

Circuit Breaker Analyzer and Micro-Ohmmeter MOD. CBA 3000

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1 INTRODUCTION

The circuit breaker analyser and micro-ohmmeter model CBA3000 is a two-in-one test set.

When used as a circuit breaker analyser, it allows the off-line testing of the characteristics of all modern MV and HV circuit breakers. The test set measures CB operation times as they are defined in the IEC standard 62271-100; in particular:

- Opening time: see 3.7.133
- Closing time: see 3.7.136
- O-C time: see 3.7.139
- C-O time: see 3.7.143
- Minimum trip duration: see 3.7.146
- Minimum close duration: see 3.7.147

When used as a micro-ohmmeter, it allows measuring the contact resistance of the circuit breaker contact, or also of joints or other circuit parts. It allows also to perform the dynamic test of the contact resistance, that is to record and display how does the contact resistance change while the breaker is closing or opening: this allows detecting hidden defects, that are otherwise impossible to be diagnosed.

The instrument performs the following features:

- **Test set control:** via keypad plus selection knob plus dedicated keys, and a large colour display (800 x 480 pixels; view area 152 x 92 mm). In this way it's possible to look at the results, analyse them, zoom and so on USB and Ethernet interface for data communication with the PC.

Capability to transfer results directly to an USB pen drive.

Huge recording capability: more than 256 MB (typically 1000 results).

All possible test sequences are programmable. The tests can be included into a single test plan that defines all the operations that must be executed on a breaker.

- **Sixteen contact inputs** (optionally available 24) totally configurable. Each contact can be programmed as main breaker contact sensing circuit (to detect time delays of a breaker) or auxiliary contact. In this way it's possible to verify a breaker with up to 8 chambers per phase. If a contact it's programmed as main, the measurement of the time delay and of the value of pre-insertion resistor it's available.

The Open or Closed state of main inputs is displayed on the screen and continuously monitored.

For the main and/or auxiliary inputs, measurement of delays with respect to coil currents or other references.

- **Two driving coil circuits** (O+C); 4 or 6 optionally available in order to control each phase (Open or Close) independently. Three different current ranges can be used to measure the coil current of each circuit.
- **One micro-ohmmeter** (optionally 3), equipped with a high current generator up to 200 A, in order to perform static or dynamic resistance measurements of a breaker contact. With three micro-ohmmeters (up to 200 A each) it is possible to perform three phases measurements at the same time.

Moreover, the instrument it's able to perform a both side grounded test of a breaker, measuring the main contacts timing even if both ends of the CB are connected to ground in order to enhance the safety. The option solves also the problems of wrong detections when the connection cables are subject to a rather high induced current.

- **Eight analogue input measurement circuits** totally configurable. Any input can be configured as the following:
 - Generic AC or DC analogue input up to 300 V AC (or 420 V DC peak) for measuring standby battery or motor supply
 - Low voltage measurement, for motion analysis with transducers
 - Low voltage measurement, for pressure transducers
 - Very low voltage measurement for current clamps with voltage output
 - Very low voltage measurement for micro-ohmmeter function
 - Generic voltage input for other purposes

On the connectors of analogue inputs, it's available a DC voltage source for potentiometer transducers polarization.

- **One auxiliary relay output**, non programmable

The software TDMS (that operates with WINDOWS XP up), is included: it allows to execute tests and to analyze results, adding notes and saving into a data base and so on. It allows also to store and recall test settings.

All circuits have been designed to ensure safe operation in the noisy environment of HV and MV substations.

The instrument is housed in a transportable aluminium box, that is provided with a cover and handles for ease of transportation.

Dimensions (without handles and pins): 407 mm (H) x 450 mm (W) x 230 mm (D)

The following table lists the key features of CBA 3000 with respect to CBA 1000:

Performance	CBA 3000	CBA 1000
Coil command circuits	2, 4 or 6 (optional) circuits	2 or 4 (optional) circuits
Timing (main) contact inputs	16 inputs configurable (24 optional). All the channels may be defined as main or auxiliary depending upon the configuration setup. Optionally, PIR measurements on the channels are available	3 groups of 2 (no PIR measurement)
Timing (auxiliary) contact inputs		2 groups of 2 (no PIR measurement)
Auxiliary binary outputs	One relay contact : 8 A, 250 V	No
Analogue inputs	14 analogue inputs: <ul style="list-style-type: none"> (4 or 6) coil currents 8 configurable analogue inputs. Each input can be defined as generic high voltage input up to 300Vac (420 V DC peak) or analogue transducer input or micro-ohmmeter low voltage input 	6 analogue inputs: <ul style="list-style-type: none"> (or 4) coil currents 1 up to 500 V DC 1 up to 5 V DC
Digital incremental transducers inputs	3 inputs (RS422)	No
USB pen drive	Yes	No
ETHERNET	Yes	No
Dimensions	(407 x 450 x 230) mm	(400 x 300 x 240) mm
Weight	15 kg	10 kg

Table 1 - Key features

The following image exhibits the CBA 3000 front panel:



Figure 1 - CBA 3000 front panel

The following image exhibits the rear panel:

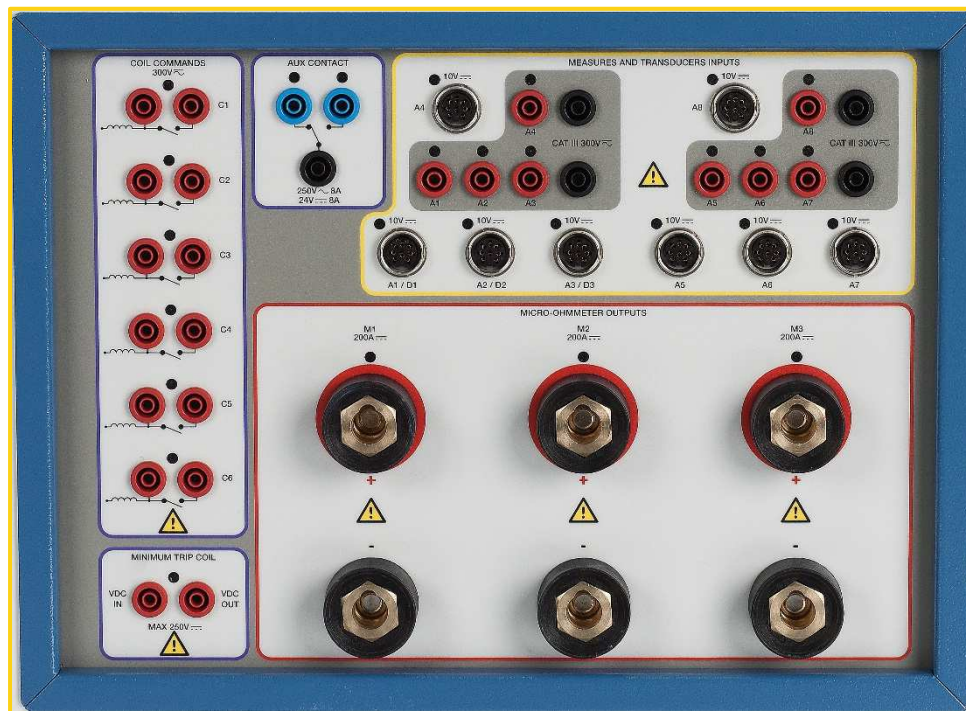


Figure 2 - CBA 3000 rear panel

The following image exhibits the side panels:



Figure 3 - CBA 3000 side panels

2 APPLICABLE STANDARDS

The test set conforms to the EEC directives regarding Electromagnetic Compatibility and Low Voltage instruments.

