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

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

NOTE
This notes give important information on specific subjects.
2.2 Safety instructions for 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. admissable 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.

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-changer. 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.

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.
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 optocoupler 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.
### 3.1 Technical Data

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<td>0.1 V</td>
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<td>49 – 140 V&lt;sup&gt;†&lt;/sup&gt;</td>
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<td>0.1 V</td>
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<td>Bandwidth</td>
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<td>0.01 %</td>
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<td>Delay time 1</td>
<td>1 to 600 s</td>
<td>1 s</td>
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<td>Switching pulse duration</td>
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<td>1.5 s</td>
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<tr>
<td>LDC</td>
<td>(U_r = 0) to (\pm 25) V</td>
<td>0.1 V</td>
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<tr>
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<td>(U_x = 0) to (\pm 25) V</td>
<td>0.1 V</td>
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<td>0 to 999,9 kV/100 V to 110 V</td>
<td>0 kV/100 V</td>
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<td>100 to 10,000 A/5/1/0.2 A</td>
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<td>phase angle adjustable between (U) and (I) for 1-phase and 3-phase system according to CT/VT connection</td>
<td></td>
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<td>Function monitoring</td>
<td>15 min.</td>
<td>On</td>
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<sup>†</sup> including max. possible limit values
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 \( U\textsubscript{<}, U\textsubscript{>}, I\textsubscript{>} \)
- 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

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<th>Output relays and rating of relay contacts:</th>
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<td>AC: 250 V 5A</td>
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<tr>
<td>1x lower</td>
<td>DC: 30 V 5 A, 110 V 0.4 A;</td>
</tr>
<tr>
<td>1x manual control mode</td>
<td>220 V 0.3 A</td>
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<td>1x automatic control mode</td>
<td>1x raise</td>
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<tr>
<td>1x Master / Follower</td>
<td>1x lower</td>
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<td>1x high-speed circuit-breaker of voltage limit supervisory control</td>
<td>1x manual control mode</td>
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<td>1x parallel operation group 1</td>
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<td>1x function monitoring</td>
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<td>1x cam-operated contact from motor-drive</td>
<td>1x desired voltage level 2</td>
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<td>1x status</td>
<td>1x desired voltage level 3</td>
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<tr>
<td>1x group alarm ( U\textsubscript{&lt;}, U\textsubscript{&gt;}, I\textsubscript{&gt;} )</td>
<td>1x parallel operation active</td>
</tr>
<tr>
<td>1x function monitoring</td>
<td>1x parallel operation disturbed</td>
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Voltage transformer
- 85 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 In/1 s

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

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, 1.2/50μs

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 60688-2-1: Dry cold, -25°C / 20 hours
- IEC 60688-2-2: Dry heat, +70°C / 16 hours
- IEC 60688-2-3: Moist heat, constant, +40°C / 93% / 2 days, no moisture condensation
- IEC 60688-2-30: 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 Description of the device

3.3 Description of the display

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

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.

Changing the measured value display
The following options are available. By default, the system deviation rate dU is displayed first when the device is switched on.

Deviation - dU - current(A) - apparent power(VA) - active power(W) - reactive load(VAr) - phase angle(deg.) - Cos - hotspot - topoil

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 Basic screen display showing current measuring values

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.

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).

3.6 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.

3.7 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.
4 Voltage regulation of transformers with TAPCON® 260

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 additional "measuring value recorder" module (8 MB capacity) can be used to store and display valuable measuring values. All measured data can also be displayed and analysed on your PC via the software included:

**Measured values:**
- on-load tap-changer positions
- voltage
- active current
- reactive current

**Calculated values:**
- active power
- reactive load
- apparent power
- power factor

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.

Reasons include:
1. Higher short circuit capacity
2. Higher throughput

However, parallel operation requires special control measures for minimizing equalizing currents (circulating reactive currents) between the transformers.

The formation of circulating currents is described in the following chapter. Under adverse conditions, circulating currents \( I_{kr} \) may lead to overload or uneconomic operation of transformers.
4.1.1 Formation of circulating currents

With unequal no-load voltages $U_1 = U_x$, the differential voltage $\Delta U = U_1 - U_x$ as an EMF (electro-motive force) causes a current to flow through the windings of the transformers operated in parallel. This current is independent of the load current.

Unequal no-load voltages occur if the angle and/or magnitude of the voltages differ.

The magnitude and angle of the circulating current is determined by the short-circuit impedances $Z_k$ (in series) of the transformers operated in parallel, including the impedance of the connecting lead between the transformers. The impedance of the load is negligible, because this circulating current flows through the transformers even in the absence of a load.

The circulating currents $I_{kr}$ depend on the short-circuit impedances $Z_{k1} \ldots Z_{kx}$ and the differences between the no-load voltages $U_1 - U_2$.

$$I_{kr} = \frac{U_1 - U_2}{Z_{k1} + Z_{k2}}$$

**Definition:**

$U_1 \ldots U_x$: no-load voltages

$I_{kr1} \ldots I_{krx}$: circulating currents

$Z_{k1} \ldots Z_{kx}$: short-circuit impedance

The formation of circulating currents is represented in the following figure.

The short-circuit impedances $Z_{k1} \ldots Z_{kx}$ of the transformers are usually very low. This results in considerable circulating currents $I_{kr}$.

In this example we assume that the driving voltage $U_1$ is greater than $U_2$ to $U_x$.

$U_1 > U_2, U_x$

**Fig. 5**
Parallel operation of transformers - equivalent circuit diagram
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 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

4.1.2 Parallel operation with TAPCON® 260

TAPCON® 260 enables control of sixteen transformers operated in parallel in one or two groups. Parallel operation is managed via the CAN bus. Parallel operation is activated via one of two status inputs or via a control system. This ensures that the TAPCON® 260 knows in which group the associated parallel-operated transformer is located.

For safe and economic parallel operation of transformers, TAPCON® 260 has to ensure the following operating conditions of the transformers:

1. Avoidance or minimization of circulating currents
2. Avoidance of an unequal transformer load

Different control techniques are used for meeting these requirements. These techniques are described below:

4.1.2.1 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.

4.1.2.2 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.

4.1.2.3 Circulating reactive current principle

This technique is suitable for transformers with comparable power and voltage rating, impedance voltage and vector group with identical or different step voltage. The tap position of the transformer is irrelevant.

The circulating reactive current is calculated via the transformer currents and their phase angles ($\Delta\sin\varphi$, $\Delta\sin(S)$ and $\Delta\cos\varphi$) at the supply and minimized through specific adjustment of the on-load tap-changer.

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 Voltage regulation of transformers with TAPCON® 260

4.2.1.2 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.

4.2.1.3 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 ($U_{\text{actual}}$) 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: $\pm 15 (= 30 \text{ steps})$
Setting range: $85 \text{ kV} ... 115 \text{ kV}$
Step voltage: $(115 \text{ kV} - 85 \text{ kV}) / 30 \text{ steps} = 1 \text{ kV / step}$

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 T1. 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 time 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 T1, 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 T1 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 \( U_{\text{actual}} - U_{\text{desired}} \pm B \% \), 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 T2. The first output pulse is issued after the specified delay time T1. Further pulses required for stabilization are issued after the specified delay time T2, usually between 10 and 15 sec.

