Voltage regulator
VC 100-BU
Operating Instructions
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**Please note:**

Drawings and illustrations contained herein may differ in detail from the tap changer equipment delivered. They are for reference only and are subject to change without notice.
1. GENERAL

1.1 Safety regulations

Personnel involved with installation, putting into service, operation, maintenance and repair of the voltage regulator,
– must have adequate professional qualification
– must strictly observe the following operating instructions.

Improper operation or misuse
– represent a danger to the voltage regulator and other property of the user
– jeopardize the efficient operation of the voltage regulator.

Safety instructions are represented in two different ways to emphasize important information:

**WARNING:**
This information indicates particular danger to life and health.

**NOTE !** These notes give important information on a certain subject.
1.2 Application

The electronic voltage regulator VC 100-Bu (fig. 1, 2) is used for automatic control of transformers with a motor driven on-load tap changer. The control follows the step-by-step principle, i.e. a single control pulse operates the tap changer from one service position to the next.

1.3 Features

Apart from the usual regulating algorithm, the voltage regulator VC 100-BU can for the first time offer the customer-oriented regulating algorithm "ARS" with many sophisticated technical possibilities for symmetrical and asymmetrical control response. By optimizing your operating parameters you can improve your voltage quality without additional tap change operations.

The parameters of the regulator can be set by means of a PC via a serial interface (RS 232). The appropriate PC software can be purchased from MR.

A load-dependent line voltage drop, e.g. of a spur line leading from the transformer to the load, can be compensated either by line simulation (Line Drop Compensator) or by load-current dependent increase of the voltage level (Z-Compensation).

Trouble-free operation is largely ensured to a large extent by undervoltage blocking, overcurrent blocking and overvoltage monitoring.

The new INFO key allows to display up to 11 different measurement results.

The functions of the voltage regulator VC 100-BU are compatible to a large extent with those of the voltage regulator MK 30 (e.g. in case of parallel-operating SKB 30 units) and can also operate with the Voltage Limit Supervisory Control LV 20.

1.4 Designs

The standard design (version 01, fig. 1) of the voltage regulator VC 100-BU can be used with the parallel control unit SKB 30 for the parallel operation of 2 up to 6 transformers. Two pre-programmed values for the voltage level modifications can be activated via external relay contacts or switches.

In special design (version 02, fig. 2) the voltage regulator VC 100-BU is equipped with a parallel control device instead of the voltage level modification function so that individual or parallel control (according to the minimum circulating reactive current method or master-follower method) of two transformers by two voltage regulators is possible without an additional parallel control unit. Please note, this version cannot be used for parallel control by the additional parallel control unit SKB 30.

Further options:

The voltage regulator VC 100-BU can be equipped with a serial optical fibre interface which allows to parameterize and operate the voltage regulator from the remote control device VC 100-RC.

NOTE ! When voltage regulation is effected by tapped 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 quite different conditions can result so that a correct regulation of the voltage cannot be guaranteed. In such cases MR should be consulted in the planning stage.
1.5 Construction

The electronic voltage regulator VC100-BU is installed in a protective housing with hinged cover and window. It is suitable for flush or projected panel mounting. The front panel contains several function keys and slide switches as well as a scroll wheel for parameter setting.

The operating state is indicated by an 8-character alphanumerical LC display and several LED lamps.

The electronic voltage regulator is controlled by an 8-bit microcontroller (see block diagram, fig. 1a and 2a). Besides a voltage transformer and a current transformer it contains optocoupler inputs with potential separation as well as potential-free output relay contacts.

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*Observe the operating instructions!*

Connection of the measuring transformers according to fig. 5a

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Block diagram with the connection of the measuring transformers (version 01)

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Block diagram with the connection of the measuring transformers (version 02)
2. TECHNICAL DATA

Setting ranges

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desired voltage level</td>
<td>85...140 V, setting in steps of 0.5 V</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>± 0.5 ... ± 9 % of desired voltage level, setting in steps of 0.1 %</td>
</tr>
<tr>
<td>Delay time 1</td>
<td>0...180 s, linear or inverse response selectable</td>
</tr>
<tr>
<td>Delay time 2</td>
<td>0...10 s, for consecutive tap change operations (can be switched off)</td>
</tr>
<tr>
<td>Line-Drop-Compensator</td>
<td>Line simulation, U_r = 0...± 25 V (resistive line drop),</td>
</tr>
<tr>
<td>Or: Z-Compensation</td>
<td>U_x = 0...± 25 V (inductive or capacitive line drop), setting in steps of 0.1 V</td>
</tr>
<tr>
<td>Voltage level change</td>
<td>Two different values, each 0...10 % of desired voltage level, setting in steps of 0.1 %</td>
</tr>
<tr>
<td>Undervoltage blocking</td>
<td>70...99 % of desired voltage level, setting in steps of 1 %, delay time 10 s for signalling relay</td>
</tr>
<tr>
<td>Overvoltage detection</td>
<td>101...130 % of desired voltage level, setting in steps of 1 %, high-speed return control by LOWER pulses, mark/space = approx. 1.5/1.5 s</td>
</tr>
<tr>
<td>Overcurrent blocking</td>
<td>50...210 % of rated current of current transformer, setting in steps of 5 %</td>
</tr>
<tr>
<td>Voltage transformer</td>
<td>Ratio setting 0.100 ... 999.0 kV / 100 V</td>
</tr>
<tr>
<td>Current transformer</td>
<td>Ratio setting 100 ... 5000 A / 5 / 1 / 0.2 A.</td>
</tr>
<tr>
<td>Measuring transformer circuit</td>
<td>Phase angle between current path and voltage path can be set to -30°, 0°, +30° and +90°, 1-phase or 3-phase system.</td>
</tr>
</tbody>
</table>

Control elements, indication

Function keys
- for parametering of current and voltage transformer measuring ranges and configuration (CT, VT SETTING),
- desired voltage level (VOLTAGE LEVEL),
- bandwidth (BANDWIDTH),
- delay time 1 (DELAY 1),
- delay time 2 (DELAY 2),
- LDC: U_r,
- LDC: U_x,
- Z-Compensation: voltage rise (VOLTRISE),
- Z-Compensation: limitation (LIMIT),
- information key D1-Dn for indication of operating data,
- undervoltage (U<),
- overvoltage (U>),
- overcurrent (I>),
- function key for customer-specific control program (ARS),
- mode of operation switch (MANUAL/AUTO).

In standard design (version 01): voltage level change (1-2) (VOLTAGE LEVEL CHANGE), individual setting up to max. ± 10 %.

In special design (version 02): parallel control, stability (STABILITY) or max. tap position (TAP MAX), sensitivity (SENSITIVITY) for circulating reactive current signal.

Incremental setting
- Scroll wheel for data input

Function selectors
- Line-Drop-Compensator or Z-Compensation (LDC/Z-COMP);
- local or remote parametering (LOCAL/REMOTE).

Indication field
- 8-character alphanumerical LC-display;
- 1 LED lamp each for signalling RAISE and LOWER as soon as the deviation exceeds the preset bandwidth limits;
- 1 LED lamp for signalling U<, U>, I; 1 LED lamp for signalling customer-specific control program;
- 1 LED lamp for signalling mode of operation.

In standard design (version 01):
- 2 LED lamps for signalling voltage level change.

In special design (version 02):
- 2 LED lamps for signalling parallel control.
Output relays
1 output relay each RAISE and LOWER control pulses,
pulse duration approx. 1.5 s or continuous pulse, 1 N/C and 1 N/O contact;
signalling relay for undervoltage blocking, 1 change-over contact with a delay time of approx. 10 s;
signalling relay for overvoltage, 1 change-over contact;
signalling relay for overcurrent blocking, 1 change-over contact;
signalling relay for function monitoring, 1 change-over contact with a delay time of approx. 15 minutes (for ARS approx. 31 minutes);
signalling relay for AUTO/MANUAL mode of operation, 1 change-over contact;
signalling relay for FAIL VOLTAGE REGULATOR, 1 change-over contact.

