Voltage regulator
VC 100 E
Operating Instructions
(Vers. 02, suitable for parallel operation of 2 transformers without any additional control devices)
NOTE

Data contained herein may differ in details from the equipment delivered. We reserve the right to make alterations without notice.
1 General

1.1 Safety instructions

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

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

NOTE
These notes give important information on a certain subject.

Improper operation or misuse can lead to
- serious or fatal injury
- damage to the equipment and property of the user
- a reduction in the efficiency of the equipment.

Safety instructions in this manual are presented in three different forms to emphasize important information.

Installation, electrical connection and commissioning of the tap changing equipment 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 tap changing equipment is used for the specified application only.

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

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

WARNING
All relevant fire protection regulations must be strictly observed.

1.2 Specified application

The Electronic Voltage Regulating Relay VC 100 E (see page 7, fig. 1) serves 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. Motor drive units without step-by-step function require a continuous control pulse, which is also available. In both cases the RAISE or LOWER control signal is generated by the voltage regulator and issued to the motor drive whenever the measured voltage deviates from preset conditions.

This version of the voltage regulator is equipped with a parallel control unit for parallel operation of 2 transformers.

Load dependent voltage drops due to line impedance, e.g. of a single feeder line between transformer and load, can be compensated by increasing the desired value either by means of the incorporated resistive and inductive line simulation network (Line-Drop Compensator) or by apparent resistance drop compensation (Z-Compensation).

Trouble-free operation is largely ensured by the incorporated undervoltage and overcurrent blocking functions and the overvoltage monitoring.
Power supply of the voltage regulator is provided by the power supply module VC 100 E-SU:
AC or DC power source 93 - 265 V,
36-72 V DC optional.

If required, the basic module VC 100 E-BU can be equipped with various extension cards and additional components, e.g.:

**Additional unit VC 100 E-0 (see para. 4)**
Selection of automatic or manual control, manual «Raise»/»Lower« control, “indication of tap change in progress” and local control of the motor drive unit, selection of local/remote control on the additional module and digital remote indication of the operating position of the tap changer.
This additional module is described in these Operating Instructions. The following extensions are described in separate Operating Instructions.

**Additional module VC 100 E-LV**
(see Operating Instructions No. BA 158)
Digitally adjustable system-independent monitoring of under and overvoltage, of the functions of motor drive unit and voltage regulator, automatic high-speed return control of the motor drive and tripping of the transformer circuit breakers.

<table>
<thead>
<tr>
<th>NOTE</th>
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</thead>
</table>
This version cannot be used for parallel control by the additional parallel control unit.

**Extension card IE**
(optional component of the basic module VC 100 E-BU, see separate Operating Instructions).
This card provides the voltage regulator with additional 16 digital inputs for functions specified by the customer.

**Extension card OE**
see Extension card IE, but with 16 digital outputs (relay contacts)

**Additional component VC 100 E-AD**
(see separate Operating Instructions)
This component provides the voltage regulator additionally with:
1 analogue output,
2 analogue inputs,
4 digital inputs,
4 digital outputs,
for functions specified by the customer
Further additional cards and extensions are available on request.

**Extension card SI**
(optional component of the basic module VC 100 E-BU, see separate Operating Instructions).
This card provides the voltage regulator with a serial interface for data communication with a superior digital control system.
1.3 Design

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

All control and display elements are located on the front panel.

1.4 Features of the basic module
VC 100 E-BU 02

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 alphanumerical LC display and several LED lamps.

The electronic voltage regulator is controlled by a microcontroller (see appendix, block/connection diagram VCEBLBU2). Besides a voltage transformer and a current transformer it contains optocoupler inputs with potential separation as well as potential-free output relay contacts.

Apart from the usual regulating algorithm, the voltage regulator VC 100 E-BU 02 offers, for the first time, a customer-oriented regulating algorithm called “ARS” with many sophisticated technical features for symmetrical and asymmetrical control response. By optimizing your operating parameters you can improve your voltage quality without the need for any additional tap change operations.

The parameters of the regulator can be set by means of a PC via the incorporated serial interface (RS 232). The appropriate PC software will be furnished by 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).

A mainly trouble-free operation is ensured by undervoltage blocking, overcurrent blocking and overvoltage monitoring features.

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

The functions of the voltage regulator VC 100 E are compatible to earlier regulator models.

The PE extension card is part of the basic unit VC 100 E-BU 02. When this card is used, the voltage regulator VC 100 E is equipped with an additional device for parallel operation instead of the voltage level change device. This allows control of two transformers equipped with one voltage regulator VC 100 E each in single and parallel operation without any additional parallel control unit (circulating reactive current method or Master/Follower method).

![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 already be consulted in the planning stage.
Electronic voltage regulator VC 100 E, with VC 100 E-SU (power supply) – VC 100 E-0 (mode of operation and tap indication)

VC 100 E-BU 02 (basic unit with PE card)

VT kV/100V

CT RATING

CT, VT PHASE

CT, VT SETTING

DATAPORT

MOTOR DRIVE

IN PROGRESS

LOC. REM.

