

CAT100 Series

Circuit Breaker Analyzers & Timers

- Simple and easy to operate
- Robust design for field use
- Accurate measurements in high voltage environment
- Timing, coil current, voltage, and motion measurement
- Touch-screen color display 7 inch
- Graphical results for quick interpretation
- Battery operation for up to 8 hours
- DV-CB software for detailed analysis of test results



Description

The **CAT100** circuit breaker analyzer & timer is a stand-alone or a PC-controlled digital instrument for circuit breaker condition assessment.

The **7" touch-screen interface** provides easy and intuitive control of test device and onsite analysis of the graphical results.

Timing channels record the closing and opening of the main arcing, resistor, and auxiliary contacts. The main contact channels can measure the resistance value of the pre-insertion resistors (if present in the circuit breaker).

CAT100 Series provides an easy selection of different operational modes:

- Trip (O)
- Close (C)
- Reclose (O-0,3s-C)
- Trip free (CO)
- O-0,3s-CO
- Trip-Close (O-C)
- Close-Trip (C-O)
- Trip-Close-Trip (O-C-O)

Multiple operations, such as Trip-Close and Trip-Close-Trip, can be initiated by using a predefined delay time or by sensing a breaker's contact position.

The CAT100 Series records graphs of both trip and close coil current and displacements of the HV and MV circuit breaker moving parts. The two coil control analog channels can measure and record the coil currents simultaneously (TRIP and CLOSE), up to 35 A AC/DC.

The circuit breaker operation can be initiated in different ways (for instance from a control room, by a local switch or externally by a testing device) depending on the testing condition. Several time measurement triggers are available to record measurements in various testing conditions:

- external trigger
- analog channels
- auxiliary channels
- coil control channel

The **auxiliary inputs** are used to monitor dry and wet auxiliary contacts. The external trigger input can be used as the additional auxiliary input.

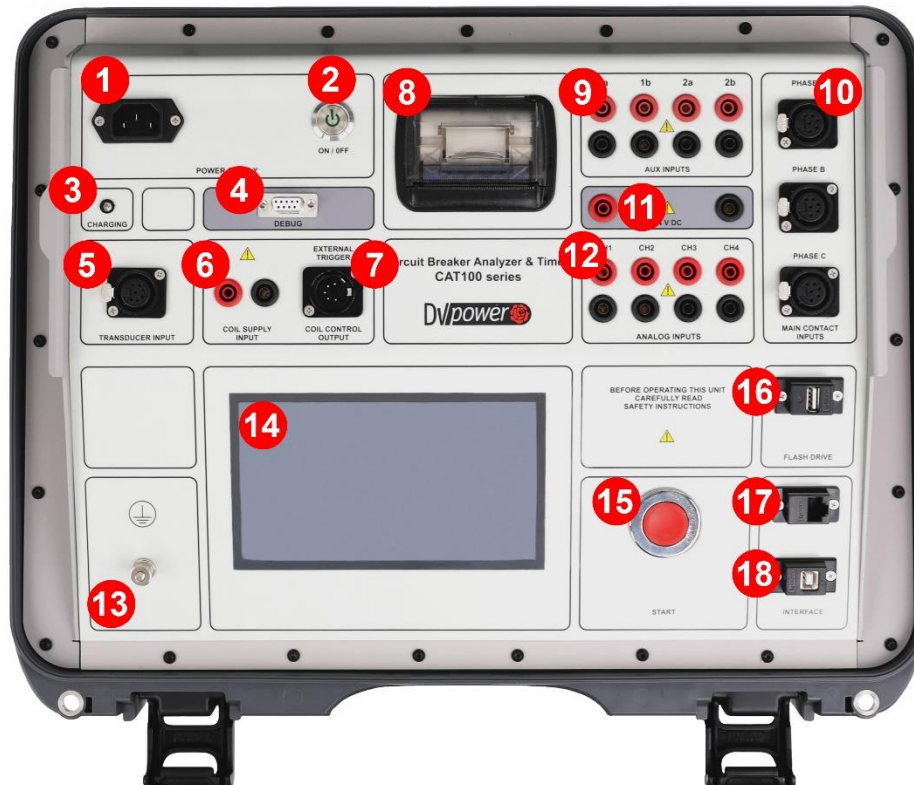
Test results can be printed on the 58 mm (2.28 inch) **thermal printer (optional accessory)** in tabular and graphical form.

