SPECIFICATION

STS + TD 5000 FAMILY

for the test of CT, VT and PT

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1 GENERAL

The portable, high accuracy test sets of the STS family allow performing all tests foreseen by international Standards on CTs, measurement VTs, Power Transformers, and to measure the Tan(δ), dissipation factor and capacitance of any device. With the option STLG + STSG it is also possible to execute the Earth resistance and Step and Touch voltage measurements. Each instrument of the STS family can be used in all the substations, HV and EHV included.

The following table lists the models of the STS Family:

Model	Description
STS 5000	It is the most performing test set of the STS family of devices. It allows executing all listed tests
STS 4000	It is the same as STS 5000, unless the high AC and DC current generators. High AC current tests can be performed using the BUX 3000 option; micro-Ohm metering is not available
STS 3000 light	It allows performing Tan(δ) tests with the option TD 5000

Table 1 - STS Family models

The following table summarizes the differences among the models:

Model	High current, AC & DC	High voltage	Low Ac-DC outputs	Optional Tan(δ) tests TD 5000	Optional High AC current BUX 3000
STS 5000	X	X	X	X	X
STS 4000		X	X	X	X
STS 3000 light				X	

Table 2 - Differences among the STS Family models

Keyboard, dedicated keys, control knob and display can control all test sets of the family locally. Test results and settings can be saved in a PC by the software suite TDMS, which comes with the device. The optional PADS program allows also controlling the device from the PC.

The following table lists the tests performable by the Current Transformers:

No.	Test	STS 5000	STS 4000	STS 3000 light
1	Ratio Polarity and Burden	X	+BUX +Manual Measure	+BUX +Manual Measure
2	Burden Secondary Side	X	X	
3	Excitation Curve	X	X	
4	Winding or Burden Resistance	X	X	
5	ALF/ISF	X	X	
6	Voltage Withstand	X	X	
7	Polarity Check	X		
8	Ratio Polarity Voltage Mode	X	X	
9	Rogowski (Ratio)	X	+BUX +Manual Measure	+BUX +Manual Measure
10	Low Power (Ratio)	X	+BUX +Manual Measure	+BUX +Manual Measure
11	Tangent δ	TD 5000	TD 5000	TD 5000
12	Ratio IEC61850-9-2LE	X		

Table 3 - Current Transformer tests

BUX is the BUX 2000, BUX 3000, BUX 5000 option, for high current injection tests. The Ratio test for Not-Conventional transformer with the option IEC61850-9-2LE is available only in remote control mode, using the PADS software.

The following table lists the tests performable by the Voltage Transformers:

No.	Test	STS 5000	STS 4000	STS 3000 light
1	Ratio	X	X	
2	Ratio Electronics	X	X	
3	Burden	X	X	
4	Voltage Withstand	X	X	
5	Polarity Check	X		
6	Tangent δ	TD 5000	TD 5000	TD 5000
7	Ratio IEC61850-9-2LE	X	X	

Table 4 - Voltage Transformers tests

The Ratio test for Not-Conventional transformer with the option IEC61850-9-2LE is available only in remote control mode, using the PADS software.

The following table lists the tests performable by the Power Transformers:

No.	Test	STS 5000	STS 4000	STS 3000 light
1	Ratio	X	X	
2	Ratio with Tan(δ)	TD 5000	TD 5000	TD 5000
3	Winding Resistance	X	X	
4	Winding Resistance – Auto	X	X	
5	Voltage Withstand	X	X	
6	Short-Circuit Impedance	X	X	
7	No-Load Current	X	X	
8	Tangent δ	TD 5000	TD 5000	TD 5000
9	Demagnetizer	X	X	
10	Vector Group	X	X	

Table 5 – Power Transformers tests

The following table lists the tests performable by the Circuit Breakers:

No.	Test	STS 5000	STS 4000	STS 3000 light
1	Resistance - μΩ	X		
2	Tangent δ	TD 5000	TD 5000	TD 5000

Table 6 - Circuit Breakers tests

The following table lists the tests performable by the Resistances:

No.	Test	STS 5000	STS 4000	STS 3000 light
1	Resistance - μΩ	X		
2	Earth Resistance	X	X	
3	Soil Resistivity	X	X	
4	Step and Touch	X	X	
5	Line Impedance	X	X	

Table 7 – Resistances tests

The test Ratio IEC61850-9-2LE can be executed only in remote mode, using the PADS software.

Tests are performed in accordance with the following standards:

- IEC EN 60044-1
- IEC EN 60044-2
- IEC EN 60044-5
- IEC EN 60044-7
- IEC EN 60044-8
- IEC EN 61869-x
- IEC EN 60076-1
- ANSI/IEEE C57.13.1

Earth resistance and step and touch tests are performed according to the following standards:

- IEC EN 50522:2011
- IEEE 80:2000
- IEEE 81:1983
- DIN VDE 0101
- CENELEC HD 63761

STS Family has the facility to test not conventional CT, VT, and Merging Unit (MU), by the IEC 61850-9-2 (SV) protocol.

STS Family generates current or voltage and injects these quantities into primary side of the CT or VT under test. STS Family then reads the data from the network using its Ethernet port (Sample Values) in order to perform a variety of different tests, as CT ratio and polarity up to 800 A or up to 2.000 A (with BUX 2000), or 3.000 A (with BUX 3000), or 5.000 A (with BUX 5000). It is also possible to check the VT ratio and polarity, up to 2 kV. Test of MU.

The following table lists the optional modules enhance the STS features:

Item	Option	Code	Description
1	Transit Cases	PII17175 PII19175 PII51175	They allow transporting the device
2	PADS license	PII10176P PII10176T PII10176F	PC Remote control of the test set
3	Remote Safety Switch	PII42175	When the Remote Safety Switch is connected and enabled, it avoids any current or voltage generation from pressing START/STOP button on the STS only
4	Warning Strobe Light	PII43175	It alerts when the test is performed
5	STCS Plus	PII33175	This option allows with a single setup all the typical tests that are performed on a power transformer
6	STCS	PII12175	The Circuit Switch option performs the automatic measurement of the following parameters: PT transformer ratio, PT winding resistance, OLTC dynamic winding resistance
7	STCS Booster 20 A DC	PII32175	The Circuit Switch option performs the automatic measurement of the following parameters: PT winding resistance up to 20 A DC, OLTC dynamic winding resistance up to 20 A DC
8	STDE	PII27175	It allows neutralizing the residual magnetization of the power transformer core after the winding resistance test
9	STSA	PII46175	The option limits voltage surges generated on the 10 V input
10	BUX 3000 BUX 3000 BUX 5000	PII56175 PII50175 PII63175	This option performs high current tests, with currents up to 2.000 A (BUX 2000), or 3.000 A (BUX 3000), or 5.000 A and 7.000 A (BUX 5000)
11	Current Clamp	PII16102	The current clamp avoids opening the secondary current circuit when performing the primary test of CT burden
12	PLCK	PII41175	Saw tooth signal detector for CT/VT polarity test
13	STLG	PII70175	It is a high power transformer for the current injection for the Line Impedance and Step and Touch tests
14	Power factor correction module	PII85175	It is a module to increase the current in the grounding and step and touch tests
15	STLG large stations	PII88175	It is a high power transformer for current injection into transmission lines for large stations
16	STSG	PII71175	This option is used for the test of overhead lines parameters
17	Ground Grid test accessories kit	PII76175	The kit includes some accessories to perform the Soil Resistivity test, the Earth Resistance test and the Step and Touch test
18	Current Clamp Meter	PII79175	This option is used to check the induced current in the transmission line
19	Foldable Trolley	PII17175	The trolley eases the transport of STS + TD 5000
20	SFRA	PII90175	SFRA 5000, supplied with cables, software and transport case
21	TD 5000	PII11175	It performs the measurement of the Tan(δ), capacitance and Power factor of any device, at the frequency of the mains or in a wide frequency range
22	CAP-CAL (for TD 5000)	PII40175	Purpose of the reference capacitor is to check the actual calibration of TD for the measures of the capacitance and Tan(δ)
23	STOIL (for TD 5000)	PII13175	The oil cell is for Tan(δ) measurement of PT oil
24	Digital thermo hygrometer (for TD 5000)	PII44175	The option allows measuring ambient temperature and humidity, and to input them into the test settings, if it is necessary
25	RCTD (for TD 5000)	PII47175	Compensation Inductor for high current Tan(δ) test on motors and generators
26	RTD (for TD 5000)	PII41185	Capacitance for transformer ratio at high voltage

Table 8 - Optional modules

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

The capacitance and Tan(δ) measurements with TD 5000 can be performed on CTs, VTs, CBs, PTs and bushings.

STS 5000 contains a generator, with the following six outputs:

- High AC current
- Low AC current
- High DC current
- Low DC current
- High AC voltage
- Low AC voltage

In addition, there is a high power AC voltage output, not isolated from the mains, which supplies the external options (TD 5000, BUX 2000, BUX 3000, BUX 5000, STLG, STCS Booster 20 A DC).

In local control mode, the selected output is adjustable and metered on the large, graphic LCD display. With the control knob and the LCD display it is possible to enter the MENU mode, which allows setting many functions: this makes STS a very powerful testing device, with manual and automatic testing capabilities, and with the possibility to transfer test results to a PC via USB, ETHERNET or Pen Drive.

In the PC control mode, the PADS program allows performing the same tests as in the local mode, with the same control windows. It allows also downloading, displaying and analyzing test results obtained in local mode.

PADS operates with all WINDOWS versions.

The ease of operation has been the first goal of STS: this is why the LCD is graphic, and so large. With it, the dialogue in menu mode is made easy. Besides, all STS outputs relevant to the selected test are continuously measured, and output values are displayed, with no extra effort to the operator.

