TECHNICAL DESCRIPTION **ND 397 - 18/07/2018**

REMOTE TERMINAL UNITS for TELECONTROL & FAULT DETECTION in MV/LV INDOOR SUBSTATIONS

1ST REVISED EDITION / 16 JAN 2019

ABBREVIATIONS

LB	Load Breaker
CCS	Control Center System
DSL	Digital Subscriber Line
GPRS	General Packet Radio Services
IED	Intelligent Electronic Device
RTU	Remote Terminal Unit for Telecontrolling Substation Equipment
ADU	Analog Data Unit with accompanying Current / Voltage Sensor Set
RTD	Resistive Temperature Detector
TD	Technical Description
HTTPS	Hypertext Transfer Protocol Secure
SFTP	SSH(Secure Shell) File Transfer Protocol
FTPS	File Transfer Protocol SSL(Secure Sockets Layer)
IPsec	Internet Protocol Security

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Remark: In case of doubt due to differences between the English and the Greek version of this document, the Greek version's terms prevail.

1 Introduction – Scope

This specification refers to the provision of a number of Telecontrol RTUs for Telecommanding and Fault Detection purposes for the supervision of indoors MV/LV substations, connected to the MV network of HEDNO.

The distribution network (3-phase balanced) is composed of 150/20KV (Yy0) transformers in primary substations and 20(or 15)/0,4KV (Dy11) transformers in secondary substations of HEDNO and customers, connected through underground and overhead lines.

The neutral node is solidly grounded at the sending end at the HV/MV substation (MV node of HV/MV substation), through a resistance limiting the single phase earth fault current to 1000A. The MV network has the following characteristics:

- Nominal system voltage: 15 kV and 20 kV.
- Maximum system voltage: 24 kV.
- Rated frequency: 50 Hz.
- Short circuit withstanding level (Symmetrical 3-phase fault level): 9,6kA (15kV) – 7,2kA (20kV).

There are 1 or 2 MV/LV transformers of nominal power 630kVA or 1000kVA each, at the secondary substations. The LV network that departs from the transformers is three-phase 50Hz of rated voltage 230 / 400V with 4 conductors and a grounded neutral node, with grounding method either TT or TN-S.

2 Equipment general characteristics

The operating environment of the required Equipment is MV/LV substations located in building basements, underneath street pavements or dedicated buildings.

2.1 Telecontrolled equipment

The equipment that shall be remotely or locally controlled and/or supervised includes:

- 1 or 2 MV LB clusters of 2,3 or 4 breakers each. Each cluster also includes 1 MV/LV transformer fuse-protected breaker for the protection of the 20/0,4kV transformer, which is not to be controlled by the RTU. Each LB cluster's control status (Local/Remote) shall be fed to the RTU as a double digital signal (See Table 4 par.6.4).
- Underground MV 3-phase lines of (NAEKEBA 3X240 RM) or (NA2XS2Y 3X240/25+25AL) cables, connected at MV cubicles in straight-type terminations.
- The LV section (-s) of the MV/LV transformer(-s), which comprise 1 (or 2) LV switchboard(-s) and the three-phase line(-s) (2X1X300mm^2 or 3X1X300mm^2 J1VV- R per phase) connecting the LV side (-s) of the transformer(-s) to the switchboard(-s).
- Substation auxiliary devices like water level measurement devices and pumps, IEDs like power or energy meters, etc.

The LBs installed utilize DC operated mechanisms, mainly of 48V but also (~20% of the installed) of 24V. The LB operating voltage shall be supplied by the RTU.

The signaling voltage is used for identification of the LBs' or external devices' status. LB clusters are designed to accept signaling voltage in the range 12VDC/AC-230VDC/AC. RTU's digital inputs shall support external voltages up to at least 60VDC (See Table 3 par.6.2.1).

2.2 Operating conditions

The substations that will accommodate the equipment described herein have the following environmental conditions:

- Ambient air temperature: -10°C to +55° C.
- Relative humidity: 5% to 93% non-condensing.

The supplied equipment shall be suitable for long-term trouble-free operation inside the above-mentioned limits proven by the environmental test reports and tests of paragraph 11.1.1.

2.3 Dimensioning – Space Configuration

The RTU shall be a compact device that can be easily installed in all predicted locations. It shall consist of the following elements, namely **Controller** and **Battery(-ies) compartments**, respectively.

One of the following two configurations is acceptable:

a) Both compartments shall be housed in a single external cabinet and not physically separated. Both compartments shall be easily accessed from the external cabinet's front door.
b) Each compartment is contained in its own external cabinet.

The **Controller** compartment contains the logic device that monitors and/or controls the following elements: LBs, MV lines, Batteries, Power Supply, Communication Module and auxiliary devices (see par. 6.2.1). The Controller compartment shall also contain all sub-systems that make the RTU operational (controller, ADU, power supply, charger, terminal blocks, etc.). An appropriate control panel shall be located on the Controller compartment's front door or inside it (see par. 6.3).

The RTU external cabinet's dimensions and weight shall not exceed the values indicated in the following table.

Max dimensions	**Values**	**Notes**
Width (mm)	670	Extensions that protrude from the main body (e.g. hinges, glands) shall be considered. An external battery compartment shall conform to these maximum dimensions.
Depth (mm)	450	
Height (mm)	950	
Max weight (kg)	35	Max value for RTU, excluding batteries and current sensors weight. An external battery compartment's weight shall not exceed this value, too, with batteries weight excluded.

The external cabinet shall be wall-mounted, shall be designed for the service conditions specified and fitted with robust locking mechanism capable of being

padlocked by a padlock with a shank of 8mm minimum with the door in the closed position. The front door shall have appropriate document holder for the safe-keeping of the documents of wiring, installation manuals etc. accompanying the RTU.

The previous subparagraph's requirements (except for the documents requirements), apply to any external battery compartment. Cabling between this and Controller's external cabinet shall comply with par.2.2 (See also Chapter 3).

The **Communication Module** shall not be included in the bid and shall be supplied by HEDNO in a specially made cabinet. Therefore the RTU's external cabinet shall provide port connections through appropriate cable glands (for data link, power supply) to accommodate this module. More information about the requirements and characteristics of the communication module is stated below (paragraph 8.5).

3 Environmental protection

The external cabinet(-s) of paragraph 2.3 shall be rated per IEC 60529 at least at IP4X and per IEC 62262:2002, concerning the protection provided against external mechanical impacts, at least at IK07. Non-connected external connector ports and used or unused cable glands shall conform to at least the cabinet's IP rating.

The cabinets shall be made of one of the following materials:

- stainless steel per EN 10882-2, adequate for installation in C2 environments, per ISO 12944
- hot-dip galvanized steel or iron following the various processes such as sawing, cutting, punching, drilling, bending, cutting, etc. according to ISO 1461 or PPC/XK 11.02 and the specific thickness overlap referred to therein
- anodised aluminum (minimum oxide thickness 10μm) or aluminum electrostatically painted with epoxy powder coating
- thermoplastic material with flammability rating equal to 650°C or higher, per IEC 60695-2-11:2014.

It is permissible for the outer casing to be made of a combination of the aforementioned materials, as long as any electrochemical erosion of one or more of them is inhibited. However, the requirements for each material remain.

In any case, any metallic parts (external hinges, screws, washers etc.) shall be made of stainless steel per EN 10882-2, adequate for installation in C2 environments, per ISO 12944.

Condensation of water vapour on internal parts shall be avoided by appropriate means, e.g. via thermally insulating the case, etc. The bidder shall provide technical description in the tender documentation about the way this is achieved. Solutions employing forced heating or cooling elements shall not be accepted.

All internal parts shall be compatible to operating conditions of par. 2.2. All vents shall be screened against vermin entry. The abovementioned requirements apply to any external battery compartment. The connection between RTU and external Battery compartments, **which is part of this tender**, shall conform to the abovementioned IP, IK and flammability ratings.

4 Physical connections

4.1 External connections

The RTU's external cabinet shall have:

1) Latched connectors, which shall be polarized in order to secure that each of them, may be connected with its own plug only. Each connector shall correspond to a LB. The signals that shall be fed through corresponding pins of each connector are shown in Table 1 and the exact pin assignment shall be agreed with the Contractor.

Table 1 RTU connector pin assignments per LB

Pin (random)	Signal abbreviation	Comments
1	+Vc	DC voltage (48V or 24V) for LB operation
2	GND	
3	LB open command	Double digital point signal (0-1/1-0) from RTU
4	LB close command	
5	+Vs	LB signaling voltage (DC ≤60V)
6	GND	
7	LB status (closed)	Double digital point signal (0-1/1-0), LB signaling voltage dependent
8	LB status (open)	
9	Earth switch on (LB grounded)	Double digital point signal (0-1/1-0), LB signaling voltage dependent
10	Earth switch off (LB not grounded)	
11	spare	Digital point ports, LB signaling voltage dependent, input of LB related digital signals e.g. from optional MV presence sensing device in each LB cubicle
12	spare	

Acceptable connector positions of placement are the front, the bottom and the sides of the RTU's external cabinet. They shall not obstruct the door openings, while connected with their corresponding plugs. There shall be four (4) (eight -8- for the extended RTU model) connectors, already wired to terminal blocks inside the RTU (see par.4.2).

Each cable supplied for the connection of the RTU to the LBs (carrying signals of Table 1) shall be already terminated on one end to an appropriate plug. Each external cable's termination on its plug shall satisfy the IP rating of the RTU's external cabinet, ensuring the continuity of cable's electrical/mechanical insulation throughout its entire length. Each plug's cable shall be flexible multi-conductor, flame retardant and number coded (LiYCY or equivalent per IEC 60502-1) Nx1,5 mm^2 of at least 10m length (15m for the extended RTU model), where N≥12 and equals the connector's number of pins. These cables are included in the scope of supply.

2) Openings through the bottom secured with appropriate cable glands. Appropriate number of analog and digital inputs and outputs, utilizing terminal blocks (see par.4.2), shall be available in the Controller compartment for incoming cables (detailed signaling in par. 6.4). The final contractor shall be informed concerning the exact number of the openings required. Nevertheless,

Table 2 summarizes the necessary cables entering the RTU and Battery Compartment and respective openings.

All incoming cabling (signals different than those stated in Table 1) from LBs, and other external devices shall be routed through these openings, shall be firmly installed through cable glands and shall not reduce the IP rating of the external cabinet.

Table 2 External cabinet's connections

Cable numbering (random)	**Cable designation**	**Comments**	**Included in the scope of the supply**
1	230Vac power to RTU	Opening suitable for J1VV cable	No
2	ADU feed cable	Openings for accommodation of 4 MV and 1 LV Current sensing sets (8 and 2, respectively for the extended RTU model) and voltage sensors (see par.6.2.2.1), regardless of the number of LBs (2-4 or 8) controlled	Yes (Applies only to the current sensor sets)
3	RTU to Battery(-ies) connection	For external battery compartment: 1 opening (2 if additional temperature sensing of battery compartment is employed)	Yes
4	LB cluster signaling (relevant to Table 3 digital inputs)	1 opening (2 openings for the extended RTU model), signaling voltage is applied per par. 4.1-1)	No
5	Substation external signaling	Number of openings depends on number of external sensors and IEDs	No
6	Communication module	2 openings, 1 for Ethernet FTP cable, 1 for 12VDC output to Comm. module	No

4.2 Internal cable terminations

The RTUs shall be delivered with the incoming wires from all the connectors already terminated to an appropriate terminal block. Unused (spare) connector pins shall also be connected to this terminal block in the RTU for future use. The terminal block shall be already wired to the Controller, for the basic configuration of three LBs (eight for the extended RTU model). The terminal block's signal assignments shall be finalized in cooperation with the Contractor. It shall be clearly marked, documented and easily accessible. This will facilitate the disconnection for testing purposes.

All terminal blocks, that are to accommodate Input/Output signals from/to LB cluster and external auxiliary devices, shall have plug-in or screw type terminals of ≥2,5mm^2 cross section, except from the terminal block that shall accommodate the secondary windings of the CTs (if applicable) of par. 6.2.2.1, which shall be of ≥4mm^2 cross section (1.5 mm^2 in the case of use of current sensors with built-in

transducers or with a rated current ≤ 20mA in the secondary winding). This requirement does not apply to:

- Ethernet cabling to Communication module which shall be terminated to the corresponding male-type connector
- Temperature sensing ports (dedicated analog inputs and relevant 24 VDC outputs of par.6.2.2.3 are excluded)

Generally, cable routing shall be performed in a way that ensures an easy access to them and does not obstruct the door openings.

