



**I.S.A. Istrumentazioni Sistemi Automatici S.r.l.**  
Via Prati Bassi 22 - 21020 Taino (VA) - ITALIA  
tel +39 0331 956081 - fax +39 0331 957091  
e-mail: isa@isatest.com - www.isatest.com

**DATE: 21/12/2005**

**DOC.SIE10163**

**REV. 3**

**INSTRUMENT BER-3  
FOR THE VERIFICATION  
OF SOLID-STATE RELAYS**



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## 1 GENERAL

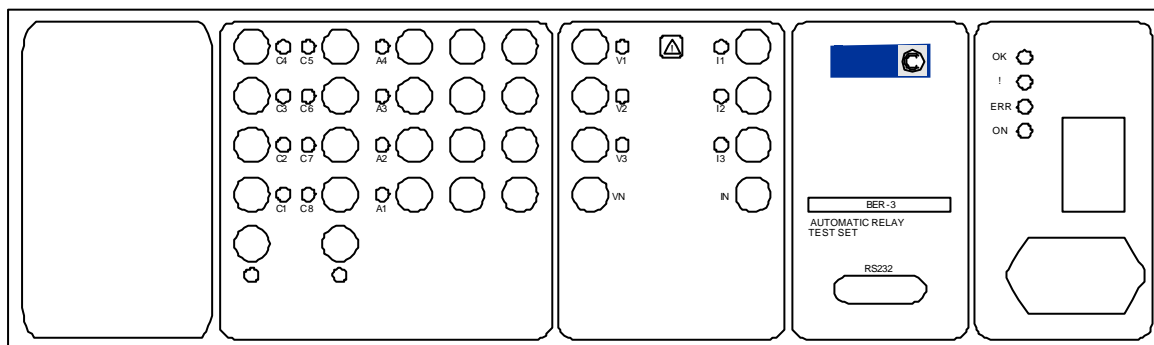
### 1.1 The instrument

The instrument BER-3 is a programmable and automatic relay test set, that permits for the automatic verification of digital protection relays, such as those used in the Medium and High voltage networks.

The test bench is realised in a case 3 U high, that contains: the power supply, the interface circuits, the control boards, the voltage and current amplifiers. All units are easily accessed and replaced in case of fault. The rack is housed into an aluminium container with handle for ease of transportation; the instrument is supplied with a plastic bag for protection during transit.

The instrument operates in connection with a computer, that controls it via the RS232 serial port. The firmware FWH2, contained in a FLASH EPROM resident into the instrument, allows the instrument to interpret all commands received from the computer and to transmit test results. Software running on the P.C. allow the user to:

- . Control all current and voltage outputs, for the simulation of all types of faults: in particular, faults that are produced on a distribution network with the neutral connected to ground;
- . Change the output in a ramp or step mode;
- . Define the state of inputs and outputs between two fault simulations;
- . Simulate complex evolution, with faults that change during the test.



**BER-3 FRONT FACE**

### 1.2 The options

- 1) Relay connection cables: set of cables for the connection to the relay to be tested.
- 2) GPS synchronizer. It allows to synchronize at the microsecond two BER-3, for the end-to-end test of relays such as cable differential.
- 3) IN1A option, for the test of 1 A- rated high-burden relays.
- 4) SEIPAV option for the series connection of current outputs or the parallel connection of voltage outputs.
- 5) Protection bag.

6) Transit case.

### **1.3 TDMS, the software for BER-3**

All controls of the instrument are performed by the software TDMS, that is described in document MSE10015.

## 2 APPLICABLE STANDARDS

The test set BER-3 and the optional modules conform to the EEC directives regarding Electromagnetic Compatibility and Low Voltage instruments.

### 2.1 Electromagnetic Compatibility

Directive no. 89/336/CEE dated may 3, 1989, modified by the directive 92/31/CEE dated may 5, 1992. Applicable Standard : EN61326 + A1 + A2.

#### EMISSION

- EN 61000-3-3: Limitation of voltage fluctuations and flicker. Acceptable limits: basic.
- CISPR16 (EN 55011 class A): Limits and measurement methods of radio-electric disturbances for industrial, medical and scientific instruments at radio-electric frequencies.

Acceptable limits for conducted emission:

- . 0.15-0.5 MHz: 79 dB pk; 66 dB avg.
- . 0.5-5 MHz: 73 dB pk; 60 dB avg.
- . 5-30 MHz: 73 dB pk; 60 dB avg.