**ΔU/E** - voltage change \( \Delta U \) in % of the desired value, in relation to the set bandwidth in % of the desired voltage level.
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 Additional performance characteristics of TAPCON® 260

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.

After 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 the transformer output voltage or supply voltage ($<30$ V) (this standard setting can be deactivated – see Parameters $\rightarrow$ Limit values $\rightarrow$ "$U<$ also below $30$ V").
6 Commissioning

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.

6.1 Installation

The standardized module frame of the TAPCON® 260 (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).

\[\text{WARNING}\]

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

\[\text{NOTE}\]

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

\[\text{NOTE}\]

Ensure correct connection of the output relays to the motor-drive unit.
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 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). Otherwise change the desired voltage level in steps of 0.1 V until a balanced state is reached.

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”.

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### 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) Set the rated transformer voltage and the rated current (see chapter “CT/VT data”).

e) Change the display to kV.

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

n) Setting the load drop LDC (the basic display with the deviation from the desired voltage level is required for this setting).

Set the mode of operation to "Manual".

Settings for Ux = Ur = 0 (deviation from desired voltage level → 0).

Setting of Ur = 20 V, Ux = 0 V (deviation from desired voltage level → -)

Setting of Ur = –20 V, Ux = 0 V (deviation from desired voltage level → +) (during this function check the minimum load current of 10 % of the rated current of the CT/VT must flow).

If the bar graph display moves in the opposite direction, change the polarity of the current transformer.

The actually desired load drop can be set upon completion of the above settings.

Set the mode of operation to "Auto".

Check if the setting is correct by observing the stability of a certain point in the network with different loads. When the setting is correct the voltage at this point will remain constant.

o) Setting of Z-Compensation as an alternative to LDC.

Set the mode of operation to "Manual".

Set the voltage rise to 0, the TAPCON® 260 is in a balanced state.

Setting Z-compensation limit = 15 %.

Setting voltage increase = 15 % (deviation from desired voltage level → -), during this function check the minimum load current of 10 % of the rated current of the CT/VT must flow.

The desired values for Z-compensation can be set upon completion of the above settings.

Set the mode of operation to "Auto".

Check if the setting is correct by observing the voltage at the line end during service and with different loads. When the setting is correct the voltage at the line end will remain constant.

p) Set the desired voltage level 2 to the desired value.

Set the mode of operation to "Manual" and connect L+ to IO-X1/17 signalling relay for desired voltage level 3 (contact IO-X1/23 and IO-X1/24). Set mode of operation to "Auto".

q) Setting the load drop LDC (the basic display with the deviation from the desired voltage level is required for this setting).

Set the mode of operation to "Manual".

Settings for Ux = Ur = 0 (deviation from desired voltage level → 0).

Setting of Ur = 20 V, Ux = 0 V (deviation from desired voltage level → -)

Setting of Ur = –20 V, Ux = 0 V (deviation from desired voltage level → +) (during this function check the minimum load current of 10 % of the rated current of the CT/VT must flow).

If the bar graph display moves in the opposite direction, change the polarity of the current transformer.

The actually desired load drop can be set upon completion of the above settings.

Set the mode of operation to "Auto".

Check if the setting is correct by observing the stability of a certain point in the network with different loads. When the setting is correct the voltage at this point will remain constant.

r) 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.

s) Setting the load drop LDC (the basic display with the deviation from the desired voltage level is required for this setting).

Set the mode of operation to "Manual".

Settings for Ux = Ur = 0 (deviation from desired voltage level → 0).

Setting of Ur = 20 V, Ux = 0 V (deviation from desired voltage level → -)

Setting of Ur = –20 V, Ux = 0 V (deviation from desired voltage level → +) (during this function check the minimum load current of 10 % of the rated current of the CT/VT must flow).

If the bar graph display moves in the opposite direction, change the polarity of the current transformer.

The actually desired load drop can be set upon completion of the above settings.

Set the mode of operation to "Auto".

Check if the setting is correct by observing the stability of a certain point in the network with different loads. When the setting is correct the voltage at this point will remain constant.
6 Commissioning

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”).

6.5.1 Parallel operation according to the principle of “circulating reactive current”

Setting the interference variable (Stability)

Individually set both transformers to identical voltage with the tap-changers so that both TAPCON® 260 are in a balanced state (bar graph display in normal position, the indication of “dU %” must be as low as possible, i.e. lower than the preset bandwidth “dU max”).

Now switch the transformers to parallel operation and enable parallel control. The TAPCON® 260 must continue to remain in a balanced state, the LED lamp “parallel operation” on the front panel is lighting up.

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

Upon modification of the setting value “Stability”, the value of the efficiency will change in the last line of the help text. Now keep adjusting the stability until the display of the efficiency exceeds the preset value for the bandwidth by approx. 0.2 to 0.3 %. Now set this value at all TAPCON® 260 engaged in parallel operation.

Select the “Auto” operating mode for both TAPCON® 260. Both voltage regulators must control the tap-changers back into their previous service positions.

If the previous service position cannot be achieved that way, the stability setting needs to be increased.

If the on-load tap-changers are regulating out of sync (“pumping”), this setting needs to be reduced.

Setting the circulating reactive current monitoring (Bandwidth Threshold)

Switch over one of the two TAPCON® 260 to the “Manual” operating mode. Using the manual control, the associated motor-drive must now be reset to “Raise” by the maximum admissible difference of the service positions between the parallel operating transformers (e. g. by 1 ... 2 steps).

Starting with the preset value of “20 %”, reset the bandwidth threshold towards a lower value in small steps until message “parallel operation disturbed” appears (please wait 2 - 3s between the individual steps).

The bandwidth threshold of the circulating reactive current monitoring is reached as soon as the LED lamp lights up. All TAPCON® 260 will block all further regulating actions and after 30s (time can be adjusted) the signalling relay will respond (connection UC-X1/1 and UC-X1/2).

Now reset the bandwidth threshold again towards a higher value until the message “Parallel operation disturbed” disappears.

Again switch the TAPCON® 260 back to the “Auto” operating mode. The motor-drive will be automatically controlled back to the original service position.

Use the value established for the bandwidth threshold to set it for all of the other regulators.
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:  100 ... 110 V

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 / 2 / 3

Menu → Parameter → Regulating parameter

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 is a prerequisite for proper display of the desired voltage level 1, 2 or 3 or of 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 I0-X1/17 or I0-X1/16 input. 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 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.

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

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 %

Setting the delay time T1 or T2 (delay time 1/delay time 2)
Menu → Parameter → Regulating parameter

Delay time T1

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 remaining time, be started anew.

Setting range: 1 … 600 s

Menu → Parameter → Regulating parameter

T1 Regulating behavior

The delay time T1 can be set with linear or integral response.

If a delay time with integral response "Integral" is set, the delay time is automatically shortened according to the relation of actual system deviation to set bandwidth (B), down to a minimum of 1s.

*) including max. possible limit values
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.

