INNOVATIVE ECONOMY
NATIONAL COHESION STRATEGY

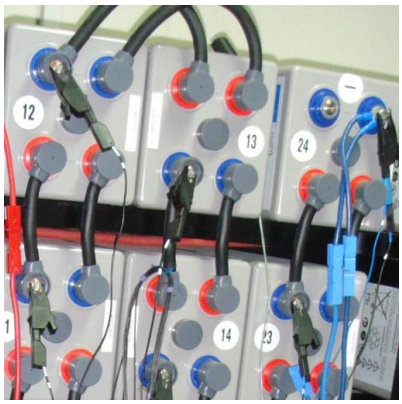
INSTYTUT ŁĄCZNOŚCI
PAŃSTWOWY INSTYTUT BADAWCZY

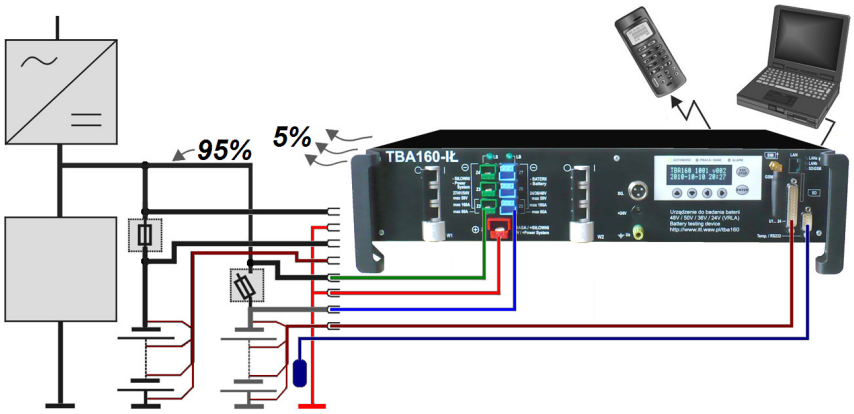
EUROPEAN UNION
EUROPEAN REGIONAL
DEVELOPMENT FUND

USER MANUAL and INSTRUCTIONS

TBA160-IL PORTABLE DEVICE

for testing VRLA batteries (48 V / 46 V/ 36V / 24 V), used in telecommunications, by the charging-discharging method





The **TBA160-IŁ** converter is an innovative, portable and programmable 160 A unit for discharging–charging 24/36/46/48 V batteries. In this unit, energy taken from the battery during discharge is transformed to the DC load connected to the power system by a transistor converter. Battery charging, controlled by the same unit, is performed by power system rectifiers. The results of operation are presented on display of the unit and saved in an SD-card and a connected PC. Co-operation with the monitoring system is realized through *Fast-Ethernet*.

TBA160-IŁ jest przenośnym programowalnym urządzeniem do kontrolnego wyładowywania–ładowania baterii akumulatorów ołowiowych kwasowych 24/36/46/48 V prądem do 160 A. W urządzeniu tym energia pobierana z baterii akumulatorów podczas wyładowywania jest przekazywana do stałoprądowych odbiorów siłowni, odciążając w tym czasie zespoły prostownikowe, a dla prądu 2 ÷ 8 A możliwe jest wyładowywanie także „na rezystor wewnętrzny". Ładowanie do zadanego napięcia i zadanym prądem, także pod kontrolą urządzenia, odbywa się przy poborze energii z prostowników siłowni. Wyniki są prezentowane na wyświetlaczu, a archiwowane w pamięci SD lub dołączanym poprzez LAN10/100 komputerze PC. O swoim „stanie pracy" urządzenie może powiadamiać SMS-em.

Предлагаемый преобразователь **TBA160-IŁ** представляет собой оригинальное современное устройство переносного типа с программным управлением для обслуживания (ток до 160 амперов) батарей на 24/36/46/48 вольт. В этой установке энергия разрядки возвращается в систему питания при помощи транзисторного преобразователя. Подзарядка аккумуляторной батареи осуществляется тоже от системы питания посредством этого тоже преобразователя. Результаты всех операций выводятся на дисплей преобразователя и сохраняются в его памяти (типа „*SD*") и могут сохранятся в памяти подключенного компьютера. Предусмотрен мониторинг процессов путем подключения к системе *FastEthernet* или посредством „*SMS*".

Warsaw, April 2011

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PROJECT
TBA160-IŁ

[2011-04-14]

Contents

ATTENTION: *In case of any problems regarding the equipment, please contact the designers (National Institute of Telecommunications).*

SAFETY. TBA160-IL is not connected to AC power network. Constant voltage on the inputs "- Power System" and "- Battery", a common (grounded), the positive pole, cannot exceed 63V.

WARNING. The device is protected against short circuits at the DC inputs with over-current circuit breakers (3 x 63A). Circuit breakers are placed in the negative poles "- Power System", and "- Battery".

DO NOT stop the operation of TBA 160-IL by switching off the circuit breakers or disconnecting wires. The device ***stops working*** *immediately after you press "ESC / STOP" and* ***disconnects*** *the power circuits after the second press.*

THE PRODUCER reserves the right to make changes in equipment, which does not deteriorate the electrical and functional parameters.

1 PURPOSE AND PRINCIPLES OF OPERATION

TBA160-IL is a portable device weighing 13 kg, designed to inspect 24 ÷ 48V lead-acid batteries by supervised discharging-charging. It is designed for batteries with a capacity of 50 to 3200Ah (max current 160A) used in telecommunication systems (Figure 1).

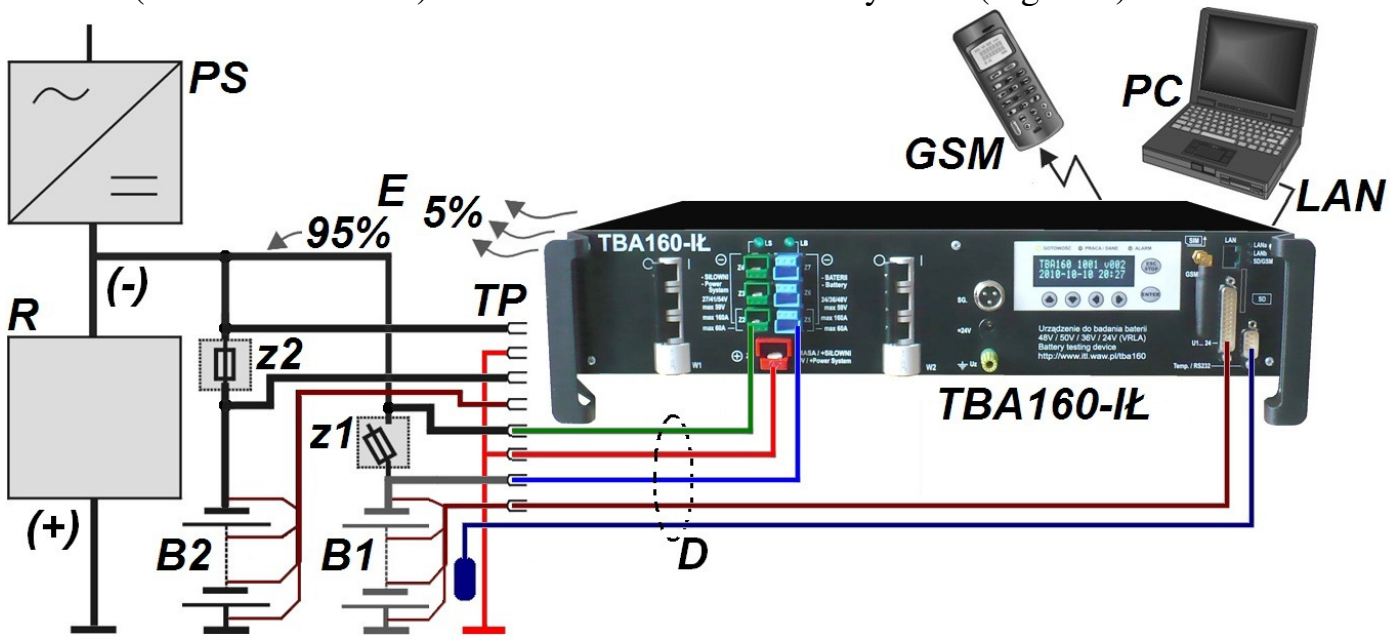


Fig. 1. Designations: PS – power system; R – load; B1 - tested battery; B2 - the second battery; z1, z2 - battery fuses/switches; D – cables; TP - an optional interface; E - energy from the discharged battery (5% loss - heat, 95% transferred to power system); GSM - SMS alarms; LAN - communication via the IP network, PC - PC.