Acceptable limits for radiated emission:

- . 30-230 MHz: 40 dB (30 m)
- . 230-1000 MHz: 47 dB (30 m)

#### IMMUNITY

- EN 61000-4-2: Immunity tests for ESD. Test values: 8 kV in air; 4 kV in contact.
- EN 61000-4-3: Immunity tests for radio frequency interference. Test values (f= 900 ± 5 MHz): field 10 V/m, modulated AM 80%; 1 kHz
- EN 61000-4-4; Immunity tests for high speed transients (burst). Test values: 2 kV peak; 5/50 ns.
- EN 61000-4-5; Immunity tests for surge. Test values: 1 kV peak differential mode; 2 kV peak common mode; 1.2/50 us.
- EN 61000-4-6: immunity to low-voltage sinusoidal waveform. Test values: 0.15-80 MHz, 3 Vrms, 80% AM 1 kHz.
- EN 61000-4-8: Immunity tests for low frequency magnetic fields. Test values: 30 Arms/m.
- EN 61000-4-11: Immunity test for power supply drops. Test value: 1 cycle; 100% drop.

### 2.2 Low voltage directive

Directive n. 73/23/CEE, modified by the directive 93/68/CEE.

Applicable standards, for a class I instrument, pollution degree 2, Installation category II: CEI EN 61010-1. In particular:

- Dielectric Rigidity: 1.4 kV 1 minute.
- Isolation resistance: > 2 MOhm.
- Earth resistance : < 0.1 Ohm.
- Dispersion current: < 5 mA.
- Inputs/outputs protection: IP 2X - CEI 70-1.

- Operating temperature: 0 - 45°C; storage: -25°C to 70°C.
- Relative humidity : 5 - 95%, without condensing.
- Altitude: less than 2000 m.

### 3 CHARACTERISTICS OF THE UNIT

#### 3.1 General

This section resumes the characteristic and the performances of the instrument. Listed characteristics are all used when the instrument is connected to a computer, with the corresponding commands. For each parameter are reported the regulation ranges, and also the control parameter format, as it is exchanged between BER-3 and PC.

In separate documents are described:

- . The BER-3 user's guide;
- . The resident program FWH2;
- . The software TDMS.

On the instrument the following connections are available:

- . Mains power supply (2 phase with ground);
- . Three voltage outputs V1-V3, with a common neutral point;
- . Three current outputs I1-I3, with a common neutral point;
- . Eight input trip contacts, divided in two groups C1-C4 and C5-C8, of four inputs each, with two zero references;
- . Four auxiliary output contacts A1-A4, without a common point;
- . Serial interface RS232;
- . USB interface.

Besides, on the front panel are available :

- . Power-on switch;
- . Four lights indicating the status of the instrument;
- . Eight lights for the status of trip input (turn on when closed);
- . Four lights for the status of auxiliary output (turn on when closed);
- . One light per output, that turns on when there it is available.

When the instrument is turned on it performs a self-diagnostic check of all of the logic and analog circuits. During the use, the instrument watches continuously the outputs, checking that they do not deviate from the nominal.

The principal operation are as follows:

- . Connect the BER-3 to the portable PC, using the supplied serial cable;
- . Connect the BER-3 to the relay that is to be tested. The input trip contacts can be either clean or with voltage, polarized using the d.c. voltage output, or the d.c. voltage of the site;
- . Execute the test;
- . Test results are examined one at a time on the screen of the PC, and printed later on, after they have been saved.

In the user manual, furnished with the instrument, are contained the following information:

- . User's guide;
- . Physical realization of the instrument;
- . Electrical drawings;
- . Diagnostic information, failure area, intervention procedures.

### 3.2 Three phase current generator

- Three independent current sources, with a common neutral.
- Type of connection: safety banana plugs.
- Output ranges, power and resolution.

