1 (RS232) interface that is integrated in the regulator and located on the front panel. The relevant software can be obtained from Maschinenfabrik Reinhausen.

The TAPCON® 230 AVT also features a CI card (highlighted in green in **Figure 2**). The TAPCON® 230 AVT can also be parameterized using this additional interface. Parameterization using the CI card requires the relevant menu settings. The additional communication interfaces are shown in **Figure 3**.

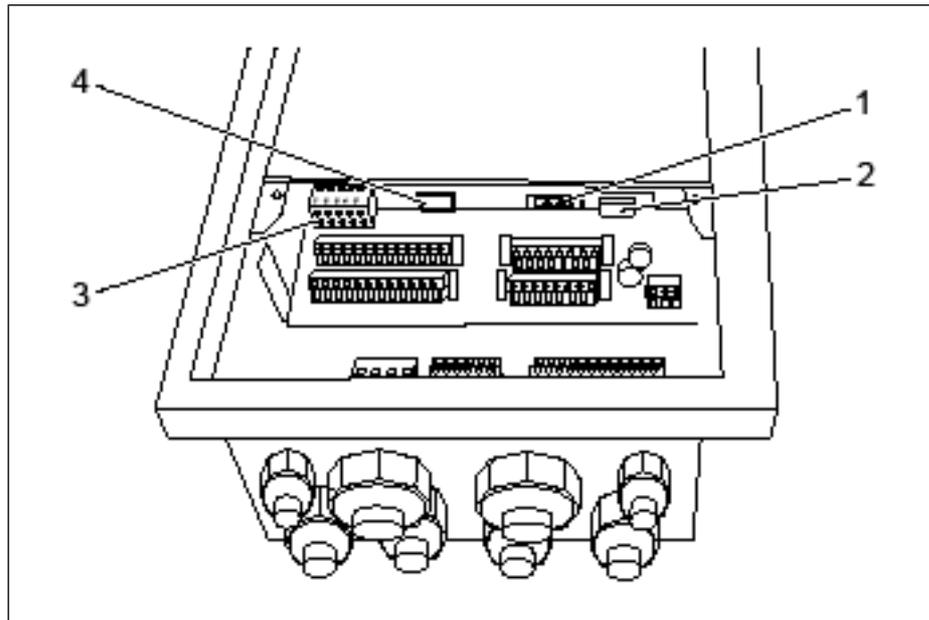


Figure 3 Additional communication interfaces in TAPCON® 230 AVT

- 1 RS485 connection
- 2 RS232 connection
- 3 CAN bus connection
- 4 RJ45 connection



The TAPCON® 230 AVT voltage regulator is functionally compatible with earlier regulator generations to a large extent.

Function keys	Manual / Automatic Raise / lower Local/Rem. Menu keys
Display	Monochromatic display with graphics capabilities, 128 x 128 dot 6 LED green for operating status 3 LED red for limit values $U >$, $U <$, $I >$ 1 LED green for parallel operation active 1 LED green for NORMset active 2 LED yellow for random assignment 1 LED yellow/green for random assignment 1 LED yellow/red for random assignment
Power supply	110 (-20%)...350 VDC 88...265 VAC Power consumption approx. 5.0 VA
Protective housing	Steel plate housing with inspection window (lockable) Dimensions (W x H) 198 x 310 mm Depth 135.5 mm Door (W x H) 242 x 343 mm Weight 7.0 kg Protection degree IP 54 according to IEC 60529
Operating temperature	-25°C ... +70°C
Storage temperature	-40°C ... +85°C

Table 7 Information on the Hardware



3.5 Description of the front panel

Figure 4 shows the front panel of the TAPCON® 230 AVT with a description of the keys. Further information on the function keys is given in Section 3.7.

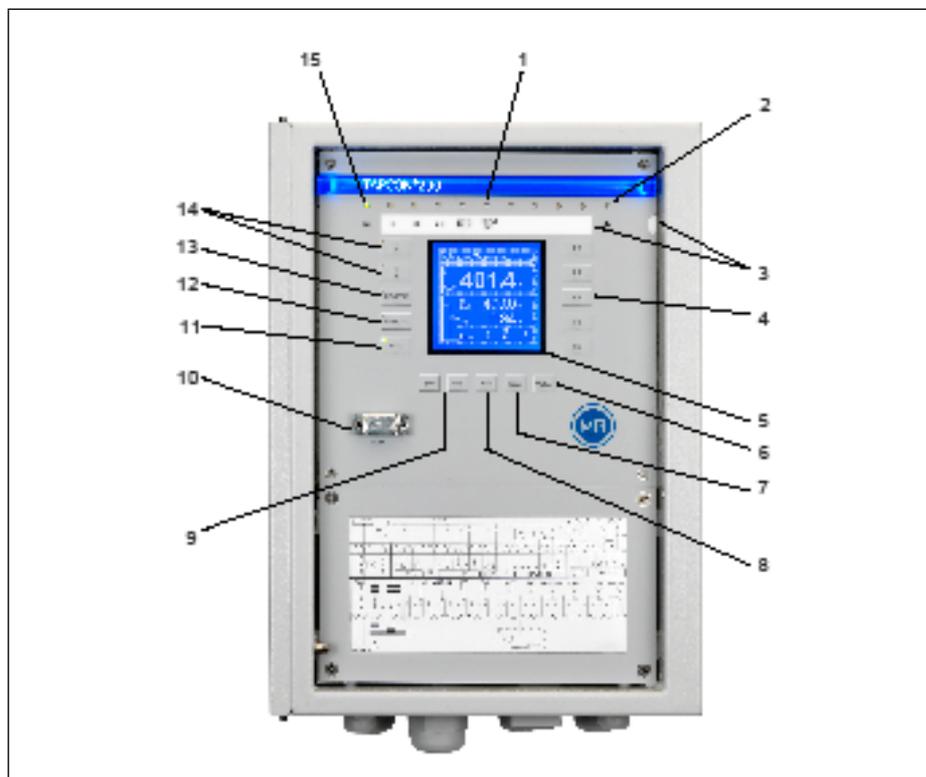


Figure 4 Front panel of the TAPCON® 230 AVT with control panel

- | | |
|--|--|
| 1 LEDs 1...10 | 9 Switching windows inside a menu level |
| 2 Setting options for display contrast | 10 Parametering interface COM 1 (RS232) |
| 3 Labeling strip for LEDs | 11 Automatic voltage regulation (with auto mode LED green) |
| 4 F1 - F5: Function and menu selection keys | 12 Manual mode (with manual control LED green) |
| 5 Display 128X128 LCD module negative blue, LED background white | 13 Remote control (with Local/Remote LED green) |
| 6 Menu selection | 14 Control for RAISE/LOWER |
| 7 Escape | 15 Status LED |
| 8 Accept entry | |

3.6 Description of the display

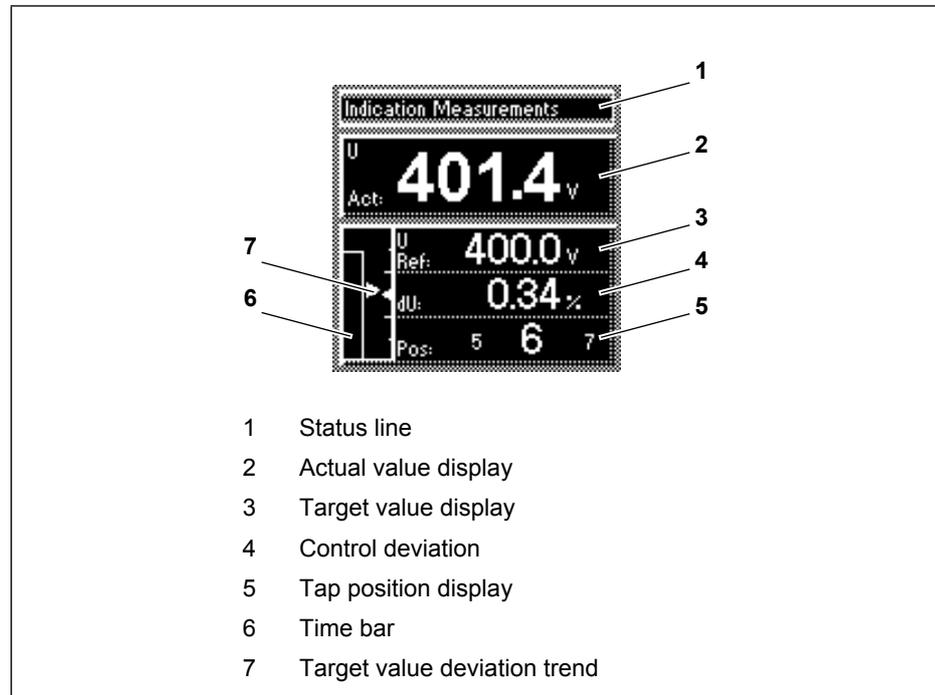


Figure 5 Main screen

In the case of a particular event or a setting, the comments on this are displayed in the status line (display text "Events").