Prior to supervised discharging-charging, selected battery ("B1" on a figure 2) shall be disconnected from the power system (in this case - disconnect the "z1"). Next, TBA160-IL connectors shall be attached, directly or via optional interface "TP", to "minus" of the battery, "minus "of the power system and to "positive" terminal

The device TBA160-IL (Fig. 2) consists from blocks:

- **W** - the input block (over-current circuit breakers W1/W2 and current transducer LEM),
- **K** - communication and measurement,
- **S** - control block (display/keypad "M"),
- **P** - the bidirectional converter (transistors T1÷T5, capacitors C1, C2 and chokes L1÷L3),
- **D -** the current cables / measurement cable.

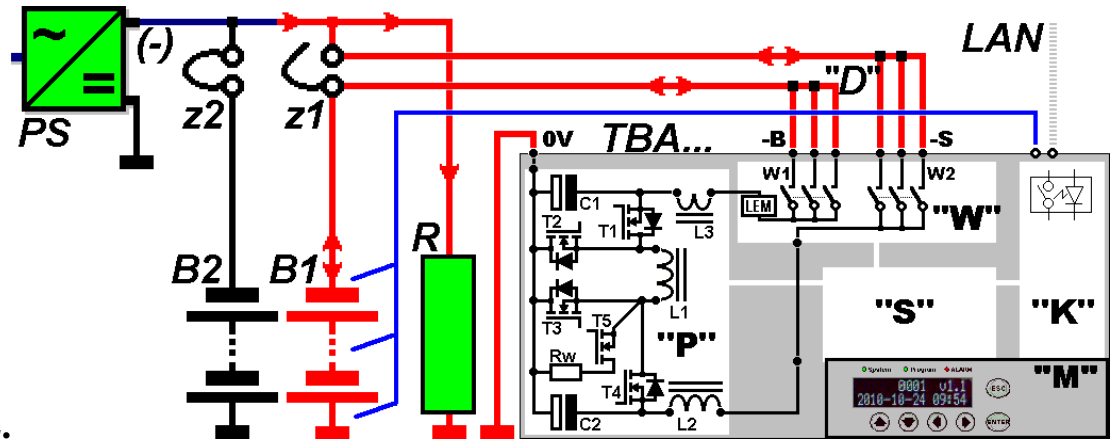


Fig. 2.

Battery is discharging in the circuit: the negative terminal of battery **B2** – connector "**-B**" – switch **W1** – transducer **LEM** – transistors **T1** and **T4** with chokes **L3-L1-L2** – switch **W2** – connector "**-S**" – the negative terminal of the power system with the load "**R**". The

transistor **T1** is switched on permanently, and the battery discharging current is achieved by applying PWM pulses to the transistor **T3**. The battery energy is transmitted to the power system by generating a slightly higher voltage than that supplied by rectifiers of the power system (**S**). Energy can be also sent to the internal resistor "**Rw**", via the transistor **T5**.

The discharging ends when the battery voltage or any cell/block drops to a preset value or by downloading the preset capacity. The process is temporarily suspended, if the voltage of the power system drops below the battery voltage. Current discharging the battery may be limited to the value resulting from energy consumption of the power system load "R".

Charging takes place in the circuit: the negative terminal of battery **B2** – connector "**-B**" – switch **W1** – transducer **LEM** – transistors **T1** and **T4** with chokes **L3**-**L2**-**L1** - switch **W2** – connector"**- S**"– the negative terminal of the power system "**PS**". When the battery voltage is lower than the voltage of the power system, programmed charging current is achieved by controlling the transistor **T4** with PWM pulses. After reaching by the battery the voltage of the power system the charging current is set at 90% of the programmed value. The process of charging is then controlled by PWM pulses applied to the transistor **T2**. In the final stage of charging the charging current is so limited, that for any block/cell voltage is not increased by more than 50 mV/cell in relation to the average value of the preset final charging voltage. Charging is stopped when the voltage drops below the float voltage of power system for example, as a result of power failures.

***Equalizing charge** (initial) lasts for a declared period of time (up to 48 hours) and **return charging** is terminated when the current flowing to the battery drops below a preset value or the set time elapses, counted from the moment when battery reaches set end voltage of charging.*

The device monitors the temperature of the battery and the environment, and voltage of 2, 3, 4, 6, 8, 9, 12, 18, 23, 24 (or 25) cells/blocks. The "voltage equalizer" discharges the cell/block of the highest voltage with current to 50 mA when activated.

The device is programmed by means of the built-in keyboard, and results of the process are presented on display. The results, records in the memory can be transferred to a PC via LAN 10/100 or SD card and processed by the "*TBA_Starter* / *TBA_Reporter*" application software (part of Report is shown on Fig. 3).

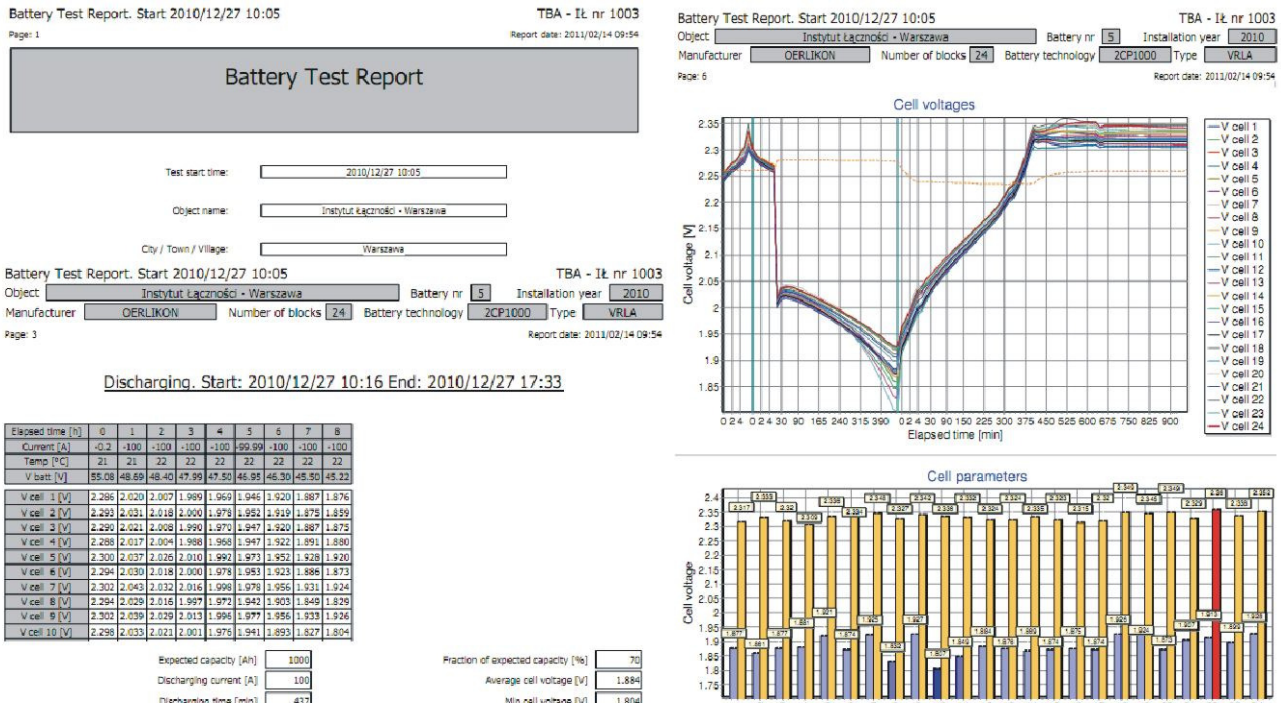


Fig. 3.