The additional **four analog channels** have four selectable voltage ranges ($\pm 1\text{ V}$, $\pm 5\text{ V}$, $\pm 60\text{ V}$ and $\pm 300\text{ V AC/DC}$). They are used to monitor:

- Circuit-breaker substation battery voltage,
- Motor voltage and current,
- Other types of analog signals that may be relevant.

The transducer channel is intended for measuring the displacement of the circuit breaker moving parts, contact wipe, over-travel, rebound, damping time, and average velocity. Either an analog or a digital transducer can be connected to this universal channel.

Features



1 – Mains power supply input
90 V – 264 V AC; 50 Hz – 60 Hz

2 – On /Off LED Push button
Turn On/ Off the CAT device.

3 – Battery charging Indicator (optional)
Indicates whether the battery is completely charged or being charged.

4 – Debug adapter
Used for accessing the SBC application directly. Only used during major upgrades or servicing.

5 – Motion transducer inputs
Intended for measuring displacement of circuit breaker's moving parts.

6 – Coil supply input
Voltage supply input for coil control.

7 – Coil control outputs and external trigger input
Used for operating the circuit breaker OPEN and CLOSE coil or external trigger feature.

8 – Thermal printer (optional)
(Built-in 58 mm wide) Graphic and numeric printout of contact and travel wave form.

9 – Auxiliary inputs
Used for timing measurement of dry or wet auxiliary contacts.

10 – Main contacts inputs
Used for timing of the main and pre-insertion resistor contacts, and for the resistance measurement of the pre-insertion resistors.

11 – 24 V DC output
Used for current clamp supply.

12 – Analog channels inputs
Used for voltage measurement of an analog signal that may be relevant.

13 – Earth (ground terminal)

14 – LCD display
Touch-screen color display 7 inch

15 – START button
Initiates start of the test.

16 – Flash drive
Used for a direct download of test results on a USB memory stick.

17 – PC communication - USB
USB connection interface.

18 – PC communication - Ethernet
Ethernet connection interface.

Application

The list of the instrument applications includes:

- Simultaneous timing measurement of up to 6 main contacts (2 breaks per phase) including pre-insertion resistors (if present in the circuit breaker) and 4 auxiliary contacts,
- Resistance measurement of the pre-insertion resistors (if present in the circuit breaker),
- Evaluation of synchronization (simultaneity) between the circuit breaker poles,
- A measurement of the coil currents, simultaneously for 2 coils,
- Evaluating the state of the substation's batteries by graphically showing the voltage value,
- A measurement of displacement, contact wipe, over-travel, rebound, damping time and average velocity of the breaker's moving parts.

Timing Measurement

Timing measurement of mechanical operations is one of the most important tests to determine the real condition of the circuit breaker. Timing measurement tests fulfill all the requirements defined by IEC 62271-100 and IEEE C37.09.

In three-phase systems, not only the contacts in a single-pole have to operate simultaneously, but all poles must also operate at the same time. All contacts must be synchronized, within a certain tolerance limit.

Synchronization between the circuit breaker poles during opening shall not exceed 1/6 of the rated frequency cycle (3,33 ms at 50 Hz; 2,78 ms at 60 Hz) and during closing shall not exceed 1/4 of the rated frequency cycle, as well (5,0 ms at 50 Hz; 4,17 ms at 60 Hz).

Simultaneous measurements within a single phase are important in situations where a number of contacts are connected in series.

The maximum difference between the instants of contact separation within series connected interrupter units shall not exceed 1/8 of a cycle of rated frequency (2,50 ms at 50 Hz; 2,08 ms at 60 Hz).

Maximum difference between the instants of contacts touching within series connected interrupter units shall not exceed a 1/6 of a cycle of rated frequency (3,33 ms at 50 Hz; 2,78 ms at 60 Hz).

Auxiliary contacts are mechanically driven by the operating mechanism and are used for control and indication of the main contacts' state. There are no general requirements, related to timing measurement of auxiliary contacts, described in IEC[®] and IEEE[®] standards. Anyway, to assess the condition of high-voltage circuit breakers, it is important to check their operation.

Type "a" contact follows circuit breaker main contact position and must close/open ahead of the closing/opening of the main contact. Type "a" contact is connected in series with the trip coil and interrupts the trip coil circuit when the circuit breaker opens.

The "b" contact must open/close when the operating mechanism has released its stored energy in order to close/open the breaker. Type "b" contact is connected in series with the closing coil, interrupting the closing coil circuit when the circuit breaker closes.

