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NOTE!

The product may have been modified after this document went to press. We expressly reserve the right to make changes to the technical data, the design or the scope of delivery. In general, the information provided and the arrangements agreed during processing of the relevant offers and orders are binding.
1 Safety

1.1 Safety labels

The following safety labels relating to the operation of the VA-CUTAP® AVT are used in these Operating Instructions.

These labels must be observed at all times!

<table>
<thead>
<tr>
<th>![DANGER!]</th>
<th>DANGER!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refers to an <em>imminent danger</em> that may result in death or severe injury.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>![CAUTION!]</th>
<th>CAUTION!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refers to a <em>potentially harmful situation</em> that may result in damage to the product or adjacent equipment.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>![NOTE!]</th>
<th>NOTE!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contains important information and special notes.</td>
<td></td>
</tr>
</tbody>
</table>

Special safety labels are used for certain hazards, such as electric shock:

<table>
<thead>
<tr>
<th>![DANGER!]</th>
<th>Electric shock!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refers to an <em>imminent danger through electricity</em> that may result in death or severe injury.</td>
<td></td>
</tr>
</tbody>
</table>

The following specific safety warnings are used in these Operating Instructions:

<table>
<thead>
<tr>
<th>![Risk of electric shock!]</th>
<th>![Risk of tipping!]</th>
</tr>
</thead>
</table>

1.2 Safety instructions

As the operator it is your responsibility to make sure that the on-load tap-changer is used for the specified application only.

The VACUTAP® AVT on-load tap-changer may only be used with the transformer specified in the order.

For safety reasons, any unauthorized work, i.e. installation, modification, alteration of the on-load tap-changer equipment, electrical connection or commissioning of the equipment is forbidden without first consulting MR Guangdong!

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

- **All warnings and safety instructions must be observed at all times!**
  Failure to follow the safety instructions may lead to accidents and severe personal injury.
- **Please read these operating instructions before commissioning the equipment!**
  Please read these instructions before switching on the VACUTAP® AVT. As the operator, you are responsible for ensuring that users of the equipment have fully understood the operating and safety instructions.
- **Train your staff!**
  Before asking staff to work with the VACUTAP® AVT, provide training regarding general and special safety instructions and accident prevention regulations.
- **Only suitably qualified personnel should work with the VACUTAP® AVT!**
  VACUTAP® AVT 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.
2 Structure/Design

2.1 On-load tap-changer design

The on-load tap-changer type VACUTAP® AVT (see Fig. 1) for indoor installation is used to set the ratio for dry-type transformers under load.

The on-load tap-changer VACUTAP® AVT works according to the high-speed resistor-type on-load tap-changer principle. Vacuum interrupters are used as diverter switch contacts.

The drive unit of the on-load tap-changer VACUTAP® AVT is integrated into the on-load tap-changer housing (see Fig. 2). Electrical contacts prevent operation beyond the end positions.

In addition, the mechanical predetermined breaking point prevents a tap change operation beyond the regulation range.

The indicator gear mechanically indicates the tap change operation in the indication field.

---

DANGER!

Electric shock! Danger of death and risk of injury!

To protect against misuse and against touching accessible, live and movable components, the VACUTAP® AVT should be installed in an enclosed environment which can only be entered by authorized personnel.

Be sure to secure the danger zone of the electrical connections and leads between the transformer and the VACUTAP® AVT rear side extensively and over a wide range.

---

Fig. 1: On-load tap-changer VACUTAP® AVT, front view (without housing)

Fig. 2: On-load tap-changer VACUTAP® AVT, rear side (without housing)
2.2 Electrical components

The control elements (see Fig. 3) of the control unit are located at the front side of the VACUTAP® AVT, covered by a window.

- **S3**: Raise/Lower control switch
- **H1**: Green signal lamp
- **Q1A**: Trip coil of the motor protective switch
- **Q1**: Motor protective switch
- **Q1H**: Auxiliary current switch

The control unit of the VACUTAP® AVT (see Fig. 4) is hinge-mounted inside the device.

- **K29**: Time delay relay
- **K1/2**: Green signal lamp
- **K13/14**: Auxiliary contactor
- **K20**: Auxiliary contactor

---

**DANGER!**

Risk of personal injury and heavy material damage! The function of the monitoring systems is at risk! Never change the settings (preset by MR) at time delay relay K29 and motor protective switch Q1!

**NOTE!**

The „Green signaling light H1“ shows that the monitoring systems are ready for operation. The signaling light will go out for a short time during electrical operation.
2.3 VACUTAP® AVT monitoring systems

2.3.1 Arc monitoring

The arc monitoring system F2 (see Fig. 5) is mounted at the same level as the transfer switches, and is used for detecting arcs with a light sensor. Detection of an arc triggers transformer emergency shutdown and the green signaling light goes out.

![Fig. 5: Arc monitoring of the VACUTAP® AVT](image)

**DANGER!**

Risk of injury or death and heavy material damage!
Monitoring system faults!
The green signal lamp H1 indicates that the VACUTAP® AVT monitoring systems in service are active. If the lamp is not lit the transformer should be switched off immediately!

2.3.2 Latch monitoring

The latch monitoring system S70/71 (see Fig. 6) is used for detecting, via sensor, non-latching of the energy accumulator. Activation of the latch monitoring system triggers transformer emergency shutdown and the green signaling light goes out.

![Fig. 6: Latch monitoring of the energy accumulator](image)

**DANGER!**

Risk of injury or death and heavy material damage!
Monitoring system faults!
It is imperative that the transformer is switched off immediately both on the high-voltage and low-voltage side whenever the monitoring systems (arc monitoring and latch monitoring) are energized! Otherwise the effectiveness of the monitoring systems will be compromised.

Fig. 7 shows an example of a circuit diagram section containing the VACUTAP® AVT monitoring systems. An example of a complete circuit diagram can be found in the Appendix.

![Fig. 7: Example of a circuit diagram section](image)
3 Shipping

The VACUTAP® AVT on-load tap-changer with integrated motor drive is shipped in the adjustment position.

Only transport the on-load tap-changer (max. 350 kg) using one of the methods below:
- using a lifting device connected to the four transport loops (internal diameter 35 mm) fixed to the housing (see Fig. 8),
- using a forklift truck to lift the equipment from underneath (see Fig. 9).

Please be sure to always use appropriate hoisting gear when lifting and transporting the on-load tap-changer. When using cranes to lift the on-load tap-changer, be sure to use only the four (4) eyelets situated atop the on-load tap-changer.

Be sure to lift the on-load tap-changer simultaneously by all four eyelets, making sure that the lifting force is distributed over all four eyelets as evenly as possible. When using forklifts to transport the VACUTAP® AVT, be sure to insert the forks centrally underneath the unit.

Tilting must be avoided at all cost!

---

**DANGER!**

Risk of tipping! Risk of severe injuries or death!
All equipment must be supported securely when working on the on-load tap-changer, the motor drive unit or other components! Uncontrolled tipping of the device must be prevented!

---

**NOTE!**

The consignment is to be checked for completeness based on the shipping documents.
It is very important to store and transport the on-load tap-changer in the original factory packing and in a dry environment before its arrival and installation at the final destination point.
4 Transport to the operating site

Be sure to move the VACUTAP® AVT into its adjusting position (bottom end position) prior to transporting it to the operating site.

Please be sure to check the VACUTAP® AVT for visible damages upon its arrival at the operating site. Transportation damage may compromise the functions of the VACUTAP® AVT.

Furthermore, it is very important to secure the on-load tap-changer against violent shocks during transportation and installation, and to protect it from tilting and toppling over. Especially transports of longer duration require original factory packing to protect the on-load tap-changer against dirt and moisture.

NOTE!

It is very important to store and transport the on-load tap-changer in the original factory packing and in a dry environment before its arrival and installation at the final destination point.

CAUTION!

