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T2000 TEST SET
for testing CT's, PT's, primary injections and relay tests

REVISIONS			SUMMARY	VISA
N	PAGE	DATE		
1	All	24/08/2004	Issued	Lodi.
2	16	12/10/2005	Added the dynamic tap changer test	Lodi
3	17	20/6/2007	Added paragraphs 3.9.8, 3.9.9, 3.9.10 and 3.9.11	Lodi
4	19	9/4/2008	Added information for the 110 V model	Lodi
5	All	13/12/2010	Added the test of protection relays (FW revision 1.40)	Lodi
6	All	4/10/2011	Minor corrections	Lodi

1 INTRODUCTION

T2000 allows performing all tests on current and voltage transformers, and of some protection relays. The following table lists the tests that can be performed on CT and VT.

N.	TEST OF	TEST DESCRIPTION
1	CT	Ratio, Voltage mode
2	CT	Ratio, polarity and burden
3	CT	Burden; secondary side
4	CT	Excitation curve
5	CT	Winding or burden resistance
6	CT	Voltage withstand
7	CT	Polarity by impulses
8	VT	Ratio; polarity
9	VT	Burden, secondary side
10	VT	Ratio, electronic transformers
11	VT	Voltage withstand
12	VT	Secondary over-current protection
13	PT	Ratio per TAP
14	PT	Resistance of Tap Changer contacts
15	PT	Tap Changer dynamic resistance test
16	R	Ground resistance and resistivity

Tests are performed in accordance with the following IEC standards: EN 60044-1; EN 60044-2; EN 60044-5; EN 60044-7; EN 60044-8; EN 60076-1, and also in accordance with ANSI/IEEE C57.13.1.

The following table lists the tests that can be performed on protection relays (FW revision 1.40).

Type of relay	IEEE code
- Thermal	26
- Over/under-voltage	27 - 59
- Under current	37
- Instantaneous overcurrent	50
- Ground fault	50N
- Timed overcurrent	51
- Circuit breaker	52
- Automatic reclose	79
- Tripping relay	94
- Timers	

In addition to the above, T2000 can test the impedance and coupling coefficient of overhead lines.

With external options, T2000 can test:
. With the High IDC module, up to 400 A: contact resistances, in the micro-Ohm range;
. With the current booster: primary tests, up to 2000 A; with the very high current booster option, up to 4000 A.

The basic T2000 function is to generate current and voltages, as requested by the type of test to be performed, that is selected on the LCD screen by means of the multi-function knob. Test results are kept in memory, and can be transferred to a PC at a later time, along with settings.

The instrument contains a generator, with six outputs: High AC current; Low AC current; Low DC current; Current impulses; High AC voltage; Low AC voltage.

The selected output is adjustable and metered on the large, graphic LCD display. With the multi-purpose knob and the LCD display it is possible to enter the MENU mode, that allows to set many functions, that make T2000 a very powerful testing device, with manual and semi-automatic testing capabilities, and with the possibility to transfer test results to a PC via the RS232 interface. These results can be recorded, displayed and analysed by the powerful TDMS software, which operates with all WINDOWS versions.

The ease of operation has been the first goal of T2000: this is why the LCD is graphic, and so large. With it, the dialogue in MENU mode is made easy. Besides, all T2000 outputs relevant to the selected test are continuously measured, and output values are displayed, with no extra effort to the operator. Also the show waveform feature can be of help: any doubt about strange measurements, distortion and so on can be solved.

Additional feature: two meters, current and voltage, with independent inputs, and with High and Low inputs each, allow measuring CT or VT outputs or any other source.

The instrument is housed in a transportable aluminium box, which is provided with removable cover and handles for ease of transportation. The picture shows T2000 without the protection cover.

The following is the list of available options:

1. Power supply 110 V, to be specified at order;

2. Optional high voltage 1200 V, instead of 3000 V (better choice for 5 A rated CT's), to be specified at order;
3. T2000E, model with high voltage at 1200 V and the high current output power boosted to 850 VA;
4. Transit cases: moulded plastic or aluminium;
5. Secondary current clamp meter;
6. Local thermal printer;
7. BU2000: very high current booster, for currents up to 4000 A AC, for primary injection tests;
8. High IDC current generator module, up to 400 A DC, for the measurement of joint resistances;
9. SU3000: protection module for line impedance measurement.
10. FT/100: filter for highly inductive loads, that tend to distort the current waveform.
11. Cables and electrodes kit for the measurement of plant earth resistance, and soil resistivity.

NOTE: WINDOWS is a trademark of MICROSOFT inc.

2 APPLICABLE STANDARDS

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

A) Electromagnetic Compatibility:
Directive no. 2004/108/EC. Applicable Standard : EN61326-1 + A1 + A2.

EMISSION

- EN 61000-3-2: Harmonic content of power supply. Acceptable limits: basic.
- 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, 10 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 dops. Test value: 1 cycle; 100% drop.

B) Low Voltage Directive:
- - Directive n. 2006/95/EC.
- Applicable standard: EN 61010-1. In particular, for a pollution degree 2: dielectric rigidity 1.4 kV AC, 1 minute. The rigidity is 4600 V AC 1 minute between the high voltage output and the rest of inputs and outputs.
- Inputs/outputs protection: IP 2X, per IEC 60529, for all but high voltage outputs; IP4X for high voltage outputs.
- Operating temperature: 0 to 50 °C; storage: -20 °C to 70 °C.
- Relative humidity : 5 - 95%, without condensing.
- Vibration: IEC 68-2-6 (20 m/s^2 at 10 – 150 Hz);
- Shock: IEC 68-2-27 (15 g; 11 ms; half-sine).
- Altitude: less than 2000 m.

3 CHARACTERISTICS

3.1 FOREWORD

T2000 incorporates a generator with six outputs. When an output is generated, also all other outputs are present at sockets, unless for the high AC voltage, that can be generated only if it is selected and confirmed by a key.

The generator is made of a variable transformer followed by a transformer. The variable transformer does not reach the zero position; so, when you are adjusting the output current on a low burden, the minimum current can be up to 5% of the range. If this is a problem on relay tests, select the 60 VA power: the current is reduced to one fifth.

3.2 MAIN GENERATOR

The main generator has six outputs: High AC current; Low AC current; Low DC current; Current impulses; High AC voltage; Low AC voltage. Output adjustment is performed via a knob. The following specification applies to the separate usage of these outputs.

3.2.1 High AC current

- Output characteristics: see table below.

CURRENT OUTPUT A	OUTPUT POWER VA	LOAD TIME s	RECOVERY TIME min
100	600	STEADY	-
150	800	15 min	30
200	1000	4 min	15
400	1600	15	5
600	2000	5	3
800	2000	1	2

- Connection: two high power sockets, with safety protections.

NOTE: the 800 A output is reached with the 4 m long cable supplied. Longer cables imply that 800 A cannot be reached. The maximum current is reduced by 25 A for a length increase of 1 m; so, for instance, with a cable 10 m long, the maximum current is 650 A.

3.2.2 Low AC current

- Output characteristics: see table below.