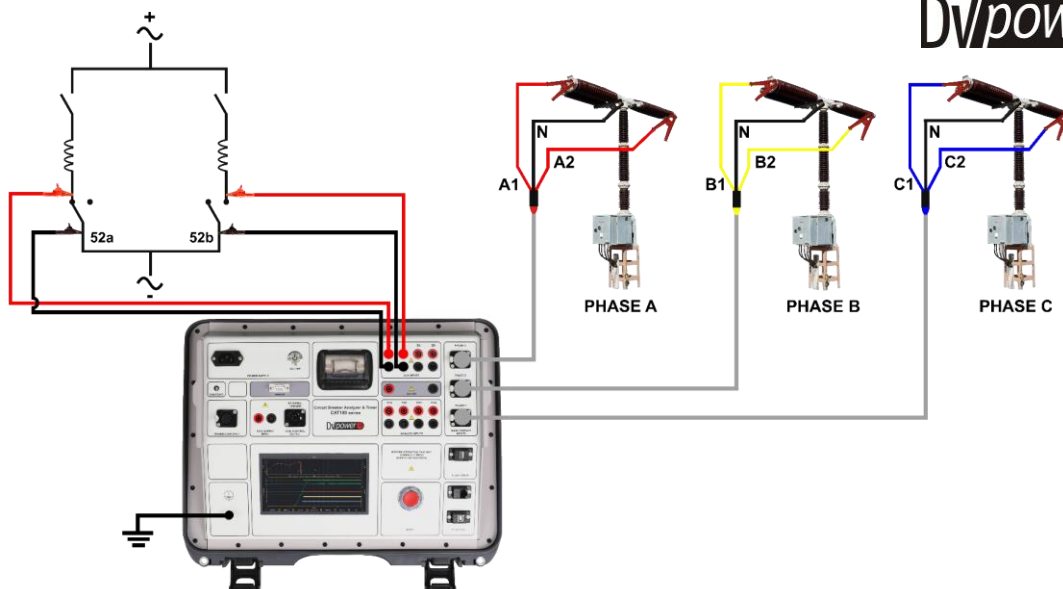


Figure 1: Connecting the main contact timing cables and auxiliary timing cables to a test object.

Motion measurement

Motion measurement of the high voltage circuit breakers' contact system is of crucial importance for assessing a condition of the test object. The motion transducer channel can acquire data from a linear or rotary motion transducer. Each channel can be configured for either an analog or a digital transducer.

Due to the universal transducer channels design, a user is able to connect a variety of motion transducers available on the market.

Performance values such as stroke, over-travel, rebound, contact wipe are obtained as a result of the measurement. These values can be compared to the manufacturer's reference data and data acquired from previous measurements. This provides indications about potential wear of the breaker.

Average velocity is calculated between the two points on the motion curve. The upper point is defined as a distance in length or time elapsed from the breaker's closed position, or contact-separation point. The lower point is determined based on the upper point. It can either be a distance below the upper point or a time before the upper point.



Figure 2: Digital rotary transducer mounted on ABB LTB 245 kV SF6 circuit breaker

User is usually allowed to mount transducers on accessible parts of the circuit breaker's mechanical linkage. Beside this, instrument often records rotary motion, even it is known the main contacts motion is linear.

As a result, motion results obtained do not represent real movement of the main contacts, but just linear or nonlinear interpretation of the main contacts moving parts displacement.

DV-CB software provides the transfer function feature which allows user to define linear or non-linear parameters in order to obtain actual displacement values of the main contact moving parts.