AUTO MANUAL

REGULATION SETTING LINE-COMPENSATION INFO

VOLTAGE LEVEL

DELAY 1

DELAY 2

Ur

VOLT TRISE

Ux

LIMIT

D1-Dn

LOCAL

REMOTE

LDC

Z-COMP

ALTERN.LIMIT CONTROL

U< U>

I>

SENSITIVITY

MASTER

FOLLOWER

ARS

PARALLEL

ALARM BAND-

WIDTH

STABILITY

TAP MAX
2 Technical Data

Regulator basic unit VC 100 E-BU 02 with power supply unit VC 100 E-SU in module frame

Setting ranges in the standard regulating mode

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting Range</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...±0.9 % 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...\pm 25 \text{ V} ) (resistive line drop), ( U_x = 0...\pm 25 \text{ V} ) (inductive or capacitive line drop), setting in steps of 0.1 V</td>
</tr>
<tr>
<td>optional change to Z-compensation</td>
<td>Load-current dependent</td>
</tr>
<tr>
<td></td>
<td>voltage rise 0...15 % of desired voltage level, setting in steps of 0.1 %</td>
</tr>
<tr>
<td></td>
<td>limitation 0...15 % 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 %, delay time 10 s for signalling relay</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 ratio setting</td>
<td>ratio setting 0.100 ... to 999.0 kV/100 V</td>
</tr>
<tr>
<td>Current transformer ratio setting</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>

Setting ranges in ARS mode

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desired voltage level</td>
<td>85...140 V</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>2...1800 s independently adjustable for each absolute deviation</td>
</tr>
<tr>
<td>Delay time 1</td>
<td>0.5...10 % of desired voltage level, independently adjustable for +( \Delta U ) and -( \Delta U )</td>
</tr>
<tr>
<td>Tendency function</td>
<td>70...100 % of each delay time, independently adjustable for +( \Delta U ) and -( \Delta U )</td>
</tr>
</tbody>
</table>

Control elements, indication

Function keys
- for parameterizing of current and voltage transformer measuring ranges and configuration (CT, VT SETTING),
- desired voltage level (VOLTAGE LEVEL),
- bandwidth (\( \Delta U_{\text{max}} \)),
- 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),
- two function keys for parallel control

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
- Alphanumeric LC-display (2 lines with 16 characters each);
- 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;
- 2 LED lamps for signalling parallel operation
Regulator basic unit VC 100 E-BU 02 with power supply unit VC 100 E-SU in module frame

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 FAIL VOLTAGE REGULATOR, 1 change-over contact. signalling relay for "parallel operation ON", 1 N/O contact; signalling relay for "parallel operation failure", 1 N/O contact; 8 signalling relays for BCD-coded tap position indication, N/O contacts; 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, 40-60 Hz, r.m.s. measurement, measuring error < 0.5 % ± 40 ppm/°C, consumption < 1 VA, admissible overload 2 - 1.5I 0 continuously; 40 - I 0, 1 s; 1 input with potential separation for additional VC 100 E-LV unit; 1 serial interface RS232 for parametering via PC; 2 inputs with potential separation for parallel operation 8 inputs with potential separation for BCD-coded tap position indication 1 analogue input with potential separation for tap position indication 4-20 mA 1 serial interface RS232 for parallel control with a second VC 100 E

Power supply

93 .. 265 V AC and DC, consumption approx. 12 VA (at 230 V AC), optional: 36 ... 72 V DC

Protective housing

19-inch module frame according to DIN 41 494 part 5, width x height x depth = 483 · 133 · 245 mm, enclosure protection IP00 according to IEC 529, weight approx. 5.8 kg (including mode of operation module VC 100 E-0)

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 6/8 kV, IEC 1000-4-3 electromagnetic fields 10 V/m, 80-1000 MHz, IEC 1000-4-4 burst 1 MHz, 2/4 kV; IEC 1000-4-5 surge 2/4 kV; IEC 1000-4-6 HF interference immunity of leads 10 V / 150 kHz - 80 MHz EC conformity according to EN 50081-2 and 50082-2.
Technical Data

1 – Slide switch LOCAL/REMOTE
2/3 – Function key and signalling LED for customer-specific control program ARS
4 – Scroll wheel
5 – Setting of the measuring transformer ratio and configuration
6 – Function key INFO
7 – Function key for Ux (LDC and voltage limit (Z-COMP))
8 – Slide switch for LDC/Z-COMP
9 – Function key for Ur (LDC) and voltage rise (Z-COMP)
10 – LC display
11 – Function key for delay time DELAY 1/DELAY 2
12 – Presignal "Raise"
13 – Function key for bandwidth
14 – Function key for desired voltage level
15 – Presignal "Lower"
16 – Function key for overcurrent blocking
17 – Function key for overvoltage monitoring
18 – Function key for undervoltage blocking
19 – LED lamp for signalling U<, U>, I>
20 – Parametering interface
21/22 – Function keys and LED lamps for voltage level change
3 Operation
3.1 Input and output of data, functions

When the voltage regulator is inactive, the operating data listed 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 displayed value 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.

The language can be selected in the PC parametering software (see 8.2.2.1).

3.1.1 Indication field

The indication field consists of a two-line 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>, parallel operation “ON”: “Parallel” and failure in parallel operation: “Alarm”, customer-specific control program ARS.

3.1.2 Parametering mode, fig. 3

For parametering directly on the voltage regulator, set the Local/Remote slide switch to Local position.
In Remote position, the parameters are set via the serial parametering interface using a PC.