3.7 Description of key functions

Key	Symbol	Function
RAISE		In manual mode the motor drive unit can be operated directly using the RAISE key. Using RAISE, the motor drive unit changes the on-load tap-changer and therefore the step voltage.
LOWER		In manual mode the motor drive unit can be operated directly using the LOWER key. By switching lower, the motor drive unit changes the on-load tap-changer and therefore the step voltage.
REMOTE		In the "Remote" operating mode, commands from an external control interface are executed. In this case, manual operation of the RAISE, LOWER, MANUAL and AUTO keys is disabled.
MANUAL		Manual mode. For manual control of the motor drive unit and parameterization of the TAPCON® 230 AVT.
AUTO		Automatic mode. Voltage is controlled automatically.
Arrow keys NEXT/ PREVIOUS	 	In auto and manual mode the measured value display can be set using the arrow keys. They can also be used to switch between windows in the sub-menus. After switching on the device, the control deviation dV is always displayed in the measured value display. The arrow keys can be used to switch between the following readings: <ul style="list-style-type: none"> • Control deviation (dV:) • Current (I:) • Apparent power (Powr.:) • Active power (P:) • Reactive power (Q:) • Phase angle (Phase:) • Cosine (Cos:)
ENTER		Confirms or saves a changed parameter in the parameter menu.



3 Product description

ESC		Pressing the ESC key transfers you to the menu level above, in other words, always back one menu level.
MENU		Pressing this key displays the menu selection win-dow.
F1-F5	 	The function keys are menu selection keys. They are also used to scroll through the menu subgroups and to mark decimal points which can be set by the user.
COM 1 Interface		TAPCON® 230 AVT connection to a computer. The parameterization software is not included in the scope of delivery.



The parameters can only be changed in manual mode, see MANUAL key in the table above and **Figure 4**.



3.8 TAPCON® 230 AVT operating safety

The voltage regulator is equipped with a key lock as the default factory setting for protection against unintentional operation. To activate or deactivate, press the ESC and F5 keys (**Figure 4**) simultaneously. The key lock can be switched off using the menu.

The operating panel on the TAPCON® 230 AVT is divided into two different levels.

These are the operation control level and the level for parameterization and configuration.

The keys for operating the device are completely separate from those used for parameterization. On the operation control level, activating the keys is signalled visually by means of the LEDs.

The LEDs integrated in the RAISE/LOWER keys are illuminated during the entire tap change operation of the on-load tap-changer if "motor running" is signalled at the status input. This signal requires that it has previously be parameterized.

This visual monitoring option makes operation of the TAPCON® 230 AVT easier.



4 Packaging, transport and storage

4.1 Packaging

4.1.1 Purpose

The packaging is designed to protect the packaged goods both during transport and for loading and unloading as well as during periods of storage in such a way that no (detrimental) changes occur. The packaging must protect the goods against permitted transport stresses such as vibration, knocks and moisture (rain, snow, condensation). The packaging also prevents undesired changes during storage of the packaged goods within the packaging. Before the actual packaging the products must be prepared for shipping in order to ensure that they can be transported safely, properly, and economically.

4.1.2 Suitability, structure and material

The goods are packaged in a stable cardboard box. This ensures that the consignment is secured in the intended transport position and that none of its components touches the load platform during transport or the floor after it is unloaded.

The box is designed for a maximum load of 10 kg.

Inlays inside the box stabilize the goods against undue changes of position and protect them from vibration.

4.1.3 Labeling

The packaging bears symbols with instructions for safe transport and correct storage. The following symbols apply to the dispatch (of non-hazardous goods) (Figure 6). These labels must be complied with.

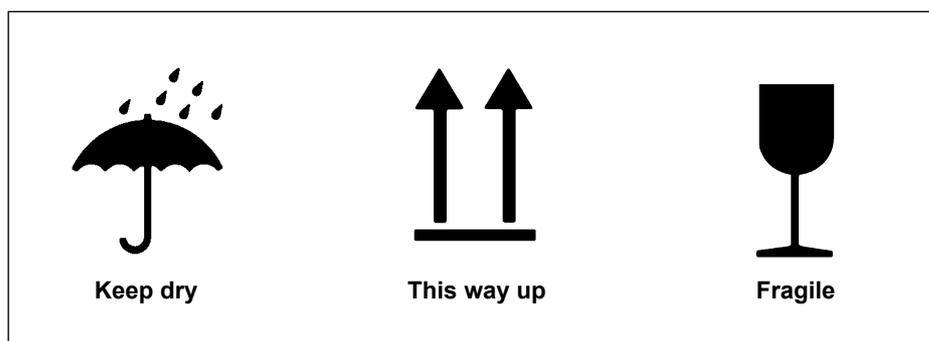


Figure 6 Dispatch symbols



4.2 Transport, reception and handling of shipments

During transport the product may be subjected to stress from vibration, shock and pressure. In order to prevent possible damage the product must be protected from being dropped, falling, tipping, and impact.

If a box is subject to a fall above a certain height or an unbroken fall, then damage will occur, irrespective of the weight involved.

Before acceptance, all deliveries must be checked by the recipient (acknowledgement of receipt) for

- completeness based on the delivery note
- external damage of any type.

If external transport damage is detected on receipt of the shipment, proceed as follows:

- Immediately record the transport damage in the shipping documents and have this countersigned by the carrier.
- In the event of severe damage, total loss and high damage costs immediately notify the distribution division of Maschinenfabrik Reinhausen and the relevant insurance company.
- After identifying the damage do not modify the condition of the shipment further and retain the packaging material for inspection by the transport company or the insurance company.
- Record the details of the damage immediately together with the carrier involved. This is essential for any claim for damages.
- Take photographs of any damage to the packaging and product if possible. This also applies to signs of corrosion on the product due to moisture inside the packaging (rain, snow, condensation).
- List the damaged parts.

For concealed damage, i.e. damage that only becomes apparent after receipt of the shipment and during unpacking, proceed as follows:

- Make the party responsible for the damage liable asap by telephone and in writing, and prepare a damage report.
- Check and observe the relevant deadlines applicable in the respective country.

In the case of concealed damage, recourse to the transport company (or other parties that may be responsible for the damage) may be difficult. Any claims for such damages can only be successful if associated provisions are specified in the insurance terms and conditions.



4.3 Storage of shipments

Selection and arrangement of the storage location should meet the following requirements:

- Stored items must be protected against moisture (flooding, melt water from snow and ice), contaminants, pests such as rats, mice, termites etc. and against unauthorized access.
- Store the box on timber beams and planks as a protection against rising damp and for better ventilation.
- The surface must have adequate load carrying capability.
- Unobstructed access must be available.

Check stored items at regular intervals, and additionally after gales, heavy rain, significant snowfall etc., and take appropriate action.



5 Mounting

5.1 Unpacking

The goods are packaged in a stable cardboard box. This ensures that the consignment is secured in the intended transport position and that none of its components touches the load platform during transport or the floor after it is unloaded.

Inlays inside the box stabilize the goods against undue changes of position and protect them from vibration, see (3) in **Figure 7**.

To unpack the TAPCON® 230 AVT proceed as follows:

1. Remove the lid from the lower part of the cardboard box.
 - ↳ The accompanying accessories and a separate box labelled "Documentation" on the left side of the box are now visible in the upper inlay, see (1) in **Figure 7**. This second box contains all the device documentation.



If specified in the order, the accessories also contain a CD with the TAPCON® visualization software for parameterizing the TAPCON® 230 AVT using the computer and an interface cable (RS232-USB converter).

2. Check that all specified accessories have been included in the scope of delivery (**Section 3.3**).
3. Remove the box marked "Documentation".
4. Remove the upper inlay from the packaging.
 - ↳ The TAPCON® 230 AVT is now visible in a further inlay.
5. Lift the TAPCON® 230 AVT out of the packaging.

The TAPCON® 230 AVT has now been completely unpacked and can be mounted. For mounting, proceed as described in **Section 5.2**.