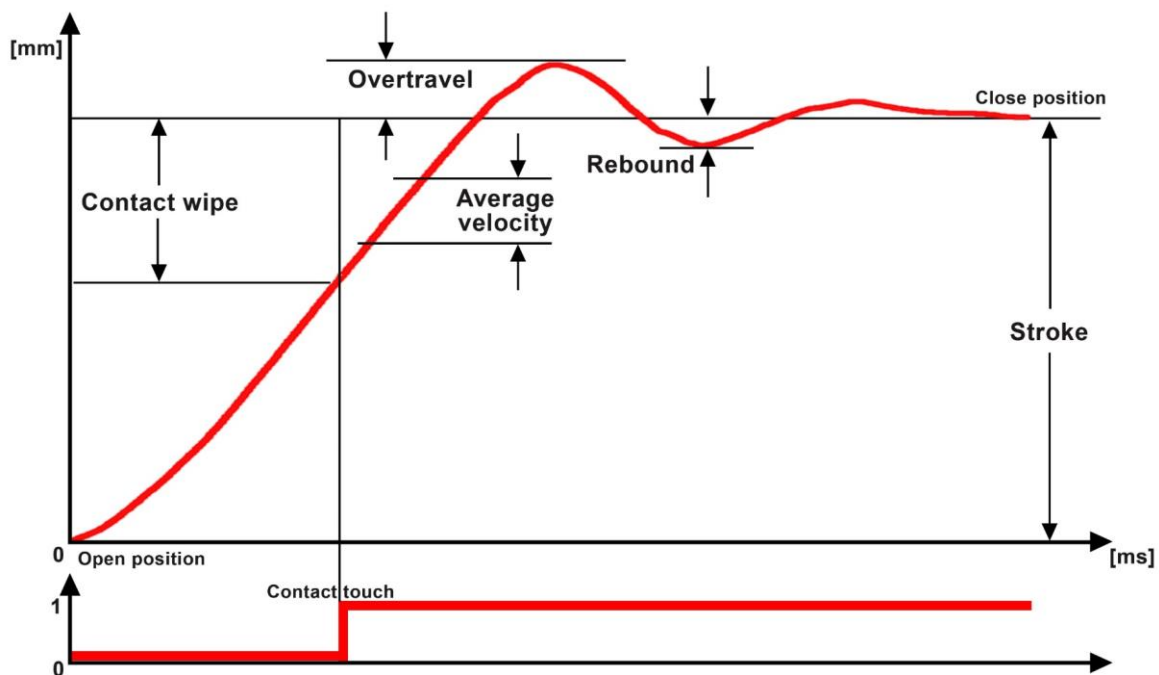


Figure 3. Travel curve and important travel parameters

Coil current measurement

The IEC 62271-100 standard states that it is desirable to record the coil currents waveform, since it provides information about coils' condition (e.g. increased friction of the plungers, burned insulation, short-circuited part of the winding), the latch for release of the operating mechanism (e.g. increased friction) and the operating mechanism (e.g. if there is reduced operating mechanism speed that can be seen based on the opening time of auxiliary contacts).

When the opening or closing command is initiated, the coil is energized (point 1) and the current rises causing a magnetic field to apply a force on the iron plunger. When the force on the plunger exceeds the retaining force the plunger begins to move (point 2). The motion of the iron plunger induces an *EMF* in the coil, effectively reducing the current. The combined mass of the plunger and the latch continue to move at a reduced velocity causing a further reduction in the coil current (points 2-3) until it hits a buffer

bringing it to a rest (point 3). If the current values at points 2 and 3 are higher than specified and the time at point 3 is longer than specified, it may indicate a friction of the plunger and latch. With the plunger at rest, the current increases to the saturation level (DC current, which is proportional to the coil resistance, point 4). If the current value from point 4 to point 5 deviates from specific it may indicate a burned insulation or short-circuited part of the winding of coil. Meanwhile, the latch unlocks operating mechanism, releasing the stored energy to open the main breaker contacts. Typically, after a short delay the auxiliary contacts open, disconnecting the opening coil from the control voltage (point 5). As the coil is de-energized the current drops quickly to zero in accordance with the coil inductance (point 6). Longer time than specified at points 5 and 6 may indicate auxiliary contact malfunction or insufficient driving energy of the operating mechanism.