The following table lists the standards related to the EMC Directive, 2014/30/EU:

Standard	Title	Requirement
IEC EN 61000-3-2	Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)	Acceptable limits: basic
IEC 61000-3-3	Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection	Acceptable limits: basic
CISPR 16 (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: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 30÷230 MHz: 40 dB (30 m) 230÷1.000 MHz: 47 dB (30 m)
IEC EN 61000-4-2	Electromagnetic compatibility (EMC)- Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	Test values: 8 kV in air; 4 kV in contact
IEC EN 61000-4-3	Electromagnetic compatibility (EMC)- Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	Test values ($f = 900 \pm 5$ MHz): field 10 V/m, modulated AM 80%; 1 kHz
IEC EN 61000-4-4	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	Immunity tests for high speed transients (burst) Test values: 2 kV peak; 5/50 ns
IEC EN 61000-4-5	Electromagnetic compatibility (EMC)- Part 4-5: Testing and measurement techniques – Surge immunity test	Test values: 1 kV peak differential mode; 2 kV peak common mode; 1,2/50 us
IEC EN 61000-4-6:	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	Test values: 0,15-80 MHz, 10 V, 80% AM 1 kHz
IEC EN 61000-4-8	Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test	Test values: 30 Arms/m
IEC EN 61000-4-11	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests	Test value: 1 cycle; 100% drop

Table 2 – Standards related to the EMC Directive

The following table lists the standards related to the LV Directive, 2014/35/EU:

Standard	Title	Requirement
IEC EN 61010-1	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements	For a pollution degree 2: dielectric rigidity 1,4 kV AC, 1 minute <ul style="list-style-type: none"> Inputs/outputs protection: IP 2X Insulation resistance, at 500 V DC: >10 MΩ Ground resistance, at 200 mA DC: $<0,1$ Ω Operating temperature: $(-10 \div 55)$ °C; storage: $(-20 \div 70)$ °C Operating relative humidity: 5÷95%, without condensing. Storage relative humidity: 0÷96%, without condensing Altitude: less than 2.000 m
IEC 60068-2-6	Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)	Vibration: 20 m/s ² at 10÷150 Hz
IEC 60068-2-27	Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock	Shock: 15 g; 11 ms; half-sine

Table 3 - Standards related to the LV Directive

3 CHARACTERISTICS

3.1 Coil command circuits

The coil command circuits features are the following:

- Number of circuits: 2; optionally 4 or 6
- Type of driver: electronic; it ensures superior timing control
- Driver characteristic: 300 V DC max; 60 A DC max; 300 V AC max; 42 A AC max
- Operating time accuracy: 0,025% of delay $\pm 20 \mu\text{s}$
- Coil current ranges: 3 A; 10 A; 60 A full scale, user selectable
- The coil current is measured by a dedicated circuit, which is enclosed in the test set, so that a single connection is enough to connect the coil and to measure its current
- Number of coil current measurement circuits: 2 (optionally 4 or 6)
- In case of 4 or 6 outputs, it is possible to select the single or multiple phase opening
- Coil current measurement accuracy: 0,1% of the reading $\pm 0,1\%$ of the selected range
- Connection: via 4 safety sockets (optionally 8 or 12)
- Outputs are isolated between them and between ground

3.2 Timing contact inputs (main or auxiliary)

The timing contact inputs features are the following:

- Number of contact inputs: 16 (optionally 24) divided in 8 (or 12) groups of 2 each
- Each input group is isolated with respect to the others
- Connection: via 24 or 36 safety sockets
- The contact inputs may be configured as main breaker contact or auxiliary contact
- The contacts status (closed or opened) are displayed on the screen

Main breaker contact

The features are the following:

- Test of the main contact and detection of the pre-insertion resistor contact, selectable
- PIR resistance range: 30 Ω to 10 k Ω
- PIR resistance measurement value (optional): accuracy $\pm 2\%$ of the reading, $\pm 0,1\%$ of the range
- The contact is closed when the contact resistance is less than 10 Ω
- Contact test voltage: 24 V; test current: 100 mA

Auxiliary contact

The features are the following:

- Capability of testing dry contacts. Contact test voltage: 24 V; test current: 5 mA
- Capability of testing wet contacts. If wet, the input contact has these characteristics:
 - Impedance: > 150 k Ω or >500 k Ω (if PIR resistance measurement value option code PII62178 is mounted)
 - Voltage threshold: 15/77 V or programmable with steps of 5 V if PIR measurement option code PII62178 is mounted
 - Contact selection (dry or wet with thresholds) can be different on the groups
 - Maximum voltage: 300 V

3.3 Auxiliary binary output

The auxiliary binary output features are the following:

- One relay auxiliary output
- Characteristics of the contacts with a resistive load:
 - AC: 300 V; 8 A; 2.400 VA
 - DC: 300 V; 8 A; 50 W
- The contact operation can be timed with respect to test start

3.4 Inputs timing

The inputs timing features are the following:

- Sample rate: from 10 Hz to 100 kHz maximum, for recording up to 1s to 10 Hz, for recording up to 10.000s (see the table 5 for more details)
- Resolution: 0,01 ms to 100 ms

The following table lists the inputs timing accuracy:

Range [s]	Frequency [Hz]	Resolution [ms]	Accuracy [ms]
1	100.000	0,01	$\pm 0,02 \pm 0,01\%$ of the reading
2	50.000	0,02	$\pm 0,02 \pm 0,01\%$ of the reading
4	20.000	0,05	$\pm 0,05 \pm 0,01\%$ of the reading
10	10.000	0,1	$\pm 0,1 \pm 0,01\%$ of the reading
20	5.000	0,2	$\pm 0,2 \pm 0,01\%$ of the reading
40	2.000	0,5	$0,5 \pm 0,01\%$ of the reading
100	1.000	1	$1 \pm 0,01\%$ of the reading
200	500	2	$2 \pm 0,01\%$ of the reading
400	200	5	$5 \pm 0,01\%$ of the reading
1.000	100	10	$10 \pm 0,01\%$ of the reading
2.000	50	20	$20 \pm 0,01\%$ of the reading
5.000	20	50	$50 \pm 0,01\%$ of the reading
10.000	10	100	$100 \pm 0,01\%$ of the reading

Table 4 – Inputs timing accuracy

3.5 Analogue inputs

Number of analog inputs: 8 in all, programmable as analog input, transducer etc.

