On-load tap-changer with motor-drive unit
ECOTAP® VPD® III 30D-24 / MD&C
Operating Instructions
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Infringements will result in liability for compensation. All rights reserved in the event of the granting of patents, utility models or designs.

The product may have been altered since this document was published.

We reserve the right to change the technical data, design and scope of supply.

Generally the information provided and agreements made when processing the individual quotations and orders are binding.

The original operating instructions were written in German.
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1 Introduction

This technical file contains detailed descriptions on the safe and proper installation, connection, commissioning and monitoring 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 product is manufactured by:

C.A.P.T. srl
Via Postale Vecchia, 17- Trissino
36070 (VI) Italy
Tel. +39 0445 962297
E-mail: info@capt.it

Further information on the product and copies of this technical file are available from this address if required.

1.2 Completeness

This technical file is incomplete without the supporting documents.

The following documents are considered supporting documents:
- Connection diagrams
- Routine test report

Also observe generally valid legislation, standards, and guidelines as well as specifications on accident prevention and environmental protection in the respective country of use.

1.3 Safekeeping

Keep this technical file and all supporting documents ready at hand and accessible for future use at all times.

1.4 Notation conventions

1.4.1 Hazard communication system

Warnings in this technical file are displayed as follows.
1.4.1.1 Warning relating to section

Warnings relating to sections refer to entire chapters or sections, sub-sections or several paragraphs within this technical file. Warnings relating to sections use the following format:

⚠️ WARNING

Type of danger!
Source of the danger and outcome.
► Action
► Action

1.4.1.2 Embedded warning information

Embedded warnings refer to a particular part within a section. These warnings apply to smaller units of information than the warnings relating to sections. Embedded warnings use the following format:

⚠️ DANGER!
Instruction for avoiding a dangerous situation.

1.4.1.3 Signal words and pictograms

The following signal words are used:

<table>
<thead>
<tr>
<th>Signal word</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>DANGER</td>
<td>Indicates a hazardous situation which, if not avoided, will result in death or serious injury.</td>
</tr>
<tr>
<td>WARNING</td>
<td>Indicates a hazardous situation which, if not avoided, could result in death or serious injury.</td>
</tr>
<tr>
<td>CAUTION</td>
<td>Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.</td>
</tr>
<tr>
<td>NOTICE</td>
<td>Indicates measures to be taken to prevent damage to property.</td>
</tr>
</tbody>
</table>

Table 1: Signal words in warning notices
Pictograms warn of dangers:

<table>
<thead>
<tr>
<th>Pictogram</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Exclamation Mark]</td>
<td>Warning of a danger point</td>
</tr>
<tr>
<td>![Flash Symbol]</td>
<td>Warning of dangerous electrical voltage</td>
</tr>
<tr>
<td>![Flame Symbol]</td>
<td>Warning of combustible substances</td>
</tr>
<tr>
<td>![Human Figure]</td>
<td>Warning of danger of tipping</td>
</tr>
<tr>
<td>![Fist]</td>
<td>Warning of danger of crushing</td>
</tr>
</tbody>
</table>

Table 2: Pictograms used in warning notices

1.4.2 Information system

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

Important information.

1.4.3 Instruction system

This technical file contains single-step and multi-step instructions.

Single-step instructions

Instructions which consist of only a single process step are structured as follows:
Aim of action
✓ Requirements (optional).
► Step 1 of 1.
✓ Result of step (optional).
✓ Result of action (optional).

Multi-step instructions
Instructions which consist of several process steps are structured as follows:
Aim of action
✓ Requirements (optional).
1. Step 1.
✓ Result of step (optional).
2. Step 2.
✓ Result of step (optional).
✓ Result of action (optional).

1.4.4 Typographic conventions
The following typographic conventions are used in this technical file:

<table>
<thead>
<tr>
<th>Typographic convention</th>
<th>Purpose</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPPERCASE</td>
<td>Operating controls, keys</td>
<td>AVR MANUAL</td>
</tr>
<tr>
<td>Bold</td>
<td>Displays/menus</td>
<td>P21</td>
</tr>
<tr>
<td>Italic</td>
<td>System messages/LED displays</td>
<td>ERROR LED</td>
</tr>
</tbody>
</table>

[► Page number]. Cross reference [► 41].

Table 3: Typographic conventions
2 Safety

- Read this technical file through to familiarize yourself with the product.
- This technical file is a part of the product.
- Read and observe the safety instructions provided in this chapter.
- Read and observe the warnings in this technical file in order to avoid function-related dangers.
- The product is manufactured on the basis of state-of-the-art technology. Nevertheless, risks to life and limb for the user or impairment of the product and other material assets due to the function may arise in the event of improper use.

2.1 Appropriate use

The product is an on-load tap-changer with motor-drive unit and control unit and adjusts the transmission ratio of transformers without interrupting the load flow. The product is designed solely for use in electrical energy systems and facilities. If used as intended and in compliance with the requirements and conditions specified 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 danger to people, property or the environment. This applies throughout the service life of the product, from delivery, installation and operation to removal and disposal.

The following is considered intended use:

- Only use the ECOTAP® VPD® on-load tap-changer in systems set up in accordance with IEC 61936-1.
- You will find the standard valid for the product and the year of issue on the nameplate.
- Only operate the product in accordance with this technical file and the agreed delivery conditions and technical data.
- Only operate standard design on-load tap-changers in entirely oil-filled transformers.
- Operation with alternative insulating fluids is possible in accordance with the specification in the Technical data (Section 14, Page 115). In such cases, you must ensure compliance with the limited temperature ranges by means of temperature blocking (Section 6.3.9, Page 67).
- The serial numbers of the on-load tap-changer and motor-drive unit must match. Operating an on-load tap-changer and motor-drive unit with differing serial numbers is not permitted.
- Ensure that all necessary work is performed by qualified personnel only.
- Use the equipment and special tools supplied solely for the intended purpose and in accordance with the specifications of this technical file.

Permitted electrical operating conditions

In addition to the design data in accordance with the order confirmation, observe the following limits for the through-current and the step voltage:
In the standard version, the on-load tap-changer is designed for sinusoidal 50/60 Hz AC current with a curve form symmetrical to the zero axis and can switch twice the rated through-current \(I_r\), at its rated step voltage \(U_{ir}\).

Exceeding the rated step voltage \(U_{ir}\) for a short period by up to 10% is permitted if the rated through-current \(I_r\) is not exceeded.

### 2.2 Inappropriate use

Use is considered inappropriate if the product is used in a way other than as described in the "Appropriate use" section. In addition, observe the following:

**Prohibited electrical operating conditions**

All operating conditions that do not comply with the design data in accordance with the order confirmation are prohibited.

Prohibited operating conditions may arise due to short circuits as well as due to inrush current impulses when energizing transformers or other electrical machines. This applies to the affected transformer itself just as it does to transformers electrically connected in parallel or serially or other electrical machines.

Higher voltages may occur due to transformer overexcitation following load shedding, for example.

Operations outside of the permitted operating conditions can lead to injury to persons and damage to the product.

- Prevent any such operations outside of the permitted operating conditions by taking suitable measures.

### 2.3 Fundamental safety instructions

To prevent accidents, malfunctions 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:

**Personal protective equipment**

Loosely worn or unsuitable clothing increases the danger of becoming trapped or caught up in rotating parts and the danger of getting caught on protruding parts. This poses a danger to life and limb.

- Wear appropriate personal protective equipment such as a helmet, work gloves, etc. for the respective activity.
- Never wear damaged personal protective equipment.
- Never wear rings, necklaces, or other jewelry.
- If you have long hair, wear a hairnet.
Work area

Untidy and poorly lit work areas can lead to accidents.

▪ Keep the work area clean and tidy.
▪ Make sure that the work area is well lit.
▪ Observe the applicable laws for accident prevention in the relevant country.

Working during operation

The product may only be operated in a sound, operational condition. Otherwise it poses a danger to life and limb.

▪ Regularly check the operational reliability of safety equipment.
▪ Comply with the inspection work, maintenance work and maintenance intervals described in this technical file.

Working with current transformers

Dangerous high voltages may occur when a current transformer is operated with an open secondary circuit. This can lead to injuries and property damage.

▪ Never operate a current transformer with an open secondary circuit; short-circuit the current transformer to prevent this.
▪ Observe the information in the current transformer operating instructions.

Explosion protection

Highly flammable or explosive gases, vapors and dusts can cause serious explosions and fire.

▪ Do not install or operate the product in areas where a risk of explosion is present.

Safety markings

Warning signs and safety information plates are safety markings on the product. They are an important aspect of the safety concept.

▪ Observe all safety markings on the product.
▪ Make sure all safety markings on the product remain intact and legible.
▪ Replace safety markings that are damaged or missing.

Ambient conditions

To ensure reliable and safe operation, the product must only be operated under the ambient conditions specified in the technical data.

▪ Observe the specified operating conditions and requirements for the installation location.
2 Safety

Modifications and conversions
Unauthorized or inappropriate changes to the product may lead to personal injury, material damage and operational faults.

- Only modify the product after consultation with Maschinenfabrik Reinhausen GmbH.

Spare parts
Spare parts not approved by Maschinenfabrik Reinhausen GmbH may lead to physical injury, damage to the product and malfunctions.

- Only use spare parts that have been approved by Maschinenfabrik Reinhausen GmbH.
- Contact Maschinenfabrik Reinhausen GmbH.

2.4 Personnel qualification
The person responsible for assembly, commissioning, operation, maintenance and inspection must ensure that the personnel are sufficiently qualified.

Electrically skilled person
The electrically skilled person has a technical qualification and therefore has the required knowledge and experience, and is also conversant with the applicable standards and regulations. The electrically skilled person is also proficient in the following:

- Can identify potential dangers independently and is able to avoid them.
- Is able to perform work on electrical systems.
- Is specially trained for the working environment in which (s)he works.
- Must satisfy the requirements of the applicable statutory regulations for accident prevention.

Electrically trained persons
An electrically trained person receives instruction and guidance from an electrically skilled person in relation to the tasks undertaken and the potential dangers in the event of inappropriate handling as well as the protective devices and safety measures. The electrically trained person works exclusively under the guidance and supervision of an electrically skilled person.

Operator
The operator uses and operates the product in line with this technical file. The operating company provides the operator with instruction and training on the specific tasks and the associated potential dangers arising from improper handling.
Technical Service

We strongly recommend having maintenance, repairs and retrofitting carried out by our Technical Service department. This ensures that all work is performed correctly. If maintenance is not carried out by our Technical Service department, please ensure that the personnel who carry out the maintenance are trained and authorized by Maschinenfabrik Reinhausen GmbH to carry out the work.

Authorized personnel

Authorized personnel are trained by Maschinenfabrik Reinhausen GmbH to carry out special maintenance.

2.5 Personal protective equipment

Personal protective equipment must be worn during work to minimize risks to health.

- Always wear the personal protective equipment required for the job at hand.
- Never wear damaged personal protective equipment.
- Observe information about personal protective equipment provided in the work area.

<table>
<thead>
<tr>
<th>Protective clothing</th>
<th>Close-fitting work clothing with a low tearing strength, with tight sleeves and with no protruding parts. It mainly serves to protect the wearer against being caught by moving machine parts.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety shoes</td>
<td>To protect against falling heavy objects and slipping on slippery surfaces.</td>
</tr>
<tr>
<td>Safety glasses</td>
<td>To protect the eyes from flying parts and splashing liquids.</td>
</tr>
<tr>
<td>Visor</td>
<td>To protect the face from flying parts and splashing liquids or other dangerous substances.</td>
</tr>
<tr>
<td>Hard hat</td>
<td>To protect against falling and flying parts and materials.</td>
</tr>
<tr>
<td>Hearing protection</td>
<td>To protect against hearing damage.</td>
</tr>
<tr>
<td>Protective gloves</td>
<td>To protect against mechanical, thermal, and electrical hazards.</td>
</tr>
</tbody>
</table>

Table 4: Personal protective equipment
3 Product description

3.1 Scope of delivery

The product is packaged with protection against moisture and is delivered as follows:

- On-load tap-changer
- Motor-drive unit with connection cable
- Control unit (TDSC function optional)
- O-ring
- Additional seal
- Fixing screws with locking washers
- Technical documents

Note the following information:

- Check the shipment for completeness on the basis of the shipping documents.
- Store the parts in a dry place until installation
- The product must remain in its airtight, protective wrapping and may only be removed immediately before installation

You will find more information in the "Packaging, transport, and storage" [► Section 4, Page 22] chapter.

3.2 Function description

On-load tap-changer

On-load tap-changers are used to adjust the desired tap of a tap winding under load.

The on-load tap-changer is based on the high-speed resistor-type tap-changer principle and uses vacuum cells to change the tap position under load. In this process, the arc is extinguished while isolated in a vacuum cell, preventing contaminants from entering the oil.

Motor-drive unit

The motor-drive unit adjusts the operating position of on-load tap-changers in regulating transformers to the individual operating requirements. The tap-change operation is initiated by activating the motor-drive unit (a single control impulse is triggered). This adjustment operation is always completed regardless of any other control impulses issued during the tap-change operation. In the standard design, the next tap-change operation can only proceed once all control devices have reached their resting positions.
Control unit

The motor-drive unit is equipped with a control unit which enables automatic voltage regulation. This is used to keep the output voltage of a transformer with an on-load tap-changer constant. The control unit compares the transformer's measured voltage \( U_{\text{actual}} \) with a defined reference voltage \( U_{\text{desired}} \). The difference between \( U_{\text{actual}} \) and \( U_{\text{desired}} \) is the control deviation \( dU \). If the control deviation \( dU \) is greater than the set bandwidth, the control unit triggers a tap-change operation after the delay time \( T1 \) has elapsed in order to reduce the control deviation.

You can set all parameters needed to set the voltage regulation via a parameterization menu.

OLTC PreCheck

Before each tap-change operation, the motor-drive unit checks whether the drive train of the on-load tap-changer is tight or whether one or more micro-switches have failed. In the event of a micro-switch defect, the device switches to fault mode and issues an error message.

Exception: In the EXTERNAL CONTROL operating mode, the device performs an automatic OLTC-PreCheck once every 24 hours, not before each tap-change operation.

Behavior in the event of a voltage interruption

Should a voltage interruption occur during a tap-change operation, the motor-drive unit completes the tap-change operation that has already started. Open both relay contacts on X5 and the device will block further on-load tap-change operations until the voltage supply is restored. You can adapt this response using the "Target position for loss of voltage" [► Section 7.4.4, Page 81] function so that the on-load tap-changer is changed to a defined tap position before this blocking. For this purpose, the control unit is equipped with an energy accumulator. If it is ready to work, this is indicated by the \( \square \) LED staying lit. After a loss of voltage or a deliberate disconnection from the mains, it takes around 30 minutes for this energy accumulator to discharge.

3.3 Operating modes

The control ensures that the required cooling time of approx. 3 seconds is maintained after each on-load tap-change operation. During this time, the control will not accept any tap-change commands. An exception to this is the optional multi-tap-change function, which is only possible in the operating mode EXTERNAL CONTROL.

There are 3 operating modes on the control unit for controlling the on-load tap-changer.
AVR MANUAL manual mode
In AVR MANUAL manual mode, there is no automatic control. The motor-drive unit can be controlled using the device’s operating panel (↑ = increase voltage, ↓ = reduce voltage). The device settings can be changed.

AVR AUTO auto mode
In auto mode, the device automatically regulates the voltage in accordance with the set parameters. The voltage is measured in a single phase via the supply voltage. You have to switch to AVR MANUAL manual mode to configure the control unit.

Control via EXTERNAL CONTROL
In the EXTERNAL CONTROL operating mode, the commands of an external control unit (e.g. ECOTAP® VPD® CONTROL PRO) are executed. In this case, manual operation using the RAISE and LOWER keys is not possible.

When operating in this mode, observe the safety instructions and the description in the external control unit operating instructions.
3.4 Design

You will find a detailed drawing of the on-load tap-changer in the "Drawings" section.

Figure 1: Front view

<table>
<thead>
<tr>
<th>1</th>
<th>Motor-drive unit</th>
<th>2</th>
<th>Nameplate</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Sealing module</td>
<td>4</td>
<td>Additional seal</td>
</tr>
<tr>
<td>5</td>
<td>Connection contacts</td>
<td>6</td>
<td>O-ring</td>
</tr>
</tbody>
</table>
3.5 Control unit operating concept

You can operate the device using the operating controls on the front panel.

<table>
<thead>
<tr>
<th>Key</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>MENU</td>
<td>MENU Call up or closing the parameterization menu</td>
</tr>
<tr>
<td>AVR AUTO</td>
<td>AVR AUTO Activate automatic voltage regulation</td>
</tr>
<tr>
<td>RAISE</td>
<td>RAISE In AVR MANUAL operating mode: Raise tap-change operation</td>
</tr>
<tr>
<td></td>
<td>In parameterization menu: Increase displayed value</td>
</tr>
<tr>
<td>+ AVR AUTO</td>
<td>RAISE + AVR AUTO In parameterization menu: Increase displayed value quickly</td>
</tr>
<tr>
<td>LOWER</td>
<td>LOWER In AVR MANUAL operating mode: Lower tap-change operation</td>
</tr>
<tr>
<td></td>
<td>In parameterization menu: Decrease displayed value</td>
</tr>
<tr>
<td>+ AVR AUTO</td>
<td>LOWER + AVR AUTO In parameterization menu: Decrease displayed value quickly</td>
</tr>
</tbody>
</table>
### Key

<table>
<thead>
<tr>
<th>Key</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVR MANUAL</td>
<td>Activating manual mode</td>
</tr>
<tr>
<td></td>
<td>In parameterization menu:</td>
</tr>
<tr>
<td></td>
<td>Confirm selection</td>
</tr>
<tr>
<td>EXTERNAL</td>
<td>EXTERNAL CONTROL</td>
</tr>
<tr>
<td>CONTROL</td>
<td>Activate voltage regulation via external con-</td>
</tr>
<tr>
<td></td>
<td>trol unit</td>
</tr>
</tbody>
</table>

Table 5: Operating elements

**Example** To set parameter P2.2, delay time T1, proceed as follows:

1. Press AVR MANUAL to activate manual mode.
   - The LED above the AVR MANUAL key lights up.
2. Press MENU to call up the parameterization menu.
   - 
3. Press to select the menu P2.
   - 
4. Press AVR MANUAL to confirm the selection.
   - P2
5. Press to select the parameter P2.2.
   - P2
6. Press AVR MANUAL to confirm the selection.
   - 
7. Press or to set the desired value (e.g. 15).
   - 15
8. Press AVR MANUAL to accept the selection.
9. Press MENU to leave the parameterization menu.
   - The parameter P2.2, delay time T1, is set.