5 Earthing

Provision shall be made to ensure the electrical continuity of all electrically conductive exposed parts. Earthing terminals shall be fitted to all such equipment. An earthing strap shall be provided between the electrically conductive parts of the door and the tank of each cabinet.

An earthing terminal shall be provided for connecting the RTU metal work and mounting frame to the substations's earthing system. The earthing terminal shall be suitable for accommodating a 16 mm^2 Cu conductor.

6 RTU Functionality

6.1 General requirements

The RTU shall be of a modular design, capable of monitoring and controlling 2 to 4 LBs at the substation (standard version). A special version of this RTU (extended version) shall also be offered with the capability of monitoring and controlling up to 8 (eight) LBs at the substation (See Chapter 10). Corresponding MV 3-phase underground lines and the LV lines from the transformer(-s) shall also be monitored, in terms of voltage and current measurements and detection of fault currents.

Standard version RTUs shall be supplied for **monitoring** and **control** of **3 (three) LBs** and designated as **"Type 1"** and **"Type 2"** for the control of 48VDC and 24VDC LBs, respectively. The extended version RTUs shall be supplied for **monitoring** and **control** of **8 (eight) LBs,** and designated as **"Type 3"** and **"Type 4"** for the control of 48VDC and 24VDC LBs, respectively**.** The contractor shall have ensured that the conversion of RTU from one type to another (e.g. from 3 into 4, 3 into 2, 8 into 7 controlled LBs) is a well-documented and technically accepted procedure. Related parts (e.g. Expansion modules, current or voltage sets, etc.) shall be included in the spare parts list (see chapter 14) along with detailed documentation about the technical characteristics and the conversion process.

Moreover, the RTU, via an embedded watchdog service, it shall monitor the status of the external equipment, e.g. communication module and the internal equipment, e.g. power supply, battery(-ies) and the Controller itself.

Logged events include internal faults (Controller, ADU), external device (LB, auxiliary devices) change of status, local/remote control assumption,

communication with CCS failures, etc. and are presented below. These events shall be transmitted to the CCS at configurable regular time intervals, at each interrogation from CCS or immediately after their generation (see paragraphs 6.4, 8.1 and 8.3). In general, the RTU shall be designed for:

- Implementation of SCADA functions
- Electrical Measurements (current and voltage vectors and derived quantities cosφ, active and reactive power)
- Monitoring the qualitative characteristics of the above-mentioned electrical quantities in the LV side of the transformer(-s)
- Detection of fault currents in MV & LV lines.

The local or remote programming of the RTU shall also involve the designation of the I/O status changes – the status of certain inputs or outputs - that lead to the automatic energization of certain RTU functions and outputs, utilizing IEC 61131-3 (PLC) or equivalent functionality (see par. 7.1).

6.1.1 Monitoring requirements

6.1.1.1 LB monitoring

For every LB the RTU shall monitor the following (see also Table 1):

a) The change of the state of the LB (open-close).
b) The Ground switch position (on/off).
c) Two (2) auxiliary digital signals.

The transition from one state to another provokes the switchover of respective contacts. The RTU shall employ appropriate double digital inputs (0-1/1-0) for this purpose (see Par. 6.4).

6.1.1.2 Analog data monitoring

The RTU via the ADU shall perform the following:

a) MV and LV line current measurements (see par.6.2.2.1).
b) Voltage measurements at the LV side of the transformer (-s) (see par.6.2.2.2). The RTU shall monitor, according to EN50160 & IEC 61000-4-30 class S, harmonics, voltage dip and swells, voltage interruption, frequency and voltage unbalance.
c) Power measurement at the LV side of the transformer (-s) using the abovementioned current and voltage measurements. Power measurement, including the calculated active power, reactive power and energy, in the four quadrants, shall be in accordance with IEC 61557-12 and IEC 62586-PQI-S or IEEE 1159 for the power quality.
d) Temperature measurements (See also 6.1.1.3d).

6.1.1.3 RTU monitoring function

Equipment's firmware shall perform extensive self-checking in order to monitor the most important functions. Relevant alarms and diagnostics shall be transmitted to the CCS (see Par. 6.4).

The following shall be monitored

a) Presence of 230V AC external supply
b) DC Output presence for LB switchgear control

c) Internal Software or Hardware hang-ups or freezes (watchdog). In such an event, RTU shall perform a restart. This event is not required to be transmitted to the CCS.
d) Temperature threshold overrun inside controller compartment and at the additional temperature sensors' locations. For measurements inside the controller compartment, appropriate sensor shall be included in the RTU, either embedded or connected to a dedicated port, different from the temperature sensing port(-s) of par. 6.2.2.3. Measurements shall be logged in configurable time intervals (see par. 7.2) and also used for temperature compensation of battery charging (see par. 9.3).
e) Battery status from measurement of battery's voltage. Alarm may arise when the RTU is operating under battery and the Battery (-ies) are in the deep discharging phase or the Battery (-ies) have reached end-of-life status or have malfunctioned (See chapter 9).
f) Battery load test status (success/failure), assuming the full RTU's load. (See chapter 9)
g) Communication status with the CCS (see 6.1.2.2d).
h) The status of the RTU control (Local/Remote).
i) Signaling voltage presence to the digital inputs.
j) ADU health status, concerning any malfunction.
k) RTU's external door status (open/close).
l) Data & Communication -security related activity (see par. 8.2)
m) AC Power supply unit health status (see par. 9.1)

6.1.1.4 MV & LV line fault detection

The RTU through the ADU shall monitor the MV lines connected to the controlled LBs and the LV line (-s) from the transformer (-s) to the LV switchboard (-s) for detection of power-line faults (short circuits either phase to phase or phase to ground) and other faults stated in par. 6.2.2.1 and par. 6.2.2.2. The current, voltage and time limits that distinguish a fault from normal operation shall be user-adjustable. The inrush current shall be detected by evaluating the ratio of second harmonic or by another scientifically proven method. A delay applied on the detection sensing time on power recovery is not acceptable.

6.1.2 Control requirements

6.1.2.1 LB control

For every LB the RTU shall control:

The status of the LB (opening-closing). The operation commands shall be given either locally or remotely from the CCS. Double digital signals (0-1/1-0) shall be used for each command per LB.

The following local operation modes shall be included:

- Immediate LB operation only after the user presses the LB selecting switch and – without releasing it – subsequently presses the corresponding operation switch. In the case of a touchscreen, sequential pressing of these buttons is acceptable.

- Delayed LB operation. The time delay for the local LB operation shall be set from the control panel, from 0 to at least 60 sec in user adjustable steps.

The RTU shall be able to control DC operated LB motors with peak current demand of 12Amps (solenoid actuation – see par.9.2). Therefore, the Power Supply shall be rated accordingly (see Chapter 9). LB max operation time shall be adjustable at least in the range from 3 to 10sec in user adjustable steps. The time adjustment shall be done by software remotely and locally.

6.1.2.2 Additional required control signals

a) Time synchronization from the communication with the CCS. (See chapter 7)
b) Battery load test command issued at least remotely. (See chapter 9)
c) Commands for changing the settings of the RTU. (See paragraphs 6.3, 7.1, 8.3, 19.a), 19.b))
d) Restarting communication module by temporarily cutting and restoring power to the 12V output. This shall be issued from the Controller, after successive failures to communicate with CCS. The number of failures shall be configurable.

6.2 Additional requirements

6.2.1 Digital I/O

The following inputs and outputs shall be provided for external device monitor or control. LB cluster signaling voltage shall be supplied by the RTU.

Table 3 Aux Digital Inputs - Outputs

Digital I/O type	Digital I/O port numbering (random)	Signal abbreviation	Comments
Inputs	1	LB cluster Local Mode status	Double digital point signals (0-1/1-0), RTU signaling voltage dependent
	2	LB cluster Remote Mode status	
	3	MV fuses' status OK	
	4	MV fuse(-s) blown	
	5	Spare (or 2nd LB cluster Local mode status for extended RTU model)	Substation or RTU signaling voltage (DC≤60V) dependent[1]
	6	Spare (or 2nd LB cluster Remote Mode status for extended RTU model)	
	7	Spare (or 2nd LB cluster MV fuse status OK for extended RTU model)	
	8	Spare (or 2nd LB cluster MV fuse(-s) status blown for extended RTU model)	
	9	Spare	
	10	Spare	
	11	Spare	
	12	Spare	
	13	Spare	
	14	Spare	
	15	Spare	
	16	Spare	
Outputs	1	Spare	Per IEC-61131-2 part 3.15/Rated as the LBs control outputs
	2	Spare	
[1]All LB cluster mode status signals (Local/Remote) and MV fuse status signals depend on RTU signaling voltage			

6.2.2 Analog inputs

All analog signal ports shall have reverse input protection (where applicable), at least 12-bit digital resolution and shall be electrically isolated up to at least 1,0kV rms AC between input and power circuit's ground. Their input characteristics, such as jitter correction and delta variation shall be locally or remotely configurable (this requirement does not apply to the RTD or thermistor or thermocouple sensor inputs of par.6.2.2.3).

6.2.2.1 ADU current measurement and fault detection

The RTU shall provide per controlled LB three (3) (or 4 if an additional residual current sensor is used) current measurements (one on each MV line phase conductor) through the use of a set of respective current sensors and appropriate analog inputs. It shall also provide current measurements at the LV side (-s) of the single transformer installed (standard RTU version) or the two transformers installed (extended RTU version).

For the MV line measurements, the standard version of the RTU to be delivered shall have at least 9 inputs from corresponding current sensors, expandable to 12 (respectively 12 and 16 if an additional residual current sensor is used). The extended version of the RTU to be delivered shall have at least 24 inputs from corresponding current sensors (or 32 if an additional residual current sensor is used). The possibility of integrating a residual current sensor into the sensor set is provided to bidders so that faults can be detected according to the ANSI detection curves listed below.

For the power quality line measurements at the LV side (-s) of the single transformer installed (standard RTU version) or the two transformers installed (extended RTU version), the RTU to be delivered shall have 3 and 6 inputs from corresponding current sensors, respectively.

Acceptable sensors in any case are:

- Current transformers (CT) with 20mA to 5A secondary windings
- Current transformers with embedded transducers powered by the RTU with output of at least one of the following standards: 0..20mA, 4..20mA, 0-10V DC or rated output in the range 0…20 V AC. The power supply of the transducers is included in the scope of this tender.

Sensors offered shall be compatible with the respective analog inputs of the RTU. In case CTs with 20mA to 5A secondary windings are offered, the respective analog inputs (CT terminals) of the RTU shall employ appropriate insulated jumpers (bridges) for short circuiting of each CT terminal. These jumpers can be omitted only if the current sensors have suitable provision against the development of dangerous voltages at the ends of their windings, e.g. through the use of a diode.

A set of MV-suitable current sensors consists of:

- Three (3) MV-suitable 1-phase current sensors and optionally one (1) MV-suitable additional residual current sensor.

A set of LV-suitable current sensors consists of:

- Three (3) LV-suitable 1-phase current sensors.

The number of current sensor sets provided with each RTU shall equal the default number of LBs controlled and the LV 3-phase lines monitored, namely three (3) MV sets and one (1) LV set for the standard and eight (8) MV sets and two (2) LV sets for the extended RTU model. The CTs shall be suitable for installation on MV cables (LV cables for the power quality and fault detection at the LV side of each transformer), rated at 50Hz and compliant with the requirements of the standards of the IEC61869 series where applicable.