**T2 Delay time**

Setting range: 1 ... 10 s

**NOTE**

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

\[
\frac{\Delta U}{E} \text{ - voltage change } \Delta U \text{ in % of the desired value, in relation to the set bandwidth in % of the desired voltage level.}
\]
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<")

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 (%)

Setting range: 60 ... 100%
Setting the limiting values for undervoltage blocking as absolute value.

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: 60 V ... 160 V

... kV

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

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 range: 100 ... 140%

Setting the limiting value for overvoltage blocking as absolute value.

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>)

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.
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

Function monitoring

Menu → Parameter → Limit values

Delayed response of the message undervoltage U<

Set a delayed response time for this message to avoid the immediate generation of a message in the event of short-term voltage drops.

Menu → Parameter → Limit values

U< Delay

Setting range: 0...20 s

Deactivating the undervoltage blocking

It is possible to deactivate the blocking of “Lower” output pulses in the event of a shortfall of the undervoltage threshold. In that case, only a message will be emitted.

Menu → Parameter → Limit values

U< Blocking

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

U< even under 30 V

7.2.3 Line compensation

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 ϕ
- 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.
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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. \( \frac{30000 \ V}{\sqrt{3}} \)
- \( r \) = Ohmic resistance of line in \( \Omega \) / km per phase
- \( x \) = Inductive reactance of line in \( \Omega \) / km per phase
- \( L \) = Length of line in km

If the active voltage drops \( Ur \) 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

7.2.3.2 Z-Compensation
For correct setting of the parameters the voltage rise (\( \Delta U \)) has
to be calculated in consideration of the current.
Calculation of the required setting values:

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

\( \Delta U \) = Setting of Z-Compensation in %
\( U_{Tr} \) = Transformer voltage at current I
\( U_{Load} \) = 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 voltage rise
Menu → Parameter → Compensation
Z-Compensation

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 %

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

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Setting the limiting value for \( \Delta U \) (LIMIT)
Menu \( \rightarrow \) Parameter \( \rightarrow \) Compensation
Z Comp Limit
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 \( \ldots \) 15%

7.2.4 Cross checking (option)
The cross check mode permits the mutual monitoring of two TAPCON® 260.
It should be noted that standard self-checks of the TAPCON® 260 will automatically detect and indicate potential errors in the following equipment:
- power supply unit
- processor errors
- absence of program
Any occurring errors will be indicated via the status contact.
As a result, mutual crosschecks are by their very nature limited to the following:
1. absence of measuring value and/or measuring module error
2. voltage control checks within adjustable upper and lower limits
Re.: 1.
Each one of the two TAPCON® 260 mutually monitoring each other is fed the respective measuring values of the other TAPCON® 260 via second measuring inputs.
Also, the TAPCON® 260 measuring values thus computed are accessed via CAN bus for comparison with the "original measuring values".
If any deviations occur, a message indicating a "measuring value error" will be sent via an output relay.
The second measuring inputs shall be regarded as entirely separate from the first measuring inputs, which is why TAPCON® 260 from entirely different voltage levels are capable of monitoring each other.
Re.: 2.
A regulator receives measuring voltage via a second measuring input. It is possible to set a separate desired voltage level, a bottom and upper limit and a time delay value to go with this measuring value.
If one of these limits is exceeded, a message will be sent via output relay after the preset time limit. The Raise/Lower pulse to the motor-drive can be blocked via relay contacts, provided these relay contacts are appropriately wired.
Limit monitoring will not affect the regulating performance of the individual regulators.
Press the F1 and F5 function keys to preset the desired value, bottom and upper limit, and time delay value.
The CAN address must be entered to ensure communication of the mutually monitoring TAPCON® 260 via the CAN bus interface. To this end, the CAN address assigned to the first TAPCON® 260 shall be '1', and the CAN address assigned to the second TAPCON® 260 shall be '2'.

Settings
Menu \( \rightarrow \) Parameter \( \rightarrow \) Cross checking

Desired value regulator 2
Desired voltage level of the TAPCON® 260 subject to monitoring during the cross check mode.
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.
If no primary CT/VT voltage is set (see "U prim. regulator 2"), conversion V/kV is not active.

Menu \( \rightarrow \) Parameter \( \rightarrow \) Cross checking

\( U< \) regulator 2 (%)
Undervoltage limit of the TAPCON® 260 subject to monitoring during the cross check mode in percentage values referred to the desired voltage level.
Menu → Parameter → Cross checking
*U< regulator 2 (V)*

Undervoltage limit of the TAPCON® 260 subject to monitoring during the cross check mode, input of the undervoltage limit in absolute values.

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 → Cross checking
*U> regulator 2 (%)*

Overvoltage limit of the TAPCON® 260 subject to monitoring during the cross check mode in percentage values referred to the desired voltage level.

Menu → Parameter → Cross checking
*U> regulator 2 (V)*

Overvoltage limit of the TAPCON® 260 subject to monitoring during the cross check mode in absolute values.

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 → Cross checking
*Alarm*

Error signalling delay during the cross check mode if an error is registered in the TAPCON® 260 subject to monitoring.
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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 primary VT voltage
Menu → Configuration → CT/VT data
Primary voltage

Setting range: 0 ... 999,9 kV

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

Setting range: 100 ... 110 V

Setting the primary CT current
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.

Setting of the current transformer connection in use
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).
7 Parametering

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

Diagram showing different configurations of CT and VT connections with adjustable phase differences.
7 Parametering

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

Menu → Configuration → General

Language

Regulator identification

Regulator identification is comprised of a four-digit string.

Setting the transmission speed

Menu → Configuration → General

COM1 setting

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

Adjustable values:
9600 Baud
19200 Baud
38400 Baud
57600 Baud

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

R/L pulse time

The Raise/Lower pulse duration can be changed within a range of 0 ... 10 s.
Please extend the pulse time if the motor-drive mechanism refuses to start up in the standard setting.

ATTENTION

If the pulse duration is set to 0 s, a continuous pulse will be emitted.
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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 triggering
- "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 protective switch" 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
7 Parametering

7.3.3 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.

Parallel control is possible in two different ways:

- Parallel operation according to the principle of "minimum circulating reactive current" or
- Parallel operation according to the principle of tap-change synchronism (Master-Follower).

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

Setting of parallel operation principle

Menu → Configuration → Parallel operation

Parallel operation principle

Set the desired parallel operation principle by pressing the F1 and F5 function keys.

Setting options:

- Off = no parallel operation
- Circulating reactive current = parallel operation following the principle of minimum circulating reactive current
- 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

**SKB Parallel Operation**

Set the parallel control device to parallel operation by pressing the F1 and F5 function keys.

- **Off** = Parallel control via CAN bus
- **On** = Parallel control using the existing parallel control device

**CAN Address**
To permit regulator communication via CAN bus, each individual regulator needs a separate identifier.
Menu → Configuration → Parallel operation

**CAN Address**

Assign a number as address to each regulator by pressing the F1 or F5 function keys.
The values assigned as CAN address may range between 1 and 127.

0 = no communication
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System configuration, settings
Feed the additional connections/terminals to the regulators (see appendix).
To do this use "parallel group 1" 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.