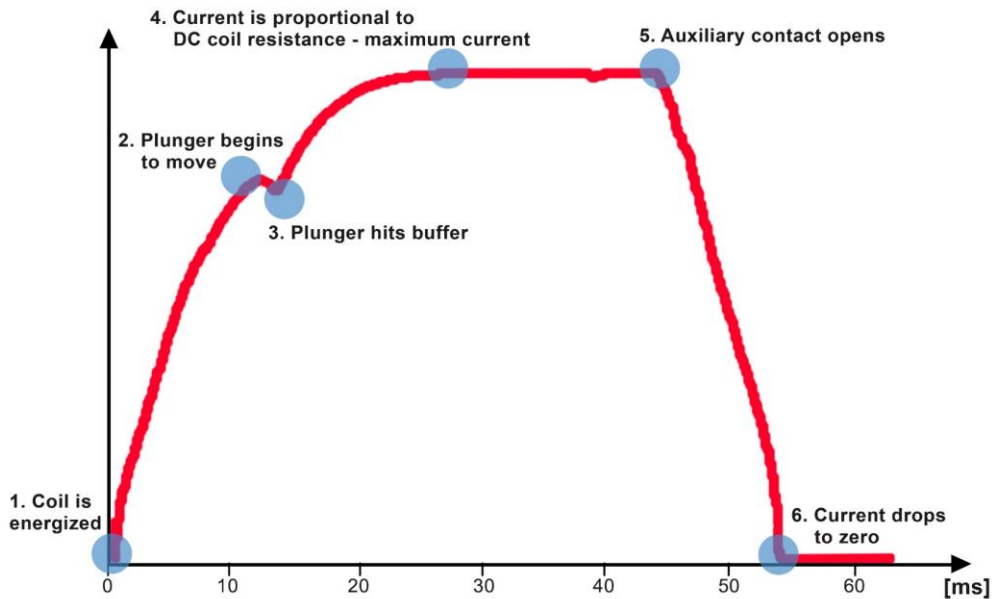


Figure 4. Typical coil current waveform

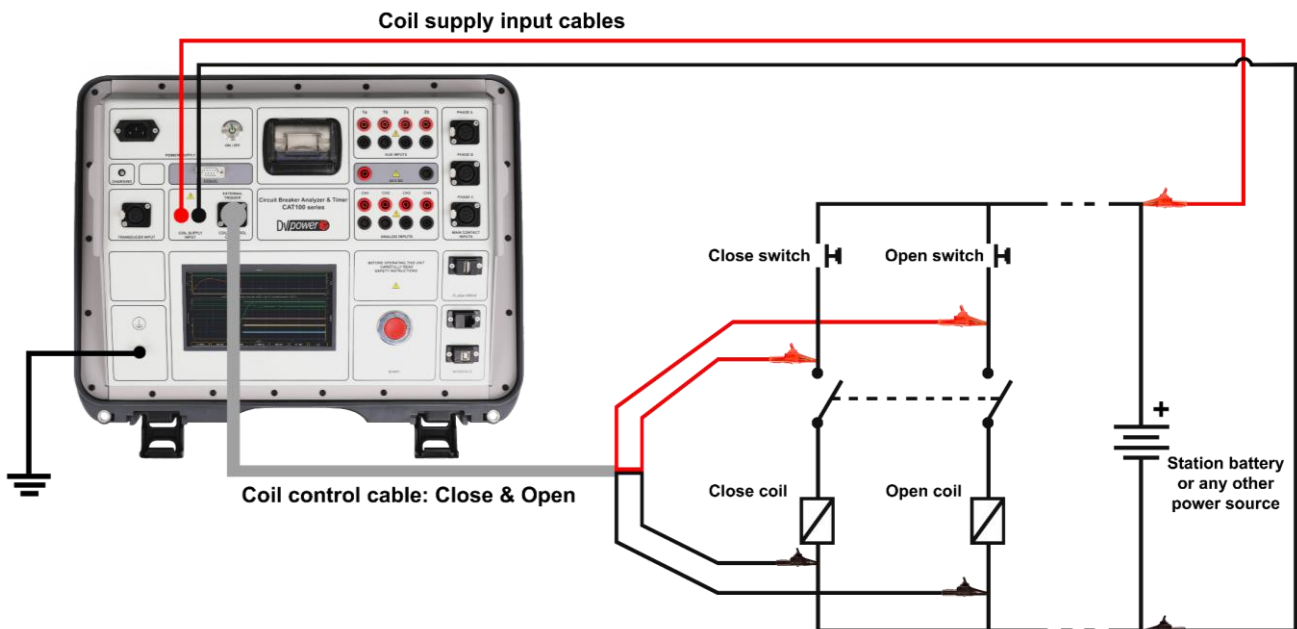


Figure 5. Connecting the coil control cables to circuit breaker control circuit

DV-CB software

Acquisition and Analysis

DV-CB software provides acquisition and analysis of the test results, as well as control of all of the functions of the CAT100 from a PC. It supports measurements process and step by step guidance through the entire test procedure, providing faster, easier, and safer testing.

Graphical presentation

Graphical presentation of a variety of measurements and timing test results uses cursors and powerful zoom functions for detailed analysis. Colors, grids, scales, and positioning of the test data are all controlled by the user. DV-CB supports automatic unit conversion (e.g.: cycles to seconds or mm to inches). The test records can be exported in .dwc file format for further analysis.