2 TECHNICAL DATA

Lp.	PARAMETER	DATA
1	Nominal battery voltage:	**48 V** and 24, 36, 46 V (optional 50 V)
2	Power system voltage (required)	2.22 ÷ 2.30 V/cell.
3	Charging/discharging current [1)]	**2 ÷ 160 A** (with 1 A step)
4	Discharging energy is typically transferred to the	load of DC power system
5	Discharging current transferred to built-in resistor	**2 ÷ 8 A**
6	Voltage measurement points of cells or blocks	2 ÷ 24 (optional 25)
7	The accuracy of the voltage measurement of cells /blocks	±1% (typically ±0.5%)
8	Equalizing the cell voltage / battery block	with max current 50 mA
9	The accuracy of battery voltage measurement	±0,5% (typically ±0.1 V)
10	The accuracy of battery capacity and current measurement	±1.5% (typ. 1%) for current >10 A
11	Range of setting and measurement of battery capacity	1 Ah to 3 200 Ah (related to 20°C)
12	Range of battery or ambient temperature measurement	+5 ÷ +50°C / ±1°C
13	The range of the final voltage battery discharge [2)]	**40÷48 V** or 20÷23 V / 30÷34 V
14	Final voltage of cells or blocks discharge	between 1.95÷1.6 V/cell, with 0.05 V step
15	Final battery charge voltage	**54÷59 V** or 27÷29 V / 40÷44 V
16	Unbalance cell voltage / blocks while charging	to 50 mV/cell over an average voltage of battery
17	Adjustable charging time (equalizing charging/ return charging)	between 10 minutes to 48 hours [3)]
18	Programmed final current of return charging	controlled 0 ÷ 10 A with 0.2 A step
19	Efficiency (for 48V battery and 40 ÷ 100% of load)	≥ 95%
20	Temperature of operation / allowed humidity	+5°÷ +40°C / 15 ÷ 85%
21	Alternating current component put into battery circuit	< 5% of charging / discharging current
22	Degree of protection / Protection class	IP 20 / 1
23	Electromagnetic interference level	A class
24	Remote communications	LAN (results), GSM (status by SMS)
25	Communication languages	Polish/English
26	Software for archiving and reporting	included, under XP/Vista/Windows7
27	Dimensions: height x width x depth	108 x 440 x 524 mm
28	Equipments weight / with set of cables and connectors	13 kg / less than 18 kg

NOTE: [1)] *Current may be lower than the preset level, e.g. due to properties of load;*
[2)] *Voltage measured at the terminals of the device;*
[3)] *Return charging time is measured from achieving the final battery voltage.*

3 DEVICE OPERATION

The device is designed to test the battery disconnected from the power system and returns the energy to the power system. The device performs the test charge and discharge of the battery.

CHARGING the battery is performed "by the IU method". Charging energy is taken from the rectifiers of power system. Charging is performed when the power system voltage is higher than:

- 25 V – for 24 V battery; /
- 38 V – for 36 V battery;
- 49 V – for 46 V battery; /
- 51 V – for 48 V battery

and must be lower than 57V. Charging is temporarily suspended if power system voltage is outside of this range. If this situation happens 5 times, then the charging current will decreases 2 times.

When the battery voltage reaches the power system voltage then the charging current is limited to 90% of set value. During operation the device reduces charging current if any

monitored block / cell voltage exceeds by more than 50 mV/cell an average battery voltage. During charging it is posibble to activate the equalizer of voltages of cells/blocks.

Equalizing charging is performed before battery test discharging and assures full charge and equalizes cell voltages. The final charge voltage must be equal to the value recommended by battery manufacturer (2.30 ÷ 2.45 V/cell).

Return charging of the battery is carried out after the discharging. The final charge voltage should be set according to the battery manufacturer's recommendation (2.30 ÷ 2.45 V/cell). The end of return charging may also be selected by the determination of the final charging current Ik (Ik = 2mA * 10 Q, for 2A for 1000Ah battery).

Recommended temperatures of charging are between +5℃ and +35 ℃. If temperature of charging is other than 20℃, the voltage of the battery and its cells/blocks can be corrected by the device according to the formula: $U_t = U_{20℃} - (t - 20℃) * K$, *where:*
K = *temperature correction factor,* $U_{20℃}$ = *the voltage at 20℃,*
t = *battery/ambient average temperature,* U_t = *voltage at the* actual *temperature.*

In case of **DISCHARGING the battery** with current up to 160 A, the device transmits energy coming from the battery to the load, telecommunications equipment, of the power system. The unit stops discharging when the voltage of the power system is lower than the battery voltage. If the discharging current is set too high and the load of the power system is not able to consume this energy, the power system voltage is increasing to the upper limit and the device must reduce the value of the discharge current. During the discharging by means of the built-in resistor, the device converts the energy from the battery into heat.

Measurements during battery DISCHARGING are is carried out to measure the real capacity – performed with discharge current 0.1 Q or (for batteries with very large capacity) with discharge current 0.05 Q.

The battery discharge is finished when:

(1) the declared energy is retrieved, or

(2) the programmed lower limit of the battery voltage is achieved, or

(3) the minimal voltage of any the cell/block (range 1.60 ÷ 1.95 V/cell) is achieved.

The battery capacity "Q" is calculated as the equivalent value at +20℃ according to the formula: $Q_{t=20℃} = Q_t / ((1+0.01*(t-20℃))$, ***where:***
Q_t = *measured value,* $Q_{t=20℃}$ = *equivalent value at +20℃*
t = *temperature of the battery – the average of initial and final values.*

During charging/discharging the user is informed of its progress on the built-in display: charge retrieved from or delivered to the battery, operation duration, the minimum voltage of each cell and its number, the position of the cell with maximum voltage and its value, the battery temperature, charging/discharging current, voltages, and temperature inside the unit. The user can observe the realization of the cycle (voltage, current charging/discharging, time, alarm status) also on the PC screen. If:

- the power system voltage or battery/cell voltages are off limits, or
- the temperature is too high, or
- the measuring cable is disconnected;

this will cause:

- suspension of the device operation;
- an acoustic signal (the signal fades after pressing „▼”);
- displaying and sending error messages (SMS, LAN) about the event.

After removal of the cause of the alarm you can select "continue work” and „ENTER” or terminate session by pressing key „ESC STOP”.

After completion of a session, or interruption of work by pressing key „ESC STOP" device disconnects the negative poles of the battery and rectifiers of the power system and a user can:

- download the results of charging-discharging to a PC (via an SD memory or LAN);
- view at the built-in display results of charging-discharging (menu „RESULTS"), that is:
  - start and end time,
  - the reason for finishing the session (achievement of value/interrupted session/failure),
  - retrieved/delivered charge Q,
  - operation duration,
  - final voltage of the battery/cells,
  - battery temperature.

CPU unit is powered all the time.

4 FRONT PANEL

All descriptions, switches, peripherals are located on the front panel (Fig. 4). Only the SIM card slot is located underneath the top cover.