3.1.3 Measuring transformers (CT, VT SETTING, fig. 4, display see fig. 5)

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

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

Example:
Voltage transformer used: 22 kV/110 V.
Setting on the voltage regulator:
(22 kV · 100) / 110 V = 20 kV

Ratio of the current transformer CT (Iₚ)
The rated primary current (referred to 0.2 / 1 / 5 A secondary current) is set from 100 A to 5000 A by scroll wheel.
Measuring transformer configuration CT, VT PHASE
(Phase angle of current/voltage transformer, fig. 5)

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)
3.1.4 Setting 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 E-BU.

3.1.5 Setting the bandwidth (BANDWIDTH, fig. 7)
The bandwidth can be set from ±0.5 % to ±9 % in steps of 0.1 % by pressing the function key BANDWIDTH and turning the scroll wheel.
For the correct setting of this value the step voltage of the transformer has to be known:

\[
BW (%) = \frac{100 \cdot U_{St}}{U_N}
\]

- BW = bandwidth (%)
- \(U_{St}\) = step voltage
- \(U_N\) = 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 (contacts IO-X1:b16/z18/z16) is energized. This relay is de-energized again when the value is within the bandwidth limit.

3.1.6 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. 100 s int). 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.

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

Delay time 2 (DELAY 2, fig. 9)
The delay time 2 becomes effective only 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 twice 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.

### 3.1.7 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 a delay time of approx. 10 s, the associated signalling relay is energized and remains energized (contacts IO-X1: z26/b26/b24). The signalling relay does not respond in case of a failure of the actual voltage or supply voltage (< 30 V).

### 3.1.8 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 via the “Lower” output relay. The set delay time is inactive during this operation.

At the same time the „Alarm“ LED lamp responds and a signalling relay is energized (contacts IO-X1: b22/z24/z22) as long as overvoltage is present.
If the voltage regulator, due to unfavourable parametering, regulates towards a higher voltage than the set limit $U >$ (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).

3.1.9 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 (contacts IO-X1: z14/b14/b12).

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 and 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 paragraph 3.1.3, fig. 4.

**Setting the ohmic voltage drop $U_r$**
The calculated ohmic 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, 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, value “0” is to be set.**
Calculation of the required settings:

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

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

where

- \( U_r \) = LDC setting for resistive line voltage drop in V
- \( U_x \) = LDC setting for inductive line voltage drop in V
- \( I_N \) = rated current in A of the selected current transformer connection to the voltage regulator, i.e. 0.2 A or 1 A or 5 A
- \( R_{CT} \) = current transformer ratio, e.g. 200 A/5 A
- \( R_{VT} \) = voltage transformer ratio, e.g. \( \frac{30000 \, \text{V}}{\sqrt{3} \, 100 \, \text{V}} \)
- \( r \) = ohmic resistance of line in \( \Omega/\text{km} \) per phase
- \( x \) = inductive reactance of line in \( \Omega/\text{km} \) per phase
- \( L \) = length of line in km

If the resistive and inductive line voltage drops \( U_r \) and \( U_x \), 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 considering the current.

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:

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

where:

- Voltage rise = setting of Z-Compensation in %
- \( U_{Tr} \) = transformer voltage at current \( I \)
- \( U_{Load} \) = line end voltage at current \( I \) and with the same service position of the tap changer
- \( I \) = load current in A
- \( I_N \) = rated current in A of the selected current transformer connection to the 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)

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.

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

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 compensation of the line voltage drops,
- more difficult to set,
- exact line data must be known.
3.1.11 Indication of operating data (INFO, fig. 15)

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>U-act, secondary 110.5 V</td>
</tr>
<tr>
<td>Measured voltage in kV</td>
<td>U-act, primary 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</td>
<td></td>
</tr>
<tr>
<td>current of the CT</td>
<td></td>
</tr>
<tr>
<td>Apparent power in kVA or MVA</td>
<td>I-act 105.5 %</td>
</tr>
<tr>
<td>Active power in W, kW or MW</td>
<td>Active power 500 kW</td>
</tr>
<tr>
<td>Reactive power in Var, kVar o.</td>
<td>Reactive power 330 kVar</td>
</tr>
<tr>
<td>MVA</td>
<td></td>
</tr>
<tr>
<td>Power factor cos</td>
<td>Power factor cos 0.85</td>
</tr>
<tr>
<td>Phase angle in degrees</td>
<td>Phase angle -31.8 DEG</td>
</tr>
<tr>
<td>Frequency in Hz</td>
<td>Frequency 50.0 Hz</td>
</tr>
<tr>
<td>Tap position</td>
<td>Tap position 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.
The additional module VC 100 E-0 (see page 7, fig. 1) allows manual RAISE or LOWER of the motor drive unit from the voltage regulator panel and selection of automatic (AUTO) or manual control (MANUAL). In addition, the functions AUTO/MANUAL, »Raise«/ »Lower« can be controlled via relay inputs, or optionally, via a digital remote control system. Manual control of the motor drive is required when certain adjustments have to be made on the voltage regulator.

Furthermore, the additional module of the VC 100 E-0 is equipped with a digital remote position indication of the tap changer.

The additional module is fixed to the front panel of the rack at the top and bottom. Electrical connection is provided at the back via plug connectors according to DIN 41 612. Connection to the basic module is provided via a DC and a data bus.