Database

Results are automatically stored and organized in the database on your PC and are available for analysis and reporting. Each test can be automatically assessed according to manufacturer specifications or based on your individual limit values.

DV-CB software database can be updated with over 500 test plans of different apparatus commonly used in most utilities and substations. This valuable benchmark data used for test results evaluation is provided upon request.

Reports

DV-CB automatically generates reports including all asset-related information and performed tests. This gives you a comprehensive overview of the test object, test results and assessment. You can easily adapt test reports, for example, by choosing from different types of result tables and diagrams and by providing comments on every test. Furthermore, you can incorporate your company logo, photos and other test results.

- Full control of the CAT functions from a PC
- Downloading the test results from the instrument
- Acquisition and analysis of the test results
- The test results can be viewed, edited, saved, printed and exported
- Viewing and overlaying several graphs, for an easy test result comparison
- Selecting the measurement points and intervals using the two cursors
- Zoom and pan graph feature
- Specific test sequence setup
- Creation of predefined test plans for an easy and quick field testing
- Customized configuration of the test result graphs



Figure 6. DV-CB software components view

Technical Data

Main contact inputs

- Number of contact inputs: up to 6(3x2), 2 per phase
 - Each channel detects Main and pre-insertion resistor contacts.
 - Closed $\leq 10 \Omega$
 - Resistor contacts range 10Ω to $5 \text{ k}\Omega$
 - Open $\geq 5 \text{ k}\Omega$
- Open circuit voltage: 20 V DC
Short circuit current 50 mA
- Each channel measures resistance of pre-insertion resistors

Auxiliary inputs

- Number of channels: 4, galvanically isolated
- User selectable: dry or wet
 - Contact sensing (dry):
Open circuit voltage 24 V DC
Short circuit current 5 mA
 - Voltage sensing (wet):
Working voltage 300 V DC, 250V AC
Low activation mode $\pm 5\text{V}$
High activation mode $\pm 10\text{V}$
- Overcurrent and overvoltage protection

Time measurement

Time measurement resolution:

- 0.025 ms for 1 s test duration (sampling rate 40 kHz)
- 0,1 ms for 2 s test duration (sampling rate 10 kHz)
- 1 ms for 20 s test duration (sampling rate 1 kHz)
- 10 ms for 200 s test duration (sampling rate 100 Hz)

Time accuracy: 0,05% of the reading \pm resolution

Breaker operation

- Close (C)
- Open (O)
- Close-Open (C-O)
- Open-Close (O-C)
- Open-Close-Open (O-C-O)

The user can select any desired test sequence.

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Coil driver

- Number of channels: 2 (Trip and Close coil)
- Two separate outputs for coil triggering
- Driver characteristics: 300 V DC max, 35 A DC max
- Electronic drivers provide superior timing control
- Overcurrent and overvoltage protection
- Coil supply input: 300 V DC max, 35 A DC max

Current measurement

- Current measurement for Trip and Close coil, 2 channels, Hall-Effect sensor
- Range $\pm 35 \text{ A DC}$ to 5 kHz
- Accuracy: $\pm (0,5 \% \text{ rdg} + 0,1 \% \text{ FS})$
- Graphic presentation: currents waveform is displayed with a resolution of 0,1 ms

Analog inputs

- 2 channels – Coil current measurement
- 4 Voltage channels, each channel has four measurement ranges: $\pm 1 \text{ V}$, $\pm 5 \text{ V}$, $\pm 60 \text{ V}$ and $\pm 300 \text{ V AC/DC}$

The analog inputs are isolated with respect to all other circuits

DC output

24 V voltage supply for current clamps

PC Interface

- USB
- Ethernet

Display

- Touch screen color display 7 inch.

Printer (optional)

- Thermal printer
- Graphic and numeric printout
- Paper width 58 mm (2.28 in)
- Printer operating temperature:
- 20 °C - + 70 °C / - 4 °F - +158 °F

Transducer input

- Digital transducer inputs: 1
- Analogue transducer inputs: 1

Time measurement triggers

- External trigger: 2 channels (trigger input voltage: 10 V – 300 V AC/DC)
- Coil currents: threshold level user selectable
- Auxiliary inputs (change of contacts state)

Dimensions and weight

- Dimensions (W x H x D):
 - 503 mm x 406 mm x 193 mm
19.8 in x 15.9 in x 7.6 in
- Weight:
 - 8.5 kg / 18.7 lbs.

