Description of the design and basic technical data

1. Characteristic.

UTXvRNT is a device with very expanded regulation, recording and remote control functions, destined to use in all the on-load tap changer regulation systems, on any high and medium voltage power lines, operating with directly earthed, compensated or isolated neutral point. It provides fast and reliable regulation. Extended functions of voltage drop compensation, 24-hours, scheduled, weekend and holiday settings, disturbance and event recording, voltage quality recording enable realization of the most sophisticated applications.

The device is equipped with serial and ethernet communication ports, which makes possible operation as a part of **CSR 5** system, in accordance with **XMD-CCbus** protocol and **IEC 870-5-103.**

Controller UTXvRNT can be delivered in **EURO 19“ 3U casing** – destined to be built into a cabinet or in CPRO63 casing – for surface mounting.

Irrespective of casing type, controllers are manufactured in a few versions, depending on internal circuits configuration:

- type “**UTXvRNT2**” is equipped with single voltage U and current I measuring circuits,

- type “**UTXvRNT3**” possesses two voltage U measuring circuits and two current (I) measuring circuits (preferred for three-windings transformers)

All variants are conventionally equipped with a graphic display, panel with 16 signaling LEDs, 8-key keyboard, 8 output relays and 14 binary inputs (8 high voltage inputs 110/220 [V] AC/DC and 6 inputs 12/24 [V]DC, destined for cooperation with tap changer position decoder. The regulator can be expanded with additional binary inputs and outputs.

UTXvRNT can be characterized by following features :

- multi-processor measuring and regulating system
- fully digital information processing
- galvanic separation of inputs and outputs (analogue and binary)
- operation with two or three-windings transformers
- compensation type XR and Z, set independently for each measuring circuit
- operation in automatic or manual mode
- four main regulation rules:
    - based on voltage U1 of circuit 1
    - based on voltage U2 of circuit 2
    - based on mean value of voltages U1 and U2
    - based on max value (U1,U2)
- overcurrent protection of tap changer's motor
- systems of energy quality control
- functions of tap changer remote control
- operation reporting, event and disturbance recording

2. Structure and principles of operation.

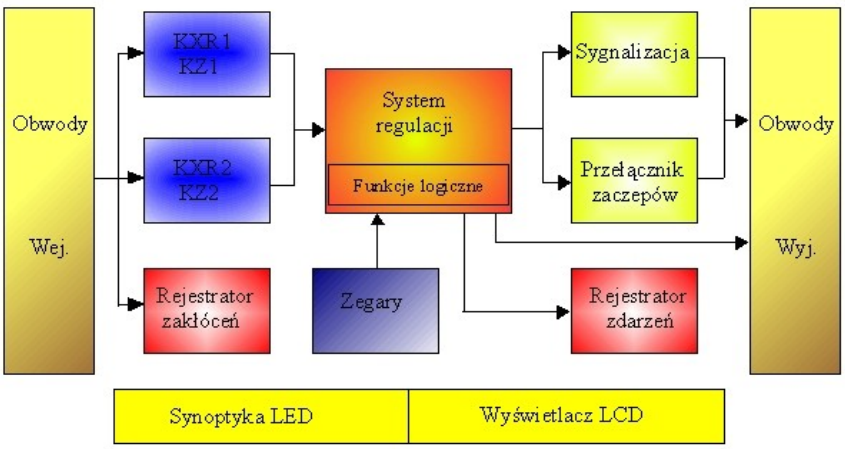
Measuring values of voltages and currents are connected to AA connector, while binary signals to connector IF. Input statuses are read by controlling processor. Measuring modules equipped with fast 12 or 14-bit converters ensure precise digital converting of signals with 1 [ms] resolution. Samples are stored in disturbance recorder module, and after preliminary processing, by means of Fast Fourier Transform and Euler's Integrate Method, vectors coordinates and modules of voltages and phase currents are determined.
On a base of programmed settings and present state of input signals, tap changer and signaling circuits are controlled through output modules of the regulator. In the same time, programmed signals and messages are sent to local panel of regulator. UTXvRNT is equipped with communication port, which realizes transmission between regulator and remote control system, in accordance with firmware protocol XMDs-CCbus or IEC 870-5-103. .