1) NOMINAL POWER 300 VA

RANGE A AC	CURRENT OUTPUT A	OUTPUT POWER VA	LOAD TIME s	RECOVERY TIME min
40	12	300	STEADY	-
	18		15 min	30
	24		4 min	15
	36	800	15	5
	48		5	3
	60	1000	1	2
10	5	400	STEADY	-
	7.5		15 min	30
	10	800	60	15
	15		30	10
	20	1000	15	5

2) NOMINAL POWER 60 VA

RANGE A AC	CURRENT OUTPUT A	OUTPUT POWER VA	MAX. TEST DURATION s	RECOVERY TIME s
40	12	60	STEADY	-
	17		10 min	30
	23		60	10
	36		1	2
10	5	60	STEADY	-
	6		10 min	45
	7		60	2
	10		1,5	2

- Power selection: via menu.

- Connection: three high current safety sockets.

3.2.3 Low DC current

- Output characteristics: see table below.

CURRENT OUTPUT A	LOAD RESIST. Ohm	OUTPUT POWER VA	LOAD TIME min	RECOVERY TIME min
10	0	0	STEADY	-
3	2	18	STEADY	-
1	8	8	STEADY	-

- Type of DC voltage: unregulated, via diode bridge rectifier and capacitor, plus limiting resistor.

- Output connection: two safety sockets.

3.2.4 Current impulses

Current impulses are only positive; this solves the problem of the ambiguity of secondary impulse polarity that is found if a DC voltage is used.

- Type of waveform: R-C discharge; polarity: positive.
- Current range: from 0 to 10 A peak.
- Repetition rate: a pulse every 3 s.
- Output connection: two safety sockets.

3.2.5 High AC voltage

- Type of generator: variable transformer and high voltage transformer.

- Output characteristics: see table below.

VOLTAGE OUTPUT V	CURRENT OUTPUT A	OUTPUT POWER VA	LOAD TIME Min	RECOVERY TIME min
3000	0.2	600	STEADY	-
2500	0.6	1500	1	8

- Output connection: two H.V. safety sockets.

3.2.6 Low AC voltage

- The AC voltage is isolated from the high AC current.
- AC voltage range: 250 V.
- Available power and duty cycle: see table below.
- Connection: two safety banana sockets.

RANGE V AC	VOLTAGE OUTPUT V	OUTPUT POWER VA	LOAD TIME min	RECOVERY TIME min
250	250	125	STEADY	-
	220	250	3	9

3.2.7 Other features of main outputs

- Zero crossing control. Main AC outputs are generated and stopped as the output waveform is zero. This implies that in mode ON+TIME the output drops to zero with a delay from 0 to one cycle after STOP is detected.

- Over-current alarm message.

- Thermal protection: by NTC. The operator is alerted by a message.

- Output adjustment: from less than 5% to 100% of the output.

- Output measurement. The used output is software selected; the selected socket is confirmed by a light.

3.3 AUXILIARY CONTACT

- Possibility to delay the auxiliary contact switch with respect to test start. Delay range: from 0 to 99.99 s.

- Contacts range: 5 A; 250 V AC; 120 V DC

3.4 TIMER

The electronic digital timer has a fully automatic stop, both for make and break of the input, that can be either a clean contact or a contact under voltage. All selections are menu-driven via the multi-function knob.

- Characteristics of Stop input:
.. Input connection: two banana sockets;
.. Input may be selected as Normal Open or Normal Close. It is possible to select timer stop on input level transition;
.. Type of input: either dry or under voltage; selection via the multi-function knob. Maximum input: 250V AC or 275 V DC;
.. With dry input selection, the wetting voltage is 24 V; the test current is 3 mA nominal;
.. With voltage input selection, two thresholds can be selected: 24 V or 80 V;
.. Selections are displayed on the front panel by 5 dedicated lights;
.. When the input is closed or with voltage an LED turns on;
.. When the relay intervenes the TRIP light turns on;
.. Wrong selection protection. If voltage is applied when clean input is selected, input circuits are not damaged;
.. Timer start: as the fault is generated.

- Available measurement: elapsed time between test start and STOP input.

- Time can be metered as seconds or cycles. Metering range, in seconds: see table.

Range	**Resolution**	**Accuracy**
From 0 to 9.999 s	1 ms	± (1 ms + 0.005%)
From 10.00 to 99.99 s	10 ms	± (10 ms + 0.005%)
From 100.0 to 999.9 s	100 ms	± (100 ms + 0.005%)
From 1000 to 9999 s	1 s	± (1 s + 0.005%)

. Metering range, in cycles, selectable at 50 Hz or at 60 Hz.

Range	**Resolution**	**Accuracy**
From 0 to 1,000 (Equal to 19.998 s @ 50 Hz; 16.665 s @ 60 Hz)	0.1 cycles	± (0.1 cycles + 0.005%)
From 1000 to 499,998.5 cycles @ 50 Hz; From 1000 to 599,998 cycles @ 60 Hz (Equal to 9999 s)	1 cycle	± (1 cycle + 0.005%)

- Display reset: automatic, at test start.

3.5 OUTPUTS MEASUREMENT

3.5.1 Current and voltage

- The displayed measurements follow the test selection.

- Type of measurement: true rms for AC outputs; average for DC outputs.

- Readings, resolution and accuracy: see table. Note that the available ranges can be greater than the maximum value of the output to which the load is connected: this means that higher values can be measured without saturation. For example, on the 800 A output the measuring range is up to 999 A.

Actually, the test set will not generate more than 800 A, as the test is stopped by the software, that indicates overload, and on the display currents more than 800 A will not be shown.

OUTPUT	RANGE	RESOLUTION	ACCURACY
HIGH AC CURRENT	19.99 A	20 mA	± (0.5% + 50 mA)
	199.9 A	200 mA	± (0.5% + 400 mA)
	999 A	1 A	± (0.5% + 1 A)
LOW AC CURRENT; 10 A	1.999 A	1 mA	± (0.5% + 5 mA)
	19.99 A	10 mA	± (0.5% + 20 mA)
LOW AC CURRENT; 40 A	7.999 A	4 mA	± (0.5% + 20 mA)
	79.99 A	40 mA	± (0.5% + 80 mA)
VOLTAGE OF LOW AC CURRENT	19.99 V	20 mV	± (0.5% + 50 mV)
	99.9 V	100 mV	± (0.5% + 200 mV)
HIGH AC VOLTAGE; 3000 V	199.9 V	200 mV	± (0.5% + 0.5 V)
	1999 V	2 V	± (0.5% + 4 V)
	2999 V	3 V	± (0.5% + 6 V)
CURRENT OF HIGH AC VOLTAGE	19.99 mA	50 uA	± (0.5% + 200 uA)
	199.9 mA	200 uA	± (0.5% + 500 uA)
	0.999 A	1 mA	± (0.5% + 2 mA)
LOW AC VOLTAGE 250 V AC	19.99 V	20 mV	± (0.5% + 50 mV)
	199.9 V	200 mV	± (0.5% + 400 mV)
	299.9 V	300 mV	± (0.5% + 600 mV)
CURRENT OF LOW AC VOLTAGE	19.99 mA	20 uA	± (0.5% + 50 uA)
	199.9 mA	200 uA	± (0.5% + 400 uA)
	1.999 A	2 mA	± (0.5% + 4 mA)
LOW DC CURRENT	199.9 mA	100 uA	± (0.5% + 200 uA)
	1.999 A	1 mA	± (0.5% + 2 mA)
	19.99 A	10 mA	± (0.5% + 20 mA)
I IMPULSES	19.9 A	0.1 A	± (5% + 0.5 A)

NOTES:

- The change range is the actual value at which the range is changed. This avoids saturation problems when we have to measure fast-changing values.

- Metering temperature coefficient: ± 0,05%/°C of the value ± 0,02%/°C of the range.