Common characteristics of analog inputs:

- Measurement resolution: 16 bit
- Number of ranges: 3
 - 300 V AC (420 V DC peak)
 - 10 V DC
 - 1 V DC
- Measurement accuracy:
 - 1 V range: $\pm 0,2\%$ of the reading $\pm 0,2\%$ of the range
 - 10 V range: $\pm 0,1\%$ of the reading $\pm 0,01\%$ of the range
 - 420 V range: $\pm 0,5\%$ of the reading $\pm 0,1\%$ of the range
- Input impedance: more than 600 k Ω
- Measurement sampling rate: 100 kHz max
- Number of independent neutrals: 4. 2 groups of 3 channels each (to be used for example as transducer inputs for motion analysis and for voltage coming from micro-ohmmeter) and 2 different neutrals for the remaining 2 channels (for monitoring motor current or DC coil supply)
- Connection: via 12 safety sockets or via 8 multi-pole shielded connectors, depending upon the channel configuration. On the same connectors is available a polarizing voltage to supply linear position transducers or incremental digital encoders
- Voltage value: +5 V; maximum output current 30 mA; minimum transducer resistance 170 Ω . It is also available a +12 V supply with the same power. The output has the same reference as the three low voltage analog inputs
- Insulation between different neutrals: 1 kV AC

When used with position transducers, the software allows the displaying of: positions, strokes, speed (datum point). These measurements are defined by the position of the cursors. In this instance, it is possible to input the transducer stroke, and to set the unit of measurement as millimeters, degrees or inches.

When the transducer movement is 50% of the total transducer length, the position error is 1% of the reading. The error is inversely proportional to the percentage of the transducer movement. When datum points are 25% of the total transducer length, and the corresponding time is 10 ms, the speed accuracy is 3%. The error is inversely proportional to the percentage of the transducer movement and to the movement time.

When used as analog inputs, the most important use is the monitoring of the secondary current of an energized CB, to perform the first trip test, that is, the measurement of the Open delay while the CB is in service. This test is very important to detect the delay caused by the friction, which sticks the CB that has operated a long time without opening.

Additional inputs for motion analysis

If PIR resistance measurement value option code PII62178 is mounted, up to three additional analog inputs for motion analysis are available. It is available also an additional supply voltage for position transducers : 29V , 30 mA .

In the same way as for the 8 analog inputs, the software allows the displaying of: positions, strokes, speed (datum point). These measurements are defined by the position of the cursors. In this instance, it is possible to input the transducer stroke, and to set the unit of measurement as millimeters, degrees or inches.

3.6 Digital transducers

CBA 3000 allows monitoring up to 3 digital transducers at the meantime.

The digital transducers features are the following:

- Maximum input frequency: 50 kHz
- Interface: RS422
- Accepted transducers: up to 5.000 impulses
- Connection: by 3 multi-pole connectors used also for the analog inputs

3.7 Time measurement triggers

The following time measurement trigger options are user selectable:

- **Internal:** the time measurement starts as the first Open or Close coil command is issued by the driving circuit. Timing accuracy: 20 μ s
- **Coil current:** the time measurement starts as soon as the first Open or Close coil current exceeds the selected percentage, from 1% to 30%, of the selected current range
- **Auxiliary input:** the time measurement starts when the selected auxiliary input turns ON or changes its state. The trigger can be performed also on a logical combination of auxiliary inputs
- **Analogue input:** the time measurement starts when the analogue input level crosses (greater than, lower than) the selected threshold

3.8 Programmable sequences

The user can select the following single operations that can be all included in a unique test plan:

- **Open:** the selected open coil phase is driven (all the combinations: all phases, phase1, phase 2, phase 3, phase 1+2 , phase 2+3, phase 3+1)
- **Close:** the Close coil is driven. In case of six coils, the selected close coil phase is driven (all the combinations as Open coil)
- **OC:** In sequence, the Open and Close coils are driven (all the combinations)
- **CO:** In sequence, the Close and Open coils are driven (all the combinations)
- **OCO:** In sequence, the Open, the Close and then again the Open coils are driven. The first Open command is issued on the selected Open coil phase, while the second Open command is issued on all coil phases
- **Static resistance:** the instrument performs a breaker resistance contact measurement using the available micro-ohmmeters on the selected phase (or on all the phases together)
- **Dynamic open or close resistance:** the instrument measures dynamically the resistance profile during an open or close operation, and the result of the test will be a diagram and the breaker time delay based on the profile analysis.

These sequences are also selected by means of a dedicated pushbutton; the selected sequence is confirmed by a LED.

In this way, user defined sequences (i.e. CO-CO, O-CO-CO and so on) can be executed.

For all the above sequences, the user can program the following delays:

- Open command duration: range 1 ms to 10 s
- Close command duration: range 1 ms to 10 s
- Open to Close delay: delay range 1 ms to 199.990 s
- Close to Open delay: delay range 1 ms to 199.990 s
- Dynamic open or close: range from 30 ms to 1 s
- Recording duration: range 10 ms to 199.990 s
- After programming, it is possible to view on the display the sequence timing: this helps avoiding programming errors

The following image exhibits an example of the shown sequence timing on the display:

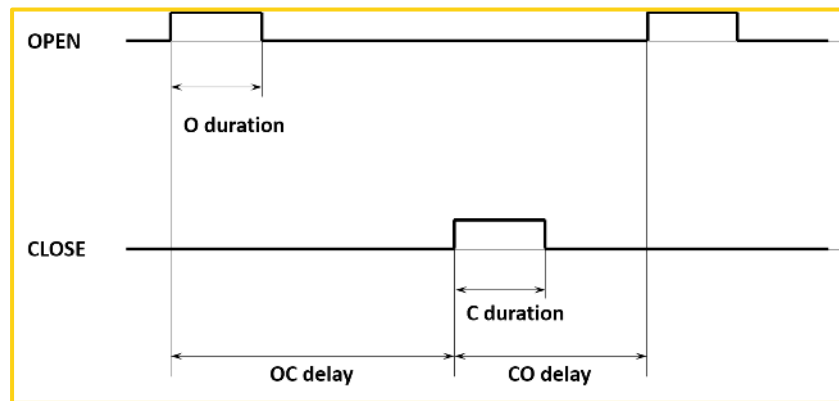


Figure 4 –Example of sequence timing

3.9 Static resistance measurement (micro-ohmmeter characteristics)

This measurement is performed connecting CBA 3000 to the test sample and measuring its resistance. Test samples can be joints, main contacts and so on. Main contacts resistance is measured in the closed position.

