NOTE

Changes may have been made to a product after going to press with this documentation.
We expressly reserve the right to make changes to a product's technical data and design as well as changes to the scope of delivery.
In all cases, the information submitted and agreements concluded during processing of the quotation and order in question shall be binding.
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1 General

1.1 Foreword

The TAPCON® 260 voltage regulator is part of a new device generation from MR Reinhausen. The simple user interface enables the user to quickly master the individual functions.

Please read these instructions before commissioning the TAPCON® 260. The operator is responsible for ensuring that users of the device have fully understood the operating and safety instructions.

1.2 Manufacturer

The voltage regulator TAPCON® 260 is manufactured by:
Maschinenfabrik Reinhausen GmbH
Falkensteinstrasse 8
93059 Regensburg, Germany
Tel.: (+49) 9 41/40 90-0
Fax: (+49) 9 41/40 90-6 00
E-Mail: sales@reinhausen.com

Further copies of these operating instructions are available from the above address, if required.
2 Safety

2.1 Safety instructions

Safety instructions for operating the TAPCON® 260 voltage regulator are presented in three different forms in this manual. These instructions must always be followed! Failure to follow the safety instructions may lead to accidents and severe personal injury.

What you should always do!

Read the operating instructions!

Please read these instructions before switching on the TAPCON® 260. As the operator, you are responsible for ensuring that users of the device have fully understood the operating and safety instructions.

Only let skilled personnel work with the TAPCON® 260!

The TAPCON® 260 voltage regulator is designed exclusively for application in electrical or energy systems and facilities operated by appropriately trained staff, i.e. staff who are familiar with the installation, assembly, commissioning and operation of such products.

Train your staff!

Before asking staff to work with the TAPCON® 260, provide training about:
- the general and special safety instructions
- the accident prevention regulations
- the specified use of TAPCON® 260

WARNING

Transformer test! If the 19-inch electronics sub-rack is installed in the ED motor-drive unit, ensure that the supply and control lines leading to the motor-drive are disconnected directly at the motor-drive before carrying out lightning and max. admissible voltage tests for the transformer.

WARNING

Fire hazard! All relevant fire protection regulations must be strictly observed.

WARNING

Risk of electric shock! Ensure that the TAPCON® 260 is connected and its housing earthed with due care. Otherwise there is an increased risk of electric shock when working on live parts.

CAUTION

Risk of injury! For safety reasons, no unauthorized and improperly executed work, i.e. installation, modification, alteration of the equipment, electrical connection, or commissioning of the equipment, is permitted without first consulting MR.

NOTE

This notes give important information on specific subjects.
2.3 Warranty and liability

Warranty and liability claims for personal injury or damage to property are excluded, if they were caused by one or more of the following:

- Inappropriate use of the TAPCON® 260.
- Improper commissioning and operation of the TAPCON® 260.
- Operation of TAPCON® 260 with safety equipment that is faulty, or with safety or protection equipment that is installed incorrectly or non-functioning.
- Non-adherence to the notes in the operating instructions with regard to installation, commissioning and operation of the TAPCON® 260.
- Unauthorized modification of the TAPCON® 260.

2.4 Specified application

The TAPCON® 260 is used for automatic control of transformers with motor-driven on-load tap-changers. The motor-drive mechanism receives the corresponding control signals from the voltage regulator. With these signals, the on-load tap-changer moves to the next position and the transformer’s voltage value is adapted to the preset desired voltage level.

TAPCON® 260 provides three options to select which winding should be controlled:

1. The transformer winding with the higher current flow is controlled.
2. A digital input signal is used to select which winding should be controlled.
3. Two digital input signals are used to select which winding should be controlled, cf. table below.

The uncontrolled voltage is monitored for under- and overvoltage. The signal corresponds to the under- and overvoltage signal for the controlled voltage. In contrast to normal overvoltage, in the event of an overvoltage on the non-controlled side the “Raise” pulses are blocked and no rapid down-switching occurs. Similarly, unlike for normal undervoltage, blocking of the “Lower pulses” is initiated on the uncontrolled side, if this behaviour has been activated for normal undervoltage.

To allow individual adaptation of the control system to the various field service conditions encountered, influencing variables such as:
- Time delay
- Bandwidth
- line or load-dependent parameters for compensating voltage drops
- voltage or current-dependent limits can be programmed.

As a special feature, the TAPCON® 260 is also capable of controlling parallel transformer operation.

<table>
<thead>
<tr>
<th>Input 'Winding 1'</th>
<th>Input 'Winding 2'</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>The transformer winding with the higher current flow is controlled.</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>Transformer winding 1 is controlled.</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>Transformer winding 2 is controlled.</td>
</tr>
</tbody>
</table>

NOTE

Which of the three options is implemented in TAPCON® 260 is dependent on the specification of the customer and determined by an internal parameterization. Consequently, it can only be changed by MR.
3 Description of the device

The individual components are mounted in a standardized 19-inch rack. The front plates of the components are fixed to the rack at the top and at the bottom. Electrical connection is provided by plug connectors according to DIN 41612. The components are connected to each other via data bus and separate DC supply, making it very easy to retrofit the system with additional plug-in modules or extension modules at any later date, if required.

The front panel of TAPCON® 260 contains an LCD graphic display, several LED lamps and several function keys and menu keys.

The device is controlled by a microcontroller (see Appendix, block/connection diagram). Besides a voltage transformer and a current transformer it contains opto-coupler inputs with potential separation as well as potential-free output relay contacts. The parameters of the TAPCON® 260 can be set via a PC and an integrated serial interface (COM 1 or RS232) installed at the front panel; the associated software is included in the scope of supply. The functions of the TAPCON® 260 voltage regulator are largely compatible with those of the earlier voltage regulator generations.
### Technical Data

#### Setting ranges

<table>
<thead>
<tr>
<th>Setting</th>
<th>Range</th>
<th>Step width</th>
<th>Standard factory settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desired voltage level 1</td>
<td>49 – 140 V</td>
<td>0.1 V</td>
<td>100 V</td>
</tr>
<tr>
<td>Desired voltage level 2</td>
<td>49 – 140 V</td>
<td>0.1 V</td>
<td>100 V</td>
</tr>
<tr>
<td>Desired voltage level 3</td>
<td>49 – 140 V</td>
<td>0.1 V</td>
<td>100 V</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>0.5 to 9 %</td>
<td>0.1 %</td>
<td>1 %</td>
</tr>
<tr>
<td>Delay time 1</td>
<td>1 to 600 s</td>
<td>1 s</td>
<td>40 s</td>
</tr>
<tr>
<td>Delay time 2</td>
<td>1 to 10 s</td>
<td>1 s</td>
<td>10 s</td>
</tr>
<tr>
<td>Switching pulse duration</td>
<td>0 to 10 s</td>
<td>1.5 s</td>
<td>1.5 s</td>
</tr>
<tr>
<td>LDC</td>
<td>Ur = 0 to ± 25 V</td>
<td>0.1 V</td>
<td>0 V</td>
</tr>
<tr>
<td></td>
<td>Ux = 0 to ± 25 V</td>
<td>0.1 V</td>
<td>0 V</td>
</tr>
<tr>
<td>With optional Z-Compensation selection</td>
<td>Voltage rise 0 to 15 % of desired voltage level</td>
<td>0.1 %</td>
<td>0 %</td>
</tr>
<tr>
<td></td>
<td>limitation 0 to 15 % of desired voltage level</td>
<td>0.1 %</td>
<td>0 %</td>
</tr>
<tr>
<td>Undervoltage blocking</td>
<td>60 to 100 % of desired voltage level</td>
<td>1 %</td>
<td>90 %</td>
</tr>
<tr>
<td>Overvoltage detection with high-speed return control (interruptible)</td>
<td>100 to 140 % of desired voltage level pulse signal 1.5 / 1.5 s</td>
<td>1 %</td>
<td>110 %</td>
</tr>
<tr>
<td>Overcurrent blocking</td>
<td>50 to 210 %</td>
<td>1 %</td>
<td>110 %</td>
</tr>
<tr>
<td>Voltage transformer</td>
<td>0 to 999,0 kV/57 V to 110 V</td>
<td>0 kV/100 V</td>
<td></td>
</tr>
<tr>
<td>Current transformer</td>
<td>100 to 10,000 A/5/1/0.2 A</td>
<td>no presetting</td>
<td></td>
</tr>
<tr>
<td>Measuring circuit</td>
<td>phase angle adjustable between U and I for 1-phase and 3-phase system according to CT/VT connection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function monitoring</td>
<td>15 min.</td>
<td>On</td>
<td></td>
</tr>
</tbody>
</table>
3 Description of the device

Control elements, display

Function keys
- Manual / automatic control mode
- Raise / lower
- Menu keys

Display
- Monochromatic 128x128 dot display with graphics capacity
- 1 LED lamp (green) operation display
- 1 LED lamp (red) each for signalling U<, U>, I>
- 1 LED (yellow) for signalling parallel operation active
- 1 LED lamp (green) for signalling 'Normset active' status
- 3 LED lamps (yellow) for random assignment by user
- 1 LED lamp (green/red) for random assignment by user

Inputs and outputs

Input relays
- 1x raise
- 1x lower
- 1x manual control mode
- 1x automatic control mode
- 1x Master / Follower

Output relays and rating of relay contacts:
- 1x high-speed circuit-breaker of voltage limit supervisory control
- 1x parallel operation group 1
- 1x parallel operation group 2
- 1x desired voltage level 2
- 1x desired voltage level 3
- 1x cam-operated contact from motor-drive

Voltage transformer
- 49 to 140 V, measuring range 60 ... 185 V, r.m.s. value 40 to 60 Hz, intrinsic consumption < 1 VA

Current transformer
- 0.2 / 1 / 5 A, 40 ... 60 Hz, r.m.s. value intrinsic consumption < 1 VA, overload capacity 2 x In continuously, 40 x ln/1 s