3.5.2 Phase angle

- Readings, resolution and accuracy: see table.

MEASUREMENT	RANGE	RESOLUTION	ACCURACY
PHASE	0 - 360	1°	1° ± 1 DIGIT *

* Specified accuracy applies to outputs greater than 10% of the selected range.

- Phase angle temperature coefficient: ± 1 ppM/°C of the value.

3.5.3 Other measurements

Starting from the above measurements, the test set can compute derived measurements, according to test selection.

The following is the list of available measurements. For all of them the following range and resolution applies; the accuracy is the sum of voltage, current and possibly angle accuracy.

N.	PARAMETER , AC outputs	DERIVED FROM	FORMULA	UNITS
1	RATIO, CT or VT or PT	I out, I in or Vout, V in	R = I out / I in R = V out / V in	-
2	POLARITY, CT or VT or PT	φ I out, I in or φ Vout, V in	OK = φ < 10°	-
3	BURDEN, CT	Vout;Iout	VA= IN^2*Vout/Iout	VA
4	VOLTAGE AND CURRENT KNEES	Vout, Iout	VKm, IKm: according to standards	V, A
5	Resistance	Iout, Vout	R = Vout/Iout	Ohm

For the **CT, VT and PT ratio measurement**, the following applies.
- Range: 9999;
- Accuracy: 0.5% typical; 1% maximum.

For the **polarity test**, the phase shift between the two parameters is tested. Answer is OK if phase shift is less than 10°.

For the **burden measurement**, the following applies.
- Range: 9999 Ohm;
- Accuracy: 0.5% typical; 1% maximum.

For the **voltage knee**, the following applies.
- Range: 9999 V;
- Accuracy: it depends upon the test conduction. When properly executed, the error is 1% typical; 2% maximum.

For the **resistance**, the test set measures up to 250 Ohm at 50 mA; the accuracy is: 0.5% typical; 1% maximum.

3.6 EXTERNAL INPUTS MEASUREMENT

- It is possible to meter the current and the voltage of an external (or internal) generator.

- Input connection: by four safety sockets; three for current and two for voltage.

- Metering circuits are isolated between them and from the rest of the instrument.

3.6.1 Current measurement

- Two inputs: 20 mA or 10 A AC.

- Range, resolution, accuracy: see tables below.

RANGE 20 mA	RESOLUTION	ACCURACY
25 mA DC	0.1 mA	± (0.5% + 0.2 mA)

RANGE 10 A	RESOLUTION	ACCURACY
1.999 A AC	1 mA	± (0.5% + 4 mA)
9.99 A AC	10 mA	± (0.5% + 40 mA)

- Metering temperature coefficient: ± 0,05%/°C of the value ± 0,02%/°C of the range.

- Possibility to display the current waveform.

3.6.2 Voltage measurement

- Two inputs: 10 V or 600 V, AC or DC

- Range, resolution and accuracy: see tables below.

RANGE 10 V	RESOLUTION	ACCURACY
0.199 V AC	1 mV	± (0.5% + 2 mV)
1.999 V AC	2 mV	± (0.5% + 10 mV)
9.999 V AC	10 mV	± (0.5% + 50 mV)

RANGE 600 V	RESOLUTION	ACCURACY
19.99 V AC	10 mV	± (0.5% + 40 mV)
199.9 V AC	50 mV	± (0.5% + 400 mV)
599.9 V AC	300 mV	± (0.5% + 1000 mV)
19.99 V DC	10 mV	± (0.5% + 40 mV)
199.9 V DC	50 mV	± (0.5% + 400 mV)
599.9 V DC	300 mV	± (0.5% + 1000 mV)

- Metering temperature coefficient: ± 0,05%/°C of the value ± 0,02%/°C of the range.
- Possibility to display the voltage waveform.

3.6.3 Other measurements

With relay selection, it is possible to compute measurements on external inputs. In this instance, measurements available depend upon the AC or DC selection for both inputs (no measurement for mixed selections).

N.	PARAMETER , AC INPUTS	DERIVED FROM	FORMULA	UNITS
1	ACTIVE POWER, P	Iext, Vext; φ	P= I*V*cos (φ)	W
	REACTIVE POWER, Q	Iext, Vext; φ	Q= -I*V*sin(φ)	VAr
2	APPARENT POWER, S	Iext, Vext	S= I*V	VA
	POWER FACTOR, p.f.	φ	p.f. = cos(φ)	-
3	IMPEDANCE, Z and φ	Iext, Vext, φ	Z = V/I	Ohm, °
4	ACTIVE IMPEDANCE COMP., R	Iext, Vext; φ	R = Z* cos(φ)	Ohm

	REACTIVE IMPEDANCE COMP., X	Iext, Vext; φ	X = Z* sin(φ)	Ohm
5	FREQUENCY, F	Vext	-	Hz

The angle measurement accuracy is ± 1° ± 1 digit. This accuracy applies to inputs greater than 10% of the input range, and for frequencies of 50 ± 0,5 Hz, and 60 ± 0,6 Hz. Temperature coefficient: ± 1 ppM/°C of the value.

The frequency measurement accuracy is ± 1 mHz ± 1 digit. This accuracy applies to inputs greater than 10% of the input range, and for frequencies of 50 ± 0,5 Hz, and 60 ± 0,6 Hz. Temperature coefficient: ± 1 ppM/°C of the value.

For other parameters, the accuracy is the sum of voltage, current and angle accuracies, as applicable.

PARAMETER , DC INPUTS	**DERIVED FROM**	**FORMULA**	**UNITS**
POWER, W	Iext, Vext	P= I*V	W
RESISTANCE, R	Iext, Vext	R = V/I	Ohm

With CT or VT or PT selection, the measurement follows the selected test.

3.7 DISPLAY

The graphical display has the following main features:

- pixels: 240x128
- backlight color: white
- LCD type: FSTN
- View area: 135x80 mm.

3.8 TEST CONTROL

3.8.1 Relay selection

- Manual start control:

. OFF: main outputs are not generated; Vac aux is generated, and it can be either the pre-fault value or the fault value, according to selections; VDC aux is generated.

. ON: main outputs are generated; Vac aux has the fault value. In this situation it is possible to verify and memorize the relay threshold, both trip and reset.

. From OFF to ON + time: main outputs are generated and the timer starts according to selections; as STOP is sensed, main outputs are removed and the elapsed time displayed and test result can be memorized.

. From ON to OFF + time: main outputs are removed the timer starts according to selections; as STOP is sensed, the elapsed time is displayed and test result can be memorized.

- Other test control selections:

. Momentary: in ON mode, main outputs are generated until the push-button is pressed;
. Timed: main outputs are generated for the programmed maximum time;
. External. This mode allows for the synchronization of more T3000;
. OFF delay: fault parameters can be maintained for the specified time after relay trips: this allows simulating the circuit breaker delay.

- Save selections:
  . Automatic saving.
  . Test data can be saved after confirmation. After relay trip, pressing the multi-function knob it is possible to save the test result.

3.8.2 Transformers selection

- The LED by the side of the selected output turns on: this helps the operator not to mistake test connections.

- Test control: by two push-buttons: OFF an ON.

- OFF: all outputs are not generated.

- ON: outputs are generated, according to the selected test. During ON, the selected parameter is adjusted to the desired value. The OK signal blinks 3 s after the parameter did not change any more, and tells the operator that the test is finished. At this moment outputs are cut off, and the operator is warned to set back to zero the adjustment knob.