STS feature four measurement inputs:

- DC voltage, up to 10 V DC
- AC or DC voltage
    - High range, up to 300 V
    - Low range, up to 3 V
- AC or DC current, up to 10 A

All inputs, unless the 3 V and 300 V voltage measurements, are isolated among them, and allow measuring CT or VT outputs or any other source.

In all STS models, it is available a digital input, which accepts an input, which can be voltage free, or with a voltage up to 300 V. It allows measuring the time response of a protection relay. It is also possible to test the M.V. CB's timing: the time is stopped when the injected current is opened by the CB.

The instrument is housed in a transportable aluminum box, which is provided with removable cover and handles for ease of transportation. An optional trolley is also available.

The following image exhibits the STS 5000 as an example of the model of the family, with the protection cover lifted:

Figure 1 - STS 5000

The following image exhibits the front panel:

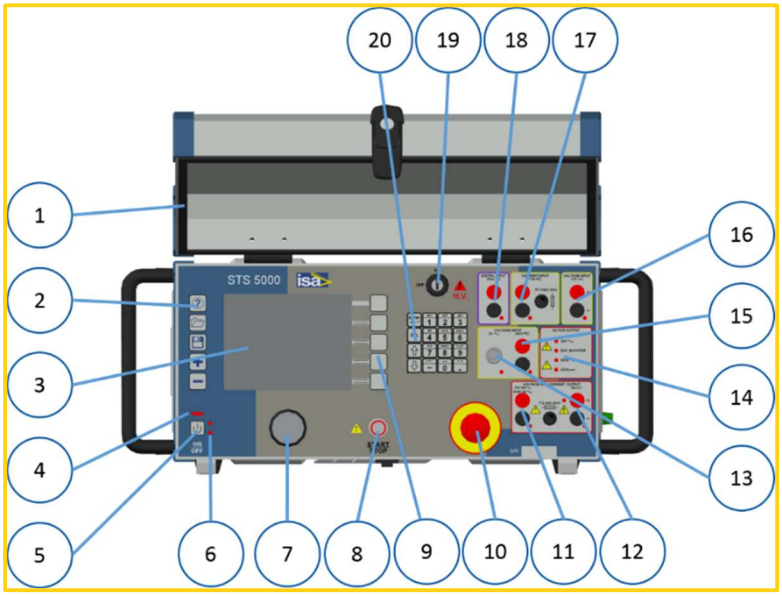


Figure 2 - Test set front panel

The following table lists all the elements of the front panel:

ITEM	Component		
1	Cover		
2	Pushbuttons		Help. Pressing it, the screen displays the information related to the test performed
			Open file. It allows to access the list of saved test results (the list can be located in the internal memory or on the USB key)
			Save file. It allows saving the test result. Pressing it, it is possible to access the list of saved test results (the list can be located in the internal memory or on the USB key)
			Increment and decrement buttons. To input a value, select the field, and then: • Edit the desired value, via the keypad • Increment or decrement the value, pressing the above pushbuttons • Rotate the knob clockwise (increment) or anti-clockwise (decrement) • Press the keyboard up key to increment, and the keyboard down key to decrement The amount of the increment or decrement is: ten units, for the plus and minus keys; one unit, for the knob, and one tenth, for the up-down arrows
			
3	Display		
4	Power-on light: it is ON when the test set is operating		
5	Power ON and OFF push-button		
6	Mains lights: they turn on very shortly as the test set is connected to the mains		
7	MENU control knob, with switch		
8	Test START and STOP push-button		

Table 9 - Frontal panel components (1/2)

<table>
<tr><th>ITEM</th><th colspan="3">Component</th></tr>
<tr><td>9</td><td colspan="3">16-keys alpha-numeric keyboard</td></tr>
<tr><td>10</td><td colspan="3">Emergency push-button with lock-in</td></tr>
<tr><td>11</td><td colspan="3">AC voltage and current output, up to 6 A – 70 V or 3 A - 140 V, fuse protected. Fuse rating: FF 6.3 A 250 V. The LED turns ON when it is active</td></tr>
<tr><td>12</td><td colspan="3">DC current output, up to 6 A, fuse protected. Fuse rating: T 6.3 A 250 V. The LED turns ON when it is active</td></tr>
<tr><td>13</td><td colspan="3">AC voltage input connector, up to 3 V. The LED turns ON when it is active
  ATTENTION: The connector to this input can be removed only acting on the connector body. Do not pull the cable</td></tr>
<tr><td>14</td><td colspan="3">Active output lights. The LED turns ON when the corresponding output is active</td></tr>
<tr><td>15</td><td colspan="3">AC or DC voltage input sockets, up to 300 V. The LED turns ON when it is active</td></tr>
<tr><td>16</td><td colspan="3">DC voltage input sockets, up to 10 V. The LED turns ON when it is active</td></tr>
<tr><td>17</td><td colspan="3">AC or DC current input sockets, up to 10 A, fuse protected. Fuse rating: FF 10 A 250 V. The LED turns ON when it is active</td></tr>
<tr><td>18</td><td colspan="3">Digital input sockets, for voltage clean contact or with voltage up to 300 V. The LED turns ON when the input is closed or with voltage</td></tr>
<tr><td>19</td><td colspan="3">Enable key, for HV tests</td></tr>
<tr><td>20</td><td>Function keys</td><td>  </td><td>• The twelve buttons to the right behave as a portable phone
• ENTER confirms what is edited
• DEL
○ If the field is numeric, it deletes the first digit to the left. It is not possible to select the digit to delete: as the wheel is touched, the digit changes
○ If the field is alphabetic, it is possible to use the knob to reach for the letter to be deleted: the deleted letter is the one to the left with respect to the cursor. If the cursor is completely to the left, DEL deletes the letter to the right
• As explained above the arrows, when the context is numeric, increment or decrement the value; in a selection page, they allow to move around</td></tr>
</table>

Table 10 – Frontal panel components (2/2)

The following iamge exhibits the side panel on the left:

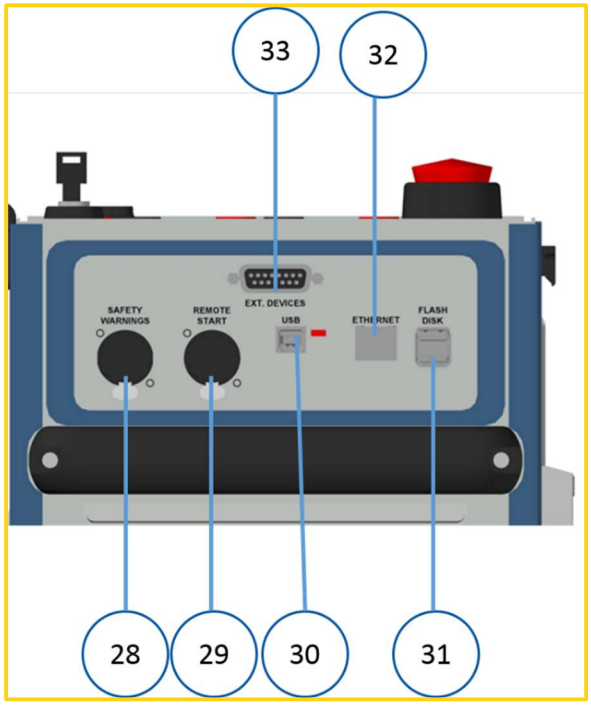


Figure 3 – Left panel components

The following table lists the elements of the left panel:

ITEM	Component
28	Alarm output connector, for the light strobe with buzzer option PII43175
29	Remote start input connector, for the remote push-button option PII42175
30	USB connection only for ISA diagnostic
31	Flash disk connector for the local test results saving or for moving the local test results from the local memory
32	ETHERNET connection to the PC. It incorporates two lights which turn on when the test set is connected
33	Communication Connector to the external devices (TD 5000, STCS, STDE)

Table 11 – Left panel components

The following image exhibits the side panel on the right:

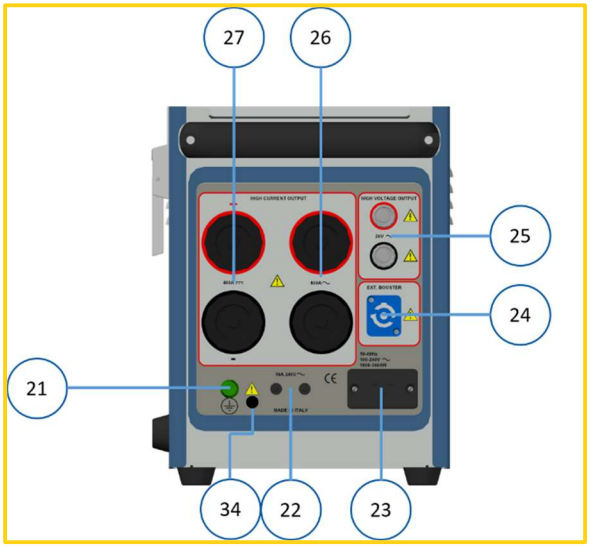


Figure 4 - Right panel components

The following table lists the elements of the right panel:

ITEM	Component
21	Ground connection socket
22	Resettable power supply automatic fuses, rated 16 A 240 V
23	Power supply plug
24	Power supply connection to external optional modules (TD5000, BUX3000, STCS Booster 20 A DC)
25	High voltage output connectors, rated 2 kV AC  ATTENTION: The connectors to this input can be removed only acting on the connector body. Do not pull the cable
26	High AC current output connectors, rated 800 A
27	High DC current output connectors, rated 400 A
34	F6 fuse

Table 12 – Right panel components

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/EC:

Standard	Title	Requirement
EN 61326	Electrical equipment for measurement, control and laboratory use. EMC requirements. General requirements	
IEC EN 61000-3-2:	Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)	Harmonic content of power supply Acceptable limits: basic
IEC 61000-3-2	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	Limitation of voltage fluctuations and flicker Acceptable limits: basic
CISPR 16-1	Specification for radio disturbance and immunity measurement apparatus and methods	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÷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	Immunity tests for ESD 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	Immunity tests for radio frequency interference Test values (f= 900 ± 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 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	Immunity tests for surge 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	Immunity to low-voltage sinusoidal waveform Test values: 0.15-80 MHz, 10 Vrms, 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	Immunity tests for low frequency magnetic fields. 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	Immunity test for power supply drops. Test value: 1 cycle; 100% drop

Table 13 – Standards related to the EMC Directive

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

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 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 • Insulation resistance, at 500 V DC: > 10 MΩ • Ground resistance, at 200 mA DC: < 0.1 Ω • Operating temperature: (-10÷55) °C; storage: (-20÷70) °C • Operating relative humidity: 5÷95%, without condensing. Storage relative humidity: 0÷96%, without condensing • Altitude: 2,000 m , up to 5000m with limits on high voltage outputs (max 1300V for 2kV output on STS5000, or 7.5kV for TD5000 option)
IEC 60068-2-6	Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)	Vibration: 20 m/s^2 at 10÷150 Hz , 40 sweep each axis
IEC 60068-2-27	Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock	Shock: 15 g; 11 ms; half-sine , 8 pulses each axis

Table 14 - Standards related to the LV Directive

3 CHARACTERISTICS

3.1 Foreword

STS XXXX incorporates a generator with six outputs. When an output is generated, there is voltage also on all other outputs, unless for the high AC voltage.

The generator is made of an electronic type D switching amplifier, followed by a power transformer, which adapts the suitable current or voltage output.

3.2 Main generator

The main generator has six outputs:

- High AC current
- High DC current
- Low AC current
- Low DC current
- High AC voltage
- Low AC voltage

Output adjustment is performed automatically, as a function of the selected test. The following specification applies to the separate use of these outputs.

For all outputs, the following applies:

- **Type of generator**. Electronic type D switching amplifier, followed by a high power transformer, with a number of secondary windings, fort the following outputs: high AC current, high DC current, high AC voltage. Loop control of the selected output. The transformer includes also the outputs: Low AC current, Low DC current, Low AC voltage, but they are not loop controlled
- **Output adjustable** from zero to the maximum value
- The specified **output power** is available at 25 °C maximum of external temperature, and with a power supply error of 2% maximum. For higher temperatures, the maximum power decreases of 20 VA/°C
- The specified **output accuracy** and THD applies at (25±2) °C, resistive load, and burden less than 20% of the maximum, currents up to 50% of the maximum. With full temperature range, maximum current and maximum burden, errors are twice as bigger
- The specified **output characteristics** may vary for frequencies below 50 Hz and above 60 Hz
- The **generated frequency** can be synchronized with the mains (with the Power Line Synchronizer option)
- The **selected output** is shown by a LED

3.2.1 High AC current

The output is available only on the STS 5000.

The following table lists the output characteristics, at 50 to 60 Hz and supply of 230 V:

Current output [A]	Output power [VA]	Load time [s]
800	4.800	25
600	3.780	200
400	2.560	500
300	1.940	900 (15 min)
200	1.300	> 2 h

Table 15 - High AC current: output characteristics (1/2)

	ATTENTION: The output range decreases below 50 Hz and above 60 Hz

The following table lists some more characteristics:

Connection	Two high power sockets, with safety protections
Generation resolution	100 mA
Measurement accuracy	Typical < 0,1% of the reading < 0,1% of the 800 A range
	Guaranteed ±0,2% of the reading ±0,2% of the 800 A range

Table 16 - High AC current: output characteristics (2/2)

3.2.2 High DC current

The output is available only on the STS 5000.

The following table lists the output characteristics:

Current output [A]	Output power [W]	Load time [s]
400	2.600	140
300	1.950	180
200	1.300	> 2 h
100	630	>> 2 h

Table 17 - High DC current: output characteristics (1/2)

The following table lists some more characteristics:

Connection	Two high power sockets, with safety protections
Generation resolution	100 mA
Measurement accuracy	Typical < 0,2% of the reading < 0,05% of the 400 A range
	Guaranteed ±0,4% of the reading ±0,1% of the 400 A range

Table 18 - High DC current: output characteristics (2/2)

3.2.3 Low AC current

The output is available on the STS 5000 and STS 4000.

Type of generator: not controlled low AC current.

The output current can be manually adjusted using the front panel controls, and measured via the test set current meter.

The following table lists the output characteristics:

Maximum output current	6 A or 3 A
Maximum output voltage	70 V AC or 140 V AC
Maximum output power	360 VA, for both ranges
Duration of the generation	> 2 h (at 50 V for 70 V range)
Output protection	Fuse type T6A; electronic protection on the 3 A range
Connection	Two safety 4 mm banana sockets

Table 19 – Low AC current: output characteristics

3.2.4 Low DC current

The output is available on the STS 5000 and STS 4000.

Type of generator: not controlled low DC current.

The output current can be manually adjusted using the front panel controls, and measured via the test set current meter.

The following table lists the output characteristics:

Maximum output current	6 A DC
Maximum output voltage	65 V DC
Maximum output power	360 W
Duration of the generation	> 2 h (at 50 V)
Output protection	Fuse type T 6 A
Connection	Two safety 4 mm banana sockets

Table 20 – Low DC current: output characteristics

	ATTENTION: During the high impedance burdens tests, the output sinks the energy stored into the inductance

3.2.5 High AC voltage

The output is available on the STS 5000 and STS 4000.

The high AC voltage output is coming from the same transformer as high AC or DC current, but an HV switch inside the test set isolates it.

	ATTENTION: This switch is closed only when the operator selects a High voltage test, after the enable key is turned on

Three voltage ranges are available:

- 2.000 V
- 1.000 V
- 500 V

The following table lists the output characteristics for each range:

Voltage range [V]	Output current [A]	Output power [VA]	Load time [s]
2.000	1,25	2.500	60
2.000	1	2.000	130
2.000	0,5	1.000	> 2 h

Table 21 - High AC voltage: output characteristics (1/4)

Voltage range [V]	Output current [A]	Output power [VA]	Load time [s]
1.000	2,5	2.500	60
1.000	2	2.000	130
1.000	1	1.000	> 2 h

Table 22 - High AC voltage: output characteristics (2/4)

Voltage range [V]	Output current [A]	Output power [VA]	Load time [s]
500	5	2.500	60
500	4	2.000	130
500	2	1.000	> 2 h

Table 23 - High AC voltage: output characteristics (3/4)

	ATTENTION: The output range decreases below 50 Hz and above 60 Hz

The following table lists the output characteristics:

Generation resolution	100 mV, on all ranges
Total Harmonic distortion	Less than 2% on linear loads
Measurement accuracy	For all ranges, there are four measuring ranges, with automatic switch: 2,000 V; 1,000 V; 500 V; 250 V
Accuracy	Typical < 0.05% of the reading < 0.05% of the metering range
	Guaranteed ±0.1% of the reading ±0.1% of the metering range
Connection	Two HV safety sockets

Table 24 – High AC voltage: output characteristics (4/4)

On this output is also measured the output current, with automatic range selection, and the phase shift of the current with respect to the voltage.

The following table lists the current ranges and the associated errors:

Current range [A]	**Resolution [mA]**	**Typical amplitude error**		**Guaranteed amplitude error**		**Typical phase error [°]**
		[<%rdg]	**[<%rg]**	**[±%rdg]**	**[±%rg]**	
5	1	< 0,2	< 0,05	±0,4%	±0,1%	< 0,1
0,5	0,1	< 0,05	< 0,05	±0,1%	±0,1%	< 0,1
0,05	0,01	< 0,1	< 0,1	±0,2%	±0,2%	< 0,2

Table 25 - High AC voltage: current ranges and associated errors

The following table lists the phase shift metering characteristics:

Metering range	0°÷360.0°
Resolution	0.1°
Accuracy	< 0,1° typical
	0,2° maximum, for amplitudes more than 10% of the metering range

Table 26 – High AC voltage: phase shift metering characteristics

3.2.6 Low AC voltage

The output is available on the STS 5000 and STS 4000.

Type of generator: not controlled low AC voltage.

The output voltage can be manually adjusted using the front panel controls, and measured via the test set voltage meter.

The following table lists the output characteristics:

Two voltage ranges	140 V AC or 70 V AC
Output power	420 VA, for both ranges
Output protection	Fuse type T6A
Connection	Two safety 4 mm banana sockets

Table 27 – Low AC current: output characteristics

3.2.7 High power output to the external modules

The output is available on all models of the STS family.

The output feeds the external modules type TD 5000, BUX 2000, BUX 3000, BUX 5000, STLG, STCS Booster 20 A DC.

The following table lists the output characteristics:

Insulation	Output not insulated from the mains supply
Output voltage	Adjustable in the range (0÷220) V AC
Output power	Supply 230 V: 1.500 VA steady, 4.000 VA during 5 minutes; 5.000 VA during 25 s
	Supply 110 V: 1.360 VA steady, 2.500 VA during 1 minute; 3.150 VA during 25 s

Table 28 – High power output: output characteristics

This output goes to a safety connector.