In special design (version 02):
signalling relay for INDIV./PARALLEL mode of operation, 1 change-over contact;
signalling relay for PARALLEL OPERATION DISTURBED, 1 change-over contact.

Rating of all relay contacts:
AC: 250 V, 5 A;
DC: 30 V, 5 A; 110 V 0.4 A; 250 V 0.3 A.

Inputs
Voltage transformer 85...140 V, measuring range 60...185 V, 40-60 Hz,
r.m.s. measurement, measuring error < 0.3 % ± 40 ppm/°C,
consumption < 1 VA;
current transformer 0.2 / 1 / 5 A, r.m.s. measurement,
measuring error < 0.5 % ± 40 ppm/°C, consumption < 1 VA,
admissible overload 2 · I_n continuously; 100 · I_n, 1 s;
1 input with potential separation for additional LV 20 unit;
1 serial interface RS 232 for parametering via PC;
1 optical fibre input for remote control with VC 100-RC (option).

In standard design (version 01):
2 inputs with potential separation for voltage level change,
1 serial interface RS 232 for additional parallel control unit SKB 30.

In special design (version 02):
3 inputs with potential separation for parallel control,
1 serial interface RS 232 for communication with
a second VC100-BU (version 2) for parallel control,
1 input 4...20 mA for tap position indication.

Power supply
115 V (+25 % - 35 %), 40...60 Hz, either from measuring voltage or separate supply voltage,
consumption approx. 6.5 VA (at 110 V, idle state),
supply voltage AC 230 V can be set at the factory.

Protective housing
Steel plate housing with window for flush or projecting panel mounting, flint grey finish RAL 7032,
width x height x depth = 216 x 326 x 115 mm,
enclosure protection IP44 according to IEC 529,
weight approx. 5.4 kg.

Temperature limits
Admissible ambient temperature -10 C ... +70 C

Tests
Insulation according to IEC 255-4/5:
high voltage 2.5 kV, 50 Hz, 1 minute,
impulse voltage 5 kV, 1.2/50 μs;

Interference immunity according to IEC 1000:
IEC 1000-4-2 electrostatic discharge 8 kV,
IEC 1000-4-3 electromagnetic fields 10 V/m,
80-1000 MHz,
IEC 1000-4-4 burst 1 MHz, 4 kV,
IEC 1000-4-5 surge 4 kV.

IEC 1000-4-6 HF interference immunity of leads 10 V / 150 kHz - 80 MHz
EC conformity according to EN 50081-1 and 50082-2.
1 - Slide switch Local/Remote
2 - LED lamp for mode of operation AUTO
3 - Mode of operation switch
4/5 - Function key and signalling LED for customer-specific control program ARS
6 - Scroll wheel
7 - Setting of the measuring transformer ratio and configuration
8 - Function key INFO
9 - Function key for $U_x$ (LDC) and voltage limit (Z-COMP)
10 - Slide switch for LDC/ZCOMP
11 - Function key for $U_x$ (LDC) and voltage rise (Z-COMP)
12 - LC-Display
13 - Function key for delay time
14 - Presignal RAISE
15 - Function key for bandwidth
16 - Function key for desired voltage level
17 - Presignal LOWER
18 - Function key for overcurrent blocking
19 - Function key for overvoltage monitoring
20 - Function key for undervoltage blocking
21 - LED lamp for signalling $U<$, $U>$, $I>$
22 - Parametering interface
23/24 - Function key and LED lamp for voltage level change
25 - Function key for parallel control
26 - LED lamp for indication of parallel control
3. OPERATION

3.1 Input and output of data, functions

When the voltage regulator is inactive, the operating data listed on page 14 under 3.1.12 can be displayed. When the function key is pressed, the last setting of the corresponding parameter appears on the display. This setting can be changed by means of the scroll wheel as required. When the function key is released, the value displayed is stored.

Some keys allow to set several parameters which are selected by pressing the key repeatedly. Exceptions are the function keys for LINE COMPENSATION where the parameters are selected by means of the slide switch LDC/Z-COMP.

All values entered are automatically protected when the power supply of the voltage regulator is interrupted, and they are immediately available when the voltage regulator is switched on again.

3.1.01 Indication field

The indication field consists of the 8-character LC display and of two LED lamps each for undelayed signalling of RAISE and LOWER when the deviation exceeds the preset bandwidth limits. There are further signalling LED lamps for the following functions: U<, U>, I>, voltage level change, customer-specific control program, mode of operation, and parallel control (in version 02).

3.1.02 Mode of operation (MODE OF OPERATION, fig. 4)

For parametering directly on the voltage regulator, set the Local/Remote slide switch to Local position. In Remote position, the parameters are set via a serial interface using a PC or optionally the remote control device VC 100-RC.

3.1.03 Measuring transformers (CT, VT SETTING, fig. 5, display see fig. 5a)

The ratios and configuration of the voltage and current transformers are to be set by selecting the corresponding parameters by repeatedly pressing the corresponding function key and change of the selected parameter by turning the scroll wheel.

Example:
Voltage transformer used: 22 kV/110 V.
Setting on the voltage regulator:
\[(22 \text{ kV} \cdot 100) / 110 \text{ V} = 20 \text{ kV}\]

Ratio of the voltage transformer VT (kV/100 V)
The rated primary voltage (referred to 100 V secondary voltage) is set from 0.100 kV to 999 kV using the scroll wheel.

Ratio of the current transformer CT (I_n)
The rated primary current (referred to 0.2 / 1 / 5 A secondary current) is set from 100 A to 5000 A using the scroll wheel.

Manual or automatic operation is selected by actuating the MANUAL/AUTO switch accordingly.

MANUAL position: The voltage regulator is in service. However, the RAISE/LOWER output contacts are inactive. The motor drive is operated by manual control.

AUTO position: The LED lamp for AUTO lights up. The voltage regulator is in service with all its functions. The motor drive cannot be operated by manual control.

The selected mode of operation is signalled by relay contacts (terminals 51, 52, 54).

A supply voltage breakdown or voltage regulator failure is signalled by relay contacts (terminals 57, 58, 59).

MODE OF OPERATION

MANUAL

AUTO

LOCAL

REMOTE

90 3 PH

CT, VT SETTING

VT

kV/100 V

CT

RATING

CT, VT

PHASE

from int079

from int079
Measuring transformer configuration CT, VT PHASE
(Phase angle of current/voltage transformer, fig. 5a)

Possible settings:
0 for 1-phase systems (Indication: 0 1PH)
0 for 3-phase systems (Indication: 0 3PH)
90 for 3-phase systems (Indication: 90 3PH)
30 for 3-phase systems (Indication: 30 3PH)
-30 for 3-phase systems (Indication: -30 3PH)
3.1.04 Setting of the desired voltage level (VOLTAGE LEVEL, fig. 6)

The desired voltage level can be set from 85 V to 140 V in steps of 0.5 V by pressing the function key VOLTAGE LEVEL and turning the scroll wheel.

This setting refers to the secondary side of the voltage transformer connected to the VC 100-BU.

3.1.05 Setting the bandwidth (BANDWIDTH, fig. 7)

The bandwidth can be set from \(\pm 0.5\%\) to \(\pm 9\%\) in steps of 0.1 % by pressing the function key BANDWIDTH and turning the scroll wheel.