The static resistance measurement features are the following:

- Available nominal test currents: 200 A, 150 A, 100 A, 50 A, 25 A
- Resistance measurement ranges: 250 $\mu\Omega$, 1 m Ω , 10 m Ω , 50 m Ω , 500 m Ω
- Minimum resolution: 0,1 $\mu\Omega$
- Contact resistance accuracy: 0,2% of the reading \pm 0,2% of the range (for ranges 250 $\mu\Omega$ and 1 m Ω)
- Contact resistance accuracy: 0,3% of the reading \pm 0,3% of the range (for ranges 10 m Ω , 50 m Ω and 500 m Ω).
Type of current source: electronic current generator, driven by a discharging capacitor
- Current generation duration: minimum 1 s, accordingly to the test current and the load
- Maximum test voltage: 5 V

3.10 Dynamic resistance measurement

With this measurement it is possible to record the main contact resistance during the CB close or open. The test current passes through the contact, and CBA 3000 measures the contact resistance variations during the close or open movement.

Test current, resistance ranges and other characteristics: as for the static resistance measurement. Unlike the static resistance measurement, the test result is not a table of resistance measurements: it is the resistance profile during the test, along with voltage and current profiles.

3.11 Both Side Grounded tests

Using the 3 independent micro-ohmmeters of CBA 3000, it is possible to perform breaker time delay tests even if both grounds are closed. The operating principle takes advantage of the fact that the ground connection has a resistance that is at least 100 times the CB contact resistance.

The 3 micro-ohmmeters generators inject a higher current (i.e approximately 100 A) than CBA 3000 timing contact inputs (100 mA , refer to Paragraph 3.2), to detect the closed contact: the higher current allows to generate a voltage drop that is 1 V up for the ground connection (supposed to be 10 mΩ), and at least 100 times less for the closed CB contact ($0,1 \text{ m}\Omega \times 100 \text{ A} = 10 \text{ mV}$). In this way, it's possible to detect first moment when poles are touching.

The both side grounded test can be applied to one break per phase or two breaks per phase (with option PII68178) circuit breakers.

The timing tests are not affected by current noise in the breaker phases and ground leads due to the substation induction, even if relevant (up to 10 A).

The following image exhibits both sides grounded connection for a phase of the CBA 3000:

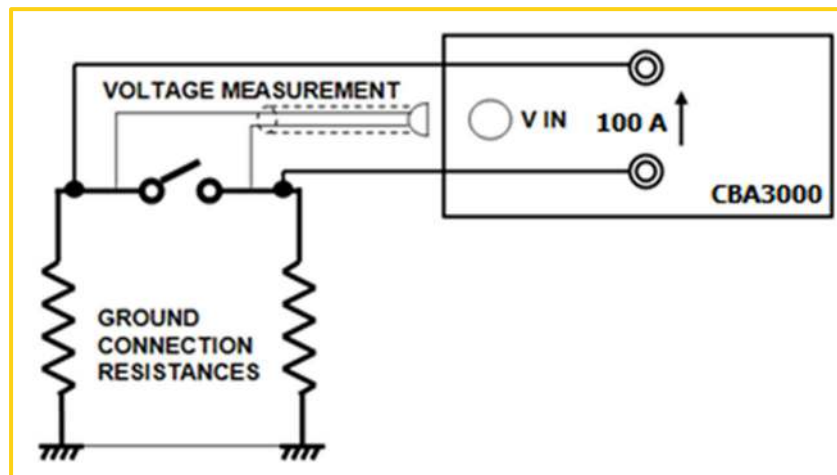


Figure 5 – BSG connection of the CBA 3000

3.12 Test set control

The test set control features are the following:

- The control is local, via keypad, selectors and display: no PC control is necessary
- Keypad: 16 keys (numeric and alphabet): it allows inputting all test references. The arrangement is the same as portable phones
- Two dedicated pushbuttons for test start and sequence selection
- Numeric encoder with pushbutton for menu selection (see below the selections list)
- Five dedicated keys for main functions as Load, Save etc., plus five pushbuttons that have different functions depending upon the active menu
- As the test is started, a buzzer warns the operator
- The graphical display has the following main features:
 - Type: Color LCD
 - Pixels: 800 x 480
 - View area: 152 x 92 mm
- Displays: menu selections prior to test start; then, current waveforms, contact inputs (main/resistance), auxiliary inputs, analog input (those enabled). For dynamic resistance, it is possible to display the resistance profile, along with voltage and current profiles
- Memory size: 256 Mbytes (approx. 500 results)
- Capability of saving and re-calling up to 256 test settings

3.13 Data management

The communication to the PC can be performed via two communication ports:

- ETHERNET
- USB

Test results can be saved also into an USB pen memory: this allows transferring all test results to the office without the need of transporting the test set.

3.14 PC software

The dedicated TDMS software has the following main features:

- Tests execution
- Download of test sequences
- Download of test results
- Test sequences and test results can be viewed, edited in the missing descriptions, saved, printed, exported
- Test data can be organized in a data base including all sub-station devices
- Possibility of viewing, overlaying and gluing more results, for an easy test result comparison
- Possibility to pre-set test sequences and to download them into the test set
- Two cursors to select measurement points and intervals
- Zoom in and out feature
- Pass/Fail timing test result analysis
- Pass/Fail current profile test result analysis
- Enhanced measurement features for movement/speed/acceleration control
- The software is upgraded for free until a new version is released. Upgrading is simple: just connect to the ISA WEB site, and download the latest version. This applies also to the test set resident program.

3.15 Menu selections

The menu is operated by means of the menu control knob, which incorporates a switch. The menu is entered pressing the knob and selecting the item moving the knob.

After test start, measurements are displayed in the corresponding window. Pressing the knob it is possible to return to menu selections and modify them, and then it is possible to return to the measurements window.

Any setting can be saved to and recalled from the memory, with a line of text description. At power-on, the default one is displayed: it can also be recalled as necessary. Settings are permanently stored in the memory; new settings can be written to the same address after confirmation. For normal mode operation it is possible to recall the standard setting, that cannot be modified.

During the test, test results can be stored in the memory, according to selections.

3.16 Other characteristics

Other characteristics are the following:

- Mains supply:
 - From 85 to 265 V AC; 47-63 Hz
 - From 120 to 350 V DC
- Maximum supply current: 3,6 A @100 V AC or 1,8 A @ 200 V AC
- Maximum power consumption: 360 VA
- Housing: aluminium case, with hinged removable cover and handles
- The instrument comes complete with the following items:
 - Mains cable
 - User's manual
 - Ethernet cable
 - One cable, yellow/green, for the connection to ground. Cable length: 4 m; cross section 1 mm², terminated with a crocodile
 - Spare fuses
 - Software TDMS

All measured values are guaranteed at 23±5 °C, after a warm-up time greater than 20 min.