3.2.8 Output frequency

The following table lists the frequency range on all the AC outputs:

Frequency	15÷500 Hz
Frequency resolution	10 mHz
Frequency accuracy	< 100 ppM; output voltage > 200 V

Table 29 – Frequency range on all the AC outputs

3.2.9 Other features of main outputs

The following table lists other features of main outputs:

Zero crossing control	The generation starts and stops on the zero crossing
Over-current	Alarm message
Thermal protection	For: Power supply, Power amplifier, Power transformer. The operator is alerted by a message
Output measurement	The used output is selected from the front panel

Table 30 – Other features of main outputs

3.3 Outputs measurement

The display shows the following:

- The High AC current
- The High DC current
- The High AC voltage
- The corresponding output current

All of them are shown in their evolution during the test.

The display shows also the selected measurement inputs.

Type of measurement	True rms for AC outputs DC component for DC outputs
Metering temperature coefficient	±0,05%/°C of the value ±0,02%/°C of the range

Table 31 – Outputs measurement

3.4 External inputs measurement

The following measurements are performed by all the test sets of the family. It is possible to meter the current and the voltage of an external (or internal) generator. Four metering inputs are available, isolated between them and with respect to the rest of the test set:

- AC or DC current, up to 10 A, with two 4 mm safety banana sockets. This input is also protected by a FF10A fuse
- AC voltage, with two independent connections, in alternative:
    - High range, up to 300 V AC (four ranges with automatic selection), with two 4 mm safety banana sockets
    - Low range, up to 3 V AC (three ranges with automatic selection), with a shielded connector
- DC voltage, up to 10 V DC (four ranges with automatic selection), with two 4 mm safety banana sockets. On the same sockets is also available an Ohmmeter, for the 2-wire resistance measurements from 0.1÷20 kΩ

Above inputs allow measuring CT or VT outputs or any other source. The selected input is shown in the front panel with a LED. All inputs have two or more metering ranges, with automatic range selection.

The following table list the resolution and accuracy:

Input	Range	Impedance	Resolution	Typical error		Guaranteed error	
				[<%rdg]	[<%rg]	[±%rdg]	[±%rg]
AC current	10 A 1 A	0,1 Ω	1 mA 0,1 mA	< 0,05%	< 0,05%	±0,10%	±0,10%
DC current	10 A 1 A	0,1 Ω	1 mA 0,1 mA	< 0,03%	< 0,08%	±0,05%	±0,15%
High AC voltage range (sockets)	300 V 30 V 3 V 300 mV	500 kΩ	15 mV 1,5 mV 0,15 mV 0,015 mV	< 0,05% < 0,05% < 0,10% < 0,15%	< 0,05%	±0,10% ±0,10% ±0,20% ±0,30%	±0,1%
Low AC voltage range (connector)	3 V 300 mV 30 mV	10 MΩ	150 µV 30 µV 3 µV	< 0,03% < 0,08% < 0,1%	< 0,05% < 0,08% < 0,25%	±0,05% ±0,15% ±0,2%	±0,10% ±0,15% ±0,50%
DC voltage	10 V 1 V 100 mV 10 mV	500 kΩ	400 µV 75 µV 4 µV 0.4 µV	< 0,03% < 0,03% < 0,05% < 0,05%	< 0,08% < 0,08% < 0,10% < 0,15%	±0,05% ±0,05% ±0,10% ±0,10%	±0,15% ±0,15% ±0,20% ±0,30%

Table 32 - Resolution and accuracy

3.5 Timer

The STS 5000 and STS 4000 allow to measure a device timing, using a special input.

At the test start with voltage or current generation, a timer is started; the timer stops when the relay has tripped. It is also possible to stop the timer when the injected current is stopped by the intervention of the device under test.

Characteristics of the Digital Input:

- The input is isolated with respect to all other inputs and outputs
- The input may be selected as Normal Open or Normal Closed
- The timer can start from an analog input (current or voltage)
- The timer can start and stop at the changing of the digital input, both dry or wet contact
- Type of input: either dry or wet. Maximum input: 300 V AC or DC
- With the dry input selection, the wetting voltage is 24 V nominal (unregulated); the test current is 3 mA nominal. With a resistance less than 200 kΩ the contact can be seen closed
- With the voltage input selection, four thresholds can be selected: 5 V, 24 V, 48 V or > 80 V
- Input impedance: ≥1 MΩ
- When the input is closed or with voltage, an LED on the front panel turns on
- Wrong selection protection. If a voltage is applied when clean input is selected, input circuits are not damaged, provided that the voltage is less than 300 V
- Input connection: two safety 4 mm banana sockets
- Time measurement: elapsed time between the test start and the Digital Input
- Timer resolution: 1 ms
- Timer accuracy, digital input: ±0,01% of the measurement ±0,1 ms, for inputs lasting more than 1 ms
- Maximum measured time: 9.999 s

3.6 Phase angle

The test set measures the phase angle between the two AC selected parameters, which are used during the test.

The following table lists the resolution and the accuracy:

Measurement	Range	Resolution	Accuracy
Phase	(0÷360) °	0,01 °	Typical ±0,1 ° Guaranteed ±0,2 °

Table 33 - Phase angle resolution and accuracy

The angles accuracy is valid for values greater than 10% of the measurement range used.

Phase shift variation (temperature function) angle temperature drift: ±0,002 °/°C.

3.7 Other measurements

Starting from the internal and external measurements, the test set computes derived measurements, according to the test selection.

The following table lists the available measurements (the accuracy is the sum of voltage, current and possibly angle accuracy):

No.	Parameter AC outputs	Derived from	Formula	Units
1	Ratio (Rat) CT or VT or PT	I_{out}, I_{in} or V_{out}, V_{in}	$Rat=I_{out}/I_{in}$ $Rat=V_{out}/V_{in}$	-
2	Polarity CT or VT or PT	φ I_{out}, I_{in} or φ V_{out}, V_{in}	K => φ < 10 °	-
3	Burden CT and VT	V_{out}, I_{out}	$VA=IN^2 \cdot V_{out}/I_{out}$	VA
4	Saturation knee CT	V_{out}, I_{out}	VKn, Ikn: according to the standards	V, A
5	Resistance CB and others	I_{out}, V_{out}	$R=V_{out}/I_{out}$	Ω
6	Impedance CT and VT insulation test	I_{out}, V_{out}	$Z=V_{out}/I_{out}$	Ω
7	Short circuit impedance PT test	I_{out}, V_{out}	$Z=V_{out}/I_{out}$	H

Table 34 - Available measurements

The following table lists the parameters for the CT, VT and PT ratio measurement:

Range	Resolution	Ratio range	Typical accuracy	Maximum accuracy
0÷9,999	1	0,8÷166	0,20%	0,40%
		167÷1.666	0,25%	0,50%
		1.667÷9.999	0,30%	0,60%

Table 35 - Parameters for CT, VT and PT ratio measurement

For the polarity test, the phase shift between the two parameters is tested. Answer is OK if phase shift is less than 10 °. The ratio and the polarity are checked also for non-conventional transformers through IEC61850-9-2LE protocol.

For the burden test, the result is the product of voltage and current; the accuracy depends upon the VA range. The following table lists the parameters for the burden test:

Test voltage [V]	Test current [A]	VA range [VA]	Resolution [VA]	Typical accuracy		Maximum accuracy	
				%	%	%	%
130	3	3.000	0,05	±0,1	±0,1	±0,2	±0,2
30	2	300	0,01	±0,1	±0,1	±0,2	±0,2
10	1	30	0,005	±0,1	±0,1	±0,2	±0,2
3	1	3	0,001	±0,2	±0,1	±0,3	±0,2

Table 36 - Parameters for the burden test

For the resistance test it is possible to perform it with four wires, with the two available DC sources, or with two wires, using the 10 V measurement input. The following table lists the corresponding range and accuracy (the maximum resistance is 20 kΩ):

Source	Resistance range	Resolution	Typical accuracy	Guaranteed accuracy
High current 400 A 4-wire	10 µΩ 100 µΩ 1 mΩ 10 mΩ	0,01 µΩ 0,1 µΩ 1 µΩ 10 µΩ	< 0,7% < 0,5% < 0,5% < 0,5%	1,35% 1,10% 0,95% 0,95%
Low DC current 6 A 4-wire	100 mΩ 1 Ω 10 Ω	0,1 mΩ 1 mΩ 10 mΩ	< 0,3% < 0,3% < 0,2%	0,6% 0,6% 0,4%
DC voltage meter 2-wire	100 Ω 1 kΩ 20 kΩ	0.1 Ω 1 Ω 10 Ω	< 0,6% < 0,5% < 0,5%	1,2% 1,0% 1,0%

Table 37 - Resistance test: range and accuracy

The impedance test is performed applying high voltage and measuring the corresponding current. The following table lists the range and accuracy (the impedance is 100 Ω, the maximum impedance is 2 MΩ):

HV source [V]	I output [A]	Impedance range [Ω]	Resolution [mΩ]	Typical accuracy		Maximum accuracy	
				%	%	%	%
500	0,5÷5	1.000	20	±0,25	±0,1	±0,5	±0,2
500	0,05÷0,5	10.000	200	±0,10	±0,1	±0,2	±0,2
1.000	0,5÷2,5	2.000	400	±0,25	±0,1	±0,5	±0,2
1.000	0,05÷0,5	20.000	2.000	±0,10	±0,1	±0,2	±0,2
2.000	0,05÷1,25	4.000	800	±0,25	±0,1	±0,5	±0,2
2.000	0,05÷0,5	40.000	2.000	±0,10	±0,1	±0,2	±0,2
2.000	0,001÷0,05	2 M	10^5	±0,15	±0,15	±0,3	±0,3

Table 38 - Impedance test: range and accuracy

The following table lists the range and tolerances for the short-circuit impedance test:

Measurement range	Digits No	Range	Maximum Resolution	Accuracy
10 mH÷2 H	5	Self-adjusting	0,001 mH	1% of the reading, ±0,5 mH

Table 39 - Phase angle resolution and accuracy

3.8 Display

The following image exhibits the STS display:

Figure 5 - STS display

The following table lists the main features of the display:

Pixel	Light	LCD type	View area
640 x 480, colors	Backlight	TFT	132 x 99 mm

Table 40 - Main features of the display

3.9 Test control

Test control: by the START / STOP pushbutton. Pressing it, the output is generated, after test selection, according to the type of test. During ON, if a manual control test is selected, the operator adjusts the output at the desired value.