The step voltage of the transformer must be given for the correct setting of this value:

\[
\text{BW} (\%) = \frac{100 \times \text{USt}}{\text{UN}}
\]

\[
\text{BW} = \text{bandwidth (\%)}
\]

\[
\text{USt} = \text{step voltage}
\]

\[
\text{UN} = \text{rated voltage}
\]

Lower values can be set without endangering the stability. The set value should however not be below 60 % of the calculated value.

When the measuring voltage changes during operation to the extent that the bandwidth limits are exceeded, the presignal LED lamp for RAISE or LOWER lights up. If the change is not corrected within 15 minutes (31 minutes for the ARS), the “Function Monitoring” relay (terminals 87, 88, 89) is energized. This relay is de-energized only when the presignal LED lamp goes out.

3.1.06 Setting the delay time 1, 2 (DELAY 1, DELAY 2)

The key for delay time has two functions and allows to set two different delay times. The delay time starts as soon as the deviation exceeds the set bandwidth limits above or below. At the same time the corresponding presignal LED lamp lights up. If the deviation is still present after the delay time has elapsed a control pulse is emitted. If the deviation returns to within bandwidth limits, then the current delay time is cancelled immediately.

Delay time 1 (DELAY 1, fig. 8)

By pressing the function key and turning the scroll wheel, the delay time can be set from 0 to 180 s with linear response (indication: e.g. 100 s lin) or from 0 to 180 s with inverse response (indication: e.g. 100s inv).

The setting with inverse response is achieved by turning the scroll wheel beyond 180 s lin.

The setting “0 s” results in an undelayed continuous pulse of the output relay.
If a delay time with inverse response is set, the delay time is automatically shortened inversely to the percentage deviation down to a minimum of 1 s, i.e.

\[
\text{effective delay time (s)} = \text{set delay time (s)} \cdot \text{BW} (\%) / \text{voltage deviation } dU (\%)
\]

where \( \text{BW} \) = bandwidth (\%)

Delay time 2 (DELAY 2, fig. 9)
The delay time 2 only becomes effective if more than one tap change operation is necessary to return the deviation to within bandwidth limits. The set delay time 2 is then applicable to all consecutive output pulses.
The delay time 2 can be set from 0 to 10 s in steps of 1 s by pressing the function key and turning the scroll wheel (indication for example “DEL2 8 s”).
The setting „0 s” results in an undelayed continuous pulse of the output relay.
The delay time 2 can be made inactive (setting “OFF”) so that only delay time 1 is active.

3.1.07 Setting the undervoltage blocking (U <)
The response threshold for undervoltage blocking (fig. 10) can be set from 70 % to 99 % of the voltage level in steps of 1 % by pressing the function key and turning the scroll wheel.
Undervoltage blocking prevents tap change operations in the event of a network breakdown. The voltage regulator output pulses are blocked and the alarm signalling LED lamp responds when the actual voltage falls below the set blocking value. After delay time of approx. 10 s, the associated signalling relay is energized and remains energized (terminals 22, 23, 56). The signalling relay does not respond in case of a failure of the actual voltage or supply voltage (< 30 V).

3.1.08 Setting the overvoltage detection (U >) with automatic return control
The response threshold (fig. 11) can be set from 101 % to 130 % of the voltage level in steps of 1 % by pressing the function key and turning the scroll wheel.
In the event of an overvoltage detection the tap changer is operated by periodic pulses to the motor drive unit 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. The set delay time is inactive during this operation.
At the same time the alarm signalling LED lamp responds and a signalling relay is energized (terminals 24, 25, 55) 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. This condition is signalled by the signalling relay for function monitoring, after 15 minutes (in case of ARS function: after 31 minutes).

3.1.09 Setting the overcurrent blocking ($I >$)

The overcurrent blocking response threshold (fig. 12) can be set from 50% to 210% (of the rated current of the current transformer) in steps of 5% by pressing the function key and turning the scroll wheel. Overcurrent blocking prevents tap change operations in the presence of excessive overcurrent. The voltage regulator output pulses are blocked and the alarm signalling LED lamp responds when the overcurrent percentage exceeds the set blocking value. At the same time the corresponding signalling relay is energized and remains energized (terminals 26, 27, 28).

3.1.10 Line drop compensation (LINE COMPENSATION)

The line drop compensation, i.e. the inclusion of the voltage drop of a line connected to the transformer in the regulating process, can be accomplished in two different ways. Two keys each with two functions as well as the slide switch for LDC/Z-COMP are used.

Line drop compensator (LDC, fig. 13, 13a)

The slide switch LDC-COMP must be in position LDC.

NOTE ! For the correct setting of the LDC it is necessary to calculate the resistive and inductive line voltage drop, referred to the secondary side of the voltage transformer in $V$ and the correct setting of the existing measuring transformer configuration according to 3.1.03, fig. 5.

Setting the resistive voltage drop $U_r$

The calculated resistive voltage drop is set by pressing the function key $U_r$ and turning the scroll wheel. 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 the inductive voltage drop $U_x$

The calculated inductive voltage drop is set by pressing the function key $U_x$ and turning the scroll wheel. 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.
Calculation of the required settings:

\[
Ur = \frac{I_N \cdot R_{CT}}{R_{VT}} \cdot r \cdot L \quad (V)
\]

\[
Ux = I_N \cdot \frac{R_{CT}}{R_{VT}} \cdot x \cdot L \quad (V)
\]

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. 30000 V / 100 V
- \( r \) = 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 resistive and inductive line voltage drops \( Ur \) and \( Rx \), respectively, are correctly set, the voltage at the line end will remain constant, independent of the load.

Z-Compensation (Z-COMP, fig. 14)

The slide switch for LDC/Z-COMP must be in position Z-COMP.

For the correct setting of the parameters the voltage rise is calculated while taking the current into consideration.

### Setting the voltage rise (VOLTRISE)

The calculated percentage of the voltage rise, referred to the voltage level, is set by pressing the function key and turning the scroll wheel.

### Calculation of the required setting:

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

where:
- \( U_{Tr} \) = 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 voltage regulator, i.e. 0.2 A or 1 A or 5 A
- \( R_{CT} \) = current transformer ratio, e.g. 200 A/5 A

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

### Setting the limitation of the voltage rise (LIMIT)

The value is set by pressing the function key and turning the scroll wheel.

If a certain compensation is desired, while avoiding excessive transformer voltage rises (e.g. in case of an unusually high load), the voltage rise can be limited to a max. allowable value, referred to the desired voltage level.

### Comparison between LDC and Z-Compensation

**Application of the Z-compensation:**
- small shift of the phase angle \( \cos \phi \),
- easy to set,
- can be used in meshed network applications.

**Application of the vectorial compensation (LDC):**
- more accurate determination of the line voltage drops,
- more difficult to set,
- exact line data must be known.
3.1.11 Setting the voltage level change
(VOLTAGE LEVEL CHANGE, fig. 15)

This function is included in the standard design (version 01).

The alternative design (version 02) is equipped with a parallel control module instead of the voltage level change function, so that the parallel control of two transformers by two voltage regulators is possible without an additional parallel control unit (see connection diagram, fig. 2a, and fig. 17). The description is given below.

The desired percentage of the voltage level change can be set from 0 % to 10 % in steps of 0.1 % by pressing the function key VOLTAGE LEVEL CHANGE 1 or 2 and turning the scroll wheel.

This function allows, for example, a reduction of the power in 1 or 2 steps by a preprogrammed lowering of the voltage level. In this case it is necessary to set a negative value for the voltage change. The reduction in percent of the active and reactive power corresponds approximately to twice the reduction in percent of the voltage level. It is appropriate to reduce the voltage level in steps.

\[ P_{\text{act./react.}} = 2 \Delta U_{\text{voltage level}} \]

The respective step of the voltage level change is activated by an external switch or by an N/O relay contact (terminals 31/33/34) and indicated by a LED lamp.