1-phase MV-side current sensors shall have the following characteristics:

- MV Cable type Split-Core CT
- Minimum Window: 40mm
- Primary Nominal Current (I_n): in the range 400-600A

- Precision Class: 1 or better
- Overcurrent precision factor: FS2 or FS5
- Signal Line Length: At least 10m per CT (15m for the extended RTU model)
- Operating Temperature: -10 to 55 ^{o}C

Residual Current Sensor shall have the following characteristics:

- MV Cable type Split-Core CT
- Minimum Window: 150mm
- Primary Nominal Current (I_n): in the range 10 – 40A
- Precision Class: 1 or better
- Overcurrent precision factor: FS2 or FS5
- Signal Line Length: At least 10m per CT (15m for the extended RTU model)
- Operating Temperature: -10 to 55 ^{o}C

1-phase LV-side current sensors shall have the following characteristics:

- LV Cable type Split-Core CT
- Minimum Window: 80mm
- Primary Nominal Current (I_n): in the range 900-1000A
- Precision Class: 1 or better
- Overcurrent precision factor: FS2 or FS5
- Signal Line Length: At least 10m per CT (15m for the extended RTU model)
- Operating Temperature: -10 to 55 ^{o}C

Faults (current or voltage) in conjunction with the voltage measurements of paragraph 6.2.2.2 (where applicable) shall be detected according to ANSI standard detection curves:

- ANSI 50/51 for phase overcurrent fault detection at the MV side and at the LV side of the transformer
- ANSI 50N/51N for phase to earth overcurrent fault detection at the MV side and at the LV side of the transformer
- ANSI 47 or ANSI 46BC for broken conductor check at the LV side of the transformer
- ANSI 27/59 for phase undervoltage/overvoltage at the LV side of the transformer

The RTU shall also support directional overcurrent detection at the MV side, to be applied in the future at substations where LBs employ suitable measurement VTs. The detection, using 3 single-phase inputs of paragraph 6.2.2.2, shall be based on standard ANSI curves:

- ANSI 67 for directional phase overcurrent fault detection
- ANSI 67N for directional phase to earth overcurrent fault detection

For each detection scheme per LB, at least 2 groups of settings shall be provided. Each group's settings shall be fully adjustable regarding current and voltage deviation settings and operating time.

Faults of permanent and transient type shall be discriminated and if selected during the parameterization, they shall be transmitted to CCS.

6.2.2.2 ADU Voltage measurement

The RTU shall have at least the following analog inputs, which shall be used to identify current and voltage faults, for voltage quality measurements and power measurements (par. 6.1.1.2):

- Three (3) 1-phase voltage inputs for LV power quality measurements and fault detection, expandable to six (6) for the standard version of the RTU
- Six (6) 1-phase voltage inputs for LV power quality measurements and fault detection, expandable to nine (9) for the extended version of the RTU,

all supporting 0V - 230V AC for the connection to the LV side of the transformer(-s) of the substation. The expandability of the voltage inputs is required if future controlled LBs employ measuring VTs thus providing a reference voltage for the detection at the MV side of directional phase overcurrent faults (according to ANSI 67 & 67N), broken conductor (according to ANSI 46 or 46BC) and undervoltage/overvoltage (according to ANSI 27/59).

The configuration of these analog inputs, as a part of the parameterization process, shall involve at least the following:

- Type of input signal (voltage, current, range, etc.)
- Phase correction of -180^{o} : $+180^{o}$
- Magnitude correction

  Any MV sensors are outside the scope of this tender.

6.2.2.3 ADU Spare inputs

The RTU shall have one (two for the extended RTU model) RTD or thermistor or thermocouple sensor input, in order to measure temperatures such as ambient air, or transformer oil temperatures. This(-ese) port(-s) is(are) different from the port used for temperature sensing inside of controller compartment.

Alternatively, the replacement of any of the temperature sensing ports with dedicated analog input(-s) (supporting 4…20mA DC standard) is also acceptable. In this case, a special 24VDC output per such analog input shall be provided in the RTU, in respect to the requirements of par.9.1, for the supply of the current loop.

The configuration shall involve, through the selection of user-identified set-points, the automatic energization of certain outputs or functions, utilizing IEC 61131-3 (PLC) or equivalent functionality.

6.2.3 Local Communication

The RTU shall have an Ethernet port **(Communication port)** suitable for its **communication** with the **communication module** (See par. 8.1). Specifically, this port shall adopt 100 Base-TX standard and typical RJ-45 female form factor. The same physical port shall be used at the same time for protocol communication with the SCADA system and for remote configuration of RTUs operational parameters and protocol configuration (ModBus and IEC 60870-5-104).

An additional port **(IED port)** shall be available on the RTU for future IED integration, utilizing **Modbus** based on Ethernet 100 Base-TX or RS-485 standard interfaces (Modbus TCP or RTU, respectively).

Also, the RTU shall accommodate a port **(Setup/Diagnostics port)** for the communication with a portable PC on-site, using USB and/or Ethernet interfaces. The use of this port is for troubleshooting, local RTU's parameter configuration, logged event list downloading, maintenance and firmware update purposes.

Abovementioned ports shall be standard electrically isolated ports.

6.2.4 Local Distribution Automation Functions

The RTU's firmware shall include the functionality of programming Automation Functions, e.g. between compatible equipment in adjacent substations. The RTU shall be fully compliant with IEC-61850, which shall be embedded in the RTU's firmware (GOOSE messaging can be excluded) without the need for additional license purchasing. Programming per RTU (or group of RTUs) of simple or complex functions shall be executed by the configuration tool of paragraph 7.1.

6.3 Control panel

The RTU shall be equipped with appropriate control buttons and indicators (LEDs) forming a control panel for the operation of the unit, of the controlled switchgear and monitoring of the equipment's status. The control panel shall reside either on the controller's external enclosure's front door (thereby meeting the IP, IK and flammability requirements of the enclosure) or inside the Controller's compartment as a part of the Controller itself.

The control panel shall be able to operate in the environmental conditions of paragraph 2.2 without causing failure and/or mal-operation. Details shall be provided in the tender documentation.

The control panel shall be equipped with:

- A switch for LOCAL / REMOTE operation of the RTU. In LOCAL position the RTU shall not execute incoming commands from CCS.
- LEDs to indicate the control status of the RTU (LOCAL, REMOTE), the control status of the LB cluster(s) (LOCAL, REMOTE), the health status of the RTU, of the battery (-ies), the positions of the LBs and earth switches (paragraph 6.1.1.3) and the presence of the supply voltages (mains 230V, LB operating and signalling).
- Buttons (or other means) for LB operation.
- Button (or other means) for "restarting" the RTU and all the subsystems, including the communication module (see par.9.4). Alternatively, this is allowed to be placed inside the controller's compartment.
- Ports mentioned in paragraph 6.2.3 (it is also acceptable that these are inside the controller's compartment, clearly marked).

A built-in touch-screen in place of some or all of the above-mentioned controls and/or indications is acceptable, apart from the RTU LOCAL/REMOTE function, which shall be operated by a switch and its status shall be indicated by a LED.

6.4 RTU Functions & I/O list

The following table summarizes the functions of the RTU presented in the previous sections.

All digital input ports shall be configurable through software or hardware (dip switches) as double digital inputs (DDI) or single digital inputs (SDI). DDI designation shall employ at least the exclusive OR (XOR) logic (e.g. DDI number 3 assigned to DI terminal pins 3 and 6, is high only if one of DI pin 3 and 6 is high). Software or hardware interlocking is acceptable, as long as it is thoroughly justified in the accompanying documentation.

The aforementioned are also required for all digital output ports.

Table 4 Functions and inputs/outputs of RTU

Function/ State	**Signal type***	**Comment** **	**Comment**	**Total number of I/O involved (DI/DO: digital input/output, AI: analog input)**	**Internal Ref. (§)**
Change LB state (Open command)	I/O Command	24 or 48 V DC output, Local & remote control,	Separate 2 bit Commands/signals, per LB Locally logged activity****	3 DDO expandable to 4 and 8 DDO for the extended RTU model	6.1.2.1, 9.2
Change LB state (Close command)					
LB state (Open)	I/O Status	LB signaling-powered 2 bit digital inputs, Local & remote indication		3 DDI expandable to 4 and 8 DDI for the extended RTU model	6.1.1.1 a)
LB state (Close)					6.1.1.1 a)
Local immediate operation	Function	Local control only	Locally logged activity		6.1.2.1
Local delayed LB operation	Function	Local control only	Locally logged activity		
Change RTU control state (Local-Remote)	Internal Command	Local only, 2 bit command	Locally logged activity	Depending on the key type for switching between states	6.3
RTU control state (Local-Remote)	Internal Status	Local & remote indication, 2 bit signal	Locally logged activity		6.1.1.3 h)
Restart RTU & all subsystems	Internal Command	Local & remote control and indication	Locally logged activity, Restarts all systems inside RTU and Communication module		6.3, 9.4
LB Ground Switch state (LB Grounded)	I/O Status	Local and remote indication	Separate 2 bit binary signals, LB signaling-powered digital inputs, per LB Locally logged activity	3 DDI expandable to 4 and 8 DDI for the extended RTU model	6.1.1.1 b)
LB Ground Switch state (LB Not Grounded)					
LB related spare digital signals (e.g. from optional	I/O Status	Local and remote indication,	Separate 2 bit binary signals, LB signaling-powered digital	6 DI expandable to 8 and 16 DI for the extended RTU model, through spare pins of	Table 1

MV sensing device in each LB cubicle)			inputs, per LB Locally logged activity	RTU latched connectors of Table 1		
ADU data	Measurements	Remote indication	Analog inputs for 3-phase Voltage/Current /Power Measurements per LB, Local storage/archiving-Local/Remote download	Standard RTU model	Extended RTU model	6.1.1.2, 7.2, 6.2.2
				9-12[4] (or 12-16[1]) AI from MV side, 3 AI from transformer's LV side	24 (or 32[1]) AI from MV side, 6 AI from transformers' LV sides	
				(for current measurements)		
				3-6 AI	6-9 AI	
				for voltage measurements (0V : 230V AC)		
RTU external door status (open/closed) monitoring	Status	Remote indication	1-bit digital input allocated, RTU signaling voltage dependent, Locally logged activity	1 SDI		6.1.1.3k)
External device status monitoring (Substation water penetration, Water-pump working, Substation door open/close status, etc.)	Status	Local & remote indication	Substation signaling voltage (DC≤60V) dependent, Locally logged activity	≥12 spare DI[3]; ≥8 spare DI[3] for extended RTU model;		6.2.1
LB cluster Local-Remote Mode	I/O Status	Local & remote indication	2 digital inputs allocated, separate 2-bit binary states, RTU signaling voltage dependent, Locally logged activity	1 DDI (2 DDI for extended RTU model)		6.2.1
MV fuse status OK/Blown	I/O Status	Local & remote indication		1 DDI (2 DDI for extended RTU model)		6.2.1
External device controlling	Command	Local & remote control	2 digital outputs allocated, Locally logged activity	2 SDO or 1 DDO (configurable)		6.2.1
IED monitoring/ control	Status /Command	Local & remote control and indication	Ethernet or RS-485 port supporting Modbus protocol, Locally logged activity	1 port minimum		6.2.3

Diagnostics	Status	Local & remote control	Local & Remote download	1 port minimum	6.2.3, 7.1
Software or Hardware hang-up or freeze System Restart	Internal Status/ Function	Internal automatic restart of RTU	Number of restarts configurable		6.1.1.3c)
RTU Signaling voltage status	Status	Local & remote indication	Locally logged activity		6.1.1.3i)
Battery Health Status	Status	Local & remote indication	Locally logged activity	Battery Voltage Monitor	6.1.1.3e)
				Battery Load Test	6.1.2.2b)
Modem restart after: Communication failure(-s) or Command	Status /Command	Local & remote control	Number of failed communicating attempts before 12V DC output reset configurable, Locally logged activity	Suitable output for resetting modem voltage	6.1.2.2d), 9.4
RTU Power supply normal/abnormal status	Status	Local & remote indication	Locally logged activity		6.1.1.3m)
230V AC presence monitoring	Status	Local & remote indication	Locally logged activity		6.1.1.3a)
RTU LB control voltage presence monitoring	Status	Local & remote indication	Locally logged activity		6.1.1.3b)
Time synchronization with CCS	Status /Command	Local & remote control and indication	Locally logged activity		7.2
Data and Communication-Security Monitoring	Status	Internal function, Remote indication	Security related activity locally logged		6.1.1.3l), 8.2
Temperature limit overrun monitoring (ADU).	Status	Local & remote indication	Locally logged activity. External or embedded sensor shall be included in the RTU for temperature measurements in the Controller compartment.	2 (3 for extended RTU model) Temperature measurements: 1 inside the Controller compartment (embedded sensor or dedicated input[2]) 1 (2 for extended RTU model) external dedicated input(-s)[2,5]	6.1.1.3d), 7.2, 6.2.2.3,
Remote Parameterization	Control	Remote***	Use of Communication Port, Locally logged activity	In case of licensed software, six (6) full licenses shall be offered	7.1, 8.2

Local Parameterization	Control	Local	Use of Setup/Diagnostics Port, Locally logged activity		6.3, 7.1, 7.2

*** Alarm designation of status parameterized in RTU & Scada**
****Local refers to RTU's control panel operation/indication, Remote refers to CCS-SCADA operation/indication**
*****Remote refers to Maintenance WebServer**
******"Locally logged activity" is written in order to emphasize that data is stored in the RTU's local storage**
[1] In case of Residual Current Sensor, one input is added per LB
[2] RTD or thermistor or thermocouple sensor input
[3] Configurable as SDI or DDI by software or dip switches
[4] 9-12 is for 3 expandable to 4 per LB
[5] The external dedicated input(-s) can be replaced by analog input(-s) (4-20mA), provided that for each one, a 24VDC output shall be offered in the RTU.