3. Functional structure.

Some features of UTXvRNT should be distinguished:

Compensation of XR and Z voltage drops (individually for two circuits)
Interlocking system : U>, U<, I>, (U1-U2) > etc.
Regulation system
Tap changer control module, including motor protection
Remote control interface unit
Disturbance recorder
Event recorder
Logic modules
Local mimic panel

what was presented graphically, in simplification below



The device should be treated as a series of independent functional modules, which can be connected by user in their operation by specific "configuration" of the device. Process of "configuration" consists in proper programming of input and output functions of particular modules. Detailed list of functional modules is placed in the table below.

Pos.	***Module name***	***Description***
1	Inversion of current I1(I2)	Current vector inversion through an angle of 180°, accordingly I1 and/or I2
2	Compensation XR of circuit 1	Determine of voltage drop on the line (lengthwise and lateral).
3	Compensation XR of circuit 2	Same as above
4	Compensation Z of circuit 1	Determine of voltage drop on the line (modules with limitation)
5	Compensation Z of circuit 2	Same as above
6	Regulation principle No 1 (U1)	U1 input, after making consideration to presumable compensation determines deviation
7	Regulation principle No 2 (U2)	U2 input, after making consideration to presumable compensation determines deviation
8	Regulation principle No 3 (U1+U2)/2	Mean value of voltages after compensation determines deviation of regulation
9	Regulation principle No 4 (maxU12)	Higher voltage, after compensation, determines deviation.
10	Interlocking U1>, U1<	Instantaneous signaling. Interlocking after delay
11	Interlocking U2>, U2<	Same as above
12	Interlocking (U1-U2) < I and II stage	Same as above
13	Interlocking I1>, I2>	Same as above
14	Signaling Ik	Equalizing current signaling (parallel operation – option)
15	Signaling U1 > U2	Signaling after delay
16	Signaling U2 > U1	Same as above
17	Motor protection	Based on measurement of I1 or I2, overcurrent defined time protection
18	Quality of energy recorder	Option
19	Event recorder	Released by inputs, periodically etc.
20	Disturbance recorder	Wave shapes recorder, fs = 1kHz, 8 disturbances x 2.3 s
21	LED mimic panel and Pu outputs	Freely programmable
22	24-hours settings (three sets)	Change of regulation level by preset value
23	Remote settings (three sets)	Change of regulation level by preset value, controlled by inputs
24	Holiday settings (10 sets)	Changes of levels, valid for particular days of the year
25	System clocks	Delays, date and real time clock

Mentioned above elements of the device can be practically freely functionally interconnected.

More detailed clarification of device configuration problem, definitions and explanations concerning input and output functions have been submitted below.

To understand this feature of the device, Reader should become familiar with informations below.

Definition 1.

Module is a functional part of the device intended to perform precisely defined function.

Definition2.

Input function is a conventional control input, which controls the operation of device functional module.

Definition 3.

Output function is a conventional output of any functional module of the device, destined for signal generation, which indicates operational status of that module.

Definition 4.

Input signals of IF group are physical transoptor inputs connected to the device through IF connector (see UTXvRNT connection diagram).

Definition 5.

Internal signals of SWE group form a conventional register of memory cells (bits). Every cell has input and output. To each cell, through its input can be written a value of single output function. Output of each cell can be used to control input function.

Definition 6.

Logic function is a functional module, which realizes logic expression

fxl = (Top) (A x B + C x D); - sum of two products
fxl = (Top) (A + B + C + D); - sum of four arguments
fxl = (Top) (A x B x C x D); - product of four arguments
fxl = (Top) (S=(A x B), R=(C x D)+zas); - RS flip-flop* (product of inputs)
fxl = (Top) (S=(A x B), R=(C x D)); - RS flip-flop (product of inputs)
fxl = (Top) (S=(A + B), R=(C + D)+zas); - RS flip-flop* (sum of inputs)
fxl = (Top) (S=(A + B), R=(C + D)); - RS flip-flop (sum of inputs)
fxl = (Impulse) (A + B + C + D); - RS flip-flop (sum of inputs)
fxl = (Wave) (S=(A + B + C + D), R=reset signal.;- RS flip-flop (sum of inputs)
fxl = (Latch) (S=(A + B + C + D), R=reset sig;- RS flip-flop (sum of inputs)

where :

A, **B**, **C**, **D** are arguments of the expression in simple or negated form and they can correspond to :

- "**0**" logic (FALSE),
- "**1**" logic (TRUE),
- status of single physical input from **IF** signal group

- status of output signal from logic function selected from **FXL** group
- status of output signal of internal signals; one from **SWE** group

Top – is programmed time delay.
* - resetting of a flip-flop after voltage loss;

Definition 7.