The voltage level change remains active as long as the respective contact is closed.

3.1.12 Indication of operating data (INFO, fig. 16)

The following operating data is indicated when the key INFO D1-Dn is pressed and the scroll wheel is turned:

<table>
<thead>
<tr>
<th>Operating data</th>
<th>Indication (e.g.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured voltage in V</td>
<td>110.5 V</td>
</tr>
<tr>
<td>Measured voltage in kV</td>
<td>110.5 kV</td>
</tr>
<tr>
<td>Deviation (\Delta U) in %</td>
<td>(dU) -2.5 %</td>
</tr>
<tr>
<td>Current in % of the rated current of the current transformer</td>
<td>105.5 %</td>
</tr>
<tr>
<td>Apparent power in kVA, MVA</td>
<td>330 kVA</td>
</tr>
<tr>
<td>Active power in W, kW, MW(r)</td>
<td>500 kW</td>
</tr>
<tr>
<td>Reactive power in VA, kVAR, MVAR</td>
<td>330 kVAR</td>
</tr>
<tr>
<td>Power factor (\cos \varphi)</td>
<td>(\cos 0.85)</td>
</tr>
<tr>
<td>Phase angle (\varphi) in degrees</td>
<td>-31.8 deg</td>
</tr>
<tr>
<td>Frequency in Hz</td>
<td>50.0 Hz</td>
</tr>
<tr>
<td>Tap position (for version 02 only)</td>
<td>TAP 19</td>
</tr>
</tbody>
</table>

When the key is released, the selected value is indicated until another type of operating data is selected. When the voltage regulator is switched on, the "Measured voltage in V" is indicated.
3.2 Putting into service

3.2.1 Installation

The voltage regulator is suitable for flush or projected panel mounting (see dimension drawing). The unit should be installed in an easily accessible place in the control room or in a switchbox mounted to the transformer tank.

3.2.2 Connection

The voltage regulator is to be connected according to the connection diagram (fig. 1a).

Attention should be paid to:

- the correct phase relation of the secondary connections of the current and voltage transformers (see 3.1.03),
- the correct connection of the output relays to the motor drive unit.
- the correct connection of the housing to ground.

The power supply for the voltage regulator is usually provided by the voltage transformer.

NOTE ! If an auxiliary voltage AC 115 V, 50...60 Hz, is used, the jumpers between the terminals 1/3 and 2/4 have to be removed.

The voltage transformer is to be connected to the terminals 1 and 2, the auxiliary voltage to the terminals 3 and 4 (see fig. 18).

The voltage regulator can be factory-set for a supply voltage of AC 230 V (option).

NOTE ! The voltage regulator VC100-BU was designed to meet the relevant EMC standards. In order to maintain the EMC requirements the following instructions should be observed:

- Make sure that the housing is grounded by means of the grounding screw attached to the housing and that the wire diameter is not less than 4 mm².
- Use separate leads to connect the individual circuits (motor drive control, inputs, outputs) to the terminals.
- Use shielded cables for the data communication between VC100-BU and SKB 30 (or between one VC100-BU to the other VC100-BU in case of version 02).

Ground the shield at both cable ends to the housing using the angular bracket and the cable clamps supplied with the equipment (fig. 19).

3.2.3 Function tests, operational settings

Prior to putting the voltage regulator into service, check the entire measuring configuration as well as the measured voltage and the supply voltage.

To assess the operation of the voltage regulator, a device to record the voltage transformer voltage (= actual voltage) is used. The associated transformer should have a normal load.

a) Set the Local/Remote switch to Local position and select Manual operation (according to 3.1.02).
b) Set the ratios and configuration of the voltage and current transformers according to 3.1.03.

c) Let the measured voltage (= voltage from the voltage transformer) be indicated on the display of the voltage regulator (select “Measured voltage in V” using the INFO key and scroll wheel according to 3.1.12).

d) 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.

e) Set VOLTAGE LEVEL to this value as described under 3.1.04.

f) Let the current, power, and phase angle values be indicated on the display by pressing the INFO key and turning the scroll wheel. 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.

g) Set BANDWIDTH to 1.0 % as described under 3.1.05. In most cases the voltage regulator is now in a balanced state (no presignal LED lamp lights up). Otherwise change the desired voltage level in steps of 0.5 V until a balanced state is reached.

h) Set BANDWIDTH according to 3.1.05 as a function of the step voltage (= service setting):

i) Set the delay time 1 (DELAY 1) to 20 s lin. as described under 3.1.06. By manual control move the tap changer towards “Raise” by one step, the presignal LED lamp for LOWER must light up. Set the mode of operation switch to AUTO. Then 20 s after the presignal the voltage regulator must control the tap changer back to its initial position. The presignal LED lamp goes out.

Set the mode of operation switch to MANUAL. Repeat the procedure towards “Lower”.

Set the delay time 2 (DELAY 2) to 10 s. Set the mode of operation switch to MANUAL. By manual control move the tap changer towards “Raise” by two steps, the presignal LED lamp for LOWER must light up. Set the mode of operation switch to AUTO. Then 20 s after the presignal the voltage regulator must control the tap changer by one step and after further 10 s by another step back to its initial position.

Set the delay times DELAY 1 and DELAY 2 to the desired value. If DELAY 2 is not used, the setting OFF is necessary.

When putting the voltage regulator into service, it is recommended to set DELAY 1 provisionally to 100 s. Depending on the existing operating conditions, the definitive setting can only be determined 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 per day.

If an inverse response of the voltage regulator is desired, set DELAY 1 to a value with the addition “inv”. 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 % as described under 3.1.07. Set the mode of operation switch to MANUAL, and reduce the desired voltage level, e.g. 110 V, to 110 V · 0.85 = 94 V so that the actual voltage now corresponds to the set response threshold for undervoltage blocking. The presignal LED lamp for RAISE must light up. Set the mode of operation switch to AUTO. After approx. 10 s the signalling relay “U <” must be energized, the signalling contact (terminals 22, 23) must open, but the output relay RAISE must not issue a control command (terminal 18). Now set the desired response threshold for undervoltage blocking.

l) Set the response threshold for overvoltage detection U> to 115 % as described under 3.1.08. Set the mode of operation switch to MANUAL, and increase the desired voltage level, e.g. 110 V, to 110 V · 1.15 = 127 V so that the actual voltage now corresponds to the set response threshold for overvoltage detection. The presignal LED lamp for LOWER must light up. Set the mode of operation switch to AUTO. The output relay LOWER must issue periodic control commands at 1.5 s intervals. The relay contact (terminals 24, 25) must open.

Now set the desired response threshold for overvoltage detection and set the desired voltage level to its initial value.

m) Set the response threshold for overcurrent blocking I > as described under 3.1.09. A function check is not necessary.

n) Setting of LDC (see paragraph 3.1.10)
Set the mode of operation switch to MANUAL. Set Ux and Ur to 0, no presignal LED lamp must light up.

Set Ur to 20 V and Ux to 0 V, the presignal LED lamp for RAISE must light up.
Set Ur to -20 V and Ux to 0 V, the presignal LED lamp for LOWER must light up.

(During this function check a load current of 5 % of the rated current of the current transformer must flow.)
Carry out the required setting of the LDC as described under 3.1.10.