The front panel of the additional module (fig. 16) contains all necessary control and indication elements, this includes:

- Two push-buttons for selecting between automatic mode of operation (AUTO) and manual mode of operation (MANUAL) with corresponding signalling lamps.
- Two push-buttons for »Raise«/ »Lower« control
- A lamp indicating "Tap Change in Progress"
- A slide switch for local/remote control of the AUTO/MANUAL and »RAISE«/ »LOWER« functions
- A lamp signalling local control of the motor drive
- A two-digit 7-segment indication with sign (+, –) as remote position indication of the tap changer.

Control and display elements of the additional module VC 100 E-0
4.3 Functions

4.3.1 Mode of operation Automatic control (AUTO)

The switch LOCAL/REMOTE is in position LOCAL. By pressing the push-button AUTO (fig. 17) the voltage regulator is connected to the control circuit of the motor drive unit. The motor drive unit is then controlled exclusively by the output relays of the voltage regulator.

Automatic control is indicated by the corresponding signalling lamp and potential-free relay contact.

4.3.2 Mode of operation Manual control (MANUAL)

The switch LOCAL/REMOTE is in position LOCAL. By pressing the push-button MANUAL (fig. 18) the voltage regulator is disconnected from the control circuit of the motor drive.

Manual control is indicated by the corresponding signalling lamp and potential-free relay contact.
The motor drive can be operated manually by local control (on the motor drive) or by pressing the push-buttons «Raise» or «Lower» (fig. 19).

If a step-by-step switch is installed, a short pressing of the push-button results in the operation of the motor drive by one step.

Operation of the motor drive is signalled by the "tap change in progress" indication (lights c. 5 sec)

Local control of the motor drive unit is signalled by an additional lamp. This requires a Local/Remote switch with a potential-free signalling contact in the motor drive unit.

The voltage regulator is equipped with potential-free relay contacts for indicating "Tap change in progress" and local control.

4.3.3 Remote control of functions

AUTO/MANUAL and «Raise»/«Lower»

The selection of automatic or manual control and manual "Raise/Lower" control described in 4.3.1 and 4.3.2 can also be made separately from the voltage regulator by external push-buttons via remote control. For this purpose the LOCAL/REMOTE switch is to be set to REMOTE (fig. 20).
4.3.4 Digital remote position indication

The additional module VC 100 E-0 is equipped with a digital remote position indication.

Prerequisite for a digital position indication is the conversion of the position indicating signal into BCD code and its transmission. For this purpose an N/O contact range connected to a diode matrix and the corresponding transmission lines between motor drive unit and voltage regulator are required (fig. 21).

The combinational logic function of the diode matrix assigns the corresponding parallel BCD signal to each operating position of the tap changer that is simulated by the N/O contact range in the motor drive unit (fig. 22).

<table>
<thead>
<tr>
<th>Operating position no.</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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<td></td>
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<td>18</td>
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<td>19</td>
<td></td>
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</tr>
</tbody>
</table>

Fig. 22
Conversion of numerical position signals 1 ... 19 into corresponding BCD signals (example).
4.4 Technical Data

Control elements, indication

**Push-buttons**
- Automatic control (AUTO)
- Manual control (MANUAL)
- Manual RAISE control
- Manual LOWER control

**Selector switch**
- Local/remote control (LOCAL/REMOTE) of AUTO/MANUAL and RAISE/LOWER functions

**LED lamps**
- Indication AUTO/MANUAL
- “Tap change in progress” indication of the motor drive unit (IN PROGRESS)
- Indication of motor drive local control

**Remote position indication**
- 2-digit 7-segment display with sign (− 99 ... 0 ... + 99)

**Inputs**
- 1 Relay input each for remote control of AUTO/MANUAL and RAISE/LOWER functions
- 1 Relay input each for “Tap change in progress” indication and local control indication of the motor drive unit
- BCD input for remote position indication, controlled by +40 ... 250 VDC

**Outputs**
- 1 Relay output (N/O contact) each for manual control RAISE/LOWER
- 1 Relay output (change-over contact) each for indicating AUTO/MANUAL/LOCAL/REMOTE
- 1 Relay output (change-over contact) each for “Tap change in progress” indication and local control indication of the motor drive unit
- BCD signal output for tap position
- All relay contacts are potential-free,
- make/break capability of contacts:
  - AC: 250 V, 5 A
  - DC: 30 V, 5 A
  - 110 V, 0.4 A
  - 250 V, 0.4 A

**Control voltage**
- 48 ... 250 VDC

**Width of front panel**
- 12 standard width units = 60.96 mm

**Temperature range**
- identical to basic module VC 100 E-BU

**Tests**
- identical to basic module VC 100 E-BU
5 Commissioning

5.1 Installation

The standardised module frame of the voltage regulator (see annex, dimension drawing 898 832) is suitable for installation into a 19-inch control cabinet. The swing frame design is recommended as it offers easy access to the terminals at the back.

5.2 Connection

The voltage regulator is to be connected according to the connection diagram (see annex, connection diagram).

Please observe the following points:
- the correct phase relation of the secondary connections of the current and voltage transformers (see 3.1.3)
- the correct connection of the output relays to the motor drive unit
- the correct connection of the housing to ground

![Warning]

Take care to properly connect the voltage regulator and the housing to ground. Danger to life!

The voltage regulator is normally supplied with 93 ... 265 AC, DC auxiliary voltage.

The unit can be supplied with a supply input with 36 - 72 VDC, on request.

![Note]

The VC 100 E was designed to meet the relevant EMC standards. In order to maintain the EMC requirements please observe the following instructions:
- make sure that the housing is grounded by means of the grounding screw attached to the housing.
- use shielded cables for the data communication between the VC 100 E-BU and the second VC 100 E-BU.