Value of an input function can be equal to one of the following values:
- 0 logic (FALSE),
- 1 logic (TRUE),
- status of physical input from IF signal group (INA1 - 15), (package of transoptor inputs IF)
- status of output signal from logical function, one from FXL,
- status of output signal from internal signals, one from SWE.

Definition 8.

Value of output function can be equal:
- 0 logic (FALSE),
- 1 logic (TRUE).

Definition 9.

Output for an output function is a "destination", where value of output function is written. It can be:
- one of the "physical" signaling relays,
- one of the signaling diodes LED, located on a front panel of the device,
- one of the memory cells, belonging to SWE internal signal group register,
- trigger signal for disturbance recording.

UTXvRNT has strictly defined list of available output functions.
During programming (configuration) of UTXvRNT, every output function is set according to following pattern:

Control of relay or input of logic function	Yes/No	**Number of relay** **Number of function**	No.	**Type**	__-- _--_
Control of LED	Yes/No	**Number of LED**	No.	**Type**	__--
Internal signal	Yes/No	**Number of signal**	No.		
Disturbance recorder trigger	Yes/No				

Type can assume following values:
_--_ - dynamic signal, e.g. active as long as the cause of signal generation is active,
__-- - static signal, e.g. signal is active from the start of the cause until it will be reset by operating staff.

Similar situation is for the input functions. Particular modules, as for instance compensation modules, are equipped with input functions to control, for instance blocking or activation of the given function.

During programming (configuration) of UTXvRNT, every input function is set according to following pattern:

Function enabled: Yes/No
Control input : Yes/No
Number of input : IF (INA1-14), FXL, SWE,
Active level : low/high (logic 0/1)

Practically, one is very often faced with the necessity of conditioning functioning of one module with an output signal generated by the other one. To use the signal of the output function generated by module "X" to control input function of module "Y", following things must be done:

- signal of the module "X" output function must be assigned to SWE signal group with a number "i"
- then, signal No. "i" from the SWE group or output from the one of the logical functions FXL, where one of arguments is SWE signal No. "i" must be assigned to the input function of module "Y".

It can be clearly seen from above, that:
To make available a signal from the given functional module's output function to control the input function of any other module, it must be assigned to one of the SWE memory cells first.
In the next chapters of this documentation, details are presented concerning input and output functions, their meaning, and their mutual connections.

4. Basic technical parameters.

Amount of analogue inputs	- max. 4
Amount of voltage inputs	- 2
- measuring range of U1 and U2 voltage	- 2.0 Un (Un= 100[V])
Amount of current inputs	- 2
- measuring range of current	- 2.0 In (In = 1 or 5 [A])
Overload withstand of 5A current inputs	- 100 In / 1[s], 2 In / continuously
Overload withstand of 1A current inputs	- 100 In / 1[s], 5 In / continuously
Voltage withstand	- 3Un / continuously
Dynamic withstand of 5A current inputs	- 200 In/ 20 [ms]
Dynamic withstand of 1A current inputs	- 250 In/ 20 [ms]
Rated burden of analogue inputs	
- current	- max. 0.2 [VA] at 1In
- voltage	- max. 0.04 [VA] at 1Un
Insulation withstand	- 3 [kV] AC/DC, 5 [kV] 5[μs] pulse
Amount of binary inputs	- 14
High voltage section	– 110[V]DC nominal voltage case: (0-60)[V]= FALSE, (70-121)[V]=TRUE – 220[V]DC nominal voltage case: (0-145)[V]=FALSE,(165-242)[V]=TRUE
Low voltage section	– 12[V]DC nominal voltage case: (0-8)[V]=FALSE,(9-30)[V]=TRUE – 24[V]DC nominal voltage case: (0-16)[V]=FALSE,(18-30)[V]=TRUE
Amount of binary outputs	- 8 (programmable)
- switching capacity	- 250 [V]/8 [A] AC, 250[V]/0.3 [A] DC
Casing	- 19 " EURO 3U or CPRO63
Power supply	- 80 - 230 [V] DC/AC
Power consumption	- max. 10 [VA]
Operation temperature	- -5° +50[°C]
Storage temperature	- -10° +60[°C]
Weight CPRO63 case	- max. 8kg
Weight 3U case	- max. 5kg
Disturbance recorder - capacity	- 8 disturbances
Amount of recorded analogue channels	- 4
Amount of binary signals	- 15
Duration of single disturbance	- 0,4 [s]pre-event + 1,9 [s] event time
Capacity of event recorder	- ~2000 records
Record length	- 32 bytes
Supervisory system interface	- Ethernet, RS232, RS485 and CL(optoisolated), fiber optic(optional)
Type of transmission	- asynchronous
Transmission speed	- 300 ÷ 57600 bits/s