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.

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**
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 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 1**
To configure the analog input, the upper value of the pending signal has to be assigned an absolute value (e.g. the value “1” for the lowest tap position).
Menu → Configuration → Continue → Analog inputs

**Lower value of analog input 1**

**Upper value of the analog input 1**
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 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, 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 %**

Menu → Configuration → Continue → Analog inputs

**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**

Menu → Configuration → Continue → Analog inputs

**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**

Menu → Configuration → Continue → Analog inputs

---

**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).

---

**7.3.5 LED selection**

Use the settings of this sub-group to assign inputs or functions to the four unoccupied LEDs.

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 / LED4 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
- hotspot

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
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

7.3.7 Cooling system
The fan control described here handles five-stage cooling for high-power transformers.
The type of oil circulation and the cooling agent used can be specified as desired when certain rules are followed.
This means that, for each cooling stage, separate switchon and switchoff thresholds can be parameterized via the topoil temperature (i.e., oil temperature), the hotspot temperature (i.e., winding temperature) or a combination of both.
In addition, a hysteresis and a switchoff delay can be set for each cooling stage. With equivalent cooling stages (e.g., fan groups), alternating operation with monitoring of a uniform load can be specified.

7.3.7.1 Cooling, general
The subitem "Cooling, general" is located in the menu "Configuration". The general parameters of hotspot specification and signaling thresholds for alarm and trip can be set here.

Alternate interval
The applicable number of operating hours is recorded and stored for each cooling group. After this interval, the alternating cooling groups are resorted by their operating hours and this sequence is then used.
This parameter is specified in hours and can be varied between "1" and "100".
### Hotspot factor

Factor for the calculation of the hotspot temperature in accordance with IEC 354 (transformer-specific). This parameter has no unit and can be varied between “1” and “2” in increments of 0.1.

![Hotspot factor parameter](image)

### Indication in Fahrenheit

This parameter can be used to switch the input and output of the temperatures between Celsius and Fahrenheit.

![Indication in Fahrenheit parameter](image)

This function was not integrated.

### Oil temperature alarm

When the set threshold values are reached or passed below, the alarm or trip relays are activated. This parameter is specified in degrees and can be varied between –40 °C and +180 °C. With Fahrenheit the range is –40 °F to 356 °F.

![Oil temperature alarm parameter](image)

**NOTE**

In addition to the threshold values, the set hysteresis values must be added (cf. drawing for hysteresis trip or hysteresis alarm).

### Winding temperature alarm

When the set threshold values are reached or passed below, the alarm or trip relays are activated. This parameter is specified in degrees and can be varied between –40 °C and +180 °C. With Fahrenheit the range is –40 °F to 356 °F.

![Winding temperature alarm parameter](image)

**NOTE**

In addition to the threshold values, the set hysteresis values must also be added (cf. drawing for hysteresis trip or hysteresis alarm).
**Hysteresis alarm**

The switchoff threshold is calculated from the switchon threshold minus the hysteresis. The hysteresis is used for both topoil and hotspot-related threshold values.

**Explanation:**
1. Activation of the alarm when the signaling threshold is reached (i.e., value is above the defined range).
2. Deactivation of the alarm when the specified limit value is passed below.

This parameter is specified in degrees and can be varied between 0 °C and +100 °C.

**Delay alarm**

When the set limit value is exceeded, a relay is not set until after the specified switchon time. This relay is reset immediately after the switchoff threshold is passed below. This parameter is specified in seconds and can be varied between „0 s“ and „120 s.“

**Oil temperature trip**

When the set threshold values are reached or passed below, the alarm or trip relays are activated. This parameter is specified in degrees and can be varied between –40 °C and +180 °C. With Fahrenheit the range is –40 °F to 356 °F.

**NOTE**

In addition to the threshold values, the set hysteresis values must also be added (cf. drawing for hysteresis trip or hysteresis alarm).
**Winding temperature trip**

When the set threshold values are reached or passed below, the alarm or trip relays are activated.

This parameter is specified in degrees and can be varied between $-40 \, ^\circ \text{C}$ and $+180 \, ^\circ \text{C}$. With Fahrenheit the range is $-40 \, ^\circ \text{F}$ to $356 \, ^\circ \text{F}$.

**NOTE**

In addition to the threshold values, the set hysteresis values must also be added (cf. drawing for hysteresis trip or hysteresis alarm).

**Hysteresis trip**

The switchoff threshold is calculated from the switchon threshold values minus the hysteresis. The hysteresis is used for both a topoil- and hotspot-related threshold value.

This parameter is specified in degrees and can be varied between $0 \, ^\circ \text{C}$ and $+100 \, ^\circ \text{C}$. With Fahrenheit the range is $+32 \, ^\circ \text{F}$ to $212 \, ^\circ \text{F}$.

**Delay trip**

When the set limit value is exceeded, a relay is not set until after the specified switchon time. This relay is reset immediately after the switchoff threshold is passed below.

This parameter is specified in seconds and can be varied between $0 \, \text{s}$ and $120 \, \text{s}$.
7.3.7.2 Contact S1-S5

The subitem "Contact S1-S5" in the "Configuration" menu is used to define the switching points for cooling stage activations.

The parameters are described below using examples for contact S1. The other contacts (S2 to S5) can be set similarly.

**Oil temperature S1**

This is the threshold value for the oil temperature measured in the transformer tank. This is also called the topoil temperature.

This parameter is specified in degrees and can be varied between –40 °C and +180 °C. With Fahrenheit, the range is -40 °F to 356 °F.

The topoil temperature is acquired with the analog input via 4-20 mA signal on the following terminals.

- AD-X1.1 4-20 mA (plus)
- AD-X1.2 4-20 mA (minus)

**Winding temperature S1**

This parameter is the threshold value for the calculated hotspot temperature. The hotspot temperature is calculated from the power flow over the transformer. The transformer and cooling-stage-specific parameters of the transformer are used for this.

This results in the following equations.

\[
\vartheta_{\text{Hotspot}} = \vartheta_{\text{Topoil}} + \vartheta_{\text{Load-dependent excess temperature}}
\]

\[
\vartheta_{\text{Hotspot, end value}} = \vartheta_{\text{Topoil}} + (H \cdot gr \cdot K \cdot e^{t_0 y})
\]

- H  Hotspot factor
- gr Gradient in Kelvin
- K Load factor = (actual power/rated power)
- y Winding exponent
- t0 Time constant in seconds

The parameter is specified in degrees and can be varied between –40° and +180°. With Fahrenheit the range is -40 °F to 356 °F.

**Hysteresis S1**

The parameter is specified in degrees Celsius and can be varied between 0 °C and +100 °C. With Fahrenheit the range is +32 °F to 212 °F.
7 Parametering

Delay S1
This parameter is specified in seconds and can be varied between „0 s“ and „120 s.“

Alternating S1
When cooling stages are equivalent, these can be operated alternately. This parameter supplies the enable for this.

NOTE
Oil pumps are never used in alternating operation.

Switching criterion S1
This selection is used to define which threshold will be used for the switching on or off. The following table shows the different choices.