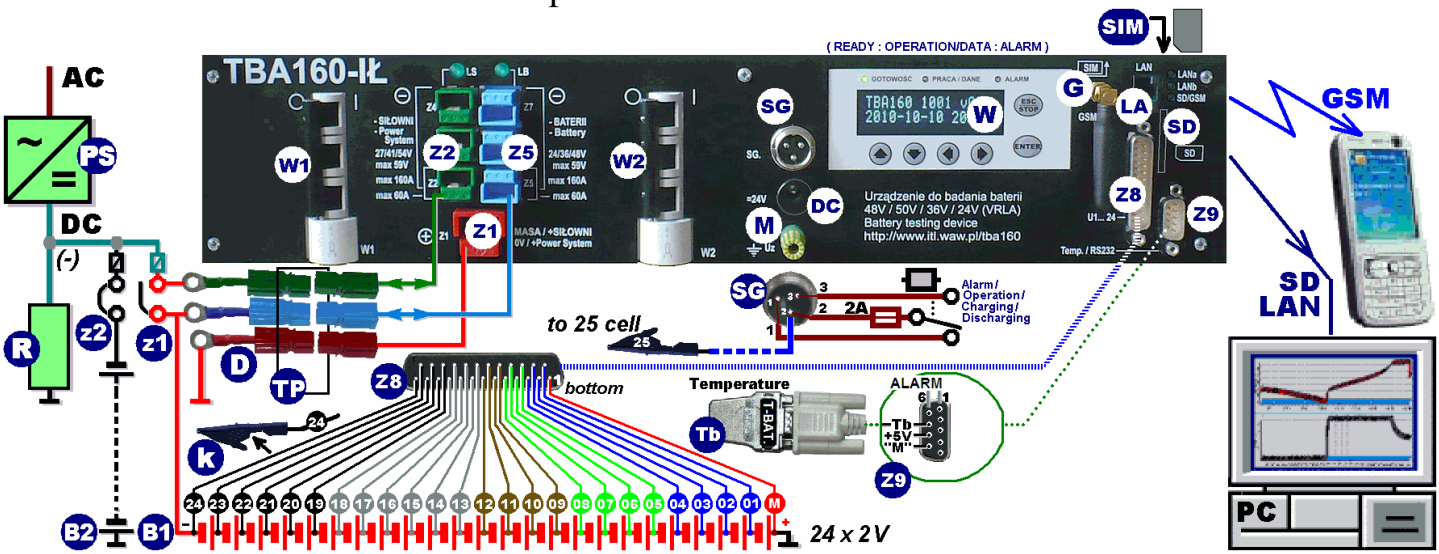


Fig. 4. Designations: PS= Power system, R= load; B1/B2= batteries, z1/z2= battery switch, D= power cable connectors, TP = an optional interface

(**W1/W2**) *switch* MCB of the power system / of the battery;
(**Z1**) *red socket* – "**0V/+POWER SYSTEM**"/ tested battery;
(**Z2**) *green sockets* – "**- POWER SYSTEM**" for power system;
(**Z5**) *blue sockets* – "**-BATTERY**" for battery 24V or 36V or 46V or 48V or 50V;
(**LS**) *LED* (over **Z2**) – power system voltage indication (LED is controlled by the processor);
(**LB**) *LED* (over **Z5**) – the battery voltage indication (LED is controlled by the processor);
(**SG**) *external alarm connector* – signalization of alarm/operation/charging/discharging;
(**DC**) *DC socket* – jack for power processor and display, during working without a power system;
(**M**) *ground socket* (ground is recommended but not necessary);
(**W**) *display, status LEDs* and a *keyboard*;
(**LA**) *socket* RJ45 – LAN10/100 data transmission (and LED indicator);
(**SD**) *card slot* for SD memory card;
(**Z8**) DB25 *connector* to the cable for measuring voltage of cells/blocks of tested BATTERY;
(**Z9**) DB9 *connector* to the signalization of alarm, temperature sensor, or optional to RS port;
(**G**) SMA connector for an GSM modem antenna;
(**SIM**) SIM card to GSM-modem, available after removing the top cover.

5 PREPARATION FOR USE

5.1 External DC power supply

If the device is not connected to a battery or the power system, the socket "= 24V" of device should be connected to an external DC unit (voltage between 18V to 60V) in order to read the results or enter settings.

5.2 Connection to the power system and the battery

The device must be connected according to the specification. The room must be clean, free of dust, hydrogen and substances harmful to electronic circuits (Figure 1 and Figure 4). The operator should:

- disconnect the tested battery (**B**) from the power system (**S**), for example by disconnecting the battery *fuse*;
- connect the positive terminal of the battery/0V power system – directly or via the optional interface "TP" (Fig. 1) to the **"0V"** socket (**Z1**);
- connect the negative terminal of the power system – directly or via the optional interface "TP" to the "- **POWER SYSTEM**" sockets (**Z2**);
- connect the negative battery terminal – directly or via the optional interface "TP" to the "-Battery" sockets (**Z5**).

*We recommend use of an optional "TP" interface or alternatively the power cable connectors (**D**) such as (**Z1/Z2/Z5**), those used in the device.*
*It is recommended to use the connector / current cable (Fig. 5a) in the following colors: **0V** – red, "**-POWER SYSTEM**" – green, "**- BATTERY**" – blue.*
For current up to 50A use *16mm^2 cable. For higher currents three such cables are needed. Cable marked "**0V**" is always single, 16 mm², because its current is 4 times smaller than the battery current.*

When battery and power system voltage is applied the "LS" and "LB" LEDs turn on. They light continuously when voltages are correct.

The display shows: the device name, its serial number, software version, date and time. On the keyboard, you can select the desired mode of operation (see Table-1 and Fig. 6).

5.3 Communications with the supervision system

Device TBA160-IL can be connected to the supervision system of the power system by:

- 3-pin connector (**SG**) which signals short-circuit (center-right) or break (center-left) selected status "alarm / operation / charging/ discharging" (max current 2A),
- RJ45 "LAN" (**LA**) - either directly or by IP network,
- optionally through the DB9 connector (**Z9**) – port RS232/RS485.

5.4 Measurement of a cell / block voltage and temperature

It is recommended to connect the device via the optional interface "TP" (Fig. 1):

- *battery temperature sensor* (with IC LM35CZ) via DB9 connector (**Z9**/Tb);
- *measuring input* (**Z8**) for battery cell/ block voltages through a DB25 connector, but
  - the red wire (marked "M(+)") must be connect to the "+" of the battery,
  - wires marked "1" to "24" must be rightly connected to the "-" of the battery cells / blocks,
  - the blue wire (marked "24/-Bat") must be connect to the "-" of the battery.

"TP" Measuring Circuits must be fused 2A.

A direct connection without "TP" is allowed. The cable with tips or "alligator clip" (Fig. 5c) is dedicated for direct connection to the battery terminals.

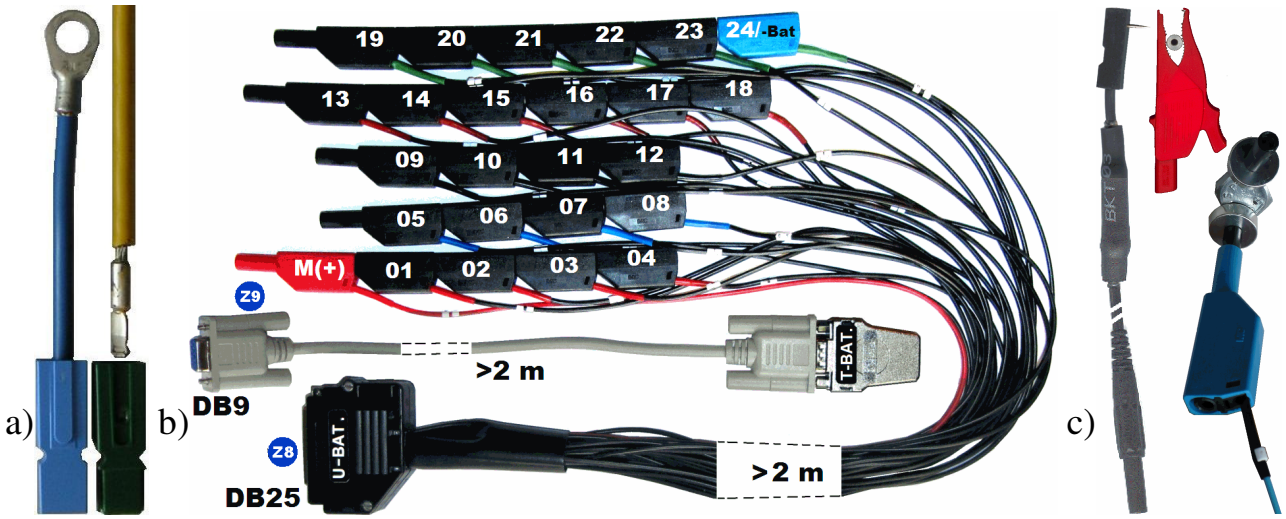


Fig. 5.