Settings are only saved once the parameterization menu is exited via the MENU key. If you do not press the MENU key within 30 s, the parameterization menu is exited automatically and the changes are not saved.

You will find a detailed description of all control unit parameters and functions in the "Configuring control unit" [Section 7.4, Page 75] chapter.
4 Packaging, transport and storage

4.1 Packaging

The products are sometimes supplied with sealed packaging and sometimes in a dry state, depending on requirements.

Sealed packaging surrounds the packaged goods with plastic foil on all sides.

Products that have also been dried are identified by a yellow label on the sealed packaging. In the dry state, delivery is also possible in a transport container.

The information in the following sections should be applied as appropriate.

4.1.1 Suitability

**NOTICE**

Property damage due to incorrectly stacked crates!

Stacking the crates incorrectly can lead to damage to the packaged goods.

► The outer marking on the packaging states if, for example, the on-load tap-changer or selector has been packed upright. Never stack these crates.

► General rule: Do not stack crates above a height of 1.5 m.

► For other crates: Only stack up to 2 equally sized crates on top of one another.

The packaging is suitable to ensure undamaged and fully functional means of transportation in compliance with local transportation laws and regulations.

The packaged goods are packed in a sturdy crate. This crate ensures that, when in the intended transportation position, the packaged goods are stabilized to prevent impermissible changes in position, and that none of the parts touch the loading surface of the means of transport or touch the ground after unloading.

Sealed packaging surrounds the packaged goods with plastic foil on all sides. The packaged goods are protected from humidity using a desiccant. The plastic foil was bonded after the desiccant is added.
4.1.2 Markings

The packaging bears a signature with instructions for safe transport and correct storage. The following symbols apply to the shipment of non-hazardous goods. Adherence to these symbols is mandatory.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>☄️</td>
<td>Protect against moisture</td>
</tr>
<tr>
<td>⬆️</td>
<td>Top</td>
</tr>
<tr>
<td>🥃</td>
<td>Fragile</td>
</tr>
<tr>
<td>💁‍♀️</td>
<td>Attach lifting gear here</td>
</tr>
<tr>
<td>🔞</td>
<td>Center of mass</td>
</tr>
</tbody>
</table>

Table 6: Shipping pictograms
4.2 Transportation, receipt and handling of shipments

**WARNING**

Danger of death or severe injury!

- Only transport the crate when closed.
- Do not remove the securing material used in the crate during transport.
- If the product is delivered on a pallet, secure it sufficiently.
- Only trained and authorized persons may select the sling gear and secure the load.
- Do not walk under the suspended load.
- Use means of transport and lifting gear with a sufficient carrying capacity in accordance with the weight stated on the delivery slip.

In addition to oscillation stress, jolts must also be expected during transportation. In order to prevent possible damage, avoid dropping, tipping, knocking over and colliding with the product.

If a crate tips over, falls from a certain height (e.g. when slings tear) or is subject to an unbroken fall, damage must be expected regardless of the weight.

Every delivered shipment must be checked for the following by the recipient before acceptance (acknowledgment of receipt):

- Completeness based on the delivery slip
- External damage of any type

The checks must take place after unloading when the crate or transport container can be accessed from all sides.

**Visible damage**

If external transport damage is found upon receipt of the shipment, proceed as follows:

- Immediately record the identified transport damage in the shipping documents and have this countersigned by the carrier.
- In the event of severe damage, total loss or high damage costs, immediately notify the manufacturer and the relevant insurance company.
- After identifying damage, do not modify the condition of the shipment further and retain the packaging material until an inspection decision has been made by the transport company or the insurance company.
- Record the details of the damage immediately on site together with the carrier involved. This is essential for any claim for damages.
- Photograph damage to packaging and packaged goods. This also applies to signs of corrosion on the packaged goods due to moisture inside the packaging (rain, snow, condensation).
- **NOTICE!** Damage to packaged goods due to damaged sealed packaging. If the product is delivered in sealed packaging, check the sealed packaging immediately. If the sealed packaging is damaged, do not under
any circumstances install or commission the packaged goods. Either re-
dry the dried packaged goods as per the operating instructions, or contact
the manufacturer to agree on how to proceed.

- Identify the damaged parts.

Hidden damage When damages are not determined until unpacking after receipt of the ship-
ment (hidden damage), proceed as follows:
- Make the party responsible for the damage liable as soon as possible by
telephone and in writing, and prepare a damage report.
- Observe the time periods applicable to such actions in the respective
country. Inquire about these in good time.

With hidden damage, it is very hard to make the transportation company (or
other responsible party) liable. Any insurance claims for such damages can
only be successful if relevant provisions are expressly included in the insur-
ance terms and conditions.

4.3 Storage of shipments

Packaged goods dried by Maschinenfabrik Reinhausen

Upon receipt of the shipment, immediately remove the packaged goods
dried by Maschinenfabrik Reinhausen from the sealed packaging and store
air-tight in dry insulating fluid until used if the packaged goods were not sup-
plied in insulating fluid.

Non-dried packaged goods

Non-dried packaged goods but with a functional sealed packaging can be
stored outdoors when the following conditions are complied with.

When selecting and setting up the storage location, ensure the following:
- Protect stored goods against moisture (flooding, water from melting snow
and ice), dirt, pests such as rats, mice, termites and so on, and against
unauthorized access.
- Store the crates on timber beams and planks as a protection against ris-
ing damp and for better ventilation.
- Ensure sufficient carrying capacity of the ground.
- Keep entrance paths free.
- Check stored goods at regular intervals. Also take appropriate action after
storms, heavy rain or snow and so on.

Protect the packaging foil from direct sunlight so that it does not disintegrate
under the influence of UV rays, which would cause the packaging to lose its
sealing function.
If the product is installed more than 6 months after delivery, suitable measures must be taken without delay. The following measures can be used:

- Correctly regenerate the drying agent and restore the sealed packaging.
- Unpack the packed goods and store in a suitable storage space (well ventilated, as dust-free as possible, humidity < 50% where possible).

### 4.4 Unpacking shipments and checking for transportation damages

- **NOTICE!** Damage to packaged goods due to ineffectively sealed packaging. Transport the packaged crate to the place where the packaged goods are to be installed. Do not open the sealed packaging until just before installation.
- **WARNING!** Serious injuries and damage to the packaged goods due to the packaged goods tipping out. Place the packaged goods in an upright crate and protect it from tipping out.
- Unpack the packaged goods and check the condition.
- Check the completeness of the accessories kit using the delivery slip.
5 Mounting

5.1 Fastening on-load tap-changer to transformer cover

Do not paint the surface on the underside of the transformer cover, which later makes contact with the sealing module's O-ring. Only one coating of primer is permitted.

1. Make opening for sealing module and holes for fixing screws in the transformer cover. The dimensions and position are to be found in the accompanying dimensional drawing.

Figure 3: Top view of transformer cover with opening for sealing module
2. Clean sealing surfaces on sealing module and underside of transformer cover. Insert O-ring supplied in sealing module.

3. **NOTICE!** Damage to the on-load tap-changer due to incorrect screw connections. Guide the on-load tap-changer from below through the opening in the transformer cover and affix horizontally to the transformer cover using 4 screws. Evenly tighten screws crosswise by hand.

4. Tighten the screws crosswise with 9 Nm. Ensure that the fastenings are not subject to mechanical stress.

5. Check the fit of the flange and O-ring for evenness.
6. Tighten the screws crosswise with 16 Nm. Ensure that the fastenings are not subject to mechanical stress.

Figure 5: Fastening the on-load tap-changer

7. **NOTICE!** Damage to the on-load tap-changer due to incorrect screw connections. Attach the additional seal with 4 screws. Evenly tighten screws crosswise by hand.
8. Tighten the screws crosswise with 9 Nm and then crosswise with 16 Nm. Ensure that the fastenings are not subject to mechanical stress.

5.2 Connecting tap winding and on-load tap-changer take-off lead

**NOTICE**

**Damage to the on-load tap-changer!**

Mounting mistakes will damage the on-load tap-changer and jeopardize safe operation.

► Connect connecting leads without warping or deforming them and ensure that no forces are transferred from the connecting leads to the on-load tap-changer.

► The diagram below shows the areas particularly critical for insulation spacing. Avoid laying the connection cables in these critical areas.
Figure 7: Insulation spacings

1 Transformer cover
2 Critical area: Spacing to grounded parts
3 Critical area: Spacing between the phases

**NOTICE**

Damage to the on-load tap-changer!

Improperly carried out crimp connections jeopardize safe operation.

➤ Carry out crimp connections in accordance with DIN EN IEC 61238-1-3.

➤ The length of the stripped part of the connecting cable may not exceed 16 mm.
Connect the tap-winding connecting leads and on-load tap-changer take-off leads by crimping them onto the connection contacts on the on-load tap-changer and ensure that they are not subject to mechanical stress.

Figure 8: Connecting leads and connection contacts
5.3 Mounting motor-drive unit

Checking the operating position

The on-load tap-changer has to be in a defined operating position when mounting the motor-drive unit.

1. **DANGER!** Check the operating position prior to commissioning the transformer, or ensure that the transformer is de-energized and secured against reconnection. Failure to do so can lead to death or serious injuries.

2. Remove the transport locking plate and store it safely for later use. Do not leave the sealing module open for long periods in order to prevent soiling and damage to the mechanics.

3. Check the on-load tap-changer operating position. The current operating position is displayed by the control wheel.

---

Figure 9: Removing the transport locking plate

Figure 10: Checking operating position (example illustration)
4. Also check the position of the shaft of the on-load tap-changer: If the previous on-load tap-change operation has been finished correctly, the arrow on the cam disk 1 will point to the arrow in the cover 2.

![Figure 11: Position of the shaft of the on-load tap-changer](image)

If the shaft of the on-load tap-changer is in this position, the on-load tap-changer is in a defined operating position. If this is not the case, correct the position as described below.

5. **NOTICE!** Only use the emergency drive shaft built into the sealing module. Failure to do so can result in damage to the on-load tap-changer.

6. Pull the emergency drive shaft out of the bracket in the sealing module.

![Figure 12: Removing emergency drive shaft](image)
7. Plug the emergency drive shaft with feather key into the shaft of the on-load tap-changer.

Figure 13: Attaching emergency drive shaft

8. Rotate the emergency drive shaft in the direction of the desired operating position using an appropriate tool.

Figure 14: Emergency drive shaft actuation
9. **NOTICE!** Using the emergency drive shaft, turn for every tap-change operation in one direction until one revolution has been completed and the arrow on the cam disk (1) is again pointing to the arrow in the cover (2). Otherwise, the tap-change operation has not been completed correctly, which may result in damage to the on-load tap-changer and transformer.

![Figure 15: Position of the shaft of the on-load tap-changer](image)

.Dial: The current operating position is displayed by the control wheel.

![Figure 16: Checking operating position (example illustration)](image)

10. Pull the emergency drive shaft out of the shaft of the on-load tap-changer and plug it back into the bracket.

![Figure 17: Plugging the emergency drive shaft back in](image)
Mounting motor-drive unit

1. Clean sealing surfaces on the sealing module and underside of the motor-drive unit and check that the O-ring is in the correct position.

![Figure 18: Cleaning sealing surfaces of the motor-drive unit](image)

2. When mounting for the first time: Remove label with warning.

![Figure 19: Removing the label](image)
3. Ensure that the feather key is seated correctly.

![Figure 20: Checking the feather key is seated correctly](image)

4. Check the position of the motor-drive unit. If mounted incorrectly, the motor-drive unit may be damaged. The feather key 1 of the motor shaft must be facing the mark 2. If necessary, cover the motor shaft with a cloth and carefully turn using pliers until the feather key is facing the mark.

Ensure that the motor-drive unit and on-load tap-changer are aligned as described below. In the event of incorrect mounting, the control unit recognizes the incorrect mounting and delivers the event code E6 [► Section 11.2, Page 110]. This event code can only be reset by the Maschinenfabrik Reinhausen GmbH Technical Service department.

![Figure 21: Checking the position of the motor-drive unit](image)
5. Checking the position of the on-load tap-changer: The mark on the cam disk 1 must be in the marked area on the cover 2. If not, correct the position as described in the "Actuating motor-drive unit with emergency drive shaft" [► Section 7.3, Page 71] section.

Figure 22: Checking the position of the on-load tap-changer

6. Attach motor-drive unit to sealing module.

7. **NOTICE!** Attach the motor-drive unit without warping or deforming; to do so, gradually tighten screws crosswise. Otherwise the motor-drive unit is not correctly connected to the on-load tap-changer, which may result in damage to the on-load tap-changer and transformer.

Figure 23: Mounting the motor-drive unit
8. Connect the motor-drive unit and transformer cover with a grounding conductor. For the ground connection on the motor-drive unit, we recommend using an M8 cable shoe.

![Figure 24: Connecting the motor-drive unit grounding](image)

Perform an automatic adjustment [► Section 7.4.9.1, Page 87] each time the motor-drive unit is replaced or mounted.

### 5.4 Connecting control unit at the transformer manufacturer’s site

This section describes how you connect the control unit before initial commissioning. Connection and mounting of the control unit for permanent operation are described in the Commissioning transformer at operating site chapter.

**DANGER**

Risk of fatal injury due to electrical voltage!

Danger of death due to electrical voltage when assembling and connecting the device.

► De-energize the device and system peripherals and lock them to prevent them from being switched back on.
5.4.1  Cable recommendation

Please note the following recommendation from Maschinenfabrik Reinhausen GmbH when wiring the device:

<table>
<thead>
<tr>
<th>Cable</th>
<th>Terminal</th>
<th>Cable type</th>
<th>Conductor cross-section</th>
<th>Max. length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply and voltage measurement</td>
<td>X1</td>
<td>Unshielded</td>
<td>1.5 mm² with ferrule</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.5 mm² without ferrule</td>
<td>-</td>
</tr>
<tr>
<td>Blocking contact</td>
<td>X3</td>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Customer messages</td>
<td>X5</td>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>RS485; SUB-D</td>
<td>X6</td>
<td>Shielded</td>
<td>0.25 mm²</td>
<td>500 m</td>
</tr>
<tr>
<td>Optional control cabinet grounding</td>
<td>-</td>
<td>Unshielded</td>
<td>≥ 16 mm²</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 7: Recommendation for connection cables

The connection cable between the motor-drive unit and the control unit is supplied as standard.

**DANGER**

An impermissibly long connection cable between the motor-drive unit and control unit can lead to malfunctions of the motor-drive unit and the on-load tap-changer. This allows the on-load tap-changer to remain in an impermissible operating position. This can lead to an explosion in the transformer.

► Only use the connection cable provided.
► The connection cable may not be altered.

5.4.2  Connecting motor-drive unit and voltage supply

**All-pole isolating device**

You may connect the control unit only to circuits with an external overcurrent protection device and an all-pole isolating device, enabling the equipment to be fully de-energized if required (service, maintenance, etc.).

Suitable equipment includes isolating devices in accordance with IEC 60947-1 and IEC 60947-3 (e.g. circuit breakers). Observe the properties of the relevant circuits (voltage, maximum currents) when selecting the circuit breaker type. In addition, observe the following:

- It must be easy for the operator to access the isolating device
- The isolating device must be labeled for the device and the circuits to be isolated
- The isolating device may not be a part of the power line
- The isolating device may not interrupt the main protective conductor
You must connect the power supply circuit with a conductor cross-section of at least 1.5 mm² (AWG 16) and protect it with a C10A or B10A type miniature circuit breaker.

Supply via voltage transformers

Electric shock!

If you supply the device via a voltage transformer, the output voltage of the voltage transformer has no bearing on the protective conductor. As a result, protection of the device against electric shock in the event of an error is not guaranteed.

► Take appropriate measures to protect against electric shock according to IEC 61140 and the local connection regulations.

Further conditions:

▪ For the correct dimensioning of the voltage transformer, observe the information in the section "Technical data of the control unit" [► Section 14.6, Page 121].

▪ During the charging process for the energy accumulator, the measuring error of the voltage transformer can increase significantly (±2.3%). The charging process for the energy accumulator takes approx. 35 s during initial charging and approx. 0.3 s after each on-load tap-change operation.

▪ The transmission ratio of the voltage transformer must be taken into consideration when setting the desired value.

The transmission ratio influences the voltage measurement value shown in the display. Conversion within the controller is not possible.
Connecting the control unit

1. Connect the 5-wire connection cable of the motor-drive unit to terminal X4 (0.4 Nm).

2. Connect the 2-wire connection cable of the motor-drive unit to terminal X2 (0.5 Nm).

3. **DANGER!** Ensure that the connections PE, N, and L are not interchanged. Otherwise, dangerously high voltages could occur at the housing. Tighten (0.5 Nm) the control unit power supply to the plug connector for X1 in accordance with the supplied connection diagram. In addition, use the green cable housing supplied for touch protection.

4. The plug connector is coded. Carry out the installation without using force. Connect the plug connector to terminal X1 correctly according to the device labeling and screw it tight with 0.5 Nm.
5.5 Taking measurements

**WARNING**
Electric shock from incorrect operation!
Danger of death or severe injury from electric shock!
► Only take measurements when the transformer is de-energized.
► Only perform tap-change operation with the control unit.
► Tap-change operations initiated by actuation with the emergency drive shaft are not permitted during this test.

**NOTICE**
Damage to on-load tap-changer and motor-drive unit!
Damage to on-load tap-changer and transformer due to improper transformer ratio test!
► Do not perform more than 100 tap-change operations without a full oil fill.
► Only switch on-load tap-changer with the help of the control unit.
► Only use emergency drive shaft to rectify faults and never operate with a drill.

Carrying out automatic adjustment
Carry out an automatic adjustment ►Section 7.4.9.1, Page 87 prior to performing the transformer ratio test and DC resistance measurement.

Performing the transformer ratio test
1. Press on the control unit to activate manual mode.
   ⇔ LED above the key lights up.