Violent shocks or toppling-over may damage the finely tuned mechanics of the on-load tap-changer and lead to malfunctions or increased wear and tear. It is therefore imperative to notify the manufacturer of any such excessive stress or any externally visible damage. It is then up to the manufacturer to decide whether the on-load tap-changer concerned will be replaced, repaired, or reinspected at the manufacturer's premises. Damage and failure caused by improper handling of the on-load tap-changer during transportation, inspection and installation will under no circumstances be covered by the manufacturer's product liability!
5 OLTC function checkout at the transformer manufacturer’s works

Please be sure to check the VACUTAP® AVT for visible damage before the functional test. Transportation damage may compromise the functions of the VACUTAP® AVT. To check the on-load tap-changer’s functions, please be sure – before applying voltage to the transformer – to perform operational tests involving the entire range of operations, starting from the adjusting position (bottom end position; anti-clockwise rotation of the hand crank) all the way to the top end position, and back to the adjusting position (clockwise rotation of the hand crank).

5.1 Checking step-by-step operation

Press the Raise/Lower control switch S3 (see Fig. 3) to trigger a step-by-step operation in direction 9 and keep the control switch pressed during the entire operating time of the motor-drive mechanism.

- Now check to make sure that the motor-drive mechanism switches off automatically following a tap change by the on-load tap-changer. Should this not be the case, verify the connection of the control unit!
- Please perform this check for both directions of rotation of control switch S3 (Raise/Lower).

5.2 Checking the motor protective switch

Please check the tripping functions of motor protective switch Q1 (see Fig. 10) as follows:

- Please disconnect the motor protective switch from the supply and secure it.
- Connect terminal X1B:4 with terminal X1B:5.
- Reapply voltage. Motor protective switch Q1 must now be triggered immediately, closing must be impossible.
- Remove the jumper between terminals X1B:4 and X1B:5.

5.3 Electrical transformer tests

All electrical tests required for transformer acceptance can be performed after completion of the previous works.

The following standards were valid at the time this documentation was prepared:

- GB 6450-86 „Dry-type power transformers“
- GB 50150-91 “Standard for handover test of electric equipment installation engineering"
6 Installation of the OLTC

Fixing the on-load tap-changer beside the transformer
Drill holes (ø 18 mm) are provided on the U-frames on the underside of the on-load tap-changer for fixing the on-load tap-changer securely before commissioning (see Appendix 899019, 899109 and Fig. 11).

Use studs M16 (max. 45 mm long) for fixing. The U-frames can be mounted on the on-load tap-changer housing so they point inwards (see Fig. 11) or outwards.

NOTE!
Before fixing the on-load tap-changer, ensure there is easy access to the tap selector connection terminals on the rear of the housing (see Fig. 11).

Fig. 11: On-load tap-changer VACUTAP® AVT, rear side
7 Connecting the tap winding and the OLTC connecting lead

Connect the tap winding and the on-load tap-changer connecting lead according to the connection diagram supplied with the delivery.

**CAUTION!**

Damage to the on-load tap-changer!
Carefully connect and secure all connections. The tap selector connecting leads must be connected to the VACUTAP® AVT without tension. If necessary, guide the ends of the leads using an extension loop. Ensure the connecting terminals are fixed in position and cannot be forcibly twisted.

Connecting the tap selector connecting leads and the on-load tap-changer connecting leads

The tap selector connecting terminals are marked on the rear side of the housing (see Fig. 12, illustration is only an example). The maximum tightening torque for an M10 screw connection is 40 Nm.

The terminals are flat at the connection end and have a through hole (ø 11 mm) so the tap selector connecting leads can be connected using cable sockets (see Fig. 13). Use screws M10 (max. 35 mm long) for the connection. Ensure the screws are properly tightened.

![Fig. 12: Connecting the terminal contact with the transformer connecting lead](image)

![Fig. 13: Terminal contacts](image)
8 Electrical connection of the motor drive

8.1 Grounding/supply connections

**DANGER!**

Danger of death!
When carrying out the electrical connection of the motor drive ensure that the relevant safety regulations are adhered to.

**CAUTION!**

Damage to the on-load tap-changer!
Please make sure that the motor-drive mechanism is duly supplied with the voltage indicated on the rating plate (see Fig. 10).

Connect the mains supply of the motor drive according to the connection diagram in the accompanying documentation.

PG cable glands are provided on the rear side (Fig. 14, no. 1) or optionally on the underside (see Fig. 14, no. 2) of the motor drive for this. The connecting leads are guided through these cable glands to the on-load tap-changer housing interior.

**DANGER!**

Risk of injury or death and heavy material damage!
Please make sure that an appropriate ground connection was established between the on-load tap-changer and the transformer via the on-load tap-changer ground screws (M 10) (see Fig. 15).

To ensure proper grounding the cross-sectional conductor area must be equal or greater than that of the transformer’s ground connection.

Feed the connecting leads from the PG cable glands to the terminal strips in the housing interior. Fig. 16 shows an example of a terminal strip assignment. The specific terminal strip assignment for your VACUTAP® AVT on-load tap-changer be found in the circuit diagram in the VACUTAP® AVT documentation.

Fix the leads with the cable ties provided on the attachment elements on the inside of the housing. To earth the on-load tap-changer properly, connect the on-load tap-changer ground screws (M10) to the transformer (see Fig. 15).
8.2 Connecting the transformer’s emergency shutdown

![DANGER!]

Risk of personal injury and heavy material damage!
Effectiveness of the monitoring systems may be compromised!
It is imperative for the transformer to be switched off immediately both on the high-voltage and low-voltage side whenever the monitoring systems (arc monitoring and latch monitoring) are energized.

All connections must be established in accordance with the connection diagram enclosed with the VACUTAP® AVT (example shown in Fig. 17).

The switchgear control which serves to disconnect the transformer from the distribution system on the high-voltage and low-voltage sides if the VACUTAP® AVT monitoring systems are triggered must be connected to terminal X1A:4 and X1A:9 or X1A:10 (Fig. 17).

![Fig. 17: Example of a circuit diagram section]
9 Mechanical functionality test

Before commissioning the transformer, carry out a mechanical functionality test. This test must be performed from the lower end position (anti-clockwise rotation of the hand crank) through to the upper end position and back again (clockwise rotation of the hand crank).

Use the hand crank attached to the base of the housing to operate the on-load tap-changer.

Remove the cover of the drive shaft end (3 screws M6/w.s.10) and attach the hand crank. A single tap-change occurs after half a rotation of the large bevel wheel. Note the markings on this wheel. Make sure that the indicator is at 0° after a tap-change operation is complete. If it is not at 0°, the tap-change operation has not yet been completed properly. Five rotations of the hand crank are required for each step. The tap-change operation of the diverter switch is clearly audible.
The end positions may not be exceeded under any circumstances. Therefore, always check the attained operating position through the inspection window on the on-load tap-changer and the rotation marking on the gear motor.

Once the mechanical functionality test has been completed, the on-load tap-changer must be moved back to the adjustment position (lower end position).
10 Commissioning at the installation site

Before commissioning the transformer, a functionality test must be carried out on the on-load tap-changer and the motor drive as described in Sections 5 and 9.

The window of the control unit must be kept shut during automatic operation (see Fig. 21).

**DANGER!**

Danger of death!
Do not commission the transformer until the functional tests described in section 5 and 9 have been completed!

**DANGER!**

Risk of tipping!
Risk of severe injuries or death!
When carrying out any work on the on-load tap-changer, ensure it is positioned securely!
Uncontrolled tipping must be prevented!

The door to the VACUTAP® AVT motor drive mechanism must be kept shut during operation. The door must only be opened by authorized staff.

---

Fig. 21: VACUTAP® motor drive door and control panel window
11 Operating the VACUTAP® AVT by hand crank

Recommendation: Please keep the transformer de-energized on the high-voltage and low-voltage sides when operating the VACUTAP® AVT by hand crank.

The following conditions must be met if VACUTAP® AVT operation by hand crank under load is required:

- Switch off motor protective switch!
- Ensure that the green indicator light is switched on!
- Verify that the VACUTAP® AVT is connected such that the transformer is immediately disconnected from the supply on the high-voltage and low-voltage sides whenever the VACUTAP® AVT monitoring system is energized (see Section 2.3 and 8.2)!
- Ensure that the transformer is disconnected from the supply of the VACUTAP® AVT monitoring systems are energized!

VACUTAP® AVT operation under load by hand crank as described in Section 9 is admissible if the required safety clearances are observed. Prior to electrical commissioning of the VACUTAP® AVT and following maintenance work, please be sure to perform operational tests involving the entire range of operations, starting from the adjustment position (bottom end position) all the way to the top limit position, and back to the adjustment position.