Test saving:

- Automatic save
- After operator confirmation

3.10 Menu selections

The following image exhibits the Home page of the test set of the Test Plan Editor:

Figure 6 – Home page

The menu is entered pressing the knob and selecting the item moving the knob.

The Test Plan Editor is an innovative and advanced software module, allowing the operator to define and plan a sequence of tests. The operator defines the desired sequence of tests and sets the parameters of each test: the Editor creates a sequence of tests to be performed automatically. The feature is available for the tests of Current, Voltage and Power transformers.

Test plans can be saved or recalled, like test results. Up to 64 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.

For instance, in the Home page select the icon “Current Transformers” and press the knob:

Figure 7 – “Current Transformers" icon

The following image exhibits the “Power Transformers – Header and Nominal Values” page (tab Description), visible at first time in which entering this section, or pressing the button “Header/Nominal Values”:

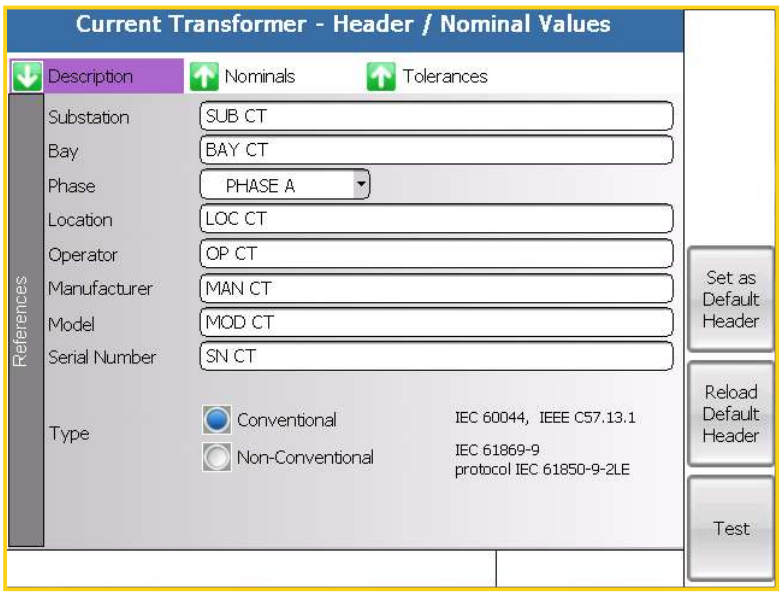
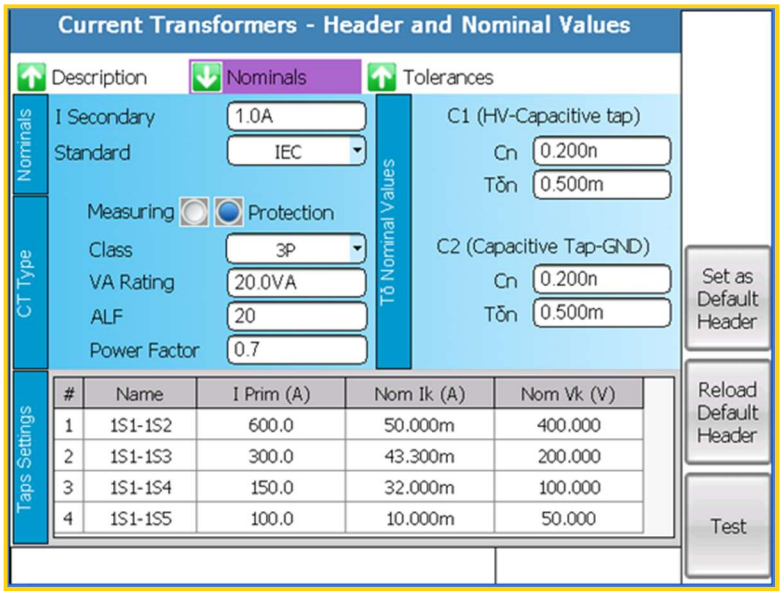


Figure 8 - "Current Transformers/Header and Nominal Values" page (tab Description)

The following image exhibits the tab “Nominals” (Conventional Type without the IEC61850-9-2LE output):



.

Figure 9 - "Current Transformers/Header and Nominal Values" page (tab Nominals)

From these nominal data, the program computes the nominal saturation knee.

The following image exhibits the tab “Tolerances”:

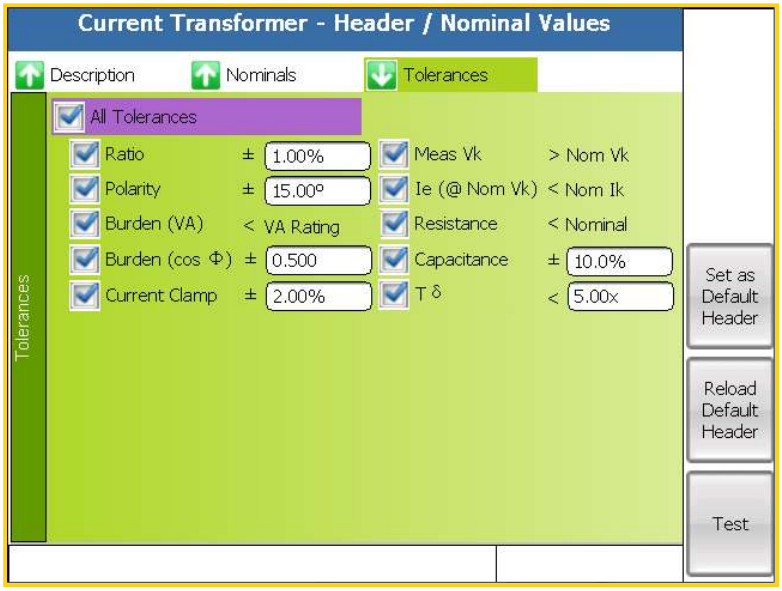


Figure 10 - "Current Transformers/Header and Nominal Values" page (tab Tolerances)

The page allows setting the tolerances for each of the available tests. If the tolerance is exceeded, the deviation is shown in the test result table.

After having set this basic information, pressing the shortcut “Edit Test Plan” at the side of the icon and enter the Editor mode; else, it is possible to continue with a single test.

The following image exhibits the “Current Transformers” test page (Conventional Type):

Figure 11 - "Current Transformers" test page (Conventional Type)

The page allows selecting the test to be performed: the corresponding window is opened, and test parameters can be programmed

For instance, the following image exhibits the “CTs – Ratio Polarity and Burden Current Method” page:

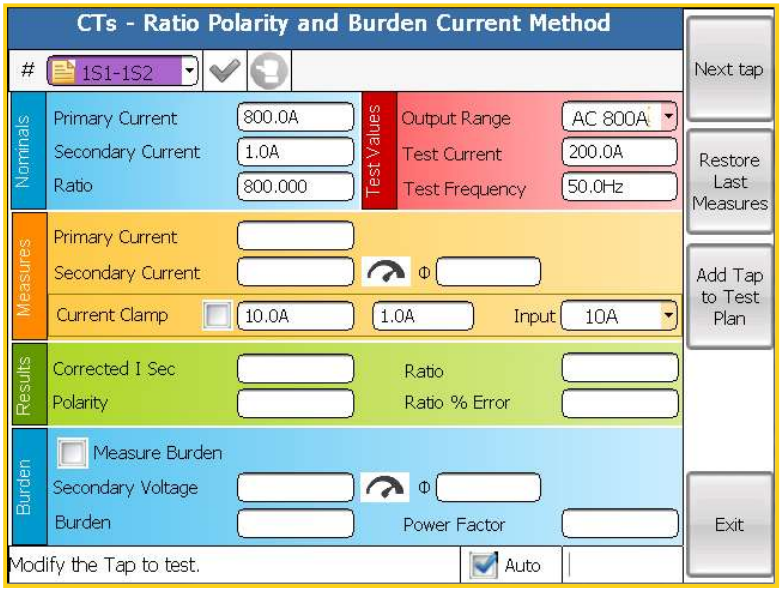


Figure 12 - "CTs – Ratio Polarity and Burden Current Method" page

As the test programming is finished, pressing the shortcut “Exit” by the side of the icon, it is possible to come back to the test selection table. Pressing here the shortcut “Exit Ct’s” by the side of the icon, it is possible to come back to the main menu, and the Editing is finished.

At the end of the programming, starting the first test, the test set executes the complete sequence. During the test, test results are stored in the memory.

At the end of the tests, settings and results can be downloaded to a PC, with PADS program included in the TDMS suite, which comes with the device. The software allows saving test results into a file, examining them, printing them.

Optionally, PADS allows controlling the device from the PC. It is also possible to edit settings with PADS, and to upload them to STS XXXX.

In general, the test is performed ramping the parameter until the desired value is reached; after the necessary test duration, the parameter is reduced to zero.

The following tables summarizes all tests and the corresponding performances.