![Figure 26: Activating manual mode](image-url)
5 Mounting

2. Press △ or ▽ until the desired operating position is reached.
   ⇒ The new operating position is displayed on the control unit.
3. Carry out the transformer ratio test in all operating positions.
   ⇒ Once the results have been checked, the transformer ratio test is complete.

Check the transformer configuration in accordance with the supplied connection diagrams if the tap-change operation is not in the desired direction.

The behavior of the control unit (lowest voltage at smallest or largest position) can be adjusted accordingly via parameterization. To do so, follow the description in the ECOTAP® VPD® MD&C motor-drive unit operating instructions, section "Inverting travel commands".

Carrying out DC resistance measurement

The measured DC current is normally restricted to 10% of the rated current of the measured transformer winding in order to prevent the winding from overheating.

Observe the maximum permitted measured currents for the on-load tap-changer during the DC resistance measurement on the transformer.

<table>
<thead>
<tr>
<th>Transformer tank state</th>
<th>Maximum permissible measured current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer tank empty</td>
<td>Maximum 10 A DC</td>
</tr>
<tr>
<td>Transformer tank filled with insulating oil</td>
<td>Maximum 10 A DC</td>
</tr>
</tbody>
</table>

Table 8: Maximum permissible measured currents

1. Press AVE on the control unit to activate manual mode.
   ⇒ LED above the key lights up.
2. Switch the on-load tap-changer through the complete regulating range using the buttons △ and ▽ to remove any potential foreign-particle build ups on the contacts.
   ⇒ The operating position will be displayed on the control unit.
3. Carry out the DC resistance measurement in all operating positions.
   ⇒ Once the results have been checked, the DC resistance measurement is complete.
5.6 Drying the on-load tap-changer

**NOTICE**

Damage to the on-load tap-changer, motor-drive unit and control unit.

If temperature-sensitive components are dried, they may become damaged.

- Remove motor-drive unit and control unit and do not dry.
- Affix the transport locking plate prior to drying to protect the on-load tap-changer.
- Ensure that the temperature of the on-load tap-changer does not exceed 135°C.

Removing motor-drive unit and control unit

1. **DANGER!** Risk of fatal injury due to electrical voltage. Ensure that all cables in the working area are de-energized and that the shutdown equipment is locked so that it cannot be switched on again.

2. Remove connectors from the terminals X1, X2 and X4 on the control unit.

3. Coil the connection cable and secure it on the motor-drive unit.

![Figure 27: Disconnecting the connection cable](image)
4. Remove the motor-drive unit.

![Figure 28: Removing the motor-drive unit](image)

5. Clean sealing surfaces on sealing module and transport locking plate and check that O-ring is in the correct position.

6. Affix the transport locking plate.

![Figure 29: Transport locking plate](image)

**Drying the on-load tap-changer**

You can dry the on-load tap-changer using one of the following methods. The drying time depends on the transformer.

- Vacuum-drying in an autoclave
- Vacuum-drying in the transformer tank
• Low-frequency drying in an autoclave
• Low-frequency drying in a transformer tank

5.7 Filling transformer with oil

For the oil filling of the transformer, use new mineral insulating oil for transformers as per IEC 60296 (Specification of unused mineral insulating oils for transformers and switchgear).

If approved by the transformer manufacturer, synthetic ester liquids as per IEC 61099 (Specification for unused synthetic organic esters for electrical purposes) or natural ester liquids as per IEC 62770 (Specification for unused natural esters for transformers and similar electrical equipment) can be used as alternatives.

Contact Maschinenfabrik Reinhausen GmbH if you want to use an alternative insulating fluid.

Observe the permitted temperature range of the transformer oil in the “Technical data” section.

**NOTICE**

Damage to the on-load tap-changer!

If a transformer is not completely filled with oil, the on-load tap-changer may be damaged!

► Before commissioning the on-load tap-changer, completely fill transformer with oil.

1. Completely fill transformer with oil.
2. Take oil sample from transformer.
3. Record temperature of oil sample just after sample is taken.
4. Determine dielectric strength and water content at an oil temperature of 20°C ± 5°C. The dielectric strength and water content must comply with the limit values stated below:

<table>
<thead>
<tr>
<th></th>
<th>U₉</th>
<th>H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>When commissioning the transformer for the first time</td>
<td>&gt; 60 kV/2.5 mm</td>
<td>&lt; 12 ppm</td>
</tr>
</tbody>
</table>

Table 9: Limit values for mineral insulating oil (dielectric strength U₉ measured in accordance with IEC 60156)
6 Commissioning

6.1 Commissioning the on-load tap-changer at the transformer manufacturer’s site

**WARNING**

Flying parts and spraying of hot oil resulting from on-load tap-changer overload!

The on-load tap-changer can switch currents of up to twice the rated through-current. Higher currents occur when activating transformers (inrush current impulse) or in the event of short-circuits, for example. Higher voltages may occur due to transformer overexcitation following load shedding, for example.

Danger of death or severe injury due to flying parts and spraying of hot oil!

► Ensure that the on-load tap-changer is not overloaded.

► Prevent on-load tap-change operations if higher currents arise.

► Ensure that the rated step voltage is not exceeded. The rated step voltage may be briefly exceeded by up to 10% as long as the rated through-current is not exceeded.

► Ensure that the temperature limit values stated in the technical data are not exceeded.

**NOTICE**

Damage to on-load tap-changer resulting from switching without oil!

Performing too many operations without a complete transformer oil fill will damage the on-load tap-changer!

► Do not perform more than 100 tap-change operations without a full oil fill.

► Only use emergency drive shaft to rectify faults and never operate with a drill.

Checking the correct position of the on-load tap-changer and motor-drive unit

**DANGER**

Danger of explosion!

An incorrect position of the on-load tap-changer or the motor drive shaft can lead to malfunction and, consequently, to an overload of the on-load tap-changer. This overload can lead to an explosion in the transformer.

► Carry out automatic adjustment and trial tap-change operations on a voltage-free transformer.

► Supply the controller and motor-drive unit via a separate voltage source during these tests.

► If a separate voltage source is not available, it is imperative that the correct position of the on-load tap-changer and motor-drive unit be checked again according to the section “Mounting the motor drive” before these tests.
1. Ensure that the motor-drive unit is positioned correctly: The feather key 1 on the motor-drive unit must be facing the marking 2:

Figure 30: Checking the position of the motor-drive unit

2. Ensure that the on-load tap-changer is positioned correctly: The marking on the cam disk 1 must be within the marked range of the cover 2:

Figure 31: Checking the position of the on-load tap-changer

3. Mount and connect motor-drive unit and control unit.

**Commissioning**

**NOTICE**

**Damage to device and system periphery**

An incorrectly connected device can cause damage to the device and system periphery.

► Check the entire configuration before commissioning.
► Make sure that the supply voltage (= measured voltage) corresponds to the specifications in the technical data.
1. Activate power supply for motor-drive unit and control unit.

   ⇒ The control unit starts automatically. The 🔄 LED flashes for 10 s to indicate the inrush interlock. After 10 s, this LED lights up blue continuously.

   ⇒ The 🔴 LED also starts by flashing and then lights up continuously as soon as the internal energy accumulator is fully charged.

   ⇒ At the same time, the red ⬆️ LED on the control unit lights up and the event code E4 appears on the display to indicate that adjustment is necessary.

2. Carry out "Automatic adjustment" [☞ Section 7.4.9.1, Page 87].

### 6.1.1 Performing trial tap-change operations

Before you activate the transformer, you must carry out trial tap-change operations to check the mechanical and electrical functions of the on-load tap-changer and the motor-drive unit.

✓ You have already carried out automatic adjustment [☞ Section 7.4.9.1, Page 87] of the on-load tap-changer and the motor-drive unit.

1. Press AVR MANUAL to activate the AVR MANUAL operating mode.

   ⇒ The status LED above the key lights up.

2. Use the RAISE/LOWER arrow keys to undertake trial tap-change operations across the entire range of settings.

3. Check that the control unit records and correctly displays every position. Otherwise, carry out automatic adjustment again.
The control ensures that the required cooling time of approx. 3 seconds is maintained after each on-load tap-change operation. During this time, the control will not accept any tap-change commands.

6.1.2 Tests on the transformer

Please contact Maschinenfabrik Reinhausen GmbH (MR) if any aspect of the tests is not clear.

6.1.2.1 Electrical high-voltage tests on the transformer

**WARNING**

**Danger of death or severe injury from explosive gases when testing the transformer!**

Danger of death from flying debris and spraying of hot oil if incorrect action is taken when explosive gases accumulate under the transformer cover, in the piping, in the oil conservator, and at the dehydrating breather opening!

► Ensure that there are no naked flames, hot surfaces or sparks (for example caused by static charging) in the immediate surroundings and that none occur.
► Ensure that the on-load tap-changer is fully submerged in oil.
► Only use conductive and grounded hoses, pipes, and pump equipment that are approved for flammable liquids.
► Ensure that all safety equipment is ready for use.
► Use suitable personal protective equipment/clothing.
► Keep away from the danger area during the transformer test.
► Observe applicable fire protection regulations.
► Make sure that only trained technicians perform work on the transformer.

Every on-load tap-changer has been specially designed by the manufacturer for the transformer in the respective purchase order and is subjected to strict tests and quality controls at the manufacturer’s factory.

However, joint operation of transformer and on-load tap-changer cannot be simulated by the manufacturer and cannot be tested on the on-load tap-changer alone.

For this reason, irregularities or malfunctions cannot be completely ruled out during the transformer test (i.e. testing the first joint operation of transformer and on-load tap-changer).
It is essential that you ensure only trained, instructed expert personnel who are familiar with and comply with the pertinent safety and technical regulations, who are aware of the potential risks, and who consistently use the occupational safety equipment provided to prevent injury and property damage are assigned to perform such a transformer test.

Remove all leads used for testing before the high voltage test as these function as antennas. Ensure that the clearance needed between bushings and motor-drive unit, including the connection cable, is observed at all times.

If you have any questions about possible sources of danger, consult the manufacturer before starting to test the transformer.

Only undertake the electrical tests required for transformer acceptance once the aforementioned work is complete.

### 6.1.2.2 Dielectric tests on transformer wiring

The motor-drive unit and control unit are subjected to dielectric tests before delivery. Another dielectric test is not necessary.

1. **DANGER!** Risk of fatal injury due to electrical voltage. Ensure that all cables in the working area are de-energized and that the shutdown equipment is locked so that it cannot be switched on again.

2. Remove connectors from the terminals X1, X2 and X4 on the control unit.

![Figure 33: Connection cable](image-url)
The LED can remain lit for up to 30 minutes after the voltage supply is disconnected. This indicates that the energy accumulator is still charged. This does not represent a hazard during mounting or removing the control unit.

1. Coil the connection cable and secure it on the motor-drive unit.
2. **NOTICE!** Damage to the control unit. Ensure that the control unit is fully disconnected.
3. Carry out dielectric tests on the transformer wiring.
4. Connect the connectors to the terminals X4, X2 and X1 on the control unit.

### 6.1.3 Resetting automatic adjustment

Reset the automatic adjustment prior to transporting the transformer to the installation site. This ensures that automatic adjustment is carried out again during commissioning at the installation site.

To reset the automatic adjustment, proceed as follows:

- The AVR MANUAL operating mode is active.

1. Press \[\text{MENU}\]
2. Press \[\text{▲} + \text{▼}\] for longer than 5 seconds.
   - \[\text{▲} \text{▲} \text{▲} \text{▲} \text{▲}\]
3. Press \[\text{▲}\] until code 3 is displayed.
   - \[\text{▲} \text{▲} \text{▲} \text{▲} \text{▲}\]
4. Press \[\text{AVR MANUAL}\] to confirm the selection.
   - The LED ▲ lights up and event code E4 is displayed.
6 Commissioning

6.2 Transporting transformer to the operating site

**DANGER**
Risk of life-threatening injury due to electric shock!
If the device and system peripherals are not disconnected from the mains, electric shock may occur!

- De-energize the device and system peripherals and lock them to prevent them from being switched back on.

**NOTICE**
Damage to the on-load tap-changer!
Damage to the on-load tap-changer due to incorrect positioning!

- Do not disconnect the motor-drive unit from the on-load tap-changer after the on-load tap-changer's automatic adjustment.

1. To transport the transformer, disconnect connection cable from control unit. You will find a description of this process in the “Dielectric tests on the transformer wiring” section.

2. **NOTICE!** Damage to the motor-drive unit due to moisture ingress. Coil the connection cable, secure it on the motor-drive unit and use plastic film and adhesive tape to protect from moisture.

3. **NOTICE!** Damage to the control unit due to incorrect transportation or storage. Transport control unit in MR packaging used for delivery. Do not transport or store the control unit in the open.

6.3 Commissioning transformer at operating site

**WARNING**
Flying parts and spraying of hot oil resulting from on-load tap-changer overload!
The on-load tap-changer can switch currents of up to twice the rated through-current. Higher currents occur when activating transformers (inrush current impulse) or in the event of short-circuits, for example. Higher voltages may occur due to transformer overexcitation following load shedding, for example.

Danger of death or severe injury due to flying parts and spraying of hot oil!

- Ensure that the on-load tap-changer is not overloaded.
- Prevent on-load tap-change operations if higher currents arise.
- Ensure that the rated step voltage is not exceeded. The rated step voltage may be briefly exceeded by up to 10% as long as the rated through-current is not exceeded.
- Ensure that the temperature limit values stated in the technical data are not exceeded.
6.3.1 Checking the correct position of the on-load tap-changer and motor-drive unit

**Danger of explosion!**

An incorrect position of the on-load tap-changer or the motor drive shaft can lead to malfunction and, consequently, to an overload of the on-load tap-changer. This overload can lead to an explosion in the transformer.

- Carry out automatic adjustment and trial tap-change operations on a voltage-free transformer.
- Supply the controller and motor-drive unit via a separate voltage source during these tests.
- If a separate voltage source is not available, it is imperative that the correct position of the on-load tap-changer and motor-drive unit be checked again according to the section "Mounting the motor drive" before these tests.

1. Ensure that the motor-drive unit is positioned correctly: The feather key \(^1\) on the motor-drive unit must be facing the marking \(^2\):

![Figure 34: Checking the position of the motor-drive unit](image)

2. Ensure that the on-load tap-changer is positioned correctly: The marking \(^1\) on the cam disk must be within the marked range of the cover \(^2\):

![Figure 35: Checking the position of the on-load tap-changer](image)

For further details, see section "Mounting the motor-drive unit [› Section 5.3, Page 33]."
6.3.2 Mounting the control unit on an even surface

1. Secure the control unit to the even surface using the fixing brackets provided for this purpose. Note the dimensional drawing in the appendix.

2. Use one of the lower attachment points to ground the control unit housing. To do so, crimp a grounding conductor (minimum cross-section 8 mm²) with a ring-type cable terminal and attach it with washers (contact washer and safety washer) and M6 bolt.

![Figure 36: Mounting the control unit](image)

6.3.3 Connecting control unit at operating site

The following section describes how to make the electrical connection to the control unit at the operating site.

**DANGER**

**Risk of fatal injury due to electrical voltage!**

Danger of death due to electrical voltage when assembling and connecting the device.

- De-energize the device and system peripherals and lock them to prevent them from being switched back on.
### 6.3.3.1 Cable recommendation

Please note the following recommendation from Maschinenfabrik Reinhausen GmbH when wiring the device:

<table>
<thead>
<tr>
<th>Cable</th>
<th>Terminal</th>
<th>Cable type</th>
<th>Conductor cross-section</th>
<th>Max. length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply and voltage measurement</td>
<td>X1</td>
<td>Unshielded</td>
<td>1.5 mm² with ferrule</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.5 mm² without ferrule</td>
<td>-</td>
</tr>
<tr>
<td>Blocking contact</td>
<td>X3</td>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Customer messages</td>
<td>X5</td>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>RS485; SUB-D</td>
<td>X6</td>
<td>Shielded</td>
<td>0.25 mm²</td>
<td>500 m</td>
</tr>
<tr>
<td>Optional control cabinet grounding</td>
<td>-</td>
<td>Unshielded</td>
<td>≥ 16 mm²</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 10: Recommendation for connection cables

The connection cable between the motor-drive unit and the control unit is supplied as standard.

**Danger of explosion!**

An impermissibly long connection cable between the motor-drive unit and control unit can lead to malfunctions of the motor-drive unit and the on-load tap-changer. This allows the on-load tap-changer to remain in an impermissible operating position. This can lead to an explosion in the transformer.

- Only use the connection cable provided.
- The connection cable may not be altered.

### 6.3.3.2 Electromagnetic compatibility

The device has been developed in accordance with applicable EMC standards. The following points must be noted in order to meet the EMC standards.

#### 6.3.3.2.1 Wiring requirement of installation site

Note the following when selecting the installation site:

- The system’s overvoltage protection must be effective.
- The system’s ground connection must comply with all technical regulations.
- Separate system parts must be joined by a potential equalization.
6.3.3.2 Wiring requirement of operating site

Note the following when wiring the operating site:

- Route the connecting leads in grounded metal cable ducts.
- Do not route lines which cause interference (for example power lines) and lines susceptible to interference (for example signal lines) in the same cable duct.
- Maintain a clearance of at least 100 mm between lines causing interference and lines susceptible to interference.

Figure 37: Recommended wiring

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable duct for lines causing interference</td>
<td>Line causing interference (for example power line)</td>
<td>Cable duct for lines susceptible to interference</td>
<td>Line susceptible to interference (e.g. signal line)</td>
</tr>
</tbody>
</table>

- Short-circuit and ground reserve lines.
- Never connect the device with a multi-core bus line.
- For signal transmission, use shielded lines with individual conductors (outgoing conductor / return conductor) twisted in pairs.
- The shield must be connected across the entire surface (360°).

For optional installation of the control unit in a control cabinet, also note the following:

1. If both the control cabinets in which the start and end of the cable are connected are on the same potential: Use shield on both sides.
2. \textbf{NOTICE!} If both the control cabinets in which the start and end of the cable are connected are on a different potential: Only use shield on one side. Otherwise circulating currents caused by potential equalization will arise which may cause damage due to grounding loops.
6.3.3.3 Requirements for the power supply circuit

Power supply during commissioning tests

⚠️ Danger!
An incorrect position of the on-load tap-changer or the motor drive shaft can lead to malfunction and, consequently, to an overload of the on-load tap-changer. This overload can lead to an explosion in the transformer.