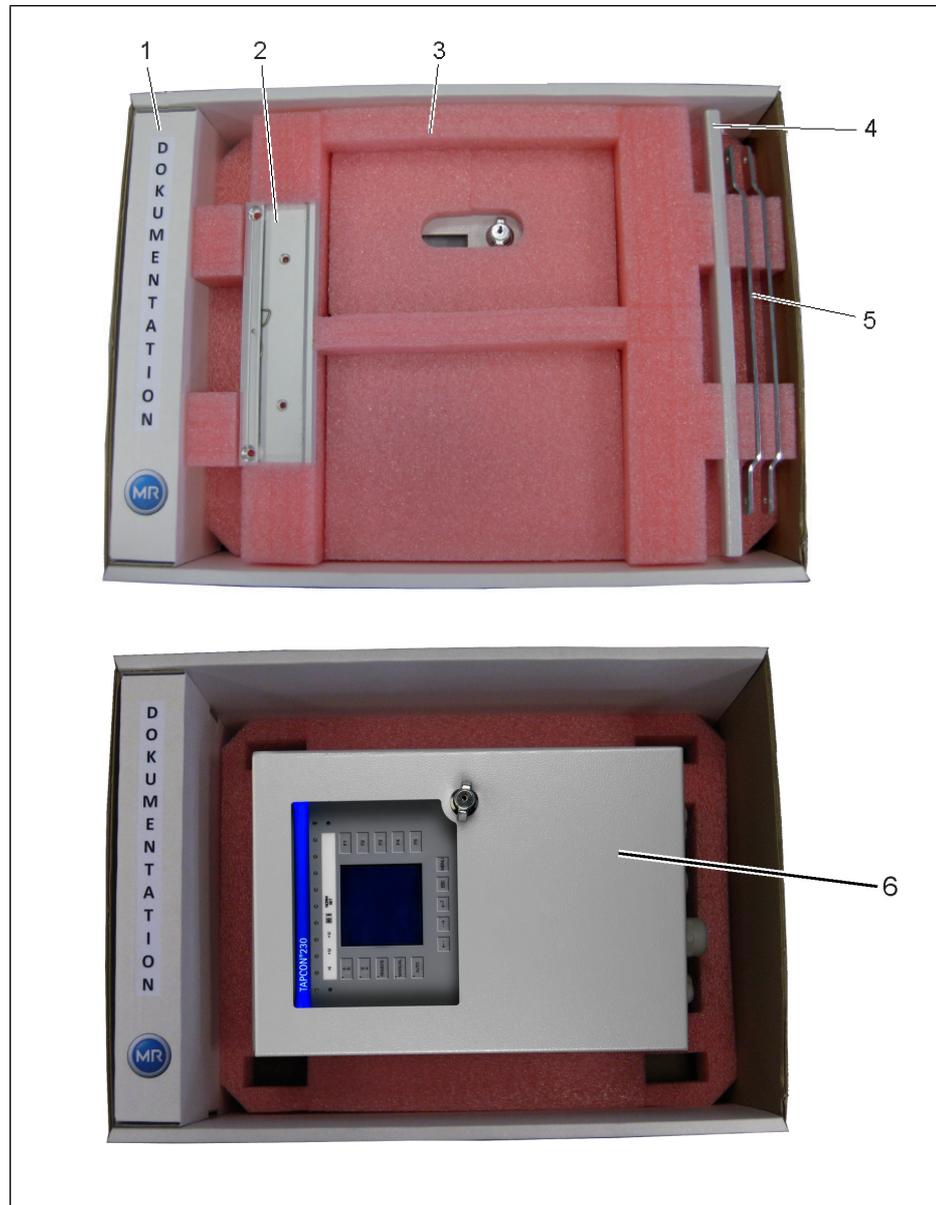


Figure 7 TAPCON® 230 AVT in packing box

- 1 Box containing all the device documentation
- 2 DIN rail clip (optional)
- 3 Inlay
- 4 Covering strip for door
- 5 Mounting bracket for wall mounting
- 6 TAPCON® 230 AVT



5.2 Mounting

After unpacking, the TAPCON® 230 AVT can be mounted.

Mounting the TAPCON® 230 AVT requires the Allen key, wrench 3 supplied. This is delivered along with the door key in a plastic bag attached to the inside of the inspection window on the swing door.

The TAPCON® 230 AVT can be mounted in 4 different ways:

1. Flush panel mounting
2. Wall mounting
3. Wall mounting with mounting bracket
4. DIN rail mounting (optional)

These 4 mounting options are described below.

Figure 8, Figure 9 and Figure 10 show the components which are referred to in the installation instructions.

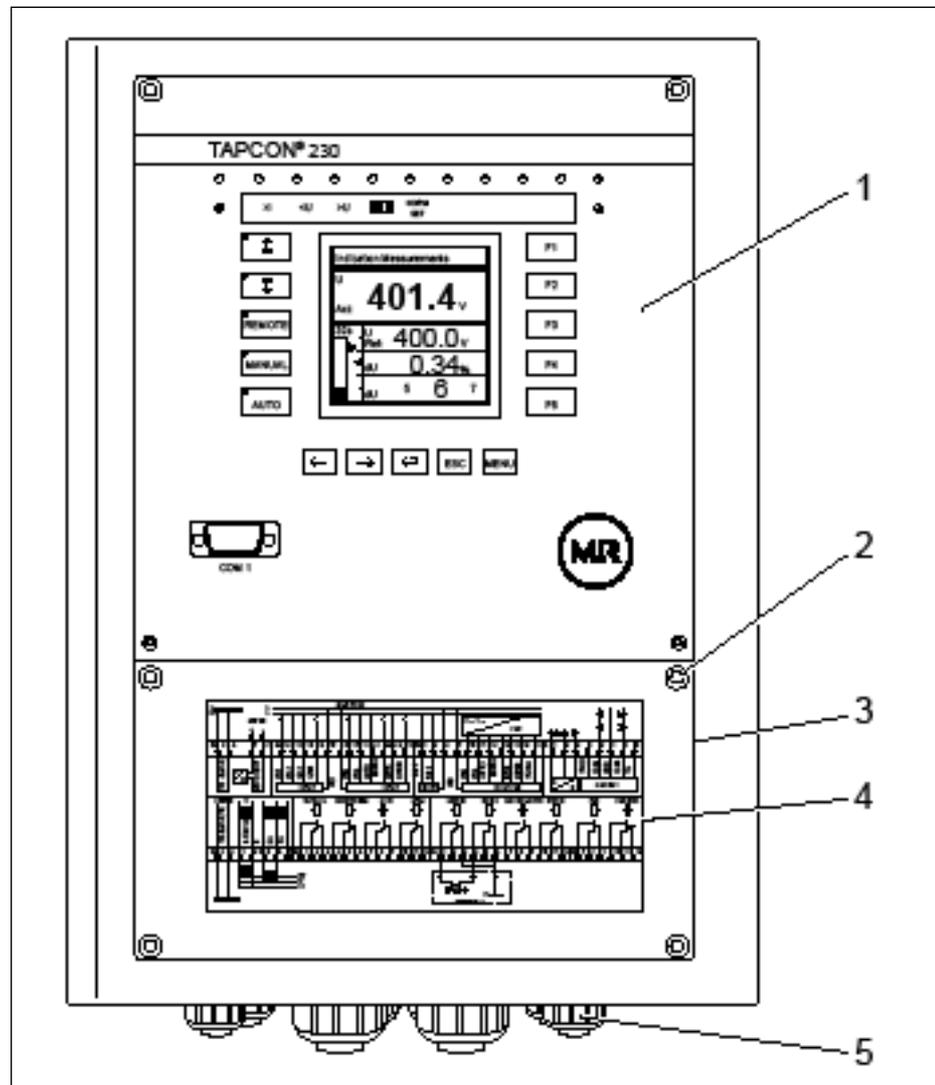


Figure 8 Description of TAPCON® 230 AVT components

- 1 TAPCON® 230 AVT front panel
- 2 Hexagon socket screws for cover plate
- 3 Cover plate
- 4 TAPCON® 230 AVT connection diagram
- 5 Cable bushings in M connecting plate

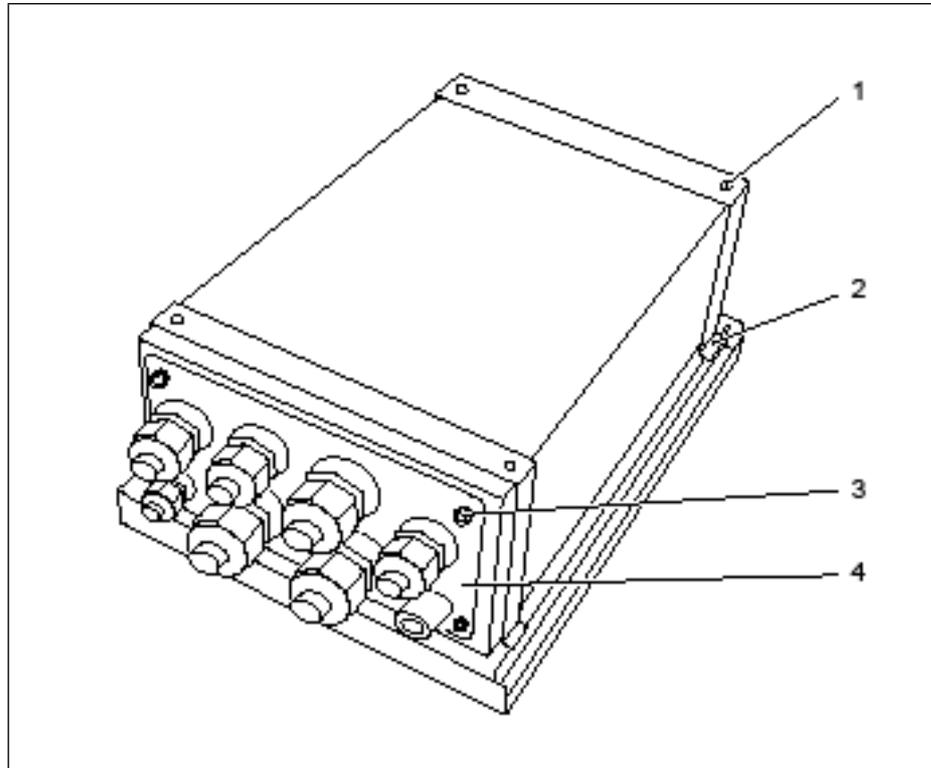


Figure 9 TAPCON® 230 AVT rear view

- 1 Hexagon socket screws on the pre-mounted brackets
- 2 Mounting bracket
- 3 Hexagon socket screws for M connecting plate
- 4 M connecting plate