Ground the shields at both cable ends of the cable to the housing by means of the cable clamps supplied (see fig. 23).
5.3 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. A device for recording the voltage transformer voltage (= actual voltage) is recommended to assess the operation of the voltage regulator. The associated transformer should have a normal load.

a) Set the Local/Remote switch at VC 100 E-0 to Local position and select Manual operation (according to 4.3.2).

b) Set the ratios and configuration of the voltage and current transformers according to 3.1.3.

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. Bring the tap changer to the service position by manual control of the motor drive so that the desired voltage level is obtained.

e) Set VOLTAGE LEVEL to this value as described under 3.1.4.

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 operation 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 3.1.5. 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 has been reached.

h) Set BANDWIDTH according to 3.1.5 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 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 also 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 “int”. 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 3.1.7. Set the mode of operation switch to MANUAL, and reduce the desired voltage level, e.g. 110 V, to 110 V / 0.85 = 130 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 (IO-X1: b26/z26) must open, but the output relay RAISE must not issue a control command. Now set the desired response threshold for undervoltage blocking.

l) Set the response threshold for overvoltage detection U > to 115 % as described under 3.1.8. Set the mode of operation switch to MANUAL, and increase the desired voltage level, e.g. 110 V / 1.15 = 95 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 signalling contact (IO-X1: z24/b22) 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 3.1.9. A function check is not necessary.
6 Customer-specific control program ARS (Advanced Regulating System)

6.1 General

The voltage regulator VC 100 E offers the choice of two control algorithms which are independent from each other. Apart from the well-known 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 user-friendly 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 E 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 E.

It is possible, for example, to set an unsymmetrical control response and thus define the operation of the tap changer individually for those voltage ranges which are most important to the energy supply system.

By activating the function “Tendency” the quality of the voltage supply can be increased without requiring 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 E 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 (\(U_\text{>}, U_\text{<}, I\)) and auxiliary functions (line compensation, voltage level change, parallel control) of the voltage regulator VC 100 E remain active irrespective of the selected control algorithm.
6.2 Control criteria

The transformer voltage measured by the VC 100 E is compared with the set voltage level. The actual deviation is determined from the difference between these values and the set bandwidth.

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

A timer is started and only stopped when the preset delay time ± nT (+1T, +2T, ..., or -1T, -2T, ...) assigned to the magnitude of this deviation has elapsed, see fig. 24.

During this delay time the VC 100-BU determines the percentage of time during which the deviation was really present (see fig. 25), 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. 25.

The setting Tend = 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.

For 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 be permanently tolerated by the VC 100 E.

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 differently in a supply network. 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.

6.3 Parametering

The entire ARS parametering is carried out by means of the blue ARS key in the SPECIAL field on the VC 100 E-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 E-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 E-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:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>Desired voltage level</td>
</tr>
<tr>
<td>+1T</td>
<td>Delay time in case of positive deviations of &gt; 1 · (+Bw)</td>
</tr>
<tr>
<td>-1T</td>
<td>Delay time in case of negative deviations of &gt; 1 · (-Bw)</td>
</tr>
<tr>
<td>+2T</td>
<td>Delay time in case of positive deviations of &gt; 2 · (+Bw)</td>
</tr>
<tr>
<td>-2T</td>
<td>Delay time in case of negative deviations of &gt; 2 · (-Bw)</td>
</tr>
<tr>
<td>+3T</td>
<td>Delay time in case of positive deviations of &gt; 3 · (+Bw)</td>
</tr>
<tr>
<td>-3T</td>
<td>Delay time in case of negative deviations of &gt; 3 · (-Bw)</td>
</tr>
<tr>
<td>+Tend</td>
<td>Tendency value in case of positive deviations from the desired voltage level</td>
</tr>
<tr>
<td>-Tend</td>
<td>Tendency value in case of negative deviations from the desired voltage level</td>
</tr>
<tr>
<td>+Bw</td>
<td>Bandwidth in case of positive deviations from the desired voltage level</td>
</tr>
<tr>
<td>-Bw</td>
<td>Bandwidth in case of negative deviations from the desired voltage level</td>
</tr>
<tr>
<td>ARS OFF (ON)</td>
<td>Deactivating (activating) the ARS function</td>
</tr>
</tbody>
</table>
6.4 Setting ranges

<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>+ 3 T = 2 s...1800</td>
<td>+Tend = 70...99 %, Aus</td>
<td>+ Bw = 0.5 ... 10 %</td>
<td>OFF/ON</td>
</tr>
<tr>
<td></td>
<td>+ 2 T = 2 s...1800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ 1 T = 2 s...1800, Off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1 T = 2 s...1800, Off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 2 T = 2 s...1800</td>
<td>-Tend = 70...99 %, Aus</td>
<td>- Bw = 0.5 ... 10 %</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 3 T = 2 s...1800</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.5 Universal presetting of parameters

To facilitate setting of parameters during commissioning of the voltage regulator VC 100 E-BU, 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, if required, the 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 regulator.

Presetting at the factory

<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>to be set by user!</td>
<td>+ 3 T = 5 s</td>
<td>+ Tend = 97 %</td>
<td>+ Bw = 1.1 %</td>
<td>OFF</td>
</tr>
<tr>
<td></td>
<td>+ 2 T = 20 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ 1 T = 900 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1 T = Aus</td>
<td>-Tend = 97 %</td>
<td>- Bw = 1.2 %</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 2 T = 60 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 3 T = 10 s</td>
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</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 Uₙ
- 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.
6.6 Important notes

For the proper function of the voltage regulator in the ARS system, 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 needed.