► Carry out automatic adjustment and trial tap-change operations on a voltage-free transformer.
► Supply the controller and motor-drive unit via a separate voltage source during these tests.
► If a separate voltage source is not available, it is imperative that the correct position of the on-load tap-changer and motor-drive unit be checked again according to the section "Mounting the motor drive" before these tests.

Ensure the correct position of motor-drive unit: The feather key 1 of the motor shaft must be facing the mark 2.

Figure 38: Example: Shield with cable screw connections

Figure 39: Check the position of the motor-drive unit
Ensure the correct position of the on-load tap-changer: The marking on the cam disk 1 must be in the marked area on the cover 2.

![Figure 40: Checking the position of the on-load tap-changer](image)

Further details: See section "Mounting the motor-drive unit".

### Power supply during operation

After completing the test tap-change operations, you must adjust the power supply for the control unit supplied from a separate power source for the tests.

The electrical voltage of the motor-drive unit and control unit has to be supplied by the controlled transformer itself during operation, because this signal is also used as the measurement signal.

### All-pole isolating device

You may connect the control unit only to circuits with an external overcurrent protection device and an all-pole isolating device, enabling the equipment to be fully de-energized if required (service, maintenance, etc.).

Suitable equipment includes isolating devices in accordance with IEC 60947-1 and IEC 60947-3 (e.g. circuit breakers). Observe the properties of the relevant circuits (voltage, maximum currents) when selecting the circuit breaker type. In addition, observe the following:

- It must be easy for the operator to access the isolating device
- The isolating device must be labeled for the device and the circuits to be isolated
- The isolating device may not be a part of the power line
- The isolating device may not interrupt the main protective conductor

You must connect the power supply circuit with a conductor cross-section of at least 1.5 mm² (AWG 16) and protect it with a C10A or B10A type miniature circuit breaker.
Supply via voltage transformers

**DANGER**

Electric shock!
If you supply the device via a voltage transformer, the output voltage of the voltage transformer has no bearing on the protective conductor. As a result, protection of the device against electric shock in the event of an error is not guaranteed.

► Take appropriate measures to protect against electric shock according to IEC 61140 and the local connection regulations.

Further conditions:

- For the correct dimensioning of the voltage transformer, observe the information in the section "Technical data of the control unit" [► Section 14.6, Page 121].

- During the charging process for the energy accumulator, the measuring error of the voltage transformer can increase significantly (±2.3%). The charging process for the energy accumulator takes approx. 35 s during initial charging and approx. 0.3 s after each on-load tap-change operation.

6.3.3.4 Connecting control unit in standard design

For the correct connection, observe the connection diagram supplied.

1. Connect the 5-wire connection cable of the motor-drive unit to terminal X2 (0.5 Nm).

2. Connect the 2-wire connection cable of the motor-drive unit to terminal X2 (0.5 Nm).

3. Secure the connecting cable of the motor-drive unit with a strain relief in the area before the cable harness is split.

Figure 41: Connection cable connection
4. Screw the signal for blocking (e.g. door interlock or temperature blocking) onto the supplied plug connector for X3 with a torque of 0.4 Nm. Tighten the plug connector onto terminal X3 with a torque of 0.4 Nm.

5. Screw the wiring for the "Customer messages" interface (ready/error) to the supplied plug connector for X5 with a torque of 0.4 Nm. Tighten the plug connector onto terminal X5 with a torque of 0.4 Nm.

6. **DANGER!** Ensure that the connections PE, N, and L are not interchanged. Otherwise, dangerously high voltages could occur at the housing. Tighten (0.5 Nm) the control unit power supply to the plug connector for X1 in accordance with the supplied connection diagram. In addition, use the green cable housing supplied for touch protection.

7. The plug connector is coded. Carry out the installation without using force by connecting the plug connector to terminal X1 correctly according to the device labeling and screwing it tight with 0.5 Nm.

### 6.3.4 Switching on power supply

**Danger of explosion!**

An incorrect position of the on-load tap-changer or the motor drive shaft can lead to malfunction and, consequently, to an overload of the on-load tap-changer. This overload can lead to an explosion in the transformer.

- Carry out automatic adjustment and trial tap-change operations on a voltage-free transformer.
- Supply the controller and motor-drive unit via a separate voltage source during these tests.
- If a separate voltage source is not available, it is imperative that the correct position of the on-load tap-changer and motor-drive unit be checked again according to the section "Mounting the motor drive" before these tests.

Ensure that the transformer is idle.

To protect the loads from impermissible fluctuations in voltage, only activate the load circuits (low-voltage busbar) after all tests are finished.
To activate the motor-drive unit and control unit, proceed as follows:

1. Activate the power supply for the control unit.
   - The control unit starts automatically after a few seconds. The LED flashes for 10 s to indicate the inrush interlock. After 10 s, this LED lights up blue continuously.
   - The LED also starts by flashing and then lights up continuously as soon as the internal energy accumulator is fully charged.
   - If the LED is not lit up, then the control unit is ready.
   - If the red LED is lit up and the E4 event code appears in the display, the motor-drive unit and control unit have not yet been adjusted to one another.

2. Before commissioning, an automatic adjustment of the on-load tap-changer and the motor-drive unit must be made. Observe section "Automatic adjustment [Section 7.4.9.1, Page 87]" for this.

6.3.5 Performing trial tap-change operations

Before you activate the transformer, you must carry out trial tap-change operations to check the mechanical and electrical functions of the on-load tap-changer and the motor-drive unit.

✓ You have already carried out automatic adjustment [Section 7.4.9.1, Page 87] of the on-load tap-changer and the motor-drive unit.

1. Press to activate the AVR MANUAL operating mode.
   - The status LED above the key lights up.
2. Use the RAISE/LOWER arrow keys to undertake trial tap-change operations across the entire range of settings.

3. Check that the control unit records and correctly displays every position. Otherwise, carry out automatic adjustment again.

The control ensures that the required cooling time of approx. 3 seconds is maintained after each on-load tap-change operation. During this time, the control will not accept any tap-change commands.

6.3.6 Switching on medium voltage

After completing the trial tap-change operations, you must adjust the voltage supply for the control unit supplied through a separate power source. The voltage supply has to be supplied by the controlled transformer itself during operation, because this signal is also used as the measurement signal.

1. **DANGER!** Ensure that all cables in the working area are de-energized and that the shutdown equipment is locked so that it cannot be switched on again. Otherwise, there is a risk of fatal injury due to electrical voltage during the subsequent work.

2. Screw on the plug connector for terminal X1 on the control unit.

3. Disconnect wiring to the separate power source from this plug connector.

4. Adjust the voltage supply from the transformer to the specification and the information in the technical data [► Section 14, Page 115].

5. **DANGER!** Ensure that the connections PE, N, and L are not interchanged. Otherwise, dangerously high voltages could occur at the housing. Tighten (0.5 Nm) the wiring for the transformer power supply to the plug connector for X1 in accordance with the supplied connection diagram.

6. The plug connector is coded. Carry out the installation without using force. Connect the plug connector to terminal X1 correctly according to the device labeling and screw it tight with 0.5 Nm.

To protect the loads from impermissible fluctuations in voltage, only activate the load circuits (low-voltage busbar) after all tests are finished.
To activate the motor-drive unit and control unit, proceed as follows:

► Switch on medium voltage (transformer is idle).

◇ The control unit starts automatically after a few seconds. The (LED flashes for 10 s to indicate the inrush interlock. After 10 s, this LED lights up blue continuously.

◇ The  LED also starts by flashing and then lights up continuously as soon as the internal energy accumulator is fully charged.

◇ If the  LED is not lit up, then the control unit is ready.

◇ If the red  LED lights up and the E4 event code is shown in the display, the automatic adjustment was not carried out correctly.

### 6.3.7 Setting parameters

Set the most important parameters for commissioning the device in accordance with your requirements:

1. P1: Set desired voltage [► Section 7.4.1.1, Page 76].
2. P2.1: Set bandwidth B1 [► Section 7.4.1.2, Page 77].
3. P2.2: Set delay time T1 [► Section 7.4.1.3, Page 78].
4. P3.1: Set bandwidth B2 [► Section 7.4.1.4, Page 78].
5. P3.2: Set delay time T2 [► Section 7.4.1.5, Page 79].
6. P4.1: Set undervoltage blocking [► Section 7.4.2.1, Page 80].
7. P4.2: Set overvoltage blocking [► Section 7.4.2.2, Page 80].
8. P5: Set blocking function [► Section 7.4.3, Page 81].
9. F5: Set inverting [► Section 7.4.13, Page 91].

◇ The most important parameters for voltage regulation have been set.

If you would like to set further parameters, follow section Configuring the control unit [► Section 7.4, Page 75].

### 6.3.8 Checking automatic voltage regulation

To check the automatic voltage regulation, proceed as follows:

1. Measure voltage on low-voltage side of transformer.
2. Press  to activate the AVR MANUAL operating mode.
3. Press  or  as often as necessary until the measured voltage is beyond the range of the set bandwidth (desired voltage ± bandwidth).
4. Press  to activate AVR AUTO operating mode.

◇ After the delay time, the on-load tap-changer moves back into the range of the set bandwidth. If this does not happen, check the voltage regulation parameters [► Section 7.4.1, Page 75] and repeat the test.
5. Press \textsuperscript{AVR MANUAL} to activate the AVR MANUAL operating mode.
\(\Rightarrow\) Automatic voltage regulation has been checked.

6.3.9 When operating with alternative insulating liquids: activating temperature blocking

You can operate the on-load tap-changer with alternative insulating fluids upon request. When doing so, you must ensure that switching operations cannot be performed during operation if the transformer's insulating fluid temperature is less than the permissible temperature. You can use the control unit blocking contact for this.

To use the control unit blocking contact, observe the following points:
- The temperature sensor in the transformer tank must be adjusted to the permissible temperature range.
- The temperature sensor must make a signal in the form of a floating contact available, and it must be connected to the control unit blocking contact (terminal X3).
- The blocking function parameter (P5) must be set to the value 2 [\(\Rightarrow\) Section 7.4.3, Page 81].

6.3.10 Switching on the low-voltage busbar

\textbf{NOTICE}

Damage to the on-load tap-changer and transformer!

An inrush current impulse which has not fully subsided can damage the on-load tap-changer and transformer in the event of an on-load tap changing operation!

\(\Rightarrow\) Once the transformer has been switched on, ensure that the inrush current impulse has fully subsided before undertaking an on-load tap changing operation. The inrush current impulses are usually a multiple of the transformer rated current and can overload the on-load tap-changer during the diverter switch operation.

Once you have connected the control unit and undertaken trial tap-change operations, you can commission the low-voltage busbar as follows:

1. Move the on-load tap-changer to the adjustment position.

   It may be a good idea to move the on-load tap-changer into a position other than the adjustment position. This allows you to reduce the voltage differences between the grids to be connected and thereby minimize the inrush current impulse.

2. On the control unit, set the desired operating mode by pressing the corresponding key:
   - Auto mode: AVR AUTO
   - Manual mode: AVR MANUAL
   - Control via remote connection: EXTERNAL CONTROL.

3. Switch on the low-voltage busbar.
4. Once the transformer has been switched on, ensure that the inrush current impulse has subsided.

⇒ On-load tap-change operations can now be undertaken both when idling and under load conditions.
7 Operation

On-load tap-change operations can be undertaken both manually and automatically. You can see the selected operating mode on the LED display on the control unit.

In the EXTERNAL CONTROL operating mode, the device executes control commands from an external controller (e.g., ECOTAP® VPD® CONTROL PRO). In this case, manual operation using the LOWER and RAISE keys is not possible. In this case, please note the safety instructions and the detailed description in the associated operating instructions for the external controller.

In the AVR AUTO operating mode, the tap-change operations are executed in accordance with the set control parameters.

By pressing the AVR MANUAL key once, you can switch to the manual operating mode and then execute tap-change operations by pressing the UP/DOWN arrow keys.

Standard mode is not designed for tap-change operations without a control unit.

Should you experience problems in operating the control unit or on-load tap-changer, consult the "Fault elimination" section.

7.1 Monitoring on-load tap-changer

Monitoring of the on-load tap-changer, motor-drive unit, and control unit is limited to occasional visual checks. For efficiency reasons, these visual checks can be combined with the usual checks on the transformer.

Pay particular attention to the following:

- Oil impermeability at transition points between sealing module and transformer cover
- Cable connections between control unit and motor-drive unit are in a sound condition
- Other damage

In the event of noticeable discrepancies, contact Maschinenfabrik Reinhausen GmbH's Technical Service department.
**NOTICE**

**Damage to the on-load tap-changer!**

Damage to the on-load tap-changer resulting from switching the on-load tap-changer at impermissible oil temperatures!

- The on-load tap-changer can be operated in the temperature range of the surrounding transformer oil of between −25 °C and +105 °C and in accordance with IEC 60214-1 up to +115 °C (during emergency transformer operation in accordance with IEC 60076-7).

- If using alternative insulating liquids, only a limited temperature range is permitted during operation. Ensure compliance with the specified temperature limit values and observe the following information.

The temperature limit values to be taken into account depending on the insulating fluid used can be found in the "Technical data" section.

Ensure that the temperature limit values are not exceeded and that the "Temperature blocking [► Section 6.3.9, Page 67]" function works correctly.

### 7.2 Selecting the operating mode

You can select the operating mode via the operating controls on the front panel of the control unit.

**AVR MANUAL** manual mode

In manual mode, you can perform tap-change operations via the [▲] (increase voltage) and [▼] (reduce voltage) keys.

**NOTICE**

**Damage to property through uncontrolled on-load tap-change operations.**

As a result of uncontrolled manual tap-change operations, the line voltage of the consumers may exceed the permitted limit values. This may result in damage to the devices and subsequent damage.

- Only undertake manual tap-change operations if no consumers are connected or if you can ensure that the line voltage on the consumer side does not leave the permitted operating range.

To perform manual tap-change operations, proceed as follows:

1. Press [AVR MANUAL] to activate manual mode.
2. Press [▲] or [▼] to execute a tap-change operation.
AVR AUTO auto mode

In auto mode, the device executes the tap-change operations automatically, depending on the set control parameters. Observe section "Configuring the control unit" [Section 7.4, Page 75] for further information on the control parameters. To activate auto mode, proceed as follows:

► Press AVR AUTO to activate auto mode.

Control via EXTERNAL CONTROL

In the EXTERNAL CONTROL operating mode, the device executes the control commands of an external control unit (e.g. ECOTAP® VPD® CONTROL PRO). Refer to the operating instructions supplied with the control unit for more information.

To activate control via EXTERNAL CONTROL, proceed as follows:

► Press EXTERNAL CONTROL to activate control via EXTERNAL CONTROL.

The device will perform the OLTC-PreCheck. In this mode, the OLTC-PreCheck is automatically repeated every 24 hours.

7.3 Actuating on-load tap-changer using the emergency drive shaft

WARNING

Danger of death or severe injury!

Improper actuation of the on-load tap-changer may result in death or serious injury!

► Fully de-energize the transformer and lock to prevent it from being switched back on.

► Only actuate the on-load tap-changer using the emergency drive shaft to set the adjustment position or for emergency operation. Emergency operation is to be understood as the failure of the motor-drive unit's voltage supply when there is an urgent need to perform an on-load tap-change operation.

► Only actuate the on-load tap-changer using the emergency drive shaft installed in the sealing module.
1. **DANGER!** Risk of fatal injury due to electrical voltage. Ensure that all cables in the working area are de-energized and that the shutdown equipment is locked so that it cannot be switched on again.

2. Remove connectors from the terminals X1, X2 and X4 on the control unit.

![Figure 43: Removing the connection cable](image)

3. Loosen screws and lift motor-drive unit off sealing module.

![Figure 44: Removing the motor-drive unit](image)
4. Pull the emergency drive shaft out of the bracket in the sealing module.

Figure 45: Pulling the emergency drive shaft out of the bracket

5. Plug the emergency drive shaft with feather key into the shaft of the on-load tap-changer.

Figure 46: Inserting the emergency drive shaft into the shaft of the on-load tap-changer
6. **NOTICE!** Damage to the on-load tap-changer due to a tap-change operation not being completed correctly. Turn the emergency drive shaft using a suitable tool in one direction until reaching one complete revolution and the arrow on the cam disk is again facing the arrow in the cover.

![Figure 47: Turning the emergency drive shaft](image)

The operating position reached is displayed by the control wheel.

![Figure 48: Checking the operating position](image)

7. Pull the emergency drive shaft out of the shaft of the on-load tap-changer and insert it into the bracket.

![Figure 49: Inserting the emergency drive shaft into the bracket](image)
8. Mount the motor-drive unit.
9. Connect the connectors to the terminals X4, X2 and X1 on the control unit.

### 7.4 Configuring the control unit

This chapter describes how to configure the control unit.

Settings are only saved once the parameterization menu is exited via the \[\text{MEN}\] key. If you do not press the \[\text{MEN}\] key within 30 s, the parameterization menu is exited automatically and the changes are not saved.

#### 7.4.1 Regulation

All of the parameters required for the regulation function are described in this section.

In AVR AUTO auto mode, voltage regulation works as follows:

- If the measured voltage $U_{\text{actual}}$ is within the set bandwidth $\delta$, no control commands are issued to the motor-drive unit for the tap-change operation.
- Control commands will also not be issued to the motor-drive unit if the measured voltage returns to the tolerance bandwidth within the set delay time $T_1$.
- However, if the measured voltage deviates from the set bandwidth for a longer period, a tap-change command occurs after expiration of the set delay time. The on-load tap-changer carries out a tap-change in a raise or lower direction to return to the tolerance bandwidth.
7.4.1.1 Desired voltage (P1)

You can use this parameter to set the desired value for voltage regulation. To do so, proceed as follows:

- **✓** The AVR MANUAL operating mode is active.

1. Press \( \text{MENU} \) until the desired parameter is displayed.

2. Press \( \text{AVR} \) to confirm the selection.

3. Press \( \text{or} \) to select the desired value.

4. Press \( \text{AVR} \) to confirm the selection.

5. Press \( \text{MENU} \) to save the setting.
7.4.1.2 Bandwidth B1 (P2.1)

You can use this parameter to set the maximum permissible deviation in measured voltage $U_{\text{actual}}$ from the desired value $U_{\text{desired}}$. The following section describes how you determine and set the bandwidth.