⚠️ DANGER!
Risk of personal injury and heavy material damage!
The transformer may only be reconnected to the supply once all faults have been rectified and the green indicator light is on.
12 Monitoring during operation and faults

12.1 Information required when contacting MR regarding faults

The following information is required when contacting MR regarding faults:

- On-load tap-changer number (see nameplate on the control panel, Fig. 20)
- Operation counter reading (see control panel in Fig. 20)
- Operating position (see control panel in Fig. 20)
- Date
- State of green indicator light H1 (on/off)
- Other information identified by the user

12.2 Failure mode A: The green signaling light H1 has gone out

- Please check whether supply voltage is available at the VACUTAP® AVT monitoring system.
- If yes: The VACUTAP® AVT monitoring system has detected a fault.
- If not: Please apply supply voltage at the VACUTAP® AVT monitoring system according to the circuit diagram.
- If the green signaling light comes on, please perform operational tests as outlined in Section 11.
- The transformer must not be connected to the supply until the green indicator light has come on!

Please contact your MR representative, the transformer manufacturer, or:
Guangdong MR OLTC Ltd.
First Industrial Estate, Xihuan Road East, Lonqi Village
Shawan Town
Panyu, Guangdong, PC: 511 483 P.R.C.
Phone: (+86) 20/8473-6138
Fax: (+86) 20/8473-7816
Internet: www.reinhausen.com

12.3 Failure mode B: The green signaling light H1 does not go out

- Please close the motor protective switch.
  If this is not possible a fault has occurred in the control system.
  In the event of on-load tap-changer faults (tripping of the motor protective switch) that cannot be rectified on site, please contact your MR representative, the transformer manufacturer, or Guangdong MR OLTC Ltd. direct.
- Please perform operational tests with the motor protective switch closed.
  If necessary, with the loads disconnected move from the adjusting position (bottom end position) to the top end position and back to the adjusting position by operating the Raise/Lower control switch S3.

Danger of death!

It is imperative for the user/transformer manufacturer to ensure that the transformer will be switched off immediately both on the high-voltage and low-voltage side whenever the monitoring systems (arc monitoring and latch monitoring) are energized.
13 Maintenance

Service, cleaning and lubrication

It is imperative to clean and lubricate the on-load tap-changer every 2 years or every 100,000 tap-change operations, whichever comes first.

Carefully carry out this work according to the lubrication diagram.

The lubricating points and insulation distances should be cleaned with a dry cloth.

NOTE!

Inspections on the on-load tap-changer should be carried out according to the instructions in order to maintain a high level of operating safety.

The first service (after 2 years or 100,000 tap-change operations) is to be carried out by the Technical Service department of MR or of MR’s subsidiary Guangdong MR.

Provided all relevant preparations have been carried out, further inspections can usually be carried out within one day by qualified personnel or personnel trained by MR.

We always recommend that inspections be performed by the Technical Service department of our subsidiary Guangdong MR. This ensures that the inspection is carried out by an expert and that individual components are retrofitted to the latest manufacturing standard.

A relevant report supplementing Guangdong MR’s maintenance file must be prepared.

The on-load tap-changer must be replaced after 500,000 tap-change operations.

On-load tap-changer type VACUTAP® AVT: cleaning, visual inspections and lubrication

The following components must be lubricated after 2 years or 100,000 tap-change operations, whichever comes first:

- Toothed wheels
- Silver-plated contacts and connecting leads (see Fig. 22, 23)
- Tap selector step-by-step gear (see Fig. 24)
- Rollers, coupling bearings, locking mechanism (see Fig. 25)
- Link guides on the energy accumulator and on the vacuum-interrupter control (see Fig. 26)
- Position transmitter (see Fig. 27)

Lubrication diagram

Lubricant: ISOFLEX TOPAS NCA 5051, MR item no. 09947300
13 Maintenance

Fig. 22: Tap selector contacts

Fig. 23: Change-over contacts

Fig. 24: Tap selector step-by-step gear

Fig. 25: Energy accumulator

Fig. 26: Vacuum cell link guides

Fig. 27: Position transmitter drive
## 14 Technical data

### 14.1 Technical data for the on-load tap-changer

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of phases</td>
<td>3</td>
</tr>
<tr>
<td>Max. rated through-current $I_{nm}$ per phase (A)</td>
<td>170</td>
</tr>
<tr>
<td>Rated short-time withstand current (kA)</td>
<td>4</td>
</tr>
<tr>
<td>Rated duration of short-circuits (s)</td>
<td>2</td>
</tr>
<tr>
<td>Rated peak withstand current (kA)</td>
<td>7.5</td>
</tr>
<tr>
<td>Rated stepping voltage $U_{nm}(V)$</td>
<td>500</td>
</tr>
<tr>
<td>Rated frequency (Hz)</td>
<td>50 to 60</td>
</tr>
<tr>
<td>Number of operating positions</td>
<td>9</td>
</tr>
<tr>
<td>Tap-change operation</td>
<td>max. of every 30 seconds</td>
</tr>
<tr>
<td>Temperature range (ambient temperature)</td>
<td>-20°C ... + 65°C</td>
</tr>
<tr>
<td>Insulation to ground (f) and phase b, phase b</td>
<td></td>
</tr>
<tr>
<td>Highest voltage for equipment $U_{in}$</td>
<td>11.5</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage $U_{(f+b)}$ (kV, 1.2/50μs)</td>
<td>75</td>
</tr>
<tr>
<td>Rated short-duration power-frequency withstand voltage $U_{(f+b)}$ (kV)</td>
<td>35</td>
</tr>
<tr>
<td>Internal insulation</td>
<td></td>
</tr>
<tr>
<td>Rated impulse withstand voltage over 1 tap $a_0$, $a_1$ (kV)</td>
<td>10</td>
</tr>
<tr>
<td>Rated short-duration power-frequency withstand voltage over 1 tap $a_0$, $a_1$ (kV)</td>
<td>0</td>
</tr>
<tr>
<td>Rated impulse withstand voltage over the setting range (a) (kV)</td>
<td>45</td>
</tr>
<tr>
<td>Rated short-duration power-frequency withstand voltage over the setting range (a) (kV)</td>
<td>15 kV</td>
</tr>
</tbody>
</table>

![Fig. 28: Insulation distances](image.png)
### 14.2 General technical data

<table>
<thead>
<tr>
<th>Housing dimensions</th>
<th>((w \times h \times d) = 1752 \times 1612 \times 810 \text{ mm})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>350 kg</td>
</tr>
<tr>
<td>On-load tap-changer design according to</td>
<td>IEC 60214-1 and GB 10230</td>
</tr>
</tbody>
</table>

### 14.3 Technical data for the drive unit

<table>
<thead>
<tr>
<th>Drive (integrated in on-load tap-changer housing)</th>
<th>0.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power motor (kW)</td>
<td>0.1/0.03</td>
</tr>
<tr>
<td>Power control (kW)</td>
<td></td>
</tr>
<tr>
<td>Voltage (V)</td>
<td>3AC 220/380</td>
</tr>
<tr>
<td>Rated current (A)</td>
<td>1.55/0.9</td>
</tr>
<tr>
<td>Frequency (Hz)</td>
<td>50</td>
</tr>
</tbody>
</table>
15 Voltage Regulator TAPCON® 230C

15.1 General

15.1.1 Specified application

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

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

In addition to the usual well-known, versatile and individual setting options for the MR control system, the TAPCON® 230C voltage regulator also offers the option of fast and easy parametering via the innovative "Normset" function.

The term "Normset" stands for an automatic mechanism which considerably simplifies configuration of a voltage controller. If the desired voltage level is entered while the "Normset" function is active, the voltage controller will examine the given network conditions and proceed to perform an automatic adaptation of all further inputs (comprised in part of the pre-parametering and standard reference values) which used to be required for customary regulators (see settings according to Section 15.4).

The parameters of the regulator can be set by means of a PC via the incorporated serial interface (RS485) integrated in the controller (see Section 15.7).

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

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

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

15.2 Design and performance features of the TAPCON® 230C

The electronic voltage controller TAPCON® 230C is mounted in a protective housing with hinged cover and inspection window. The protective housing is suitable for both control panel flush mounting as well as surface mounting.

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

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

The electronic voltage regulator is controlled by a 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.

![CAUTION!]