7 Configuration - Memory

7.1 Configuration

The RTU shall be configurable locally and remotely. Configurable settings are listed in the following table.

Table 5 Configurable parameters

Parameter abbreviation	Comment	Internal Reference (§)
Alarm assignment of status change	Supported for all internal and external signals, ADU related and digital	6.1
Type of Information sent to CCS	• Following an alarm condition • After RTU's interrogation from CCS • At preset time intervals	6.1, 6.1.2.2, 8.3
Automation functions	Enabling/Disabling, Programming	6.2.4
Number of communication failures to CCS	For communication module restart function	9.4
LB operation mode: Local delayed operation	Mode selection Delay set	6.1.2.1
LB operation activation time	Time set	6.1.2.1
Digital input/output function assignment		6.1, 6.2.2.3
Clock sync with CCS	Method and time of sync to time-server applied	7.2
ADU connected equipment parameters	Current/Voltage sensor type and ratio, temperature sensor type, signal input-output, DELTA variation, jitter correction	6.2.2
ADU data logging frequency/thresholds	Current limits, Voltage limits, Sampling frequency, Detection method/curves, Standards followed (IEC 61000-4-30, EN50160, etc.)	6.1.1
ADU MV/LV line fault detection/discrimination		6.2.2.1

Communication module, IED settings	Port/Communication protocol settings	6.2.3
Data & Communication-Security settings		8.2
LB control voltage select (24/48 VDC)	If applicable	9.2
Firmware update	Remote (through configuration tool or by webserver)/Local	7.1, 8.2
Battery load test activation frequency	Automatic activation at preset time	9.3, 6.1.2.2b)
Battery voltage check frequency	Automatic activation after preset time elapsed	9.3, 6.1.1.3e)

A configuration tool, based on PC and fully compatible with concurrent Microsoft® Windows versions, shall be provided for configuration of the RTU. In case of licensed software, six (6) licenses shall be offered with the RTU. This tool shall be connected locally or remotely to update the RTU's firmware and download or upload the configuration into the RTU. This procedure shall be able to be performed in parallel with the SCADA protocol communication. Locally the PC where the maintenance tool is installed shall be connected to the RTU through the Setup/Diagnostics port (See par. 6.2.3).

A webserver shall be integrated into the RTU and shall provide facilities for maintenance, settings - including data & communication security settings (see par.8.2) - and historical logs management. This Webserver shall be accessible locally by means of a standard laptop PC through the Setup/Diagnostics port (See par.6.2.3) and remotely, too.

In the environment of the webserver and the configuration tool, markings, messages, commands shall be in English with the ability to use Greek. During the period of finalization of the equipment designs of par.16, the designation of the aforementioned markings, messages and commands in Greek shall be determined by HEDNO.

7.2 Memory

The RTU shall provide storage of at least 5.000 time-tagged events in an internal non-volatile memory. These events will be all the state changes and alarms (internal and external), the switchgear operations, changes to operating parameters and settings and ADU logged data.

The RTU shall employ an internal time stamping method (Event Log) for these events and alarms as well as an internal battery or super-capacitor backed-up real-time clock (expected battery life > 10 years). All events shall be written to the Event Log in chronological order. Time resolution shall be no more than 1 msec. Log files shall be produced in non-proprietary wide-spread formats. They shall be available for download remotely from CCS.

Synchronization of the RTU's internal clock with that of the CCS shall be done in regular configurable time intervals with appropriate messages issued by the CCS either via the SCADA protocol or SNTP.

The local user shall have access to the time settings and the alarm and event list through a portable PC (using Diagnostics port, see paragraph 6.2.3).

8 Communication

8.1 Means of Communication

The equipment (RTU) shall communicate with the Central Control System (CCS) of a SCADA via GPRS or DSL connections using the IEC 60870-5-104 protocol. HEDNO will provide the required SIM cards and GPRS routers with a private APN network range and non-public static IP addresses. The RTU shall provide the necessary DC operating power for this communication module (par. 9.4) and shall also have an Ethernet port that shall be used for the communication with this module (**Communication port** of par.6.2.3). RTU shall try to establish communication with CCS under the following conditions:

- CCS interrogates RTU.
- At configurable time intervals.
- In case of an alarm condition.

The Bidder shall describe the procedure that the RTU follows in order to detect loss of communication with the CCS and subsequently restart the communication module.

8.2 Data and Communication Security

In order to secure all controls and data acquisition, the RTU shall be designed to employ secure access based on RBAC (Role-based Access Control), compatible with a full centralized RBAC management.

At least the following functions and data shall be controlled through RBAC:

- Configuration files
- Software update
- User management
- Executing program or shell command
- I/O on local maintenance access

Local and remote access connection shall be secured for maintenance (locally and remotely) with HTTPS, SFTP or FTPS, IPSEC and SSH protocols. The RTU service application shall support individual user passwords and shall enforce a high complexity of passwords. The RTU shall lock the access after several password errors (configurable).

The RTU shall not contain active default, guest and anonymous accounts. All remote access to root accounts on the RTU shall be disabled. All Vendor-owned accounts, where feasible, shall be removed. The list of all accounts on the RTU shall be provided by the Supplier.

The RTU shall provide a local audit trail for all security events that occur. Log files shall be produced in non-proprietary wide-spread formats. Security events shall be logged locally in a dedicated security log or/and on a server.

The RTU shall support local and remote firmware updates, through the use of a configuration tool or a webserver (see par.7.1), utilizing the aforementioned security protocols.

8.3 Communication with existing central control systems

HEDNO has in operation two types of CCSs: the Telegyr TG8000 that uses the IEC 60870-5-101 protocol and the EFACEC SCATEX+ that uses the IEC 60870-5-104 protocol. The Supplier will have to implement the communication to the 2 SCADA systems, mentioned above based on the interoperability and address tables attached.

The communication between the RTU and the SCADA of EFACEC shall be direct and use IEC 60870-5-104 . The communication between the RTU and the SCADA of Telegyr shall be performed via Protocol Converter (Gateway) as described in paragraph 8.4 for conversion of the protocol of the offered RTU to the IEC 101 of Telegyr. In this latter case, IEC 60870-5-104 will be used to communicate between Gateway and the RTUs and a serial link with IEC 60870-5-101 between the Gateway and the Telegyr SCADA (see Figure 1). In all protocol implementation, every RTU shall be assigned with a unique combination of the Application/ASDU Address and the Link/Device Address.

The SCADA system shall interrogate each one of the RTUs in a predefined time interval and acquire the information described in paragraphs 6.1.1 and 6.2.1. This time interval is user selectable per RTU from the SCADA system. The RTU shall respond to these requests, but also transmit events or alarms as they are generated. Each data type shall be individually configurable to be sent or not to the SCADA.

8.4 Protocol Converter (Gateway)

The protocol converter (Gateway) shall respect the following requirements:

1. Conversion of the IEC 60870-5-104 RTU protocol to IEC 60870-5-101 of Telegyr TG8000 SCADA system.
2. Each protocol converter (Gateway) shall be able to communicate with and manage the data from at least 40 RTUs.
3. The Gateway shall have at least 2 LAN ports available to communicate with the RTUs using a GPRS Router or a DSL internet VPN connection.
4. The protocol converter (Gateway) shall be configurable with PC based software. The software package will be provided by the Supplier. The configuration will be saved in the PC as a portable file and can be downloaded and uploaded from Gateway by the user.
5. The protocol converter (Gateway) must support at least the following functions.
   a) Communication frame monitoring for master and slave protocol.
   b) Modem operation status monitoring.
   c) Internal database monitoring.
   d) Internal database event display.
   e) Internal database and communication protocols setting.
   f) Interrrogate, upon start, of secondary substation status in case of gateway power down or restart. During this procedure the Gateway shall broadcast to SCADA system all entities as invalid, until the interrogation procedure is complete.

8.5 GPRS/DSL Routers

HEDNO will provide a private communication network for the communication between the HEDNO's SCADA Central Control Systems (CCS) and the RTU. HEDNO will provide also the suitable communication module/routers at the RTU and at the CCS sites. The network will use static IP addresses, GPRS and DSL physical connections and the IEC-104 protocol. During the tests to verify the compatibility of the provided system with the existing SCADA systems as well as during the final system configuration, all the communication infrastructure and equipment shall be provided by HEDNO.

The bidders shall state in their offer the following:

- A verification of acceptance of routers with nominal power consumption of 6 W without affecting the battery autonomy or the operating temperature range
- Available 12 VDC power supply, and a separate 1.5A resettable fuse (see par.9.1, 9.4), for the communication module
- LAN port interface specifications
- The minimum TCP IP Network characteristics, if required, such as the bandwidth, throughput, latency, jitter and error rates.
- Any other parameters requirements necessary for the compatibility of the communication infrastructure.

9 Power supply

9.1 General

The RTU shall be supplied by the substation's low voltage (230V/50Hz). It shall be surge protected against voltage spikes as per T2 & T3 classification of IEC 61643-11 and protected against neutral cutout. It shall be capable of enduring the harsh electromagnetic conditions of the substation, proven by the type tests of par. 11.1.1. It shall have adequate power supply in order to provide power to individual circuits for:

- charging of the batteries
- control voltage for the LBs,
- signaling voltage, for wet digital inputs
- 24VDC supply for 4-20mA analog input(-s) of par. 6.2.2.3 (if applicable)
- operational voltage for the communication module and
- the local controller itself.

Each abovementioned circuit shall have its own overcurrent protection, which may involve self-resetting devices (employing for example PTC thermistors) in line with a mandatory hand-resettable device. This device shall be either a thermal magnetic circuit breaker or changeable fuse and shall be commercially available and not be of a proprietary design. All DC circuits shall be protected against reverse polarity input. The power supply circuitry shall be equipped with over-power and over-temperature protection. The selection of the power supply scheme shall be such that the simultaneous charging of the batteries and the control operation of the LBs shall not have an effect on the RTU operation.

The Power supply's status shall be monitored and in case of malfunction, relevant alarm shall be sent to CCS. Possible implementation is by a dedicated dry digital output connected to RTU's digital inputs.

9.2 LB control output

RTUs shall be installed in:

- substations having LBs with rated control voltage of DC 48V
- substations having LBs with rated control voltage of DC 24V

The RTU shall not allow simultaneous operation of two or more LBs. The LBs' operating (DC) current peak is ~12A (~5-10ms from 0A to peak – solenoid operation) followed by constant current ~6A (~2-8sec duration, depending on the LB manufacturer). These figures stand for both 24V & 48VDC LB clusters.

The quantities of each type (48 or 24VDC) are:
85% of the total amount of RTUs purchased shall be rated at 48VDC.
15% of the total amount of RTUs purchased shall be rated at 24VDC.
Nevertheless, the contractor shall have ensured that conversion of one type to another (48 to 24V and vice versa) is a well-documented and technically accepted procedure. Related parts (e.g. Power Supply, etc.) shall be included in the spare parts list (see chapter 14) along with detailed documentation about the technical characteristics and the conversion process.
Acceptable implementation is also the following:

- RTU inherently supports both voltages, set locally by e.g. a dip switch or via the parameterization process (locally, via the control panel only).

9.3 Electrical Supply Backup system

In case of 230VAC network power failure, there shall be suitable battery supply for the continuous supply to the relevant circuits of par.9.1. Means for the recharging of the battery(-ies) shall be included in the RTU and shall employ temperature-compensated battery charging method. The charger shall be able to keep the battery(-ies) constantly fully charged with minimal loss of its(their) life (float charge mode). The charger shall satisfy the requirements of both, the battery and the load. Over-charge protection shall be implemented in the charger.

Batteries shall not be recharged when battery temperature exceeds 50°C ± 3°C. Recharge time for the battery(-ies), from "protective low-cutoff" to 80% or more of full battery charge capacity, shall not exceed ten (10) hours.