4 CBA 3000 MODELS

The following table lists some of the CBA models:

Code	Characterisitcs
PII20178	CBA 3000 with TDMS software N° 16 Configurable Main/Auxiliary inputs N° 1 200 A DC Micro-ohmmeter N° 8 configurable Analogue inputs N° 2 Coil commands (Open/Close) Test cable kit with transport case (code PII40188) One Micro-ohmmeter cable kit (code PII42188)
PII21178	CBA 3000 with TDMS software N° 24 Configurable Main/Auxiliary inputs N° 1 200 A DC Micro-ohmmeter N° 8 configurable Analogue inputs N° 4 Coil commands (Open/Close) Test cable kit with transport case (code PII41188) One Micro-ohmmeter cable kit (code PII42188)
PII22178	CBA 3000 with TDMS software N° 24 Configurable Main/Auxiliary inputs N° 3 200 A DC Micro-ohmmeters N° 8 configurable Analogue inputs N° 4 Coil commands (Open/Close) Both Side Grounded function Test cable kit with transport case (code PII41188) One Micro-ohmmeter cable kit (code PII42188) Additional two Micro-ohmmeters cable kit (code PII43188)
PII76178	CBA 3000 with TDMS software N° 24 Configurable Main/Auxiliary inputs N° 3 200 A DC Micro-ohmmeters N° 8 configurable Analogue inputs N° 4 Coil commands (Open/Close) Both Side Grounded function Test cable kit with transport case (code PII41188) One Micro-ohmmeter cable kit (code PII42188) Additional two Micro-ohmmeters cable kit (code PII43188)
PII23178	CBA 3000 with TDMS software N° 24 Configurable Main/Auxiliary inputs N° 3 200 A DC Micro-ohmmeters N° 8 configurable Analogue inputs N° 6 Coil commands (Open/Close) Both Side Grounded function Test cable kit with transport case (code PII41188) One Micro-ohmmeter cable kit (code PII42188) Additional two Micro-ohmmeters cable kit (code PII43188)

Table 5 - CBA 3000 models

NOTE: upon request, hardware configurations other than those listed in *Table 5* can be supplied.

5 TEST CABLE KIT FOR HIGH VOLTAGE CIRCUIT BREAKERS

5.1 Test cable kit – two breaks per phase (code PII40188)

The following table lists the elements of the cable kit for connecting up to two breaking chambers per phase:


Item	Description	Scheme
1	<p>N° 3 cables with silicone isolator for the connection to the main contacts, each of three conductors</p> <p>Cable length: 15 m</p> <p>Cross section 1,5 mm²</p> <p>Terminated on the CBA 3000 side with safety banana sockets, with colours: black, red, blue, and on the CB side with three clamps, with the same colours</p>	 
2	<p>N° 2 cables with silicone isolator for the connection to the auxiliary contacts, each of three conductors</p> <p>Cable length: 6 m</p> <p>Cross section 1,5 mm²</p> <p>Terminated with safety banana sockets, with colours: black, red, blue</p>	
3	<p>N° 2 cables with four conductors each, for the connection to the CB coils.</p> <p>Cable length: 10m</p> <p>Cross section 1,5 mm²</p> <p>Terminated with safety banana sockets; colours: black, red, yellow, blue</p>	
4	<p>N° 1 set of 13 cables, 2 m long, of different colours (3 yellow, 4 black , 4 red, 2 blue), terminated with banana plugs on both sides, for the connection to other inputs</p>	
5	<p>N° 1 set of adaptors from banana sockets to terminators, 20 in all, with different colours, for the auxiliary contacts and for the coil inputs</p>	

Table 6 - Cable kit (code PII40188) (1/2)



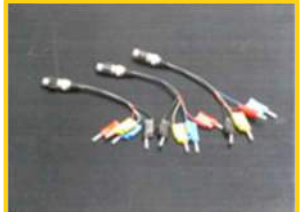



Item	Description	Scheme
6	N° 4 short cables, to put in common the coils supply	
7	N° 1 cable for the MTC option	
8	N° 1 cable for the connection to an analogue transducer. Length: 1 m Terminated with a 8-way connector on the CBA 3000 side, and with a three-way connector on the transducer side	
9	N° 1 adapter for the connection to an analogue transducer. Length: 1 m Terminated with a three-way connector on one side, and with four banana plugs on the other side	
10	N° 1 8-way cable for the connection to a digital transducer. Length 1 m; terminated with a 8-way connector on the CBA3000 side, and with seven banana sockets on the other side	
11	N° 1 set of crocodiles, 12 in all, with different colours, for the connection to auxiliary contacts and for the measurement inputs connection	
12	N° 1 plastic bag that hosts all the cables, with handle. Dimensions: 45 x 55 x 22 cm	

Table 7 - Cable kit (code PII40188) (2/2)

5.2 Test cable kit (code PII41188) – four breaks per phase

The following table lists the elements of the cable kit for connecting up to four breaking chambers per phase:


Item	Description
1	N°1 test cable kit code PII40188
2	<p>N° 3 cables with silicone isolator for the connection to the main contacts, each of three conductors Cable length: 15 m Cross section 1,5 mm² Terminated on the CBA 3000 side with safety banana sockets, with colours: black, red, blue, and on the CB side with three clamps, with the same colours</p> 

Table 8 - Test cable kit (code PII41188)

Upon request, n° 6 cables with silicone isolator for the connection to the main contacts, each of 3 conductors, can be provided with a maximum length up to 38 m.

5.3 1 Micro-ohmmeter cable kit (code PII42188)

The following table lists the cable set for 1 Micro-ohmmeter:





Item	Description
1	<p>n.2 cables for current injection up to 200 A DC Length: 15 m Section: 35 mm²</p> 
2	<p>n.4 clamps for connecting the current injection cables to the main breaker contacts</p> 
3	<p>n.1 cable for voltage measurement Length: 15 m</p> 
4	<p>n.2 kelvin clamps</p> 

Table 9 - Cable kit for 1 Micro-ohmmeter (code PII42188)

5.4 Additional 2 Micro-ohmmeters cable kit (code PII43188)

The following table lists the cable set for additional 2 Micro-ohmmeters:

Item	Description
1	N° 2 cable kit code PII42188

Table 10 - Cables set for additional 2 Micro-ohmmeters (code PII43188)

5.5 Cable kit for measuring operation times up to two breaking chambers per phase in BSG mode (codice PII44188)

This option only applies to CBA 3000 models equipped with 3 micro-ohmmeters.

The following table lists the elements of the cable kit:


Item	Description	
1	n.3 cable for voltage measurement Length: 15 m	
2	N. 6 cables for the connection to the main contacts Length: 3 m Section: 4 mm ² Terminated on both sides with clamps	

Table 11 – test cable kit (code PII44188)

5.6 Cable kit extension for 1 Micro-ohmmeter (PII55178)

The cable kit extension is provided to extend the micro-ohmmeter length (since 20 m).