Set the mode of operation switch 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.
o) Setting of Z-Compensation (see paragraph 3.1.11) as an alternative to LDC.
Set the mode of operation switch to MANUAL and the slide switch for LDC/Z-COMP to Z-COMP.
Set VOLTRISE to 0, the voltage regulator is in a balanced state, no presignal LED lamp must light up.
Set VOLTRISE to 15 %, the presignal LED lamp for RAISE must light up.
(During this functional check a load current of 10 % of the rated current of the current transformer must flow.)
Carry out the required setting of the Z-Compensation as described under 3.1.10.
Set the mode of operation switch 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 VOLTAGE LEVEL CHANGES 1 and 2 to the desired values as described under 3.1.11.
Set the mode of operation switch to MANUAL and jumper the terminals 31, 34. Depending on the direction of the set VOLTAGE LEVEL CHANGE 1, the presignal LED lamp for LOWER or RAISE must light up, as well as the LED lamp for VOLTAGE LEVEL CHANGE 1.
Set the VOLTAGE CHANGE 2 in the same way, but jumpering the terminals 31, 33.
Set the mode of operation switch to AUTO.

4.0  CUSTOMER-SPECIFIC CONTROL PROGRAM „ARS“
(Advanced Regulating System)

4.01  General
The voltage regulator VC 100-BU offers the choice of two control algorithms which are independent from each other. Apart from the usual symmetrical control algorithm there is another algorithm with the designation ARS which is a new, adaptable and customer-oriented voltage regulation system. It is possible to change over from one control algorithm to the other without losing the set parameters.
The ARS is a control algorithm that can be defined completely by the customer. It is straightforward and can be checked at any time.
The open structure of the ARS algorithm allows the voltage regulation to be individually and more efficiently effected than any other control system used to date.
The reaction of the voltage regulator VC 100-BU can be defined individually for each direction of the deviation of the actual voltage from the set voltage level by assigning different delay times and bandwidths directly on the VC 100-BU.
It is possible, for example, to set an unsymmetrical control response and thus define the operation of the tap changer individually for the most important voltage ranges.
By activating the function “Tendency” the quality of the voltage supply can be increased without more tap change operations.
The permanent monitoring of the control criteria allows the setting of extremely long delay times even while a switching delay is in progress which can result in a reduction of the number of switching operations without deteriorating the quality of the voltage supply.
Since the ARS system in the VC 100-BU is parallel to the usual control system, it can also be activated temporarily, for example to solve certain network situations, and thus contribute to an optimized voltage regulation.
All monitoring functions (U>, U<, I>) and auxiliary functions (line compensation, voltage level change, parallel control) of the voltage regulator VC 100-BU remain active irrespective of the selected control algorithm.
4.02 Control criteria

The transformer voltage measured by the VC 100-BU is compared with the set voltage level. The actual deviation is determined from the difference and the set bandwidth.

\[
\text{Deviation} = \frac{\text{Difference between actual and set voltage}}{\text{set bandwidth}}
\]

A timer is started and only stopped when the preset delay time $\pm nT$ (+1T, +2T, ..., or -1T, -2T, ...) assigned to the magnitude of this deviation has elapsed. See fig. 20.

During this delay time the VC 100-BU determines the percentage of time during which the deviation was really present (see fig. 21) and compares it with the set „Tendency“ value. The voltage regulator only emits a RAISE or LOWER control pulse when the determined percentage exceeds the „Tendency“ value. This way the negative effects of short-time voltage fluctuations which in the standard regulating system would prevent the adaptation of the transformer voltage is eliminated. See fig. 21.

The setting $T_{end} = \text{OFF}$ corresponds to an effective delay time of 100 %, i.e. the deviation must be present for the whole duration of the delay time before a tap change is initiated.
As each case of absolute deviation is monitored individually by ARS and can be treated according to the existing requirements, it is possible to assign an extremely long delay time to small deviations without running the risk of not being able to compensate large voltage deviations in time. In the case of the smallest deviation by one step it is even possible to set an infinite delay time (display text: +1T OFF or -1T OFF) so that such a deviation will permanently be tolerated by the VC 100-BU.

In many cases it might be useful from the point of view of control engineering to treat positive and negative deviations from the set voltage level in a supply network differently. As it is possible to assign different bandwidths to the two directions of deviation, ARS allows to set an unsymmetrical control response so that voltage ranges with different importance for the actual application can be treated differently.

4.03 Parametering

The entire ARS parametering is carried out by means of the blue ARS key in the SPECIAL field on the VC 100-BU front panel.

The individual parameters, i.e. voltage level V, delay times +1T, -1T, +2T, -2T, +3T, -3T, +Tend, -Tend, +Bw, -Bw, and ARS ON/OFF, can be selected and displayed by repeatedly pressing the ARS key, and if required they can be modified with the scroll wheel.

The desired voltage level can be set either in the standard system by pressing the VOLTAGE LEVEL key and turning the scroll wheel or in the ARS system by selecting the parameter V (turning the scroll wheel). This ensures that the voltage regulator always operates with the same voltage level setting irrespective of the control algorithm chosen.

With the setting ARS ON the VC 100-BU operates according to the criteria of the Advanced Regulating System which is indicated by the LED lamp “ACTIVE” lighting up in the field “SPECIAL” of the VC 100-BU. The standard control system is then automatically switched off. It is possible to return to the standard control system at any time by deactivating the ARS function (position OFF).

Of course, complete parametering of the ARS is also possible from a PC through the parametering interface and with the aid of the communication software supplied with the equipment.

Explanation of the symbols used and their representation in the set of ARS parameters:

- **V**: Desired voltage level
- **+1T**, **-1T**, **+2T**, **-2T**, **+3T**, **-3T**, **+Tend**, **-Tend**, **+Bw**, **-Bw**: Delay time in case of positive and negative deviations from the desired voltage level
- **OFF**/**ON**: Deactivating (activating) the ARS function

Of course, complete parametering of the ARS is also possible from a PC through the parametering interface and with the aid of the communication software supplied with the equipment.

<table>
<thead>
<tr>
<th>Desired voltage level</th>
<th>Delay time</th>
<th>Tendency function % of T</th>
<th>Bandwidth % of desired voltage level</th>
<th>ARS function</th>
</tr>
</thead>
<tbody>
<tr>
<td>85 ... 140 V</td>
<td>+3T = 2s...1800</td>
<td>+Tend = 70...99%, off</td>
<td>+Bw = 0.5 ... 10 %</td>
<td>OFF/ON</td>
</tr>
<tr>
<td></td>
<td>+2T = 2s...1800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+1T = 2s...1800, off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-1T = 2s...1800, off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-2T = 2s...1800</td>
<td>-Tend = 70...99%, off</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-3T = 2s...1800</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.05 Universal presetting of parameters

To facilitate setting of parameters as much as possible when the voltage regulator VC 100-BU is put into service, the unit is delivered with a universal presetting. After the desired voltage level, the measuring transformer ratios and configuration, the limit values to be supervised, and values for line drop compensation, if required, have been set (in the standard control system), the universal presetting can either be used for a “single-knob control” with defined results after the ARS function has been activated, or it can serve as a basis for a further, application-specific optimization of the voltage regulation.

<table>
<thead>
<tr>
<th>Desired voltage level</th>
<th>Delay time</th>
<th>Tendency function % von T</th>
<th>Bandwidth % of desired voltage level</th>
<th>ARS function</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be set by user!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ 3 T = 5 s</td>
<td>+ Tend = 97 %</td>
<td>+ Bw = 1.1 %</td>
<td>OFF</td>
<td></td>
</tr>
<tr>
<td>+ 2 T = 20 s</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ 1 T = 900 s</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 1 T = Aus</td>
<td>-Tend = 97 %</td>
<td>- Bw = 1.2 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 2 T = 60 s</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 3 T = 10 s</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The desired voltage level set in the standard control system is also used in the ARS system.