The battery(-ies) shall provide energy for the operation of all units (RTU and communication module). The RTU shall only use batteries of nominal voltage of 12V. Batteries shall be delivered with the RTUs. Batteries delivered, shall be pre-installed into the respective compartment, but with their terminals not connected. The production date of the batteries, which shall be clearly marked on their casing, shall not be more than 6 months earlier than the date of delivery of their respective RTUs. The batteries shall be hermetically sealed and maintenance free. They shall be deep cycle, sealed prismatic lead-calcium based AGM/VRLA (Absorbed Glass Valve Regulated Lead Acid). Batteries shall be certified by the manufacturer to operate over a temperature range of –10 °C to +55 °C. They shall have a design life expectancy of at least 5 years at 20°C operating temperature. The bidder shall provide detailed documentation from the manufacturer of the batteries to prove the

above-mentioned design life. Battery terminals shall be covered and electrically insulated to prevent accidental shorting.

The batteries shall comply with IEC 60896 Part 21 & 22 and have adequate capacity:

- to supply the operation of the RTU and communication system for at least 24 hours without charging (i.e. with AC supply OFF).
- to perform at least 8 subsequent cycles of operations (1 cycle = open & close or vice versa) during the above time interval. The Supplier shall provide documentation of the discharge charts and available capacity per temperature range, of the batteries used.

The bidder shall include in the offer the proof of its compliance with these requirements (according to the battery manufacturer specifications), giving with enough detail how the necessary capacity of the battery was chosen. Tables showing both the nominal and the maximum consumption of the RTU shall be provided, considering the communication module's consumption, stated in the paragraph 8.5.

Automatic battery cut-off circuit (protective low-cutoff) shall be provided in the RTU. It shall operate when the battery DC voltage drops below the safety limit (deep discharge), which may damage the batteries. Appropriate alarm must be generated and transmitted (several minutes before the cut-off) to the SCADA CCS.

The charging status of the batteries shall be monitored and tested automatically. The battery system shall incorporate a temperature compensated **battery load test** facility, which on-demand (at least remotely, that is, from the CCS) or at preset time intervals:

- draws power needed for RTU's and external devices' operation for a preset time duration from the battery(-ies) and
- monitors the battery's(-ies') voltage drop during this time.

Apart from the load test, the voltage across the battery terminals shall be monitored.

The battery types provided shall have such external dimensions and electrical characteristics, as of batteries commercially available and not be of a proprietary design.

9.4 Communication module

A 12 VDC power supply shall be provided for the communication module. It shall be monitored and controlled locally or remotely (par.8.5). In case of a configurable number of successive communication failures with the CCS, RTU shall cut the power to this output for a few seconds and then resupply the module. Restarting the RTU (locally or remotely) shall involve cutting this power supply, too.

10 Extended version of RTU

A special version of the RTU shall be offered with the capability of monitoring and controlling up to 8 (eight) LBs at the substation (extended version). The extended version RTUs that will be supplied shall be fully configured for **monitoring** and **control** of **8 (eight) LBs.** The extended version RTU for the control of **48 VDC**

and **24 VDC** LBs shall be designated as **"Type 3"** and **"Type 4",** respectively. It is permissible to separate the extended version of RTU into two sections (e.g. via master-slave mode), each of which shall be located in its own outer casing with its own control panel and shall control and monitor 4 LBs with the corresponding MV lines and LV side, under the following conditions:

- the two sections shall be displayed and managed in the CCS functionally unified as a unit
- the sum of the external dimensions and the weights does not exceed the maximum dimensions and maximum weight of the following table and of the table in paragraph 2.3
- there is one connection with the communication unit for these two sections
- the connection between the two sections, which is included in the scope of supply, must be in accordance with the IP, IK and flammability requirements of par. 3.

All requirements of this TD apply also for the extended RTU model, unless otherwise explicitly stated. The following values of the table of paragraph 2.3 apply for the extended version of the RTU:

Properties	**Values**	**Notes**
Max weight (kg)	55	Max value for RTU, excluding batteries weight. One external battery compartment is allowed, which shall not exceed this value, too, but with batteries weight included.
Max height (cm)	120	
Minimum number of LB open-close cycles	12	For battery capacity calculation. (See par. 9.3)

11 Tests

11.1 Type tests

Table 6 refers to type tests which shall be carried out before the series production of equipment and prior to the delivery of the first lot (and also prior to lot acceptance tests). It also contains the requirements for the execution of each test, namely the applicable ports or component involved and the minimum acceptable test levels (applied voltage, EM field intensity, etc.).

The type tests shall be carried out by a test laboratory accredited by a recognized independent private or public laboratory accreditation body. Each test shall be carried out in conformity with one of the relevant standards stated in Table 6. The test laboratory, the tests' time schedule, the standards on the basis of which

the tests will be carried out as well as the number of samples, shall be proposed from the Supplier to be approved by HEDNO's Inspection Service within two (2) weeks from the successful execution of the tests of paragraph 11.4 of this TD. Simultaneously within this same time period, the Supplier shall have available samples of the equipment (RTU, current sensor sets, etc.) ready to be shipped to the test laboratory.

HEDNO will request the execution of the below mentioned type tests to the test laboratory which will then send the results of the type tests directly to HEDNO.

In case of failure of the type tests the Supplier must first analyse and report to HEDNO the reasons of the failure. After making the necessary changes, the Supplier may submit new samples within one (1) month from the announcement of the materials failure to him, for the repetition of the tests. In case of a failure on the new samples HEDNO will terminate the Contract due to Supplier's fault.

The cost of the tests shall be borne by HEDNO in case the results are successful while in case of a failure their cost shall be borne by the Supplier. The costs for the samples as well as their transport to the test laboratory will be charged to the Supplier in both cases of results (failure or success of the tests).

During the period of the validity of the contract, no modification to the study, planning and construction of the equipment is permitted. The specifications of the pending technical issues during the finalization period of paragraph 16, which will be made on the initiative of the HEDNO, are excluded. In case of any modifications detected, in comparison to the documentation stated in par.16, HEDNO will terminate the Contract due to Supplier's fault.

11.1.1 Type tests for monitoring and control circuits

Table 6 Type tests to be conducted and acceptable type test reports

Index No	Test Reports to be attached to the Technical Bid		Tests to be conducted at the beginning of the execution of the contract	TYPE TEST REPORTS MINIMUM ACCEPTABLE TEST LEVELS / TYPE TEST LEVELS		
	Reports acceptable per:	***Applicable Ports for test execution***	***Requirements for test execution / Applicable Ports***			
Steady state voltage withstand tests						
1	RTU / AC Power Supply Unit	RTU AC Supply voltage input	RTU AC Supply voltage input	**IEC 60870 -2-1:** Table 18 Class VW3: 2,5 kVrms /50Hz /1 min	**IEC 60255-27**: Table C.6 Class I Equipment, Overvoltage category III & Pollution Degree 2: 2,2kVrms /50Hz/1min	**IEC 61010-1**: Table K.6, Overvoltage category III & Basic Insulation: 2,21kVrms /50Hz/1min per Par. K.1.3.1 (Note 3)
2	RTU / Component	RTU Digital inputs / Component digital inputs	RTU Digital inputs	**IEC 60870 -3:** Table 6 Class 3 (2,5 kVrms /50 Hz /1 min)	**IEC 60255-27**: Table C.6 Class I Equipment, Overvoltage category III & Pollution Degree 2: 2,0kVrms /50Hz/1min (2,2kV for working voltage >150 and <300 VDC)	**IEC 61010-1**: Table K.11, Secondary Circuits & Overvoltage category III: 1,8kVrms /50Hz/1min per Par. K.2.2
3	RTU / Component	RTU Analogue inputs / Component analogue inputs	RTU Analogue inputs	**IEC 60870 -3:** Table 7 Class 2 (0,5 kV /DC/1 min)	**IEC 60255-27** : Table C.6 Par.: 10.6.4.3.3: 2,0kVrms /50Hz/1min	**IEC 61010-1**: Table K.11, Secondary Circuits & Overvoltage category III: 1,8kVrms /50Hz/1min per Par. K.2.2
DC impulse voltage withstand tests						
4	RTU / AC Power Supply Unit	RTU AC Supply voltage input	RTU AC Supply voltage input	**IEC 60870 -2-1:** Table 18 Class VW3: 5 kV single HV impulse /1,2/50 μs	**IEC 60255-27**: Table C.6 Class I Equipment, Overvoltage category III & Pollution Degree 2: 5 positive & 5 negative 4 kV HV impulses /1,2/50μs per Par. 10.6.4.2.2	**IEC 61010-1**: Table K.6, Overvoltage category III & Basic Insulation: 5 positive & 5 negative 4 kV HV impulses /1,2/50μs per Par. 6.8.3.3

5	RTU / Component	RTU Digital inputs / Component digital inputs	RTU Digital inputs	**IEC 60870 -3:** Table 6 Class 3: 5 kV single HV impulse	**IEC 60255-27**: Table C.6 Class I Equipment, Overvoltage category III & Pollution Degree 2: 5 positive & 5 negative 4 kV HV impulses /1,2/50µs per Par. 10.6.4.2.2	**IEC 61010-1**: Table K.16 Required Clearance: 1,5mm from Table K.11, Overvoltage category III & Basic Insulation: 5 positive & 5 negative 2,56 kV HV impulses /1,2/50µs per Par. 6.8.3.3
6	RTU / Component	RTU Analogue inputs / Component analogue inputs	RTU Analogue inputs	**IEC 60870 -3:** Table 7 Class 2: 2 kV single HV impulse	**IEC 60255-27** : Table C.6 Class I Equipment, Overvoltage category III & Pollution Degree 2: 5 positive & 5 negative 1,5 kV HV impulses /1,2/50µs per Par. 10.6.4.2.2	**IEC 61010-1**: Table K.16 Required Clearance: 1,5mm from Table K.11, Overvoltage category III & Basic Insulation: 5 positive & 5 negative 2,56 kV HV impulses /1,2/50µs per Par. 6.8.3.3
<u>EMC Immunity tests</u>						
7	RTU / Component	All ports, RTU / Component, in operating condition	All ports, RTU in operating condition	**IEC 60870-2-1** Surges, Table 12 A2.2: Level 3 Criterion A - 2kVp (CM) - 1kVp (DM), Level 2 Criterion A - 1kVp (CM) - 0,5kVp (DM) for comm. Port	**IEC 61000-4-5** Surges, Class 3 2kVp (CM) - 1kVp (DM) Criteria B all ports except: communication port: Class 2 1kVp (CM) - 0,5kVp (DM) (acc. Annex C.3)	
8	RTU / Component	RTU / Component, in operating condition	RTU in operating condition	**IEC 60870-2-1** Electrostatic discharge, Table 13 A3.1: Level 3 Criterion A - 6 kV in contact	**IEC 61000-4-2** Electrostatic discharge, Level 3 Criteria B - 6 kV in contact/8 kV in air discharge mode	
9	RTU / Component	RTU / Component, in operating condition	RTU in operating condition (current sensors included)	**IEC 60870-2-1** Radiated EM field, Table 15 A5.1: Level 3 Criterion A - 10 V/m radiated EM field test	**IEC 61000-4-3** Radiated EM field, Level 3 Criteria B - 10 V/m radiated electromagnetic field test	

Vibration endurance tests					
10	RTU / Component	RTU / Component	RTU	Vibration endurance tests as per **IEC 60255-21-1, Class 1**	**IEC 60068-2-6 ed.6 (1995):** Sweeping frequency test compatible to the application (Table B.1)
Environmental tests					
11	RTU / Component	RTU / Component, in operating condition	RTU in operating condition (current sensors included)	Cold test as per **IEC 60068-2-1**, test Ad, continuous operation at (-10°C) for 16 hrs	
12	RTU / Component	RTU / Component, in operating condition	RTU in operating condition (current sensors included)	Dry heat test as per **IEC 60068-2-2**, test Bd, continuous operation at (55°C) for 16 hrs	
13	RTU / Component	RTU / Component, in operating condition	RTU in operating condition (current sensors included)	Cyclic humidity test as per **IEC 60068-2-30**, test Db or variations with upper temperature ≥ 55 °C & number of cycles ≥ 2.	

Notes

- For **Test Reports** to be attached to the Technical Bid, RTU includes the controller, I/O cards, power supply, control panel, all interconnected for the fulfillment of the required functionality of par. 6.1. The external enclosure is optional, unless otherwise stated.
- Component includes the controller, I/O cards, power supply, control panel or any functional combination of them.
- For **Tests to be conducted** at the beginning of the execution of the contract, RTU is the complete device of par. 2.3 that is in the scope of supply (external cabinets and batteries included).
- "/" symbol in 2nd & 3rd columns denotes logical "OR".