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

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

![NOTE!]

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

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<th>Standard step width</th>
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<td></td>
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<td>intermediate transformer only)</td>
<td></td>
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<tr>
<td>Number of tap-change operations ≤ 150 A</td>
<td>max. 1 tap-change operation /</td>
<td></td>
</tr>
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<td></td>
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<td>max. 1 tap-change operation /</td>
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<td>1 LED lamp (red) each for signalling U &lt;</td>
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<td></td>
<td>1 LED lamp (green) for signalling parallel</td>
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</tr>
<tr>
<td></td>
<td>1 LED lamp (green) for signalling Nominal</td>
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<td></td>
<td>1x automatic control mode</td>
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</tr>
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<td></td>
<td>1x parallel control mode</td>
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</tr>
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<td></td>
<td>1x high-speed circuit breaker of voltage</td>
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<td>AC: 250 V 5 A</td>
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<td>DC: 30 V 5 A, 110 V 0.4 A, 220 V 0.3 A</td>
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<td></td>
<td>1x raise</td>
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<tr>
<td></td>
<td>1x lower</td>
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</tr>
<tr>
<td></td>
<td>1x automatic control mode</td>
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<tr>
<td></td>
<td>1x status (self-monitoring)</td>
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<td></td>
<td>1x common alarm U,&lt;, U&gt;</td>
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<tr>
<td></td>
<td>1x monitoring</td>
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<tr>
<td><strong>Voltage measurement</strong></td>
<td>220 VAC, measuring range 60 ... 195 V,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>r.m.s. value 40 ... 60 Hz in bias</td>
<td></td>
</tr>
<tr>
<td><strong>Current transformer</strong></td>
<td>0.2 / 1 / 5 A, 40 ... 60 Hz, r.m.s. value</td>
<td></td>
</tr>
<tr>
<td></td>
<td>intrinsic consumption &lt; 1 VA,</td>
<td></td>
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<tr>
<td></td>
<td>overload capacity 2x In continuously, 40</td>
<td></td>
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<tr>
<td><strong>Measuring errors</strong></td>
<td>Voltage measuring: &lt; 0.3% ± 40 ppm/°C</td>
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<td>Current measuring: &lt; 0.5% ± 40 ppm/°C</td>
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<td>1x serial interface RS232 (frontside</td>
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<td></td>
<td>1x RS485 for parallel operation with</td>
<td></td>
</tr>
<tr>
<td><strong>Power supply</strong></td>
<td>220 V, 40 - 60 Hz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power consumption approx. 5.5 VA</td>
<td></td>
</tr>
</tbody>
</table>
| Protective housing | Steel-plate housing with inspection window for flush or projected panel mounting  
|                    | W x H x D: 216 x 326 x 137 mm  
|                    | Degree of protection provided by enclosure: IP 44 according to IEC 60529  
|                    | Weight: approx. 5.4 kg  |
| Temperature limits | Admissible ambient temperature for operation: -10 °C ... +60 °C  
|                    | Admissible ambient temperature for storage and transport: -25 °C ... +80 °C  |
| Tests IEC 255-5 | Dielectric tests performed at 2.5 kV / 1 Minute operating frequency and 5 kV impulse voltage  |
| IEC 61000-4-2 | Interference immunity tests (EMC): electrostatic discharge 4 kV / 8 kV  |
| IEC 61000-4-3 | Interference immunity tests (EMC): electromagnetic fields 10 V/m  
|                    | 80-1000 MHz  |
| IEC 61000-4-4 | Interference immunity tests (EMC): burst 1 MHz, 4 kV  |
| IEC 61000-4-5 | Surge 4 kV  |
| IEC 61000-4-6 | HF interference immunity of leads: 10 V, 150 kHz - 80 MHz  |
| EN 50081-1 | CE-conformity  |
| EN 50081-2 | CE-conformity  |
| VDE 0435 | Short-time current and continuous rating of the current transformer inputs, 100 x Ln/1s and 2 x Ln/continuously  |
| VDE 0100 | Provisions governing the erection of electrical power installations featuring rated system voltages up to 1,000 V  
|                    | Grounding conductors, protective conductors, equipotential bonding conductors, arrangement of operating elements  |
| IEC 61010/VDE 0411 | Safety requirements for electrical equipment for measurement, control, regulation and laboratory equipment  |
| VDE 0110 | Provisions governing the rating of clearance in air and creepage distances in electrical equipment  |
| IEC 60529 | Determination of the degree of protection provided by enclosures: „Shock-hazard protection, protection against ingress of solid foreign bodies and protection against the ingress of water for electrical equipment” Level IP44  |
| IEC 60068 | Basic environmental test procedures  |
| IEC 60068-2-1 | Cold test for heat-dissipating specimens, with slow temperature change rate -10 °C / 20 hours  |
| IEC 60068-2-2 | Dry-heat test for heat-dissipating specimens, with slow temperature change rate +70 °C / 15 hours  |
| IEC 60068-2-3 | Humid heat, constant +40 °C / 93 % / 56 days  |
| IEC 60068-2-30 | Humid heat, cyclical (12 + 12 hours) +55 °C / 93 % and +25 °C / 95 % / 6 cycles  |
| IEC 60068-2-31 | Dropping and toppling in unpackaged condition from a drop height of 100 mm  |
| IEC 61000-4-8 | Power frequency magnetic field immunity test  |
| IEC 61000-4-11 | Voltage dips, short interruptions and voltage variations immunity tests  |
15.3 Operation

15.3.1 Description of the front panel

Generally, the keys located at the front (see Fig. 29) panel fall into two different basic groups.

a) Control keys

To switch between manual and automatic operating mode, simply toggle between the and keys. The current operating mode is displayed by the LED integrated in the key.

While in “Manual” mode, the on-load tap-changer can be controlled manually in the directions “Higher” and “Lower” by keep on pressing the key and operating the or key.

During this procedure, the corresponding presignal will appear in the 3rd line of the display.

b) Function keys for menu guidance

The or key is used in combination with the or key for parameterizing the regulator (see description in Section 15.3.2.2).

The LEDs located in the upper section of the front panel serve for signaling the following system states:

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

Figure 29
15 Voltage regulator TAPCON® 230C

15.3.2 Display
The TAPCON® 230C features a 4-line, 16-digit LC display.

A distinction is made between the following types of display:
Basic display and parametering display.

15.3.2.1 Basic display
In addition to the actual voltage level, the desired voltage level and the deviation the basic display indicates an additional measuring value in the 4th line during normal operation. Selection of this measured value in the display window "SELECT 4th LINE".

The following values are available:
- Current I
- Apparent power S
- Reactive power Q
- Active power P
- Phase angle PHI

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

Generally, these windows are set up as follows:
1st line: Parameter name
2nd line: Set value
3rd line: Possible setting values/ranges
4th line: Current number of the display

The displays are situated behind one another in a ring arrangement, as shown in the illustration to the right, and can be selected by operating the function keys SELECT and . The display will remain visible for as long as the SELECT key is being pressed, plus an additional 10 seconds after the SELECT key was released.

It is possible to move in both directions within the menu. As a result, display no. 27 of the basic display can be reached just as quickly as parametering window no. 1.

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

For parametering purposes, please use the parametering windows as listed below, the functions of which are explained in detail in the following.
15.4 Parametering

15.4.1 “Normset” setting

The term “Normset” stands for an automatic mechanism which considerably simplifies configuration of a voltage controller. The only operator input during commissioning in “NormSet” mode is to enter the desired voltage level and subsequently taking 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 optimized in accordance with the results gained from this check.

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

The time parameters are handled in the same way by the regulator, which ensures optimum self-adjustment of the regulator after only a few regulating sequences. Should the marginal conditions change, the regulator will again optimize itself automatically.

It goes without saying that network-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.

15.4.2 Setting the desired voltage level 1

The setting of the desired voltage level refers either to the measured voltage connected to the TAPCON® 230C (see Section 15.4.8).

Press the SET and function keys to set the desired voltage level.

15.4.3 Setting the bandwidth

Set the bandwidth (B) from ± 0.5% to ± 9% in steps of 0.1% by pressing the SET and keys. The transformer’s tap-change step must be known to ensure proper setting of this value.

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. Higher values will cause a decrease in regulating sensitivity.