RANGE	OUTPUTS	CONNECTION	CURRENT (A)	POWER (VA)	Z MAX (Ohm)	RISOLUT.
1	3 X	DIRECT	0...12,5	40	0.25	760 $\mu$ A
2	3 X	DIRECT	0...1.25		0.25	100 $\mu$ A
3	3 X	DIRECT	0...0.125		0.25	10 $\mu$ A
4	1 X	3 IN PARALLEL	0...30 (3x10)	100	0.11	1.8 mA
5	1 X	2 IN SERIES	0...12.5	80	0.5	760 $\mu$ A

- Automatic switch to the range closest to the output, and independent range selection.
- Output frequency: from d.c. to 2000 Hz; transient 5 kHz.
- Waveform resolution: 24 bit (14 for the amplitude, 10 for the shape).
- Output adjustable from zero to the maximum value, with the resolution of 1/16384 of the selected range.
- Possibility of step changing the value of the output within 0.1 ms.
- Possibility of ramping the current. Rate of change programmable between  $\pm 0.001$  A/s and  $\pm 999$  A/s.
- Output accuracy.
  - . Typical:  $\pm 0.05\%$  of the regulated value  $\pm 0.01\%$  of the full scale range.
  - . Maximum:  $\pm 0.1\%$  of the regulated value  $\pm 0.02\%$  of the full scale range.
- Gradient accuracy:  $\pm 0.5\%$  of the selected value.
- Distortion: 0.1% .
- Automatic protection for overloads (including open circuit). In this case, the output is taken to zero and the ! LED turns on.

### 3.3 Three phase voltage output

- Three independent voltage sources, with a common neutral.
- Type of connection: safety banana plugs.
- Voltage ranges, power and resolution.

RANGE	OUTPUTS	CONNECTION	VOLTAGE (V)	POWER (VA)	Z MAX (Ohm)	RISOL.
1	3 X	DIRECT	0...125	40	390	7.6 mV
2	3 X	DIRECT	0...12,5			760 $\mu$ V
3	3 X	DIRECT	0...1			100 $\mu$ V
4	1 X	2 IN SERIES	0...250	80	780	15.2mV
5	1X	2 IN PARALLEL	0...125	80	195	7.6 mV

- Automatic range switch to the range closest to the output, and independent range selection.
- Output frequency: from d.c. to 2000 Hz; transient 5 kHz.
- Waveform resolution: 24 bit (14 for the amplitude, 10 for the shape).
- Output adjustable from zero to the maximum value, with the resolution of 1/16384 of the selected range, with a minimum of 100 Uv.
- Possibility of step changing the value of the output within 0.1 ms.
- Possibility of ramping the voltage. Rate of change programmable between  $\pm 0.001$  V/s and  $\pm 999$  V/s.
- Output accuracy.
  - . Typical:  $\pm 0.05\%$  of the regulated value  $\pm 0.01\%$  of the full scale range.
  - . Maximum:  $\pm 0.1\%$  of the regulated value  $\pm 0.02\%$  of the full scale range.
- Voltage gradient accuracy:  $\pm 0.5\%$  of the selected value.
- Distortion: 0.1% total maximum, with any load.
- Automatic protection for overloads (short circuit included). In this case, the output is taken to zero and the ! LED turns on.

### 3.4 Angles

- All angles are referred to the same absolute reference.
- Possibility to set independently the angle of all the outputs: V1; V2; V3; I1; I2; I3, in the field between zero and  $\pm 360^\circ$  (phase angle).
- Possibility of slewing all the angles. Variation range: 0.1 $^\circ$ /s to 999  $^\circ$ /s.
- Angle resolution: 0.01 $^\circ$ .
- Angle accuracy:  $\pm 0.1^\circ$ , with a p.f. between 0.8 and 1.

### 3.5 Output frequency

- Possibility of selecting the output frequency between 0.0000 and 1999.9999 Hz.

- Possibility to select the output frequency on:

- . V1 only;
- . I1 only;
- . All voltages (V1-V3);
- . All outputs.

With the first three selections it is possible to have a second frequency on other outputs.

- Maximum frequency error: 50 uHz (1 ppM).

- Resolution: 0.1 mHz.

- Possibility of step switching the output frequency, separately or together with the amplitude change.

- Possibility of slewing the frequency, with a slope from 0.001 Hz/s to 999.999 Hz/s. Resolution: 0.001 Hz/s.

- Slew accuracy: 0.01 Hz/s, with a minimum of 0.1 Hz/s.

### **3.6 Intervention time measurements**

- Digital inputs: 8 inputs, either clean or with voltage, from 4.5 to 250 V d.c. (24 to 250 V a.c.), divided in two groups of four input each, with two common points isolated at 1 kVac. This feature allows the measurement of polarized trip contacts with two different zeroes that can't be put in common.