11.2 Routine tests

Routine tests shall be carried out at manufacturer's premises and the relevant test protocols shall be provided to the assigned inspector. The routine tests are the following:

- Insulation breakdown voltage test (2,5kV/60 Sec/50Hz) (Index No 1 test of Table 6 as per IEC 60870-2-1)
- Cabinet inspection to verify that the construction is according to the contract and the cabinet ready for installation (cabling, earthling devices etc.)
- Functionality tests of all RTUs (as of paragraph 6)
- Design and visual checks in accordance with the requirements of the present TD.

11.3 Sample tests (Factory Acceptance Tests - FAT)

These tests shall be performed in presence of HEDNO's personnel at the manufacturer's premises, prior to delivery, after successful routine testing performed on each specimen of the batch done by the Supplier.

The assigned HEDNO's inspector shall select a random sample from any lot under delivery based on IEC 410 plans, simple sampling, normal inspection, inspection level I, AQL=2,5%, on which all the routine tests described in the paragraph 11.2 shall be successfully carried out.

Also a full operation check must be carried out to ensure that the system (cabinet, RTU etc.) operates according to the present TD. Operational checking must be done using simulation techniques at the premises of the Supplier.

The Supplier has to propose the procedure and duration of such tests. HEDNO has the right to modify these procedures, up to 30 days prior to the inspection period.

11.4 Sample approval regarding its communication and functionality capabilities

The following tests shall be carried out after the end of the finalization period of the equipment designs. The Supplier shall deliver a sample RTU of Type 1 and a sample RTU of Type 3, which shall be accompanied by the necessary equipment and conversion instructions to type 2 and 4 RTUs, respectively, a sample protocol converter and the simulating devices of chapter 13 of this TD in order to demonstrate his successful communication with existing HEDNOS'S SCADA Central Control System (CCS) types (of Telegyr TG8000, EFACEC SCATEX+) as well as to demonstrate the compliance of RTU's functionalities to the requirements of this TD. The Supplier will also submit complete equipment documentation (so HEDNO's personnel may familiarize with the equipment and be able to follow the tests) and also the list of the tests to be made and the test equipment used. All the above-mentioned equipment with the documentation stated in par.16, shall be delivered to HEDNO's warehouse within eight (8) weeks from the end of the finalization period of the equipment designs.

After that, HEDNO will move the equipment to its Inspection Service and with the continuous presence of Supplier's personnel, the samples will be connected to the CCSs and a full complement of tests will be carried out. These tests will last three (3) weeks (two (2) weeks for the communication demonstration with the two (2) types of HEDNO's CCSs – one (1) week per CCS type – and one (1) week for the functionality tests with one of the SCADA system). During the tests period, the Supplier will have the opportunity to make any corrections and adjustments to the HW and SW offered, in order to achieve the required performance.

During communications tests HEDNO reserves the right to ask for any kind of test it considers necessary to prove that the equipment communicates properly with the HEDNO's CCSs and thus increase its confidence to the offered solution. All the communication infrastructure and equipment (SIM cards, GPRS routers etc.) needed shall be provided by HEDNO.

The functionality tests will follow the successful communication test's demonstration. During this phase the Supplier will demonstrate the equipment's functionality compliance with the requirements of the TD. The tests will include all

the functions which the equipment is made to perform in accordance to TD's requirements described in Chapters 6, 7, 8 and 9.

If HEDNO find out problems that have occurred in this 3-week period, due to Supplier's culpability, which justify an extension of the duration of the tests' period, the tests may be repeated. The repetition of the tests could last three (3) additional weeks at maximum, beginning at the end of the first period. This additional period shall include the time required for correcting any problems in the RTU software and hardware that have arisen during the tests. Any problems found shall be solved without any additional cost for HEDNO.

The test period(s) shall be extended proportionally to every justified delay caused by Force Majeure or HEDNO's responsibility (equipment or SCADA system preparation, etc.).

In case where, upon expiry of the fourteen (8+3+3) weeks period and any possible necessary justified time period due to force majeure or HEDNO's responsibility, the samples have not been delivered to HEDNO or they failed to pass the aforementioned tests, HEDNO will terminate the Contract due to Supplier's fault.

It is stated that the Supplier will have to cover the expenses of its personnel during the period of the aforementioned tests.

11.5 Validity of the contractual delivery time

The contractual time of equipment delivery will begin on the issuing date of the results of successful type tests of paragraphs 11.1 and 11.1.1 by the test Laboratory. It is clarified that the time required for testing, issue of the relevant test reports and tests evaluation, will be excluded from the delivery schedule, i.e. the delivery time will be extended equally to the time required for the testing. The extension of the delivery time concerning the time required for the tests, concerns all the partial deliveries and not only the first one.

The above contractual delivery time is valid only if the Supplier respects the contractual time concerning the finalization of equipment designs and the submittal of the samples for the execution of the tests of paragraph 11.4 (8 weeks) as well as the contractual time concerning its proposal for the execution of the type tests of paragraphs 11.1 and 11.1.1 (Test Laboratory, tests time schedule, test standards followed, number of samples) and the sample's availability, namely 2 weeks from the successful execution of the tests of paragraph 11.4 for the first samples plus 4 weeks for the improved sample in case the first sample has been rejected (see attached Figure 2). In case of delay in the submittal of the aforementioned samples and data, the issuing date of the results of successful type tests by the test Laboratory shall not be considered a starting point of the contractual delivery time but a previous date for a time period equal to the delay of the aforementioned samples and data.

12 Portable PCs

In order to ensure the access of HEDNO's personnel to the equipment (RTU, simulators, gateways etc.) in the most effective and convenient way, six (6)

portable PCs (Laptops) shall be provided. The purpose of the portable PCs is to serve the programming of the RTU as well as uploading and downloading information at the installation site. They shall be of rugged type and conform to the following specifications:

Operating conditions:

- -10 to +55 °C

Environmental protection:

- IP 4X or higher, per IEC 60529

Screen:

- Size: at least 12,5", maximum 15”.
- Resolution : HD or better
- Brightness: at least 220 Nits.
- Optional touch screen as long as it does not affect the brightness specifications

Features:

- Processor: i5 or better
- HDMI port: 1 (with adapter if needed)
- HDD: SSD, 128GB minimum
- Memory: 4GB minimum
- Battery life: 8 hours (as stated by the manufacturer on official brochures or website)
- USB 3.0 ports: 2
- Weight: 3000gr maximum without accessories
- RS-232 port or USB to Serial adaptor compatible with the offered equipment (RTU, simulators, gateway etc.)
- Optical drive internal or external included

Keyboard:

- Illuminated
- Greek characters
- Detachable keyboard as option, is accepted, if it does not affect the weight specifications

Operating system:

- Microsoft Windows®

13 Function simulating devices

Portable LB and MV line fault simulator equipment shall be provided, for the purpose of testing the configuration of the SCADA software and of the functions of the RTU. The simulators shall input to the RTU, all the digital indications of the status of the LBs (paragraph 6.1.1.1) and the MV line measurements (paragraph 6.1.1.2) and simultaneously simulate the outputs to the LBs (paragraph 6.1.2.1). They shall also bear additional inputs and outputs in order to meet the requirements of paragraph 6.2.1.

The simulation equipment will also execute all commands available for the LBs and shall provide feedback to the controller of the status of the LBs. This simulator equipment will allow HEDNO personnel to perform all tests required, to ensure that the SCADA system and the RTU controller are properly configured.

Seven (7) separate devices shall be provided to cover these requirements, accompanied by their respective usage licenses.

14 Spare Parts

The bidders shall attach to their technical and economic Bid a complete list of spare parts stating the cost per unit of the equipment offered. Spare parts list shall include:

- The spare RTUs that shall accompany the main provision. They shall be the same RTUs as of the current TD, except from the batteries (part number 8 & 9 of the MATERIALS AND QUANTITIES DESCRIPTION TABLE of Annex 1 in the Call of Tender).
- Complete list of spare parts, with expansion cards and modules of RTU (components and input-output cards needed to fulfill the requirements of this tender, etc.), controller, cabling etc. and the parts needed for the conversion of a 48VDC output RTU into a 24VDC one and vice versa. In short, everything inside the RTU that will be supplied except from the external cabinet and batteries (part number 10 & 11 of the MATERIALS AND QUANTITIES DESCRIPTION TABLE of Annex 1 in the Call of Tender).
- The cables connecting the RTU to the LBs for the standard and the extended version of the RTU (part number 12 & 13 of the MATERIALS AND QUANTITIES DESCRIPTION TABLE of Annex 1 in the Call of Tender).
- Current sensor sets of par.6.2.2.1 for the standard and the extended version of the RTU (part number 14 & 15 of the MATERIALS AND QUANTITIES DESCRIPTION TABLE of Annex 1 in the Call of Tender). **Each spare sensor set contains an MV-side and a LV-side sensor set**, as defined in par. 6.2.2.1.

The prices of these spare parts must be included only in the economic bid and shall be taken into consideration for the economic evaluation of the Bids, according to the quantities mentioned in the Call of Tender.

The bidder shall commit for at least 10 years availability period of all spare parts. During this period, any spare parts required, shall be purchased according to the prices of this list. Changes to the spare parts in this list are acceptable if newer parts replacing older ones offer similar functionality and if they are functionally and spatially fully compatible to the already obtained equipment.

15 Special information that must be given with the bid - References

Every bid in order to be evaluated as technically accepted must be followed with the following information:

a) Declaration of the type of the offered units and informative leaflet of the manufacturer.

b) Regarding the column «REFERENCES» of the Questionnaire of Technical Variations and Clarifications, the following will be taken into consideration. In this

column the bidder will deliver all the evidence, proof, indication, explanation, to show that / how the TD's requirements are met, even with the cost of repeating certain information. Any discrepancies shall be clearly and thoroughly reported. Offers repeating the wording of this TD or providing only promotion leaflets will not be considered for evaluation and the offer will be rejected. In this requirement HEDNO gives particular importance in order to secure easier comprehension and evaluation of the offer, in short time given (without doubts and misunderstanding), without posing too much burden on the work of the Technical Evaluation Committee. Failure to do so, will result to the bid's rejection.

c) Typical drawings, leaflets, etc. that show characteristics of the offered units, their dimensions and proposed installation layouts with instructions.

d) Certificates to ensure that the units comply with the IEC standards required in this technical description.

e) A declaration of conformity of the equipment offered with the requirements of the present TD. Any discrepancies shall be clearly and thoroughly reported.

f) Type test reports or Reports of Performance for the offered equipment, issued by a test laboratory accredited by a recognized independent private or public laboratory accreditation body.

The Reports shall concern the types of tests of paragraph 11.1.1 of the present TD which have been performed on the equipment offered, either on the basis of the standards referred to therein or on the basis of equivalents thereof (Table 6).

The Type Test Reports or Reports of Performance submitted, shall state that the equipment tested are strictly in accordance with the relevant requirements of the corresponding IEC standard. Type Test reports or Reports of Performance shall refer to tests either per component (or group of components) from the offered equipment or to the offered equipment as a whole, depending on the acceptance criteria indicated in Table 6. A component, for the application of the provisions of this paragraph is one of the following: Digital Input / Output Card, Analog Input Card, Controller, Control Panel, Power Supply Unit (Power Supply). The test results shall verify the ratings assigned by the manufacturer.

The Bidder shall certify the Type test Reports, Reports of Performance or the detailed Type test Certificates as true copies of the original.

It is explicitly stated that after the signing of the contract any tests of paragraphs 11.1 and 11.1.1 of the present TD for the RTU shall be carried out by a test laboratory accredited by a recognized independent private or public laboratory accreditation body, in accordance with the standards of paragraph 11.1.1.

g) A statement that upon receipt of the equipment, any labels of the control panel (buttons, switches, LEDs etc.) shall be written in Greek language.

h) The Bidder must provide a detailed description on methodology to implement communication between the offered RTU on the field with two concurrent SCADA systems (Telegyr and Efacec).

i) Declaration of the factory/ies where the following products are manufactured: Controller, Current sensors, batteries and the external cabinet of the RTU and a declaration of the factory that produces the RTU (with or without external accessories and batteries) as a final product, with analytical information (full address, number of employees, a brief description of the installations, testing capabilities etc.). Each factory shall possess the following certifications and capabilities and provide the relevant certificates:

- ISO 9001 certification of the manufacturer covering the production field of the offered equipment. The certificate shall be guaranteed by the manufacturer, which shall also provide communication data for the Certification Body together with its accreditation certificate as well as any other relevant data requested during the stage of the technical evaluation of the offer, facilitating the examination of the soundness of the certificate. ISO 9001 certificate shall be in effect on the date of the offer. In addition, a declaration shall be submitted that during any Contract resulting from the Call of Tender, the ISO 9001 certification of the factory of the manufacture shall be in effect.
- Adequacy of the testing equipment for routine and lot acceptance testing and competency in quality control equipment (refers to the factories where these tests will take place).