Warranty

- 3 years + additional 1 (one) year upon registration on DV Power official website (www.dv-power.com)

Mains power supply

- Connection according to IEC/EN60320-1; UL498, CSA 22.2
- Mains supply: 90 V - 264 V AC
- Frequency: 50/60 Hz
- Input power: 250 VA

Internal battery supply (optional)

- Built-in rechargeable battery
- Li-Ion 14.4 V Cell – 6800 mAh 98 Wh

Applicable standards

- Installation / Overvoltage: Category II
- Pollution: Degree 2
- Safety: LVD 2014/35/EU (CE Conform)
Standard EN 61010-1
- EMC: Directive 2014/30/EU (CE Conform)
Standard EN 61326-1
- CAN/CSA-C22.2 No. 61010-1

Environmental conditions

- Operating temperature:
- 20 °C to + 55 °C / - 4 °F to + 131 °F
- Storage & transportation:
- 40 °C to + 70°C / - 40 °F to + 158 °F
- Humidity 0 % - 95 % relative humidity, non-condensing

*All specifications herein are valid at ambient temperature of + 25 °C and standard accessories.
Specifications are subject to change without notice.*

Accessories



Main contacts cables 5 m (16.4 ft) with SCT clamps* (CM-05-65MXST)



Main contacts extensions cables 5 m (16.4 ft)* (E3-05-65MXFX)



Coil control cable 5 m (16.4 ft) with banana plugs* (CO-05-00C5B1)



Auxiliary channels cable set 8 x 5 m (16.4 ft) with banana plugs* (A8-05-02BPBP)



Analog channels cable set 8 x 5 m (16.4 ft) with banana plugs* (C8-05-02BPBP)



Coil supply cable set 2 x 5 m (16.4 ft) 2,5 mm² (14 AWG) with banana plugs* (C2-05-02BPBP)



Current clamp 30/300 A power supplied from the instrument with adapter 5 m (16.4 ft) (CACL-0300-07)



Linear to rotary converter (LTR-CON-0000)



Digital rotary transducer with 5 m (16.4 ft) connection cable (DRT-SET-0005)



Linear analog transducer with 5 m (16.4 ft) connection cable (LAT-225-C305)**



Universal transducer mounting kit (UTM-KIT-0000)



Universal transducer mounting kit (extended version) (UTM-KIT-0001) + digital rotary transducer with accessories (DRT-SET-0005)



Cable bag (CABLE-BAG-00)



Cable plastic case - large size (CABLE-CAS-03)

*The above cables are also available in several lengths and terminations.

**The above linear analog transducers are available in several lengths. Please contact DV Power for more information.

Order info

Instrument	Article No.
Circuit Breaker Analyzer & CAT100 with 3 timing channels	CAT100-03-01
Circuit Breaker Analyzer & CAT100 with 3 timing channels (battery operated)	CAT100-B3-01
Circuit Breaker Analyzer & CAT100 with 6 timing channels	CAT100-06-01
Circuit Breaker Analyzer & CAT100 with 6 timing channels (battery operated)	CAT100-B6-01

Included accessories	Article No.
Transport case	
Windows based DV-CB PC software including USB cable	
USB Memory Stick	
Ethernet cables	
Debug adapter	
Mains power cable	
Ground (PE) cable	

Standard accessories	Article No.
Main contact cables 5 m (16.4 ft) with SCT clamps (<i>for CAT100 with 3 timing channels</i>)	CM-05-34MXST
Main contact cables 5 m (16.4 ft) with SCT clamps (<i>for CAT100 with 6 timing channels</i>)	CM-05-65MXST
Main contact cables extension 5 m (16.4 ft)	E3-05-65MXFX
Coil control cable 5 m (16.4 ft) with banana plugs	CO-05-00C5B1
Coil supply cable set 2 x 5 m (16.4 ft) 2,5 mm ² (14 AWG) with banana plugs	C2-05-02BPBP
Jumper cable 1 x 15 cm 2,5 mm ² with banana plugs with retractable isolation (red) (x3)	JCR-15-2REBP
Jumper cable 1 x 15 cm 2,5 mm ² with banana plugs with retractable isolation (black) (x3)	JCB-15-2REBP
Auxiliary channels cable set 8 x 5 m (16.4 ft) with banana plugs	A8-05-02BPBP
Analog channels cable set 8 x 5 m (16.4 ft) with banana plugs	C8-05-02BPBP
Cable plastic case - medium size	CABLE-CAS-02