3.9 MENU SELECTIONS

The following is the list of features which are menu selected. The menu is operated by means of the control knob marked MENU, which incorporates a switch. The menu is entered pressing the knob and selecting the item moving the knob. Once the item has been found and programmed, pressing the arrow the menu moves back of one step, so that other programming can be performed; else, selecting ESC the menu returns to the main window.

The first selection is RELAY or TRANSFORMERS; after this, the corresponding selections are accessible.

Any setting can be saved to and recalled from the memory. Up to 10 settings can be stored and recalled; setting no. 0 is the default one, and pops up at power-on. 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, which cannot be modified.

During the test, test results can be stored in the memory (up to 500 results may be stored). At the end of test, settings and test results can be transmitted to a PC provided with TDMS. The software allows saving test results, examining them and so on. The specification of TDMS is given in a separate document.

When the PC is connected, settings can also be created and transferred into T2000 using TDMS.

The following table summarizes all tests and the corresponding performances.

3.9.1 Relay selection

During menu selections the display shows output measurements, in reduced format. After confirmation, menu messages disappear, and measurements are displayed in the standard format.

The flux diagram of menu selections can be found in Appendix 1.

LEVEL1	LEVEL 2	LEVEL 3	LEV. 4	FUNCTION
TEST CONTROL	**Test mode**	Normal (default)		Measures the time delay from test START to STOP (internal, external).
		Trip + pulse time		Measures the time delay from test START to STOP (internal, external), and the duration of STOP.
	Fault injection	Maintained (default)		Generation lasts indefinitely
		Momentary		Generation lasts until the ON button is pressed
		Timed	Max time	Generation lasts for the pre-set time duration. Max time 999 s.
		OFF delay	T delay	The main output OFF is delayed by the set amount of time or cycles.
	Output power	300 VA (default) – 60 VA		Selection of full (300 VA) or reduced (60 VA) power
	Save	Don't save (default)		Test data are not saved
		Automatic, at trip		As relay trips data are saved to the next memory location
		Confirm, at trip		As relay trips data can be saved, after confirmation
		Manual		When selected, generated values are saved.
	Auxiliary contact	Timing		Sets the contact timing with respect to test start

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	FUNCTION
TIMER STOP	**Stop**	INT		Timer stops when the current of the main generator is interrupted.
		EXT (def.t)	NO-NC-EDGE (def.t)	Timer stops when the STOP input is detected. External STOP input Normally Open or Normally Closed or Both (EDGE).
			CLEAN-24 V – 80 V	Timer stops when the STOP input is detected. External STOP input without or with voltage. If with voltage, two voltage thresholds are available: 24 or 80 V.
	Timer	s (default)		Time duration metered in seconds
		cycles		Time duration metered in cycles

LEVEL 1	LEV. 2	LEVEL 3	LEVEL 4		FUNCTION
METERS	**Internal**	Units of I	Normal		If selected, current values are displayed in A.
			I/IN	IN	If selected, displayed values are defined as I/IN, that can be defined.
		Units of V	Normal		If selected, voltage values are displayed in V.
			V/VN	VN	If selected, displayed values are defined as V/VN (phase voltage), that can be defined.
	External I	Enabled	AC (default) - DC		With selection AC the meter performs the true rms measurement; with selection DC, the measurement is performed on the average.
			10A – 20 mA		Selects the current input socket
			Waveform		If selected, the current waveform is displayed
	External V	Enabled	AC (default) - DC		With selection AC the meter performs the true rms measurement; with selection DC, the measurement is performed on the average.
			Shunt : 1 – 1000 mOhm		If the voltage is coming from a current dropping on a shunt, specifying the shunt value the current is displayed; default 100 mOhm.
			Waveform		If selected, the voltage waveform is displayed

LEVEL1	LEVEL 2	LEVEL 3	FUNCTION
METERS (continued)			
	Other external	None (default)	No extra measurement displayed
		Active power	P; W
		Reactive power (AC)	Q; VAr
		Impedance module	Z, Ohm
		Impedance argument	φ, °
		Active impedance component	R, Ohm
		Reactive impedance component (AC)	X, Ohm
		Phase, I (AC)	φ, Vmain-Iext; reference Vaux
		Phase, V (AC)	φ, Vmain-Vext; reference Vaux
		Apparent power (AC)	S; VA
		Power factor	p.f. = cos φ(V-I)
		Frequency of V (AC)	f, Hz

LEVEL1	LEVEL 2	LEVEL 3	LEVEL 4	FUNCTION
RESULTS	**Display**			Display selected result
	Delete			Delete selected result
	Print			Print selected result
CONFIGU-RATION	**Settings**	Save to address	1..10	Saves current settings to X
		Restore address	1..10	Restores settings from X
		Restore default	1..10	Restores default settings
	Language	**To be specified at order**		
	Display	Speed	Slow	The displayed value is refreshed every 1000 ms
			Fast	The displayed value is refreshed every 300 ms
		Hold mode	Hold trip	As relay trips, test data measured 4 periods before trip are held.
			Hold min	As relay trips, the minimum value within 0.5 s is held.
			Hold max	As relay trips, the maximum value within 0.5 s is held.

Note: measurements marked AC apply only if both inputs are selected as alternate current.

3.9.2 Transformers selection

With this selection, you can choose the desired type of test. After entering the selection, the operator can input the relevant parameters, still by using the multi-function knob: turning it allows changing the parameter; pressing it makes it possible to go to next parameter.

Once all parameters are set, it is possible to start the test and execute it. Test time is kept to the minimum to avoid the excess of heating. The following table summarizes all tests and the corresponding performances.

TEST OF	TEST DESCRIPTION	INPUT DATA	CONN. OUT	CONN. IN	MEASUREMENTS
CT N. 1	Ratio Voltage mode	- I primary; - I secondary (nominal values) - Voltage output - Voltage input	High/Low V AC to CT secondary	CT primary to low or high Vin	1) High / Low VAC out; 2) Low V in; 3) Polarity; 4) Actual ratio; 5) Ratio error %; and excitation curve, if selected
CT N. 2	Ratio, polarity and burden	- I primary; - I secondary (nominal values); - Clamp Y/N; - Clamp ratio; - Voltage input.	High I AC to CT primary	CT secondary to high I in; (Low Iin with Clamp); CT secondary to Vin low or high.	1) High I AC out (primary); 2) I in (secondary); 3) Nominal ratio; 4) Actual ratio; 5) Ratio % error; 6) Polarity 7) VA rating 8) Power factor;
CT N. 3	Burden, secondary side	- IN secondary (nominal value); - Voltage input. - Current output	Low I AC to CT burden	CT burden to Vin	1) I out (secondary); 2) V out (secondary); 3) Phase V-I out (secondary); 4) Power factor; 5) VA rating;
CT N. 4	Excitation curve	- Voltage output - I nom secondary - VA rating - Accuracy class - Overload - Internal loss - Standard (IEC, ANSI: see NOTE)	High V AC to CT secondary		1) High V AC out; 2) I out of High V AC; 3) Iout-Vout curve; 4) Current at knee, IKm; 5) Voltage at knee, VKm
CT N. 5	Winding or burden resistance	- Temperature compensation Y/N - Ambient and target temperatures	Low I DC to CT burden or winding	CT burden to Vin	1) Low I DC out; 2) V of lowI DC out; 3) Resistance; 4) Compensated resistance
CT N. 6	Voltage withstand	- Max High V AC ; - Max I test - Tmax	High V AC to: Primary and secondary;		1) High V AC out; 2) I out of High V AC ; 3) Elapsed Time
CT N. 7	Polarity by impulses		Low IDC to CT primary	CT sec. to Iin	1) I DC out; 2) I secondary; 3) Polarity

NOTE: for the excitation curve test, the following standards apply:
1. IEC 60044-1; paragraph 14.4.1. The knee point is the voltage at which the increase of 10% of voltage causes the increase of the 50% of the exciting current.
2. ANSI C57.13.1; chapter 9. When you plot a log-log diagram with the excitation current on the X axis and the exciting voltage on the y axis, the knee point is the one where the tangent of the curve is at 45°.
3. ANSI C57.13.1; chapter 9. When you plot a log-log diagram with the excitation current on the X axis and the exciting voltage on the y axis, the knee point is the one where the tangent of the curve is at 30°.