The following table lists the Current Transformers tests:

No.	Test	Test description
1	Ratio Polarity and Burden	The ratio measurement is performed applying high current to the CT primary, and measuring the CT secondary current. The burden can be by-passed, or left in series for the measurement: in this instance, the voltage drop is measured. The secondary current can be measured by a clamp. Input parameters are the following: • The nominal primary and secondary current, from which the program computes the nominal ratio • The nominal test current The display shows: • The actual current output • The corresponding current input, and the value of the secondary current with the nominal primary current* • Actual ratio and ratio error • Phase shift and polarity* When the burden is tested, the following parameters are displayed • The voltage drop across the burden • For the burden: VA rating at the nominal current, angle, power factor The measurements are narrow filtered in order to reduce the noise, coming from the environment. *For Non - CT transformers equipped with IEC61850-9-2LE interface, the STS reads the CT samples output from its Ethernet interface to measure ratio and polarity
2	Burden Secondary Side	The burden measurement is performed applying low AC current to the CT burden, and measuring the voltage drop. Input parameters are the following: • The nominal secondary current • The nominal test current The display shows: • The actual current output • The voltage drop across the burden • For the burden: VA rating at the nominal current, angle, power factor The measurements are narrow filtered in order to reduce the noise, coming from the environment.
3	Excitation Curve	The excitation curve is tested connecting the high AC voltage to the CT secondary, slewing the voltage and measuring at the same time the output voltage and current. Input parameters are taken from the CT Nominal Values window. Other inputs are the following: • Maximum test voltage and current • Test frequency The test set controls the output voltage and current during the test, and stops as the knee is recognized. The display shows the following: • The characteristic curve • The actual voltage knee and the error with respect to the nominal • The actual current error at knee In addition to this, it is possible to define a point-by-point test, where: • It is possible to input the desired number of test points, defined with current and voltage • The test result reports the deviation from the nominal values, and shows if results are in the set tolerance

Table 41 - Current Transformers tests (1/4)

No.	Test	Test description
4	Winding or Burden Resistance	The resistance (not impedance) is measured connecting the low DC current source to the winding or burden, and measuring the test current and the voltage drop. Input parameters are the following: • The nominal resistance • The connected output • The test current • The resistance limits It is also possible to compensate the test temperature. The test set controls the output current and voltage during the test, and stops as the test current is reached. The display shows the following: • The test current • The voltage drop • The measured resistance and the compensated resistance • The test duration • The current deviation when the measurement was achieved
5	ALF/ISF	Purpose of the test is to calculate the ALF/ISF value using the Winding Resistance test results and the Burden Secondary Side test results. ALF = Accuracy Limit Factor and ISF = Instrument Security Factor. Input parameters: Burden and Winding test results. Results: ALF value.
6	Voltage Withstand	The test is performed connecting the high AC voltage source between the CT secondary cabling and the ground or between the CT primary and secondary. Input parameters are the following: • Maximum test current (with automatic switch-off) • Test time • Output range • Test voltage • Test frequency The display shows the following: • During the HV ramping, the test voltage and current; • As the test is completed, the test voltage, the maximum current, the total elapsed time, the isolation impedance (not resistance)
7	Polarity Check	The test is performed connecting the high AC current source to the primary side, generating a special waveform, and measuring the induced secondary current with the optional PLCK polarity sensor. Input parameters are the following: • The test current • The generation duty cycle • The test result (OK or NO) The display shows the test current and records the test result of the different points
8	Ratio Polarity Voltage Mode	The ratio measurement is performed applying High V AC to the CT secondary, and measuring the CT primary voltage. Input parameters are the following: • The nominal primary and secondary current, from which the program computes the nominal ratio • The voltage range • The nominal test voltage and the test frequency The display shows the following: • The current test voltage on the secondary side • The secondary measured voltage and the secondary current with the nominal primary current • Actual ratio and ratio error • Phase shift and polarity The measurements are narrow filtered in order to reduce the noise, coming from the environment.

Table 42 - Current Transformers tests (2/4)

No.	Test	Test description
9	Rogowski (Ratio)	The test is performed connecting the high AC current source to the primary side, and connecting the CT secondary side to the low voltage measurement. Input parameters are the following: • The nominal primary current and the nominal secondary voltage, from which the program computes the nominal ratio • The current range • The test current • The test frequency The display shows the following: • The nominal primary current and the test current • The actual test current, the secondary voltage, and the value of the primary current with the nominal secondary voltage • Actual ratio and ratio error • Phase shift and polarity The measurements are narrow filtered in order to reduce the noise, coming from the environment.
10	Low Power (Ratio)	The test is performed connecting the high AC current source to the primary side, and connecting the CT secondary side to the low voltage measurement. Input parameters are the following: • The nominal primary current and the nominal secondary voltage, from which the program computes the nominal ratio • The current range • The test current • The test frequency The display shows the following: • The nominal primary current and the test current • The actual test current, the secondary voltage, and the value of the primary current with the nominal secondary voltage • Actual ratio and ratio error • Phase shift and polarity

11	Tan(δ) measures	The test is performed using the TD 5000 optional module, and then connecting the high AC voltage source to test target.
		Displayed parameters are the following:
		• *Test type (1)*: Where the HV output is applied: in case of a specific device under test (CT, VT, PT or bushing), the options are displayed
		• *Capacitance (2)*: In case of a specific device under test (CT, VT, PT or bushing), the options are displayed
		• *Generation mode*: to execute a single shot, a voltage or a frequency gradient
		• *Test mode*: It is selected in reference to the TD 5000 and the device under test connection. In case of a specific device under test (VT, in this case), the more correct test mode is automatically selected, considering also the selections (1) and (2)
		• *Voltage/Frequency test table*: It allows to input the test voltage and frequency
		• *Nominal Values*: Capacitance and TD reference values. In case of a specific device under test (CT, VT, PT or bushing), these values are kept from the related headers
		• Temperature compensation: The Capacitance and TD values vary with the temperature: optionally, the “k” factor is used to compensate the measures (according to the ANSI/IEEE C57.12.90 standard)
		• Test table
		• Results table
		  • Test voltage, current and frequency
		  • Capacitance, Tan(δ), power factor (PF)
		  • Power: active, reactive, apparent
		  • Impedance: module, argument, components

Table 43 - Current Transformers tests (3/4)

No.	Test	Test description
12	Ratio IEC61850-9-2LE	Ratio measure and currents polarity for Not Conventional Transformers. The test is executed applying current to the primary side and reading the corresponding “Sample Values”. The test is executed using the test set remote connection with the PC, using the PDS program. Input parameters are the following: • Nominal primary current • Test current and frequency • The sender MAC address • The recipient MAC address • The svID (sample value ID) • The Stream Number The results are the following: • The primary current • The measured Sample Values • The angle between the primary current and the Sample Values • Corrected primary current, polarity, error ratio and error %

Table 44 - Current Transformers tests (4/4)

	ATTENTION: for the excitation curve test, the following standards apply: • 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 • ANSI/IEEE C57.13.1; chapter 9. Plotting 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° • ANSI/IEEE C57.13.1; chapter 9. Plotting 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°

The following table lists the Voltage Transformers tests:

No.	Test	Test description
1	Ratio	The ratio measurement is performed applying high voltage to the VT primary, and measuring the VT secondary voltage. Input parameters are the following: • The nominal primary and secondary voltage, from which the program computes the nominal ratio • Type of connection (Y or Delta) • The HV range • The nominal test voltage and frequency • The selected voltage meter The display shows the following: • The actual test voltage • The secondary voltage* • The value of the secondary voltage with the nominal primary voltage • Actual ratio and ratio error • Phase shift and polarity* The measurements are narrow filtered in order to reduce the noise, coming from the environment. *For Non-conventional VT transformers equipped with IEC61850-9-2LE interface, the STS reads the VT samples output from its Ethernet interface to measure ratio and polarity
2	Ratio Electronics	The ratio measurement is performed applying high voltage to the VT primary, and measuring the low-level VT secondary voltage. Input parameters are the following: • The nominal primary and secondary voltage, from which the program computes the nominal ratio • Type of connection (Y or Delta) • The HV range • The nominal test voltage and frequency The display shows the following: • The actual test voltage • The secondary voltage • The value of the secondary voltage with the nominal primary voltage • Actual ratio and ratio error • Phase shift and polarity The measurements are narrow filtered in order to reduce the noise, coming from the environment.
3	Burden	The burden measurement is performed applying low AC voltage to the VT burden, and measuring the corresponding current. Input parameters are the following: • The nominal secondary voltage • The voltage range • The test voltage and frequency The test current can also be metered by a clamp. The display shows the following: • The actual voltage and current test The results are the following: • Performance in VA at rated voltage • Cos(φ)
4	Voltage Withstand	The test is performed connecting the high AC voltage source between the VT secondary cabling and the ground or between the VT primary and secondary. Input parameters are the following: • Maximum test current (with automatic switch-off) • Test time • Output range • Test voltage • Test frequency The display shows the following: • During the generation, the test voltage and current • As the test is completed, the maximum current, the total elapsed time, the isolation impedance

Table 45 - Voltage Transformers tests (1/2)

No.	Test	Test description
5	Polarity Check	The test is performed connecting the high AC voltage source to the primary side, and measuring the induced secondary voltage with the optional PLCK polarity sensor. Input parameters are the following: • The test voltage • The generation duty cycle • The test result (OK or NO) The display shows the test voltage, and records the test result of the different points