- Connections: on safety banana plugs, marked C1 - C4 and C5 - C8.

- Selection of the type of input: Voltage clean; TTL; 24V; 48 V; 100 V; software controlled. The selection clean/voltage is displayed by two warning lights (one per group) : the light turns on if the group is under voltage.

- Input impedance: 1 MOhm.

- Selection of the input debounce duration, from 0 us to 2 ms, in 64 steps of 32 us each, program controlled.

- For all selections, inputs are protected against voltages up to the maximum specified above.

- Indication of the state of the inputs by lights mounted on the operator panel.

- Selection N.O./N.C., independent for each input.

- Measurements available:

- . Timing from the start of the test (injection) until the change of state or the reset of the selected input;
- . Timing from the change of state or the reset of an input in respect to any other input.

- Timer range: 0 - 999,999.9999 s (277 hours); resolution: 0.1 ms.

- Timer accuracy: 0.025% of the measure  $\pm$  0.1 ms, for input changes lasting more than 1 ms.

### **3.7 Auxiliary outputs**

- Four auxiliary contacts (A1, A2, A3, A4), timed, voltage clean, not polarized, whose termination C, N.O., N.C. are connected to safety banana connectors or to the A+C 28 way connector.
- Characteristics of the contacts with a resistive load:
  - . Maximum voltage : 250 V a.c.;
  - . Maximum current : 5 A.
- Range of programmable delay: from 0 to 999.99 s.
- Indication of the state of the outputs by lights mounted on the operator panel.

### **3.8 Interface connections**

- Interface 1: RS232.
  - . Transmission rate: 19,200 baud.
  - . Serial interface cable: 2 meters, included.
  - . Protocol: BUSY/READY.
- Interface 2: USB (from September 2005).
  - . Transmission rate: 3x minimum.
  - . Interface cable: 2 meters, included.

### **3.9 Operator's lights**

- The following lights are mounted on the operator panel of the instrument:
  - . OK: it turns on after power-on and after self-check.
  - . !: it turns on when an output (V or I) detects an overload, or in case of an internal failure of the instrument.
  - . ERR: it turns on in case of a failure of the internal logic circuits.
  - . ON: it turns on whenever there is a voltage or current on the outputs of the instrument.

### **3.10 Sequence of commands**

- The PC software allows controlling the instrument for the execution of automatic or manual tests.
- The elementary operations which compose all tests are:
  - . Measurement of the time delay from parameters step change;
  - . Search of the threshold, slewing parameters and memorize the value at the instant of the tripping of the input;
  - . Step change of parameters during a fixed time, reporting inputs that have changed their state (pause).
- Tests are executed in the following way:
  - . The PC defines the parameters to inject or vary;
  - . At the command of the operator, parameters are transmitted to the BER-3 by the serial interface;
  - . The BER-3 generates the specified values, waits for the trip of the selected input contacts, and then transmits the results to the PC by the same serial interface;
  - . The PC examines the results, performs calculations and then displays them to the operator.

- During the execution of the test the BER-3 is self controlled and does not depend on the serial communication.
- The simulation of the fault can be made of single or multiple tests (case of evolving failures).
- Between two simulations parameters may return to zero, return to the healthy value or maintain the last injected value.
- Maximum number of elementary tests (cycles) in a multiple test: 49.
- Duration of the cycle: from 1 ms to 999999.9999 s;
- Accuracy of the cycle duration: 1 ms.
- Delay between two cycles: 1 ms maximum.

### **3.11 Reproduction of faults**

- Possibility to reproduce a fault that has been recorded with a COMTRADE format, by means of the software R-PRO.
- Maximum recording dimension: 16 word; 64 kWord per channel; maximum sampling frequency 50 kHz.

### **3.12 Protections**

- Fuse on the mains supply.
- Electronic protections on the internal d.c. supplies of the instrument and alert to the program.
- Electronic protection for overload on the current (open circuit) or voltage outputs (short circuit), with immediate release of the output and lighting of the alarm light. The program resets the fault condition.
- Electronic protection in case of counter-feed of voltage outputs. In this instance, the ! alarm light turns on.
- Protection against over-temperature, on all outputs.
- Diagnostic messages for the setting of wrong data, mistakes on the inputs etc.