5.5 Connecting to a PC

PC can be connected:

- directly via an RJ45 connector / "LAN" by special X-cable, or
- through the Internet / Intranet (LAN 10/100) by a typical cable.

The IP address should be set in the PC and in the device TBA160-IL.

*For current and archive data (both "on line" and stored in TBA) the operator should run the **TBA_Starter / TBA_Reporter** program on the connected PC.*
Any web browser will provide a simplified live overview.
When the test session is finished, then it may be archived on the PC.

6 PROGRAMMING AND VIEWING RESULTS

Test session programming and device operation control are done via the front panel with the 2-line display and 6-button keypad, shown in the top of Figure 6.

After connecting the device to power - the display shows: the device name "TBA160", the device number, number of version, current date-time.

Settings menu is shown on Table-1, Table-2 and in Figure 6.

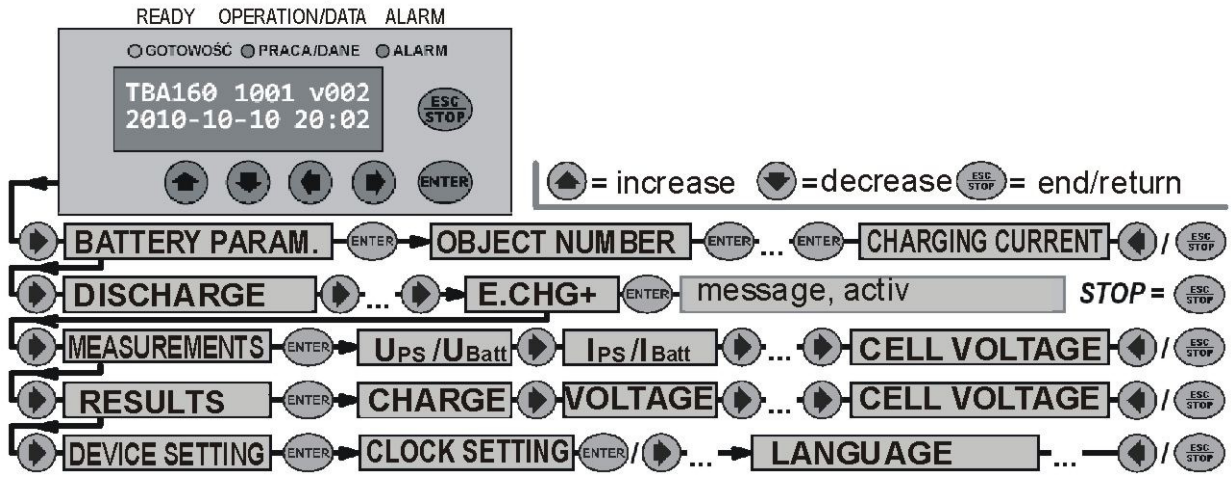


Fig. 6.

Buttons:

„◄" navigating left through a menu or setting higher number or previous parameter;

„►" navigating right or setting lower values or next parameter;

„▲" increases the value indicated by the cursor or "wakes up" screen;

„▼" decreases the indicated value;

„ENTER" acknowledgement of setting; / „ESC STOP" return to a higher level menu or session suspension.

Table-1.

CONNECTION TO POWER (to power system / battery / additional DC supply unit „=24V")				
Display:	***Operation (by „ENTER")***	***Option:***	***Subsequent option:***	***Result/NOTE***
TBA160 1001 v002 2010-10-10 20:02	Name, number, version, date and time			After starting and after: „ESC STOP – ESC STOP"
BATTERY PARAM.? PARAMETRY BAT.?	Battery description (see. Table-2)	Site, voltages, current, charge, ... - charging/ discharging / charging ret.		**see Table 7**
DISCHARGING? ROZŁADOWANIE?	Discharging of battery	Start by pressing „ENTER"	stop – by „ESC STOP"; the end of the second press „ESC STOP"; continuation of the „ENTER" Current measurements: by „◄ ►"	<u>After stopping:</u> displays the outcome of the session or the type of **alarm** and voltages, current, charge, temperature
CHARGING.? ŁADOWANIE POWR.?	Return charging of battery	Start by pressing „ENTER"		
EQUAL. CHARGING? ŁADOWANIE WYR.?	Equalizing charging of battery	Start by pressing „ENTER"		
DISCHARG.+CHARG? ROZŁAD.+ŁAD.P?	Discharging and charging of battery	Start by pressing „ENTER"		
E.CHG+DCHG+CHG? ŁAD.W+ROZ+ŁAD.P?	Equalizing charging, discharging, charging	Start by pressing „ENTER"		
MEASUREMENTS? POMIARY?	Display of voltages, current, temperature...	Parameter selection by „◄ ►"		Block voltage measurements, every 10 s
RESULTS? WYNIKI?	Display last session of summary results			Delete results after „start"
DEVICE SETTINGS? UST.URZĄDZENIA?	Settings: data/time, **IP adress**, signaling mode on „SG", delay display blanking, **language** (**język**), ... – by: „◄ ►"			Features

NOTE: before the discharge-charge operation battery, parameters should be set in menu „***BATTERY PARAM.***" (Table-2).

6.1 Date and time setting

The indications of internal clock can be changed in „***DEVICE SETTINGS–CLOCK SETTING***" menu by:

▲ increases the value / ◄ previous sign / ► next sign / ESC STOP acknowledge.

Backup battery of the clock is located in the unit „*S160*" and should be changed every 10 years.

6.2 Setting signalling mode

Menu „***DEVICE SETTINGS* –SIGNALLING**" determines signaling mode „SG", that is:

□ alarm or □ operations or □ charging or □ discharging.

6.3 Settings: IP addresses, the display mode, language

Through menu DEVICE SETTINGS, operator can:

- set the IP address through "**CHANGE ADDRESS**" (this setting must be set by the network admin):
  - □ IP ADDRESS – e.g. 172.016.050.030
  - □ SUBNET GATEWAY – e.g. 255.255.000.000
  - □ DEFAULT GATEWAY – e.g. 172.016.007.007
- setting delay display blanking (0 = no blanking, other = delay in minutes) in „***LCD BLANKING***" menu. <u>Note:</u> Wake display by pressing ▲;
- set language by choosing the menu „***DEVICE SETTINGS***" (***UST.URZĄDZENIA***) and next "**LANGUAGE**" (***JĘZYK***) – Polish (***Polski***) or English.

6.4 Setting the battery parameters

Setting the battery parameters must be made before initiating the measurements session in menu "BATTERY PARAM." (see Table-2). The number of the site should be changed when operator move the device to another site. If there is no dedicated site number it is possible to use e.g. postal code.

Table-2.