Characteristics of the universal presetting:

- Very suitable for step voltages: 1.2 - 1.6 % of \( U_N \).
- Basic tolerance of the regulated voltage:
  - 1 step voltage / -2 step voltages of desired voltage level.
- Positive deviations are corrected faster than negative deviations.
- The negative effects of short-time voltage fluctuations that extend into the set bandwidth are eliminated due to the tendency setting (97 % of T).
- A “slightly unsymmetrical” bandwidth setting can contribute to an increase of the stability of the regulating system.

4.06 Important notes

The correct setting of the measuring transformer ratios and configuration, the values for line drop compensation, if required, as well as the limit values (\( U_<, U_>, I_> \)) are also required in the ARS system for the proper function of the voltage regulator.

Version 01 of the voltage regulator VC 100-BU offers a two-step voltage level change function that is easily usable by remote control. This function is also available in the ARS system.

If there is no control function for 31 min. the relay “function monitoring” is energized (terminals 87, 88, 89).

Parallel control can be effected by both versions of the voltage regulator VC 100-BU and in the standard regulating system as well as in the ARS system without any restriction.

In the ARS system the bandwidth can even be changed during parallel control without any negative effect on the parallel operation.

Note! To put the VC 100-BU into service refer to the instructions given in the section “Putting into service”. The preset ARS parameters can then be checked and the ARS system activated.

It is recommended to note down the current parameter settings. When the ARS function is switched on or off, respectively, the standard regulating system is automatically de-activated or activated.
5. PARALLEL CONTROL

Parallel control of two transformers with two voltage regulators without an additional parallel control unit by VC 100-BU in special design (version 02)

This version of the voltage regulator is equipped with a parallel control device for two transformers (PARALLEL CONTROL, fig. 23) instead of the voltage level modification function.

The parallel control can be accomplished in two ways, either according to the minimum circulating reactive current method or according to the Master-Follower method.

The desired method is selected by means of a jumper on the terminal strip (see connection diagram, fig. 22) which automatically determines the function of the corresponding keys (fig. 23).

For both methods it is necessary to connect the two voltage regulators by a shielded data cable.

5.1 Parallel control according to the “minimum circulating reactive current method”

The circulating reactive current is calculated from the two transformer currents and their phase angles. A voltage proportional to the circulating reactive current is added to the actual voltage measured by the autonomously operating voltage regulator to act as correcting voltage. This correcting voltage can be reduced or increased by means of the “Stability” setting.

When an inadmissibly high circulating reactive current is found, a tap change operation by the tap changers involved is initiated already after 10 s have elapsed, regardless of the set delay time.

This method is suitable for transformers with similar power and voltage and with identical or different step voltage. No information about the tap position is required.

5.1.1 System configuration, settings

Make the additional connections between the two voltage regulators according to fig. 22.

Setting of the correction value (STABILITY, fig. 23)

The stability value can be set from 0 to 100 by pressing the function key STABILITY and turning the scroll wheel. It determines the effect of the circulating reactive current on the voltage regulator operation. With a setting of “0” there is no effect.

A setting of “10” would effect a voltage correction of 10 % in the voltage regulators when the value for the circulating reactive current corresponds to the rated current of the current transformer.

Setting of the response threshold for circulating reactive current monitoring (SENSITIVITY, fig. 23)

The response threshold can be set from 0.5 % to 20 % (referred to the rated current of the current transformer) by pressing the function key SENSITIVITY and turning the scroll wheel. The LED lamp “Alarm” lights up and both voltage regulators are blocked when the circulating reactive current exceeds the set response threshold during parallel operation. After 30 s both signalling relay contacts (terminals 83, 84, 85) are activated.

Activation of the parallel control

The parallel control is activated when the terminals 90, 91, on both voltage regulators are connected with each other by a switch contact. The LED lamp “Parallel” lights up and the signalling contact (terminals 80, 81, 82) is activated.
Set one of the two voltage regulators to the MANUAL mode to prevent automatic control of its associated motor drive. By manual control move this motor drive by the number of steps corresponding to the maximum permissible difference between the parallel-operating transformers (e.g. 1...2 steps) towards RAISE.

Starting from 20 %, set SENSITIVITY to a smaller value (in steps, release the key between the steps) until the LED lamp for ALARM lights up. The SENSITIVITY threshold is reached as soon as the LED lamp lights up. Both voltage regulators are blocked and after 30 s a signalling relay (terminals 83, 84, 85) is activated.

Increase the SENSITIVITY setting until the LED lamp for ALARM goes out.

Set the voltage regulator to AUTO mode to enable automatic control of the motor drive. The motor drive must be automatically reset to its initial position.

Set the SENSITIVITY value determined above on the second voltage regulator also.

5.1.3 Parallel control failure

If one or both voltage regulators are signalling “Parallel control failure” instead of “Parallel” although the control inputs (terminals 90, 91) on both voltage regulators are correctly configured, the causes can be the following:

- Interruption of the data communication between the voltage regulators. The shielded cable must be checked for such an interruption.
- The second voltage regulator is not operable.
- Different parallel control methods have been selected.

In such a case the regulators are blocked.

5.2 Parallel control according to the “Master-Follower method” (synchronism control)

This method is suitable for transformers with the same rated voltage, step voltage, and the same number of tap positions. The motor drive must signal the tap position by means of a constant current of 4...20 mA (4 mA corresponding to the lowest tap position, 20 mA corresponding to the highest tap position).

During the parallel control one voltage regulator performs the actual voltage regulation (Master function). The user can determine which voltage regulator shall be the Master. The Master signals the tap position of the motor to the second voltage regulator (Follower) which compares it with the position of its own motor drive. When the follower notices a position difference it gives a correcting control command to its motor drive.
5.2.1 System configuration, settings

The additional connections to the two voltage regulators are carried out according to fig. 24.

The following jumpers are attached to the terminals 90, 92, 93:

- Jumper A (terminals 90, 92), it determines the parallel control according to the "Master-Follower" method (synchronism control);
- Jumper B (terminals 90, 93), if the increase of the tap position number shall not result in an increasing but a decreasing transformer voltage.

The tap position signal from the motor drive is to be applied to the terminals 94, 95.

Setting of the tap position range (TAP MAX, fig. 23)

A value of 4 to 40 can be set by pressing the TAP MAX key and turning the scroll wheel. This value is determined as follows:

\[ TAP \, MAX = n_{\text{max}} - n_{\text{min}} \]

\[ n_{\text{min}} = \text{lowest tap position,} \]
\[ n_{\text{max}} = \text{highest tap position.} \]

Examples:

<table>
<thead>
<tr>
<th>Tap position range</th>
<th>TAP MAX setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1...19</td>
<td>18</td>
</tr>
<tr>
<td>1...39</td>
<td>38</td>
</tr>
<tr>
<td>-9...0....+9</td>
<td>18</td>
</tr>
<tr>
<td>-13...0....+13</td>
<td>26</td>
</tr>
</tbody>
</table>

The function test of the tap position signalling is carried out as follows:

Operate the transformer over the complete tapping range and check the tap position indication by means of the INFO key (according to 3.1.12).

In the lowest tap position the indication should be "TAP 1".
When the tap position signalling is interrupted, the indication is "TAP 0".

Master-Follower configuration (fig. 23).

Either voltage regulator can be selected as Master or Follower by pressing the MASTER/FOLLOWER key and turning the scroll wheel. The indicator shows "MASTER" or "FOLLOWER" as long as the key is kept pressed. During parallel operation the indicator of the voltage regulator chosen as Follower shows "FOLLOWER" constantly.

If both voltage regulators are chosen as Follower or as Master during parallel operation, the voltage regulators are blocked and "Alarm" is signalled (terminals 83, 84, 85, of the signalling relay).