### **3.13 Power supply**

- Mains power supply: 90 to 132 and 180 to 264 V a.c., sinusoidal, single phase.
- Frequency: 47 to 63 Hz.
- Power consumption:
  - . at rest: less than 100 W;
  - . maximum load: 500 W.

### **3.14 Realization**

- Instrument: 3U high, lab type.
- Case: Aluminum, with carrying handle. The instrument may be operated in the horizontal or vertical positions.

### **3.15 Accessories**

The following items are supplied with the BER-3:

- . Mains supply cable;
- . Serial cable;
- . USB cable.
- . Relay connection cables kit: 12 in all, 4 red, 4 black, 2 blue, 2 yellow; length 2 m, cross section 1 sq. mm.
- . Ground connection cable: 2 m, yellow/green, terminated with crocodile clamp.

### **3.16 Weight and dimensions**

- Weight: 10 kg.
- Dimensions: 170 (h) x 470 (w) x 320 (d) mm.

## 4 BER-3 OPTIONS

### 4.1 Introduction

Hereafter are described options to be installed inside BER-3 and other smaller options.

### 4.2 Relay connection cables

This option includes 25 cables, with different colours, with banana plugs, 2 m long, that allow for the connection to the relay under test to the following sockets:

- Current outputs (4 cables);
- Voltage outputs (5 cables);
- Trip inputs (10 cables);
- Auxiliary outputs (8 cables);

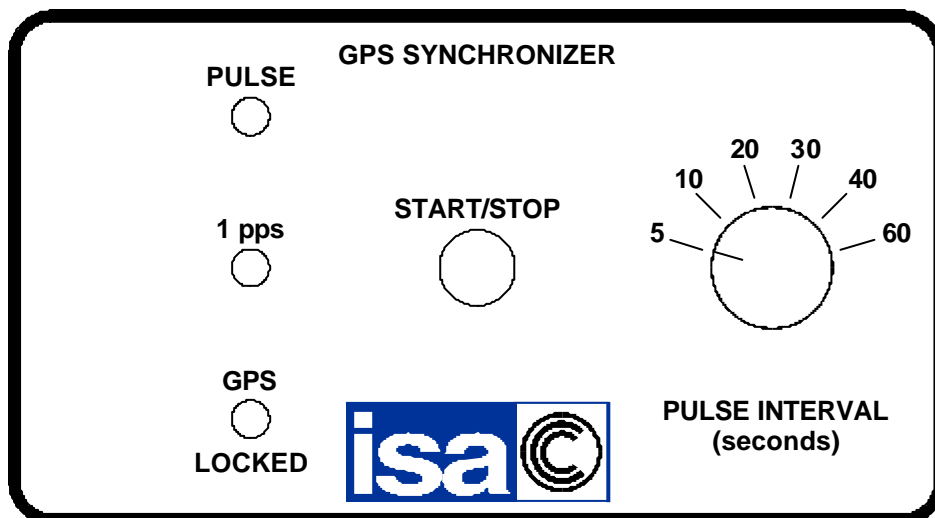
### 4.3 GPS synchronizer

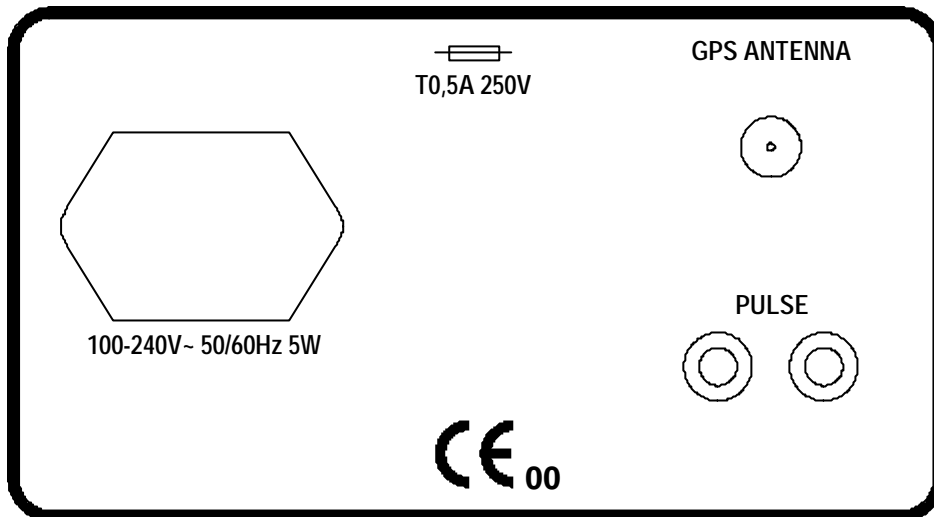
The GPS synchronizer is an external module that allows to synchronize test start of two BER-3.