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

If the system has not reached a stable state after 15 minutes, the “monitoring” relay is triggered (see connection diagram).

The relay is reset once the deviation falls below the set limit.

Standard setting range: ± 0.5% - ± 9%
Standard step width: 0.1%

15.4.4 Setting the delay time T1 or T2 (DELAY 1 / DELAY 2)

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

Delay time T1

The delay time can be set for a range of 0...180 s by pressing the SET and keys.

NOTE!
The parameters for undervoltage/overvoltage and overcurrent are not set by the Normset function. These parameters have to be entered manually during commissioning.
15 Voltage regulator TAPCON® 230C

T1 linear/integral

The delay time T1 can be set with linear or integral response.
If an "integral time" is set, the delay time is reduced down to a minimum of 1 second, depending on the ratio of the actual control deviation and the set bandwidth (see Fig. 30).
The desired time behavior can be set by pressing the SET and keys.

Fig. 30

Delay time T2

The delay time T2 will become effective only if more than one tap change is required for reduction of the system deviation below the bandwidth limit. The set delay time T2 is then valid for all consecutive output pulses.
Set the delay time T2 for a range of 1.0 ... 10 s by pressing the SET and function keys.
If the voltage controller is set to PERM, it will emit a continuous signal. If it is set to OFF, the delay time T2 will be deactivated.

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

The response threshold can be set from 101% to 130% of the desired voltage level in steps of 1% by pressing the SET and function keys.
In the event of an overvoltage detection response, the on-load tap-changer is repeatedly activated by periodic pulses to the motor drive until the overvoltage falls below the response threshold. The motor drive is controlled by periodic pulses of 1.5 s through the "Lower" output relay while the set delay time remains inactive during this operation.
At the same time the "U>" LED and a signaling relay are energized (contacts 17/18/19) as long as overvoltage is present. If the voltage regulator regulates towards a higher voltage than the set limit U> due to unfavorable parametering (e.g. LDC settings too high), it is prevented from exceeding the limit. This condition is signaled by the "monitoring" relay (contacts 20/21/22) after 15 minutes.

15.4.6 Voltage and current measurement

Voltage measurement
For voltage measuring purposes the TAPCON® 230C is connected directly to the 220 V AC voltage supply (see Fig. 31, circuit a).
If a measurement is possible only in a three-wire network (line terminal voltage), it is imperative to use a matching transformer (see Fig. 31, circuit b,c,d).

CAUTION!
The voltage applied at the measuring inputs (terminals 1;2 – see connection diagram) of TAPCON® 230C must under no circumstances exceed a value of 260 V AC.

If a current transformer is connected, use the SET and function keys to set the primary transformer current. Make sure that the transformer is properly connected to the secondary side at terminals 6/9/10 (see connection diagram).
Transformer phase, measuring circuit

To obtain correct measuring results it is important to make sure that the phase angle between voltage and current is properly set (see circuit options shown in Fig. 31). Selection via the SET and function keys.

Setting values for customary measuring circuits:
- 0° (for single-phase systems)
- 0° (for three-phase systems)
- 90° (for three-phase systems)
- 30° (for three-phase systems)
- -30° (for three-phase systems)

15.4.7 Setting the desired voltage levels SW2 and SW3

The voltage regulator TAPCON® 230C permits preselection of three different desired voltage levels which are activated by energizing inputs 13 and 14.

- No signal present at terminals 13 and 14 => Desired voltage level 1 is active
- Signal present at terminal 1 => Desired voltage level 2 is active
- Signal present at terminal 14 => Desired voltage level 3 is active

Desired voltage levels 2 and 3 are set in the same way as desired voltage level 1 by operating the function keys SET and.

15.4.8 Line compensation

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

Comparison between LDC and Z Compensation

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

Z compensation:
- can be used in case of minor shifts of phase angle j
- if compensation in relation to the load current is required.

15.4.8.1 Line-Drop Compensation (LDC)

NOTE!

For the correct setting of the LDC it is necessary to calculate the resistive and inductive line voltage drop and the correct setting of the existing configuration according to Section 15.4.8.
Setting the resistive voltage drop \( UR \)

The calculated voltage drop is set via function keys SET and \( \text{[ ]} \) in the UR window. The effect of the compensation can be reversed by 180° (minus sign preceding the set value).

If no compensation is required the value should be set to "0".

Setting the inductive voltage drop \( UX \)

The calculated inductive voltage drop is set in the UX window by pressing the function keys SET and \( \text{[ ]} \). The effect of the compensation can be reversed by 180° (minus sign preceding the set value).

If no compensation is required the value should be set to 0 (delivery state).

Calculation of the required setting values:

\[
\begin{align*}
UR &= \frac{I_N \cdot R_{CT}}{R_{VT}} \cdot r \cdot L \ (V) \\
UX &= \frac{I_N \cdot R_{CT}}{R_{VT}} \cdot x \cdot L \ (V)
\end{align*}
\]

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. 30000 V/100 V
\( r \) = Ohmic resistance of line in W/km per phase
\( x \) = Inductive reactance of line in W/km per phase
\( L \) = Length of line in km

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

15.4.8.2 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:

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

\( \Delta U \) = Setting of the Z compensation in %
\( U_{Tr} \) = Transformer voltage at current I
\( U_{La} \) = Line end voltage at current I and with the same operating position of the on-load tap-changer
\( I \) = Load current in A
\( I_N \) = Rated current in A of the selected current transformer connection to the voltage regulator, i.e. 0.2 A or 1 A or 5 A
\( R_{CT} \) = Current transformer ratio, e.g. 200 A/5 A
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Setting the voltage rise (VOLTRISE)
The calculated percentage of the voltage rise, referred to the desired voltage level, is set by pressing the function keys SET and .

If no compensation is required the value should be set to „0”.

Note: Make sure that the tap position at TAPCON® 230C is identical to the tap position displayed at VACUTAP® AVT.

Setting the limit value for DU (LIMIT)
The value is set by pressing the function keys SET and .

If compensation to a certain value is desired and at the same time excessive voltage rise on the transformer is avoided, (e.g. in case of an unusually high load), the limit value can be set to the desired voltage rise.

If no compensation is required the value should be set to „0”.

15.4.9 Analog position indication
The TAPCON® 230C voltage regulator features an analog input for position indication.
Analog values between 0 - x Ohm (potentiometer contact range) can be processed.
Press the SET and function keys to set the respective minimum and maximum positions.
For ‘POS MIN’, please enter the position corresponding to 0 Ohm; for POS MAX, please enter the position corresponding to x Ohm.

To that end the VACUTAP® AVT on-load tap-changer is moved to the bottom position while the transformer is switched off. If the display does not show the correct tap position, use the left potentiometer R45 to adjust.

Please proceed in the same manner for setting the highest position “POS MAX”, in which case the on-load tap-changer is in the highest position and the right potentiometer R46 is used for adjusting purposes, if required.
Access to both potentiometers is from the front, as shown in the front view (see Appendix, „Front view” diagram).

The following measuring values are available:
- Current I
- Apparent power S
- Reactive power Q
- Active power P
- Phase angle PHI
- Power factor cos PHI
- Frequency f
- Status line
- Position

The screen texts are available in different languages. Select the desired language via the SET and function keys.

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

The following measuring values are available:

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

The regulator identification serves for assignment of a unique „address” to every voltage controller to ensure that it can be explicitly operated via the serial interface RS485 (see Section 15.7.2). Hence, different regulators require different addresses.

A number ranging between 0 and 9999 can be entered to serve as a „name” by operating the SET and function keys.

15.4.10 Regulator identification

The regulator identification serves for assignment of a unique „address” to every voltage controller to ensure that it can be explicitly operated via the serial interface RS485 (see Section 15.7.2). Hence, different regulators require different addresses.

A number ranging between 0 and 9999 can be entered to serve as a „name” by operating the SET and function keys.

15.4.12 Language selection

The screen texts are available in different languages. Select the desired language via the SET and function keys.
15.5 Commissioning

15.5.1 Installation

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

15.5.2 Connection

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

When connecting the equipment, please pay attention to:

- the correct phase angle of the measured current and voltage and
- correct connection of the output relays to the motor drive unit (Higher - Lower)
- correct connection of the housing ground.