If there is no control function for 31 min. the relay “function monitoring” is energized.

Parallel control can be effected in the ARS system without any restriction.

In the ARS mode both voltage regulators involved in the parallel operation of two transformers can keep their individually set values (which are optimized for single operation), except for the different voltage levels, without any negative effects on the function of the parallel operation.

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.

7 Parallel control

The individual or parallel operation of 2 transformers is automatically possible. It is not necessary - and indeed not possible - to use an additional parallel control unit (e.g. VC 100 E-PC) (see 1.2 Specified application).

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 (switch S1 on the PE card must be in position OFF!) or by the DIL switch S1 on the back of the PE card (without jumper on the terminal strip): S1 OFF - circulating reactive current method S1 ON - Master/Follower method (see connection diagram fig. 26). Thus the assignment of the function keys (fig. 27) is determined at the same time. For both methods it is necessary to connect the two voltage regulators by a shielded data cable.

7.1 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 correction 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 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 on the tap position is required.
7.1.1 System configuration, settings

Establish the additional connections between the two voltage regulators according to fig. 26.

Setting of the correction value (STABILITY, fig. 27)

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 10 % voltage correction in the voltage regulators when the value for the circulating reactive current corresponds to the rated current of the current transformer.

Setting the response threshold for circulating reactive current monitoring (SENSITIVITY, fig. 27)

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 „Alarm“ lights up and both voltage regulators are blocked when the circulating reactive current exceeds the set response threshold during parallel operation. The signalling relay contact (PE-X1:z6/z2) is activated after 30 sec.

Activation of the parallel control

The parallel control is activated by applying L+ to both voltage regulators at the terminals PE-X1:z24. The LED „Parallel“ lights up and the signalling contact (PE-X1:z6/z4) is activated.

7.1.2 Function test, putting into service

Presettings

NOTE! A precondition for the correct function of the parallel operation is the commissioning of the voltage regulators in the INDIVIDUAL mode according to 5.3 (L+ disconnected from PE-X1:z24).

The inputs for the current transformers must be connected and the VT, CT CONFIGURATION must be performed even if no line drop compensation is required.

The voltage regulators must have the same operating parameter settings for voltage level, bandwidth, delay 1 and, if required, line compensation.

If necessary, set STABILITY to „0“ and SENSITIVITY to „20“. Select „MANUAL“ mode on both voltage regulators.

Setting the correction value (STABILITY)

Operate the tap changers of the two transformers in INDIVIDUAL mode so that their voltage levels are identical and both voltage regulators are in a balanced state (no RAISE or LOWER presignal, the value indicated as deviation dU should be as small as possible and smaller than the bandwidth set according to 3.1.5).

Connect the transformers in parallel, apply L+ to PE-X1:Z24 on both regulator units. The regulator units must still be in a balanced state and the LED lamps for „Parallel“ must light up.
7.1.3 Parallel control failure

If one or both voltage regulators are signalling „Parallel Control Failure“ although the control inputs 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.
- SENSITIVITY value of circulating reactive current has been exceeded.

In such a case the regulators are blocked.

7.2 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 BCD or of a constant current of 4 ... 20 mA (4 mA corresponding to the lowest tap position, 20 mA corresponding to the highest tap position). The selection is done by means of DIL switch S2 on the back of the PE card.

S2 ON ➞ tap position input 4 ... 20 mA by PE card
S2 OFF ➞ tap position input BCD by VC 100 E-0.

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.

7.2.1 System configuration, settings

The additional connections are to be carried out on both voltage regulators as follows:

The DIL switch S1 on the PE card in position „ON“ determines the parallel control principle „synchronism control“

Bring the DIL switch S3 in position „ON“ when the transformer output voltage becomes lower instead of higher even though the tap position is increased.

The tap position signal of the motor drive is to be connected to PE-X1:b32/z32 when the tap position is signalled in mA (see 7.2 and connection diagram).
Setting the tap position range
(TAP MAX, fig. 27)

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

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

\( n_{\text{min}} \) = lowest tap position,
\( n_{\text{max}} \) = 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).

The indication is „TAP 1“ in the lowest tap position. When the tap position signalling is interrupted, the indication is „TAP 0“.

Master-Follower configuration (fig. 27)

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 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 (signalling relay PE-X1:z6/z2).

Activation of the parallel control

Parallel control is activated when on both voltage regulators PE-X1:z24 is connected to L+.

The LED lamp for „Parallel“ lights up and the signalling contact (PE-X1:z6/z4) is activated.

7.2.2 Function test, putting into service

Presettings

<table>
<thead>
<tr>
<th>NOTE</th>
</tr>
</thead>
</table>

A precondition for the correct function of the parallel control is the commissioning of the voltage regulators in the INDIVIDUAL mode according to 5.3 (L+ disconnected from PE-X1:z24).

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 measures according to 7.2.1 must be carried out and the tap position signalling must function correctly.

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

Connect the transformers in parallel and connect L+ to both voltage regulators at the terminal PE-X1:z24. The voltage regulators must remain in a balanced state.

Select the AUTO mode for the FOLLOWER voltage regulator. The LED lamps for „Parallel“ on both voltage regulators must light up.