<table>
<thead>
<tr>
<th></th>
<th>Oil/Oil</th>
<th>Hotspot/Hotspot</th>
<th>Hotspot/Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch on</td>
<td>( \theta_{\text{top}} )</td>
<td>( \theta_{\text{winding}} )</td>
<td>( \theta_{\text{hotspot}} )</td>
</tr>
<tr>
<td>Switch off</td>
<td>( \theta_{\text{top}} )</td>
<td>( \theta_{\text{winding}} )</td>
<td>( \theta_{\text{top}} )</td>
</tr>
</tbody>
</table>

Example:
- Switch on via "hotspot" (70 °C)
- Switch off via "oil" (60 °C)
- Hysteresis (4 °C)
- Delay (300 seconds)

At a calculated hotspot temperature of 70 °C, the applicable cooling stage is switched on. When 56 °C is passed below, cooling is switched off after 300 seconds.
7.3.7.3 Cooling stage 0–5

The subitem "Cooling stage 0-5" in the menu "Configuration" is used to specify the parameters for the calculation of the hotspot temperature.

Type of oil circulation S1

This parameter is used to specify the cooling stage at which an oil pump is to be activated. This parameter can also be used to specify the type of pump (OD, OF or OP) to be used. A maximum of two pump circuits can be integrated in fan control.

Indication of the type of cooling

The customer can enter separate parameters for each of the five cooling stages which can be managed and controlled. The integrated parameters of oil circulation and the cooling agent can be used to indirectly determine which cooling unit is connected to relay contacts S1 – S5. Activation is performed in ascending order, beginning with S1 and ending with S5.

The following values can be parameterized for the type of oil circulation which can be performed with one or more pumps.

- ON Oil Natural (no oil pump)
- OF Oil Forced (via radial pump)
- OP Oil Forced (via impeller pump)
- OD Oil Directed

The following types can be parameterized as cooling agent.

- AN Air Natural
- AF Air Forced (fan)
- WF Water Forced (water cooler)

NOTE

When switching thresholds for higher cooling stages are exceeded, all cooling stages relays in front are also always switched on. Only one type of cooling unit can be connected to each relay switching contact. These are either "pumps" or "fans". Oil circulation pumps are preferably connected to "S1" and "S2" although this is not mandatory – they are never subject to alternating operation.

The cooling stage S0 represents normal operation without activated fans or pumps. For this reason, in contrast to cooling stages S1 to S5, neither "Type of oil circulation" nor "Cooling agent" can be selected.

Type of oil circulation S1

This parameter is used to specify the cooling stage at which an oil pump is to be activated. This parameter can also be used to specify the type of pump (OD, OF or OP) to be used. A maximum of two pump circuits can be integrated in fan control.
7 Parametering

Cooling agent S1

A cooling agent (e.g., fan or water cooler) can be specified for each cooling stage. When the cooling stage was not recognized for control of oil circulation pumps, a cooling agent can be programmed. In addition, equivalent cooling agents (fan groups) can be alternately operated. When used like this, the fans are loaded as uniformly as possible – the change when the systems are activated uses about the same amount of fan running times (operating hours counter). Pumps cannot be used for alternating operation.

Gradient S1

This parameter is used to specify the hotspot temperature in accordance with IEC 354 or ANSI. The value is specified in Kelvin and can be varied between “0” and “50”.

Winding exponent S1

This parameter is used to specify the hotspot temperature in accordance with IEC 354 or ANSI.

Time constant S1

This parameter is used to specify the hotspot temperature in accordance with IEC 354 or ANSI. The value is specified in minutes and can be varied between “0” and “30” in increments of 0.1.

Scaling S1

This parameter can be used to specify the hotspot temperature in accordance with IEC 354 or ANSI. In particular, it is used for the calculation of the load factor “k”. This is the rated capacity which applies to the currently actual type of cooling. The rated capacity always increases as the cooling intensity increases. The value is specified in MVA and can be varied between “0” and “1000”.

AC voltage and AC current channel of the secondary side are used for the power measurement.

NOTE

It is absolutely essential that the converter data were parameterized (cf. chapter on "configuration" → "converter data").
7.3.7.4 Inputs/Outputs of Fan Control

Inputs of Fan Control

Status message of cooling system S1 „on“          UC3-X1.12
Status message of cooling system S2 „on“          UC3-X1.11
Status message of cooling system S3 „on“          UC3-X1.33
Status message of cooling system S4 „on“          UC3-X1.32
Status message of cooling unit S5 „on“            UC3-X1.31
Error message of cooling system S1                UC3-X1.30
Error message of cooling system S2                UC3-X1.17
Error message of cooling system S3                UC3-X1.16
Error message of cooling system S4                UC3-X1.15
Error message of cooling system S5                UC3-X1.14

Relay Outputs of Fan Control

Cooling system on S1 „on“                          UC3-X1.1 - 2
Cooling system on S2 „on“                          UC3-X1.3 - 4
Cooling system on S3 „on“                          UC3-X1.5 - 6
Cooling system on S4 „on“                          UC3-X1.7 - 8
Cooling system on S5 „on“                          UC3-X1.9 - 10
Alarm signaling output                              UC3-X1.18 - 19
Trip signaling output                               UC3-X1.20 - 21
Group error message "cooling system" based on the inputs "error message“  UC3-X1.22 - 23
Group error message "status" based on missing re-registration  UC3-X1.24 - 25
Emergency operation with max. cooling capacity     UC3-X1.26 - 27

NOTE

When a pump fails, all fans are switched on first during emergency operation until the critical temperature is passed below. Normal fan operation is then used. However, an error message is output and kept active.

If, in contrast, a currently operating fan fails, another fan is started if alternating operation is active. In addition an error message is output with a reference to the failure.

7.3.7.5 Info

In the "Info" menu, the current measured values are indicated in addition to the settings and status information of fan control as shown in the next few figures. This area provides a quick overview of fan control.
7 Parametering

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.

7.4.1 Information

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

<table>
<thead>
<tr>
<th>INFO</th>
<th>LCD STATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type designation</td>
<td>LED TEST</td>
</tr>
<tr>
<td>Line 1: Type designation</td>
<td>Keg F1: LED1</td>
</tr>
</tbody>
</table>
| Line 2 and 3: Software version and its date of issue | Keg F2: LED2 |=
| Line 4 to the left: EEPROM size | Enter ALL LEDs |
| Line 4 to the right: Internal regulator ID number | < 00 > |
| Line 5 and 6: Size of the built-in RAM and flash memory | < 02 > |

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.