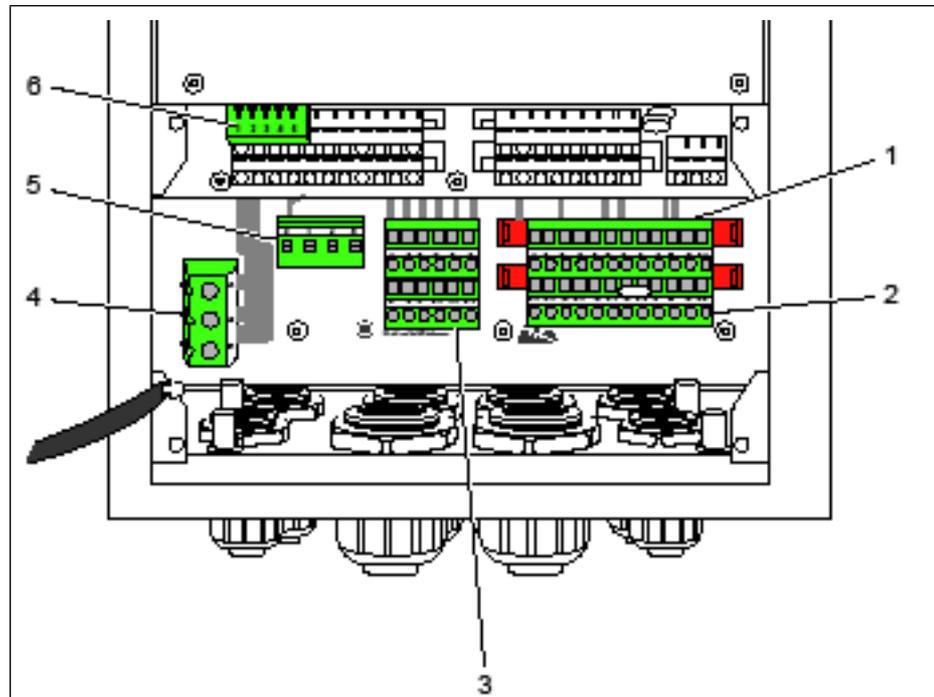


Figure 10 TAPCON® 230 AVT MIO and CPU card with connectors

- 1 Relay outputs
- 2 Signal inputs
- 3 Relay outputs
- 4 Current transformer connection
- 5 Connections for voltage transformer and power supply
- 6 CAN bus connection

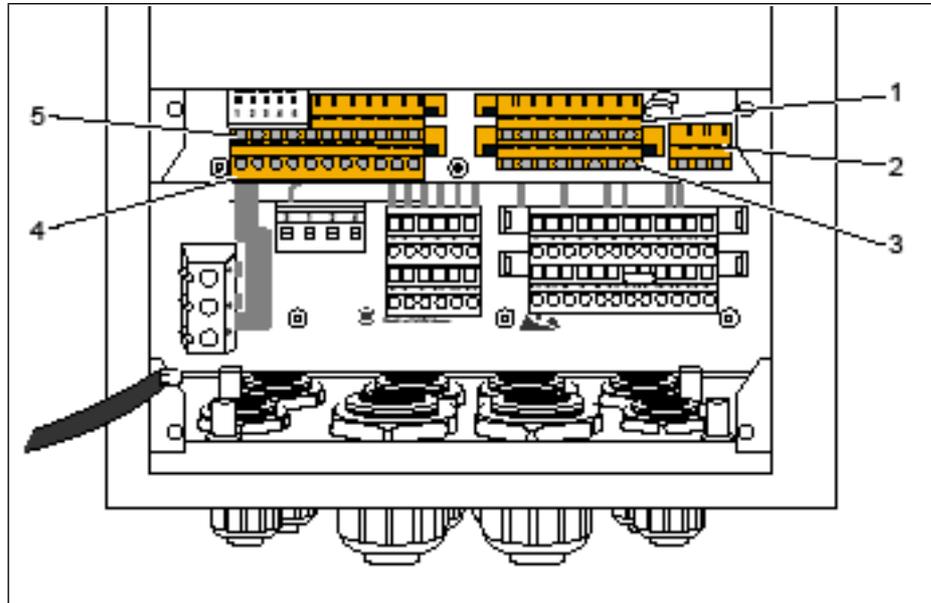


Figure 11 TAPCON® 230 AVT PIO card with connectors

- 1 Signal inputs and auxiliary voltage generation
- 2 Analog input
- 3 Digital tap position inputs
- 4 Relay outputs
- 5 Relay outputs

5.2.1 Preparation for mounting

The following preparations must be made for all 4 mounting options:

1. Unscrew the 4 hexagon socket screws on the pre-mounted fixing brackets with the Allen key.
2. Remove the fixing brackets.
3. Unscrew the 4 hexagon socket screws on the M connecting plate using the enclosed Allen key.
4. Remove the M connecting plate.

5.2.2 Flush panel mounting

For flush panel mounting the TAPCON® 230 AVT is inserted through a cutout in the control panel and fixed to the control panel or cabinet from behind using the mounting brackets.

Figure 12 shows the dimensions required for the control panel cutout.

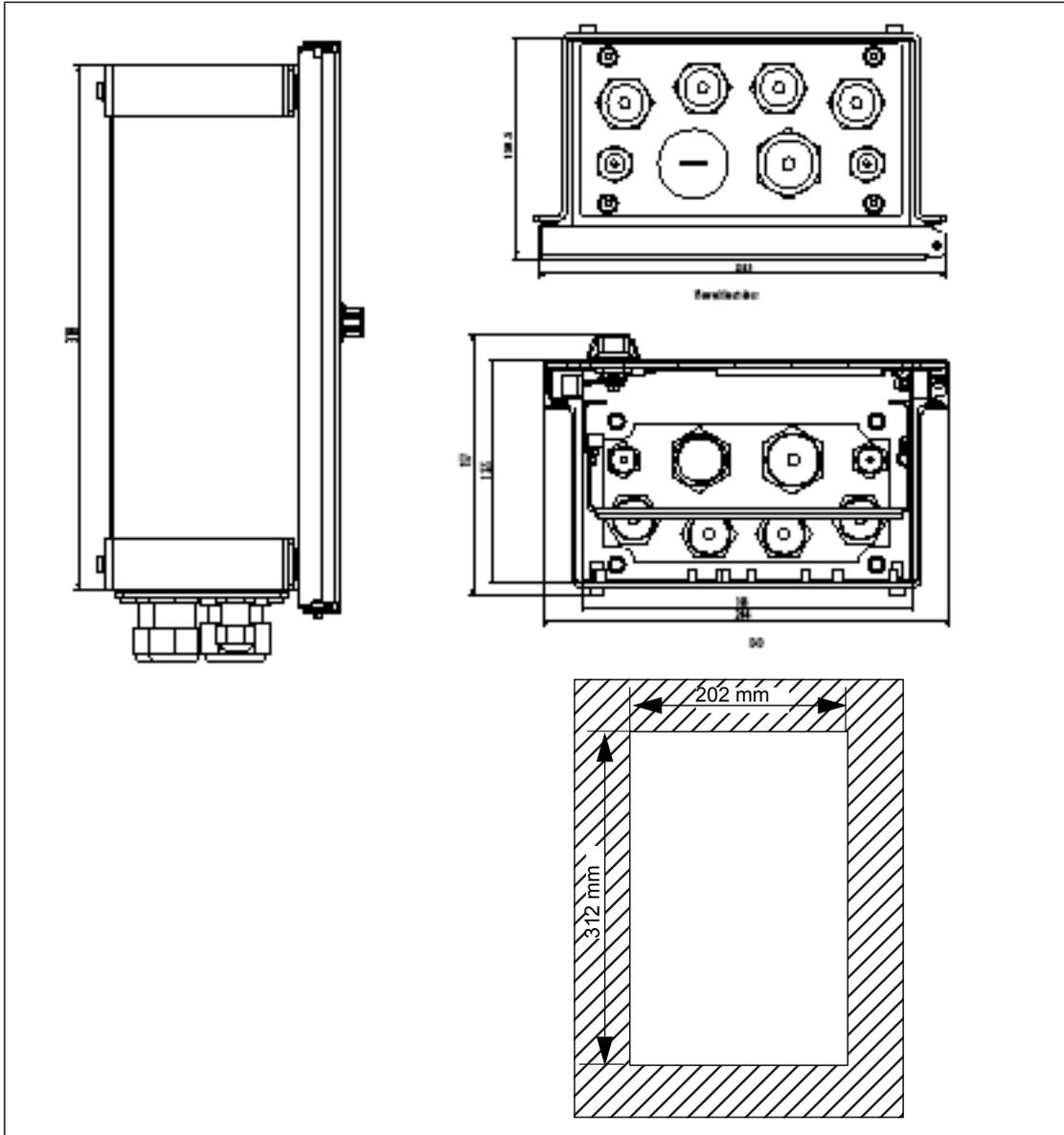


Figure 12 Drawing of TAPCON® 230 AVT housing and dimensions for the control panel cutout



For flush panel mounting, fixing the TAPCON® 230 AVT in position requires a wall thickness of 2-5 mm.