6	Tan(δ) measures	The test is performed using the TD 5000 optional module, and then connecting the high AC voltage source to test target.
		Displayed parameters are the following:
		• *Test type (1)*: Where the HV output is applied: in case of a specific device under test (CT, VT, PT or bushing), the options are displayed
		• *Capacitance (2)*: In case of a specific device under test (CT, VT, PT or bushing), the options are displayed
		• *Generation mode*: to execute a single shot, a voltage or a frequency gradient
		• *Test mode*: It is selected in reference to the TD 5000 and the device under test connection. In case of a specific device under test (VT, in this case), the more correct test mode is automatically selected, considering also the selections (1) and (2)
		• *Voltage/Frequency test table*: It allows to input the test voltage and frequency
		• *Nominal Values*: Capacitance and TD reference values. In case of a specific device under test (CT, VT, PT or bushing), these values are kept from the related headers
		• Temperature compensation: The Capacitance and TD values vary with the temperature: optionally, the “k” factor is used to compensate the measures (according to the ANSI/IEEE C57.12.90 standard)
		• Test table
		• Results table
		  • Test voltage, current and frequency
		  • Capacitance, Tan(δ), power factor (PF)
		  • Power: active, reactive, apparent
		  • Impedance: module, argument, components

7	Ratio IEC61850-9-2LE	Ratio measure and currents polarity for Not Conventional Transformers. The test is executed applying current to the primary side and reading the corresponding “Sample Values”. The test is executed using the test set remote connection with the PC, using the PDS program. Input parameters are the following: • Nominal primary current • Test current and frequency • The sender MAC address • The recipient MAC address • The svID (sample value ID) • The Stream Number The results are the following: • The primary current • The measured Sample Values • The angle between the primary current and the Sample Values • Corrected primary current, polarity, error ratio and error %

Table 46 - Voltage Transformers tests (2/2)

The following table lists the Power Transformers tests:

No.	Test	Test description
1	Ratio	The ratio measurement is performed applying high voltage to the PT primary, and measuring the PT secondary voltage for each tap. If the STCS option is available, connection is performed via the option, and the test is completely automatic. Input parameters are the following: • The nominal primary and secondary voltage, from which the program computes the nominal ratio • Type of connection (Y or Delta) • The type of Tap changer • The nominal test voltage and frequency The display shows the following: • The test voltage, primary and secondary • Actual ratio and ratio error • Phase shift and polarity The measurements are narrow filtered in order to reduce the noise, coming from the environment.
2	Ratio with Tan(δ)	Ratio test is performed by measuring a sample capacitance two times using the RTD and TD 5000 options. Voltage values up to 12 kV can be generated on the High Voltage side. Capacitance values on both High Voltage and Low Voltage sides are measured and then turn ratio is calculated using the ratio between them.
3	Winding Resistance	The test is performed applying low DC current to the PT primary plus Tap Changer and measuring the voltage drop. The tester measures the resistance peak during the switch and the resistance after the selection. Input parameters are the following: • The nominal resistance • The output current (6 A or 400 A) • The test current • The nominal resistance and the resistance limits It is also possible to compensate the test temperature. The test set controls the output current during the test and issues the Tap Change command. The display shows the following: • The test current • The tap number • For the static resistance: the test voltage and resistance, also compensated • For the dynamic resistance: the measured values are the Ripple and the Slope and the diagrams of the current or of the resistance During the current discharge, voltage and current are displayed. The dynamic resistance measurement is performed also without the STCS option. The tap changer command is manual
4	Winding Resistance – Auto	The test is performed applying low DC current to the PT primary plus Tap Changer and measuring the voltage drop. The tester measures the resistance peak during the switch and the resistance after the selection. Using the STCS option, the connection to the PT is performed using the option and the test is completely automatic. Input parameters are the following: • The nominal resistance • The output current (6 A or 400 A) • The test current • The nominal resistance and the resistance limits It is also possible to compensate the test temperature. The test set controls the output current during the test and issues the Tap Change command. The display shows the following: • The test current • The tap number • For the static resistance: the test voltage and resistance, also compensated • For the dynamic resistance: the measured values are the Ripple and the Slope and the diagrams of the current or of the resistance During the current discharge, voltage and current are displayed. The dynamic resistance measurement is performed also without the STCS option. The tap changer command can be automatic

Table 47 - Power Transformers *tests (1/3)*

No.	Test	Test description
5	Voltage Withstand	The test is performed connecting the high AC voltage source between the CT secondary cabling and the ground or between the CT primary and secondary. Input parameters are the following: • Maximum test current (with automatic switch-off) • Test time • Output range • Test voltage • Test frequency The display shows the following: • During the HV ramping, the test voltage and current; As the test is completed, the test voltage, the maximum current, the total elapsed time, the isolation impedance (not resistance)
6	Short-Circuit Impedance	The test is performed applying low AC current to the winding under test, while other windings are short-circuited, and measuring the associated voltage and phase shift. If the STCS option is available, connection is performed via the option, and the test is completely automatic. • Input parameters are the following: • The test current and frequency • The type of winding • The phase under test It is also possible to compensate the test temperature. The test set measures the output voltage, and computes the related parameters. The display shows the following: • Phase shift; the power loss; the R, X, Z and inductance of the transformer • The same parameters, but expressed in Per Unit
7	No-Load Current (Excitation current)	The test is performed connecting the TD 5000 optional module (or the HV output), to the device under test. Input parameters are the following: • The test voltage • The frequency The test set applies the high voltage and measures the output current during the test. The display shows the following: • The test voltage • The current and the phase shift • The power losses • The reactance (inductive, capacitive or resistive)

Table 48 – Power Transformers tests (2/3)

No.	Test	Test description

8	Tan(δ) measures	The test is performed using the TD 5000 optional module, and then connecting the high AC voltage source to test target.
		Displayed parameters are the following:
		• *Test type (1)*: Where the HV output is applied: in case of a specific device under test (CT, VT, PT or bushing), the options are displayed
		• *Capacitance (2)*: In case of a specific device under test (CT, VT, PT or bushing), the options are displayed
		• *Generation mode*: to execute a single shot, a voltage or a frequency gradient
		• *Test mode*: It is selected in reference to the TD 5000 and the device under test connection. In case of a specific device under test (VT, in this case), the more correct test mode is automatically selected, considering also the selections (1) and (2)
		• *Voltage/Frequency test table*: It allows to input the test voltage (i.e. voltage sweep, that is Tip Up or Down test) and frequency
		• *Nominal Values*: Capacitance and TD reference values. In case of a specific device under test (CT, VT, PT or bushing), these values are kept from the related headers
		• Temperature compensation: The Capacitance and TD values vary with the temperature: optionally, the "k" factor is used to compensate the measures (according to the ANSI/IEEE C57.12.90 standard)
		• Test table
		• Results table
		  • Test voltage, current and frequency
		  • Capacitance, Tan(δ), power factor (PF)
		  • Power: active, reactive, apparent
		  • Impedance: module, argument, components

9	Demagnetizer	Purpose of this test is to apply a DC current with alternate polarity to the winding, in order to remove from the core the residual magnetism due to a previous winding resistance measurement. Input parameters are the following: • Nominal current (primary and secondary) • Connections A, B, C according to the vector group • Transformer side selection • Output Range • Test current The display shows the following: • DC current and voltage • Current behavior during the demagnetization procedure
10	Vector Group	This test is necessary to verify the nameplate vector group of the power transformer, in order to be sure that the internal connections between the windings and the phase bushings are correct. Input parameters: Turn Ratio and STCS (if present) Results: Connection and Phase Displacement.

Table 49 – Power Transformers tests (3/3)

The following table lists the Circuit Breakers tests:

No.	Test	Test description
1	Resistance - μΩ	The contact resistance test is performed using the high DC current output. The test set measures the contact resistance down to the μΩ range. With the same selection, and different generators, it is also possible to measure higher resistances. Input parameters are: current output range, test current, and resistance limits. The display shows the following: • DC current • DC voltage • Resistance

2	Tan(δ) measures	The test is performed using the TD 5000 optional module, and then connecting the high AC voltage source to test target.
		Displayed parameters are the following:
		• *Test type (1)*: Where the HV output is applied: in case of a specific device under test (CT, VT, PT or bushing), the options are displayed
		• *Capacitance (2)*: In case of a specific device under test (CT, VT, PT or bushing), the options are displayed
		• *Generation mode*: to execute a single shot, a voltage or a frequency gradient
		• *Test mode*: It is selected in reference to the TD 5000 and the device under test connection. In case of a specific device under test (VT, in this case), the more correct test mode is automatically selected, considering also the selections (1) and (2)
		• *Voltage/Frequency test table*: It allows to input the test voltage and frequency
		• *Nominal Values*: Capacitance and TD reference values. In case of a specific device under test (CT, VT, PT or bushing), these values are kept from the related headers
		• Temperature compensation: The Capacitance and TD values vary with the temperature: optionally, the “k” factor is used to compensate the measures (according to the ANSI/IEEE C57.12.90 standard)
		• Test table
		• Results table
		  • Test voltage, current and frequency
		  • Capacitance, Tan(δ), power factor (PF)
		  • Power: active, reactive, apparent
		  • Impedance: module, argument, components

Table 50 - Circuit Breakers tests

The following table lists the Resistances tests:

No.	Test	Test description
1	Resistance - μΩ	The contact resistance test is performed using the high DC current output. The test set measures the contact resistance down to the μΩ range. With the same selection, and different generators, it is also possible to measure higher resistances. Input parameters are: current output range, test current, and resistance limits. The display shows the following: • DC current • DC voltage • Resistance
2	Earth Resistance	For the resistivity test, input parameters are the following: • Voltage range • Test voltage • Test frequency The measurements are narrow filtered in order to reduce the noise, coming from the environment. Input parameters are the following: • Output voltage range • Test voltage • Test frequency The display shows the following: • Test probe distance • Output voltage • Test probe voltage • Output current • Phase shift • Earth resistance • Evaluation Ground Resistance Values : from 0.05 Ω to 300 Ω The test of ground grid resistance is performed applying current between the ground grid and the auxiliary ground spikes. With the STLG option the test is performed using an overhead line to connect to the remote ground
3	Soil Resistivity	The test of soil resistivity is performed applying AC voltage to two spikes, and measuring the injected current, and the voltage across the voltage spikes. The display shows the following: • Location • Probes distance • Output voltage • Voltage between probes • Output current • Corresponding resistivity • Evaluation