<table>
<thead>
<tr>
<th>UPCOMING MESSAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>&lt; 14 &gt;</td>
</tr>
</tbody>
</table>

Status display of the inputs at the I/O module

<table>
<thead>
<tr>
<th>INPUT / OUTPUT STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>33 0 31 0</td>
</tr>
<tr>
<td>29 0 29 0</td>
</tr>
<tr>
<td>17 0 16 0</td>
</tr>
<tr>
<td>14 0 13 0</td>
</tr>
<tr>
<td>11 0 12 0</td>
</tr>
<tr>
<td>&lt; 03 &gt;</td>
</tr>
</tbody>
</table>

Status display of the inputs at the UC1 module

<table>
<thead>
<tr>
<th>UC1 MODULE STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 6 11 0</td>
</tr>
<tr>
<td>30 6 30 1</td>
</tr>
<tr>
<td>31 6 30 0</td>
</tr>
<tr>
<td>17 0 16 0</td>
</tr>
<tr>
<td>15 0 14 1</td>
</tr>
<tr>
<td>40 0.0</td>
</tr>
<tr>
<td>&lt; 04 &gt;</td>
</tr>
</tbody>
</table>

Status display of the inputs at the UC2 module (optional)

<table>
<thead>
<tr>
<th>UC2 MODULE STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 6 11 0</td>
</tr>
<tr>
<td>33 6 32 0</td>
</tr>
<tr>
<td>31 6 30 0</td>
</tr>
<tr>
<td>17 0 16 0</td>
</tr>
<tr>
<td>15 0 14 1</td>
</tr>
<tr>
<td>40 0.0</td>
</tr>
<tr>
<td>&lt; 05 &gt;</td>
</tr>
</tbody>
</table>

Status display of the inputs at the UC3 module (optional)

<table>
<thead>
<tr>
<th>UC3 MODULE STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 6 11 0</td>
</tr>
<tr>
<td>33 6 32 0</td>
</tr>
<tr>
<td>31 6 30 0</td>
</tr>
<tr>
<td>17 0 16 0</td>
</tr>
<tr>
<td>15 0 14 1</td>
</tr>
<tr>
<td>40 0.1</td>
</tr>
<tr>
<td>&lt; 06 &gt;</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>DATA ON CANBUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controller no.?</td>
</tr>
<tr>
<td>Controller no.?</td>
</tr>
<tr>
<td>Controller no.?</td>
</tr>
<tr>
<td>Controller no.?</td>
</tr>
<tr>
<td>Controller no.?</td>
</tr>
<tr>
<td>Controller no.?</td>
</tr>
<tr>
<td>&lt; 07 &gt;</td>
</tr>
</tbody>
</table>

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!
7.4.4 Measuring values

**Indication of measured values**
- Line 1: Voltage at the first measuring input
- Line 2: Current on first measuring input
- Line 3: Phase position U1 to I1
- Line 4: Voltage on the second measuring input
- Lines 5 and 6: Active and reactive current on the first measuring input

**Storage of peak value**
Display of the minimum and maximum voltages occurred since the last reset (drag hand function for voltage and tap position)

**Storage of measuring values**
The TAPCON® 260 is optionally available with a long-term storage module.

The relevant storage information will be displayed in this menu window.

---

### Measured Values

<table>
<thead>
<tr>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>30.3V</td>
</tr>
<tr>
<td>I1</td>
<td>122.9V</td>
</tr>
<tr>
<td>Phase1</td>
<td>0°</td>
</tr>
<tr>
<td>U2</td>
<td>0°</td>
</tr>
<tr>
<td>Iact</td>
<td>0.000%</td>
</tr>
<tr>
<td>f0act</td>
<td>100.000%</td>
</tr>
</tbody>
</table>

### Peak Memory

<table>
<thead>
<tr>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UI</td>
<td>30.3V</td>
</tr>
<tr>
<td>Tap pos</td>
<td>26</td>
</tr>
<tr>
<td>UI min</td>
<td>13.53400</td>
</tr>
<tr>
<td>UI max</td>
<td>16.51403</td>
</tr>
<tr>
<td>P1 with P4 Reset</td>
<td>13</td>
</tr>
</tbody>
</table>

### Measured Value Memory

<table>
<thead>
<tr>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module select</td>
<td>10 days</td>
</tr>
<tr>
<td>Events</td>
<td>3 / 20</td>
</tr>
</tbody>
</table>

---

### Cooling System

In the "Info" menu, the current measured values are indicated in addition to the settings and status information of fan control as shown in the next few figures.

This area provides a quick overview of fan control.
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>•</td>
</tr>
<tr>
<td>2</td>
<td>•</td>
</tr>
<tr>
<td>3</td>
<td>••</td>
</tr>
<tr>
<td>4</td>
<td>•</td>
</tr>
<tr>
<td>5</td>
<td>•</td>
</tr>
<tr>
<td>6</td>
<td>••</td>
</tr>
<tr>
<td>7</td>
<td>••</td>
</tr>
<tr>
<td>8</td>
<td>•</td>
</tr>
<tr>
<td>9</td>
<td>••</td>
</tr>
<tr>
<td>10</td>
<td>•</td>
</tr>
<tr>
<td>11</td>
<td>•</td>
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<tr>
<td>12</td>
<td>••</td>
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<td>16</td>
<td>••</td>
</tr>
<tr>
<td>17</td>
<td>••</td>
</tr>
<tr>
<td>18</td>
<td>••</td>
</tr>
<tr>
<td>19</td>
<td>••</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

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 potentialfree contacts or as analog signal (e.g. 0(4) – 20 mA, 0 – 10 V, -5 ... 5 mA).
9 Options

9.1 Serial interface

As an option, the TAPCON® 260 can already be equipped with a serial interface on delivery or it can be upgraded later.

The following standardized protocols are available for the TAPCON® 260:

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

The description and additional protocols (e.g., IEC 61850) are available on request.

9.2 Memory submodule/measured value recorder

The additional module "Measured value recorder" (8 MB) allows the storage of the following measuring data for a certain period of time and evaluation of these data via the visual display software included in the delivery. For details and explanations of hardware and visualisation software see the related operating instructions.

Direct measuring values:
- Tap changer positions
- Voltage
- Active current
- Reactive current

Computed measuring values:
- Active power
- Reactive power
- Apparent power
- Power factor

The measured-value recorder is basically divided into the average value memory and the event memory. With the average value memory, all measured and computed values are averaged with an average value interval which can be set by the user in steps between 1 s and 40 s, and then stored. With the event memory, the highest resolution of the data is always stored without previous averaging. The user can specify how much of the total memory (8 MB hardware) will be exclusively available to the event memory.

The measured value recorder is equipped with a so-called event trigger which triggers an event based on the adjustable upper and/or lower overvoltage limit value. The data obtained in this way are stored in the event memory of the measured value memory.

To achieve better evaluation of limit value violation (upper and lower limit), the time period for the measured and computed values also includes the last ten seconds prior to the actual limit value violations. The storage timeframe is restricted to a maximum of five minutes per event.

NOTE

The event memory only contains the time progressions of the measured and calculated values while the event is queued, while the average value memory contains all data. When the event memory is full, the oldest data record is overwritten by the new values. Information on the current contents of the event memory can be called via the "Info" pages on the TAPCON® 260.

NOTE

Calculation of the stated values is based on the acquired measured values on the one hand, and on the other hand, on the set configuration values as well as the measuring circuit, the primary current and the CT/VT data of primary and secondary side.