To mount the TAPCON® 230 AVT in the control panel or control cabinet, proceed as follows:

1. Close the door of the TAPCON® 230 AVT.
2. Insert the TAPCON® 230 AVT through the cutout in the control panel or cabinet.
3. Screw the fixing brackets back onto the rear of the TAPCON® 230 AVT using the 4 hexagon socket screws.

The TAPCON® 230 AVT is mounted and can be wired up. To carry out the wiring, proceed as in **Section 5.4**.

5.2.3 Wall mounting

For wall mounting, the TAPCON® 230 AVT is fixed directly to the wall.

For this mounting option, drill 4 holes of 5.5 mm diameter in the wall as shown in the drilling template in **Figure 13**.

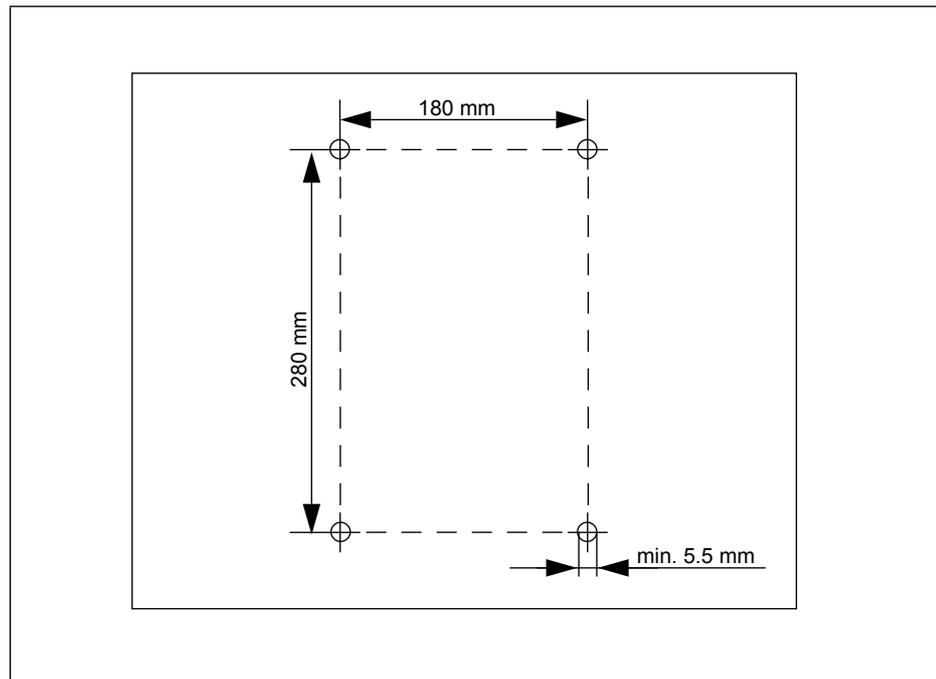


Figure 13 Drilling template for mounting directly on the wall

To mount the TAPCON® 230 AVT directly on the wall, proceed as follows:

1. Close the door of the TAPCON® 230 AVT.
2. Fix the TAPCON® 230 AVT on the wall from behind using four screws (M5) suitable for the wall thickness. These screws are not included in the delivery.

The TAPCON® 230 AVT is mounted and can be wired up. To carry out the wiring, proceed as in **Section 5.5**.

5.2.4 Wall mounting with mounting bracket

As an alternative to mounting the TAPCON® 230 AVT directly on the wall, it can be fixed to the wall using the mounting brackets supplied (**Figure 14**).

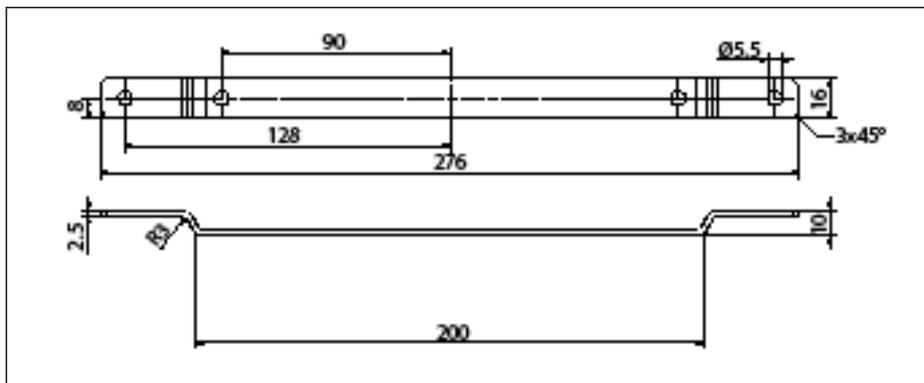


Figure 14 Mounting bracket for mounting the TAPCON® 230 AVT

For this mounting option, drill 4 holes of 5.5 mm diameter in the wall as shown in the drilling template in **Figure 15**.

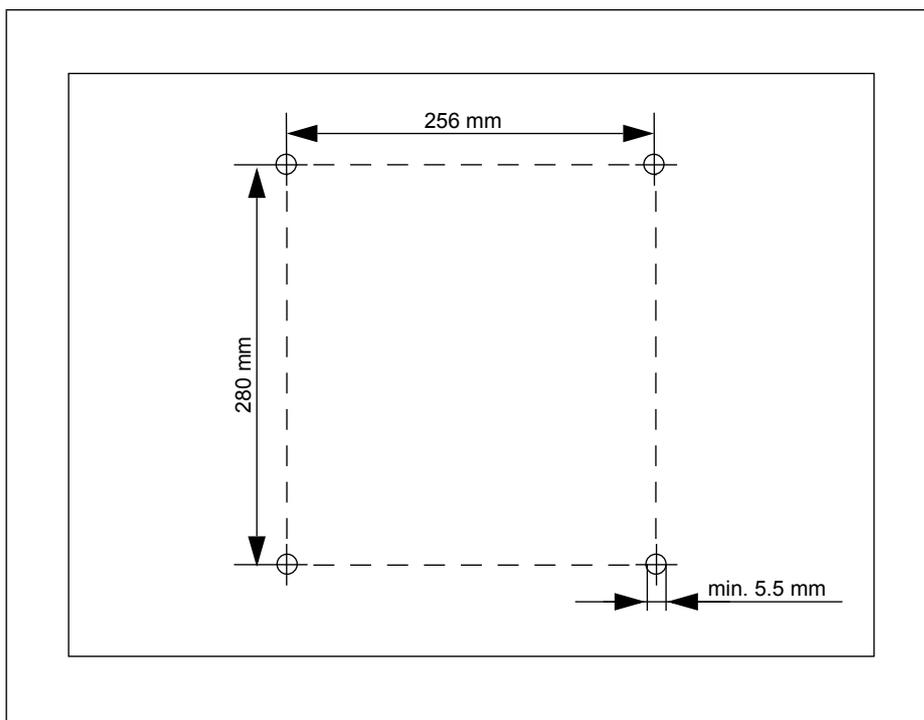


Figure 15 Drilling template for wall mounting with mounting bracket



To mount the TAPCON® 230 AVT using the mounting bracket, proceed as follows:

1. Lay the TAPCON® 230 AVT carefully on the door.
2. Screw the mounting bracket supplied to the back of the TAPCON® 230 AVT using the hexagon socket screws. Make sure that the mounting brackets are fixed to the TAPCON® 230 AVT in such a way that the curved ends point away from the regulator.
3. Fix the TAPCON® 230 AVT to the wall from behind using four screws which are suitable for the wall thickness (maximum diameter 5 mm). These screws are not included in the delivery.

The TAPCON® 230 AVT is mounted and can be wired up. To carry out the wiring, proceed as in **Section 5.4**.

5.2.5 DIN rail mounting

Alternatively, the TAPCON® 230 AVT can be mounted using a DIN rail clip (aluminum extrusion with central integrated wire spring) (**Figure 16**).