Lp.	PARAMETERS OF THE BATTERY/ setting	Range of settings for: battery 24 V	battery 36 V	battery 48 V	Suggested for 48 V
1	SITE NUMBER (postal code possible)	00000 ÷ 99999 („0" initial)			**number**
2	BATTERY NUMBER (In the site)	00 ÷ 99 („0" initial)			**1 or 2**
3	BATTERY (nominal voltage)	24 V, 36 V, 46 V, 48 V, (50 V)			**48 V**
4	NUMBER OF BATTERY BLOCKS	2 ÷ 12	2 ÷ 18	2 ÷ 24	**4 ÷ 24**
5	CURrent MEASUING RANGE	max 60 A / max 160 A			**> $I_{10zn.}$**
6	NOMINAL BATTERY CAPACITY	1 Ah ÷ 3 200 Ah			**$Q_{zn.}$**
7	CHARGE FROM BARTERY	--- (no limit), 1 ÷ 3 200 Ah			**80% $Q_{zn.}$**
8	DISCHARGING VIA RESISTOR (internal)	NO, YES			**NO**
9	DISCHARGING CURRENT	2÷50/160 A (via resistor 2÷8 A)			**$I_{10zn.}$**
10	DISCHARGING CELL VOLTAGE	1.60 ÷ 1.95 V ±0.05 V			**1.80 V**
11	DISCHARGing BATTery VOLTAGE	20÷23 V	30÷34.6 V	40÷46 V	**43.0 V**
12	MAX VOLTAGE ON LOAD	27÷29.6 V	40÷43.8 V	54÷56.8 V	**56.0 V**
13	EQUALCHARGING CURRENT	2÷50 A / 5÷160 A, 1 A step			**$I_{20zn.}$**
14	E. CHARGING BATTery VOLTAGE	27÷29,6 V	40÷44 V	54÷59 V	**56.4 V**
15	EQUAL. CHARGING TIME	10 minutes ÷ 48 hours			**10 hours**
16	CHARGING CURRENT	2÷50 A / 5÷160 A, 1 A step			**$I_{10zn.}$**
17	END CHARGING CURRENT	--- (no limited), 0.2÷50 A, 0.2 A step			**0.4 A**
18	CHARGING BATTERY VOLTAGE	27÷29.6 V	40÷44 V	54÷59 V	**56.4 V**
19	CHARGING TIME	10 minutes ÷ 48 hours			**10 hours**
20	MAX TEMPERATURE	--- (no limited), 30, 35, 40, 45, 50°C			**40°C**
21	REFERENCE TEMPERATURE	20°C, 25°C			**20°C**
22	CELL TEMPerature COMPensation	--- (no), 1 ÷ 10 mV/cell °C			**---**
23	EQALIZATION CELLS during loading	YES, NO			**YES**

6.5 Measurements

Current indications of measured values can be displayed by means of menu „MEASUREMENTS". Parameters which are irrelevant to realized mode of operation can be omitted. Inactive measuring inputs indicate value "0".

6.6 Displaying final results

From menu "RESULTS" the operator can display final results of the last completed discharging-charging session unless the setting parameters of the battery have been changed. Parameters which are irrelevant to the current settings are omitted.

NOTE: When the temperature sensor is attached, then the charge „Q" taken from and returned to the battery is always related to the value of charge in the temperature of 20ºC (or 25ºC).

6.7 Internal Memory and SD card

Results of measurements are always stored in internal memory and SD card memory (FAT 32 format). At least results of the last three sessions are collected in internal memory. The number of sessions saved on an SD card depends on its capacity. One session requires about 15 kB.

The sessions saved in memory are available via LAN. SD card erasing/formatting is possible on a PC. Any problems with the SD card are signalized by displaying the message "SD ERROR".

NOTE: Do not remove the SD memory card when LED SD/GSM is flashing.

6.8 Notification via GSM

The unit may send status via the GSM network. Angular GSM antenna can be replaced with an external antenna with SMA connector if necessary. The SIM card is located (Fig. 4) in module "K" under the top cover. Status of the GSM-modem is indicated by the SD / GSM LED

on the front panel. This feature can be activated in menu „***DEVICE SETTING***" and next *"**GSM**"*. GSM radio signal level is displayed in menu "MEASUREMENT".

*Operator will activate notification via SMS by sending an SMS with the command **„TBA numer XXXX status XXXXX".** That device sends an SMS after the change of state (end of session, alarm). In response to a text message "TBA status", the device sends the current status and deactivate the notification function when the TBA160-IL is disconnected from the power.*

7 BATTERY CHARGING-DISCHARGING

7.1 Start of charging-discharging session

Before the session the operator should:

- check and correct the parameters set of the battery **-** "**BATTERY PARAM**." (default values are from previous session, except site number and battery number);
- set mode of operation and acknowledge it by pressing ENTER.

The device starts the fan and displays commands to switch W1/W2: "BATTERY SWITCH" and "POWER SWITCH". If settings and conditions are correct then device starts session.

All problems during operation are signalized by:

- acoustic alarm;
- displayed messages;
- alarms on the SG connector;
- notification via SMS (messages given in Table-3).

The session can be continued, if the operator had corrected the problem, by pressing ENTER or stop it by pressing ESC STOP.

7.2 End of charging-discharging session

Session is finished automatically when programmed cycle of operations has been realized or can be stopped in case of error or by the operator by pressing ESC STOP .

Messages about the cause of suspension of operation are shown on the display (Table-3) as well as the results of current measurements. This helps to take decision about further proceedings.

Operation of the device can be continued by pressing ENTER or finished by pressing ESC STOP. It is strongly recommended not to terminate the session by switching off W1/W2 or disconnecting cables.

7.3 Battery discharging

"DISCHARGING" (only this cycle) is selected generally in order to discharge the battery under the inspection of the operator, who then starts the charging, or to total discharging the battery before utilization.

Settings are described in chapter 6.4 and starting the session in chapter 7.1. The session is finished if:

- charge "Q" was reached;
- voltage of any cell reached lower limit;
- battery voltage reached a preset lower value;
- duration of the session exceeded 50 hours.

7.4 The "equalizing charging" session

"EQUAL. CHARGING" is dedicated to fully charge the battery and minimalize (when option "equalization cells" is active) the difference between voltages of battery cells or blocks. Settings are described in chapter 6.4 and initiating the session in chapter 7.1. Session is finished when the set charging time elapses.

7.5 The "return charging" session

„CHARGING." is mainly dedicated to test battery. Settings are described in chapter. 6.4, starting session in chapter 7.1. The session should be finished when:

- current flowing to the battery falls below a preset value, or
- time of charging (counted from the moment of current reduction) elapses, or
- "initial charging" time is longer than 50 hours.

7.6 The „discharge and recharge" session

Type of session " DISCHARG.+CHARG" is used in order to test the capacity of the battery which is fully charged and after the test must be ready to work with a power system. If $Q_{charge} > Q_{discharge}$ it means that the battery collected as many energy as it was discharged. Settings are described in chapter 6.4 and initiating the operation in chapter 7.1.

The device finishes battery discharging and starts to charge it :

- after discharging the preset charge "Q" (when the expected capacity was set), or
- after reaching the lower limit voltage by the any cell of battery, or
- after reaching the lower voltage threshold by the battery voltage, or
- if the duration of discharging exceeds 50 hours.

The device must finish charging the battery when:

- current flowing to the battery drops below a preset value, or
- preset time has elapsed (counted from the current reduction), or
- the duration of charge exceeds 50 hours.

7.7 The „charging- discharging - charging" session

This session is a full test. After the session the battery is fully charged and ready to connect to the power system. Session covers: initial charging, discharging and return charging (E. CHG+DCHG+CHG). Settings are described in chapter 6.4 and start of session in chapter 7.1.

The time of equalizing charging is preset by the operator.

The device finishes discharging battery and starts to charge it:

- after discharging the preset charge "Q" (when the expected capacity was set), or
- after reaching the lower limit voltage by the any cell of battery, or
- after reaching the lower voltage threshold by the battery voltage, or
- if the duration of discharging exceeds 50 hours.

The device must finish charging the battery when:

- current flowing to the battery drops below a preset value, or
- preset time has elapsed (counted from the current reduction), or
- if the duration of charging exceeds 50 hours.

8 RESULTS STORING

The device displays and stores a number of parameters including voltage of the battery and the cells / blocks, duration of each session, device internal temperature, battery temperature, discharging and charging current and delivered / retrieved charge. This data (Table-3) may be:

- transmitted to a computer in real time, or
- transmitted from the internal memory on the LAN, or
- transferred via memory card.

The device creates a unique "session number", which is also the name of the file on the SD memory card. PC (Windows) processes the stored data by means of the application software ***TBA_Starter / TBA_Reporter***.

Table-3.