Determining bandwidth

In order to set the correct value, the transformer step voltage and nominal voltage must be known. Note that a large bandwidth will result in a large control deviation.

The bandwidth must always be greater than the following value:

$$\pm B\% \geq 0.6 \cdot \frac{|U_{n-1} - U_n|}{U_{\text{nom}}} \cdot 100\%$$

The following transformer values are used to determine the minimum bandwidth:

- Nominal voltage $U_{\text{nom}} = 400\,\text{V}$
- Step voltage in tap position 4 $U_{\text{Pos.4}} = 390\,\text{V}$
- Step voltage in tap position 5 $U_{\text{Pos.5}} = 400\,\text{V}$

$$\pm B\% \geq 0.6 \cdot \frac{|390\,\text{V} - 400\,\text{V}|}{400\,\text{V}} \cdot 100\%$$

$$\pm B\% \geq 1.5\%$$

Setting bandwidth B1 (P2.1)

To set the bandwidth, proceed as follows:

1. The AVR MANUAL operating mode is active.
2. Press $\text{Men}$ > $\text{P}$ until the desired parameter is displayed.
7.4.1.3 Delay time T1 (P2.2)

The delay time T1 delays the issuing of a tap-change command for a defined period. This prevents unnecessary tap-change operations if the tolerance bandwidth is exited only briefly.

To set the delay time T1, proceed as follows:
- The AVR MANUAL operating mode is active.

1. Press [>] until the desired parameter is displayed.

2. Press [ ] to confirm the selection.

3. Press [ ] until the desired parameter is displayed.

4. Press [ ] to confirm the selection.

5. Press [ ] or [ ] to select the desired value. Alternative: Press [ ] + [ ] or [ ] + [ ] to set the value in larger steps.

6. Press [ ] to confirm the selection.

7. Press [ ] to save the setting.

7.4.1.4 Bandwidth B2 (P3.1)

You can use this parameter to set the maximum permissible deviation of measured voltage $U_{\text{actual}}$ from the desired value $U_{\text{desired}}$ for fast regulation. Ensure that the value is always at least 0.5% greater than the bandwidth B1. If you set a lower value, the device corrects the setting automatically. If you select the "off" option, fast regulation is deactivated.
To set the B2 bandwidth, proceed as follows:

- The AVR MANUAL operating mode is active.

1. Press \( \text{MEN} > \text{eq} \) until the desired parameter is displayed.

\[ \text{P38888} \]

2. Press \( \text{AVR MAN} \) to confirm the selection.

\[ \text{P31111} \]

3. Press \( \text{AVR MAN} \) to confirm the selection.

4. Press \( \text{eq} \) or \( \text{eq} \) to select the desired value.

5. Press \( \text{AVR MAN} \) to confirm the selection.

6. Press \( \text{MEN} \) to save the setting.

### 7.4.1.5 Delay time T2 (P3.2)

The delay time delays the issuing of a tap-change command for a defined period. This prevents unnecessary tap-change operations if the tolerance bandwidth is exited only briefly. Delay time T2 enables a faster response to larger changes in voltage compared with T1. Note that the setting range is dependent on the delay time T1:

- For \( T1 \leq 10 \text{ s} \): \( T2 = 2 \text{ s} \ldots (T1 - 1 \text{ s}) \)
- For \( T1 > 10 \text{ s} \): \( T2 = 2 \text{ s} \ldots (T1 - 5 \text{ s}) \)

To set the delay time T2, proceed as follows:

- The AVR MANUAL operating mode is active.

1. Press \( \text{MEN} > \text{eq} \) until the desired parameter is displayed.

\[ \text{P38888} \]

2. Press \( \text{AVR MAN} \) to confirm the selection.

3. Press \( \text{eq} \) until the desired parameter is displayed.

\[ \text{P32222} \]

4. Press \( \text{AVR MAN} \) to confirm the selection.

5. Press \( \text{eq} \) or \( \text{eq} \) to select the desired value. Alternative: Press \( \text{AVR AUTO} + \text{eq} \) or \( \text{AVR AUTO} + \text{eq} \) to set the value in larger steps.

6. Press \( \text{AVR MAN} \) to confirm the selection.

7. Press \( \text{MEN} \) to save the setting.
7.4.2 Voltage blocking (P4)

You can use voltage blocking to define limit values for blocking the automatic voltage regulation (AVR AUTO). This allows you to avoid unnecessary tap-change operations in the event of strong voltage changes in the mains.

- Undervoltage blocking: Blocking is activated as soon as the measured value is less than the limit value.
- Overvoltage blocking: Blocking is activated as soon as the measured value is greater than the limit value.

7.4.2.1 Undervoltage blocking (P4.1)

To set the undervoltage blocking, proceed as follows:

1. Press until the desired parameter is displayed.
2. Press to confirm the selection.
3. Press to confirm the selection.
4. Press or to select the desired value. Alternative: Press to set the value in larger steps.
5. Press to confirm the selection.
6. Press to save the setting.

7.4.2.2 Overvoltage blocking (P4.2)

To set the overvoltage blocking, proceed as follows:

1. Press until the desired parameter is displayed.
2. Press to confirm the selection.
3. Press until the desired parameter is displayed.
4. Press to confirm the selection.
5. Press or to select the desired value. Alternative: Press to set the value in larger steps.
6. Press \text{AVR MANUAL} to confirm the selection.
7. Press \text{MENU} to save the setting.

7.4.3 Blocking function (P5)

The control unit is equipped with a blocking contact. You can use this to connect a door contact switch or a temperature sensor, for example. If you would like to use a temperature sensor, the temperature sensor must make a signal in the form of a floating contact available. Observe the supplied connection diagram and section "Connecting the control unit at the installation site" \cite[Section 6.3.3, Page 57]{Section} for this.

You can use the blocking function (P5) parameter to set the device's response if a blocking contact is closed:

- \(0 = \) inactive: The status of the blocking contact does not affect the behavior of the device. Use this setting if you have not connected a door contact switch or temperature sensor to the device.
- \(1 = \) active AUTO/EXTERNAL: If the blocking contact is closed, all switching operations in the operating modes AVR AUTO and EXTERNAL CONTROL are blocked by the device. Manual switching operations can still be performed in the AVR MANUAL operating mode.
- \(2 = \) active MANUAL/AUTO/EXTERNAL: If the blocking contact is closed, all switching operations in all operating modes (AVR MANUAL, AVR AUTO, and EXTERNAL CONTROL) are blocked by the device.

The \(\Delta\) LED lights up if blocking is active.

To set the blocking function, proceed as follows:

1. Press \text{AVR MANUAL} until the desired parameter is displayed.
2. Press \text{AVR MANUAL} to confirm the selection.
3. Press \text{AVR MANUAL} or \text{AVR MANUAL} to select the desired option.
4. Press \text{AVR MANUAL} to confirm the selection.
5. Press \text{MENU} to save the setting.

7.4.4 Target position for loss of voltage (P6)

The control unit is fitted with an integrated energy accumulator so that a tap-change operation that has been started can be reliably completed even if the voltage fails. You can also use the energy accumulator to drive the on-load tap-changer to a defined position in the event of a voltage failure. As a result, you can achieve a defined transformer transmission ratio once the voltage supply returns.
You can only use the function "Target position for loss of voltage" in the operating modes AVR AUTO and EXTERNAL CONTROL.

**NOTICE**

**Damage to the on-load tap-changer and transformer!**

The inrush interlock is not active when switching to the target tap position. If the voltage returns while switching to the target tap position, the on-load tap-changer and transformer may be damaged.

- Only switch the transformer back on after a voltage failure once the on-load tap-changer is in the set target position (approximately 20 seconds after the voltage failed).

### 7.4.4.1 Setting the target position (P6.1)

You can use this parameter to set the target position. To do so, proceed as follows:

- The AVR MANUAL operating mode is active.

1. Press \[\text{MENU} \gg \text{Δ} \] until the desired parameter is displayed.

   \[\Rightarrow \text{P6}\ddots\ddots\ddots\ddots\ddots\]

2. Press \[\text{AVR MENU} \gg \text{Δ} \] to confirm the selection.

3. Press \[\text{Δ} \] until the desired parameter is displayed.

   \[\Rightarrow \text{P6}\ddots\ddots\ddots\ddots\ddots\]

4. Press \[\text{AVR MENU} \gg \text{Δ} \] to confirm the selection.

5. Press \[\text{AVR MENU} \gg \text{Δ} \] or \[\text{AVR MENU} \gg \text{Δ} \] to set the desired target position.

6. Press \[\text{AVR MENU} \gg \text{Δ} \] to confirm the selection.

7. Press \[\text{MENU} \gg \text{Δ} \] to save the setting.

### 7.4.4.2 Activating/deactivating target position for loss of voltage (P6.2)

You can use this parameter to activate and deactivate the function "Target position for loss of voltage". You can select the following options:

- 0 = inactive
- 1 = active
To activate or deactivate the "Target position for loss of voltage" function, proceed as follows:

✔ The AVR MANUAL operating mode is active.

1. Press \( \text{\textgreater} \) until the desired parameter is displayed.

    \( \Rightarrow P_6 \quad \text{\textgreater} \quad \)

2. Press \( \text{AVR MANUAL} \) to confirm the selection.

3. Press \( \) until the desired parameter is displayed.

    \( \Rightarrow P_6 \quad \) \( \) 

4. Press \( \text{AVR MANUAL} \) to confirm the selection.

5. Press \( \) or \( \) to set the desired option.

6. Press \( \text{AVR MANUAL} \) to confirm the selection.

    \( \Rightarrow \) \( \) 

7. Press \( \) until code 3 is displayed.

    \( \Rightarrow \) \( \) 

8. Press \( \text{AVR MANUAL} \) to confirm the selection.

9. Press \( \text{MENU} \) to save the setting.

### 7.4.5 Number of operating positions (P7)

The control unit can be configured for different types of ECOTAP® VPD® on-load tap-changer. You must set the number of operating positions accordingly.

When you perform the automatic adjustment (F1.1), the parameter P7 is automatically set to the correct value.

To set the number of operating positions, proceed as follows:

✔ The AVR MANUAL operating mode is active.

1. Press \( \text{MENU} \) \( \text{\textgreater} \) \( \) until the desired parameter is displayed.

    \( \Rightarrow P_7 \quad \) 

2. Press \( \text{AVR MANUAL} \) to confirm the selection.

3. Press \( \) or \( \) to select the desired value.

4. Press \( \text{AVR MANUAL} \) to confirm the selection.
5. Press \( \text{MENU} \) to save the setting.

### 7.4.6 Regulating range (P8)

You can limit the permissible regulating range as necessary. Here, you can set the lowest operating position and the highest operating position.

The limited regulating range applies to all operating modes. You can, however, move to an operating position outside of the permissible regulating range via the "Target position for loss of voltage" function.

#### 7.4.6.1 Lowest operating position (P8.1)

You can use this parameter to set the lowest permissible operating position. To do so, proceed as follows:

- The AVR MANUAL operating mode is active.

1. Press \( \text{MENU} > \text{AVR MANUAL} \) until the desired parameter is displayed.

\[ P8 \]

2. Press \( \text{AVR MANUAL} \) to confirm the selection.

3. Press \( \text{AVR MANUAL} \) until the desired parameter is displayed.

\[ P8 \]

4. Press \( \text{AVR MANUAL} \) to confirm the selection.

5. Press \( \text{AVR MANUAL} \) or \( \text{AVR MANUAL} \) to select the desired value.

6. Press \( \text{AVR MANUAL} \) to confirm the selection.

7. Press \( \text{MENU} \) to save the setting.

#### 7.4.6.2 Highest operating position (P8.2)

You can use this parameter to set the highest permissible operating position. To do so, proceed as follows:

- The AVR MANUAL operating mode is active.

1. Press \( \text{MENU} > \text{AVR MANUAL} \) until the desired parameter is displayed.

\[ P8 \]

2. Press \( \text{AVR MANUAL} \) to confirm the selection.

3. Press \( \text{AVR MANUAL} \) until the desired parameter is displayed.

\[ P82 \]
4. Press \text{AVR Manual} to confirm the selection.
5. Press \text{ or } to select the desired value.
6. Press \text{AVR Manual} to confirm the selection.
7. Press \text{Menu} to save the setting.

7.4.7 Remote behavior (P9)

You can use this parameter to set the remote behavior of the device in connection with the ECOTAP\textsuperscript{®} VPD\textsuperscript{®} CONTROL PRO control unit. This setting only has an effect in the EXTERNAL CONTROL operating mode. You can select the following options:

- 0 = local: In the EXTERNAL CONTROL operating mode, automatic voltage regulation is performed via the ECOTAP\textsuperscript{®} VPD\textsuperscript{®} CONTROL PRO control unit. Control commands via SCADA are not possible.
- 1 = remote: In the EXTERNAL CONTROL operating mode, you can select the desired operating mode via SCADA command:
  - Automatic voltage regulation via the ECOTAP VPD CONTROL PRO control unit
  - Manual tap-change operations via SCADA commands

To set the remote behavior, proceed as follows:

1. The AVR MANUAL operating mode is active.
2. Press \text{AVR Manual} until the desired parameter is displayed.
3. Press \text{AVR Manual} to confirm the selection.
4. Press \text{ or } to select the desired option.
5. Press \text{AVR Manual} to confirm the selection.
6. Press \text{Menu} to save the setting.

7.4.8 Password protection (P10)

The device is equipped with password protection in order to prevent unauthorized parameter changes. If you activate the password protection function, you must first enter the password, before you can display the parameterization menu and make settings. If you do not operate the device within 5 minutes, the device is automatically blocked again.
7.4.8.1 Setting the password (P10.1)

You can use this parameter to set the password (maximum 3 characters, factory setting 0). To do so, proceed as follows:

- The AVR MANUAL operating mode is active.

1. Press \( \text{MENU} \) \( \rightarrow \) \( \uparrow \) until the desired parameter is displayed.

\[ P10.1 \]

2. Press \( \text{AVR MANUAL} \) to confirm the selection.

3. Press \( \uparrow \) until the desired parameter is displayed.

\[ P10.1 \]

4. Press \( \text{AVR MANUAL} \) to confirm the selection.

5. Press \( \downarrow \) or \( \uparrow \) to select the desired value. Alternative: Press \( \text{AVR AUTO} \) + \( \downarrow \) or \( \text{AVR AUTO} \) + \( \uparrow \) to set the value in larger steps.

6. Press \( \text{AVR MANUAL} \) to confirm the selection.

7. Press \( \text{MENU} \) to save the setting.

7.4.8.2 Activating/deactivating password protection (P10.2)

You can use this parameter to activate or deactivate the password protection function. You can select the following options:

- 0 = inactive
- 1 = active

To activate or deactivate the password protection function, proceed as follows:

- The AVR MANUAL operating mode is active.

1. Press \( \text{MENU} \) \( \rightarrow \) \( \uparrow \) until the desired parameter is displayed.

\[ P10.2 \]

2. Press \( \text{AVR MANUAL} \) to confirm the selection.

3. Press \( \uparrow \) until the desired parameter is displayed.

\[ P10.2 \]

4. Press \( \text{AVR MANUAL} \) to confirm the selection.

5. Press \( \downarrow \) or \( \uparrow \) to set the desired option.

6. Press \( \text{AVR MANUAL} \) to confirm the selection.
7 Operation

7. Press **MEN** to save the setting.

### 7.4.8.3 Entering password (C2)

If you have activated the password protection function, you must enter the password to unblock the device and to be able to call up the parameterization menu. To do so, proceed as follows:

- The AVR MANUAL operating mode is active.

1. Press **MEN**.

   ⇒ **C 8 8 8 8**

2. Press **A** or **C** to select the desired value. Alternative: Press **A** + **A** or **C** + **C** to set the value in larger steps.

3. Press **A** to confirm the selection.

   ⇒ The device is unblocked.

### 7.4.9 Adjustment (F1)

Automatic adjustment is necessary, for example, if a new control unit is connected to a tap changer. If the control unit is not yet adjusted to the tap changer, message **E4** appears on the display.

#### 7.4.9.1 Automatic adjustment (F1.1)

This function starts the automatic adjustment of the on-load tap-changer. The entire regulating range of the on-load tap-changer is passed through until the signals of the respective micro-switch for recording the end position are detected. In conclusion, the position display is synchronized with the position of the tap changer and the parameters Number of the operating positions (P7), Lowest operating position (P8.1) and Highest operating position (P8.2) are set.

Only carry out automatic adjustment with an open busbar on the low-voltage side since the on-load tap-changer moves through the entire regulating range and this can result in excessive voltage deviations for loads.

To start the automatic adjustment, proceed as follows:

- The AVR MANUAL operating mode is active.

1. Press **MEN** > **A** until the desired function is displayed.

   ⇒ **F 8 8 8 8**

2. Press **A** to confirm the selection.
3. Press \( \text{ 
} \) until the desired parameter is displayed.

\[ \text{F11111} \]

4. Press \( \text{ 
} \) to confirm the selection.

\[ \text{F11111} \]

5. Press \( \text{ 
} \) until code 3 is displayed.

\[ \text{F11111} \]

6. Press \( \text{ 
} \) to confirm the selection.

- Automatic adjustment starts.
- Once automatic adjustment is complete, the on-load tap-changer is in the middle operating position.

### 7.4.9.2 Manual adjustment n-1 (F1.2)

You can use this function to perform a manual adjustment of the on-load tap-changer starting from the current tap position through to the lowest tap position (Pos. 1). The manual adjustment does not run through the entire regulating range of the on-load tap-changer.

If you perform a manual adjustment with the busbar closed, you must check that the measured voltage is within the permitted range after the tap change operations.

To start the manual adjustment n-1 function, proceed as follows:

- The AVR MANUAL operating mode is active.

1. Press \( \text{ 
} \) until the desired function is displayed.

\[ \text{F11111} \]

2. Press \( \text{ 
} \) to confirm the selection.

3. Press \( \text{ } \) until the desired parameter is displayed.

\[ \text{F12222} \]

4. Press \( \text{ 
} \) to confirm the selection.

5. Press \( \text{ } \) to perform one on-load tap-change operation (n-1).

- The current measured voltage is displayed.
6. Repeat step 5 until the lowest tap position (Pos. 1) has been reached.
   ⇨ Once the lowest tap position (Pos. 1) has been reached, the display switches between operations counter, tap position and measured voltage.
   ⇨ Manual adjustment is complete.