TEST OF	TEST DESCRIPTION	INPUT DATA	CONN. OUT	CONN. IN	MEASUREMENTS
VT N. 8	Ratio; polarity	V primary in kV; V secondary; Connection LL, LN for primary and secondary (nominal values)	High V AC to VT primary	VT secondary to V in	1) High VAC (primary) 2) V in (secondary); 3) Phase shift ; 4) Actual ratio; 5) Ratio error %; 6) Polarity
VT N. 9	Burden, secondary side	- V secondary (nominal value) - Connection LL, LN - Voltage output - Voltage input	Low V AC to VT burden	VT burden to V in (if enabled)	1) V out (secondary); 2) I out (secondary); 3) Phase V-I ; 4) Power factor; 5) VA rating
VT N. 10	Electronic Voltage Transformers	- V primary; - V secondary; - Connection LL, LN for primary and secondary (nominal values)	High V AC to VT primary	VT secondary to V in	1) High VAC (primary) 2) V in (secondary); 3) Actual ratio; 4) Ratio error %; 5) Polarity
VT N. 11	Voltage withstand	- Max High V AC; - Max I test; - Test duration.	High V AC to Primary and secondary;		1) High V AC out; 2) I out of High V AC ; 3) Elapsed Time
VT N. 12	Over-current protection	- I Trip - Output current	Low I AC to VT protection		1) I out (secondary) 2) I trip
PT N. 13	Ratio per Tap	- V primary in kV; - V secondary; - Connection LL, LN for primary and secondary	High V AC to VT primary	VT secondary to V in	1) High V AC out; 2) I of High V AC; 3) Phase V-I 4) V in; 5) Actual ratio; 6) Ratio error %.
PT N. 14	Resistance of Tap Changer contacts	- Temperature compensation Y/N - Ambient and target temperatures	Low I DC	V in	1) I DC out; 2) V of IDC out; 3) Resistance; 4)Compensated resistance
PT N. 15	Dynamic tap changer test	- Time base - trigger level	Low I DC	V in	1) I DC out; 2) V of IDC out; 3) Resistance; 4) Resistance waveform
R Grid N. 16	Resistance or resistivity of earthing grid	- Output voltage - Input voltage	Low V AC to auxiliary spike	V input from measurement spike(s)	1) Output voltage 2) Output current 3) Input voltage 4) Ground resistance or Ground resistivity
Line imped N. 17	Overhead lines parameters	- Output voltage - Output current	Low V AC to overhead line		1) Output voltage 2) Output current 3) Line impedance 4) Earth factor 5) Mutual factor

3.10 CONNECTION CABLES

1. N. 1 Mains supply cable, 2 m long.
2. N. 1 Interface cable for RS232 port.
3. N. 2 High current connection cables, 100 sq. mm, 4 m long, for tests up to 800 A. Terminated on both sides with an high current connector (M+F).

4. N. 2 High current connection cables, 100 sq. mm, 0.5 m long, for tests up to 800 A. Terminated on one side with an high current connector (M), and on the other side with spring clamp.

5. N. 2 High voltage connection cables, 4 m long, 5 kV, with earth screen. Terminated on one side with an HV connector, and on the other side with a safety banana plug.
6. N. 2 Low current connection cables, 10 sq. mm, 4 m long. Terminated on one side with the high current connector, and on the other side with a 4 mm banana plug.
7. N. 4 Clamps to connect low voltage or low current or measurements.
8. N. 1 Cable for low voltage measurement connection, shielded, 10 m long. Terminated on one side with the measurement connector, and on the other side with two clamps.
9. N. 1 Cable for the 600 V measurement connection, shielded, 10 m long. Terminated on one side with three 4 mm banana plugs, and on the other side with two clamps.
10. N. 1 Grounding cable, 8 m long, terminated on one side with a 4 mm banana plug, and on the other side with an earth connection clamp.
11. N. 4 Crocodiles for measurements connections (2 red, 2 black).
12. N. 4 Measurement inputs cables (4 cables: 2 red and 2 black), 2 m long, terminated on both sides with a 4 mm banana plug.
13. N. 1 Connection Cables Transport case.

3.11 OTHER CHARACTERISTICS

- Interface: serial RS232; baud rate 57600 baud

- Mains supply: 230 V ± 15%; 50-60 Hz, OR 110 V ± 15%; 50-60 Hz; to be specified at order.

- Maximum supply current: 16 A.

- Power consumption:
  - Less than 100 VA, in stand-by;
  - About 1,000 VA, with low power generation;
  - Up to 3,700 VA, when generating 800 A.

- The instrument comes complete with the following items:
. User's manual;
. Spare fuses (no. 5), T16A;
. Set of connection cables, included in a suitable transport case with wheels and handle.

- Dimensions: 455 (W) * 325 (D) * 290 (H) mm.

- Weight: 31 kg.

3.12 OPTIONS

3.12.1 Power supply code PII20110

This option is to be specified at order.

- Mains supply: 110 V ± 15%; 50-60 Hz.

- Maximum supply current: 16 A.

With this power supply voltage, the high current maximum output power is limited as shown in the following table.

CURRENT OUTPUT A	OUTPUT POWER VA	LOAD TIME s	RECOVERY TIME min
100	600	STEADY	-
150	800	15 min	30
200	1000	4 min	15
250	1300	2 min	5
300	1500	1 min	5

Other output characteristics do not change with the power supply.
NOTE: the 110 V supply changes also the characteristics of the BU2000 option: see the description for details.

3.12.2 Optional high voltage output 1200 V; codes PII30110 (supply 230 V) or PII40110 (supply 110 V)

The high voltage generator can optionally have the following characteristics, that are better suited for the case of 5 A nominal secondary current. This option is to be specified at order.

VOLTAGE OUTPUT V	CURRENT OUTPUT A	OUTPUT POWER VA	LOAD TIME Min	RECOVERY TIME min
1200	0.5	600	STEADY	-
1000	1.5	1500	5	20

3.12.3 Model T2000E, code PII50110

The model must be specified at order.
This model allows to perform high current tests with more power. It is based upon the 1200 V high voltage generator.
The corresponding features of the high current output are the followings.

CURR. A	MAX POW. VA	MAX ON TIME s	OFF TIME min	MAX TOTAL LOAD mOhm	CABLE LENGTH m	LOAD AT CABLES END mOhm	POWER AT CABLES END VA
100	850	CONT.	-	86	10	80	800
150	1200	15 min	30	55	10	49	1100
200	1550	4 min	15	39	10	33	1320
300	2050	15	5	23	6	20	1800
400	2400	15	5	15	4	12	1920
600	2600	5	3	7	0.5	6	2160
800	2100	1	2	3	0.5	2	1280

NOTE: The table shows the maximum cable length, and the maximum load and power at the end of the connection cable.