Measuring error
- Voltage measuring: < 0.3 % ± 40 ppm/°C
- Current measuring: < 0.5 % ± 40 ppm/°C

Serial interfaces
- 1x serial interface RS232 (COM1 on the front plate) for parametering via PC
- 1x CAN bus for parallel operation optional
- 1x RS232 control system interface
- 1x RS485

Power supply
- DC: 18 to 72 V
- AC, DC: 93 to 265 V
- Consumption: approx. 45 VA ± 2 VA dependent on active relays and functions
3 Description of the device

Protective housing
19-inch module frame according to DIN 41 494 Part 5
Dimensions: 483 x 133 x 178 mm (W x H x D)
Degree of protection: IP 00 according to IEC 60529
Weight: approx. 5 kgs

Temperature limits
Admissible ambient temperature for operation: -25 °C to +70 °C
Admissible ambient temperature for storage and transport: -30 °C to +85 °C

Tests

Electrical safety
Protection class 1 in accordance with IEC 60536
Protection rating IP00 in accordance with IEC 60529
Degree of soiling 2 in accordance with IEC report 664-1
Overvoltage category III in accordance with IEC report 664-1
Fulfills IEC 60688
EN 61010-1 Safety provisions governing electrical measurement, control, regulation and laboratory equipment.
Dielectric test with operating frequency of 2.5 kV/1 min
IEC 60255 Dielectric test with surge voltage, 5 kV, 1.2/50 μs

Electromagnetic compatibility

IEC 61000-4-2 Interference immunity against electrostatic discharge with 6/8 kV
IEC 61000-4-3 Interference immunity against HF fields with 10 V/m, 80 to 1000 MHz
IEC 61000-4-4 Interference immunity against bursts with 2 kV
IEC 61000-4-5 Interference immunity against surges with 2 kV
IEC 61000-4-6 Interference immunity against HF on lines with 10 V, 150 kHz to 80 MHz
IEC 61000-4-8 Interference immunity against magnetic fields with 30 mA/m, 50 Hz, continuous
IEC 61000-4-11 Interference immunity against voltage drops with AC supply: 30 % / 0.5 period
60 % / 5 periods; with DC supply 100 % / 10 ms and 60 % / 100 ms
EN 61000-6-2 CE conformity
EN 61000-6-4 CE conformity

Temperature and climate resistance

IEC 60068-2-1 Dry cold, -25 °C / 20 hours
IEC 60068-2-2 Dry heat, +70 °C / 16 hours
IEC 60068-2-3 Moist heat, constant, +40 °C / 93 % / 2 days, no moisture condensation
IEC 60068-2-30 Moist heat, cyclic (12 + 12 hours) + 55 °C / 93 % / 6 cycles
3 Description of the device
3.2 Description of the front panel

The TAPCON® 260 is equipped with a key lock to protect against unintentional operation. For activation/deactivation, simultaneously press the keys ESC (fig. 1) and F5 (fig. 1). More details of the function keys will be given further on.

1 - Manual setting of display contrast
2 - LEDs
3 - Function keys
4 - Menu
5 - Cancel
6 - Enter
7 - Changing screens within the same level (arrow keys)
8 - Automatic voltage regulation
9 - Manual
10 - Remote
11 - Raise/Lower control

Fig. 1  TAPCON® 260 control panel
3.3 Description of the display

The basic screen display on the monitor shows the desired and actual voltage rates in V or kV, the system deviation rate, and the current tap-change position. You can set the unit to V or kV.

TAPCON® 260 offers several options for setting the display unit to kV or V. You can convert all values via the "kV/V Display" submenu or specify the unit via the individual input screens for the desired values.

Status line

In case of a special occurrence or in case of a setting, the corresponding occurrences will be displayed in the status line.

The following occurrences will cause information to be displayed in the status line:
- Undervoltage
- Overvoltage
- Overcurrent
- Circulating reactive current
- Master
- Follower
- Par. Error
- Motor protective switch
- Blocking

The screen shows the control voltage. The identifier for the controlled voltage is displayed at the top left next to the voltage itself, shown as "U1" in the image. The measurement readings (current, power, phase, cosine) of the second channel can be displayed in the line in which normally the deviation and the measurement readings for the first channel are displayed (see image: "dU").

NOTE

Please note that the correct display of the primary voltage depends on the correct entry of the potential transformer data (see chapter CT/VT data).
3 Description of the device

3.4 Description of the function keys (see fig. 1)

Keys F1 ... F5
are used to navigate the sub-groups or input screens

Auto mode
is used for automatic voltage regulation

Manual mode
For parameterization of the TAPCON® 260 and for manual control of the on-load tap-changer.

NOTE
Parameters can only be changed in manual mode (key with hand symbol in fig. 1).

Remote key
If the LED is on, only commands from an external control system level are executed (binary inputs of the TAPCON® 260). In this case, the Raise/Lower, Auto and Manual keys are disabled.

ESC
The ESC key takes you back to a higher level.

MENU
This key takes you back to the initial screen.

Arrow keys
In Auto and Manual mode, the arrow keys can be used for changing the „Measured value display“ (see Display) and for navigating between the sub-groups.

Raise/Lower keys
In manual mode (diagram), the on-load tap-changer can be operated directly via the Raise/Lower keys (changing the step voltage).

Enter key
For confirming / entering a modified parameter in the setup menu (see chapter “Parametering”).

Serial interface COM 1
For connecting the TAPCON® 260 voltage regulator with a PC. The associated parameterization software is included in the scope of supply.

3.5 Raise/Lower control
The tap position can only be changed in “Manual” mode. In “Manual” mode, the motor-drives can be set higher or lower by pressing the “Raise” or “Lower” key.
3.6 Special operating reliability for TAPCON® 260

The TAPCON® 260 control panel is sub-divided into two levels (so-called security levels). We refer to them as operation control level and protected level for parameterization.

The operation control keys are clearly separated from those for parameterization. In addition, all requests for user action are indicated via LEDs (visual feedback).

The LEDs integrated in the “Raise”-/“Lower” keys are illuminated over the complete duration of the on-load tap-changer operation. This visual monitoring facility makes operation of the TAPCON® 260 easier.

Digital protection and control devices such as TAPCON® 260 are normally password-protected. Due to the significant number of digital devices found in transformer stations, our developers deliberately avoided the allocation of a password in the interest of clarity.

TAPCON® 260 parameters can only be changed in manual mode. Switching to manual mode represents an operation control action and is associated with feedback to the control room. Operation / parameterization of the TAPCON® 260 can thus be monitored seamlessly without password.
Voltage regulation for transformers with on-load tap-changers is an important issue for energy supply companies. According to DIN-IEC 38, the 230 V/400 V voltage in the public low-voltage grid has to be kept constant with an accuracy of at least ± 10 %. TAPCON® 260 makes this control task simple and straightforward. The TAPCON® 260 voltage regulator continuously compares the actual value \( U_{\text{actual}} \) (output voltage at the transformer) with a fixed or load-depending desired voltage level \( U_{\text{desired}} \) that you can specify. Depending on the difference between actual and desired value, TAPCON® 260 provides the actuating pulse for the on-load tap-changer of the transformer.

The on-load tap-changer switches if the actual value falls outside the preset bandwidth (\( U_{\text{desired}} \pm B\% \)). The voltage at the transformer is thus kept constant. Fluctuations within the permissible bandwidth have no influence on the control response or the tap-change operation.

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

All you have to do is enter the desired voltage level and the potential transformer ratio via the standard NORMset function. TAPCON® 260 automatically deals with the rest.

Separate transformer signal converters are no longer required. These included, for example, programmable multi-signal converters or analog signal converters for transmission of measured current, voltage, active power and reactive load values. All these functions can now be integrated in the TAPCON® 260 digital voltage regulator.

The TAPCON® 260 enables you to set and monitor the on-load tap-changer positions directly in manual mode. Separate tap position displays directly at the transformer are therefore no longer required.

### 4.1 Parallel operation of tapped transformers

Transformer control is relatively clear and easy to handle. The situation is less clear if transformers are operated in parallel. Safe and economic parallel operation of transformers can only be ensured if their performance capability, i.e. their rated power, can be utilized fully and without overloading an individual transformer.

### NOTE

On the primary side, the transformers must be connected to the same voltage, and the voltages on the secondary side must have the same magnitude and angle. The transformers should therefore meet the following criteria:

- comparable output
- same vector group
- same rated voltage and comparable voltage ratios
- comparable relative short-circuit impedance

There are several good reasons for operating transformers in parallel. TAPCON® 260 was therefore developed further and optimized for this mode of operation.

#### 4.1.1 Master/Follower principle (synchronism control of tap-changer)

With this technique, one controller takes on a master function. This regulator is assigned overall control (master), while the other regulators (followers) execute its control commands. Via the CAN bus the master compares the tap position of the followers with its own tap position. If a tap position deviation is detected, the master ensures that the followers are brought to the same tap position.

#### 4.1.2 Master/Follower principle (automatic synchronism)

This technique is a special form of the master/follower technique.

Even in the event of the specified master regulator failing, the power supply of the customer is not interrupted. The TAPCON® 260 automatically assigns the regulator with the lowest CAN bus address as master.

### NOTE

Please ensure that each regulator has an address number assigned via the “CAN address submenu”. Only once all controllers have been picked up can they communicate with each other via the CAN bus and use the „automatic synchronism“ technique.
4.1.3 Circulating reactive current method
This option is not available with TAPCON® 260.

4.2 Description of the main variables and functions for voltage regulation
In order to be able to fully utilize the benefits offered by TAPCON® 260 right from the start, this chapter describes the main voltage regulation parameters and functions.

4.2.1 Desired voltage level $U_{\text{desired}}$
The desired voltage level is specified as a fixed value. The desired voltage level can be specified via the TAPCON® 260 user interface in the NORMset mode sub-group or in the parameter mode sub-group.