HEDNO reserves the right to examine on site the factory's capabilities in manufacturing the offered materials, during a possible Contract.

j) The manufacturer must have references from three (3) at least Electric Utilities or Network Operators (name of the Utility, address, phone number, fax number, e-mail, web-address, etc.), for RTUs (by the manufacturer) that these Utilities or Operators have used or are still using, for the following functionalities:

- Implementation of SCADA functions (telecontrol, remote monitoring)
- Electrical Measurements (current, voltage and derived quantities)
- Detection of fault currents in MV lines.

In the reference letters, the buyer, the type of RTU, the quantity, the date of delivery, the country of installation, shall be mentioned as well as, whatever information is deemed to be useful for proving the manufacturing experience and/or the long-term successful operation of the equipment. Each reference letter shall be accompanied by a statement by the purchaser or the manufacturer referring to the type tests to which the PME has been successfully submitted, if such tests have been carried out.

The aforementioned units must have been installed and operating successfully in the network for at least the last 3 years. Any differences between the equipment mentioned in the reference letters and the offered shall only be accepted where the equipment offered is a technical development of the first. This shall be evidenced by a written mention of the equipment manufacturer referred to in the reference letters.

The total number of the units stated in the reference letters, must be at least equal to the half of the number of the tender. Provision of reference letters from two (2) Electric Utilities or Network Operators is also permissible, provided that the number of units resulting from these two letters should be at least equal to the required number in the tender. As proof, original or true copies of Appreciation letters are preferred but copies of sales contract are also accepted (price units are not necessary to be visible). In case of orders awarded by Electric Utilities or Network Operators to Third Parties, such as in the case of indirect order to the RTU manufacturer, as proof of experience, true copies of the contract between the Electric Utility or Network Operator and the Third Parties as well as that between the Third Parties and the manufacturer, shall be submitted.

k) Sales record of the offered equipment or equipment that has been used for the functionalities of §15.(j), to Electric Utilities or Network Operators. Each sales list shall include the following:

- The type of the RTU controller.
- The name of the Electric Utility or Network Operator along with its full communication details.
- The quantity of the equipment purchased of each order and in total.

Note: Tests reports, reference letters, copies of contracts etc. shall refer to equipment manufactured in the factory where the equipment offered will be manufactured. However, tests reports that concern equipment manufactured in a different factory of the same multi-national company from the one where the offered equipment will be manufactured shall be accepted, as long as they refer to the exact same standard equipment. Particularly in the reference letters and the sales records, reference may be made to equipment in accordance with the provisions of this paragraph and §15.(j).

16 Finalization of equipment designs - Documentation

HEDNO shall finalize in co-operation with the Contractor all the technical issues that are not clearly formulated in this TD and relate to minor specifications of the equipment to be delivered, which cannot be specified when compiling this document. Indicatively and without limitation the following are included: the finalization of the terminal strip signaling of paragraph 4.2, the number of openings in paragraph 4.1, the assignment of the pinout of the connectors in Table 1 and consequently of the cables in Table 2, the markings of the control panel of paragraph 6.3, the initial values of the parameters of Table 5, the wording of the signals and the messages and commands displayed in the web server environment and the parameterization tool of par. 7.1, the finalization of the name plate characteristics of paragraph 21 and the control panel of paragraph 15.g.

The timeframe for the finalization of the equipment designs starts on the effective date of the Contract and expires 12 weeks thereafter. This period will be prolonged in proportion to any justified delay that may arise due to Force Majeure or due to the responsibility of HEDNO.

The Supplier shall provide (according to par.11.4), for approval by HEDNO, three complete sets of the documentation for all offered units, in hardcopy and in electronic form, in English or Greek.

The documentation must include:

- Description of all offered units
- Description of the operation of all units
- The drawing of the electronic parts of the units which will describe in every detail the internal wiring of the RTU cabinet with its terminal blocks and connectors
- Block diagrams of the various HW modules of the RTU showing the way they are interconnected and the connections between Controller – Power Supply – Communication port
- Installation, operation and maintenance instructions for the units offered, with particular reference to the conversion process between RTU of Types 1 and 2 and also between RTU of Types 3 and 4.

17 Training

The Supplier shall provide for HEDNO four (4) courses of training, each one lasting five (5) days, at four (4) different geographical sites in Greece (Athens, Thessalonica, Patras and Lamia) and not necessarily in sequential time intervals. Additionally, after the end of the 4th training course, one more training course shall be scheduled, lasting three (3) days for each one of the 4 locations mentioned above, in order to resolve any outstanding issues and problems encountered.

HEDNO and the Supplier will agree on the most convenient time for the courses.

One RTU and all the necessary equipment (protocol converter - Gateway, modems, simulator, etc.) and documentation shall be used for this training.

The training shall include, at least, the following:

- The RTU HW components piece by piece
- The RTU's SW main functions
- The function of the RTU as a unit
- Conversions to RTU by removing or adding expansion cards
- Description of the communication software
- Maintenance of the RTU
- Operation of the RTU with simulator
- The function and maintenance of the protocol converter
- The communication procedure in detail (all the parameters shall be analyzed).
- Programming and use of the simulating devices
- Installation techniques and considerations.

18 Installation and commissioning of the first forty (40) units

The installation and commissioning of the first forty (40) units (RTU) will be done by staff of HEDNO or its subcontractors, in presence of the Supplier who shall oversee the procedure and shall provide the necessary instructions for the proper installation of the units, without extra charges for HEDNO.

This procedure will serve as an additional hands-on/on-site training. Batteries required for these units of the type stated in par. 9.3, shall be also delivered with them. Specifically, these units shall be installed on each of the following Regional Departments of HEDNO:

- Regional Department of Attica,
- Regional Department of Macedonia-Thrace,
- Regional Department of Peloponnese - Epirus,
- Regional Department of Central Greece and
- Regional Department of the Islands.

Programming the RTUs and their modems as well as their integration with the existing SCADA systems of HEDNO (Telegyr TG8000, EFACEC SCATEX +) shall be implemented by staff of HEDNO, in cooperation with the Supplier' staff, which will provide technical support for communication and interoperability issues that

may arise and by this way it will be also trained for future problem solving concerning this type of work, in terms of the guarantee services mentioned in Chapter 20.

The aforementioned work will be accomplished within three (3) months upon receipt of the equipment associated with the first (1st) partial delivery to the Warehouses of HEDNO's Regional Departments in Attica, Thessaloniki, Patras and Lamia. It is estimated that the receipt of materials will have been completed within two (2) months upon their delivery to the Central reception Warehouse of HEDNO. The work will be ensured by the relevant Sections of the Network Department (Network Operations and Maintenance Section and Distribution Network's Control Centers Section) in collaboration with staff of the relevant Departments of HEDNO (Regional Departments) and the Supplier.

The installation works' program and schedule will be sent to the Supplier within five (5) days upon the initial delivery of the equipment to HEDNO's Central Warehouse and it will contain analytical information concerning the equipment installation dates and exact locations. The Supplier must take into consideration that maximum two simultaneous installations per day may take place in all regions of HEDNO. The Supplier shall provide analytical instructions concerning the equipment installation details prior to the receipt of the equipment to HEDNO's warehouses. After the successful installation and operation of the 40 units and the successful functional tests, a SAD (Site Acceptance Document) will be signed between the Supplier and HEDNO. The Supplier will have to cover the expenses of its personnel during this period.

The work of programming of the remaining RTUs and their modems for all other RTUs of the Declaration, as well as their integration to the CCS system of HEDNO, shall be implemented as indicated in Chapter 19 of this TD.

19 Works for programming of the RTUs & their modems as well as their integration to the CC systems of HEDNO

The works of programming of the RTUs of the Declaration, except the first forty (40) units of Chapter 18, as well as their integration to the CCS systems of HEDNO, will be fully implemented by HEDNO's competent personnel according to the following steps in order to expedite equipment delivery to operations:

a) The RTUs shall be delivered by the Supplier to the Central Warehouse of HEDNO in Athens with pre-configured communication settings (e.g. LAN port configuration). The RTUs shall allow remote parameterization via a web interface or equivalent configuration and programming software tool (see §8.2, 7.1, 6.2.3). In this way, the IEC protocol settings (IEC 60870-5-104 protocol mappings and selected points) as well as the customized (number of LBs controlled and monitored, fault detection etc.) and logic settings per RTU location shall be sent remotely to the RTU, after its placement in the network (see attached Figure 1). It is the responsibility of the Supplier to provide the fully configured template of the above settings that HEDNO will use to perform the abovementioned tasks.

b) The work of integrating the RTUs of each partial delivery to the CCS of the SCADA systems will be carried out en masse to the CCS sites of the Regional Departments of HEDNO in Athens, Thessaloniki, Patras and Lamia. These works are primarily concerned with the updating of the software and the database of the CCS with new data and secondly in testing the communication and the proper display of signals. For carrying out these works, programmed modems of HEDNO together with the simulator (Chapter 13) and a sample of RTU shall be used. The sample of RTU shall be programmed each time according to the location where each RTU is intended to be installed, including the number and type of LBs to be controlled, fault detection and logic and communication protocol settings. In case the installation site involves 4 LBs, expansion cards shall be installed from the RTU accessories set of the 1st delivery, in the sample RTU. Then, the RTU will be connected to the corresponding to that location modem and using the simulator, all entities of the database corresponding to this RTU will be tested. After the successful completion of these tests, the final settings file will be stored in a database within the configuration and programming software tool (see §8.2, 7.1, 6.2.3) so that it can be retrieved and sent remotely (partly, e.g. selected classes/groups of settings, or as a whole) to the associated RTU after its installation in the network.

20 Guarantee

The guarantee period will be three (3) years at maximum for all units supplied. The guarantee period will start from the date of installation and shall not exceed five (5) years from the date of delivery. According to the above mentioned, the warranty period shall expire five years after receipt of the equipment, or three years after its installation on the network, whichever comes first. The serial number regarding the equipment's installation shall be delivered by HEDNO to the Supplier each semester. On this file the serial number, the date and the location of RTU's installation shall be referred.

The Supplier must be fully responsible for the proper operation of all the units for the guaranteed period. During the guarantee time period the Supplier, free of charge shall:

- Correct any RTU SW fault which will be found. The same is also valid for the protocol converter SW.
- Correct any communication problems that may arise (due to the equipment supplied).
- Correct any error or omission which will be found in the documentation.
- Respond to any information required by HEDNO.
- Make any modification requested, which will improve the RTU's compliance to the specifications.

In the case of RTU and protocol converter SW malfunctions, HEDNO's personnel has performed all checks, according to the training and documents received, in order to solve the problem. If the fault reasons are not identified or solved, then an onsite intervention of the Supplier shall be required.

Regarding the interventions to correct any RTU and protocol converter SW fault the following will apply:

- Maximum time for answering to HEDNO (notice of a problem) to the telephone, FAX or e-mail: 2 h, from 8 a.m. to 3 p.m. from Monday to Friday, except official holidays, as they apply to Greece.
- Maximum time between acknowledging the problem reported above by HEDNO until the arrival to HEDNO's Local Unit in order to visit the site escorted by HEDNO's personnel and identify the problem locally, if needed: 2 working days.
- Maximum time between on-site intervention and resolution of the problem (return to repair conditions): 15 working days (in case the intervention has to be supplied to all locations shall be concluded within 4 months).

Failure to provide support within the above mentioned times, will incur a fine of 240,00€ per day of delay. For intermediate delays (e.g. hour) the fine will be determined by linear interpolation. In case of simultaneous events the Supplier shall proceed to interventions and corrective actions in a sequentially manner. The Supplier won't be responsible for any delays regarding compliance with the maximum times mentioned above, if those delays result from force majeure cases. The Supplier shall notify HEDNO, by registered letter, in the advent of any situations mentioned in the previous clause immediately or in any case within 15 days from the occurrence date, if all other means were tried to avoid or minimize the delay in the promised obligations.

The Supplier has the sole responsibility of employing its personnel according to all the legal requirements and providing all personal and health insurance for them. HEDNO could not be held liable for any injuries or compensation to the personnel of the Supplier.