The following items compose cable kit:

- No. 2 extensions of section 50mm² and length 7m
- No. 2 extensions for measuring cable, length 5 m, terminated on one side with a clamp and on the other side with a connector for micro-ohmmeter measuring amplifier
- Transport case

6 TEST CABLE KIT FOR MEDIUM VOLTAGE CIRCUIT BREAKERS

6.1 Test cable kit for the connection to main breaker contacts, L = 5 m (code PII86178)

The following table lists the elements of the cable kit:

Item	Description
1	N° 3 cables with silicone isolator for the connection to the auxiliary contacts, each of three conductors Cable length: 5 m Cross section 1,5 mm ² Terminated with safety banana sockets, with colours: black, red, blue
2	N°6 clamps (3 red, 3 black) for the connection to the main contacts
3	N° 1 cavo con isolatori in silicone per la connessione ai contatti ausiliari, ognuno di due conduttori Lunghezza: 5 m Sezione: 1,5 mm ² Terminati con boccole di sicurezza a banana, di colore nero, rosso
4	N° 1 cables with silicone isolator for the connection to the auxiliary contacts, each of four conductors Cable length: 5 m Cross section 1,5 mm ² Terminated with safety banana sockets, with colours: black, red, blue, yellow
5	N° 2 short cables, to put in common the coils supply
6	N° 1 set of adaptors from banana sockets to terminators, 20 in all, with different colours, for the auxiliary contacts and for the coil inputs
7	N° 1 set of 13 cables, 2 m long, of different colours (3 yellow, 4 black, 4 red, 2 blue), terminated with banana plugs on both sides, for the connection to other inputs
8	N° 1 set of crocodiles, 12 in all, with different colours, for the connection to auxiliary contacts and for the measurement inputs connection

Table 12 – Test cable kit code PII86178

6.2 Test cable kit for the connection to main breaker contacts, L = 5 m (code PII28188)

The following table lists the elements of the cable kit:

Item	Description
1	N° 3 cables with silicone isolator for the connection to the auxiliary contacts, each of three conductors Cable length: 5 m Cross section 1,5 mm ² Terminated with safety banana sockets, with colours: black, red, blue
2	N°6 clamps (3 red, 3 black) for the connection to the main contacts
3	N° 1 cavo con isolatori in silicone per la connessione ai contatti ausiliari, ognuno di due conduttori Lunghezza: 5 m Sezione: 1,5 mm ² Terminati con boccole di sicurezza a banana, di colore nero, rosso
4	N° 1 cables with silicone isolator for the connection to the auxiliary contacts, each of four conductors Cable length: 5 m Cross section 1,5 mm ² Terminated with safety banana sockets, with colours: black, red, blue, yellow
5	N° 2 short cables, to put in common the coils supply
6	N° 1 set of adaptors from banana sockets to terminators, 20 in all, with different colours, for the auxiliary contacts and for the coil inputs
7	N° 4 adapter for the connection to an analogue transducer. Length: 1 m Terminated with a three-way connector on one side, and with four banana plugs on the other side

Item	Description
8	N° 4 8-way cable for the connection to a digital transducer. Length 1 m; terminated with a 8-way connector on the CBA3000 side, and with seven banana sockets on the other side
9	N° 1 set of 13 cables, 2 m long, of different colours (3 yellow, 4 black, 4 red, 2 blue), terminated with banana plugs on both sides, for the connection to other inputs
10	N° 1 set of crocodiles, 12 in all, with different colours, for the connection to auxiliary contacts and for the measurement inputs connection

Table 13 – Test cable kit code PII28188

6.3 Test cable kit for 1 Micro-ohmmeter, L = 6 m (code PII87178)

The following table lists the elements of the cable kit:

Item	Description
1	n.2 cables for current injection up to 200 A DC Length: 6 m Section: 25 mm ²
2	n.1 cable for voltage measurement Length: 6 m
3	n.2 kelvin clamps

Table 14 – Test cable kit code PII87178

6.4 Test cable kit for the connection to main breaker contacts, L = 2,5 m (code PII24178)

The following table lists the elements of the cable kit:

Item	Description
1	N° 3 cables with silicone isolator for the connection to the auxiliary contacts, each of three conductors Cable length: 2,5 m Cross section 1,5 mm ² Terminated with safety banana sockets, with colours: black, red, blue
2	N°6 clamps (3 red, 3 black) for the connection to the main contacts
3	N° 1 cavo con isolatori in silicone per la connessione ai contatti ausiliari, ognuno di due conduttori Lunghezza: 2,5 m Sezione: 1,5 mm ² Terminati con boccole di sicurezza a banana, di colore nero, rosso
4	N° 1 cables with silicone isolator for the connection to the auxiliary contacts, each of four conductors Cable length: 2,5 m Cross section 1,5 mm ² Terminated with safety banana sockets, with colours: black, red, blue, yellow
5	N° 2 short cables, to put in common the coils supply
6	N° 1 set of adaptors from banana sockets to terminators, 20 in all, with different colours, for the auxiliary contacts and for the coil inputs
7	N° 1 set of 13 cables, 2 m long, of different colours (3 yellow, 4 black, 4 red, 2 blue), terminated with banana plugs on both sides, for the connection to other inputs
8	N° 1 set of crocodiles, 12 in all, with different colours, for the connection to auxiliary contacts and for the measurement inputs connection

Table 15 – Test cable kit code PII24178

6.5 Test cable kit for the connection to main breaker contacts, L = 2,5 m (code PII29188)

The following table lists the elements of the cable kit:

Item	Description
1	N° 3 cables with silicone isolator for the connection to the auxiliary contacts, each of three conductors Cable length: 2,5 m Cross section 1,5 mm ² Terminated with safety banana sockets, with colours: black, red, blue
2	N°6 clamps (3 red, 3 black) for the connection to the main contacts
3	N° 1 cavo con isolatori in silicone per la connessione ai contatti ausiliari, ognuno di due conduttori Lunghezza: 2,5 m Sezione: 1,5 mm ² Terminati con boccole di sicurezza a banana, di colore nero, rosso
4	N° 1 cables with silicone isolator for the connection to the auxiliary contacts, each of four conductors Cable length: 2,5 m Cross section 1,5 mm ² Terminated with safety banana sockets, with colours: black, red, blue, yellow
5	N° 2 short cables, to put in common the coils supply
6	N° 1 set of adaptors from banana sockets to terminators, 20 in all, with different colours, for the auxiliary contacts and for the coil inputs
7	N° 4 adapter for the connection to an analogue transducer. Length: 1 m Terminated with a three-way connector on one side, and with four banana plugs on the other side
8	N° 4 8-way cable for the connection to a digital transducer. Length 1 m; terminated with a 8-way connector on the CBA3000 side, and with seven banana sockets on the other side
9	N° 1 set of 13 cables, 2 m long, of different colours (3 yellow, 4 black, 4 red, 2 blue), terminated with banana plugs on both sides, for the connection to other inputs
10	N° 1 set of crocodiles, 12 in all, with different colours, for the connection to auxiliary contacts and for the measurement inputs connection

Table 16 – Test cable kit code PII29188

6.6 Test cable kit for 1 Micro-ohmmeter, L = 3 m (codice PII25178)

The following table lists the elements of the cable kit:

Item	Description
1	n.2 cables for current injection up to 200 A DC Length: 3 m Section: 25 mm ²
2	n.1 cable for voltage measurement Length: 3 m
3	n.2 kelvin clamps

Table 17 – Test cable kit code PII25178

7 OPTIONS

7.1 Additional 2 coil commands (code PII60178)

With this option the instrument can drive 2 additional coils. The option includes a printed circuit that fits on the motherboard described in Paragraph 3.1. Although it is possible to add the option later, we recommend that you include it in the order. The following table lists the cables included to drive the breaker coils:



Item	Description	Schema
1	N° 2 cables with four conductors each, for the connection to the CB coils. Cable length: 10m Cross section 1,5 mm ² Terminated with safety banana sockets; colours: black, red, yellow, blue	
2	N° 4 short cables, to put in common the coils supply	

Table 18 – Additional 2 coil commands cable kit (code PII60178)

7.2 8 Inputs Main-PIR/ Auxiliary (code PII61178, PII62178)

This option allows to measure the pre insertion resistance value of a main contact (code PII61178) and it has also a Pre-Insertion Resistor value measurement (code PII62178).