The TAPCON® 260 keeps the voltage at the transformer constant. You can set the desired voltage level to be displayed in kV or V. Accordingly, the TAPCON® 260 compares the desired voltage level with the primary voltage (kV) or the secondary voltage (V) of the potential transformer.

The TAPCON® 260 offers various further options for changing the desired voltage level during operation.

4.2.1.1 Voltage level change via standard control system
The desired voltage level can be set via standard control system protocols such as IEC 60870-5-101 or 60870-5-103. Please refer to our documentation for the respective interface protocol regarding addressing and data format.

4.2.1.2 Voltage level change via analog input
Via the analog input, you can change or adjust the desired voltage levels as follows:
- potentiometer: 50 Ohm ... 2k Ohm
- small signal current: -20 mA ... +20 mA
- small signal voltage: 0 V ... 10 V

4.2.1.3 Binary inputs (standard)
Up to three desired voltage levels (only possible in parameter mode) may be entered - desired voltage level 1 (2/3).
Desired voltage level 1 is usually used as reference value. Desired voltage levels 2 or 3 are activated in the presence of a continuous signal at the IO−X1/17 or IO−X1/16 input. If a signal is present at both inputs, desired voltage level 2 will be active.

4.2.1.4 BCD-coded voltage level change
Optionally, the desired voltage level may be specified via binary inputs. Further information is available on request.

4.2.2 Bandwidth "B %"
If the measuring voltage, i.e. the measured actual value, falls outside the specified bandwidth (deviation $\Delta U$), after the set delay time $T_1$ an output pulse is issued, and the on-load tap-changer switches up or down accordingly.

The bandwidth, i.e. the positive and negative percentage deviation from the desired voltage level ($U_{\text{desired}} \pm B \%$) should be chosen such that the output voltage of the transformer ($U_{\text{out}}$) does not exceed the specified bandwidth limits after the tap-change operation. Violation of the bandwidth would immediately cause a reversed tap-change operation in order for the system to return to the tolerance range of the defined bandwidth. This procedure would be repeated continuously, i.e. the result would be frequent tap-change operations and undesirable fluctuations of the line voltage.

Guide value for the bandwidth:

Normally, the following value is recommended for the bandwidth B %:

$$[\pm B \%] \geq 0.6 \cdot \Delta U_{\text{step}}$$

Example for determining the permissible bandwidth:

Voltage rating: $U_{\text{nom}} = 100 \text{ kV}$
Number of tap positions: $\pm 15$ (= 30 steps)
Setting range: 85 kV ... 115 kV
Step voltage: (115 kV - 85 kV) / 30 steps = 1 kV / step

Thus 1 kV/step corresponds to value 1% of $U_{\text{nom}}$.

NOTE
You may set the bandwidth "B %" at the TAPCON® 260 from 0.5 % to 9 % in steps of 0.01 %. The transformer's step voltage must be known to ensure proper setting of this value (see example). For increased regulating sensitivity it is also possible to set lower values, although it is highly unadvisable to go below 60 % ($[\pm B \%] \geq 0.6 \cdot \Delta U_{\text{step}}$) of the computed value.
4.2.3 Control delay: T1 and T2

**Delay time T1:**
A violation of the specified bandwidth is referred to as deviation $\Delta U$, in which case the regulator starts to respond. In order to avoid unnecessary switching operations caused by short-term violation of the bandwidth, the TAPCON® 260 features a delay time option. The duration of this delay is specified via the delay time parameter $T_1$. A gradually filling time bar indicates the time left until the start of the control operation. If the deviation is still present after the delay has elapsed, an output pulse is issued, and the on-load tap-changer initiates a switching operation. If the deviation returns to within bandwidth limits during the delay time $T_1$, the delay time is decremented. The bar in the time diagram is shown hatched and becomes gradually smaller. No tap-change operation occurs. The benefit of decrementing is that the regulator does not keep counting from 0 sec. if the bandwidth is exceeded regularly. Instead, the time already elapsed is used as a measure for the start of the subsequent delay time. The TAPCON® 260 meets the requirements of fast and optimized control response. Via the submenu "T1 control response", the delay time $T_1$ can be set with linear or integral response.

**Linear time:**
The regulator responds with a constant delay time, independent of the deviation.

**Integral time:**
Depending on the deviation, the response time of the regulator is reduced to a minimum of 1 sec, i.e. the greater the deviation ($U_{\text{actual}}$ from $U_{\text{desired}} \pm B\%$), the shorter the response time. The TAPCON® 260 can thus respond more quickly to unexpectedly large voltage changes in the grid. Control accuracy is increased.

**Delay time T2:**
In rare cases, more than one tap-change operation is required for returning the transformer output voltage to within the specified bandwidth $B\%$. However, particularly with integral control response this would mean that the time until an output pulse is issued would increase with each tap-change operation. This behaviour can be counteracted by using delay time $T_2$. The first output pulse is issued after the specified delay time $T_1$. Further pulses required for stabilization are issued after the specified delay time $T_2$, usually between 10 and 15 sec.
4.2.4 Line compensation: LDC and Z compensation

The energy supply quality at the customer not only depends on the busbar voltage of the supply transformer (measured value $U$), but even more the voltage directly at the customer equipment. In selected cases, voltage regulation has to take account of the feeder impedance (in the cables or overhead lines to the customers). These feeder lines may be subject to a significant (load-dependent!) voltage drop. This voltage drop depends on the impedance of the line, the current and the phase angle $\varphi$ at the consumer.

The TAPCON® 260 offers two different options for compensating a load-dependent voltage drop between transformer and consumer.

a) Line Drop Compensation (LDC) requires knowledge of the exact line data. LDC offers accurate compensation of line voltage drops. Correct setting of the LDC requires calculation of the resistive and inductive line voltage drop in relation to the secondary side of the voltage transformer in $V$ and the correct setting of the existing measuring transformer configuration.

b) Z compensation can be used in case of minor shifts of the phase angle $\varphi$, also in meshed network applications. Correct setting of the Z compensation requires calculation of the voltage increase $\Delta U$ taking account of the magnitude of the current.
5.1 NORMset

The NORMset function is an automatic mechanism that considerably simplifies configuration of a TAPCON® 260.

For starting the device, you simply have to enter the desired voltage level, the primary and secondary voltage and, if necessary, the potential transformer data. Depending on whether kV or V has been specified as the unit, the desired voltage level is compared with the primary or secondary voltage of the potential transformer. The correct application depends on the correct entry of the potential transformer data.

If the desired voltage level is entered while the NORMset function is active (LED illuminates green), the TAPCON® 260 will examine the given line/network conditions and proceed to perform an automatic adaptation of all further inputs (comprised in part of the pre-parametering and standard reference values) which used to be required for conventional regulators.

5.2 Protection functions

Trouble-free operation is ensured by the regulator’s inherent undervoltage blocking or overcurrent blocking (<U and >I) and overvoltage monitoring (>U).

Entering the limit values:

For undervoltage and overvoltage, the limit values in percent % refers to the desired voltage level \( U_{\text{desired}} \). For undervoltage and overvoltage, the limit value in kV or V refers to the primary or secondary voltage of the potential transformer.

For overcurrent, the limit value in percent % or A refers to the set rated current of the current transformer.

5.2.1 Undervoltage blocking

Undervoltage blocking prevents tap-change operations in the event of a network breakdown.

The TAPCON® 260 output pulses are blocked and the red LED "<U" illuminates as soon as the output voltage of the transformer falls below the set blocking value. The associated signalling relay (contacts IO-X1/18; IO-X1/19, IO-X1/20) is energized and remains that way.

5.2.2 Overcurrent blocking

Overcurrent blocking prevents tap-change operations in the presence of overload.

The voltage regulator output pulses are blocked and the red LED ">I" illuminates as soon as the load current falls below the set blocking value. The associated signalling relay (contacts IO-X1/18; IO-X1/19; IO-X1/20) is energized and remains that way.

5.2.3 Overvoltage detection

Overvoltage detection causes the on-load tap-changer to select an appropriate value for returning to the required operating state. The message "function monitoring" will be emitted if a regulating deviation lasting 15 min. is detected by the regulator which is not eventually compensated.

In the event of an overvoltage detection response, the on-load tap-changer keeps getting activated by periodic pulses to the motor-drive mechanism until the overvoltage falls below the response threshold.

The motor-drive mechanism is activated by periodic pulses of 1.5 s through the "Lower" output relay (can be set in the menu - see Configuration → General → Raise/Lower pulse length).

In this case, "Delay time T1" is not active. The red LED ">U" illuminates as long as overvoltage is present.

If the voltage regulator regulates towards a higher voltage than the set limit \( U > \) due to unfavourable parametering (e.g. LDC settings too high), it is prevented from exceeding the limit. The signalling relays (contacts IO-X1/18; IO-X1/19; IO-X1/20) are only activated as long as an overvoltage is present.

5.2.4 Detection of the off-status of the transformer

The TAPCON® 260 is able to detect the off state of the transformer and to prevent regulating operations independently. The user can set the voltage threshold.
6 Commissioning

6.1 Installation
The standardized module frame of the voltage regulator (see appendix) is intended for installation in a 19-inch control cabinet. The swing frame design is recommended as it offers easier access to the terminal at the back.

6.2 Connection
Connect the TAPCON® 260 in accordance with the wiring diagram (see appendix).

**WARNING**
Ensure that the TAPCON® 260 is connected and the housing earthed with due care. Otherwise there is a risk of electric shock.

**NOTE**
Pay attention to the correct phase angle of the secondary terminals of current transformer and voltage transformer.

**NOTE**
Ensure correct connection of the output relays to the motor-drive unit.

In general, the TAPCON® 260 is fed by an auxiliary voltage of 93 ... 265 V AC, DC. The TAPCON® 260 is optionally available with a supply input of 18 - 72 V DC.