7.4.9.3 Manual adjustment n+1 (F1.3)

You can use this function to perform a manual adjustment of the on-load tap-changer starting from the current tap position through to the highest tap position (Pos. N). The manual adjustment does not run through the entire regulating range of the on-load tap-changer.

If you perform a manual adjustment with the busbar closed, you must check that the measured voltage is within the permitted range after the tap change operations.

To start the manual adjustment n+1 function, proceed as follows:
✓ The AVR MANUAL operating mode is active.
1. Press \( \text{Menu} \) > \( \text{\( \uparrow \\downarrow \)} \) until the desired function is displayed.
   ⇨ \( \text{F} \)
2. Press \( \text{AVR MANUAL} \) to confirm the selection.
3. Press \( \text{\( \uparrow \\downarrow \)} \) until the desired parameter is displayed.
   ⇨ \( \text{F} \)
4. Press \( \text{AVR MANUAL} \) to confirm the selection.
5. Press \( \text{\( \uparrow \\downarrow \)} \) to perform one on-load tap-change operation (n+1).
   ⇨ The current measured voltage is displayed.
6. Repeat step 5 until the highest tap position (Pos. N) has been reached.
   ⇨ Once the highest tap position (Pos. N) has been reached, the display switches between operations counter, tap position and measured voltage.
   ⇨ Manual adjustment is complete.

7.4.10 Reading remaining life (F2)

The control unit’s integrated energy accumulator is continually monitored. With the function "Read remaining life", you can request the current status (as a percentage). If the remaining life is 0%, the function of the energy accumulator is no longer guaranteed.
If the remaining life is less than 5(%), contact Maschinenfabrik Reinhausen GmbH’s Technical Service department.

For functional reasons, the remaining life drops more quickly at the beginning of the product life cycle and levels out as the operating time increases. The typical progression of the remaining life is shown below:

![Figure 52: Typical progression of the remaining life](image)

To start the remaining life query, proceed as follows:

1. The AVR MANUAL operating mode is active.
2. Press \( \text{F2} \) until the desired function is displayed.

3. Press \( \text{AVR MANUAL} \) to confirm the selection.

4. Press \( \text{AVR MANUAL} \) to exit the display.

5. Press \( \text{MENU} \) to leave the parameterization menu.

### 7.4.11 LED function test (F3)

You can use this function to test the function of all LEDs and the display on the front of the control unit. To do so, proceed as follows:

1. The AVR MANUAL operating mode is active.
2. Press \( \text{F3} \) until the desired function is displayed.
2. Press \textbf{AVR MANUAL} to confirm the selection.
   \( \Rightarrow \) All display elements on the front of the control unit light up.

3. Press \textbf{AVR MANUAL} to exit the display.

4. Press \textbf{MENU} to leave the parameterization menu.

7.4.12 Software update (F4)

You can use this function to perform software updates. Contact Maschinenfabrik Reinhausen GmbH if you have any problems when operating the device.

7.4.13 Invert travel commands (F5)

You can use this parameter to invert the travel commands. You can use this to adjust the behavior of the device based on how your on-load tap-changer and motor-drive unit are configured. You can select the following options:

<table>
<thead>
<tr>
<th>Setting</th>
<th>Meaning</th>
</tr>
</thead>
</table>
| 0       | Normal configuration:  
          ▪ Lowest voltage (low-voltage side) in operating position 1  
          ▪ Highest voltage (low-voltage side) in operating position n |
| 1       | Inverted configuration:  
          ▪ Highest voltage (low-voltage side) in operating position 1  
          ▪ Lowest voltage (low-voltage side) in operating position n |

Table 11: Behavior

To set this function, proceed as follows:

✓ The AVR MANUAL operating mode is active.

1. Press \textbf{MENU} > \textbf{F5} until the desired function is displayed.

   \( \Rightarrow \textbf{F5} \)

2. Press \textbf{AVR MANUAL} to confirm the selection.

3. Press \textbf{AVR MANUAL} or \textbf{AVR MANUAL} to select the desired option.

4. Press \textbf{AVR MANUAL} to confirm the selection.

5. Press \textbf{MENU} to save the setting.
7.4.14 Read out software version (F6)

To read out the software version, proceed as follows:

- The AVR MANUAL operating mode is active.

1. Press \( \text{F6} \) until the desired function is displayed.

2. Press \( \text{F6} \) to confirm the selection.

3. Press \( \) to exit the display.

4. Press \( \) to leave the parameterization menu.

7.4.15 Customer message for event messages E1 and E2 (F7)

You can set whether the event messages E1 \( \text{EXTERNAL CONTROL} \) and E2 \( \text{Remote control} \) are to be reported via the customer messages interface \( \text{Ready/Error} \) (terminal X5). All further event messages will always be reported via the customer messages interface \( \text{ready/error} \) (terminal X5).

7.4.15.1 Customer message for event message E1 (F7.1)

With this function, you can set whether the event message E1 \( \text{EXTERNAL CONTROL} \) is to be reported via the customer messages interface \( \text{Ready/Error} \) (terminal X5). You can select the following options:

- 0: inactive
- 1: active

To set the customer message for event message E1, proceed as follows:

- The AVR MANUAL operating mode is active.

1. Press \( \text{MENU} > \) until the desired function is displayed.

2. Press \( \) to confirm the selection.

3. Press \( \) to confirm the selection.

4. Press \( \) or \( \) to select the desired option.

5. Press \( \) to confirm the selection.

6. Press \( \) to save the setting.
7.4.15.2 Customer message for event message E2 (F7.2)

With this function, you can set whether the event message E2 Remote control is to be reported via the customer messages interface Ready/Error (terminal X5). You can select the following options:

- 0: inactive
- 1: active

To set the customer message for event message E2, proceed as follows:

✓ The AVR MANUAL operating mode is active.

1. Press \(\text{MEN} > \) until the desired function is displayed.

\[ \Rightarrow \text{F7}\text{.7.7.7.7} \]

2. Press \(\text{AVR MANUAL}\) to confirm the selection.

3. Press \(\uparrow\) until the desired parameter is displayed.

\[ \Rightarrow \text{F7}\text{.7.2.7.7.7} \]

4. Press \(\text{AVR MANUAL}\) to confirm the selection.

5. Press \(\uparrow\) or \(\downarrow\) to select the desired option.

6. Press \(\text{AVR MANUAL}\) to confirm the selection.

7. Press \(\text{MEN}\) to save the setting.

7.4.16 Reset to factory setting (F8)

You can use this function to reset the device to the factory settings [\(\Rightarrow\) Section 12, Page 112]. To do so, proceed as follows:

✓ The AVR MANUAL operating mode is active.

1. Press \(\text{MEN} > \) until the desired function is displayed.

\[ \Rightarrow \text{F8}\text{.8.8.8.8} \]

2. Press \(\text{AVR MANUAL}\) to confirm the selection.

\[ \Rightarrow \text{C1}\text{.8.8.8.8} \]

3. Press \(\uparrow\) until code 3 is displayed.

\[ \Rightarrow \text{C1}\text{.8.8.8.3} \]

4. Press \(\text{AVR MANUAL}\) to confirm the selection.

\[ \Rightarrow \text{The device is reset to the factory settings.} \]

5. Press \(\text{AVR MANUAL}\) to exit the display.
6. Press \texttt{MENU} to leave the parameterization menu.

### 7.4.17 Display control parameters (F9)

You can use this function to check the set values of the device. Here, the device successively displays the parameter designation and the set values of the following parameters and functions:

- Parameters P1...P9
- Functions F2, F5, F6, F7.1 and F7.2

To check the control parameters, proceed as follows:

1. The AVR MANUAL operating mode is active.
2. Press \texttt{MENU} $\Rightarrow$ until the desired function is displayed.
3. Press \texttt{AVR MANUAL} to confirm the selection.
   - The display displays the parameter designation and the set values successively at a rate of 1 second.
4. Press \texttt{AVR MANUAL} to exit the display.
5. Press \texttt{MENU} to leave the parameterization menu.

### 7.4.18 Displaying event memory (E)

The event memory will show you the saved event codes. You can find an overview of the event codes in the Event messages \citep{Event messages [Section 11.2, Page 110] section.}

The event memory has 20 memory slots and displays the last 20 entries. Memory slot 1 is the latest entry, memory slot 20 is the earliest entry. The device records the number of tap-change operations when an event message happens or is reset.

A memory slot entry contains the following information:

- Event code
- Number of tap-change operations

If an entry only includes the number of tap-change operations and not an event code, this means that the event code in the previous memory slot was reset at this number of tap-change operations.

With the exception of event code \textit{E6}, all event codes are reset once the fault has been eliminated and the next correct tap-change operation has been completed. Event code \textit{E6} can only be reset by the Maschinenfabrik Reinhausen GmbH Technical Service department.
To display the event memory, proceed as follows:

✓ The AVR MANUAL operating mode is active.

1. Press \textgreater \textleft\textgreater
down until the first memory slot in the event memory is displayed.

\Rightarrow \text{E8888888}

2. Press \textless \textgreater \textleft\textgreater
to select the desired memory slot.

\Rightarrow \text{E888882}

3. Press \textbar\textbar\textbar\textbar

to call up the memory slot.

\Rightarrow \text{E41362}

4. Press \textbar\textbar\textbar\textbar

to display further event codes. If there are no further event codes present, the number of tap-change operations will be displayed.

\Rightarrow \text{000270}

5. Press \textbar\textbar\textbar\textbar
to exit the memory slot.
8 Control system protocol

8.1 Modbus RTU Parameters

The device uses the Modbus RTU (server) control system protocol with the following parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Modbus RTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission format</td>
<td>RTU</td>
</tr>
<tr>
<td>Serial interface</td>
<td>RS485</td>
</tr>
<tr>
<td>Baud rate</td>
<td>38,400 baud</td>
</tr>
<tr>
<td>Modbus address</td>
<td>1</td>
</tr>
<tr>
<td>Number of data bits</td>
<td>8</td>
</tr>
<tr>
<td>Parity</td>
<td>Even</td>
</tr>
<tr>
<td>Number of stop bits</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 12: Device parameters

8.2 Function codes

<table>
<thead>
<tr>
<th>Function code</th>
<th>Group name</th>
</tr>
</thead>
<tbody>
<tr>
<td>03</td>
<td>Read holding registers</td>
</tr>
<tr>
<td>06</td>
<td>Preset single register</td>
</tr>
<tr>
<td>10</td>
<td>Coil holding register</td>
</tr>
</tbody>
</table>

Table 13: Function codes

8.3 Data format

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>uInt8</td>
<td>unsigned integer 8 bit</td>
<td>0...255</td>
</tr>
<tr>
<td>uInt16</td>
<td>unsigned integer 16 bit</td>
<td>0...65 535</td>
</tr>
<tr>
<td>sInt16</td>
<td>signed integer 16 bit</td>
<td>- 32 768...+ 32 768</td>
</tr>
<tr>
<td>uInt32</td>
<td>unsigned integer 32 bit</td>
<td>0...+ 4.294 967 295 x 10^8</td>
</tr>
<tr>
<td>Int64</td>
<td>integer 64 bit</td>
<td>- 9.2 x 10^{18}...+ 9.2 x 10^{18}</td>
</tr>
<tr>
<td>float32</td>
<td>32 bit (single precision) in accordance with IEEE 754</td>
<td>IEEE 754</td>
</tr>
<tr>
<td>bit16</td>
<td>16 bit-register (each bit has its own meaning)</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 14: Data format
### 8.4 Data points (single inquiry)

#### 8.4.1 Coils

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Coil status</th>
<th>EXTERNAL CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>R = read / W = write</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CONTROL PRO</td>
</tr>
<tr>
<td>0</td>
<td>Change tap position raise</td>
<td>1 = raise</td>
<td>R/W</td>
</tr>
<tr>
<td>1</td>
<td>Change tap position lower</td>
<td>1 = lower</td>
<td>R/W</td>
</tr>
<tr>
<td>4&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Blocking activation P5 level 1</td>
<td>1 = active (level 1)</td>
<td>R</td>
</tr>
<tr>
<td>7</td>
<td>F5 command inverted</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>10</td>
<td>F7.1 E1 to relay output</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>11</td>
<td>F7.2 E2 to relay output</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>12&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Blocking activation P5 level 2</td>
<td>1 = active (level 2)</td>
<td>R</td>
</tr>
</tbody>
</table>

Table 15: Coils

<sup>1</sup> P5 inactive, if "coil 4" = 0 and "coil 12" = 0

#### 8.4.2 Discrete Inputs

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Coil status</th>
<th>EXTERNAL CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>R = read / W = write</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R = read / W = write</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CONTROL PRO</td>
</tr>
<tr>
<td>0</td>
<td>E1 No connection to EXTERNAL CONTROL</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>1</td>
<td>E2 EXTERNAL CONTROL command could not be performed.</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>2</td>
<td>E3.1 Error in connection between control unit and motor-drive unit</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>3</td>
<td>E3.2 Error in connection between control unit and motor-drive unit</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>4</td>
<td>E3.3 Error in connection between control unit and motor-drive unit</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>5</td>
<td>E3.4 Error in connection between control unit and motor-drive unit</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>6</td>
<td>E4.1 Automatic adjustment not undertaken or incorrect.</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>7</td>
<td>E4.2 The desired target position could not be reached when voltage failed.</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>8</td>
<td>E5.1 System not ready</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>9</td>
<td>E5.2 System not ready</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>10</td>
<td>E5.3 System not ready</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>11</td>
<td>E6.1 Tap change command cannot be performed</td>
<td>1 = active</td>
<td>R</td>
</tr>
<tr>
<td>12</td>
<td>E6.2 Tap change command cannot be performed</td>
<td>1 = active</td>
<td>R</td>
</tr>
</tbody>
</table>
## 8 Control system protocol

### 8.4.3 Input Register

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Unit</th>
<th>Decimal places</th>
<th>EXTERNAL CONTROL</th>
<th>CONTROL PRO</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Capacitor health</td>
<td>%</td>
<td>0</td>
<td>R = read / W = write</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>5</td>
<td>Software version year</td>
<td>-</td>
<td>-</td>
<td>R = read / W = write</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>6</td>
<td>Software version month</td>
<td>-</td>
<td>-</td>
<td>R = read / W = write</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>7</td>
<td>Software version day</td>
<td>-</td>
<td>-</td>
<td>R = read / W = write</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>8</td>
<td>Motor pause before next tap-change operation</td>
<td>seconds</td>
<td>1</td>
<td>R = read / W = write</td>
<td>R</td>
<td>R</td>
</tr>
</tbody>
</table>

Table 17: Input register
### 8.4.4 Holding register

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Unit</th>
<th>Decimal places</th>
<th>EXTERNAL CONTROL</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control system protocol</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Operating mode</td>
<td>-</td>
<td>0</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>▪ 1 = AVR AUTO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ 2 = AVR MANUAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ 3 = EXTERNAL CONTROL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Tap position</td>
<td>-</td>
<td>0</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>2</td>
<td>Operations counter (MSB)</td>
<td>-</td>
<td>0</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>3</td>
<td>Operations counter (LSB)</td>
<td>-</td>
<td>0</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>17</td>
<td>Tap-change operation (-3, -2, -1, +1, +2, +3)</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>R/W</td>
</tr>
</tbody>
</table>

Table 18: Holding register
## 8.5 Data points (collective inquiry)

<table>
<thead>
<tr>
<th>Address</th>
<th>Range</th>
<th>Parameter</th>
<th>Description</th>
<th>Type</th>
<th>Value</th>
<th>R/W Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>201</td>
<td>0</td>
<td>E1</td>
<td>No connection to EXTERNAL CONTROL</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>1</td>
<td>E2</td>
<td>EXTERNAL CONTROL command could not be performed</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>2</td>
<td>E3.1</td>
<td>Error in connection between control unit and motor-drive unit</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>E3.2</td>
<td></td>
<td>1 = error</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>E3.3</td>
<td></td>
<td>1 = error</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>E3.4</td>
<td></td>
<td>1 = error</td>
<td></td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>6</td>
<td>E4.1</td>
<td>Automatic adjustment not undertaken or incorrect</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>7</td>
<td>E4.2</td>
<td>The desired target position could not be reached when voltage failed</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>8</td>
<td>E5.1</td>
<td>System not ready</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>E5.2</td>
<td></td>
<td>1 = error</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>E5.3</td>
<td></td>
<td>1 = error</td>
<td></td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>11</td>
<td>E6.1</td>
<td>Tap change command cannot be performed</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>E6.2</td>
<td></td>
<td>1 = error</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>E6.3</td>
<td></td>
<td>1 = error</td>
<td></td>
<td></td>
</tr>
<tr>
<td>201</td>
<td>14</td>
<td>E7.1</td>
<td>Correct positioning not possible</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>E7.2</td>
<td></td>
<td>1 = error</td>
<td></td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>5</td>
<td>n/a</td>
<td>Relay OK</td>
<td>1 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>6</td>
<td>n/a</td>
<td>Relay ERROR</td>
<td>1 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>7</td>
<td>E2.1</td>
<td>Highest or lowest operating position reached</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>E2.2</td>
<td>Previous tap-change operation has not been completed or fault motor-drive unit</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>E2.3</td>
<td>Inrush interlock is active or automatic adjustment required</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>E2.4</td>
<td>Energy in the energy accumulator too low</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>E2.5</td>
<td>Signal for blocking activated (door interlock or temperature blocking)</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>E2.6</td>
<td>No connection to OLTC</td>
<td>0 = ok</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>203</td>
<td>0…15</td>
<td></td>
<td>Operating mode</td>
<td>UINT16</td>
<td>R</td>
<td></td>
</tr>
</tbody>
</table>