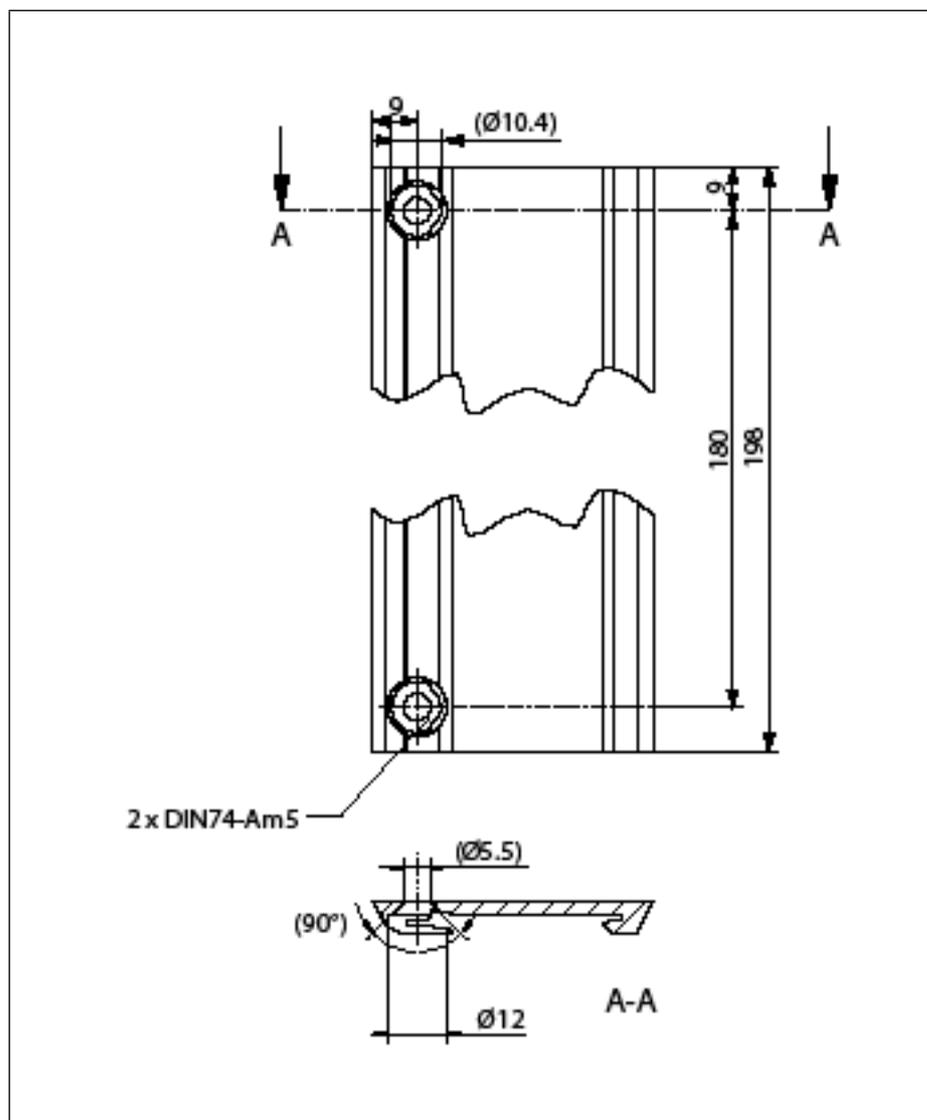


Figure 16 DIN rail clip with central integrated wire spring



When attaching the DIN rail, enough space for the TAPCON® 230 AVT must be allowed.

At least 5 cm above and **at least 35 cm** below the fixing screws of the DIN rail must be allowed for the TAPCON® 230 AVT housing.



To mount the TAPCON® 230 AVT using the DIN rail, proceed as follows:

1. Lay the TAPCON® 230 AVT carefully on the door.
2. Attach the supplied DIN rail clip with the hexagon socket screws in the upper two holes on the rear of the TAPCON® 230 AVT.
3. Suspend the DIN rail clip in the DIN rail and push the underside of the TAPCON® 230 AVT carefully towards the wall until the clip can be heard to click into place.

5.2.6 Removing the TAPCON® 230 AVT door

With the door mounted, the TAPCON® 230 AVT conforms to protection rating IP 54. The door may be dismantled if the TAPCON® 230 AVT is used solely in a dry atmosphere protected from environmental influences. It then conforms to protection rating IP 21. To remove the door, unscrew the earthing strip and the fixing screw in the door and lift it out of the upper mounting (**Figure 17**).



Figure 17 TAPCON® 230 AVT with open door

- 1 Hinge
- 2 Earthing strip
- 3 Fixing screw

Hang the covering strip supplied to the hinge at the top and secure using the fixing screw provided in order to cover the exposed attachment points for the door.

The TAPCON® 230 AVT is mounted and can be connected. For connecting, proceed as described in **Section 5.3**.



5.3 Connecting the leads to the system periphery

Connect the leads to be wired to the TAPCON® 230 AVT with the system periphery in accordance with the wiring diagram according to **Figure 18/Figure 19**.

WARNING



Electric shock!

Connection mistakes may endanger life.

- ▶ Earth the TAPCON® 230 AVT using the earthing screw on the housing.
- ▶ Pay attention to the phase of the secondary terminals for the current and voltage transformers.
- ▶ Connect the output relays correctly to the motor drive unit.

NOTE

Damage to the voltage regulator.

Connection mistakes may damage the voltage regulator and the system periphery.

Use only the specified cables for connection (**Table 8**).

The TAPCON® 230 AVT is connected and can be wired up. To carry out the wiring, proceed as in **Section 5.4**.

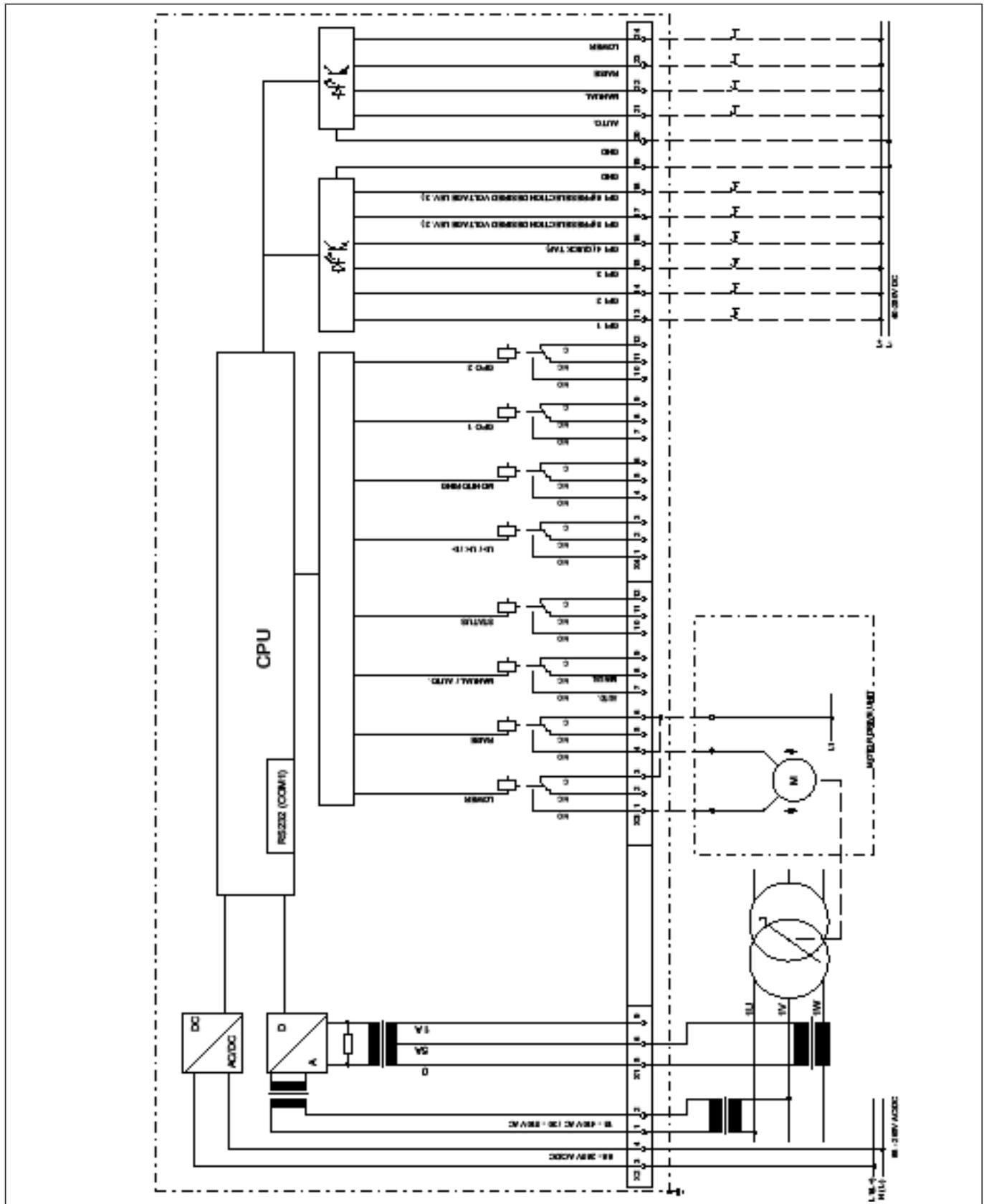


Figure 18 Connection diagram for TAPCON® 230 AVT 1 of 2

5.4 Wiring the TAPCON® 230 AVT

When wiring the TAPCON® 230 AVT, comply with the following recommendations from Maschinenfabrik Reinhausen.