Connection cables.

- N. 2 High current connection cables, 95 sq. mm, 0.5 m long. Terminated on one side with an high current connector to T2000, and on the other side with a ring terminator.
- N. 4 High current connection cables, 95 sq. mm, 4 m long. Terminated on both sides with a ring terminator.

- N. 4 High current connection cables, 95 sq. mm, 6 m long. Terminated on both sides with a ring terminator.
NOTE: this allows reaching a total of 20 m, 95 sq. mm, or 10 m, 190 sq. mm.
- N. 2 high current connection vices, rated 800 A maximum.

. Instrument weight: 37 kg.

3.12.4 Transit cases

Two types of transit cases are available: molded and aluminum.

3.12.4.1 Molded case; code PII24102

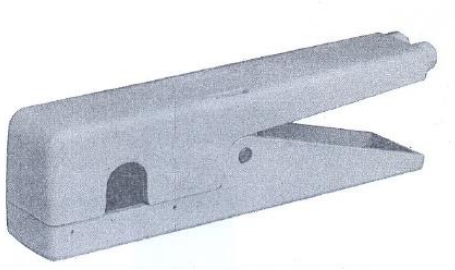
The protection of T3000 from delivery problems is provided by this robust transit case, that features the following.
- Molded-case construction;
- Handle on the top and on the side;
- Wheels;
- Dimensions: 450 x 550 x 850 mm ;
- Weight : 15 kg.

3.12.4.2 Aluminum case; code PII17102

In alternative to the above, it is possible to use the following aluminum case, that is lighter and smaller.
- Aluminum metal sheet construction;
- Handles on the side;
- Wheels;
- Dimensions: 400 x 370 x 660 mm ;
- Weight : 11.5 kg.

3.12.5 Current clamp code PII16102

The current clamp allows to avoid the opening the secondary current circuit when performing the primary test of CT burden. The clamp ratio is 1000//1; maximum primary current 100 A; maximum cable diameter 12 mm.



3.12.6 Thermal printer PII14102

Thermal printer, for the printout of the V-I curve in the CT saturation test. Paper 112 mm wide.

3.12.7 BU2000: very high AC current boosters

The very high current booster option allows performing high current primary tests with currents up to 4000 A.

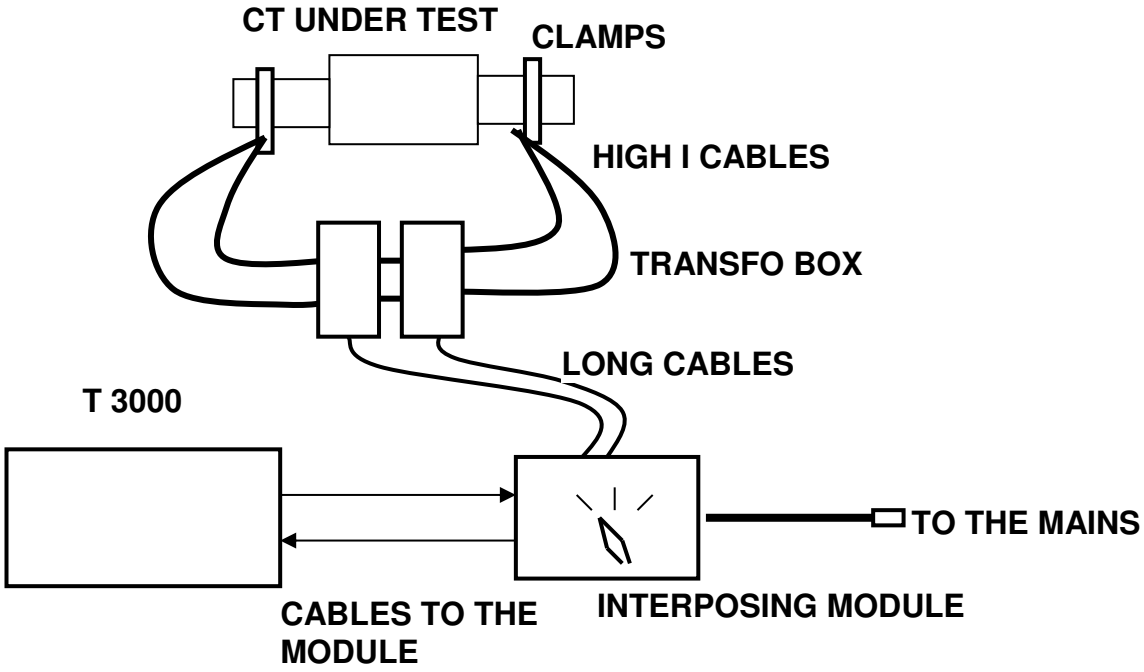
The very high current booster is designed to generate the current while over-loading the generator; its configuration changes according to the desired current value and duration. The option is made of two modules:
. Transformers BU2000 MAIN and BU2000 AUX: they include the connection cable to the CT and the clamps;
. BU2000 INTERPOSING MODULE.

The BU2000 MAIN transformer is used in all versions; the number of BU2000 AUX transformers can be selected as a function of the desired test current and/or test duration. In case of a single transformer the interposing module is not necessary.

The option is designed around the concept to avoid wasting power on the connection cables, by putting the power transformers as close as possible to the test object. This approach is particularly useful when the test is performed on CT's in the field, that are from 5 to 10 meters above the ground. The solution is sound because the weight of transformer plus cable plus clamps is comparable to the weight of the connection cables. The highest the test current the biggest the weight of the transformers, but also the biggest the weight of the connection cables. With this

solution, the connection cable to the power source is much lighter, does not pose any major problem of voltage drop, and can be any length.

The following sketch shows the connections between T2000, the BU2000 INTERPOSING MODULE and the transformers (up to 4).



The first transformer, BU2000 MAIN, has two connection cables: one with the supply, the other one with the output current measurement. The other transformers, BU2000 AUX, have only the supply cable. All cables are 20 m long.

Connections from T2000 to the BU2000 INTERPOSING MODULE are:
. The variable AC voltage output (not isolated from the mains), that performs the fine current adjustment;
. The TEST START command, coming from the auxiliary output;
. The TIMER START contact;
. The mains supply.

The following table summarizes the option codes, available configurations and the corresponding performances.

CODE	N. OF TRANS.	INTERP. MODULE	WEIGHT	N. OF TURNS	TEST CURRENT A	SUPPLY CURRENT A	ON DURATION s
PII50102	1	NO	19.5	3	1000	2.63	INFINITE
					2000	20.96	9
PII51102	2	YES	29.5	2	1000	5	INFINITE
					2000	20	100
					3000	45	6
PII52102	4	YES	49.5	2	1000	5.2	INFINITE
					2000	21	1000
					3000	47	100
					4000	83	9
				1	1000	4.5	INFINITE
					2000	18	1000

					3000	54	50

The table lists:
. The option code;
. The number of transformers of the option;
. The presence of the interposing module;
. The weight to be lifted, that includes: transformers, high current connection cable and connection clamps;
. The number of turns at the secondary side of the transformers. In the instance of four transformers, it is possible to have 1 or 2 turns, according to the desired test current and test duration;
. The test current;
. The supply current from the mains;
. The test duration, that is followed by a pause lasting 3 minutes (or a fraction proportional to the TON/TMAX ratio).