Features are:

- . 1 digital output 0-24 Vdc, for synchronisation.
- . 1 selector to program the following pulse intervals: 5 s; 10 s; 20 s; 30 s; 40 s; 60 s.
- . Maximum timing error with respect to nominal: 2 us.
- . Lights to confirm: power-on; Locked; Pulse available.
- . 1 START and STOP push-button.
- . Power supply: 110/220 Vac.
- . The option includes the antenna and connection cables.
- . Weight: 1.7 kg.
- . Dimensions: width = 150 mm; height = 100 mm, depth = 240 mm.
- . Realisation: aluminium case.

Two test sets synchronized with GPS produce the maximum error of 50 us.





GPS front and rear view

#### **4.4 IN2-CDG current booster for 1 A rated relays**

With BER3 the full power of 40 VA is available only at the current of 12.5 A. This is good for the test of relays with the nominal current of 5 A; if relays are rated 1 A the available power can be not adequate to perform the test. In addition to this, relay CDG of GE has very low current settings.

The option IN2-CDG solves this problem, by means of a set of three current transformers, with the following characteristics:

- . Primaries: 12.5 A and 15 A;
- . Secondaries: 0.5 A; 1 A; 2.5 A; 5 A;
- . Nominal power: 100 VA;
- . Current ratio error: 0.2.
- Case: plastic.
- Connections:
  - . Four primary side sockets (I1, I2, I3, IN);
  - . Three independent outputs, with one phase socket and 2 zero sockets;
  - . Ease of connecting outputs in star or delta configuration.
  - . For the single phase test of the CDG relay it is possible to have three times the above power, connecting current outputs in series.

The option includes four connecting cables to DRTS current outputs, 1 m long, 2.5 sq. mm cross section. Outputs are do not have a common neutral; this eases the star or delta connection. Included is a bridge for star connection.

NOTE: the software takes into account the transformers ratio.

#### **4.5 SEIPAV option for the series connection of currents and parallel connection of voltages**

BER-3 has a power output of 40 VA both on current and voltage outputs.

##### **A) CURRENT OUTPUTS**

If it is necessary to have more than 40 VA, it is possible to connect two amplifiers in series. In this situation it is possible to have 80 VA; however, minor differences of current outputs tend to overload the amplifier; this would make it impossible to get the desired power. To overcome this problem the option includes a low burden for current outputs of BER-3 and for AMI-3 or AMIV-3 options. Burden is 220 Ohm; at maximum load it causes an error of – 0.1%.

## B) VOLTAGE OUTPUTS

If it is necessary to have more than 40 VA, it is possible to connect two amplifiers in parallel. In this situation it is possible to have 80 VA; however, minor differences of voltage outputs tend to overload the amplifier; this would make it impossible to get the desired power. To overcome this problem the option includes small resistors to be connected in series to voltage outputs of BER-3 and of AMI-3 or AMIV-3 options. Burden is 1 Ohm; at maximum load it causes an error of – 0.2%.

- Case: plastic.
- Connections:
  - . Voltage: six input sockets (V1, V'1; V2, V'2; V3, V'3) and three output sockets (V1P, V2P, V3P);
  - . Current: eight input sockets and eight output sockets(I1, I2, I3, IN; I'1, I'2, I'3, I'N).
- Connection cables: the option includes 14 cables for the connection of BER-3 and AMIV-3 to the option. Cable length 1 m; cross section 2.5 sq. mm. Terminated with safety banana plugs.

### **4.6 Protective bag**

The protective bag of BER-3 is useful during transportation by car. It includes a pocket for connection cables.

### **4.7 Transit case**

The protection of BER-3 from delivery problems is provided by this robust transit case, that features the following.

- Molded-case construction;
- Handles top and side;
- Wheels;
- Dimensions: 30 x 50 x 80 cm.