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

- Ensure correct connection to ground by means of the ground screw attached to the housing, wire section not less than 4 mm².
- Be sure to lead the individual power circuits (motor-drive control, inputs, outputs) in separate cables.
- Be sure to use only shielded cables for the parallel operation data links. The shielding at both ends must be connected to ground via the grounding angles cable clamps at the housing included within delivery (see Fig. 34).
15 Voltage regulator TAPCON® 230C

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

The related transformer should be subject to normal load.

- Select the MANUAL operating mode at TAPCON® 230C.
- Select the NORMSET function according to Section 15.4.1.
- Set the Desired Voltage Level SW1 according to Section 15.4.2.
  Now proceed to initiate the regulator by operating the AUTO function key.
- If a current measurement is required, set the rated transformer current and the phase angle according to Section 15.4.8.
  Proceed as follows to configure the TAPCON® 230C voltage regulator to suit your specific requirements:

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

The related transformer should be subject to normal load.

- Select the MANUAL operating mode at TAPCON® 230C.
- Set the transformation ratios of the transformers as specified in Section 15.4.8, as well as the measuring circuit.
- Measure the actual voltage (measured voltage) with the display of the voltage regulator.
- Read the current, power, and phase angle values on the display and compare these values with those from any service instruments. If the signs are incorrect, reverse the polarity of the current or voltage transformer.
- Set the desired voltage level. Through manual control of the motor drive move the VACUTAP® AVT on-load tap-changer to the operating position so that the desired voltage level is obtained.
- Set the desired voltage level U DESIRED to this value.
- Set the bandwidth “DU max. to 1.0%.
  In most cases the voltage regulator is now in a balanced state (no presignal LED lamp comes on). Otherwise change the desired voltage level in steps of 0.1 V until a balanced state is reached.
- Set the bandwidth “DU max” depending on the step voltage (see Section 15.4.3).
- Set the delay time T1 to 20s lin. according to Section 15.4.4.
  Manually move the on-load tap-changer towards “Raise” by one step. The presignal LED for “Lower” must come on. Set the mode of operation to “AUTO”. 20 s after the presignal lamp comes on, the voltage regulator must return the on-load tap-changer back to its previous operating position.
  The presignal LED lamp goes out. Set the mode of operation to “MANUAL”. Repeat the control procedure towards “Lower”.
  If a delay time T2 is required, set the operating delay time T2 to 10 s. Set the mode of operation to “MANUAL”.
  Manually move the on-load tap-changer towards “Raise” by two steps. The presignal LED lamp for “Lower” must come on.
  Set the mode of operation to “AUTO”. 20 s after the presignal lamp has come on, the voltage regulator must automatically return the on-load tap-changer back to its previous operating 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.
  During commissioning of the transformer it is recommended to set the delay time T1 provisionally to 100 s. Depending on the existing operating conditions, you may want to determine the definitive setting only after some time of observation. For this purpose it is recommended to register the variation of the actual voltage and the number of tap change operations on a day-to-day basis. If an inverse response of the voltage regulator is desired, set an integral time response for the delay time 1.
  In this case the delay time is automatically shortened inversely proportional to the deviation.
- 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. 220 V, to 220 V/0.85 = 260 V, so that the actual voltage now corresponds to the set percentage of the response threshold for the blocking value. The presignal LED lamp for “Raise” must come on.
  Set the mode of operation switch to “AUTO”. After approx. 10 s the signaling relay “U<” must be energized, the signaling contact (contacts 17/18/19) will open; the “Raise” output relay does not issue a control command.
  LED U< will now respond. Upon completion of this function test you may now set the desired response threshold for undervoltage blocking.
- 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.
  The presignal LED for “Lower” must come on. Set the mode of operation to “AUTO”.
  The output relay “Lower” issues periodic control commands at 1.5 s intervals.
  The group signaling contact 17/18/19 will close/open. LED U> will now respond.
  Now set the desired response threshold for overvoltage detection to the original desired voltage level.
m) Set the response threshold for overcurrent blocking $I^>$. A function check is not necessary.

n) Setting the load drop LDC (according to Section 15.4.10.1)
   - Set the mode of operation to MANUAL.
   - Settings for $U_x = U_r = 0$, presignal LED lamp for Raise/Lower must not come on.
   - Setting of $U_r = 20\text{ V}$, $U_x = 0\text{ V}$, the presignal LED lamp for „Raise“ must come on.
   - Setting of $U_r = -20\text{ V}$, $U_x = 0\text{ V}$, the presignal LED for „Lower“ must come on (during this function check a minimum load current of 5% of the rated transformer current must flow). If the presignals appear in opposite direction, change the polarity of the current transformer.
   - The actual desired LDC can be set upon completion of the above settings.
   - Set the mode of operation to AUTO.
   - Check if the setting is correct by observing the voltage at the line end during service and with different loads. When the setting is correct the voltage at the line end will remain constant.

Setting of Z Compensation (according to Section 15.4.10.2) as an alternative to LDC.
   - Set the mode of operation to MANUAL. Set the voltage rise to 0, the voltage regulator is in a balanced state, no presignal LED lamp must come on.
   - Voltage rise setting = 15%, the presignal LED for „Lower“ must come on (during this function check a minimum load current of 10% of the rated transformer current must flow). The desired values for Z Compensation can be set upon completion of the above settings.
   - Set the mode of operation to AUTO. Verify the setting by observing the voltage at a specific point in the line and with different loads. When the setting is correct the voltage at the line end will remain constant.

p) Set the DESIRED VOLTAGE LEVEL 2 to the desired value (see Section 15.4.9). Set the mode of operation to MANUAL and connect L+ to terminal 13.
   - Depending on the set value for Desired Voltage Level 2, the „Lower“ or „Raise“ presignal must respond.
   - Please proceed in the same manner for DESIRED VOLTAGE LEVEL 3 by connecting L+ to terminal 14 signaling relay for DESIRED VOLTAGE LEVEL 3.
   - Set the mode of operation to AUTO.

15.6 Parallel operation

TAPCON® 230C permits controlled parallel operation of up to 8 transformers in a bus bar arrangement.

Parallel operation management is achieved via the CAN bus.

Activation of parallel operation is achieved via the status input, the terminal 41.

Parallel control is possible in two different ways:

- Parallel operation according to the principle of “minimum circulating reactive current”
- Parallel operation according to the principle of “master/follower tap synchronization”.

Selection of the parallel operation principle

Connect the paralleling voltage controllers via the CAN bus interface in both cases (see Fig. 35). The voltage regulators engaged in parallel operation will signal their parallel status at the terminals 38/39/40.

Setting the CAN address

To permit regulator communication via CAN bus, each regulator requires a separate identifier. Assign an address between 1 and 8 for each regulator by pressing the SET key and the function keys. No parallel operation will be possible if the address is set to 0 (delivery state).

NOTE!

The following items refer to optional control variables that are not mandatory for simple regulator operation. They may be set as required.
15.6.1 Parallel operation according to the principle of “minimum circulating reactive circuit”

The reactive circuit current is computed from the transformer currents and their respective phase angles. For correction of the measuring circuit voltage, a voltage proportional to the reactive circuit current is applied to independent regulators.

This correction voltage can be either decreased or increased through adjustment of the “Stability”.

If an inadmissibly high reactive circuit current is detected, all on-load tap-changers involved will be reset after only 10 s, regardless of the delay time preset at the on-load tap-changer. This method is suitable for transformers of comparable output and \( u_k \), either with uniform or with nonuniform step voltage. No information on tap position is required.

15.6.1.1 System configuration, settings

Feed the additional connections/terminals to the regulators (see Fig. 36).

Select the menu item by operating the SELECT key and the \( \text{SET} \) \( \text{SET} \) keys and set the a stability value between 0 and 100 via the \( \text{SET} \) \( \text{SET} \) function keys. The stability value is a measure used for determining the effect of the reactive circuit current on the voltage controller.

If it is set to 0, no effects will occur. For a reactive circuit equal to the rated current of the voltage transformer, a setting value of 10 would result in a voltage correction of 10% in the voltage controllers.

15.6.1.3 Setting the admissible reactive circuit current (blocking threshold)

Operate the SELECT key and the \( \text{SET} \) \( \text{SET} \) keys to set the bandwidth between 0.5 and 20% (in relation to the rated current of the voltage transformer). If the reactive circuit current exceeds the preset threshold value during parallel operation, the message „Circulating reactive current” will be displayed in the status line and a delayed response of the signaling relay contact (terminal 35/36/37) will ensue after 30 s. All voltage regulators engaged in parallel operation will be blocked.