With the MASTER voltage regulator in MANUAL mode, move the tap changer towards RAISE by one step. The FOLLOWER voltage regulator in AUTO mode must now automatically control the second transformer 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 (PE-X1:z6/z2) is activated after 30 sec.

7.2.3 Special features of BCD tap position with sign

- After switching on, the voltage regulator recognizes if a tap position with ± sign is present. The tap changer should not be in position 0 when the voltage regulator is switched on.
- The delay time for signal „parallel failure“ (PE-X1:z6/z2) is 40 s.

7.2.4 Parallel control failure

If one or both voltage regulators are signalling „Parallel control failure“ 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.
- An invalid tap position has been recognized.
- A difference of more than one tap has been recognized.

In such a case the voltage regulators are blocked.
Regulator parametering software VVR-Control

VRR-CONTROL offers the possibility of programming and interrogating the parameters of the voltage regulator VC 100 E-BU from a PC via the serial interface. A program disc is included in the standard delivery.

8.1 Hardware
The execution of the transmission program requires an IBM-PC compatible computer with MS-DOS operating system (version 3.3 or higher). The system should include a graphics card with VGA capability. The data transmission requires a bidirectional serial interface and a shielded data transmission cable.

Pin assignment for the transmission cable:
If the PC has a 9-pole interface connector:

<table>
<thead>
<tr>
<th>VC 100 E-BU (9-pole plug)</th>
<th>PC (9-pole socket)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCD 1</td>
<td>1 DCD</td>
</tr>
<tr>
<td>RxD 2</td>
<td>2 RxD</td>
</tr>
<tr>
<td>TxD 3</td>
<td>3 TxD</td>
</tr>
<tr>
<td>DTR 4</td>
<td>4 DTR</td>
</tr>
<tr>
<td>GND 5</td>
<td>5 GND</td>
</tr>
<tr>
<td>DSR 6</td>
<td>6 DSR</td>
</tr>
<tr>
<td>RTS 7</td>
<td>7 RTS</td>
</tr>
<tr>
<td>CTS 8</td>
<td>8 CTS</td>
</tr>
</tbody>
</table>

If the PC has a 25-pole interface connector:

<table>
<thead>
<tr>
<th>VC 100 E-BU (9-pole plug)</th>
<th>PC (25-pole socket)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RxD 2</td>
<td>2 TxD</td>
</tr>
<tr>
<td>TxD 3</td>
<td>3 RxD</td>
</tr>
<tr>
<td>RTS 7</td>
<td>4 RTS</td>
</tr>
<tr>
<td>CTS 8</td>
<td>5 CTS</td>
</tr>
<tr>
<td>DSR 6</td>
<td>6 DSR</td>
</tr>
<tr>
<td>GND 5</td>
<td>7 GND</td>
</tr>
<tr>
<td>DCD 1</td>
<td>8 DCD</td>
</tr>
<tr>
<td>DTR 4</td>
<td>20 DTR</td>
</tr>
</tbody>
</table>

8.2 Description of the program
VRR-CONTROL is started under DOS by entering

\[<A>:> mrvrr RETURN\]

In the development stage emphasis was put on user-friendly operation. All functions are mainly self-explanatory.

All entries are made via 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.

8.2.1 Main menu
The menu bar is in the upper part of the display screen. The individual menu items can be selected here by means of the cursor keys (left/right) or initial letter and the RETURN key (fig. 28).

The status bar which shows the current state of the data transmission is in the bottom part of the display screen. Possible errors in the communication with the voltage regulator can be read here (fig. 28).

A short „context help“ above the status bar describes how the program can be served at the moment (fig. 28).

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

28 Main menu and sub-menu „Communication“
8.2.2 Sub-menu Communication

This sub-menu appears after “Communication” has been selected (fig. 28) in the main menu. It contains a dialog window for the setting of the control parameters of the program:

1 PC-Port COM1, COM2, ...,:
   selection of the serial interface on the PC.

2 Interrogation clock min, 5 s, 10 s:
   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.

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:

– Does the interface cable comply with hardware specifications (point A)?

– Does the serial interface comply with program specifications?
   (Sometimes data transmission will not function via certain serial interfaces on the PC. In such cases it should be tried to use any other serial interface.)

– Is the voltage regulator in the correct operating condition?

8.2.3 Sub-menu Options

This menu allows to store the values of the parameter settings in a data file (1 Save Parameters) and to reload them into the voltage regulator (2 Load Parameters), fig. 29.

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. 30).

---

8.2.2.1 Language selection for display in VC 100 E-BU

After entering the number sequence 1, 3, 2, 4 in the main menu, special parameter 6 allows language selection.

Enter "0" for German and "1" for English.
At first all parameter settings are read from the voltage regulator under the option “Secure Parameters” and then indicated on the display screen (fig. 31).
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 E-BU. 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 E-BU directly.

First enter the version number of the voltage regulator for which the parameters are to be set, e.g. 02 (if VC 100 E-BU is equipped with extension card PE for parallel operation of two units) or 01 (standard). A different dialog window appears for each voltage regulator version (fig. 32).

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.

NOTE

This procedure does not require a communication with the VC 100 E-BU. If only this procedure shall be carried out, e.g., for pre-parametering on the PC, 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 file name.
8.2.4 Sub-menu Monitor

This sub-menu indicates the present operating status of the voltage regulator (fig. 33) including all measured values and the info data. The values are updated after a waiting time entered as “Interrogation clock”.