---

1. Address
2. Range
3. Parameter
4. Description
5. Type
6. Value
7. R/W
8. Others
## 8 Control system protocol

<table>
<thead>
<tr>
<th>Address</th>
<th>Range</th>
<th>Parameter</th>
<th>Description</th>
<th>Type</th>
<th>Value</th>
<th>R/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>204</td>
<td>0…15</td>
<td></td>
<td>Current tap position</td>
<td>UINT16</td>
<td>1…107</td>
<td>R</td>
</tr>
<tr>
<td>205, 206</td>
<td>0…31</td>
<td></td>
<td>Counter</td>
<td>SINT32</td>
<td></td>
<td>R</td>
</tr>
<tr>
<td>207</td>
<td>0…15</td>
<td></td>
<td>Cooling time motor drive after tap change</td>
<td>UINT16</td>
<td>e. g. value &quot;12&quot; = 1.2 s</td>
<td>R</td>
</tr>
<tr>
<td>209</td>
<td>0…15</td>
<td></td>
<td>Hardware version year (18, high-byte), month (19, low-byte)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>R</td>
</tr>
<tr>
<td>210</td>
<td>0…15</td>
<td></td>
<td>Firmware version (1/2) month (21, high-byte) year (22, low-byte)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>R</td>
</tr>
<tr>
<td>211</td>
<td>0…15</td>
<td></td>
<td>Firmware version (2/2) day (day 23, low-byte)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>R</td>
</tr>
<tr>
<td>212</td>
<td>0…15</td>
<td></td>
<td>MR serial number MD&amp;C (1/2)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>R</td>
</tr>
<tr>
<td>213</td>
<td>0…15</td>
<td></td>
<td>MR serial number MD&amp;C (2/2)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>R</td>
</tr>
<tr>
<td>214</td>
<td>0…15</td>
<td></td>
<td>MR serial number OLTC (1/2)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>R</td>
</tr>
<tr>
<td>215</td>
<td>0…15</td>
<td></td>
<td>MR serial number OLTC (2/2)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>R</td>
</tr>
<tr>
<td>216</td>
<td>0…15</td>
<td></td>
<td>Material number MD&amp;C (1/3)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>R</td>
</tr>
<tr>
<td>217</td>
<td>0…15</td>
<td></td>
<td>Material number MD&amp;C (2/3)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>R</td>
</tr>
<tr>
<td>218</td>
<td>0…15</td>
<td></td>
<td>Material number MD&amp;C (3/3)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>R</td>
</tr>
<tr>
<td>219</td>
<td>0…15</td>
<td></td>
<td>Set of parameters</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>R</td>
</tr>
<tr>
<td>220</td>
<td>0…15</td>
<td></td>
<td>Remaining time to the next PreCheck [min]</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>R</td>
</tr>
<tr>
<td>401</td>
<td>0…15</td>
<td></td>
<td>Multiple tap changes</td>
<td>SINT16</td>
<td>-3 to +3</td>
<td>W</td>
</tr>
<tr>
<td>403</td>
<td>0</td>
<td></td>
<td>Testing PreCheck</td>
<td>SINT16</td>
<td></td>
<td>W</td>
</tr>
<tr>
<td>404</td>
<td>0…15</td>
<td></td>
<td>MR serial number MD&amp;C (1/2)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>W</td>
</tr>
<tr>
<td>405</td>
<td>0…15</td>
<td></td>
<td>MR serial number MD&amp;C (2/2)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>W</td>
</tr>
<tr>
<td>406</td>
<td>0…15</td>
<td></td>
<td>MR serial number OLTC (1/2)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>W</td>
</tr>
<tr>
<td>407</td>
<td>0…15</td>
<td></td>
<td>MR serial number OLTC (2/2)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>W</td>
</tr>
<tr>
<td>408</td>
<td>0…15</td>
<td></td>
<td>Material number MD&amp;C (1/3)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>W</td>
</tr>
<tr>
<td>409</td>
<td>0…15</td>
<td></td>
<td>Material number MD&amp;C (2/3)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>W</td>
</tr>
<tr>
<td>410</td>
<td>0…15</td>
<td></td>
<td>Material number MD&amp;C (3/3)</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>W</td>
</tr>
<tr>
<td>411</td>
<td>0…15</td>
<td></td>
<td>Set of parameters</td>
<td>UINT16</td>
<td>0…65 535</td>
<td>W</td>
</tr>
</tbody>
</table>

Table 19: Data points

1) No offset present

2) Read/Write
3) With the command "Multiple switching operations" up to 3 successive switching operations can be executed without a regular pause of 3 seconds. This is followed by a cooling period of

- 3 seconds for 1 on-load tap-change operation
- 6 seconds for 2 on-load tap-change operations
- 9 seconds for 3 on-load tap-change operations.
9 Fault elimination

The transformer can be operated in the current operating position safely despite the red signal light. Further switching operations are blocked.

9.1 General faults

<table>
<thead>
<tr>
<th>Characteristics/details</th>
<th>Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>No function</td>
<td>No voltage supply</td>
<td>Check the voltage supply.</td>
</tr>
<tr>
<td>□ LED not lit up</td>
<td>Device-internal fuse (F1) tripped</td>
<td>Check fuse (F1) and replace if necessary.</td>
</tr>
</tbody>
</table>

Table 20: General faults

9.2 Problem with automatic voltage regulation (AVR AUTO)

<table>
<thead>
<tr>
<th>Characteristics/details</th>
<th>Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic voltage regulation not functioning.</td>
<td>Bandwidth set too high.</td>
<td>Check parameter &quot;Bandwidth B1&quot; (P2.1) [► Section 7.4.1.2, Page 77].</td>
</tr>
<tr>
<td>Automatic voltage regulation not functioning.</td>
<td>Function &quot;Invert travel commands (F5)&quot; is set incorrectly.</td>
<td>Check &quot;Invert travel commands (F5)&quot; function [► Section 7.4.13, Page 91].</td>
</tr>
<tr>
<td>□ LED is lit.</td>
<td>The on-load tap-changer is in the end position.</td>
<td></td>
</tr>
<tr>
<td>□ LED is lit.</td>
<td>Travel commands for regulating the measured voltage are in the wrong direction.</td>
<td></td>
</tr>
<tr>
<td>Automatic voltage regulation is blocked.</td>
<td>Blocking function is activated and blocking contact (X3) is closed.</td>
<td>Check signal source. Set blocking function (P5) [► Section 7.4.3, Page 81].</td>
</tr>
<tr>
<td>□ LED is lit.</td>
<td>The display does not show an event code.</td>
<td></td>
</tr>
<tr>
<td>Automatic voltage regulation is blocked.</td>
<td>Event code is present.</td>
<td>Displaying event memory [► Section 7.4.18, Page 94]. Check event messages [► Section 11.2, Page 110].</td>
</tr>
<tr>
<td>□ LED is lit.</td>
<td>The display shows an event code.</td>
<td></td>
</tr>
<tr>
<td>Automatic voltage regulation is blocked.</td>
<td>Voltage blocking is active.</td>
<td>Check voltage blocking settings [► Section 7.4.2, Page 80].</td>
</tr>
</tbody>
</table>
9 Fault elimination

<table>
<thead>
<tr>
<th>Characteristics/details</th>
<th>Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>The regulating range of the transformer cannot be used.</td>
<td>The parameter &quot;Number of operating positions (P7)&quot; does not match the on-load tap-changer.</td>
<td>Check parameter &quot;Number of operating positions (P7)&quot; [► Section 7.4.5, Page 83].</td>
</tr>
<tr>
<td>Regulating range limited.</td>
<td></td>
<td>Check regulating range settings [► Section 7.4.6, Page 84].</td>
</tr>
</tbody>
</table>

Table 21: Problem with automatic voltage regulation (AVR AUTO)

9.3 Other faults

In the event of faults on the on-load tap-changer, motor-drive unit, or control unit which cannot be easily corrected on site, please inform your authorized MR representative, the transformer manufacturer or contact Maschinenfabrik Reinhausen GmbH (MR) directly.

Please have the following data ready:
- Serial number (nameplate)
- Control unit software version [► Section 7.4.14, Page 92]

Contact address

Maschinenfabrik Reinhausen GmbH
Technical Service
Postfach 12 03 60
D93025 Regensburg
Germany

Tel.: +49 94140 90-0
Fax: +49 9 41 40 90-7001
E-mail: service@reinhausen.com
Internet: www.reinhausen.com
10 Maintenance

DANGER
Electric shock!
An energized transformer could cause death or serious injuries.
► Switch off transformer on high and low-voltage side.
► Lock transformer to prevent unintentional restart.
► Ensure that everything is de-energized.
► Visibly connect all transformer terminals to ground (grounding leads, grounding disconnectors) and short circuit them.
► Cover or cordon off adjacent energized parts.

DANGER
Electric shock!
Working on the on-load tap-changer when components are energized can lead to death or serious injuries.
► De-energize all auxiliary circuits, such as the tap-change supervisory device, pressure relief device, pressure monitoring device.
► Ensure that everything is de-energized.

WARNING
Danger of explosion!
Explosive gases in the oil compartment of the on-load tap-changer, transformer, pipe system, oil conservator and at the dehydrating breather opening can deflagrate or explode and result in severe injury or death.
► Ensure that there are no ignition sources such as naked flames, hot surfaces or sparks (e.g. caused by the build-up of static charge) in the transformer's immediate surroundings and that none occur.
► Do not operate any electrical devices (e.g. risk of sparks from impact wrench).
► Only use conductive and grounded hoses, pipes, and pump equipment that are approved for flammable liquids.

10.1 Inspection
When inspecting the transformer, at the same time undertake an inspection of the motor-drive unit and control unit. To do so, proceed as follows:

10.1.1 Visual check
Start with the visual check as follows:
► Check whether any external damage or leaks are visible.
☞ In the event of visible damage, contact Maschinenfabrik Reinhausen GmbH's Technical Service department.

If a problem occurs with the control unit and you want to contact Maschinenfabrik Reinhausen GmbH, first read out the software version.
10.1.2 Checking the control unit

1. Check remaining life of the energy accumulator [► Section 10.1.4, Page 106].
   
   ⇤ If the remaining life is less than 20(%), contact Maschinenfabrik Reinhausen GmbH's Technical Service department.

2. Check the function of the LEDs [► Section 10.1.5, Page 107].

10.1.3 Read out software version (F6)

To read out the software version, proceed as follows:

✓ The AVR MANUAL operating mode is active.

1. Press \( \text{MENU} \) > Press \( \text{ } \uparrow \text{ } \) until the desired function is displayed.

   ⇤ F6

2. Press \( \text{AVR Manual} \) to confirm the selection.

   ⇤ The control unit's software version is displayed.

3. Press \( \text{AVR Manual} \) to exit the display.

4. Press \( \text{MENU} \) to leave the parameterization menu.

10.1.4 Reading remaining life (F2)

The control unit's integrated energy accumulator is continually monitored. With the function "Read remaining life", you can request the current status (as a percentage). If the remaining life is 0%, the function of the energy accumulator is no longer guaranteed.

If the remaining life is less than 5(%), contact Maschinenfabrik Reinhausen GmbH's Technical Service department.
For functional reasons, the remaining life drops more quickly at the beginning of the product life cycle and levels out as the operating time increases. The typical progression of the remaining life is shown below:

Figure 53: Typical progression of the remaining life

To start the remaining life query, proceed as follows:

1. The AVR MANUAL operating mode is active.
2. > Press \( \text{until the desired function is displayed.} \)
3. Press \( \text{to confirm the selection.} \)
4. Press \( \text{to exit the display.} \)
5. Press \( \text{to leave the parameterization menu.} \)

10.1.5 LED function test (F3)

You can use this function to test the function of all LEDs and the display on the front of the control unit. To do so, proceed as follows:

1. The AVR MANUAL operating mode is active.
2. > Press \( \text{until the desired function is displayed.} \)
3. Press \( \text{to confirm the selection.} \)
4. All display elements on the front of the control unit light up.
5. Press \( \text{to exit the display.} \)
4. Press [MENU] to leave the parameterization menu.

10.1.6 Checking the temperature blocking

If you operate the on-load tap-changer with alternative insulating fluids, you must check the function of the temperature blocking [▶ Section 6.3.9, Page 67]. To do so, proceed as follows:

✓ Check the function of the temperature sensor in accordance with the manufacturer’s details.

✓ The △ LED is not lit; if this is not the case, resolve the cause of the error.

▶ Remove the plug at terminal X3 to simulate a blocking signal.

corev Blocking is active and the LED △ is lit.

10.1.7 Oil quality

1. Check the quality of the transformer oil at regular intervals.

2. Determine dielectric strength and water content at an oil temperature of 20°C ± 5°C.

3. The dielectric strength and water content must comply with the limit values specified in the section “Technical data”.

corev If these limit values are not complied with, change the oil.
10.2 Maintenance

The ECOTAP® VPD® on-load tap-changer and ECOTAP® VPD® MD&C motor-drive unit are maintenance-free.

<table>
<thead>
<tr>
<th>Interval</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>After 500,000 operations</td>
<td>Replacing the on-load tap-changer: Contact the Maschinenfabrik Reinhausen Technical Service department for this.</td>
</tr>
<tr>
<td>After a maximum of 20 years</td>
<td>Replace the control unit. Contact the Maschinenfabrik Reinhausen Technical Service department for this.</td>
</tr>
</tbody>
</table>

10.3 Care

You can clean the device's housing with a dry cloth.
11 Messages

11.1 LEDs

<table>
<thead>
<tr>
<th>LED</th>
<th>State</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>![ ]</td>
<td>Off</td>
<td>Voltage supply missing</td>
</tr>
<tr>
<td>![ ]</td>
<td>Flashing</td>
<td>Inrush interlock active</td>
</tr>
<tr>
<td>![ ]</td>
<td>Lit</td>
<td>Ready</td>
</tr>
<tr>
<td>![ ]</td>
<td>Off</td>
<td>Energy accumulator not ready</td>
</tr>
<tr>
<td>![ ]</td>
<td>Flashing</td>
<td>Energy accumulator is charging</td>
</tr>
<tr>
<td>![ ]</td>
<td>Lit</td>
<td>Energy accumulator is ready</td>
</tr>
<tr>
<td>![ ]</td>
<td>Off</td>
<td>Motor stationary</td>
</tr>
<tr>
<td>![ ]</td>
<td>Lit</td>
<td>Motor running</td>
</tr>
<tr>
<td>![ ]</td>
<td>Off</td>
<td>Ready</td>
</tr>
<tr>
<td>![ ]</td>
<td>Lit</td>
<td>Fault</td>
</tr>
</tbody>
</table>

Table 22: Messages via LEDs

11.2 Event messages

<table>
<thead>
<tr>
<th>Code</th>
<th>Type</th>
<th>Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Info</td>
<td>No connection to EXTERNAL CONTROL</td>
<td>Check that the cable connection between the control unit and EXTERNAL CONTROL is connected correctly. Check that the EXTERNAL CONTROL is working correctly. Follow the corresponding operating instructions when doing so. If the error is still present, contact MR.</td>
</tr>
<tr>
<td>E2</td>
<td>Info</td>
<td>EXTERNAL CONTROL command could not be performed.</td>
<td>Check the EXTERNAL CONTROL operating mode setting. Check whether the on-load tap-changer is in a permitted position. To do so, set the operating mode to MANUAL and test manual tap-change operations. After a successful manual tap-change operation in EXTERNAL CONTROL operating mode, test the remote control. If the error is still present, contact MR.</td>
</tr>
<tr>
<td>E2.1</td>
<td>Info</td>
<td>Highest or lowest permitted operating position reached.</td>
<td>Check regulating range settings.</td>
</tr>
<tr>
<td>E2.2</td>
<td>Info</td>
<td>Tap-change operation has not been completed or motor-drive unit error</td>
<td>If error is still present after the next tap-change command, contact MR.</td>
</tr>
<tr>
<td>E2.3</td>
<td>Info</td>
<td>Inrush interlock is active or automatic adjustment required.</td>
<td>Wait for inrush interlock. If error is still present, carry out automatic adjustment.</td>
</tr>
<tr>
<td>Code</td>
<td>Type</td>
<td>Cause</td>
<td>Remedy</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>-------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>E2.4</td>
<td>Info</td>
<td>Energy in the energy accumulator is too low.</td>
<td>Adjust the voltage supply to the specification.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Check remaining life of the energy accumulator (F2).</td>
</tr>
<tr>
<td>E2.5</td>
<td>Info</td>
<td>Signal for blocking the automatic voltage regulation active.</td>
<td>Check signal source.</td>
</tr>
<tr>
<td>E2.6</td>
<td>Info</td>
<td>Connection error to OLTC</td>
<td>Check that the connection cable is plugged in correctly.</td>
</tr>
<tr>
<td>E3.1</td>
<td>Warning</td>
<td>Error in connection between control unit and motor-drive unit</td>
<td>Check that all plug connections on the control unit are tight and correct. Check whether the connection cable is free of damage. Has the factory-set wiring on X2 or X4 been changed? If yes, restore to original status. If the error is still present, contact MR.</td>
</tr>
<tr>
<td>E3.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E3.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E3.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E4.1</td>
<td>Error</td>
<td>Automatic adjustment not undertaken or incorrect.</td>
<td>Carry out automatic adjustment (again).</td>
</tr>
<tr>
<td>E4.2</td>
<td>Error</td>
<td>The desired target position could not be reached when voltage failed.</td>
<td>Check correct setting of &quot;Target position for loss of voltage&quot; function (P6). The target position must be within the regulating range. Check remaining life of the energy accumulator (F2). If the error is still present, contact MR.</td>
</tr>
<tr>
<td>E5.1</td>
<td>Warning</td>
<td>System not ready</td>
<td>Check operational readiness: LED (voltage supply) and LED (energy accumulator) must light up continuously. Adjust the voltage supply to the specification. Check remaining life of the energy accumulator (F2). If the error is still present, contact MR.</td>
</tr>
<tr>
<td>E5.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E5.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E6.1</td>
<td>Error</td>
<td>Tap-change operation command cannot be performed</td>
<td>Contact MR.</td>
</tr>
<tr>
<td>E6.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E6.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E7.1</td>
<td>Error</td>
<td>Correct positioning not possible</td>
<td>Has the factory-set wiring on X2 or X4 been changed? If yes, restore to original status. Carry out automatic adjustment. If the error is still present, contact MR.</td>
</tr>
<tr>
<td>E7.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 23: Event codes
## 12 Overview of parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting range</th>
<th>Factory settings</th>
<th>Current settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1: Desired voltage</td>
<td>84…266 V</td>
<td>225 V</td>
<td></td>
</tr>
<tr>
<td>P2: Normal regulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P2.1: Bandwidth B1</td>
<td>0.5…8 %</td>
<td>2 %</td>
<td></td>
</tr>
<tr>
<td>P2.2: Delay time T1</td>
<td>5…1800 s</td>
<td>10 s</td>
<td></td>
</tr>
<tr>
<td>P3: Fast regulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3.1: Bandwidth B2</td>
<td>3%…9%; off¹</td>
<td>4 %</td>
<td></td>
</tr>
<tr>
<td>P3.2: Delay time T2</td>
<td>2 s…(T1 - 1 s / 5 s)²</td>
<td>2 s</td>
<td></td>
</tr>
<tr>
<td>P4: Voltage blocking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4.1: Undervoltage blocking</td>
<td>84…266 V</td>
<td>84 V</td>
<td></td>
</tr>
<tr>
<td>P4.2: Overvoltage blocking</td>
<td>84…266 V</td>
<td>266 V</td>
<td></td>
</tr>
<tr>
<td>P5: Blocking function</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P5.1: Undervoltage blocking</td>
<td>84…266 V</td>
<td>84 V</td>
<td></td>
</tr>
<tr>
<td>P5.2: Overvoltage blocking</td>
<td>84…266 V</td>
<td>266 V</td>
<td></td>
</tr>
<tr>
<td>P6: Target position for loss of voltage</td>
<td>1…9 (17)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>P6.1: Set target position</td>
<td>1…9 (17)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>P6.2: Activate/deactivate function</td>
<td>0 = inactive, 1 = active</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>P7: Number of operating positions</td>
<td>9 or 17</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>P8: Regulating range</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P8.1: Lowest operating position</td>
<td>1…9 (17)³</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>P8.2: Highest operating position</td>
<td>1…9 (17)³</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>P9: Remote behavior</td>
<td>0 = local, 1 = remote</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>P10: Password protection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P10.1: Set password</td>
<td>0…999</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>P10.2: Activate/deactivate password protection</td>
<td>0 = inactive, 1 = active</td>
<td>0 = inactive</td>
<td></td>
</tr>
<tr>
<td>F1: Automatic/manual adjustment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F1.1: Automatic adjustment</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>F1.2: Manual adjustment n-1</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>F1.3: Manual adjustment n+1</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>F2: Remaining life of the energy accumulator</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>F3: LED function test</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>F4: Software update</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>F5: Invert travel commands</td>
<td>0 = inactive, 1 = active</td>
<td>0 = inactive</td>
<td></td>
</tr>
</tbody>
</table>
### 12 Overview of parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting range</th>
<th>Factory settings</th>
<th>Current settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>F6: Read out software version</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>F7: Error relay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F7.1: Error relay E1</td>
<td>0 = inactive, 1 = active</td>
<td>1 = active</td>
<td></td>
</tr>
<tr>
<td>F7.2: Error relay E2</td>
<td>0 = inactive, 1 = active</td>
<td>1 = active</td>
<td></td>
</tr>
<tr>
<td>F8: Factory settings</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>F9: Display control parameters</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Table 24: Parameter overview