The following table is the same as the above, but it summarizes the test duration as a function of the test current with the different number of transformers; in brackets the number of turns.

MODEL	**1 (3)**	**2 (2)**	**4 (1)**	**4 (2)**
1000 A	INF	INF	INF	INF
2000 A	9	100	1000	1000
3000 A	-	6	50	100
4000 A	-	-	-	9

Above characteristics apply for power supply of 230 V. For the power supply of 115 V, with the optional T2000 model code PII20110, codes are different, and performances are as follows. Performance reduction follows the limitation to the supply current.

CODE	**N. OF TRANS.**	**INTERP. MODULE**	**WEIGHT**	**N. OF TURNS**	**TEST CURRENT A**	**SUPPLY CURRENT A**	**ON DURATION s**
PII57102	1	NO	19.5	3	1000	5.3	INFINITE
					2000	42	9
PII58102	2	YES	29.5	2	1000	10.2	INFINITE
					2000	40.5	100
					2500	63	30
PII59102	4	YES	49.5	1	1000	10,5	INFINITE
					2000	41	1000
					3000	80	100

Characteristics of the BU2000 INTERPOSING MODULE:
- Mains connection: by a 64 A rated connector, provided.
- Power-on: by means of a circuit breaker rated 63 A.
- Coarse current adjustment: by means of a four-position selector switch.
- Connections to T2000: power supply cord; Variable voltage output; auxiliary contact, timer START input.
- Capable to drive up to four transformers.
- Weight: 5 kg;
- Dimensions: 33 x 30 x 20 cm (WHD).

NOTE: in case of one transformer, the BU2000 INTERPOSING MODULE is not necessary.

Characteristics of the output transformers: two types.

Type BU2000 MAIN:

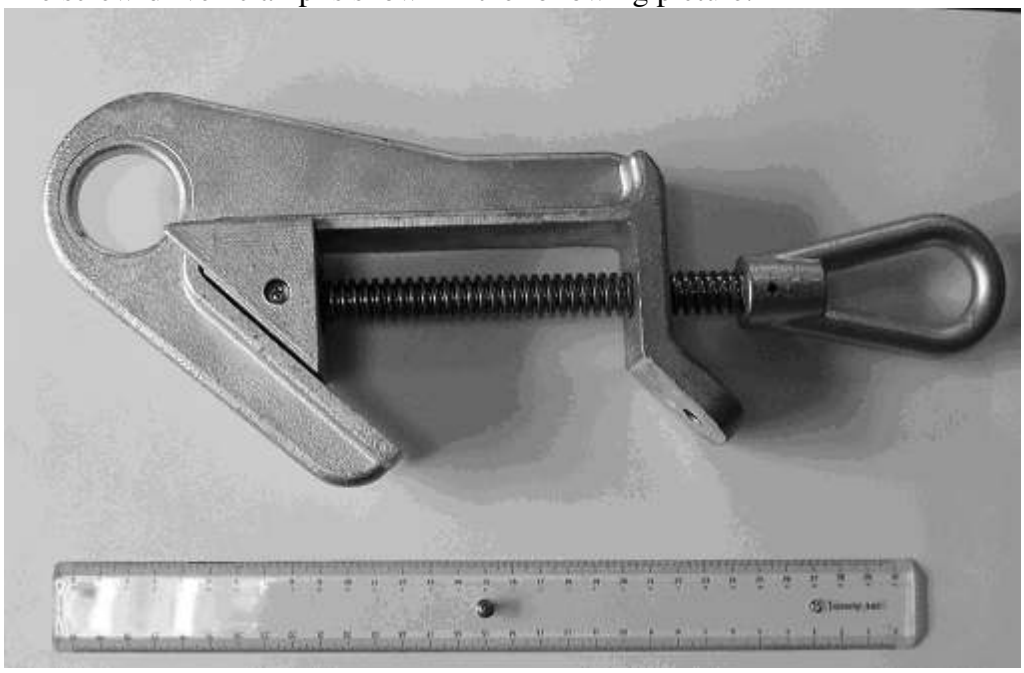
- Supply voltage: 230 V (optional 115 V).
- Voltage output (one turn): 0,91 V.
- Steady power: 1000 VA.
- Weight: 11 kg.
- Dimensions: external diameter 190 mm; height 120 mm.
- Connection of the transformer: by a cable, 20 m long, terminated with connectors on both sides.
- Output current metering: by a current transformer with ratio 1000//1. Accuracy class: 0.5%.
- Connection of the CT: by a cable, 20 m long, that includes a shunt, rated 0.1 Ohm, 25 W, accuracy 0.1%. The cable is terminated with a connector for the connection to the 10 V input of T 2000.

Type BU2000 AUX:
- Supply voltage: 230 V (optional 115 V).
- Voltage output (one turn): 0,89 V.
- Steady power: 1000 VA.
- Weight: 10 kg.
- Dimensions: external diameter 190 mm; height 120 mm.
- Connection of the transformer: by a cable, 20 m long, terminated with connectors on both sides.

Each option is provided with a connection cable having the following characteristics:
- Number of conductors: 2.
- Conductors cross section: 95 sq. mm.
- Conductors type: high flexibility.
- Conductors length: 2.8 m.
- Weight, including the screw-driven clamps: 8.5 kg.

Each option is also provided with two high current screw-driven clamps for the connection to high bars, having the following characteristics:
- Material: aluminium.
- Opening range: from 5 to 60 mm.
- Short-circuit current rating: 41 kA / 1 s.
- Applicable standard: EN 61230.
- Hole to lift the clamp on the conductor, and ring to screw it up.

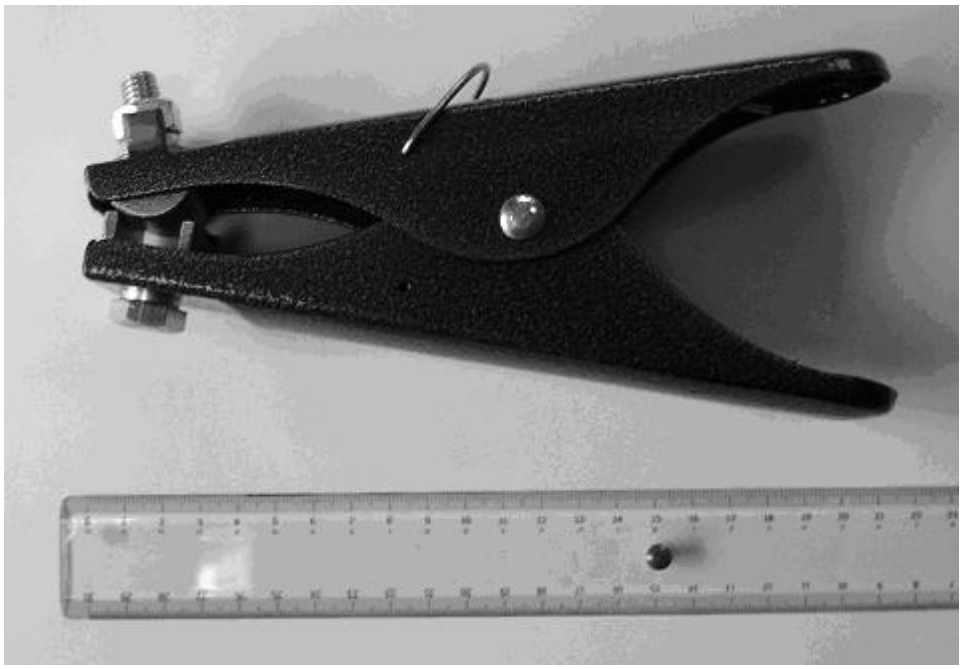
The screw-driven clamp is shown in the following picture.