5. Programmable settings of the regulator.

The regulator has three banks of settings. Each bank comprises a complete set of settings. Two settings banks PAR.NR.1 and PAR.NR.2 are totally independent. Selection of active bank is performed by changing the status of input PAR_SEL by means of local panel or through the communication link. Programming is possible using the local panel or computer running SAZ2000 software, but only if the device is unlocked. Additional settings bank (factory default) is stored in read-only memory, and is configured by C&C company according to client's requirements. This bank is operationally used in case it is selected by user or if a memory containing user's settings is corrupted.

Selection of active set is performed using function PAR_SEL, available from local panel or remotely using communication link and SAZ 2000 software. There are four options for active settings bank selection:

- number 1,
- number 2,
- factory default,
- bank selection based on the status of dedicated input PAR_SEL.

Selection of present setting bank by using PAR_SEL input is performed according to following rule:

- low status turns on settings bank No. 1
- high status turns on settings bank No. 2

Change of setting bank results in resetting of the device. Maximal restart time is about 200 ms. A few general remarks describing rules of regulator's programming are put below:

1. Settings are divided into a few thematic groups:
   main settings,
   settings for circuit 1,
   settings for circuit 2,
   regulation settings,
   settings for changes of regulated level, (remote and 24-hour settings, time schedule),
   settings for cooperation with tap changer,
   settings for interlocking system,
   masks for error signaling,
   masks for disturbance recorder,
   settings of logical, input and output functions

2. All the functions of the regulator can be conditioned to the status of one of the physical binary inputs **IF (INA 1 - 14)**, one of the internal signals **SWE** and one of the logical functions **FXL,** where both the number of the input and active level are programmable.
For all the inputs general rule applies, that selection of the input No. “0” means, that there is no control input assigned to the given function of the regulator. Single input can be assigned (is able to control) to unrestricted number of input function.
CAUTION ! Amount of available physical inputs depends on applied binary input module and is designated by connection diagram. Typically for **IF** group, module with 14 binary inputs is used, with inputs divided into 2 groups: 8 high voltage inputs 110/220 [V] AC/DC and 6 signals 24[V] DC for cooperation with tap position decoder.

3. Course of regulator's operation can be signaled or monitored with aid of 8 relay outputs, 16 synoptic outputs (LEDs on front plate of UTXvRNT) and disturbance recorder. **LED No. 16 is permanently assigned to the function "ERROR".** Each of dozens output functions can be freely assigned to any relay output, any synoptic output or any internal signal. Each output can be assigned to any number of output functions. Active level of synoptic outputs, relay outputs and internal inputs is fixed and always high. Additionally, for synoptic outputs and relays it is possible to define if signal should be dynamic or static type. Static type of a signal means, that signaling of output signal appearance lasts from the beginning of the signal until it is manually reset (latched signal). Dynamic type of a signal means, that signaling lasts only when output signal is active. **Internal signals are always dynamic ones.** For all the outputs general rule applies, that selection of the output No. "0" means, that there is no output assigned to the given function of the regulator.