1) The bandwidth B2 is always at least 0.5% greater than the bandwidth B1.
2) The delay time T2 is always at least 1 s less than T1 (if T1 ≤ 10 s) or 5 s less than T1 (if T1 > 10 s).
3) Depending on the number of tap positions of the on-load tap-changer.
13 Disposal

For disposal, observe the national requirements applicable in the country of use.

If you have any questions about disassembly and disposal, please contact Maschinenfabrik Reinhausen GmbH's Technical Service department.
14 Technical data

14.1 On-load tap-changer type designation

The designation of a particular on-load tap-changer model depends on various features, hence ensuring an unmistakable and non-interchangeable on-load tap-changer designation.

14.1.1 ECOTAP® VPD on-load tap-changer designation

<table>
<thead>
<tr>
<th>Type designation</th>
<th>ECOTAP® VPD III 30 D – 24 – 09 09 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECOTAP® VPD</td>
<td>On-load tap-changer type</td>
</tr>
<tr>
<td>III</td>
<td>Number of phases</td>
</tr>
<tr>
<td>30</td>
<td>Maximum rated through-current Irm [A]</td>
</tr>
<tr>
<td>D</td>
<td>Application: Delta</td>
</tr>
<tr>
<td>24</td>
<td>Highest voltage for equipment Um [kV]</td>
</tr>
<tr>
<td>09 09 0</td>
<td>Basic connection</td>
</tr>
</tbody>
</table>

Table 25: Designation of the ECOTAP® VPD® on-load tap-changer

14.1.2 Number of positions and basic connection

The selector must adapt to the number of positions and tapped winding circuit.

<table>
<thead>
<tr>
<th>Designation of basic connection</th>
<th>09 09 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>09</td>
<td>Contact circle pitch of selector</td>
</tr>
<tr>
<td>09</td>
<td>Maximum number of operating positions</td>
</tr>
<tr>
<td>0</td>
<td>Number of mid-positions</td>
</tr>
</tbody>
</table>

Table 26: Designation of basic connection
### 14.2 Technical data for the on-load tap-changer

<table>
<thead>
<tr>
<th>Type</th>
<th>VPD® III 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of phases</td>
<td>3</td>
</tr>
<tr>
<td>Application</td>
<td>At any point in the winding</td>
</tr>
<tr>
<td>Permitted transformer types</td>
<td>Free breathing with oil conservator</td>
</tr>
<tr>
<td></td>
<td>Entirely oil-filled hermetically sealed transformers (without gas cushion)</td>
</tr>
<tr>
<td></td>
<td>Free breathing with air cushion only in combination with a special variant of the ECOTAP VPD (on request)</td>
</tr>
<tr>
<td>Maximum rated through-current</td>
<td>30 A</td>
</tr>
<tr>
<td>Rated short-time current</td>
<td>750 A</td>
</tr>
<tr>
<td>Rated duration of short-circuits</td>
<td>2 s</td>
</tr>
<tr>
<td>Rated peak withstand current</td>
<td>1,875 A</td>
</tr>
<tr>
<td>Maximum rated step voltage</td>
<td>550 V</td>
</tr>
<tr>
<td>Step capacity</td>
<td>16,500 VA</td>
</tr>
<tr>
<td>Maximum number of operating positions</td>
<td>9</td>
</tr>
<tr>
<td>Rated insulation level:</td>
<td></td>
</tr>
<tr>
<td>Highest voltage for equipment Um</td>
<td>24 kV</td>
</tr>
<tr>
<td>Rated withstand voltages</td>
<td>See section “Permitted voltage stresses”</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50 Hz, 60 Hz</td>
</tr>
<tr>
<td>Permissible temperature range of transformer oil for on-load tap-change operations:</td>
<td></td>
</tr>
<tr>
<td>Mineral insulating oil (IEC 60296)</td>
<td>-25°C to +105°C</td>
</tr>
<tr>
<td>Synthetic ester fluid (IEC 61099)</td>
<td>On request</td>
</tr>
<tr>
<td>Natural ester fluid (IEC 62770)</td>
<td>On request</td>
</tr>
<tr>
<td>Permissible absolute pressure during operation</td>
<td>0.7…1.4 bar</td>
</tr>
<tr>
<td>Vacuum drying</td>
<td>Vacuum proof</td>
</tr>
<tr>
<td>Maximum number of tap-change operations</td>
<td>500,000</td>
</tr>
<tr>
<td>Resistance to corrosion</td>
<td>C4H</td>
</tr>
</tbody>
</table>

Table 27: ECOTAP® VPD® III technical data
14.3 Step capacity diagram

Figure 54: Step capacity diagram for ECOTAP® VPD®
14 Technical data

14.4 Permitted voltage stresses

The specifications in this section only apply to use in mineral insulating oil in accordance with IEC 60296. Data for alternative insulating fluids is available on request.

This section describes the permitted voltage stresses on the tap winding and on-load tap-changer.

When selecting the on-load tap-changer, you must check that the highest stresses on the selector do not exceed the related rated withstand voltages.

Definition of insulation distances

<table>
<thead>
<tr>
<th>Definition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Between the beginning and the end of a tap winding and, for a coarse winding version, between the beginning and the end of the coarse winding. Information for coarse tap selector connection in the (-) position of the change-over selector: When stressed with impulse voltage, the permissible withstand voltage &quot;a&quot; between the end of a coarse winding connected with the K tap selector contact and the tap selector contact at the end of the tap winding of the same phase must be adhered to.</td>
</tr>
<tr>
<td>a1</td>
<td>Between tap selector contacts of the winding of one tap position (connected or not connected)</td>
</tr>
<tr>
<td>2a1</td>
<td>Between the tap selector contacts of the winding across two tap positions (connected or not connected)</td>
</tr>
<tr>
<td>b</td>
<td>Between the tap selector contacts of different phases and between change-over selector contacts of different phases which are connected with the beginning/end of a tap winding or with a tap selector contact. The permissible voltages between the contacts for tap-changers for delta connections depend on the positions of the change-over selector and tap selector. The different permissible withstand voltages b1, b2 or b3 must therefore be noted for an insulation distance:</td>
</tr>
<tr>
<td>b1</td>
<td>Between selected contacts for different phases</td>
</tr>
<tr>
<td>b2</td>
<td>From the selected contact of one phase to non-selected contacts of other phases</td>
</tr>
<tr>
<td>b3</td>
<td>Between non-selected contacts of different phases</td>
</tr>
<tr>
<td>f</td>
<td>Between tap selector contacts and (+) change-over selector contacts to ground. Different values apply for the delta connection version:</td>
</tr>
<tr>
<td>f1</td>
<td>Between take-off lead and ground and in (+) position of change-over selector between (+) change-over selector contacts and ground</td>
</tr>
<tr>
<td>f2</td>
<td>Between non-selected tap selector contacts and in (-) position of change-over selector between (+) contacts and ground.</td>
</tr>
<tr>
<td>c1</td>
<td>From one (-) change-over selector contact to take-off lead of the same phase</td>
</tr>
<tr>
<td>c2</td>
<td>Between (-) change-over selector contacts of different phases</td>
</tr>
</tbody>
</table>

Table 28: Definition of insulation distances
Insulation distances for an ECOTAP® VPD® III without change-over selector

![Diagram of insulation distances for an ECOTAP® VPD® III without change-over selector]

Table 29: Abbreviations for the rated insulation level:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LI</td>
<td>Full wave lightning impulse (kV, 1.2/50 µs)</td>
</tr>
<tr>
<td>LIC</td>
<td>Chopped wave lightning impulse (kV, 1.2/50/3 µs)</td>
</tr>
<tr>
<td>AC</td>
<td>Applied voltage (kV, 50 Hz, 1 min)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rated insulation level (voltage magnitudes for delta applications in kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation distance</td>
</tr>
<tr>
<td>--------------------</td>
</tr>
<tr>
<td>a</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>a1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>b1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>b2</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
## Technical data

Highest voltage for equipment:

\[ U_m = 24 \, \text{kV} \]

<table>
<thead>
<tr>
<th>Insulation distance</th>
<th>Voltage waveform</th>
<th>Without change-over selector</th>
</tr>
</thead>
<tbody>
<tr>
<td>b3</td>
<td>LI 1.2/50 µs</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>LIC 1.2/50/3...6 µs</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>AC 50 Hz, 1 min</td>
<td>70</td>
</tr>
<tr>
<td>f1</td>
<td>LI 1.2/50 µs</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>LIC 1.2/50/3...6 µs</td>
<td>165</td>
</tr>
<tr>
<td></td>
<td>AC 50 Hz, 1 min</td>
<td>50</td>
</tr>
<tr>
<td>f2</td>
<td>LI 1.2/50 µs</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>LIC 1.2/50/3...6 µs</td>
<td>190</td>
</tr>
<tr>
<td></td>
<td>AC 50 Hz, 1 min</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 30: Rated insulation level (voltage magnitudes for delta applications in kV)
14.5 Limit values for dielectric strength and water content of on-load tap-changer oil

The following table provides the limit values for dielectric strength (measured in accordance with IEC 60156) and water content (measured in accordance with IEC 60814) of the on-load tap-changer oil for the ECOTAP® VPD® on-load tap-changer. The values have been established based on IEC 60422.

<table>
<thead>
<tr>
<th></th>
<th>$U_d$</th>
<th>$H_2O$</th>
</tr>
</thead>
<tbody>
<tr>
<td>When commissioning the transformer for the first time</td>
<td>&gt; 60 kV/2.5 mm</td>
<td>&lt; 12 ppm</td>
</tr>
<tr>
<td>During operation</td>
<td>&gt; 30 kV/2.5 mm</td>
<td>&lt; 30 ppm</td>
</tr>
</tbody>
</table>

Table 31: Limit values for on-load tap-changer oil

14.6 Technical data of the control unit

<table>
<thead>
<tr>
<th>Permissible voltage range</th>
<th>$U_N$: 100...240 V AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring range</td>
<td>100...240 V AC</td>
</tr>
<tr>
<td>Measuring accuracy (at $U_N$ = 100 V (-25...+70 °C)):</td>
<td>&lt; ±2.00%</td>
</tr>
<tr>
<td>Measuring accuracy (at $U_N$ = 240 V (-25...+70 °C)):</td>
<td>&lt; ±0.85%</td>
</tr>
<tr>
<td>Intrinsic consumption:</td>
<td>7.5 W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Permissible frequency range</th>
<th>50/60 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overvoltage category</td>
<td>IV</td>
</tr>
<tr>
<td>Input current</td>
<td>Max. 1.5 A at 100 V AC</td>
</tr>
<tr>
<td></td>
<td>Max. 0.63 A at 240 V AC</td>
</tr>
<tr>
<td>Power consumption</td>
<td>Max. 150 W</td>
</tr>
<tr>
<td>Internal fuse (F1)</td>
<td>Fine-wire fuse, 6.3 x 32 mm, min. 250 V, T4A</td>
</tr>
<tr>
<td>Nominal voltage of the control circuit</td>
<td>24 V DC</td>
</tr>
<tr>
<td>Nominal current of the control circuit</td>
<td>5 A</td>
</tr>
<tr>
<td>Duration of the tap-change operation</td>
<td>Approx. 420 ms</td>
</tr>
</tbody>
</table>

Table 32: Electrical data

<table>
<thead>
<tr>
<th>Operating temperature</th>
<th>-25 °C...+50 °C (continuous)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-25 °C...+70 °C (max. 2 h per day)</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>-25 °C...+85 °C</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>10...95% non-condensing</td>
</tr>
<tr>
<td>Air pressure</td>
<td>Corresponds to 2000 m above sea level</td>
</tr>
<tr>
<td>Degree of protection</td>
<td>Standard: IP30</td>
</tr>
<tr>
<td></td>
<td>With control cabinet: IP54</td>
</tr>
</tbody>
</table>
Contamination level 2

Installation site
- Standard: Indoors
- Control cabinet for outdoor use: Outdoors
- Control cabinet for indoor use version with ECOTAP® VPD® CONTROL PRO: Indoors
- The control cabinet must be protected against direct sunlight.

Table 33: Permissible ambient conditions

### Interfaces

<table>
<thead>
<tr>
<th>Interface</th>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>A (+)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>B (-)</td>
<td></td>
</tr>
</tbody>
</table>

Table 34: X6/COM1 (RS485)

### 14.7 Technical data for the motor-drive unit

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature</td>
<td>-25 °C...+70 °C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>-25 °C...+85 °C</td>
</tr>
<tr>
<td>Air pressure</td>
<td>Corresponds to 2000 m above sea level</td>
</tr>
<tr>
<td>Degree of protection</td>
<td>IP66</td>
</tr>
<tr>
<td>Installation site</td>
<td>Indoors, outdoors</td>
</tr>
</tbody>
</table>

Table 35: Permissible ambient conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>10 m</td>
</tr>
<tr>
<td>Connections</td>
<td>pre-assembled</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-25 °C...+70 °C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>-25 °C...+85 °C</td>
</tr>
</tbody>
</table>

Table 36: Connection cables from motor-drive unit to control unit
15 Drawings

15.1 Information on the drawings in the appendix

The drawings listed in this section are examples. The delivered product may deviate from these examples.

The drawings that you receive with the order confirmation are definitive.

15.2 Dimensional drawings
TRANSFORMER COVER

- Weight: approx. 17.0 kg
- Displacement volume: approx. 5.0 dm³

Sealing surface on bottom side of cover must not be painted, primer only

Grounding screw M8

Dimensions in mm:
- 365 mm
- 317 mm
- 292 mm
- 198 mm
- 188 mm
- 150.8 mm
- 150.8 mm
- 775 mm
- 785 mm
- 85 mm
- 134 mm
- 454.7 mm
- 319 mm

Sheet 1/3

ON-LOAD TAP-CHANGER ECOTAP® VPD®
24 KV, AS SHOWN FOR 9 OPERATING POSITIONS
DIMENSION DRAWING
SAME POTENTIAL AS TRANSFORMER COVER

AREA WITH PARTS AT HIGH VOLTAGE POTENTIAL

THESE COMPONENTS ARE MADE OF NON CONDUCTIVE MATERIALS
15.3 High-voltage connection diagrams
Fuer diese technische Unterlage behalten wir uns gemaess DIN 34 Abschnitt 2.1 und 2.2 alle Rechte vor.

DIN 34

STANDARD

VERIFIED

EXEC.

DATE

ORIGIN.

REPL.BY

REPL.

LANGUAGE:

PROJECT:

EN

DE

KUNDEN VERBINDUNGEN
CUSTOMER CONNECTIONS

MR VERBINDUNGEN
MR CONNECTIONS

VERSCHIEDENE SPANNUNGEN
DIFFERENT VOLTAGES

JUSTIERSTELLUNG
ADJUSTMENT POSITION

BETRIEBSSTELLUNG
SERVICE POSITION

BEZEICHNUNG DER WAHLERKONTAKTE
DESIGNATION OF TAP SELECTOR CONTACTS

BEZEICHNUNG DER STELLUNGEN
DESIGNATION OF POSITIONS

REGELBEREICH (kV)
REGULATION RANGE (kV)

BETRIEBSSTELLUNG
SERVICE POSITION

ANSICHT VON DER TRANSFORMATOR SEITE
VIEW FROM TRANSFORMER SIDE

DRAWING BY CAD

DO NOT MODIFY MANUALLY

09.07.2021
15.4 Dimensional diagram for control unit (10014680)