The TAPCON® 260 was developed in compliance with the relevant EMC standards. The following instructions must be observed to ensure preservation of the EMC properties:
- Ensure correct connection to ground of the TAPCON® 260 by means of the ground screw attached to the housing
- Be sure to use only shielded cables for the data links from the TAPCON® 260 to other equipment
- The screenings must be connected to ground via the cable clamps at the housing included in the delivery (see fig. 8: section of CPU card, bilateral grounding).

By default, the X8 interface has no function. Instructions for using it are available on request. A PC can be connected via the visualisation software and the RS232 interface at the front panel.

6.3 Easy setting of operating modes with NORMset
Prior to commissioning/initiation, be sure to check the entire switch configuration and the measuring and operating voltage. To assess the working mode of the TAPCON® 260, the use of a registering device to record the regulator voltage (actual value) is highly recommended. The related transformer should be subject to normal load.

a) Select the MANUAL operating mode at TAPCON® 260

b) Select the NORMset function as indicated

c) Set the desired voltage level 1.

If you do not require the primary voltage to be displayed in kV, you may now proceed to initiate the regulator by operating the AUTO function key. If you do require the voltage to be displayed in kV, please proceed as follows:

d) Set the rated transformer voltage and the rated current (see chapter Transformer data).

e) Change the display to kV.

Start the regulator via the "Auto" function key.
6 Commissioning

6.4 Function checks, operational settings for individual operation

Prior to commissioning/initiation, be sure to check the entire switch configuration and the measuring and operating voltage. To assess the working mode of the TAPCON® 260, the use of a registering device to record the CT/VT voltage (actual value) is highly recommended. The related transformer should be subject to normal load.

a) Select the "Manual" operating mode at TAPCON® 260.
b) Set the transformation ratios of the CT/VT, as well as the measuring circuit.
c) Let the measured actual voltage (= voltage from the voltage transformer) be indicated on the display of the TAPCON® 260.
d) Let the current, power, and phase angle values be indicated on the display and compare these values with those from possibly existing service measuring instruments. If wrong signs are indicated, reverse the polarity of the current or voltage transformer.

Please note that the factory presetting for the current transformer is 0 Ampere! To ensure proper display of the correct operating values, please be sure to enter the primary rated transformer current in the menu "Configuration → CT/VT data → primary current".

e) Set the desired voltage level. By manual control of the motor-drive, bring the tap-changer to the service position so that the desired voltage level is obtained.

f) Set the desired voltage level to this value.

g) Set the bandwidth to 1.0 %. In most cases the TAPCON® 260 is now in a balanced state (no presignal).

h) Set the bandwidth in dependence of the step voltage.
i) Set the delay time T1 to 20 s linear; by manual control, move the tap-changer towards "Raise" by one step.

Set the mode of operation to "Auto". The time bar fills up from bottom to top while the time is simultaneously displayed above the time bar until activation of the on-load tap-changer. After a period of 20 s the TAPCON® 260 must control the on-load tap-changer back to its previous service position.

At that point the bar graph display moves back into the normal position.

Set the mode of operation to "Manual". Repeat the control procedure towards "Lower".

Set the operating delay time T2 to 10 s. Set the mode of operation to "Manual". By manual control, move the tap-changer towards "Raise" by two steps.

Set the mode of operation to "Auto". After a period of 20 s the TAPCON® 260 must automatically control the on-load tap-changer back to its previous service position by one step and after further 10 s by another step.

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

When putting the transformer into service, it is recommended to set the delay time T1 provisionally to 100 s. Depending on the existing operating conditions, you may want to determine the definitive setting only after some time of observation. For this purpose it is recommended to register the variation of the actual voltage and the number of tap change operations on a day-to-day basis. If an inverse response of the TAPCON® 260 is desired, set an integral time response for the delay time 1. In this case the delay time is automatically shortened inversely proportional to the deviation.

k) Set the response threshold for undervoltage blocking U< to 85 %. Set the mode of operation to "Manual" and set the existing voltage level, e.g. 110 V, to 110 V / 0.85 ≥ 130 V, so that the actual voltage now corresponds to the set percentage of the response threshold for the blocking value. Set the mode of operation switch to "Auto".

The output relay "Raise" must not issue a control command. After approx. 10 s the signalling relay "U <" must be energized; the signalling contact (IO-X1/18 and IO-X1/19) will open (deviation from desired voltage level → -). LED U< will now respond. Upon completion of this function test you may now set the desired response threshold for undervoltage blocking.

l) Set the response threshold for overvoltage detection U> to 115 %. Set the mode of operation to "Manual", e.g. 110 V to 110 V / 1.15 = 95 V so that the actual voltage now corresponds to the set percentage of the response threshold for overvoltage detection. The signalling contact (IO-X1/18 and IO-X1/19) opens. LED U> will now respond.

Set the mode of operation to "Auto". The output relay "Lower" must issue periodic control commands at 1.5 s intervals.

Now set the desired response threshold for overvoltage detection to the initially desired voltage level.

m) Set the response threshold for overcurrent blocking I>. A function check is not necessary.
6.5 Function checks, operational settings during parallel operation

(see chapter Parallel operation settings)

**NOTE**

The prerequisite for the proper functioning of parallel operation is the commissioning of TAPCON® 260 for individual operation.

The current transformer inputs must be connected and the CT/VT configuration must be parameterised correctly. The TAPCON® 260 must be set to identical operating parameters for the desired voltage, bandwidth, time delay T1, and line compensation, if applicable (LDC or Z-Compensation, respectively).

In all cases, set stability to “0 %” and “Bandwidth Threshold” to “20 %”.

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

All settings must be performed in the “Manual” operating mode.

Each regulator must be assigned an address of its own on the CAN bus (Menu “CAN address”).
6. Commissioning

6.5.1 Parallel operation according to circulating reactive circuit principle

This option is not available with TAPCON® 260.

Disturbances during parallel operation

If one or all of the regulators signal “Parallel operation disturbed” even though the control inputs are properly connected for all regulators, the following causes may be present:

- Interruption of the data communication between the regulators. Check the data lead in that respect
- The second regulator is not functional
- Different methods of parallel operation were selected
- The bandwidth threshold of the circulating reactive current was exceeded
- Incorrect regulator addressing

The regulators will block under any of the above conditions.

6.5.2 Parallel operation in accordance with the principle of “Master/Follower tap synchronisation”

Select the corresponding method and determine which one of the regulators will assume master function and which of the regulators will assume follower function (see chapter Parallel operation settings).

6.5.3 Setting the time delay for the message "Parallel operation disturbed"

(see chapter Parallel operation settings)

6.5.4 "Tap direction turned" setting

(see chapter Parallel operation settings)

Since a comparison of the tap positions of the transformers jointly engaged in parallel operation is performed during parallel operation in accordance with the principle of "Master/Follower tap synchronisation", it is imperative to maintain identical position titles for all these transformers, and to ensure that the "Higher" and "Lower" signals will effect identical voltage changes in all the transformers.

If this is not the case, i.e. if the phenomenon appears that the follower regulator(s) switch(es) in the opposite direction of the master regulator's tapping direction, proceed by changing the setting of this parameter from "standard" to "turned".
7 Parametering

7.1 NORMset

Activating the NORMset function
Menu → NORMset → NORMset Activation

The term "NORMset" function stands for an automatism which considerably simplifies the parametering of a TAPCON® 260. The only thing left to do for the operator when commissioning during the NORMset mode is to enter the desired voltage level and, if required, the CT/VT values and subsequently take the device into operation.

All other parameters required for simple voltage regulation will be preassigned at the factory (e.g. bandwidth of 1 %).

Should the actual value exit the set bandwidth, an appropriate switching operation will be initiated at the on-load tap-changer.

The voltage change ensuing from the switching operation corresponds to the transformer’s tap voltage and is checked for plausibility by the regulator, using the preset bandwidth. The bandwidth value is then corrected and optimised in accordance with the results gleaned from this check.

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

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

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

NOTE

The parameters for undervoltage/overvoltage and overcurrent are not set by the NORMset function.
If required, these parameters have to be entered manually during commissioning/initiation.

The NORMset function is deactivated during parallel operation.

Setting the desired voltage level
Menu → NORMset → Desired voltage level 1

The setting of the desired voltage level refers either to the secondary or to the primary voltage side of the voltage transformer connected to the TAPCON® 260.

The secondary voltage is displayed in Volt (V), the primary voltage in kilovolt (kV).

This display requires the correct input of the CT/VT data in the following two menu windows.

Setting range:  49 ... 140 V / 0.1 ... 999.9 kV

Setting the primary voltage
Menu → NORMset → Primary voltage

Setting range:  0 ... 999.9 kV

Setting the secondary voltage
Menu → NORMset → Secondary voltage

Setting range:  57 ... 110 V
7 Parametering

7.2 Setting the parameters

This chapter describes all settings required in regulating functions and monitoring tasks.
To make specific parameters easier to find, sub-groups were created which contain functionally related individual parameters.

7.2.1 Regulating parameters

This sub-group comprises all parameters required for the regulating function.