15.6.1.4 Function check, commissioning

a) Preliminary settings

The current transformer inputs must be connected and the transformer configuration must be parameterized correctly. The voltage regulators must be set to identical operating parameters for the desired voltage, bandwidth, time delay 1, and line compensation, if applicable (LDC or Z Compensation). In all cases, set STABILITY to “0” and Blocking to “20”.

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

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

b) Setting the interference variable (CIR.REAC.CURR. STABILITY)

Individually set both transformers to identical voltage with the on-load tap-changers so that both voltage regulators are in a balanced state (no presignal LED lamps are lighting up, the indication of “dU %” must be as low as possible, therefore lower than the preset bandwidth “dU max”).
Now switch the transformers to parallel operation and enable parallel control (close contact at terminal 41). The voltage regulators must continue to remain in a balanced state, the „parallel operation” LED on the front panel comes on. Raise one of the two transformers by one voltage step and lower the other of the two transformers by one voltage step. Both regulators must continue to remain in a balanced state. Raise the setting value „CIRC.CURR.STABILITY” of both regulators in small steps starting with „0” until the corresponding presignals appear (the regulator of the transformer with the higher voltage step must show the tendency „lower” while the other transformer must show the tendency „higher”). Now add the setting values thus established and set the added-up value for both regulators.

Select the „Auto” operating mode for both voltage controllers. Both voltage controllers must control the on-load tap-changers back into their previous operating positions. The presignals will go out. If the previous operating position cannot be achieved that way, the „CIRC.CURR.STABILITY” setting needs to be increased. If the on-load tap-changers are regulating out of sync („hunting”), this setting needs to be reduced.

c) Setting the reactive circuit current monitoring (CIR.CURR.MON.)
Switch one of the two voltage controllers to the „Manual” operating mode. Using the manual control, the associated motor drive must now be set to „Raise” by the maximum admissible difference of the operating positions between the parallel operating transformers (e.g. by 1 … 2 steps). Starting with the preset value of „20%”, reset the blocking towards a lower value in small steps until the message „Circulating reactive current” appears in the status line of the display (please wait 2 – 3 s between the individual steps). The bandwidth threshold of the reactive circuit current monitoring is reached as soon as this message appears. All voltage controllers will block all further regulating actions and the signaling relay will respond (terminals 35/36/37). Now reset the blocking again towards a higher value until the message „Circulating reactive current” disappears from the status line of the display.

The motor-drive mechanism must signal the tap position via resistor contact range 0 - x Ohm (see Section 15.4.11).

During parallel operation, actual voltage regulation is performed by one of the voltage regulators (master function).

The second voltage regulator (Follower) receives the tap-change position of the motor drive from the first regulator, for comparison with the tap-change position of its own motor drive. If a difference is noted, the motor drive in question will receive a suitable control pulse.

15.6.2 System configuration, settings
Lead the additional connections/terminals to the regulators according to Fig. 37.

Feed the tap position signals to the regulator at terminals 44/45/46 (see connection diagram)

15.6.2.2 Setting the tapping position range
Select the menu item by operating the SELECT key and the keys and set the set the respective lowest/highest tap positions by pressing the SET and function keys. Balancing is achieved as outlined in Section 15.4.11.

NOTE!
Make sure that the tap position at TAPCON® 230C is identical to the tap position displayed at VACUTAP® AVT.

15.6.2 Parallel operation according to the principle of „master/follower tap synchronization”
This method is suitable for transformers featuring an identical rated current, identical step voltage and an identical number of operating positions.
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 synchronization“, it is imperative to maintain identical position designations for all of these transformers, and to ensure that the „higher“ and „lower“ signals will effect identical voltage changes in all the transformers. If this is not the case, e.g. if the „Higher“ command (higher voltage) is not equal to a higher position, it is also possible to „reverse the tap direction“ within the voltage controller. This function is activated/deactivated through operation of the SELECT key and function keys.

15.6.2.3 Selecting Master/Follower mode
Operate the SELECT key and the function keys to select the menu item and designate the respective regulator as a Master or a Follower by pressing the SET and function keys.

If both regulators were designated as “Follower” or “Master” during parallel operation, the regulators will be blocked (see Section 15.6.4 - Faults during parallel operation).

15.6.2.4 Function checks, commissioning

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

The tap position indication at the regulators must function correctly.

Select the „MANUAL“ operating mode at the voltage regulators.

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

Now switch the transformers to parallel operation and close the contact at terminal 41. The voltage regulators must continue to remain in a balanced state and the „Parallel“ LEDs at the regulators must respond.

Switch the follower voltage regulator to „AUTO“ mode.

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

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

15.6.3 Fault during parallel operation

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

<table>
<thead>
<tr>
<th>Message</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIRCULATING REACTIVE</td>
<td>Circulating reactive current was exceeded</td>
</tr>
<tr>
<td>CURRENT</td>
<td></td>
</tr>
<tr>
<td>TAP DIFFERENCE</td>
<td>Synchronism disturbance (tap difference ≤ 2 steps)</td>
</tr>
<tr>
<td>&gt;1 MASTER</td>
<td>More than one Master</td>
</tr>
<tr>
<td>NO MASTER</td>
<td>No Master was selected</td>
</tr>
<tr>
<td>NO POSITION</td>
<td>Failure of position</td>
</tr>
<tr>
<td>DIFF. METHOD</td>
<td>Different methods of parallel operation were selected</td>
</tr>
<tr>
<td>DATA TRANSFER</td>
<td>Data transfer between the regulators was interrupted</td>
</tr>
<tr>
<td>CAN ADDRESS ERROR</td>
<td>Wrong CAN-Address set on the regulator</td>
</tr>
</tbody>
</table>

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

15.7 Serial interface RS485

15.7.1 RS485 connection
The TAPCON® 230C features a 9-pole SUB-D-connector with the following assignment: Pin 2 = RS485 A/Pin 3 = RS485 B/Pin 5 = ground. This connector is located on the underside of the housing next to the cable glands and serves as connection to an operations control system (SCADA).

The transmission rate is 9,600 baud (bits per second).

Be sure to use only cables with a “twisted-pair” multi-point connection for the RS485 interface. To ensure interference-free communication the distance should not exceed 1,200 m.
15.7.2 Communication between TAPCON® 230C and the SCADA system

Communication is based on a binary telegram ended with a checksum. Furthermore, communication is based on the Master/Slave method, with the regulator acting as slave and answering only the telegrams addressed directly to it.

The interface supports only a single telegram type capable of both parameterizing and polling the regulators at the RS485 bus via the slave address. This telegram is also used for modifying the transmitted parameters of the responding regulator TAPCON® 230C. At the same time, the modified parameters are sent back as response to the operations control system computer in conjunction with the current measured values.

The slave address is set via the regulator identification (see Section 15.4.12)

15.7.3 Transmission protocol - telegram setup

The transmission protocol is set up for 10-bit data communication, i.e. 1 start bit, 1 stop bit, 8 data bits, no parity bit.