Activation of the parallel control

Parallel control is activated when on both voltage regulators the terminals 90, 91, are connected with each other by a switch contact. The LED lamp for "Parallel" lights up and the signalling contact (terminals 80, 81, 82) is activated.

5.2.2 Function test, putting into service

Presettings

NOTE ! A precondition for the correct function of the parallel control is that the voltage regulators are put into service in the INDIVIDUAL mode according to 3.2.3 (contact on terminals 90, 91, must be open).

The voltage regulators must have the same operating parameter settings for VOLTAGE LEVEL, BANDWIDTH, DELAY 1, as well as for LINE COMPENSATION, if any.

The jumpers according to 5.2.1 must have been attached and the tap position signalling must function correctly.
The MANUAL mode must be selected on both voltage regulators.

Operate the tap changers of the two transformers in INDIVIDUAL mode so that their tap positions are the same and both voltage regulators are in a balanced state (no RAISE oder LOWER presignal).

Connect the transformers in parallel and close the switch contacts on the terminals 90, 91, of each voltage regulator. The voltage regulators must still be in a balanced state. Select the AUTO mode on one of the two voltage regulators. The LED lamps for “Parallel” on both voltage regulators must light up.

With the second voltage regulator in MANUAL mode, move the tap changer towards RAISE by one step. The voltage regulator in AUTO mode must now automatically control its tap changer to the same tap position.

The LED lamps for “Alarm” light up for a short time while the tap positions are different. If the first transformer is not controlled to this same tap position both voltage regulators are blocked and a signalling relay (terminals 83, 84, 84) activated after 30 s.

5.2.3 Parallel control failure

If one or both voltage regulator are signalling “Parallel control failure” instead of “Parallel” although the control inputs (terminals 90, 91) on both voltage regulators are correctly configured, the causes can be the following:

- Interruption of the data communication between the voltage regulators. The shielded cable must be checked for such an interruption.
- The second voltage regulator is not operable.
- Different parallel control methods have been selected.

The voltage regulators are blocked in such a case.
B Description of the program

VRR-CONTROL is started under DOS by entering

```
<A> mrvr RETURN
```

Emphasis in the development stage was on user-friendly operation. All functions are mainly self-explanatory.

All entries are made by a keyboard, a mouse is not required.

The following short explanations show the possible functions.

After the program has been started the desired language is selected. The heading appears on the display followed by the main menu after any key has been pressed.

1. Main menu

In the upper part of the display screen there is the menu bar. The individual menu items can be selected here by means of the cursor keys (left/right) or initial letter and the RETURN key (fig. 25).

In the bottom part of the display screen there is the status bar which always shows the current state of the data transmission. Possible errors in the communication with the voltage regulator can be read here (fig. 25).

Above the status bar there is a short “context help” which describes how the program can be served at the moment (fig. 25).

To establish communication with the voltage regulator certain settings must be made first.

2. Sub-menu “Communication”

This sub-menu appears after the item “Communication” has been selected (fig. 22) in the main menu. It contains a dialog window where the control parameters of the program can be set:

1 PC-Port COM1, COM2,....:

selection of the serial interface on the PC.

2 Interrogation clock min, 5 sec, 10 sec:

This is the waiting time during monitor operation until the values are updated again.

3 Data transmission ON/OFF:

The data transmission to the voltage regulator is switched on or off.

Immediately after the start of the program, the serial interface of the PC used for the data transmission must be entered here. After the voltage regulator has been connected to the PC and the data transmission has been switched on, the message “Communication ok” should appear in the status bar. If no message appears the following points must be checked:

- Is an interface cable according to the hardware specification (point A) used?
- Does the serial interface comply with the program specifications?
  (Sometimes the data transmission does not function via certain serial interfaces on the PC. In such a case it should be tried to use any other serial interface.)
- Is the voltage regulator in the correct operating condition?
3. **Sub-menu “Options”**

Here it is possible to store the values of the parameter settings in a data file (1 Secure Parameters) and to reload them into the voltage regulator (2 Load Parameters) (fig. 26).

Then the question is asked whether the parameter values are to be stored. If the answer is affirmative, the data file name and path must be entered so that the values are stored as text file under this name (fig. 27).

All parameter settings are first read from the voltage regulator under the option “Secure Parameters” and indicated on the display screen (fig. 28).
The function “Load Parameters” is accomplished analogously. Make sure that the Local/Remote switch on the voltage regulator is set to Remote parametering so that the voltage regulator can take over the values.

The option “New parameter” allows to create a new parameter data file. Values can also be taken over from an existing file to serve as a basis.

With the option “New parameter” the same parameters can be set as on the VC 100-BU directly. Exception: The voltage regulator identification code (a four-digit registration number 0...9999) can only be set by means of this parametering program and not on the VC 100-BU directly.

First enter the version number of the voltage regulator for which the parameters are set (i.e. 01 or 02, on the nameplate of the VC 100-BU).

The dialog window for the particular voltage regulator version appears (fig. 29). The individual parameter groups are selected in the left hand area. By pressing the RETURN key the parameter entry field is displayed where the individual parameters can be selected with the cursor keys and the RETURN key. Go back by means of the escape key.

This procedure does not require a communication with the VC 100-BU. If only this procedure is to be carried out, e.g. for pre-parametering on the PC, then the data leads and settings described under paragraph 2 can be omitted.

The editor area is left by pressing the ESC key. The parameter values are stored by entering the data file name.
4. **Sub-menu “Monitor”**

This sub-menue indicates the present operating status of the voltage regulator (fig. 30) including all measured values and the info data. The values are updated after a waiting time entered as “Interrogation clock”.

5. **Sub-menu “Parameters”**

Different parameter groups for the voltage regulator can be selected by pull-down menu (fig. 31) and then the values set (fig. 32). Make sure that the Local/Remote switch on the voltage regulator is set to Remote so that the voltage regulator can take over the values.

6. **Info:**

Information on the program is shown (version, originator, ...).

7. **Quit:**

The program is terminated.
7. FAILURES

The voltage regulator is largely protected from failures by self-monitoring. If a problem does occur, however, proceed according to the following short "Trouble-Shooting Guide":

Failure symptom 1:
Indefinable signs appear on the indicator at regular or irregular intervals.
Procedure: Switch off the supply voltage and switch it on again. If this does not eliminate the cause of the failure, then the voltage regulator is defective. Consult MR.

Failure symptom 2:
No indication, failure signalling contact closed (terminals 57, 58).
Possible cause: supply voltage failed.
Is there a supply voltage of approx. 110 V on terminals 3, 4?
Is the fuse defective (fig. 33)? If so, replace it.

Failure symptom 3:
Voltage indication 0.0 V.
Possible cause: measuring voltage failed.
Is there measuring voltage on terminals 1, 2?
Is the fuse defective (fig. 33)? If so, replace it.