In case of equipment failure (controller, power supply, etc.) on the network or in HEDNO's warehouses, HEDNO shall replace it with equipment that will get from the stock of spare parts, which will be delivered with the 1st partial delivery of the Tender's materials (see Chapter 14). The equipment which has failed on the network shall be carried by HEDNO’s crews to HEDNO's Regional Warehouses to be checked for finding the causes of failure. The failure will be announced immediately to the Supplier (e.g. the place where the equipment had operated, the warehouse where it has been transferred etc.) regardless of the results of the check performed by HEDNO to ascertain the causes of failure (1st failure announcement, regardless of the causes of failure). The check of the causes of the failure shall be performed by HEDNO within 1 month from the date of the 1st announcement of failure to the Supplier. If the check reveals that the failure is due to the Supplier’s fault, this will be announced to the Supplier, within this period of 1 month (2nd failure announcement, failure due to Supplier’s fault).

Regardless of the causes of the failure, the Supplier must make the provision to replace within three months from the date of the 1rst failure announcement all the materials used, for replacing of damaged from the stock of HEDNO's spare parts, with new ones. For each month that delays the timely replacement of the materials used by the stock of HEDNO's spare parts, the price of materials will be retained by the letter of guarantee. For intermediate delays (days) the fine will be determined by linear interpolation. The delivery of these materials by the Supplier must be made with packaging similar to that provided by this TD.

Within two months from the date of the announcement of the failure due to the Supplier (2nd failure announcement, failure due to the Supplier), the Supplier has the right to demand in writing the presence of his representative during

reexamination of the causes of failure. This reexamination must take place within this period of two months. In case that the Supplier within the aforementioned period of two months does not make any request to be present during the reexamination of the causes of failure, or does not attend despite his relevant declaration, it shall be considered as a fact that he unreservedly acknowledges himself as responsible to for this failure. Furthermore, if the Supplier within this period of two months does not throw any doubt concerning the failure of the equipment it shall be considered as a fact that he unreservedly acknowledges himself as responsible to for this failure.

During reexamination of the causes of failure a relevant Control Report shall be drawn in duplicate and signed by both Supplier and HEDNO. This report shall state the cause of the failure that was ascertained and the Supplier shall declare that he acknowledges it. In cases of disagreement the matter shall be referred for further judgment by a Committee consisting of the Head of Technical Division Section of HEDNO's Network Department or his substitute, the Head of Inspection Section of the HEDNO's Material, Purchasing & Transportation Department or his substitute, as well as of the Head of the Supplier's Study Office or other representative of him. In cases of disagreement and until the Committee comes to a decision, the Supplier is deemed responsible for the failure. The acknowledgement from the part of the Supplier of the equipment failure ceases to have any legal effect from the moment the Committee judges that the failure in question is not due to the Supplier's responsibility.

In case that the equipment failure is due to the Supplier's responsibility:

- The cost of the materials to be supplied by the Supplier to replace the materials taken from the stock of spare parts, for replacing of damaged, shall be borne entirely by the Supplier.
- The Supplier is obliged to accept the failed equipment from HEDNO's Regional Warehouse, within two (2) months from the date of recognition, as above, by the Supplier that the failure is due to him, and to transfer it to his factory or to a factory of his choice. The cost of this transportation shall be borne entirely by the Supplier. In case of delay beyond of 2 months, HEDNO is entitled to send the equipment failed in the Supplier's factory, and the transportation cost shall burden the Supplier.
- All replacements, transportation and loading/uploading costs of the damaged equipment from HEDNO's workshops to HEDNO's Regional Warehouse as well as the transportation and loading/uploading cost from HEDNO's Regional Warehouse to the Supplier's factory, if these are carried out by HEDNO, shall be borne by the Supplier entirely and shall be retained by the letter of guarantee.

Replacement, transportation and loading/uploading costs of the damaged equipment, for replacing of the damaged equipment from another one, are calculated in accordance with HEDNO's Contracts that were signed with Contractors involved in the construction of distribution networks or upon final account.

In case of transportation of the damaged equipment from the HEDNO's Regional Warehouse to the Supplier's factory, transportation costs shall be calculated in accordance with applicable decisions of the Ministers of Commerce and Transportations being in force or upon final account.

These costs shall be notified to the Supplier immediately after he has received the damaged equipment or after it is sent at his factory by HEDNO.

In case that the equipment failure is not due to the Supplier's responsibility:

- The cost of the materials to be supplied by the Supplier to replace the materials taken from the stock of spare parts, for replacing of damaged equipment, shall be borne entirely by HEDNO, according to Contract's spare parts price list.
- All replacement, transportation and loading/uploading costs of the damaged equipment from HEDNO's workshops will be borne entirely by HEDNO.

At the end of the guarantee period, HEDNO and the Supplier shall sign a protocol on the equipment's behavior for the release of the Letter of Guarantee.

21 Nameplates and Marking

The RTU shall carry a nameplate, suitable to withstand the environmental conditions, at a position visible at normal operation, with engraved or indelible characters.

The RTU's nameplate shall include at least the following data:

- Name or trademark and address and phone of the manufacturer
- Date of manufacture, product type and serial number
- Contract number
- Rated input voltage (V)
- Rated continuous current (A)
- Rated frequency (Hz)
- Rated batteries type, max capacity (Ah or Wh) and voltage (V)
- Weight (batteries included) (kg)

The exact details of the nameplate shall be decided during the period of finalization of the equipment designs (par.16).

22 Packing

The equipment shall be packed in durable wooden cases of suitable dimensions, with all sides totally closed. The cases shall withstand external environmental conditions, like rain, humidity, ambient temperatures etc.

Packaging shall include all appropriate hardware for fixing the RTU onto concrete wall.

The packing shall ensure that the equipment shall be protected against damages during transportation, loading and unloading. The wooden cases shall be packed together on EU type pallets and the total weight of each pallet shall not exceed 550 Kg.

On two opposite sides of each case the following data shall be marked in a clear and indelible way:

- Manufacturer / Year of manufacture / Contract Number
- Description, type and serial number of contents
- HEDNO material code number
- Gross weight in kg

23 Applicable Standards

During the preparation of this TD. the following standards have been taken into account:

IEC International Electrotechnical Commission

- IEC 60870-2-1: Telecontrol equipment and systems - Part 2: Operating conditions - Section 1: Power supply and electromagnetic compatibility
- IEC 60870-3: Telecontrol equipment and systems. Part 3: Interfaces (electrical characteristics)
- IEC 61000-4-30:2015: Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement methods
- IEC 60870-5-101: Telecontrol equipment and systems - Part 5-101: Transmission protocols - Companion standard for basic telecontrol tasks
- IEC 60870-5-104: Telecontrol equipment and systems - Part 5-104: Transmission protocols - Network access for IEC 60870-5-101 using standard transport profiles
- IEC 62351-3:2014: Power systems management and associated information exchange - Data and communications security - Part 3: Communication network and system security - Profiles including TCP/IP
- IEC TS 62351-5:2013: Power systems management and associated information exchange - Data and communications security - Part 5: Security for IEC 60870-5 and derivatives
- IEC TS 62351-8:2011: Power systems management and associated information exchange - Data and communications security - Part 8: Role-based access control
- IEC 60529: Degrees of protection provided by enclosures (IP code)
- IEC 60044-1 and its amendments 1 & 2: Instrument transformers, Current transformers
- IEC 61869-2: Instrument transformers, Additional requirements for current transformers
- IEC 60896-21: Stationary lead-acid batteries – Part 21: Valve regulated types – Methods of test
- IEC 60896-21: Stationary lead-acid batteries – Part 22: Valve regulated types – Requirements
- IEC 60695-2-11:2014: Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products
- IEC 61131-2:2007: Programmable controllers - Part 2: Equipment requirements and tests
- IEC 61131-3:2013: Programmable controllers - Part 3: Programming languages
- IEC 61850:2017 SER Series: Communication networks and systems for power utility automation - ALL PARTS
- IEC 62262:2002: Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
- IEC 60502-1:2004: Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV(Um = 36 kV) - Part 1: Cables for rated voltagesof 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV)

- IEC 61643-11:2011: Low-voltage surge protective devices - Part 11: Surge protective devices connected to low-voltage power systems - Requirements and test methods

ISO International Organization for Standardization

- ISO 1460: Hot dip galvanized coatings on iron and steel
- ISO 1459: Metallic Coatings -Protection against Corrosion by Hot Dip Galvanizing –Guiding Principles
- ISO 1461: Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
- ISO 9000: Quality management and quality assurance standards -Guidelines for selection and use.

Harmonized European or Public Power Corporation (PPC) or Other

- EN 10882-2: Stainless steel flat products for general purpose.
- EN 50160: Voltage Characteristics Of Electricity Supplied By Public Electricity Networks
- PPC/XK 11.02/11.03.2008: Hot dip galvanizing in iron and steel hardware
- PPC/XK 11.04/ 11.03.2008: Electrolytic tin plating

Where any provision of this technical description differs from those of the standards listed above, the provision of this technical description shall apply. In case of conflict, the order of precedence shall be:

This technical description
EN standards,
IEC standards,
Other standards (ANSI, ISO, PPC etc.)

Attached:

- Figure No 1: Communication between the RTUs and the HEDNO's SCADA Central Control Systems
- Figure No 2: Time schedule from effective date of contract until start of production.
- Inter-Operability Tables of HEDNO's SCADA Systems

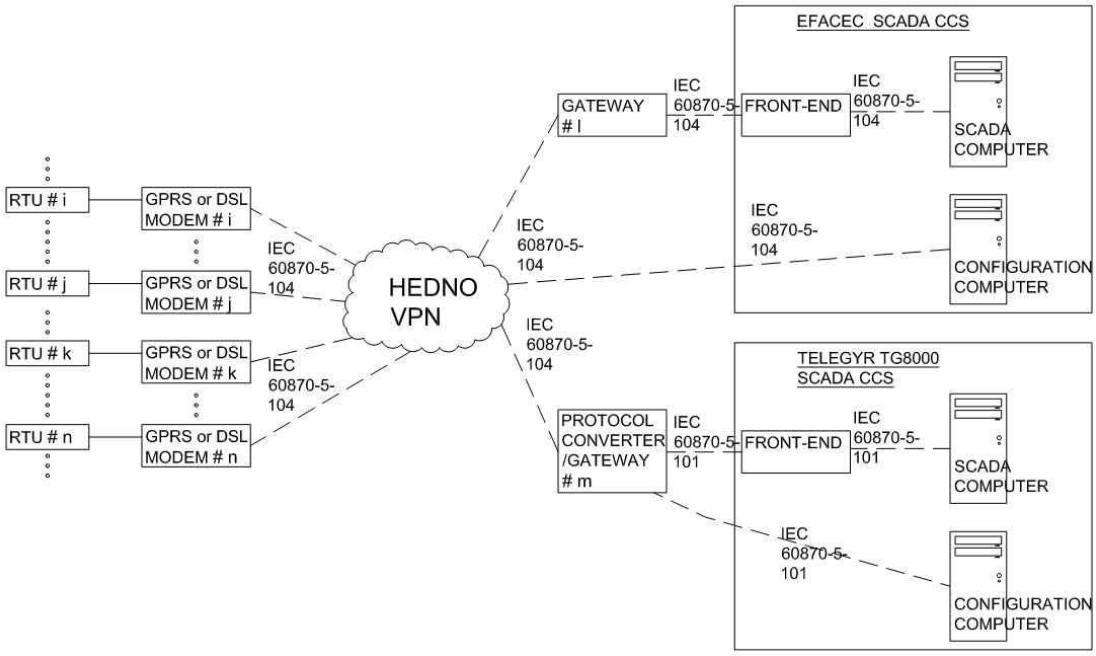

Figure 1
Communication between the RTUs
and the HEDNO's SCADA Central Control Systems

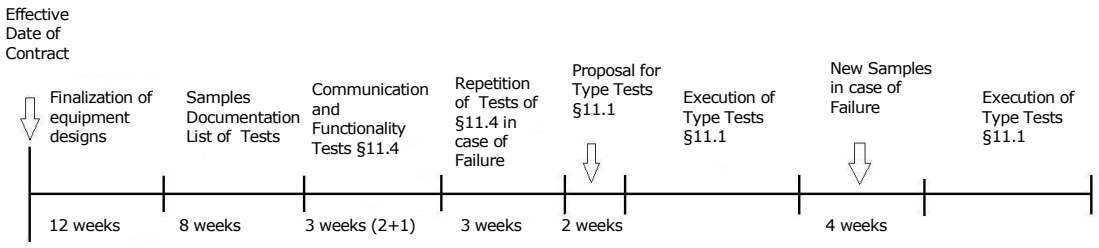

Figure 2

Time schedule from effective date of contract until start of production.