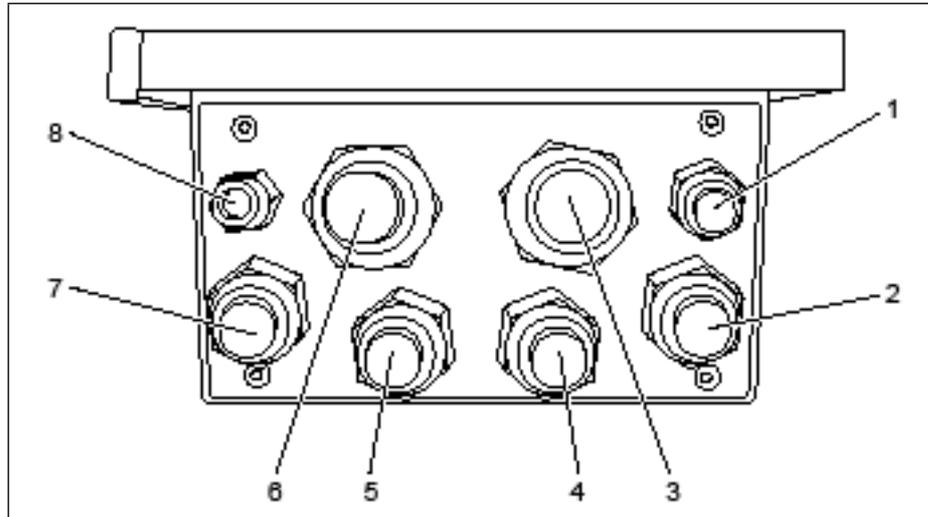


Figure 20 Bushings through the M connecting plate for wiring

No.	Cable	Terminal	Cable type	Wire diameter	Max. length	Max. perm. torque
1	Analog input	X7	shielded (< 25 Ω/km)	1.5 mm ²	400 m	-
2	Signal inputs	X4	shielded	1.5 mm ²	-	0.6 Nm
3	RS232 SUB-D	-	shielded	0.25 mm ²	25 m	-
3	RS485	-	shielded (< 50 Ω/km)	0.75 mm ²	1000 m	-
3	OF		Polymer fiber or HCT for 660 nm Glass fiber or HCT for 850 nm			
3	Ethernet RJ45		min. CAT5			
4	Relay*	X3	unshielded	1.5 mm ²	-	0.6 Nm
4	Relay* optional	X4	unshielded	1.5 mm ²	-	0.6 Nm
5	Current measurement	X1: 5/6/9	unshielded	4 mm ²	-	1.5 Nm
6	Relay outputs	X5	unshielded	1.5 mm ²	-	0.6 Nm
6	Signal inputs	X6	unshielded	1.5 mm ²	-	0.6 Nm
6	Digital tap position inputs	X6	shielded	1.5 mm ²	-	0.6 Nm
6	Auxiliary voltage	X6	unshielded	1.5 mm ²	-	0.6 Nm
7	Power supply	X2: 3/4	unshielded	1.5 mm ²	-	0.6 Nm
8	CAN bus	-	shielded	1.0 mm ²	2000 m	
* Observe notices (see below)						

Table 8 Recommendations for connection cables



NOTE

Damage to the output relay.

Excessive electrical power can prevent the relay contacts from breaking the contact current.

▶ **The effect of the cable capacitance of long leads in control circuits operated by alternating current on the functioning of the relay contacts must be taken into account.**



To obtain a better overview when connecting cables, only use as many leads as necessary.

To wire the TAPCON® 230 AVT proceed as follows:

1. Unscrew the four hexagon socket screws on the cover plate using the enclosed Allen key.
2. Remove the cover plate.
3. Pull off the connectors.
4. Keep the M connecting plate and the connectors which have been removed handy.
5. Remove the blank plugs in the M screw connections to be used so that the cables can be inserted. Leave blank plugs in the M screw connections not being used in order to maintain the IP 54 protection rating.
6. Strip the cables and wire end sleeves.
7. Insert the cables through the M screw connections according to Maschinenfabrik Reinhausen recommendation (**Table 8 on Page 55**).
8. Insert the individual wires in the connector terminals.
9. Secure the individual wires by tightening the relevant screws.
10. Take the M connecting plate and insert it with the connectors into the opening in the TAPCON® 230 AVT from below upwards.
11. Plug the connectors into the correct slots.
12. Fix the M connecting plate onto the TAPCON® 230 AVT housing using the four hexagon socket screws.
13. Tighten the M screw connections so that they relieve the terminals from strain.

5.4.1 Supplying the TAPCON® 230 AVT using an auxiliary voltage

The voltage regulator is normally supplied by the voltage transformer. However, it can also be supplied by an auxiliary supply.

In this case, connect the voltage transformer to terminals 1 and 2, the auxiliary supply to terminals 3 and 4 (**Figure 21**).

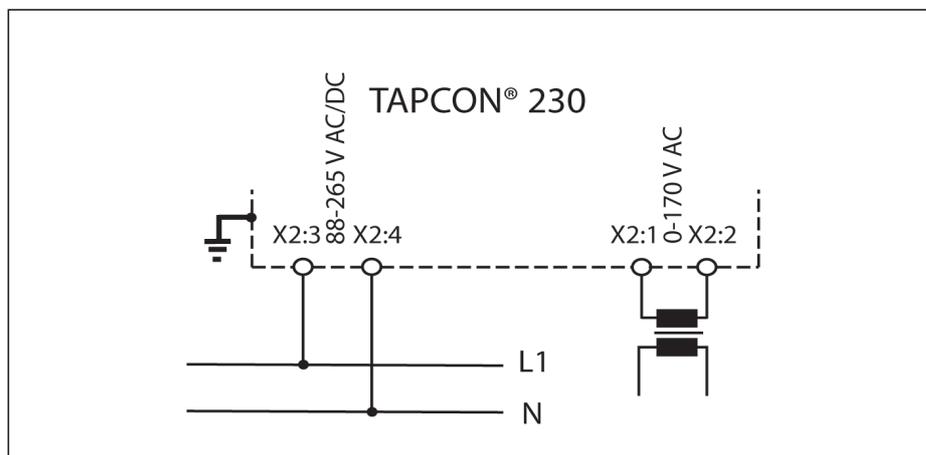


Figure 21 Voltage transformer and auxiliary supply connections



If using an auxiliary supply of 88-265 V AC/DC, 50-60 Hz, remove the bridges between the terminals 1/3 and 2/4.



5.4.2 Spare fuse specification

The TAPCON® 230 AVT is protected from overloading by means of a fuse.

A spare fuse must fulfil the following specifications:

Current: 630 mA

Voltage: 500 V

Dimensions: (Diam. x L) 6.3 mm x 32 mm

Design: ceramic tube

Circuit-breaking capacity 1000 A

Tripping characteristics: T slow blow

Complies with RoHS

5.4.3 Electromagnetic compatibility

The TAPCON® 230 AVT was developed in compliance with the relevant EMC standards. To ensure compliance with the EMC standards, please note the following points.



To comply with EMC standards

- ▶ Ensure that housing is earthed via the earthing screw on the housing; wire section no smaller than 4 mm².
- ▶ Connect individual power circuits (control, motor drive, inputs, outputs) in separate cables.

The TAPCON® 230 AVT is now wired up.

5.5 Functional check

Carry out a function check to test that the TAPCON® 230 AVT is wired correctly.

Check the following:

- After being switched on, the screen displays the MR logo and then a voltage value.
- The green LED above left on the TAPCON® 230 AVT is illuminated.

If the above applies, then the TAPCON® 230 AVT is correctly installed and wired up and the power supply and voltage measurement are functioning.

The TAPCON® 230 AVT can now be configured. To carry out the configuration, proceed as described in **Chapter 6**.



6 Commissioning

6.1 Configuration

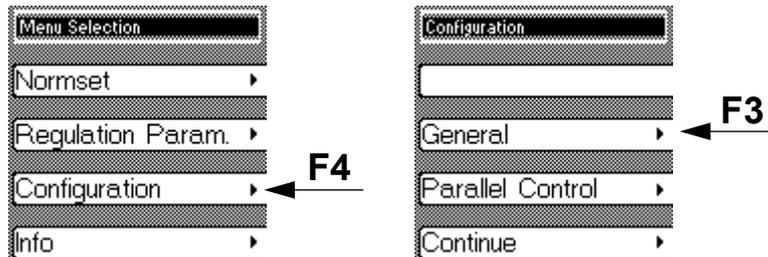
A number of parameters need to be set before commissioning the TAPCON® 230 AVT as a voltage regulator.

The functions related to these are described in detail in the TAPCON® 230 AVT operating instructions.

The relevant settings for commissioning are described in more detail in the following sections.

6.1.1 Setting the language

Menu > Configuration > General



The required display language can be set or changed. The following languages are available:

- English
- German

To set the required language, proceed as follows:



1. Menu > Configuration > General
↳ Language
2. Press the F1 key or F5 key to select the required language.
3. Press ENTER.

The display language is now set.



6.1.2 Selecting the control mode

The TAPCON® 230 AVT can be commissioned in NORMset mode or manually.

Instead of parameterizing the TAPCON® 230 AVT manually, the NORMset mode enables easy and user-friendly commissioning of the voltage regulator with a limited set of parameters. When this mode is selected, the factory settings for voltage regulation are transferred.

Prior to commissioning, be sure to check the entire configuration 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 associated transformer should be subject to normal load.

1. Select MANUAL mode
2. Select the NORMset mode
3. Set the required set value 1.
4. Execute one tap-change operation manually

When these parameters have been set, the regulator is ready to operate.

6.2 Function tests

Before switching the TAPCON® 230 AVT from manual to automatic mode and therefore activating the automatic voltage regulation for your system, Maschinenfabrik Reinhausen recommends carrying out function tests (**Section 6.2.1**, **Section 6.2.2** and **Section 6.2.3**).

Details of the specified parameters are described in the enclosed operating instructions for the TAPCON® 230 AVT.