![Sub-menu “Monitor”](image)

**Voltage Regulator Relay VC100-DO Version 01**

- **Desired Voltage**: 105.0 V
- **Actual Voltage**: 99.9 V
- **Deviation**: -4.8 %
- **Actual Current**: 0.0 A
- **Apparent Power**: 0 kVA
- **True Power**: 0 W
- **Haltless Power**: 0 kVAR
- **Power Factor**: 1.00 [cos]
- **Phase Angle**: 0 °
- **Frequency**: 50.0 Hz

**PC-DATA/TIME**: 21/01/00 09:56:25

**BREAK**: ESC

**Communication** OK | **Read Parameter**
8.2.5 Sub-menu Parameters

Different parameter groups for the voltage regulator can be selected here by pull-down menu (fig. 34) and then the values set (fig. 35). 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.

8.2.6 Info

Here information on the program is shown (version, originator, ...).

8.2.7 Quit

The program is terminated.

Selection of groups of parameters

Setting of parameters
9 Troubleshooting

The voltage regulator is largely protected from malfunctions during operation failures by self-monitoring. If, nevertheless, a malfunction does occur, proceed according to the following short „Trouble-Shooting Guide“:

Failure symptom 1:
Undefined 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 (contacts IO-X1: b28/b30).
Possible cause: supply voltage failed.
Is supply voltage present
Terminal SU-X1: b2/b6 (in supply component VC 100 E-SU, spare fuse is included.
Is the fuse defective? If so, replace it.

Failure symptom 3:
Voltage indication 0.0 V.
Possible cause: measuring voltage failed.
Is the measuring voltage present on the contacts IO-X1: b32/z32?
Is the fuse defective (fig. 36)? If so, replace it.

Failure symptom 4:
“PARAM?” appears on the indicator, failure signalling contact closed contacts IO-X1: b28/b30.
Cause: Several parameter settings have been lost due to extremely high disturbances.
Procedure: Update the parameters (at 3.1) one after the other until “PARAM?” disappears.

NOTE
If the fault symptoms described above occur repeatedly, it must be assumed that the EMC stresses at the operating site of the voltage regulator are higher than the test values specified in the applicable standards.
In these cases the cause of the fault has to be eliminated at site by appropriate measures (screening, filters).
If, after the above tests and remedial measures the voltage regulator is still defective, it is recommended to consult MR.
## Commissioning Report

<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 transf.config.:</td>
</tr>
</tbody>
</table>

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

Notes:

Carried out: | Place: | Date: | Signature: |
## Commissioning Report

### Voltage regulator VC 100 E-BU

<table>
<thead>
<tr>
<th>Function</th>
<th>Setting range</th>
<th>Set value</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>Recommendation: setting of (0.7...1) (0.7...1) [U_{step} [%] of the transformer</td>
</tr>
<tr>
<td>Delay time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Delay 1</td>
<td>0 ... 180 s lin / int</td>
<td>s lin / int</td>
<td></td>
</tr>
<tr>
<td>- Delay 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 &quot;Lower&quot; 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></td>
<td>Referred to 100 V (secondary), see page 12, fig. 5</td>
</tr>
<tr>
<td>- Current transformer</td>
<td>100 ... 5000 A</td>
<td></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>V</td>
<td>Resistive, reactive voltage drop</td>
</tr>
<tr>
<td>- U_r</td>
<td>0 ... ± 25 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- U_x</td>
<td>0 ... ± 25 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- in steps of 1 V</td>
<td>in steps of 1 V</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Z-compensation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Voltage rise</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>Parallel control</td>
<td>Minimum circulating reactive current method:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* Stability</td>
<td>0 ... 100</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>* Sensitivity</td>
<td>0.5 ... 20 %</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>* Master / Follower method:</td>
<td>4 ... 40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>* Tap max.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* Master / Follower</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ Tend</td>
<td>0 ... 1800 s, off</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Tend</td>
<td>0 ... 1800 s, off</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ 1T</td>
<td>0 ... 1800 s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1T</td>
<td>0 ... 1800 s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ 2T</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 2T</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ 3T</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 3T</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ Tend</td>
<td>70 ... 100 %</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Tend</td>
<td>70 ... 100 %</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ Bw</td>
<td>0.5 ... 10 %</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Bw</td>
<td>0.5 ... 10 %</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OFF/ON</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Instructions for the setting of the regulating parameters are found in paragraph 5.3.

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 9 “Failures”.
11 Appendix

Connection diagram ________________________________________________________________ 165EN021
Connection diagram ________________________________________________________________ 165EN022
Connection diagram ________________________________________________________________ 165EN023

Block / connection diagram,
Standard models VC 100 E-SU, VC 100 E-0, VC 100 E-BU02 _______________________________ 165EN024

19-inch module frame, dimension drawing ________________________________________________ 898 832
Appendix

Voltage regulator VC 100 E
Connection diagram
Voltage regulator VC 100 E
Block / connection diagram (left section)
Standard models VC 100 E-SU, VC 100 E-0, VC 100 E-BU02

REINHAUSEN GERMANY
Voltage regulator VC 100 E
Block / connection diagram (right section)
Standard models VC 100 E-SU, VC 100 E-0, VC 100 E-BU02

165EN025
Voltage regulator VC 100 E
19-inch module frame, dimension drawing
898 832:0E