Optional accessories	Article No.
Main contact cables 3 m (9.8 ft) with SCT clamps (<i>for CAT100 with 3 timing channels</i>)	CM-03-34MXST
Main contact cables 3 m (9.8 ft) with SCT clamps (<i>for CAT100 with 6 timing channels</i>)	CM-03-65MXST
Main contact cables 3 m (9.8 ft) with alligator clamps (A2) (<i>for CAT100 with 3 timing channels</i>)	CM-03-34MXA2
Main contact cables 3 m (9.8 ft) with alligator clamps (A2) (<i>for CAT100 with 6 timing channels</i>)	CM-03-65MXA2
Main contact cables 5 m (16.4 ft) with alligator clamps (A2) (<i>for CAT100 with 3 timing channels</i>)	CM-05-34MXA2
Main contact cables 5 m (16.4 ft) with alligator clamps (A2) (<i>for CAT100 with 6 timing channels</i>)	CM-05-65MXA2
Main contact cables extension 10 m (32.8 ft)	E3-10-65MXFX
Main contact cables extension 15 m (49.2 ft)	E3-15-65MXFX
Coil control cable 10 m (32.8 ft) with banana plugs	CO-10-00C5B1
Coil control cable 15 m (49.2 ft) with banana plugs	CO-10-00C5B1
Coil supply cable set 2 x 10 m (32.8 ft) 2,5 mm ² (14 AWG) with banana plugs	C2-10-02BPBP
Auxiliary channels cable set 8 x 5 m (16.4 ft) with banana plugs	A8-05-02BPBP
Auxiliary channels cable set 8 x 10 m (16.4 ft) with banana plugs	A8-10-02BPBP
Analog channels cable set 8 x 5 m (16.4 ft) with banana plugs	C8-05-02BPBP
Analog channels cable set 8 x 10 m (16.4 ft) with banana plugs	C8-10-02BPBP
Current clamp 30/300 A power supplied from the instrument with adapter 5 m (16.4 ft)	CACL-0300-07
Current clamp 30/300 A with internal battery supply and extension 5 m (16.4 ft)	CACL-0300-08
Small current clamp 10/100 A with internal battery power supply and extension 5 m (16.4 ft)	CACL-0100-01

Digital rotary transducer 5 m (16.4 ft) with accessories	DRT-SET-0005
Digital rotary transducer 10 m (32.8 ft) with accessories	DRT-SET-0010
Linear analog transducer (TLH) 150 mm (5.9 in) with 5 m (16.4 ft) connection cable and linear transducer rod	LAT-150-C305
Linear analog transducer (TLH) 225 mm (8.9 in) with 5 m (16.4 ft) connection cable and linear transducer rod	LAT-225-C305
Linear analog transducer (TLH) 300 mm (11.8 in) with 5 m (16.4 ft) connection cable and linear transducer rod	LAT-300-C305
Linear analog transducer (TLH) 500 mm (19.7 in) with 5 m (16.4 ft) connection cable and linear transducer rod	LAT-500-C305
Universal transducer mounting kit	UTM-KIT-0000
Universal transducer mounting kit - extended version	UTM-KIT-0001
Linear to rotary convertor	LTR-CON-0000
Doble transducer adapter with 5 m (16.4 ft) connection cable	DTA-005-C602
Doble transducer adapter with 10 m (32.8 ft) connection cable	DTA-010-C602
Doble transducer adapter with 15 m (49.2 ft) connection cable	DTA-015-C602
Thermal printer 58 mm (2.28 in) (built-in)	PRINT-058-01
Thermal paper roll 58 mm (2.28 in)	PRINT-058-RO
Cable plastic case - small size	CABLE-CAS-01
Cable plastic case - medium size	CABLE-CAS-02
Cable plastic case - large size	CABLE-CAS-03
Cable plastic case with wheels - medium size	CABLE-CAS-W2
Cable plastic case with wheels - large size	CABLE-CAS-W3
Test probe with grip jaws (black)	TESTPR-GJ-B0
Test probe with grip jaws (red)	TESTPR-GJ-R0
Test probe with split test clamps (black)	TESTPR-SC-B0
Test probe with split test clamps (red)	TESTPR-SC-R0
Dolphin clip (black)	DOLPIN-CL-B0
Dolphin clip (red)	DOLPIN-CL-R0

B-CAT100-100-EN

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Subject to change without notice

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