Failure symptom 4:
"PARAM?" appears on the indicator, failure signalling contact closed (terminals 57, 58).
Cause: Several parameter settings have been lost due to extremely high interferences.
Procedure: Reset all parameters (as in 3.1) in order until "PARAM?" disappears.
<table>
<thead>
<tr>
<th>Customer</th>
<th>Voltage regulator type:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td>MR order number:</td>
</tr>
<tr>
<td></td>
<td>Serial no:</td>
</tr>
<tr>
<td></td>
<td>Connection diagram:</td>
</tr>
<tr>
<td></td>
<td>Voltage transformer rating:</td>
</tr>
<tr>
<td></td>
<td>Current transformer rating:</td>
</tr>
<tr>
<td></td>
<td>Measuring transformer config.:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transformed data</th>
<th>Site</th>
<th>Regulating range</th>
<th>Position designation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer no.:</td>
<td></td>
<td>Tap changer no.:</td>
<td></td>
</tr>
<tr>
<td>Manufacturer:</td>
<td></td>
<td>Type:</td>
<td></td>
</tr>
<tr>
<td>Type:</td>
<td></td>
<td>Manufacturer:</td>
<td></td>
</tr>
<tr>
<td>Serial-no.:</td>
<td></td>
<td>Year of constr.:</td>
<td></td>
</tr>
<tr>
<td>Year of constr.:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:

Carried out: | Place: | Date: | Signature: |
## Voltage regulator VC 100-BU

<table>
<thead>
<tr>
<th>Function</th>
<th>Setting range</th>
<th>Unit/Setting</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desired voltage level</td>
<td>85 ... 140 V in steps of 0.5 V</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Bandwidth</td>
<td>± 0.5 % ... ± 9 % in % steps of 0.1 %</td>
<td>%</td>
<td><strong>Recommendation:</strong> setting of $(0.7 \ldots 1) U_{\text{step}} %$ of transformer</td>
</tr>
<tr>
<td>Delay time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Time 1</td>
<td>0 ... 180 s lin / inv</td>
<td>s lin / inv</td>
<td></td>
</tr>
<tr>
<td>- Time 2</td>
<td>0 ... 10 s / off</td>
<td>s / off</td>
<td></td>
</tr>
<tr>
<td>Undervoltage blocking U&lt;</td>
<td>70 ... 99 % of desired voltage level in steps of 1 %</td>
<td>%</td>
<td>Signalling delayed by 10 s</td>
</tr>
<tr>
<td>Overvoltage detection U&gt;</td>
<td>101 ... 130 % of desired voltage level in steps of 1 %</td>
<td>%</td>
<td>High-speed return control by “Lower”: pulses, pulse mark/ space 1.5 s / 1.5 s</td>
</tr>
<tr>
<td>Overcurrent blocking I&gt;</td>
<td>50 ... 210 % of rated current transformer in steps of 5 %</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Measuring transformers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Voltage transformer</td>
<td>0.1 ... 999.0 kV</td>
<td>V</td>
<td>Referred to 100 V (secondary), see page 8, fig. 5a</td>
</tr>
<tr>
<td>- Current transformer</td>
<td>100 ... 5000 A</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>- Phase angle between current path and voltage path</td>
<td>0°, 90°, 30°, –30°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- $U_l$</td>
<td>0 ... ± 25 V</td>
<td>V</td>
<td>Resitive, reactive voltage drop</td>
</tr>
<tr>
<td>- $U_x$</td>
<td>0 ... ± 25 V</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>in steps of 1 V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z-compensation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Voltage raise</td>
<td>0 ... 15 %,</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>- Limitation</td>
<td>0 ... 15 % of desired voltage level in steps of 1 %</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Voltage level change</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Level 1</td>
<td>0 ... 9 %</td>
<td>%</td>
<td>Only with version 01</td>
</tr>
<tr>
<td>- Level 2</td>
<td>0 ... 9 %</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>in steps of 1 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallel control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Minimum circulating reactive current method:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Stability</td>
<td>0 ... 100</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>* Sensitivity</td>
<td>0.5 ... 20 %</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>- Master / Follower method:</td>
<td>4 ... 40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Tap max.</td>
<td>Master / Follower</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1T</td>
<td>2 ... 1800 s, off</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ 1T</td>
<td>2 ... 1800 s, off</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+2T</td>
<td>2 ... 1800 s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ 2T</td>
<td>2 ... 1800 s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+3T</td>
<td>2 ... 1800 s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ 3T</td>
<td>2 ... 1800 s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Tend.</td>
<td>70 ... 100 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Tend.</td>
<td>70 ... 100 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ Bw</td>
<td>0.5 ... 10 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Bw</td>
<td>0.5 ... 10 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OFF/ON</td>
<td>OFF/ON</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Instructions for the setting of the regulating parameters are to be found in paragraph 3.2.3 and in paragraph 5 for the setting of the parallel operation.

If the indicator shows the failure message “PARAM” press all function keys without turning the scroll wheel and check the setting parameters. Correct if necessary (in case of double-function keys check both parameters, actuate LOCAL/REMOTE and LDC/Z-Comp. switches). If the message “PARAM” continues to be displayed, refer to paragraph 7 “operating failures”.

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**Remarks:**

- **Function Setting range:**
  - **Desired voltage level:** 85 ... 140 V in steps of 0.5 V
  - **Bandwidth:** ± 0.5 % ... ± 9 % in % steps of 0.1 %
  - **Delay time:** 0 ... 180 s lin / inv, 0 ... 10 s / off
  - **Undervoltage blocking U<:** 70 ... 99 % of desired voltage level in steps of 1 %
  - **Overvoltage detection U>:** 101 ... 130 % of desired voltage level in steps of 1 %
  - **Overcurrent blocking I>:** 50 ... 210 % of rated current transformer in steps of 5 %
  - **Measuring transformers:**
    - Voltage transformer: 0.1 ... 999.0 kV, 100 ... 5000 A
    - Current transformer: 0°, 90°, 30°, –30°
  - **LDC:**
    - $U_l$: 0 ... ± 25 V
    - $U_x$: 0 ... ± 25 V
  - **Z-compensation:**
    - Voltage raise: 0 ... 15 %, 0 ... 15 % of desired voltage level in steps of 1 %
  - **Voltage level change:**
    - Level 1: 0 ... 9 %
    - Level 2: 0 ... 9 %
  - **Parallel control:**
    - Minimum circulating reactive current method:
      - Stability: 0 ... 100
      - Sensitivity: 0.5 ... 20 %
    - Master / Follower method:
      - Tap max.: 4 ... 40
      - Master / Follower
    - +1T: 2 ... 1800 s, off
    - + 1T: 2 ... 1800 s, off
    - +2T: 2 ... 1800 s
    - + 2T: 2 ... 1800 s
    - +3T: 2 ... 1800 s
    - + 3T: 2 ... 1800 s
    - + Tend.: 70 ... 100 %
    - - Tend.: 70 ... 100 %
    - + Bw: 0.5 ... 10 %
    - - Bw: 0.5 ... 10 %
    - OFF/ON

**Remarks:**

- **Recommendation:** setting of $(0.7 \ldots 1) U_{\text{step}} \%$ of transformer
- **Signalling delayed by 10 s**
- **High-speed return control by “Lower”: pulses, pulse mark/ space 1.5 s / 1.5 s**
- **Resitive, reactive voltage drop**
- **Only with version 01**
- **Only with version 02**
- $n_{\text{max}} \cdot n_{\text{min}}$. 

**Customer-specific control program ARS**

- +1T: 2 ... 1800 s, off
- + 1T: 2 ... 1800 s, off
- +2T: 2 ... 1800 s
- + 2T: 2 ... 1800 s
- +3T: 2 ... 1800 s
- + 3T: 2 ... 1800 s
- + Tend.: 70 ... 100 %
- - Tend.: 70 ... 100 %
- + Bw: 0.5 ... 10 %
- - Bw: 0.5 ... 10 %
- OFF/ON

**Remarks:**

- **Instructions for the setting of the regulating parameters are to be found in paragraph 3.2.3 and in paragraph 5 for the setting of the parallel operation.**
- **If the indicator shows the failure message “PARAM” press all function keys without turning the scroll wheel and check the setting parameters. Correct if necessary (in case of double-function keys check both parameters, actuate LOCAL/REMOTE and LDC/Z-Comp. switches). If the message “PARAM” continues to be displayed, refer to paragraph 7 “operating failures”.**