Byte	DATA SCHEMA	byte	DATA SCHEMA
00	STARTER: b7=1; 6=0; b5=0; b4=1:1mV; b3=1: memory; b2=1; b1=1; b0=1:	37,38	settings: discharge current (resolution 0.01A)
01,02	data block number (0÷1023) in memory TBA	39,40	settings: Final cell discharge voltage (resolution 10mV)
03,04	S/N 0÷9999 (bit D7 in byte 04 denote MSB of number SITE)	41,42	settings: Final battery discharge voltage (resolution 10mV)
05,06	number SITE 0÷99999 (MSB - 04)	43	MEASUREMENTS: battery temperature (resolution 1 °C) (7fh-no measure.)
07	Realised SESSION: b0=1: discharge; b1=1: charge; b2=1: initial charge	44,45	settings: re-charging current (resolution 0.01A)
08	PROCES: b7=1: stay; b0=1: discharge; 2: charge; 3: initial charge	46,47	settings: the final re-charging current (resolution 0.01A)
09	TROUBLE CODE or CODE of FINISHING	48,49	settings: initial charging current (resolution 0.01A)
10	CURRENT TIME: minutes *(binary)*	50,51	settings: Final re-charging voltage (resolution 10mV)
11	CURRENT TIME: hours *(binary)*	52,53	settings: time initial charge (resolution 1')
12	CURRENT TIME: day *(binary)*	54	settings: b7=1: discharge on resistor; b6-b0= temp. compensation (mV/°C)
13	CURRENT TIME: month *(binary)*	55	settings: battery Max temperature (resolution 1°C; 0=no check)
14	CURRENT TIME: year *(binary)*	56,57	settings: final voltage initial charge battery (resolution 10mV)
15,16	DURATION of SESSION discharge/charge (resolution 1')	58,59	settings: re-charging time (resolution 1')
17,18	CHARGE downloaded/restored (resolution 0.1Ah)	60,61	START SESSION. – minute/hour (to create a number of sessions)
19,20	MEASUREMENTS: power system voltage (resolution 10mV)	62,63	Byte 62: START SESSION – day (to create a number of sessions) /Byte 63=7F
21,22	settings: rated battery capacity (resolution. 1Ah)	64,65	minimum voltage of cell-block
23,24	MEASUREMENTS: battery voltage (resolution 10mV)	66,67	Byte 66: No cell-block / Byte 67: Maximum voltage of cell-block (L)
25	settings: BATTERY NUMBER 0-99	68,69	Byte 68: Maximum voltage of cell-block (H) / Byte 69: No cell-block
26	settings: current range b2=0:160/1:60A; b1=1: LEM25; b0=1: two LEMs	70,71	Voltage cell-block No. 01 (resolution 10 mV or 1 mV)
27,28	MEASUREMENTS: current range (resolution 0.01A, *„-" for discharge)*	72,73	Voltage cell-block No. 02 (resolution 10 mV or 1 mV)
29,30	settings: max. output voltage (resolution 10mV)	74,75	Voltage cell-block No. (resolution 10 mV or 1 mV)
31	MEASUREMENTS: internal temperature (resolution 1 °C)	76,77	Voltage cell-block No. 04 (resolution 10 mV or 1 mV)
32	MEASUREMENTS: head sink temperature (resolution 1 °C)		Voltage cell-block No. nr 05 -23
33	settings: b6=1:equalization; b5=1: inform by GSM; b4-b0-numer of blocks/cells.	116/17	Voltage cell-block No. 24 (resolution 10 mV or 1 mV)
34	settings: b7-b5 battery type. 0=24V, 1=36V, 2=46V, 3=48V, 4=50V; b4-b0=temp.	118/19	Voltage cell-block No. 25 (resolution 10 mV or 1 mV)
35,36	settings: charge DOWNLOADS (resolution 1Ah)	120	**Check control**

9 MESSAGES AND ERROR CODES

During operation or after its interruption / end of the session, the message is displayed as text, and its code is transmitted together with the results to a PC. Messages and their codes are shown in Table-4.

Table-4.

Code	DISPLAYED / MESSAGES	COMMENTS
		In operation mode:
0	(LRL = full session) **WORK/WAIT/STOP/END**	**CHARGING / DISCHARGING / CHARGING**. session type (e.g., **WORK/WAIT** (on operator's activity)/**STOP** (halted by the operator), **END** (session end)
		FAILURE STATE
1	**FAILURE LCD**	failure of display - SUSPENSION;
2	**OVERLOAD**	overload (I_{bat} > 198 A / > 74 A for small currents) - END OF THE SESSION;
3	**HIGH TEMPERATURE INT.**	> 50°C (start), > 60°C (stop) – waiting for the temperature drop;
4	**MISSING BLOCKS VOLTAGE**	no voltage of blocks– waiting for the voltages;
5	**MISSING BATTERY TEMPERATURE**	no temperature of battery or <3 ° C - waiting for the correct temperature;
6	**MISSING EXTERNAL DATA**	no external measurements (fault) - END OF THE SESSION;
7	**OVERVOLTAGE**	overvoltage - of battery / power system> 63 V (stop of charging / discharging);
8	**BAD BATT.CONNECT**	improper connection to terminals as for current 160A but set to 60A - END OF THE CYCLE;
9	**LOW TEMPERATURE BAT.**	too low battery temperature <5 ° C (at start);
10	**HIGH TEMPERATURE BAT.**	too high battery temperature > higher 5°C than set (waiting for the temperature drop);
11	**LOW VOLTAGE BAT.**	too low battery voltage <20.9 / 31.4 / 40.1 / 41.9 / 43.9 V (start);
12	**HIGH VOLTAGE BAT.**	start order:> 27.1 / 40.6 / 54.9 / 54.1 / 56.1 V or> final voltage;
13	**TIME 50h**	achieving max. time session (50h) - END OF THE SESSION;
14	**WRONG VOLTAGE POWER**	power system voltage over range 25.4/ 38.1/ 48.8/ 50.9/ 52.9V– 28.6/ 42.9/ 54.7/ 57.1/ 57.1V (start);
16	**HIGH CELL VOLT.**	max cell voltage > limit the cell voltage (stop);
17	**DIFF CELLS VOLT.**	big voltage difference between cells (stop);
18	**NO BATTERY VOLT.**	no battery voltage or lover than< 19/ 28.5/ 36.4/ 38/ 39.6V – END OF SESSION;
19	**NO POWER VOLTAGE**	no power system voltage < 19/ 28.5/ 36.4/ 38/ 39.6V - END OF SESSION;
20	**HIGH RADIATOR TEMPERATURE**	high temperature heatsink >60°C (start), >70°C (>85°C discharge to resistor) – waiting for the reduction;
21	**WRONG VOLTAGE POWER**	too low power system voltage <25.4/ 38.1/ 48.8/ 50.9/ 52.9V (stop charge), > 57.1V (stop);
23	**HIGH CELL VOLTAGE**	max cell voltage > limit the cell voltage. - END OF SESSION (for 15 events);
24	**HIGH DIFFERENCE CELLS VOLTAGE**	Too big difference between voltage cells - END OF SESSION (for 15 events);
25	**BATTERY SWITCH**	battery switch off - END OF SESSION;
26	**POWER SWITCH**	power system switch off - END OF SESSION;
32	**USER STOPPED**	charging / discharging stopped by the user ($^{ESC}/_{STOP}$).

Code	DISPLAYED / MESSAGES	COMMENTS
		for END of DISCHARGE the "reason of finishing " available in RESULTS:
48	**DISCHARGING FINISHED – BATTERY VOLT.**	battery voltage reached the final discharge voltage;
49	**DISCHARGING FINISHED – CELL VOLTAGE**	cell/block voltage reached the final discharge voltage;
52	**DISCHARGING FINISHED – TAKEN CHARGE**	set value of charge was discharged.
		for END of CHARGE the "reason of finishing " available in RESULTS:
51	**CHARGING FINISHED – SET CURRENT**	achievement of desired final charging current.
53	**CHARGING FINISHED – TIME**	achievement of charge designed time
55	**CHARGING FINISHED–HIGH BATTERY VOLT.**	achieve desired final charging voltage +0.5 V (15 events)
In results:	**CHARGE** (provided, resolution 0.1 Ah) / **TIME CYCLE** (resolution 1 minute)	
	Usil – POWER SYSTEM VOLTAGE (V) / **Ubat** – BATTERY VOLTAGE (V)	
	UognMin – MINIMAL CELL VOLTAGE (V) (---- no results) / **Block No** - block the voltage minimum	
	UognMax - MAX CELL VOLTAGE (V) (----no results) / **Block No** - block the voltage max.	
	Ibat – CURRENT SELECTED BATTERY 1 (A) / **Tbat** – BATTERY TEMPERATURE 1 (°C) (--- no probe)	
	Trad – SINK TEMPERATURE (°C) / **Twewn** – INTERNAL TEMPERATURE (°C)	
	Ubl-NN - voltage block No NN of battery (V) / **Ubl-NN+1** - voltage block No NN+1 of battery (V)	

10 BATTERY TEST REPORT

The results stored in the memory of the device can be downloaded to a PC by *TBA_Starter / TBA_Reporter* after the test. Report is presented in tables and graphs and can be printed out (Fig. 3). The application software contains powerful help and installation files delivered on the SD card with the device.