Prior to commissioning, be sure to check the entire configuration 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 associated transformer should be subject to normal load.



6.2.1 Function tests for control functions



The on-load tap-changer can only be controlled in manual mode using the RAISE/LOWER keys.

1. Select MANUAL mode.
2. Compare the actual value (= transformer voltage) with the voltage regulator display.
3. Compare the operating values for current, power and phase angle with any available service instruments.
4. Specify the set value. Set the on-load tap-changer by manual control of the motor-drive unit in such a way that the required voltage value is achieved.
5. Set the voltage level V_{target} to this value.
6. Set the bandwidth "B %" to 1.0 %.

The voltage regulator is now usually in a balanced state (no presignal). Otherwise obtain a balanced state in the regulator by changing the set value in 0.5 V steps.

7. Set bandwidth "B %" in relation to the step voltage.
8. Set the delay time T1 to 20s lin. Move the on-load tap changer one step towards RAISE by hand.

Select AUTO mode.

↳ 20 s after choosing AUTO, the voltage regulator returns the on-load tap-changer to the original operating position.

Select MANUAL mode. Repeat the calibration process towards the LOWER setting.

Set the delay time T1 to the required value.

When the transformer is first put into operation, it is recommended to set the delay time T1 temporarily to 100 seconds. Depending on the operating conditions, it is only possible to determine the time delay after a longer period of observation. It is useful to register the values for the actual voltage and the number of tap change operations per day. If you wish the voltage regulator to exhibit an integral time response, set an integral time response for time delay T1.

The time response is shorter the larger the control deviation.



6.2.2 Function tests for miscellaneous functions



The on-load tap-changer can only be controlled in manual mode using the RAISE/LOWER keys. The transformer should be subject to normal load.

1. Set the undervoltage blocking $V<$ to 85 %. Select MANUAL mode. Set existing actual value, e.g. 400 V to $400 \text{ V} * 0.85 \approx 340 \text{ V}$ so that the existing actual value matches the percentage blocking value set.

Select AUTO mode.

- ↳ After approx. 10 s the group contact X4:1 $I>$, $V>$, $V<$ responds i.e. X4:2 opens; the output relay RAISE does not emit a control command. The LED $V<$ responds. After running this function test, the desired operating value for undervoltage blocking can be set.

2. Set overvoltage detection $V>$ to 115 %.
Select MANUAL mode. Set existing actual value, e.g. 400 V to $400 \text{ V} * 1.15 \approx 460 \text{ V}$ so that the existing actual value matches the percentage response value set.

Select AUTO mode.

- ↳ The LOWER output relay periodically emits a control command at approx. 1.5 s intervals.
- ↳ The group signal contact $I> V>$ X4:1 closes or X4:2 opens. The LED $V >$ responds.

Set the desired overvoltage detection response threshold to the original required value.

3. Set overcurrent blocking $I>$ (and optionally undercurrent blocking $I<$). A function check is not necessary.
4. Set the set value 2 to the required value. Select MANUAL mode and put L+ on terminal X4:17 (X4:17 = default setting).
5. Set the set value 3 to the required value. Select MANUAL mode and put L+ on terminal X4:18 (X4:18 = default setting).

- ↳ Set value 2 is shown on the main screen.

Select AUTO mode.

Installation of the is now complete and commissioned for simplex mode.

During operation, pay attention to the operating instructions supplied for the TAPCON® 230 AVT.

If the voltage regulator is to be used for parallel mode, then continue with **Section 6.2.3**.



6.2.3 Function tests for parallel mode



Perfect functioning in parallel mode requires the voltage regulator to be commissioned in simplex mode. Make sure that the conditions below have been fulfilled.

- ✓ All voltage regulators are set to the same operating parameters for voltage level, sensitivity and delay time T1.
- ✓ Set the circulating reactive current sensitivity to 0 % and the circulating reactive current blocking to 20 % (see TAPCON® 230 AVT operating instructions) for all voltage regulators.
- ✓ All settings should be carried out in the MANUAL operating mode.
- ✓ Give each voltage regulator an individual address on the CAN bus (see TAPCON® 230 AVT operating instructions).

6.2.3.1 Function tests in accordance with the minimum circulating reactive current method

The following sections describe how to carry out function tests for parallel mode in accordance with the circulating reactive current method.

6.2.3.1.1 Setting the parameter "circulating reactive current sensitivity"

1. Adjust both transformers in simplex mode to the same voltage by means of the on-load tap-changer.
 - ↳ When both voltage regulators are in a state of equilibrium, then the value of the control deviation "dV [%]" is smaller than the set Bandwidth "B %" and the time bar is not filled.
2. Connect the transformers in parallel and enable the parallel control.
 - ↳ The two voltage regulators must still be in a state of equilibrium.
 - ↳ The LED "Parallel mode" on the front panel is illuminated.
3. Switch one of the two transformers one voltage step higher and the other transformer one voltage step lower.
 - ↳ The two voltage regulators must still be in a state of equilibrium.
4. Set the "circulating reactive current sensitivity" until the display of the result exceeds the set value for the tolerance band by approx. 0.2 % to 0.3 %.
 - ↳ The value for the result changes in the help text in the last line of the display.
5. Set the value given in step 4 for all voltage regulators in parallel mode.
6. Select the AUTO operating mode for both voltage regulators.



↳ The voltage regulators return the on-load tap-changers to the earlier operating positions.

If the earlier operating positions are not reached, then the "circulating reactive current sensitivity" should be increased.

If the on-load tap-changers pass each other, then the "circulating reactive current sensitivity" should be reduced.

After the parameter "circulating reactive current sensitivity" has been set, continue with **Section 6.2.3.1.2**.

6.2.3.1.2 Setting circulating reactive current blocking

1. Adjust one of the two voltage regulators to MANUAL mode.
2. Using manual control, change the relevant motor drive unit upwards (e.g. 1 - 2 steps) by the maximum permitted difference of the operating positions between the parallel operating transformers.



When setting the response threshold in the following step of the procedure, wait approx. 2 to 3 seconds between the individual steps.

3. From the set value of 20 %, set the response threshold in small steps to a lower level until the message "Parallel mode error: circulating reactive current limit exceeded" appears.
 - ↳ When the LED lights up the response value for the circulating reactive current has been reached.
 - ↳ The voltage regulators block any further regulation.
 - ↳ After 30 seconds (time adjustable) the signaling relay X5:12 (X5:12 = default setting) responds.
4. Set the response threshold towards a higher value again, until the message "Parallel mode error: circulating reactive current limit exceeded" switches off.
5. Switch the voltage regulator to the AUTO mode.
 - ↳ The motor drive unit is automatically returned to the original operating position.
6. Set the value determined for the response threshold on the other regulators as well.



If one or all voltage regulators indicate "Parallel mode error: circulating reactive current limit exceeded" although the control inputs are correctly connected for all the voltage regulators, then all the voltage regulators block. This could be due to various causes. Further information is given in the chapter "Fault elimination" in the operating instructions.



6.2.3.2 Function tests in accordance with tap synchronization (master/follower/auto)

The following section describes how to carry out function tests for parallel mode in accordance with the master/follower tap synchronization method.

Before starting the function test carry out the following steps:

- ✓ Select the relevant method and assign the master function to a voltage regulator.
 - ✓ Assign the follower function to the other voltage regulators.
 - ✓ Check the tap position display. The master and follower must be in the same step.
- ↳ The function test can now be started.
1. Set the step direction.
 2. Set the master to the MANUAL mode and proceed manually.
 3. Set the follower to the AUTO mode.
 - ↳ The follower must follow the master control command.
 4. Set the master to the AUTO mode.
 5. Set the follower to the MANUAL mode.
 6. Change the follower by one step manually.
 - ↳ After expiry of the set delay time for parallel mode errors the error message "Step difference to follower" appears on the master.
 7. Set the follower to the AUTO mode.
 - ↳ The follower must follow the master control command.
 8. Set the master to the AUTO mode.
 9. Set the follower to the MANUAL mode.
 10. Change the follower manually by the maximum permitted step difference +1.
 - ↳ After expiry of the set delay time for parallel mode errors the error message "Parallel mode error: permitted step difference to master exceeded" appears on the follower AND the error message "Parallel mode error: step difference to follower" appears on the master.
 11. Set the follower to the AUTO mode.
 - ↳ There is no response. All regulators remain blocked.
 12. Set master and follower to the MANUAL mode and adjust manually to the target step.



As in parallel mode the tap positions of the transformers which are running in parallel with one another are compared according to the "automatic tap synchronization" method, it is absolutely essential that these transformers have the same position designation and that the "Raise" or "Lower" signals produce the same voltage change in all transformers.

If it should happen that the follower voltage regulator(s) switch(es) the master voltage regulator step change in the opposite direction, then the setting for the follower parameter must be changed from "Default" to "Swapped".

Installation and commissioning of the TAPCON® 230 AVT is now complete.

During operation, pay attention to the operating instructions supplied for the TAPCON® 230 AVT.



Maschinenfabrik Reinhausen GmbH
Falkensteinstraße 8
93059 Regensburg

Telefon: +49 (0)941 40 90-0
Telefax: +49 (0)941 40 90-7001
E-Mail: sales@reinhausen.com

www.reinhausen.com

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