Setting the desired voltage level 1-3 of winding 1
Menu → Parameter → Regulating parameter

Desired voltage level 1 / 2 / 3

Correct input of the voltage transformer data is a prerequisite for proper display of the desired voltage level 1, 2 or 3 of winding 1 or the actual voltage level in kV.
The desired voltage levels 2 or 3 will be activated in the presence of a continuous signal at the IO-X1/17 or IO-X1/16 input. If a signal is present at both inputs, desired voltage level 2 will be active.
Setting range: 49 ... 140 V

Setting the desired voltage level 1-3 of winding 2
Menu → Parameter → Regulating parameter

Winding 2 desired voltage level 1 / 2 / 3

The setting of the desired voltage level refers either to the secondary or to the primary voltage side of the voltage transformer connected to the TAPCON® 260.
The secondary voltage is displayed in Volt (V), the primary voltage in kilovolt (kV).
Correct input of the voltage transformer data of the second winding is a prerequisite for proper display of the desired voltage level 1, 2 or 3 of winding 2.
The desired voltage levels 2 or 3 will be activated in the presence of a continuous signal at the appropriate inputs.
If a signal is present at both inputs, desired voltage level 2 will be active.
Setting range: 49 ... 140 V

NOTE

Please bear in mind that the correct display of the primary voltage depends on the correct input of the voltage transformer data (see chapter on configuration → CT/VT data).
Setting the delay time $T_1$ or $T_2$ (delay time 1/delay time 2)
Menu → Parameter → Regulating parameter

**Delay time $T_1$**

The delay time starts as soon as the regulating deviation exceeds the set bandwidth limits above or below.
At the same time the time bar graph fills in from bottom to top and the time left until emission of the control pulse is displayed. If the regulating deviation is still present after the delay time has elapsed, an output pulse is emitted. If the deviation returns to within bandwidth limits within the delay time, then the current delay time will, starting from the time already elapsed, be deleted against zero. While this is going on, the absolute time display will be disappearing from the display. At the same time, the time bar graph is displayed as a slashed line permanently decreasing in size.

If the regulating deviation again exceeds the set bandwidth limits during deletion, the time delay will, starting from the remaining time, be started anew.

Setting range: 1 ... 600 s

---

Setting the bandwidth

Menu → Parameter → Regulating parameter

**Bandwidth**

You may set the bandwidth $B\%$ from 0.5 % to 9 % in steps of 0.01 %. The transformer's step voltage must be known to ensure proper setting of this value.

\[
B(\%) = \frac{\text{Regulating range (\%)}}{\text{No. of steps}} = \frac{\text{Regulating range (\%)}}{\text{No. of positions} - 1}
\]

For increased regulating sensitivity it is also possible to set lower values, although it is highly unadvisable to go beneath 60% of the computed value. If the measuring-circuit voltage is altered far enough during operation to exceed the set bandwidth, an output pulse will be generated according to the set delay time.

This is shown by a consecutive filling-in of the time bar in the display. Simultaneously, the time left over until emission of the output pulse is displayed.

If no compensation occurs for more than 15 min, the "function monitoring" relay will respond (see connection diagram). The relay will not be reset until the deviation falls short of the set limit.

Setting range: 0.5 ... 9%
7 Parametering

Menu → Parameter → Regulating parameter

**T2 Activation**

The delay time T2 will become effective only if more than one tap change is required for reduction of the control deviation below the bandwidth limit. The first output pulse is emitted after the set delay time T1, whereas the other pulses required for compensation will be emitted after the set delay time T2.

Menu → Parameter → Regulating parameter

**T2 Delay time**

Setting range: 1 ... 10 s

NOTE

During parallel operation, the delay time T2 must not be set lower than 8 s!

\[
\frac{\Delta U}{E} \quad \text{ΔU/E - voltage change ΔU in % of the desired value, in relation to the set bandwidth in % of the desired voltage level.}
\]
7.2.2 Limit values

This sub-group comprises all parameters required for the monitoring of limiting values.

The limiting values can be set both as percentage values and as absolute values.

If percentage values are entered, these values generally refer to the set desired voltage level for undervoltage and over-voltage parameters, whereas for overcurrent both values refer to the set rated current of the current transformer.

Menu → Parameter → Limit values

**Absolute limit values**

- Off: Percentage values
- On: Absolute values

---

**Setting the undervoltage blocking ("U<") of winding 1**

Undervoltage blocking prevents tap-change operations in the event of a network breakdown. The voltage regulator output pulses are blocked and the red LED lamp "U<" responds when the measuring voltage falls below the set blocking value.

After a delay time of approx. 10 s, the associated signalling relay (contacts IO-X1/18, IO-X1/19, IO-X1/20) is energized and remains that way. The signalling relay will not respond in case of a failure of either the measuring voltage and/or the supply voltage (< 30 V) (this standard setting can be cancelled: see parameter "U< also under 30 V" at the foot of the limit values menu).

Setting of the limiting values for undervoltage blocking as percentage value of the set desired voltage level.

Menu → Parameter → Limit values

**U< Undervoltage (%)**

Setting range: 60 ... 100 %

---

**Setting the limiting values for undervoltage blocking as absolute value (winding 1)**

When converting the display to kV (F3 key), this value can be set in reference to the primary CT/VT voltage, whereas if the display is set to V this value will be in reference to the secondary voltage.

Menu → Parameter → Limit values

**U< Undervoltage (V)**

Setting range: 34 V ... 160 V ...

---
7 Parametering

Setting the overvoltage detection (U>) with automatic return control (winding 1)

In the event of an overvoltage detection response, the tap-changer is operated by periodic pulses to the motor-drive until the overvoltage falls below the response threshold. The motor-drive is controlled by periodic pulses of 1.5 s through the “Lower” output relay (can be set in the Configuration menu) while the set delay time remains inactive during this operation. At the same time the “U>” LED lamp responds and a signalling relay is energized (contacts I0-X1/18, I0-X1/19, I0-X1/20), as long as overvoltage is present.

If the voltage regulator regulates towards a higher voltage than the set limit U> due to an unfavourable parametering (e.g. too high LDC settings), it is prevented from exceeding the limit. An unadjustable operating state is signalled by the signalling relay for “function monitoring”, after 15 minutes.

Menu → Parameter → Limit values

**U> Overvoltage (%)**

Setting of the limiting value for overvoltage blocking as percentage value of the set desired voltage level.

Setting range: 100 ... 140 %

Setting the limiting value for overvoltage blocking as absolute value (winding 1)

When converting the display to kV (F3 key), this value can be set in reference to the primary CT/VT voltage, whereas if the display is set to V this value will be in reference to the secondary voltage.

Menu → Parameter → Limit values

**U> Overvoltage (V)**

Setting range: 100 V ... 160 V

... kV

Setting the overcurrent blocking (I>) of winding 1

Overcurrent blocking prevents tap-change operations in the presence of excessive overcurrent.

The TAPCON® 260 output pulses are blocked and the “I>” LED lamp responds when the measured current exceeds the set blocking value. At the same time the corresponding signalling relay is energized and remains energized (contacts I0-X1/18, I0-X1/19, I0-X1/20).

Menu → Parameter → Limit values

**Overcurrent I>**

Press the F3 key to set the input of percentage values to absolute values. The values will in both cases refer to the rated current of the current transformer.

**Setting the undervoltage blocking (“U<”) of winding 2**

Undervoltage blocking prevents tap-change operations in the event of a network breakdown. The voltage regulator output pulses are blocked and the red LED lamp “U<” responds when the measuring voltage falls below the set blocking value.

After a delay time of approx. 10 s, the associated signalling relay (contacts I0-X1/18, I0-X1/19, I0-X1/20) is energized and remains that way. The signalling relay will not respond in case of a failure of either the measuring voltage and/or the supply voltage (< 30 V) (this standard setting can be cancelled: see parameter “U< also under 30 V” at the foot of the limit values menu).

Setting of the limiting values for undervoltage blocking as percentage value of the set desired voltage level.

Menu → Parameter → Limit values

**U< Undervoltage 2 (%)**

Setting range: 60 ... 100 %

... kV
7 Parametering

Setting the limiting values for undervoltage blocking as absolute value (winding 2)

When converting the display to kV (F3 key), this value can be set in reference to the primary CT/VT voltage, whereas if the display is set to V this value will be in reference to the secondary voltage.

Menu → Parameter → Limit values

\(U<\) Undervoltage 2 (V)

Setting range: 34 V ... 160 V

... kV

Setting the overvoltage detection (\(U>\)) with automatic return control (winding 2)

In the event of an overvoltage detection response, the tap-changer is operated by periodic pulses to the motor-drive until the overvoltage falls below the response threshold. The motor-drive is controlled by periodic pulses of 1.5 s through the "Lower" output relay (can be set in the Configuration menu) while the set delay time remains inactive during this operation. At the same time the "U>" LED lamp responds and a signalling relay is energized (contacts I0-X1/18, I0-X1/19, I0-X1/20), as long as overvoltage is present.

If the voltage regulator regulates towards a higher voltage than the set limit \(U>\) due to an unfavourable parametering (e.g. too high LDC settings), it is prevented from exceeding the limit. An unadjustable operating state is signalled by the signalling relay for "function monitoring", after 15 minutes.

Menu → Parameter → Limit values

\(U>\) Overvoltage 2 (%)

Setting of the limiting value for overvoltage blocking as percentage value of the set desired voltage level.

Setting range: 100 ... 140 %

Setting the limiting value for overvoltage blocking as absolute value (winding 2)

When converting the display to kV (F3 key), this value can be set in reference to the primary CT/VT voltage, whereas if the display is set to V this value will be in reference to the secondary voltage.

Menu → Parameter → Limit values

\(U>\) Overvoltage 2 (V)

Setting range: 100 V ... 160 V

... kV

Setting the overcurrent blocking (\(I>\)) of winding 2

Overcurrent blocking prevents tap-change operations in the presence of excessive overcurrent.

The TAPCON® 260 output pulses are blocked and the "I>" LED lamp responds when the measured current exceeds the set blocking value. At the same time the corresponding signalling relay is energized and remains energized (contacts I0-X1/18, I0-X1/19, I0-X1/20).

Menu → Parameter → Limit values

Overcurrent 2 \(I>\)

Press the F3 key to set the input of percentage values to absolute values. The values will in both cases refer to the rated current of the current transformer.
Function monitoring

The message “function monitoring” will be emitted if a regulating deviation lasting 15 min is detected by the regulator which is not eventually compensated. Use this parameter to suppress the message (= Off) to avoid the generation of an error message while the transformer is switched off and while at the same time the message has not been suppressed at U< also below 30 V (see the following paragraph).