7.3 MTC - Minimum trip coil test module (code PII37178, PII38178)

The option has the purpose of allowing to test the behaviour of the Minimum Trip Coil circuit and of Open or Close coils, when supplied at a reduced auxiliary voltage.

The following table lists the available modules and their characteristics:

Item	Description	Code	Characteristics	PII37178	PII38178
1	For battery voltages up to 250 V	PII37178	Absolute maximum voltage [V]	250	70
			Maximum operating voltage [V]	240	50
			Minimum operating voltage [V]	50	16
			Maximum voltage drop [V]	120	45
			Minimum voltage drop [V]	10	5
2	For battery voltages up to 70 V	PII38178	Adjustment step [V]	2	0,5
			Adjustment Accuracy [V]	2	0,5
			Maximum output current [A]	4 (dV < 60 V) 2 (dV < 60 V)	10 (dV < 12 V) 5 (dV < 12 V)
			Maximum test duration [ms]	500	500
			Pause duration [s]	20	20

Table 19 - Available MTC modules

The option is to be connected to the auxiliary DC supply of the plant; the option output voltage can be modified (stepped or ramped down), according to the test program.

Other characteristics:

- Connections: one input safety socket, to be connected to the auxiliary supply positive, and one output safety socket, to be connected to the minimum voltage input
- Voltage adjustment in steps
- Over-current protection

7.4 Internal printer (code PII65178)

Thermal printer, for the printout of all test results.

It is housed in the test set cover.

Paper 58 mm wide.

7.5 Heavy duty transport case (code PII57178)

The transit case allows delivering CBA 3000 with no concern about shocks.

The following image exhibits the transit case:



Figure 6 - Transport case

7.6 Position transducers

7.6.1 Analogue transducers

ISA can provide a set of analogue transducers, linear and rotating. Linear transducers have different strokes, and also different IP protections: low for the TLH series, high for the LWG series. A mounting kit is also available.

The following table lists the main characteristics of the analogue transducers:

Item	Type	Name	Stroke [mm] or [°]	Code
1	Linear	TLH 150	150	PII11166
2	Linear	TLH 225	225	PII12166
3	Linear	TLH 300	300	PII36166
4	Linear	TLH 500	500	PII13166
5	Linear	LWG 150	150	PII26166
6	Linear	LWG 225	225	PII27166
7	Linear	LWG 500	500	PII28166
8	Linear	LWG 750	750	PII42166
9	Rotary	IP6501	355 (rotation angle)	PII14166

Table 20 - Main characteristics of the analogue transducers

The following image exhibits the LWG Linear transducer, the TLH Linear transducer and the Rotary transducer:



Figure 7 - LWG Linear transducer, the TLH Linear transducer and the Rotary transducer

7.6.2 Digital transducers (code PII1169)

The digital transducer option has the following characteristics:

- Transducer name: HENGSTLER RS0-550-170
- Transducer type: RS422 interface; 5.000 impulses per turn
- Connection: the transducer is connected to the test set via a shielded cable, 10 m long, terminated with a connector

The following image exhibits the digital transducer:



Figure 8 - Digital transducer

On request, digital linear transducers are available.

7.7 Pressure transmitter PA-21Y 40BAR (code PII35178)

The KELLER pressure transmitter type PA-21Y/40bar/81554.33 allows monitoring the variation of the SF6 pressure while the circuit breaker is operated.

Main characteristics:

- Pressure range: 0 to 40 bar (pressure differential with respect to 1 bar of the atmospheric pressure)
- Supply voltage: 8 to 32 V DC
- Output voltage: 0 to 5 V DC (0 V at the atmospheric pressure, 5 V at the absolute pressure of 41 bar)
- Linearity error: maximum 0,5% of the range
- Total error, 0 to 50 °C: maximum 1% of the range
- Mounting: via an M12 plug, 10,5 mm long
- Connection to CBA 3000: via a 10 m long cable, provided, terminated with the four-poles female connector on the transducer side, and with the 10 poles male connector on the CBA side
- Once connected, CBA 3000 provides the power supply, and the transducer is ready for the measurement

The following image exhibits the pressure transducer:

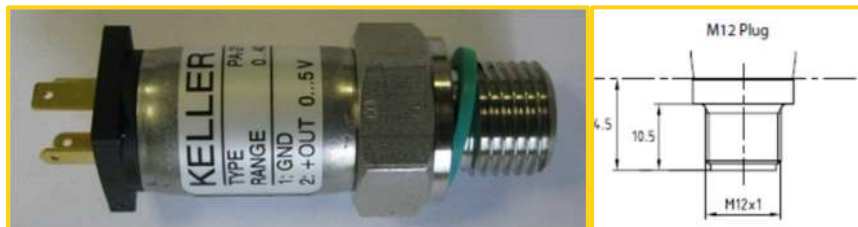


Figure 9 - Pressure transducer

7.8 Transducers mounting kits (code PII33178, code PII34178)

Mounting kit for analogue transducer: code PII33178.

Mounting kit for digital transducer: code PII34178.

The following table list the mounting kits elements:

Item	Quantity	Description
1	1	Magnetic support
2	1	Adaptive arm
3	1	Small mechanical clamp
4	1	Big mechanical clamp
5	1	Support for the rotating transducer
6	1	Connection cable, 10 m long, for analogue (PII33178) or digital transducer (PII34178)
7	1	Rotary transducer (or linear transducer, or both) The rotary transducer is supplied with the flexible shaft coupler.