<table>
<thead>
<tr>
<th>Field name</th>
<th>(hex)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slave address</td>
<td>05</td>
<td>Regulator identification of TAPCON® 230C</td>
</tr>
<tr>
<td>Function</td>
<td>17</td>
<td>for optional realization of additional functions</td>
</tr>
<tr>
<td>Byte count</td>
<td>06</td>
<td>Data security and checksum evaluation</td>
</tr>
<tr>
<td><strong>D0 Write: Delay of voltage change</strong></td>
<td>14</td>
<td>Time delay 1</td>
</tr>
<tr>
<td><strong>D1 Write: Delay of interval between instructions</strong></td>
<td>05</td>
<td>Time delay 2</td>
</tr>
<tr>
<td><strong>D2 Write: Desired voltage level High</strong></td>
<td>08</td>
<td>Desired voltage level with a factor of 10 - High byte</td>
</tr>
<tr>
<td><strong>D3 Write: Desired voltage level Low</strong></td>
<td>FC</td>
<td>Desired voltage level with a factor of 10 - Low byte</td>
</tr>
<tr>
<td><strong>D4 Write: Sensitivity (bandwidth)</strong></td>
<td>15</td>
<td>Sensitivity (bandwidth) with a factor of 10</td>
</tr>
<tr>
<td><strong>D5 Write: Display</strong></td>
<td>01</td>
<td>Flags (in the direction of a TAPCON® 230C)</td>
</tr>
<tr>
<td>Error Check (CRC)</td>
<td>-</td>
<td>Checksum of the signals sent - consisting of 2 Bytes (available upon request)</td>
</tr>
</tbody>
</table>

Table 1

15.7.3.1 Polling telegram

Data transmission to the TAPCON® 230C is based on the parameters specified in Table 1 (write mode). The specified „hex“ values result from the following exemplary values:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slave address</td>
<td>5</td>
</tr>
<tr>
<td>Delay of voltage change</td>
<td>D0 20 s</td>
</tr>
<tr>
<td>Delay of interval between commands</td>
<td>D1 5 s</td>
</tr>
<tr>
<td>Desired voltage level (High Byte)</td>
<td>D2 230.0 V</td>
</tr>
<tr>
<td>Desired voltage level (Low Byte)</td>
<td>D3 230.0 V</td>
</tr>
<tr>
<td>Sensitivity (bandwidth)</td>
<td>D4 2.1%</td>
</tr>
<tr>
<td>Display</td>
<td>D5 01 hex</td>
</tr>
</tbody>
</table>

NOTE!

Make sure that the signal level is compatible with RS485 according to ISO 8482.

NOTE!

Note regarding error check (CRC): A checksum program extract can be found in the Appendix (Section 16.10).
15 Voltage regulator TAPCON® 230C

Flags in direction => TAPCON® 230C

Significance of the flags in the data byte D5 „display“ during transmission to the regulator (write mode: Master => Slave):

D5 Bit 0 AUTO flag Command for switch-over to automatic mode
D5 Bit 1 MANUAL flag Command for switch-over to manual mode
If both flags are identical (i.e. 1 or 0), no change of operating mode will ensue.
D5 Bit 2 "Lower MANUAL" via PC Flag Command for step lowering
D5 Bit 3 "Higher MANUAL" via PC Flag Command for step raise
A change of tap position by the operations control system will be achieved only if the TAPCON® 230C was set to the manual mode.
D5 Bit 4...7 no significance for command direction

15.7.3.2 Response telegram

Reception of the data by the operations control system is in accordance with Table 2 (read mode). The specified "hex" values result from the following exemplary values:

<table>
<thead>
<tr>
<th>Field name</th>
<th>(hex)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slave address</td>
<td>05</td>
<td>Regulator identification of TAPCON® 230C</td>
</tr>
<tr>
<td>Function</td>
<td>17</td>
<td>For optional realization of additional functions</td>
</tr>
<tr>
<td>Byte count</td>
<td>0D</td>
<td>To enable data security and checksum evaluation</td>
</tr>
<tr>
<td>D0 Read: No. of OLTC positions</td>
<td>09</td>
<td>No. of tap positions resulting from the absolute value of the difference</td>
</tr>
<tr>
<td>D1 Read: Delay of voltage change</td>
<td>14</td>
<td>Time delay 1</td>
</tr>
<tr>
<td>D2 Read: Delay of interval between commands</td>
<td>05</td>
<td>Time delay 2</td>
</tr>
<tr>
<td>D3 Read: Desired voltage value High</td>
<td>08</td>
<td>Desired voltage level with a factor of 10 – High byte</td>
</tr>
<tr>
<td>D4 Read: Desired voltage value Low</td>
<td>FC</td>
<td>Desired voltage level with a factor of 10 – Low byte</td>
</tr>
<tr>
<td>D5 Read: Sensitivity (bandwidth)</td>
<td>15</td>
<td>Bandwidth with a factor of 10</td>
</tr>
<tr>
<td>D6 Read: Display</td>
<td>01</td>
<td>Flags (in the direction of a control system/SCADA display)</td>
</tr>
<tr>
<td>D7 Read: Actual voltage value High</td>
<td>08</td>
<td>Measured voltage value with a factor of 10 – High byte</td>
</tr>
</tbody>
</table>

Table 2
### Table 2

<table>
<thead>
<tr>
<th>Field name</th>
<th>(hex)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D8 Read: Actual voltage value Low</td>
<td>08</td>
<td>Measured voltage value with a factor of 10 – Low byte</td>
</tr>
<tr>
<td>D9 Read: Effective position of OLTC Low</td>
<td>06</td>
<td>Current tap position</td>
</tr>
<tr>
<td>D10 Reserve 1</td>
<td>-</td>
<td>Telegram byte 1 for potential extensions</td>
</tr>
<tr>
<td>D11 Reserve 2</td>
<td>-</td>
<td>Telegram byte 2 for potential extensions</td>
</tr>
<tr>
<td>D12 Error Byte</td>
<td>-</td>
<td>Error signal from motor-drive mechanism (OLTC fault) as digital input (motor protective switch contact Q1, see connection diagram)</td>
</tr>
<tr>
<td>Error Check (CRC)</td>
<td>-</td>
<td>Checksum of the signals sent – consisting of 2 Bytes (available upon request)</td>
</tr>
</tbody>
</table>

**NOTE!**

Note regarding error check (CRC): A checksum program extract can be found in the Appendix (Section 16.10).
Appendix
16 Appendix

16.1 On-load tap-changer VACUTAP® AVT, dimension drawing (899019)
16 Appendix
16.2 On-load tap-changer VACUTAP® AVT, dimension drawing (899109)
16 Appendix
16.3 
On-load tap-changer VACUTAP® AVT, circuit diagram ZM030100/ Sheet 1
16 Appendix

16.4 On-load tap-changer VACUTAP® AVT, circuit diagram ZM030100/

Sheet 2
16 Appendix
16.5 On-load tap-changer VACUTAP® AVT, motor drive components
16 Appendix

16.7 TAPCON® 230C, front view FRO_230C
16.8 TAPCON® 230C, surface mounting and installation in a control panel

(899564)

Remove threaded nipple when installing the control panel

Angle for control panel installation

Fixing lug for control panel installation

Control panel cutout for installation
const unsigned char tab_CRCHi[] = {0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40};

const char tab_CRCLo[] = {0x00, 0xC0, 0xC1, 0x01, 0xC3, 0x03, 0x02, 0xC2, 0xC6, 0x06, 0x07, 0xC7, 0x05, 0xC4, 0x04, 0xCC, 0x0C, 0x0D, 0xCD, 0x0F, 0xCF, 0xCE, 0x0E, 0x0A, 0xCA, 0xCB, 0x0B, 0xC9, 0x09, 0x08, 0xC8, 0x00, 0xC0, 0x01, 0xC1, 0x02, 0xC2, 0x03, 0xC3, 0x04, 0xC4, 0x05, 0xC5, 0x06, 0xC6, 0x07, 0xC7, 0x08, 0xC8, 0x00, 0xC0, 0x01, 0xC1, 0x02, 0xC2, 0x03, 0xC3, 0x04, 0xC4, 0x05, 0xC5, 0x06, 0xC6, 0x07, 0xC7, 0x08, 0xC8, 0x00, 0xC0, 0x01, 0xC1, 0x02, 0xC2, 0x03, 0xC3, 0x04, 0xC4, 0x05, 0xC5, 0x06, 0xC6, 0x07, 0xC7, 0x08, 0xC8, 0x00, 0xC0, 0x01, 0xC1, 0x02, 0xC2, 0x03, 0xC3, 0x04, 0xC4, 0x05, 0xC5, 0x06, 0xC6, 0x07, 0xC7, 0x08};

unsigned __int16 CRC16(unsigned char *puchMsg, unsigned __int16 DataLen)
{ unsigned char CRCHi = 0xFF; /* high CRC byte initialized */
unsigned char CRCLo = 0xFF; /* low CRC byte initialized */
unsigned char index; /* will index into CRC lookup able */
while (DataLen) /* pass through message buffer */
{ DataLen-;
index = CRCHi ^ *puchMsg; /* calculate the CRC */
CRCHi = CRCLo ^ tab_CRCHi[index];
CRCLo = tab_CRCLo[index] ;
puchMsg++; }
return( ( (unsigned __int16)CRCHi << 8) | CRCLo); }