11 CONTENTS of DELIVERY, STORAGE, TRANSPORT, WARRANTY

CONTENTS of DELIVERY. Standard delivery contains:

1) TBA160-IL device: 1 pc
2) cables 16mm² (ground, battery, power system), measuring cable (with DB25) temperature sensor (with DB9) and AC adapter (output = 24V/> 500mA): 1 set
3) SD card - 4 GB (install file "*TBA_Starter/TBA_Reporter*" for Windows is attached) 1 pc
4) user manual: 1 set

Options and additional services:

- LAN cable RJ45 (computer-to-network) and X cable RJ45;
- probes and power cables, connector cable for the external signalization (SG);
- dedicated software to communicate with other systems;
- laptop with preinstalled software for reporting and archiving results;
- training (at the premises of the supplier or the user).

NOTE: The device requires periodic inspection of mechanical parts (fans, switches) and a calibration check of the system measuring voltages, currents and temperature. Inspection of mechanical components, working with 60-100% load, should be made at least every 100 cycles of charging-discharging, and calibration check - every two years.

STORAGE. The device should be stored indoors at temperatures from 278K to 313K (+5ºC to +40ºC) with humidity up to 80% and without dust / fumes from chemicals.

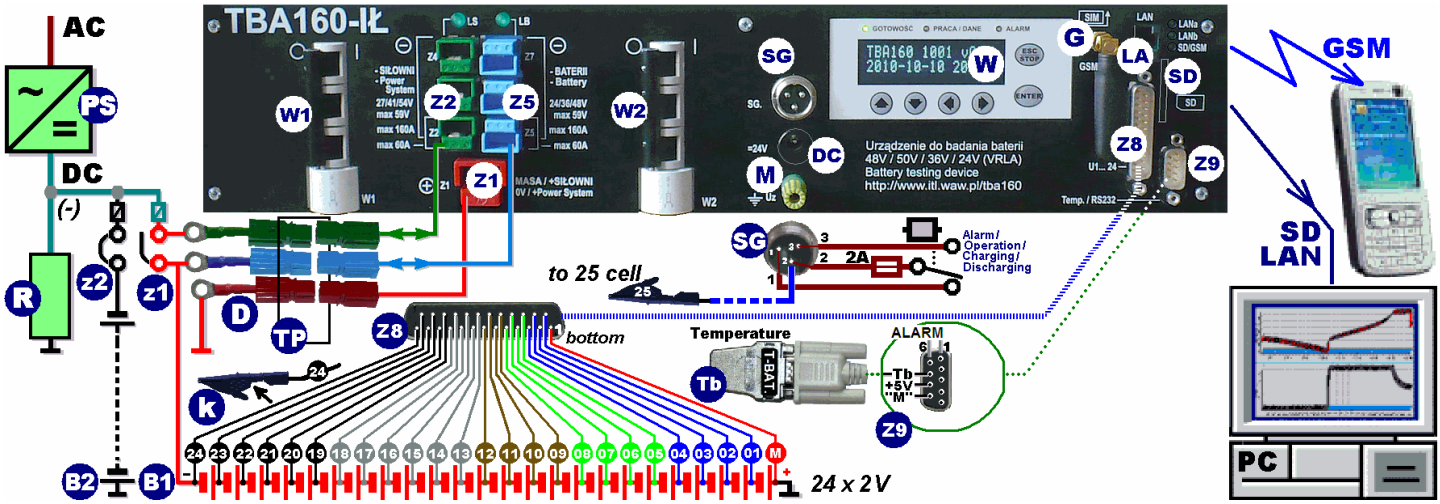
TRANSPORT. During transport the device should be protected from dust and mechanical damage, and must be in a horizontal position. If it was transported at temperatures below 5ºC, the device should be warmed to room temperature before turning on.

WARRANTY.

TBA160-IŁ Device developed at the ***National Institute of Telecommunications***
04-894 Warszawa / POLAND, ul. Szachowa 1
Z10@itl.waw.pl / fax +48 22 5128 185

TBA160-IŁ Device, S/N. .. .. / .. .. (Year / serial number in year) / Sale Date: .....

TBA160-IL Quick start



(1a) When working with the optional TP interface one should:

- disconnect the battery from the power system, connect The *TP* to connectors *TBA160* as follows: **Z1/„+”**, **Z2/„- POWER SYSTEM”** **Z5/„- BATTERY”**, measuring **Z8** (*DB25*) and temperature sensor/alarm **Z9** (*DB9*).

(1b) *When working without the optional TP interface user should*:

- disconnect the battery from the power system e.g. by extraction battery fuse;
- connect **Z1/„+”** to the „**+**” battery/power system with a 16 mm² **red power cable**;
- connect **Z2/„- Power System”** to the „**-**” power system with a 16 mm² **green power cables***;
- connect **Z5/„- BATTERY”** to the „**-**” battery B1 with a 16 mm² **blue power cables***;

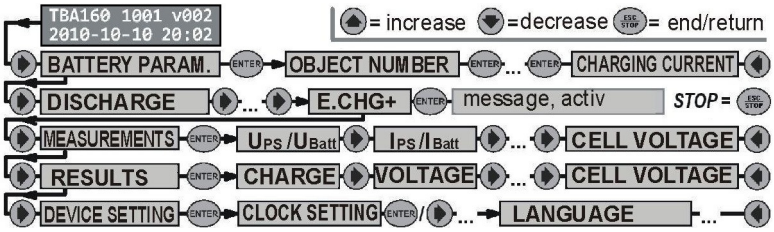
  *if current is below 50A you can use a single cable, attached to the lower sockets Z2 and Z5);
- connect the measuring cable **Z8** to cells/blocks of tested battery (**B1**);
- connect the temperature sensor (**Tb**) to **Z9** (DB9).

(2) TBA160-IL can be also connected to:

- Supervision system via **Z9** or **SG**;
- PC by **LAN** (LAN) – directly (via X cable) or via LAN.

(3) Modes and parameters setting:

After start the display shows: the device name, its serial number, software version, date and time. (navigating keys ▶ or ◀ / ENTER - acknowledgement, ESC/STOP return to the higher level of the menu). During operation should be:



- check / set **date-time**, **IP ADDRESS**, status **GSM**;
- set **battery parameters**, including: **site***, nominal capacity, charging/discharging voltages, currents, charge from battery ...;
- show results on built-in display or „*TBA_Starter*” on a connected PC displaying results - voltages, currents, temperatures;
- activating* of notification by SMS (see chapter 6.8);
- set mode TBA160 and starts with switches MCB - **W1/W2**;
- check fans activity (right hand side of frame);
- press ENTER to **activate operation** (press ESC/STOP/ESC/STOP to finish operation).

(4) In operations state: by pressing ▶ or ◀ the results, status or parameters can be displayed, (wake up display by pressing ▲); operation can be stopped by pressing ESC/STOP. At the end of the session or at the alarm state, the device will notify user by sending SMS (see chapter **6.8**).

(5) After operation: the device can display (**W**) the settings and the final results of the work, and the PC can store the complete data from the session (LAN, SD card).

* activation of funcjonality by SMS (format „**Tba sms site_number**”)