Correct calculation is only possible when the configuration data have been entered completely and correctly.
The measured-value recorder records the time behaviour exhibited by the effective voltage value. In addition, the time behaviour of the tap positions is displayed also, to permit an initial controlled system analysis. The TAPCON® 260 also allows a graphic display of the voltage curve. This combined display of voltage and tap position is made possible by the visualization software included in the delivery.

Navigation keys:

- Arrow left
- Arrow right
- Enter
- ESC
- Menu

- For altering the data, switch the instrument over to the 'manual' duty mode!
- Store any setting alterations by pressing the „Enter“, „F1“, or „F2“ keys.
- Press the „ESC“ key to exit the set-up menu or to advance to the next higher menu level without data storage.
- All units set in start screen will be transmitted to the following screens.

9.2.1 Setting the system date
Menu → Configuration → Continue → Continue → Memory → 7x “Arrow right”

Press the „Arrow right“ key (screen 07) seven times to view the input field for the system date. Press the „F4“ function key to select the digit(s) you want to edit and then press the „F1“ and „F5“ keys to set the display forward or backward in one-step increments.
The date format in „DD.MM.YY“ can be set to any date between 01/01/2001 and 29/12/2099.

9.2.2 Setting the system time
Menu → Configuration → Continue → Continue → Memory → 6 x „Arrow right”

Press the „Arrow right“ key (screen 06) six times to view the input field for the system time. Press the „F4“ function key to select the digit(s) you want to edit and then press the „F1“ and „F5“ keys to set the display forward or backward in one-step increments. The time format in „HH:MM:SS“ is available in a 24-hour format.
9.2.3 Setting the measurement units of the display

The measurement units of the display can be individually set to the user’s specific requirements (display available in V, kV, % or A). This setting will be maintained even after switchover to the write mode.

Menu → Configuration → General → 3 x "Arrow right"

Press the „Arrow right“ key (screen 03) three times to view the input field for the V/kV display. To toggle between the two modes, press the „F1“ or „F5“ keys.

Menu → Configuration → General → 4 x "Arrow right"

Press the „Arrow right“ key (screen 04) four times to view the input field for the %/A display. To toggle between the two modes, press the „F1“ or „F5“ keys.

9.2.4 Setting the write mode

Menu → Inf. → Arrow left (screen page 15)

After execution of this key sequence the instrument is now in the write mode (see illustration). After switchover to the write mode, the operator-set desired voltage level will automatically show up roughly in the center of the screen. The units of the voltages per unit are software-determined and can be altered by the operator. If the write function is called up again, however, the parameterization-determined set values will again override any other settings. While in the write mode, the settings for time axis, voltage range, return time and return date can be determined as well.

9.2.5 Symbol explanation

1 = Desired voltage level, displayed in the bottom left-hand screen corner.
2 = Actual voltage level, displayed in the bottom left-hand screen corner. The arrow will point up or down whenever the top/bottom values of the desired voltage level exceed the screen limits.
3 = Overvoltage/undervoltage bar, configurable.
4 = For the overvoltage values, the inscription in the display field always corresponds to the uppermost line.
5 = For the undervoltage values, the inscription in the display field always corresponds to the bottom-most line.
6 = Shifting the time axis backward.
7 = Shifting the time axis forward.
8 = Increasing the set values in one-increment steps.
9 = Selection of the values to be set.
10 = Decreasing the set values in one-increment steps.
9.2.6 Setting the time axis
Menu → Inf. → Arrow left → 1 x "F4" (screen page 15)

Press the „F4“ function key once to view the input field for the message times (see arrow). Press the „F3“ and „F5“ function keys to set the display forward or backward in one-step increments (see table). It is recommended to use the highest-possible resolution for the range displayed.

The subdivision of the time axis and the ensuing duration of the range displayed are shown in the following table:

<table>
<thead>
<tr>
<th>Adjustable steps</th>
<th>15 sec</th>
<th>30 sec</th>
<th>1 min</th>
<th>2.5 min</th>
<th>5 min</th>
<th>10 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>3.5 min</td>
<td>7 min</td>
<td>14 min</td>
<td>35 min</td>
<td>70 min</td>
<td>140 min</td>
</tr>
</tbody>
</table>

9.2.7 Setting the voltage range
Menu → Inf. → Arrow left → 2 x "F4" (screen page 15)

Display in V:
Press the „F4“ function key twice to view the input field for the voltage range (see arrow). Here, the display is limited to the maximum and minimum voltage. Press the „F3“ and „F5“ function keys to set the display forward or backward in one-step increments. The voltage range is subdivided in the following steps: 0.5 V, 1 V, 2 V, 5 V, 10 V and 15 V per horizontal grid line.

Display in kV:
Press the „F4“ function key twice to view the input field for the voltage range (see arrow). Here, the display is limited to the maximum and minimum voltage. Press the „F3“ and „F5“ function keys to set the display forward or backward in one-step increments. The voltage range is subdivided in the following steps: 0.1 kV, 0.2 kV, 0.5 kV, 1 kV, 2 kV, 5 kV, 10 kV and 20 kV per horizontal grid line.
9.2.8 Setting the return time
Menu → Inf. → Arrow left → 3 x “F4” (screen page 15)

Press the „F4“ function key three times to view the input field for the return time (see arrow). This function is used to set the display back to a precise specific instant. Press the „F3“ and „F5“ function keys to set the display forward or backward in one-step increments, and the „arrow left“ and „arrow right“ keys to move the selection into the adjacent field. The time input format is in HH:MM:SS and can be set from the present time all the way back to the oldest time on file in the memory.

9.2.9 Setting the return date
Menu → Inf. → Arrow left → 4 x “F4” (screen page 15)

Press the „F4“ function key four times to view the input field for the return date (see arrow). This function is used to set the display back to a precise specific instant. Press the „F3“ and „F5“ function keys to set the display forward or backward in one-step increments, and the „arrow left“ and „arrow right“ keys to move the selection into the adjacent field. The date input format is in DD:MM:YY and can be set from the present day all the way back to the oldest time file in the memory.

In case one of the past displays is no longer available in the long-term memory (the read-only storage is deleted in blocks whenever the memory capacity is exceeded), no curve will appear on the screen.

9.2.10 Setting threshold values
Menu → Configuration → Continue → Continue → Memory

If the set threshold value limits are exceeded above or below, a so-called event is additionally recorded at maximum resolution, for easier analysis at a later date.

Press the “arrow left” and “arrow right“ keys to select the various screens; the settings can be changed with the “F1” and “F5” keys. Use the “F4” key to toggle back and forth between the different digits of the figure for the different display variants in V/kV.

Screen 00:
Setting the lower threshold value in %:

Screen 01:
Setting the lower threshold value in V:

Screen 02:
Setting the upper threshold value in %:

Screen 03:
Setting the upper threshold value in V:

Which of the values are relevant (absolute or %) is shown in the following figure.
9.2.11 Setting the relative/absolute value
Menu → Parameters → Limit values

Go to the 00 screen to toggle between the relative and the absolute limit value. If this setting is „ON”, the absolute limit value will be used instead of the limit value related to the desired voltage level. For toggling, again use the „F1” or the „F5” key.