Menu → Parameter → Limit values

Suppressing the undervoltage message

Suppress the message Undervoltage U< to avoid the generation of an error message while the transformer is switched off (= measuring voltage U< 30 V).

Menu → Parameter → Limit values

7.2.3 Line compensation

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

Comparison between LDC and Z-Compensation

Application of the vectorial compensation (LDC):
- requires knowledge of the exact line data
- permits an accurate compensation of the line voltage drops

Application of the Z-Compensation:
- can be used in the case of minor shifts of the phase angle \( \varphi \)
- can be also used in meshed network applications.

NOTE

For the correct setting of the LDC it is necessary to calculate the resistive and inductive line voltage drop in relation to the secondary side of the voltage transformer in V and the correct setting of the existing measuring configuration.
7.2.3.1 Line-Drop Compensation (LDC)

Calculation of the required setting values:

\[ Ur = I_N \cdot \frac{R_{CT}}{R_{VT}} \cdot R \cdot L \ (V) \]
\[ Ux = I_N \cdot \frac{R_{CT}}{R_{VT}} \cdot X \cdot L \ (V) \]

Where

- \( Ur \) = LDC setting for resistive line voltage drop in V
- \( Ux \) = LDC setting for inductive line voltage drop in V
- \( I_N \) = Rated current in A of the selected current transformer connection to the voltage regulator, i.e. 0.2 A or 1 A or 5 A
- \( R_{CT} \) = Current transformer ratio, e.g. 200 A / 5 A
- \( R_{VT} \) = Voltage transformer ratio, e.g. \( \frac{30000 \text{ V}}{\sqrt{3}} = 100 \text{ V} \)
- \( r \) = Ohmic resistance of line in Ω / km per phase
- \( x \) = Inductive reactance of line in Ω / km per phase
- \( L \) = Length of line in km

If the active voltage drops \( Ur \) and reactive voltage drops \( Ux \) are set correctly, then the line end voltage will remain constant regardless of load.

Setting the resistive voltage drop \( Ur \)

Menu → Parameter → Compensation

\( Ur \) → Line Drop Compensation

Set the calculated resistive voltage drop in the UR display. The effect of the compensation can be reversed by 180° (minus sign preceding the setting).

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

Setting range: 0 ... 25 V

NOTE

LDC and Z-Compensation can be operated simultaneously. Set the parameters of the compensation method not in use to “0”.

7.2.3.2 Z-Compensation

For correct setting of the parameters the voltage rise (ΔU) has to be calculated in consideration of the current.

Calculation of the required setting values:

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

Where

- \( \Delta U \) = Setting of Z-Compensation in %
- \( U_{Tr} \) = Transformer voltage at current I
- \( U_{Load} \) = Line end voltage at current I and with the same service position of the tap-changer
- \( I \) = Load current in A
- \( I_N \) = Rated current in A of the selected current transformer connection to the TAPCON® 260, i.e. 0.2 A or 1 A or 5 A
- \( R_{CT} \) = Current transformer ratio, e.g. 200 A / 5 A

Setting the inductive voltage drop \( Ux \)

Menu → Parameter → Compensation

\( Ux \) → Line Compensation

Set the calculated inductive voltage drop in the Ux display. The effect of the compensation can be reversed by 180° (minus sign preceding the setting).

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

Setting range: 0 ... 25 V

Set the calculated percentage of the voltage rise, referred to the desired voltage level.

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

Setting range: 0 ... 15 %
**7 Parametering**

### 7.3 Setting of configuration

This chapter treats all settings relevant in the configuration of system-specific data. To make specific parameters easier to find, sub-groups were created which contain functionally related individual parameters.

#### 7.3.1 CT/VT data

The transformation ratios and measuring set-ups of the voltage and current transformers used can be set in the corresponding displays by pressing the F1, F4 and F5 function keys.

**Setting the limiting value for ΔU (LIMIT)**

Menu → Parameter → Compensation

**Z-compensation**

If a certain compensation is desired while excessive transformer voltage rises (e.g. in case of an unusually high load) shall be avoided the max. permissible voltage rise referred to the desired voltage level can be set.

Setting range: 0 ... 15 %

**Setting the primary VT voltage of winding 1**

Menu → Configuration → CT/VT data

**Primary voltage**

Setting range: 0 ... 999,9 kV

**Setting the secondary VT voltage of winding 1**

Menu → Configuration → CT/VT data

**Secondary voltage**

Setting range: 57 ... 110 V

**Setting the primary CT current of winding 1**

Menu → Configuration → CT/VT data

**Primary current**

Setting range: 100 ... 10,000 A

**ATTENTION**

The standard value preset at the factory is 0 ampere, i.e. 0 ampere will be displayed even in the presence of a current flow.
Parametering

Setting of the current transformer connection in use of winding 1
Menu → Configuration → CT/VT data
Current transformer connection

These data are required for the computation and display of the absolute current value. If the setting „unknown” is selected, the current will be displayed as a percentage value in reference to the terminal used (0.2 A, 1 A or 5 A).

Setting the primary VT voltage of winding 2
Menu → Configuration → CT/VT data
Primary voltage 2

Setting range: 0 ... 999.9 kV

ATTENTION
The standard value preset at the factory is 0 ampere, i.e. 0 ampere will be displayed even in the presence of a current flow.

Setting the secondary VT voltage of winding 2
Menu → Configuration → CT/VT data
Secondary voltage 2

Setting range: 57 ... 110 V

Setting the primary CT current of winding 2
Menu → Configuration → CT/VT data
Primary current 2

Setting range: 100 ... 10,000 A

These data are required for the computation and display of the absolute current value. If the setting „unknown” is selected, the current will be displayed as a percentage value in reference to the terminal used (0.2 A, 1 A or 5 A).
Setting the phase angle of current/voltage transformer

Settings of the conventional measuring circuits in accordance with fig. 10.

Menu → Configuration → CT/VT data

CT/VT connection
7.3.2 General

Regulator identification serves as the identification characteristic of a TAPCON® 260 voltage regulator. Its task is to ensure that a connection is established between the visual display software and a specifically defined TAPCON® 260. During online communication, this regulator identification is inquired by the software running on the PC and subsequently compared with the existing regulator data. This allows an accurate classification of the data and/or parameters.

Menu → Configuration → General

Setting the desired display language

Setting the transmission speed

Menu → Configuration → General

Setting the Baud rate for data transmission to the visual display software at the voltage regulator.

Conversion of the voltage displays from kV to V

Conversion of the voltage displays causes the desired voltage level and the actual voltage level in the basic display to be converted to either kV or V.

Menu → Configuration → General

Display kV/V

Setting the pulse duration during tapping operations

Menu → Configuration → General

The Raise/Lower pulse duration can be changed within a range of 0 ... 10 s.

ATTENTION

If the pulse duration is set to 0 s, a continuous pulse will be emitted.
Assigning a function to a free input
Menu → Configuration → General
I/O-X1/33  I/O-X1/31

The following functions can be assigned to the inputs I/O-I/O-X1/33 and I/O-X1/31:
- Changeover Master / Follower
- Changeover Local / Remote
- Tripping of motor protective switch
- Blocking of regulation
- High-speed return control

Assigning a function to a free output
Menu → Configuration → General
I/O-X1/25, I/O-X1/26 and I/O-X1/23, IO-X1/24

The following messages can be assigned to the outputs I/O-X1/25, I/O-X1/26 und I/O-X1/23, IO-X1/24:
- Master / Follower
- Local / Remote
- U<
- U>
- Desired value 2
- Desired value 3
- "Motor running"
- "Impulse for tripping"
- "Motor running" time exceeded
- Bandwidth <
- Bandwidth >

Illumination of the display
Menu → Configuration → General
Display dimmed

In case of activating this function, 15 min after the last pushing a button the display will be dimmed but is still readable. By pushing any button the display lights up again.

Selection of motor running time
Menu → Configuration → General
Motor running time

The running time of the motor-drive unit is monitored by the TAPCON® 260 via the input "Motor running".
When a signal is queued longer than specified on this input, the TAPCON® 260 generates an impulse on a so-called customer relay to be defined.
Two freely definable relays are always available to the user who can use them for this function.

The maximum permissible running time of the motor-drive unit can be set between 0 and 20 seconds via the "Motor run time" (see adjacent figure) in the menu Configuration → General.
When "0 s" is set, run time monitoring is disabled.

Simultaneously with the impulse for triggering the motor protective switch, the "run time exceeded" relay (relay must be assigned by the customer) is turned on. This relay is then automatically turned off again when no signal is queued on the "malfunction - motor-drive unit" input (input must be assigned by the customer).
The status on the input "malfunction - motor protective switch" (input must be assigned by the customer) is reported on the "malfunction - motor-drive unit" relay (relay must be assigned by the customer).
Similarly, the status on the input "motor-drive unit functioning" triggers a signal on the "motor-drive unit functioning" relay.
The functions described above are summarised in a functional diagram.
In this example the motor run time was set to 10 s.

- Standard input for cam-operated contact of the motor-drive unit
- Customer relay 1 for generation of an impulse to trigger the motor protective switch
- Customer relay 2 for reporting that the motor run time is exceeded
- Customer input 1 for response message on manually tripped motor protective switch on the motor-drive unit
Parallel operation settings

---

Parallel operation without system topology (with system topology as option)

Parallel operation of 16 transformers max. without system topology recognition. In this context, parallel operation of all 16 transformers is possible either in a busbar arrangement or in two groups.

Parallel operation management is achieved via the CAN bus. Activation of parallel operation is achieved via one of two status inputs. This way the TAPCON® 260 can determine in which group the associated transformer engaged in parallel operation is contained.

Setting of parallel operation principle

Menu → Configuration → Parallel operation

**Parallel operation principle**

- **Off** = no parallel operation

- **Circulating reactive current** = This option is not available with TAPCON® 260

- **Master** = Master/Follower principle: the regulator assumes Master function

- **Follower** = Master/Follower principle: the regulator assumes Follower function

- **Synchr.Auto** = Master/Follower principle: with this setting, the regulator with lowest CAN address of all other regulators is automatically selected as Master.