Each option is also provided with four high current clamps for the connection to bars located into narrow places, having the following characteristics:

- Material: iron (bronze for the contacts).
- Opening range: up to 60 mm.
- Steady current rating: 800 A / 1 s.

The spring clamp is shown in the following picture.



Additional options: heavy duty plastic transport case.
The code PII55102 applies to options codes PII50102 and PII57102 (2000 A);
The codes PII55102 and PII56102 apply to options codes PII51102, PII52102, PII58102 and PII59102 (higher currents).

3.12.8 High I DC module PII13102

The high DC current module allows the measurement of the low contact resistance of high voltage breakers or of joints. The option is connected to the high AC current output of T2000; the current measurement is connected to the low DC current measurement input; the drop voltage is connected to the low voltage measurement input. DC current output is: 100 A steady; 200 A for 4 minutes; 400 A for 15 s.
NOTE: the option can be used only with the 230 V supply.

The selection of this function is performed via menu; the screen displays: test current; joint voltage; contact resistance. Resistance measurement ranges: 100.0 uOhm, 1.000, 10.00, 100.0 mOhm; 1.000 Ohm, auto-ranging. The option includes two connection cables, with the following characteristics. Measurement accuracy is summarized in the following table.

RANGE	100.0 uOhm	1.000 mOhm	10.00 mOhm	100.0 mOhm	1000 mOhm
ERROR	± 2% ± 2 uOhm	± 2% ± 10 uOhm	± 2% ± 100 uOhm	± 2% ± 1 mOhm	± 2% ± 10 mOhm

N. 2 High current connection cables, 100 sq. mm, 1 m long, for the connection to T2000. Terminated on both sides with an high current connectors, M+F.

Dimensions: 285 mm (D) x 325 mm (W) x 295 mm (H) ; weight 20 kg.

3.12.9 SU3000 Safety device for the line impedance measurement, code ZII26102

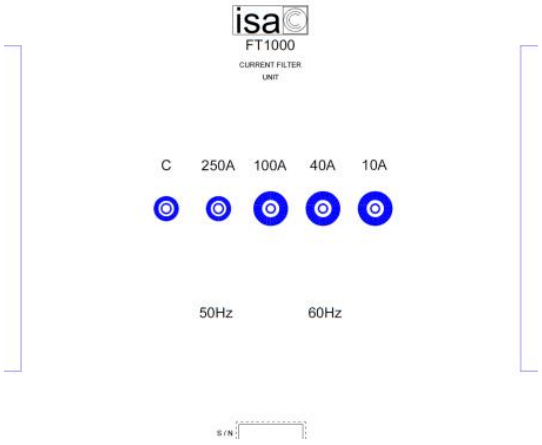
With T2000 it is possible to measure the zero sequence coefficient of an overhead line, and the coupling coefficient of parallel lines. Usually this parameter is computed, and an error can cause false interventions of the distance relay.

To perform the test, the T2000 output is connected to the overhead line to be tested, that is put out of service. The purpose of the SU3000 optional device is to protect the operator, during the connection and during the operation, against possible high voltage spikes.

To this purpose, SU3000 incorporates:
- A voltage suppressor, rated 1000 V AC and 15 kVA;
- An ON/OFF switch, rated 375 A steady, 2000 A peak, 1500 V AC.
- These devices are incorporated in a metal container with door.
-The switch is operated by a safety handle while the door is closed.
- Weight: 20 kg.
- Dimensions: 55 x 45 x 25 cm.

3.12.10 FT/1000 current filter, code PII16093

The filter unit type FT/1000 is an option to be used with the T/X000 relay test sets. It is connected in series to the relay under test, and guarantees a sinusoidal waveform also when testing current relays with reverse time characteristics, or with heavily saturating burdens, that tend to distort the current waveform.
- Current input ranges: 10 - 40 - 100 - 250 A, on terminal bushings.
- Maximum power yield: 800 VA.
- Filter burden: less than 200 VA at 200 A. The burden is proportional to the range (50 VA at 50 A).
- Service: 50 A continuous service; 200 A for 30 s.
- Selection of the mains frequency: 50 or 60 Hz, by switch.
- Overall dimensions: 220 x 250 x 310 mm.
- Weight: 15 kg.
The following is the FT1000 front panel.



3.12.11 Earth resistance and resistivity test kit, code PII19102

The test of earth resistance and resistivity is included in T2000 as a standard feature. The option is referred to the kit of connection cables and auxiliary spikes that allows executing these tests; it is optional because not all of our customers perform the tests.

The kit is made of the following devices.
A) Current generation.

- One cable for the connection of T2000 to the auxiliary spike, 100 m long, 2.5 sq. mm cross section, wound on a wheel. Terminated with a safety banana connector for the connection to the auxiliary spike, and with a safety socket for the connection to T2000.
- Three cables for the following connections: of T2000 to the above wheel, of the two earth spikes between them, and of the measurement input to the measurement wheel; 4 m long, 2.5 sq. mm cross section. Terminated on both sides with a safety banana connector.
- Two cables for the connections of T2000 to the local earth system, both for generation and measurement, 10 m long, 2.5 sq. mm cross section. Terminated on both sides with a safety banana connector.
- Two auxiliary earth spikes, screw shaped, for the dispersion of the current into the soil. Length: 0.95 m; screwed section 0.6 m. Material: zinc-plated iron. Complete with socket for the connection to the generator.
- Handle to screw the spike into the ground.
- One current clamp to connect T2000 to the local earth system.

B) Voltage measurement

- One cable for the connection of T2000 to one voltage spike, 50 m long, 2,5 sq. mm cross section, wound on a wheel. Terminated with a safety banana connector for the connection to the voltage spike, and with a safety socket for the connection to T2000.
- Two auxiliary earth spikes, to measure the voltage drop; material: zinc-plated iron; length: 0.5 m. Complete with connector for the measurement cable.
- One measurement clamp to connect T2000 to the local earth system.

4 PROTECTIONS

- If the test set is not connected to the ground, the test set does not allow for power generation, and warns the operator with a diagnostic message.

- Fuse on the mains supply.

- At power-on, a diagnostic sequence controls:
. Key microprocessor board components;
. Auxiliary supply voltages.
If something is wrong, the operator is alerted by a message.

- Emergency pushbutton: if pressed, all main outputs are removed.

- The high voltage output has the following protections:
. Confirmation key: if not turned, the HV output is not generated;
. The HV is generated only if selected; the HV selection is confirmed by warning lights;
. It is impossible to start generating the HV unless the adjustment knob is at zero.

- Thermal (NTC) sensor on the main and auxiliary transformers. In case of over-temperature, an alarm message is displayed.

- Thermal sensor on the electronic switch (SCR) that controls current injection, and of the internal temperature. In case of over-temperature, an alarm message is displayed.

- If maximum current limits and time duration of power transformer generators are trespassed, the generation is interrupted, and the operator is warned by an alarm message. Note that the opening action is driven directly, and it is not influenced by any possible problem on the microprocessor.

- The 20 mA measurement input is protected by a fuse against wrong connections. The fuse is a PTC resistor, that increases its value and self-restores in some minutes.