9.2.12 Setting the mean value memory intervals
Menu → Configuration → Continue → Continue → Memory → 4 x “Arrow right”

The long-term memory of the TAPCON® 260 has a memory capacity of 8 MB. It is divided into the mean value memory and the event memory. The mean value memory is used for storing intervals of 1 sec, 2 sec, 4 sec, 10 sec, 20 sec or 40 sec duration, depending on the setting. The operator can change this setting individually. To that end, press the ”arrow right” key four times, until screen 04 is displayed. At that point, the desired setting can be selected by pressing the “F1” or “F5” keys. An outline of the maximum recording times, using various different recording intervals, is shown in the subsequent example no. 2.

9.2.13 Setting the event memory
Menu → Configuration → Continue → Continue → Memory → 5 x “Arrow right”

The event memory can be set for a range between 256 kB and 2,048 kB. To that end, press the “arrow right” key five times until screen 05 is displayed. At that point, the desired setting can be selected by pressing the “F1” or “F5” keys.

All events involving an overshoot above or below the pre-set threshold values are stored in the event memory at a higher resolution.

The maximum number of events, in relation to the event memory capacity, is shown in the following table.

<table>
<thead>
<tr>
<th>Event memory capacity</th>
<th>256 kB</th>
<th>512 kB</th>
<th>1024 kB</th>
<th>2048 kB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum number of events</td>
<td>20</td>
<td>40</td>
<td>80</td>
<td>160</td>
</tr>
</tbody>
</table>

The following two examples show how the event memory works:

Example 1:
The duration of an event is shorter than 5 minutes.

Memorization of the event starts 10 seconds before the actual event and ends 10 seconds thereafter.
Example 2:
The duration of an event is longer than 5 minutes.

Memorization of the high-resolution data starts 10 seconds before an event. If the duration of an event is longer than 5 minutes, storage will continue at low resolution. If the voltage enters back into the "normal range", this occurrence is considered a new event. The new event has a lead time of 10 seconds and an overshoot time of 10 seconds.

The storage time, which is indicated in days, is shown in the table below. Depending on mean value interval and event memory capacity, it can last for a duration of up to 401 days.

<table>
<thead>
<tr>
<th>Mean value interval (s)</th>
<th>256</th>
<th>512</th>
<th>1024</th>
<th>2048</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>19</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>38</td>
<td>35</td>
<td>29</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>96</td>
<td>89</td>
<td>73</td>
</tr>
<tr>
<td>20</td>
<td>201</td>
<td>193</td>
<td>178</td>
<td>147</td>
</tr>
<tr>
<td>40</td>
<td>401</td>
<td>386</td>
<td>356</td>
<td>295</td>
</tr>
</tbody>
</table>

Table: Time capacity of the measured value recorder

9.1.14 Measured-value recorder display

Menu → Inf. → 4 x Arrow left (screen page 12)

The info page of the measured-value recorder also shows the number of events that have already taken place and the potential number of events still possible.

XX = the maximum storing capacity, in days, of the mean value memory.
YY = the number of events recorded in the event memory.
ZZ = the maximum number of events which can be stored.

9.2.15 Peak memory display

Menu → Inf. → 3 x Arrow left (screen page 13)

The info page of the peak memory shows the minimum and maximum voltages measured and the minimum and maximum tap position of the tap-changer. The minimum and maximum values will continue to be stored in an internal read-only memory even in the event of a power failure.

XX = Minimum voltage measured.
YY = Maximum voltage measured.
ZZ = Minimum tap position.
VV = Maximum tap position.

To reset these measured values, press the „F3“ and „F4“ keys at the same time.

9.3 TAPCON® 260 without “long-term memory”

The TAPCON® 260 voltage regulator is equipped with a short-term memory allowing a limited number of voltage and tap positions to be stored.

With a high-resolution scanning rate, it is possible to record the history of the voltage positions and on-load tap-changer positions for the last eight minutes. The voltage curve and the change in tap positions can be visualised via the visual display software included in the delivery.

Without the long-term memory module (8 MB), the display has a memory capacity for up to 1,000 values. The data are read into this memory at a maximum resolution. This has the effect that whenever the subdivision is changed, the recorded graph no longer goes all the way to the left edge of the graph chart recorder. For settings where more values are available than can be displayed, it is possible to „shift“ the screen into the past. However, this is admissible only to the extent that the graph is still visible across the entire screen. After being shifted, the display stalls at the desired value and stops moving altogether. It is “frozen”. Press the “F1” or “F2” function keys to switch back and forth between one entire page at a time.
### 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>Circulating reactive current</td>
<td>In parallel operation the regulator is operating in accordance with the circulating reactive current principle.</td>
</tr>
<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 (I0-X1:31 or I0-X1:33)</td>
</tr>
<tr>
<td>Status</td>
<td>Is present at the binary output in the event of</td>
</tr>
<tr>
<td></td>
<td>- missing operating voltage</td>
</tr>
<tr>
<td></td>
<td>- a controller failure</td>
</tr>
<tr>
<td></td>
<td>- a program crash</td>
</tr>
</tbody>
</table>

<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; limit. If the parameter „U&lt; also under 30 V“ is set to OFF, messages will be suppressed for measuring voltages under 30 V.</td>
</tr>
<tr>
<td>Overvoltage</td>
<td>The measuring voltage is higher than the preset U&gt; limit.</td>
</tr>
<tr>
<td>Overcurrent</td>
<td>The current is higher than the preset I&gt; limit.</td>
</tr>
<tr>
<td>Error Par.</td>
<td>For synchronisation:</td>
</tr>
<tr>
<td></td>
<td>- The tap positions of the regulators engaged in parallel operation were longer than the preset parallel control signalling delay was unequal.</td>
</tr>
<tr>
<td></td>
<td>- One of the regulators engaged in parallel operation is not signalling a valid tap position.</td>
</tr>
<tr>
<td></td>
<td>- None of the regulators engaged in parallel operation is Master.</td>
</tr>
<tr>
<td></td>
<td>- More than one of the regulators engaged in parallel operation is Master.</td>
</tr>
<tr>
<td></td>
<td>- One of the regulators engaged in parallel operation is operating in accordance with the circulating reactive current principle.</td>
</tr>
<tr>
<td></td>
<td>For the circulating reactive current principle:</td>
</tr>
<tr>
<td></td>
<td>- The circulating reactive current of the regulator was longer than the preset parallel control signalling delay was greater than the preset limit value.</td>
</tr>
<tr>
<td></td>
<td>- One of the regulators engaged in parallel operation is operating in accordance with the tap synchronism principle.</td>
</tr>
<tr>
<td></td>
<td>- The plant topology information is missing.</td>
</tr>
<tr>
<td></td>
<td>- Presence of a signal at one of the group inputs minimum, but no other regulator was found in the same group.</td>
</tr>
<tr>
<td>Motor protective switch</td>
<td>Presence of a signal at the input for the motor protective switch signal.</td>
</tr>
<tr>
<td>Function monitoring</td>
<td>A signal is emitted if a regulating deviation lasting 15 min is detected by the regulator which is not eventually compensated.</td>
</tr>
</tbody>
</table>