Parallel control according to the Master/Follower principle requires no further settings other than the setting of the delay time.

In each case, the voltage regulators engaged in parallel operation have to be connected via the CAN bus interface (see appendix).

---

**NOTE**

Please bear in mind that the CAN bus must be connected with a resistor of 120 Ω at both ends (at the first and last regulator).

The resistor is included in the scope of delivery.
**Parallel operation with SKB**

For the extension of an existing system, the TAPCON® 260 may optionally be equipped with a supplementary card for parallel operation with an existing parallel control device SKB 30E or VC 100E-PM/PC.

The settings required for parallel control will be performed at the parallel control device, in accordance with the currently relevant operating instructions.

Menu → Configuration → Parallel operation

**Parallel operation according to the principle of "Master/Follower" (synchronism control)**

The type of parallel operation at TAPCON® 260 can be set via the parameter “parallel operation” (see above).

According to the settings made, one of the regulators is then elected as Master. This regulator assumes the measuring tasks and adjusts the on-load tap-changer for voltage compensation in the presence of deviations. Following a tap-change operation, the Master proceeds to compare the Followers’ tap-change positions with its own via CAN bus and, if a discrepancy is noted, likewise initiates readjustment of the Followers to an identical tap-change position.

If a difference of two or more tap-change positions is noted, the message „Parallel operation disturbed“ will be emitted and automatic regulation will be blocked.

This method is suitable for transformers featuring identical electrical characteristics.

**System configuration, settings**

Feed the additional connections/terminals to the regulators (see appendix).

To do this use “parallel group1” or “parallel group 2”.

**Setting the interference variable (Stability)**

Menu → Configuration → Parallel operation

**Stability**

To set a stability value between 0 and 100 %, press the function keys F1, F4 and F5. The stability value is a measure used for determining the efficiency of the circulating reactive current on the TAPCON® 260.

If it is set to “0 %”, no efficiency will be present.

For a circulating reactive current equal to the rated current of the current transformer, a setting value of 10 % would effect a voltage correction of 10 % for the TAPCON® 260.

Changing the stability value automatically changes the efficiency value in the help text.

**Note:**

This parameter has no function for TAPCON® 260.
7 Parametering

Setting the admissible circulating reactive current (blocking threshold)
Menu → Configuration → Parallel operation

**Blocking**

Set the bandwidth from 0.5 to 20 % (in relation to the rated current of the current transformer) by pressing the function keys F1 and F5. If the circulating reactive current exceeds the preset threshold value during parallel operation, the signalling LED lamp “Parallel operation disturbed” will come on and all TAPCON® 260 engaged in parallel operation will be blocked. After the adjustable delay period, the signalling relay contact (UC-X1/1 and UC-X1/2) will respond.

**Note:**
This parameter has no function for TAPCON® 260.

Delay of error message
Menu → Configuration → Parallel operation → Alarm

A delay (1–30 s) can be set for emission of the message „Parallel operation disturbed“ to avoid the generation of short-term error messages in the event of run-time differences between the motor-drive mechanisms engaged in parallel operation.

Appearance of this error message will cause blocking of the automatic regulation, i.e. at this point tap-changer adjustment is no longer possible except in the manual mode.

Setting range: 1 … 30 s

Setting the tap direction
During parallel operation in accordance with the Master/Follower principle, the tap direction has to be turned if an adjustment of the transformer towards a higher voltage causes a change in tap position towards the position “1”.

In the standard setting, a switch operation in the direction of a higher voltage will automatically cause a tap increase (in the direction of “n”).

Menu → Configuration → Parallel operation → Tapping direction turned

**Tapping direction turned**

Standard

00:00 = pulses to pos. 1
All 0 = pulses to pos. a
Only n follower model

7.3.4 Configuration of analog input on the input card (option)

The analog input on the AD card is used for computation of the tap position information received from an analog encoder (stepping potentiometer or proportional current). Adaptation to the existing encoder will be done during commissioning.

Lower limiting value of the analog input 1

To configure the analog input, the lower value of the input signal must be specified.
With proportional current, the value 0 % must be entered here for 0mA and the value 20 % for 4mA.
If the input is used to acquire the tap position by a potentiometer as the encoder, the value 20 % must always be set.
Menu → Configuration → Continue → Analog inputs
Lower limit in %

Upper limiting value of the analog input 1

To configure the analog input, the upper value of the input signal has to be specified. With proportional current, the value 100 % must be entered here, if the whole range of the pending signal is to be used.
If the input is used to acquire the tap position by a potentiometer as the encoder, the value 100 % must always be set.
Menu → Configuration → Continue → Analog inputs
Upper limit in %

Lower limiting value of the analog input 2

To configure the analog input, the lower value of the input signal must be specified.
With proportional current, the value 0 % must be entered here for 0 mA and the value 20 % for 4 mA.
If the input is used to acquire the tap position by a potentiometer as the encoder, the value 20 % must always be set.
Menu → Configuration → Continue → Analog inputs
Lower limit in %

Upper limiting value of the analog input 2

To configure the analog input, an absolute value must be assigned to the upper value of the pending signal (e.g., for the highest tap position the value „27“).
Menu → Configuration → Continue → Analog inputs
Upper value
Upper limiting value of the analog input 2

To configure the analog input, the upper value of the input signal must be specified.

With proportional current, the value 100% must be entered here if the entire range of the pending signal is to be used.

If the input is used to acquire the tap position by a potentiometer as the encoder, the value 100 % must always be set here.

Menu → Configuration → Continue → Analog inputs

Upper limit in %

Lower value of the analog input 2

To configure the analog input, an absolute value must be assigned to the lower value of the pending signal (e.g., the value “1” for the lowest tap position).

Menu → Configuration → Continue → Analog inputs

Lower value

Upper value of the analog input 2

To configure the analog input, an absolute value must be assigned to the upper value of the pending signal (e.g., the value “27” for the highest tap position).

Menu → Configuration → Continue → Analog inputs

Upper value

NOTE

The number and the assignment of the analog inputs may differ depending on how the hardware is configured.

Usually the first analog input is located on the first analog input card AD and the second on the expansion plug-in card AD1. A third analog input may be placed on an additional AD card.

With the previous hardware versions the analog inputs were located on the UC card(s).

Lower limiting value of the analog input 3

The lower value of the input signal has to be specified for configuring the analog input.

For proportional currents, enter the value 0% for 0mA and the value 20 % for 4 mA. If the input is used for detection of the tap position by a potentiometer as encoder, generally set the value to 20 % (please refer to the chapter on „Setting Instructions”).

Menu → Configuration → Continue → Analog inputs

Lower limit in %
Upper limiting value of the analog input 3

To configure the analog input, the upper value of the input signal must be specified.

With proportional current, the value 100 % must be entered here if the entire range of the pending signal is to be used.

If the input is used to acquire the tap position by a potentiometer as the encoder, the value 100 % must always be set here.

Menu → Configuration → Continue → Analog inputs

**Upper limit in %**

![Image](image.png)

Lower value of the analog input 3

To configure the analog input, an absolute value must be assigned to the lower value of the pending signal (e.g., the value “1” for the lowest tap position).

Menu → Configuration → Continue → Analog inputs

**Lower value**

![Image](image.png)

Upper value of the analog input 3

To configure the analog input, an absolute value must be assigned to the upper value of the pending signal (e.g., the value “27” for the highest tap position).

Menu → Configuration → Continue → Analog inputs

**Upper value**

![Image](image.png)

NOTE

Depending on the configuration of the hardware, the number and allocation of analog inputs may differ. The first analog input is usually located on the first analog input card (AD), the second one on the additional plug-in card (AD1). A third analog input may be located on a further AD card.

In previous hardware versions, the analog inputs were located on the UC card(s).

7.3.5 LED selection

Menu → Configuration → Continue → LED selection

**LED1 ... LED3**

Upon activation, the LEDs will light up in “red”.

For marking the LEDs, pull out the underlying inscription strips and mark them as desired (e.g., with rub-off letters).
LED4 may light up either in „red“ or in „green“, depending on the type of activation. If both inputs are activated simultaneously, the mixed shade „yellow“ will be created.

Menu → Configuration → Continue → LED selection

**LED4 red / green**

--

**7.3.6 Configuration of measuring transducer function (option)**

Using the signal converter module, it is possible to obtain two or four measured values as analog values in the ranges ± 20 mA, ± 10 mA, ± 10 V, ± 1 mA, depending on the configuration and model of the signal transformer module. The following values are available:

- U1
- U2 (optional, via a second measuring input)
- I1
- active current
- reactive current
- active power
- reactive power
- apparent power
- tap position
- voltage level

Since the configuration is performed at the plant, please be sure to specify in your order the desired measured values and type of analog output!

If the analog outputs desired by the customer have not already been set at the factory, this can be done with the aid of the following description of measuring transducer 1. Follow the same principle for the settings for measuring transducers 2 to 4.

**Measuring transducer, value of output 1**

This parameter is used for assigning the measuring quantity to be transmitted to the output of measuring transducer 1.

Menu → Configuration → 2x Continue → Measuring transducer 1/2

**Output 1 measured value**

Possible settings:
- Off
- U1, U2, voltage level
- I1, active current, reactive current
- step
- apparent power, active power, reactive power

**Lower output value for measuring transducer 1**

Assignment of a measurable physical quantity

Menu → Configuration → 2x Continue → Measuring transducer 1/2

**Output 1 low**

Possible settings:
- 0 mA, -1 mA, -4 mA, -10 mA, -20 mA
- 0 V, -10 V

**Upper output value for measuring transducer 1**

Assignment of a measurable physical quantity

Menu → Configuration → 2x Continue → Measuring transducer 1/2

**Output 1 top**

Possible settings:
- 1 mA, 10 mA, 20 mA
- 10 V
7.4  Information menu/measuring values

Consult this menu point to find information on the TAPCON® 260 and the measuring values. Sub-groups with related information were assembled to facilitate the search.