Table 21 - Main characteristics of the analogue transducers

The kit is included into a plastic transport case. The following image exhibits the open case (refer to the previous table for the numbering correspondence):

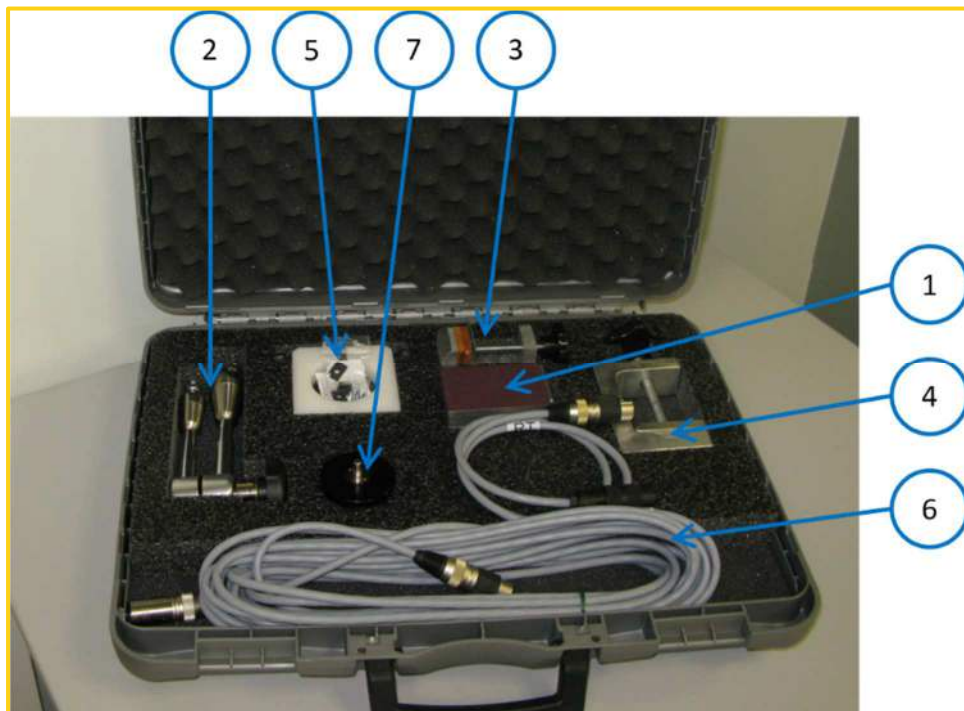


Figure 10 - Mounting kits elements

7.9 AC current clamp (code PII88169)

The current clamp allows performing the first trip test: for three phase testing, three of them are necessary.

The clamp ratio is 1 A/0,1 V.

The maximum primary current is 10 A.

The maximum cable diameter is 12 mm.

The following image exhibits the AC current clamp:



Figure 11 - AC current clamp

7.10 Hall effect clip-on transformer for current measurements (code PII29166)

The Hall effect clip-on transformer allows measuring the DC current of motors and of the auxiliary supply.

Main characteristics:

- Metering AC and DC currents.
- DC measurement null with a knob
- Ranges: 10 mV/A, 80 A DC, 40 A AC maximum, and 1 V/A, 2 A DC, 1.5 A AC maximum
- Low battery indicator
- Measurement errors: 4% of reading +20 mA for the 80 A range; 2% of reading +5 mA for the 2 A range
- Phase shift (up to 65 Hz): maximum 1°
- Maximum working voltage: 600 V_{rms}
- Power supply: alkaline 9 V battery, type 6 LR 61
- Service life: 70 h typical
- Maximum cable diameter: 10 mm
- Weight: 330 g
- Dimensions: 65 mm wide (clamp closed); 36 mm thick; 230 mm long

The following image exhibits the Hall effect clip-on:



Figure 12 - Hall effect clip-on

7.11 Flexible shaft coupler (code PII44166)

The following image exhibits the flexible shaft coupler:

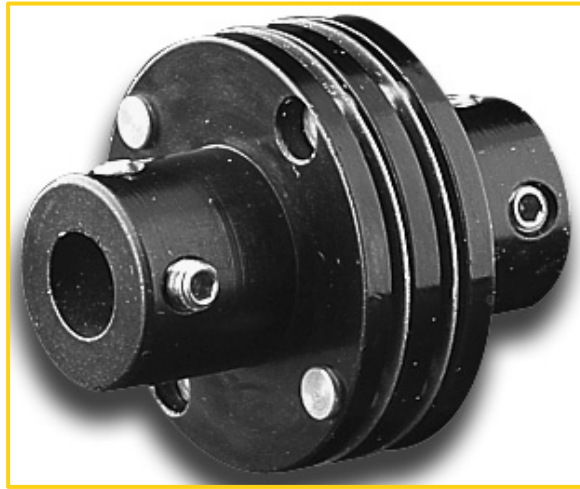


Figure 13 - Flexible shaft coupler

This option allows the coupling between the position transducer and the mobile side of the CB.

7.12 Additional cable kit for BSG option (code PII68178)

Using this option composed by some cables it is possible to perform a test on a two breaks per phase circuit breaker in BSG (both side grounded) mode. Refer to Chapter 3.11 for details.

The following table lists the cables provided in order to perform the test:

Item	Description
1	N° 3 shielded cables for the measurement of the low voltage in micro-ohmmeter tests Cable length: 10 m
2	N° 6 cables for the connection to the main contacts Cable length: 3 m Cross section: 4 mm ² Terminated on the both sides with one clamp
3	N°3 cables for ground connection Cable length: 15 m Cross section: 10 mm ² Terminated with a clamp on one side and with an universal clamp with tommy bar to the other
4	9 straps for cables fixing

Table 22 - Cables set for two breaks per phase BSG option

The kit is included into a plastic transport case.

7.13 Power cables (PII69178)

Power cables for micro-ohmmeter.

The cable kit is composed by the following:

- No. 2 cables, 15 m long, section 70 mm², terminated on one side by a high current connector and on the other side by a high current clamp.

8 PROTECTIONS

The following protections apply to the CBA 3000:

- Fuse on the mains supply
- At power-on, a diagnostic sequence controls the microprocessors. If something is wrong, the operator is alerted by a message
- The test is started pressing the START pushbutton, and then also pushing the multifunction knob
- During the test, the circuits driving the coils give alarm messages in case of coil driver over-temperature or overloaded
- During the test, if the trigger criteria (coil current, auxiliary input, analogue input) is not met within the maximum test time, the test set displays a warning message
- The 5 V transducer supply is protected against short circuit on the output

REVISIONS

The following table lists the revisions of the document:

No.	Date	Description
0	June 2015	Preliminary issue
1	July 2015	1 st issue
2	January 2016	2 nd issue – Cable set
3	April 2016	3 rd issue – Cable set. Options and models
4	April 2016	4 th issue – Layout revision
5	September 2016	5 th issue – Layout revision
6	January 2017	6 th issue – Layout revision
7	April 2017	7 th issue – Layout revision
8	June 2017	8 th issue – Layout revision
1.9.0	September 2017	In compliance with the 1.9.0 firmware revision
1.9.1	June 2018	10 th issue – added motion analysis capability on PIR option
2.0.2	March 2019	11 th issue – added cable kits PII68178 and PII40178. Chapter 3.16 (Other characteristics) revised. Chapter 5.14 (Transducer mounting kit) revised. Option PII59178 removed
2.0.3	July 2019	Chapter 5.14 (Transducer mounting kit) revised.
3.0.0	September 2021	Update of test cable kit codes
3.0.1	October 2021	Correction to code PII44188

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