Measuring transducer, lower value of output 1

This parameter is used for assigning an absolute value to the lower limit of measuring transducer 1.
Menu → Configuration → 2x Continue → Measuring transducer 1/2

Output 1 lower value

Measuring transducer, upper value of output 1

This parameter is used for assigning an absolute value to the upper limit of measuring transducer 1.
Menu → Configuration → 2x Continue → Measuring transducer 1/2

Output 1 upper value

7.4.1  Information

Consult this sub-group to retrieve information on the TAPCON® 260.

Line 1: Type designation
Line 2 and 3: Software version and its date of issue
Line 4 to the left: EEPROM size
Line 4 to the right: Internal regulator ID number
Line 5 and 6: Size of the built-in RAM and flash memory

An LED function test can be performed in accordance with the data indicated.

NOTE

This test involves only the LED itself, not the function behind it!

Display of the regulator number for parallel operation (= CAN address) and of the number of the TAPCON® 260 currently engaged in parallel operation.

Display indicating whether the parameter sets were properly stored following a regulator restart and/or whether all parameters were properly stored following the recording of a parameter set. If a parameter was not properly stored, it will be indicated as incorrectly stored and can be reset to a standard factory setting by pressing the F1 key.
To reset all parameters to standard settings, press the F3 and F4 keys.
7.4.2 Status

Display of pending messages, e.g. overvoltage/undervoltage or parallel operation disturbance.

Status display of the inputs at the I/O module
0 = no presence of signal at input
1 = presence of signal at input

Status display of the inputs at the UC1 module
0 = no presence of signal at input
1 = presence of signal at input

Status display of the inputs at the UC2 module
0 = no presence of signal at input
1 = presence of signal at input

Status display of the inputs at the UC3 module
0 = no presence of signal at input
1 = presence of signal at input

7.4.3 CAN Bus

RTC = Real Time Clock
When the TAPCON® 260 is started up for the first time a counter is set in motion which continues to run even while the regulator is inactive. For the visual display of measuring values, all of the counter’s times will be overwritten by the PC’s times.

Data on the CAN Bus
Line configuration:
No. AAA: BBB CCC DDD EEE
meaning:
AAA: CAN Address of the regulator
BBB: Voltage in V
CCC: Active current in %
DDD: Reactive current in %
EEE: Tap position

Press F1 key to call up the other information.
F: Group input 1
G: Group input 2
H: Circulating reactive current parallel operation selected
I: Tap synchronisation Master selected
J: Tap synchronisation Follower selected
K: Tap synchronisation Auto selected
L: Regulator intends to block the group due to a disturbance in parallel operation.

NOTE
This operation will cause all values to be reset to standard level, including any values already adapted and individually set earlier!
7 Parametering

7.4.4 Measuring values

**Indication of measured values**

<table>
<thead>
<tr>
<th>Line</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Voltage at the first measuring input</td>
</tr>
<tr>
<td>2</td>
<td>Current on first measuring input</td>
</tr>
<tr>
<td>3</td>
<td>Phase position U1 to I1</td>
</tr>
<tr>
<td>4</td>
<td>Voltage on the second measuring input</td>
</tr>
<tr>
<td>5</td>
<td>Active current on the first measuring input</td>
</tr>
<tr>
<td>6</td>
<td>Reactive current on the first measuring input</td>
</tr>
</tbody>
</table>

**Extension of information screen no. "01"**

For displaying the measurement readings: With the display set as indicated, the values for the first (standard) or the second measuring channel (on request) can be shown. The information screen with page no. "01" has to be selected first. The display can be switched from measuring channel 1 to measuring channel 2 by pressing and holding function key "F1". The display changes back to the standard display (channel 1) when the "F1" key is released.

**Storage of measuring values**

The TAPCON® 260 is not equipped with a storage module.
8 Digital remote position indication

The TAPCON® 260 voltage regulator is equipped with a digital remote position indication. The display can be selected/activated either with a BCD signal (standard) or optionally with an analog signal (option).

8.1 Digital remote position indication through activation with BCD signal (standard version)

Prerequisite for a digital position indication is the conversion and transmission of the position indicating signal into BCD code. For this purpose an N/O contact range connected to a diode matrix and the corresponding transmission lines between motor-drive unit and TAPCON® 260 are required (see next fig.).

The linking function of the diode matrix assigns the related parallel BCD signal to each on-load tap-changer operating position which is simulated by the N/O contact range of the motor drive unit (see table on operating positions).

<table>
<thead>
<tr>
<th>Operating-position</th>
<th>BCD signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1 1</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>1 1</td>
</tr>
<tr>
<td>6</td>
<td>1 1</td>
</tr>
<tr>
<td>7</td>
<td>1 1 1</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>1 1</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>1 1</td>
</tr>
<tr>
<td>12</td>
<td>1 1</td>
</tr>
<tr>
<td>13</td>
<td>1 1 1</td>
</tr>
<tr>
<td>14</td>
<td>1 1</td>
</tr>
<tr>
<td>15</td>
<td>1 1 1</td>
</tr>
<tr>
<td>16</td>
<td>1 1 1</td>
</tr>
<tr>
<td>17</td>
<td>1 1 1 1</td>
</tr>
<tr>
<td>18</td>
<td>1 1 1 1</td>
</tr>
<tr>
<td>19</td>
<td>1 1 1 1</td>
</tr>
</tbody>
</table>

Operating position table

Conversion of the numerical operating positions 1 to 19 into the equivalent BCD signal (example)
8 Digital remote position indication

9 Options

8.2 Digital remote position indication through activation with analog signal (option)

Upon request, the TAPCON® 260 voltage regulator is available with an analog control/activation of the remote position indication. This option requires an analog AD input card. The following analog values can be processed:

- 0 ... 10 V
- 0 ... 2 kOhm
- 0(4) ... 20 mA

If all of the following data are indicated in the order, the voltage regulator will be delivered in fully and appropriately configured condition.

Information pertaining to position indication (examples):

- 0(4) mA = Pos. 1
- 20 mA = Pos. 19
- 0 Ohm = Pos. 1
- 180 Ohm = Pos. 19
- 0 V = Pos. 1
- 10 V = Pos. 19

Should it become necessary to change the values previously preset in the factory in accordance with customer specifications, this can be effected via the displays "analog input 1", lower/upper limiting value and "analog input 1", lower/upper value.

Upon customer request, the analog input of the AD card is preset in the factory to 0-20 mA, 0-10 mA, 0-1 mA or 0-10 V. It should be mentioned that the above indicated current and voltage ranges can be in the positive or in the negative range.

If e.g. the position of an on-load tap-changer is signalled via a 4-20 mA signal, it will be necessary to define the lower limit of 4 mA with 20 % (of 20 mA).

This assignment allows a fine-tuning of the position indication (see chapter Configuration of analog input on the analog AD input card).

8.3 Remote indication of tap position

Optionally, the tap position of the TAPCON® 260 can be indicated either by way of BCD signal via potential-free contacts or as analog signal (e.g. 0(4) – 20 mA, 0 – 10 V, -5 ... 5 mA).

9 Options

9.1 Serial interface

Optionally, the TAPCON® 260 can be equipped with a serial interface, either at the time of delivery or at a later date, as required.

The following standardised protocols are available for the voltage regulator:

- IEC 60870-5-101
- IEC 60870-5-103
- ABB SPA-Bus
- Siemens LSA
- DNP 3.0
- Modbus ASCII

The related descriptions and other protocols (e.g. IEC 61850) are available on request.
## 10 Status messages and error messages on the display

The monitor screen of the TAPCON® 260 may display the following status and error messages whose causes are listed in the table.

<table>
<thead>
<tr>
<th>Status message</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>The regulator is engaged in parallel operation as Master in accordance with the synchronism principle.</td>
</tr>
<tr>
<td>Follower</td>
<td>The regulator is engaged in parallel operation as Follower in accordance with the synchronism principle.</td>
</tr>
<tr>
<td>Blocking</td>
<td>Presence of a signal at the &quot;Regulation Block&quot; customer input (IO-X1:31 or IO-X1:33)</td>
</tr>
</tbody>
</table>
| Status         | Is present at the binary output in the event of  
|                | - missing operating voltage  
|                | - a controller failure  
|                | - a program crash |

<table>
<thead>
<tr>
<th>Error message</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undervoltage</td>
<td>The measuring voltage is lower than the preset $U&lt; \text{ limit}$. If the parameter „$U&lt; \text{ also under } 30 \text{ V}” \text{ is set to } 0\text{FF}, \text{ messages will be suppressed for measuring voltages under } 30 \text{ V}.</td>
</tr>
<tr>
<td>Overvoltage</td>
<td>The measuring voltage is higher than the preset $U&gt; \text{ limit}$.</td>
</tr>
<tr>
<td>Overcurrent</td>
<td>The current is higher than the preset $I&gt; \text{ limit}$.</td>
</tr>
</tbody>
</table>
| Error Par.     | For synchronism:  
|                | - The tap positions of the regulators engaged in parallel operation were longer than the  
|                | preset parallel control signalling delay was unequal.  
|                | - One of the regulators engaged in parallel operation is not signalling a valid tap position.  
|                | - None of the regulators engaged in parallel operation is Master.  
|                | - More than one of the regulators engaged in parallel operation is Master.  
|                | - One of the regulators engaged in parallel operation is operating in accordance with the  
|                | circulating reactive current principle. |
| Motor protective switch | Presence of a signal at the input for the motor protective switch signal. |
| Function monitoring | A signal is emitted if a regulating deviation lasting 15 min is detected by the regulator which is not  
|                   | eventually compensated. |