Table 51 - Resistances tests (1/2)

No.	Test	Test description
4	Step and Touch	The step and touch voltages test is performed applying current between the ground grid and the auxiliary ground spikes, and measuring the step or touch voltage with the test probes. With the STLG option, the current generation is performed using an overhead line to connect to the remote ground. Thanks to the STLG option, higher test currents can be achieved. Input parameters are the following: • Substation fault current • Fault clearance time • Parallel resistance on the test probes Other selections are the following: • Output voltage range • Test voltage • Test frequency With the STLC option, we select the current range. Last, the operator selects the measurement mode: manual or on STS and the reference standard. The display shows the following: • Test current • Location description • Location coordinates • Measured voltage • Voltage in case of actual fault
5	Line Impedance	Test parameters are the following: • Line impedance • Earth impedance • Mutual factor The test is performed applying voltage to the line to be tested, and measuring the corresponding current and voltage. The test is performed with the STLG option. Input parameters are the following: • Type of test • Phase under test • Frequency For the line impedance test, the display shows the following data: 1) Test voltage; 2) Test current; 3) Line impedance, argument, R and X components. For the earth impedance test, the display shows the following: • Test voltage and current • Impedance and argument of: Z, ZL, ZE, earth coefficient KE For the mutual factor test, the display shows: • Module and phase of the mutual factor • ZL module and resistive component • External voltage, current, phase angle

Table 52 – Resistances tests (2/2)

The following table lists other possible tests:

No.	Test	Test description
1	Primary and secondary M.V. CB and relay tests	The selection allows injecting the test parameter, and measuring the relay threshold and trip delay. The tests are feasible using the trigger input logic, or by stopping the test when the current disappears (M.V. CB). With the option BUX 2000 and BUX 3000 it is possible to perform high current tests. Input parameters are the following: • Current range, output current • Output voltage • Frequency It is possible set the type of digital input (NO-NC, wet-dry, voltage threshold). The display shows the following data: • Test current or test voltage • Trip delay • External voltage and current measurements

Table 53 – Other possible tests

3.11 Standard connection cables (Long cables code PII16175 and extra long cables code PII57175)

Connection cables differ somewhat as a function of the type of test set. The following table lists cables provided:

Item	Description	STS 5000	STS 4000	STS 3000 light
1	No. 1 Mains supply cable, 2 m long, Schuko. Other plugs on demand	X	X	X
2	No. 1 Grounding cable, 6 m long, 6 mm^2, terminated on one side with a terminator, and on the other side with an earth connection clamp (No 2 cables for the option PII57175)	X	X	X
3	No. 1 Interface cable for the USB port	X	X	X
4	No. 1 ETHERNET interface cable	X	X	X
5	No. 1 Operating manuals + Cd-Rom with TDMS	X	X	X
6	No. 1 USB pen drive	X	X	X
7	No. 6 “Kelvin” clamps, with two sockets: one to connect the current or voltage; the other one to connect the measurement. Clamp opening: 60 mm on the rear, 80 mm on the front	X	X	
8	No. 4 Clamps to connect low voltage or low current or measurements, two red and two black, with a short cable terminating on a banana socket. Clamp opening: 25 mm	X	X	
9	No. 4 Crocodiles for measurements connections (2 red, 2 black)	X	X	
10	No. 1 Short cable, 50 cm long red, terminated with banana sockets on both sides, for the current measurement of the output 6 A DC	X	X	
11	No. 6 connection cables, three red and three black, 2.5 mm^2, 6 m long (10 m long option PII16175, 15 m long option PII57175), for the connection of the following: DC current output, low AC voltage output, digital input. Terminated on both sides with a 4 mm banana plug	X	X	
12	No. 2 High voltage connection cables, 6 m long (10 m long option PII16175, 15 m long option PII57175), 5 kV, with earth screen. Terminated on one side with the HV connector, and on the other side with a 4 mm banana plug	X	X	
13	No 2 High current connection cables, 70 mm^2, 6 m long (9 m for option PII16175 and 10 m for option PII57175 [70 mm^2, 1 m long + 95 mm^2, 9 m long]), for option PII57175). Terminated on one side with a high current male connector, and on the other side with spring-loaded clamps, with maximum opening 60 mm	X		
14	No. 1 Cable for the 10 V or 300 V measurement connection, shielded, 6 m long (10 m long option PII16175, 15 m long option PII57175). Terminated on one side with three 4 mm banana plugs (two conductors plus shield), and on the other side with two banana plugs. Plugs are colored red, black and yellow for the screen	X	X	
15	No. 1 Cable for the 3 V measurement connection, shielded, 6 m long (10 m long option PII16175, 15 m long option PII57175). Terminated on one side with the measurement connector, and on the other side with two banana plugs, red and black	X	X	
16	No. 1 Transport case for connection Cables	X	X	

Table 54 - Cables provided with the unit

	ATTENTION: The previous cables come as standard with the test set; however, they can also be ordered separately. Optionally, the marked cables can be ordered longer for the option PII16175, or the option PII57175

3.12 Other characteristics

The following table list other characteristics of the STS:

Item	Characteristic	Description
1	Memory	• Up to 64 test plans • More than 1,000 test results
2	Interfaces	• ETHERNET for the PC connection. The Ethernet port can be used also for remote service and maintenance • USB port for the USB key: this serves to download test settings and results
3	Interfaces to external modules	• Commands to TD 5000, STCS and STDE • Alarms interface from the modules
4	Other interfaces	• Remote Start input. The test is started pressing the button on the option PII42175 • Safety warning. It can be connected to the strobe with light PII43175. In case of alarm, the output drives the optional flashing siren and light
5	Mains supply	100÷230 V ± 15% (85÷264 V); 47÷63 Hz. The instrument can be supplied with a portable generator without loss of performances.
6	Power consumption	Less than 1 kW in normal use; 1.8 kW (3.600 VA; 16 A) when generating the maximum power on High AC voltage output or high DC current output. For a maximum period of 25 s, the supply power can be up to 3.6 kW, (7,000 VA; 32 A) when generating the maximum power on the 800 A output or on the BUX options
7	Dimensions	400 (H)x450 (W)x230 (D) mm STS 5000 weight: 29 kg STS 4000 weight: 22 kg STS 3000 light weight: 16 kg
8	Accessories	• User manual, in English, Italian, French and Spanish • No 5 spare fuses, type T16A • Connection cables, provided in a case with handle and wheels

Table 55 - Other characteristics of the STS

	ATTENTION: If the supply is less than 184 V AC, the test set does not guarantee the full output power on the 800 A AC output

4 OPTIONS

4.1 Transit cases (code PII17175, PII 19175, PII51175)

The following image exhibits a transit case:

Figure 13 - Transit case

This option applies to all STS XXXX models.

There are more types of transit cases:

- one for the STS XXXX
- one for TD 5000
- one for RCTD
- one for STLG
- one for BUX 2000
- one for BUX 3000

All of them allow transporting the device. The case has handles and wheels.

The following table lists the Transit case main characteristics:

Characteristic	Note
Handling	Handles on the top and on the side
Wheel	2
Dimensions	450 x 550 x 850 mm
Weight	15 kg

Table 56 – Transit case main characteristics

The following table lists the Transport cases coding:

Instrument	Code
STS XXXX	PII17175
TD 5000 RCTD STLG	PII19175
BUX 2000 BUX 3000	PII51175

Table 57 - Transport cases coding

4.2 PADS licence (code PII10176P, PII10176F, PII10176T)

The software PADS allows connecting to the PC all models of the STS.

Software features are the following:

- To download from the test set test results and settings, and to save them into a file
- To open and save or export test results in the formats: XLSX (EXCEL), CSV , Doc , RPT , PDF , JPEG and XML
- To display in real time the measurements performed by the test set, with possibility to pause the test (when applicable)
- To display, save and print test results diagrams
- To zoom and compare different curves of more than one result
- To edit, display and print the test report, with the following information:
    - Place, substation name, line, phase, model, serial number, operator, date and time
    - Nominal values: type of device, power, primary and secondary voltage or current
    - Parameters tolerances
    - For PT's: nominal tap voltages
    - Test result table, with comments about the test results OK or NO
    - Notes and comments

The program allows also to do the following:

- Upload or download test settings
- Upload or download test set calibration parameters

PADS software is subject to license, and it is available in three different licenses:

- PADS software Primary - Primary test, CTs and VTs Modules
- PADS Software Transformer - Power Transformer and Tan(δ) Modules
- PADS Full Suite - Primary test, CTs and VTs, Power Transformer and Tan(δ) Modules

	ATTENTION: The software runs with any WINDOWS© environment. Windows, EXCEL and Access are trademarks of Microsoft Corporation

4.3 Remote Safety Switch (code PII42175) and Warning Strobe Light (code PII43175)

The following image exhibits the Remote Safety Switch:

Figure 14 - Remote Safety Switch

This option applies to all STS XXXX models.

When the Remote Safety Switch is connected and enabled, it avoids any current or voltage generation from pressing START/STOP button on the STS only.

The cable length is 20 m.

The following image exhibits the Warning Strobe Light:

Figure 15 - Warning Strobe Light

This option applies to all STS XXXX models.

The Warning Strobe Light alerts when the test is performed. A siren is also included.

It has to be connected to the Safety Warnings (28) connector. The following image exhibits the (28) connector:

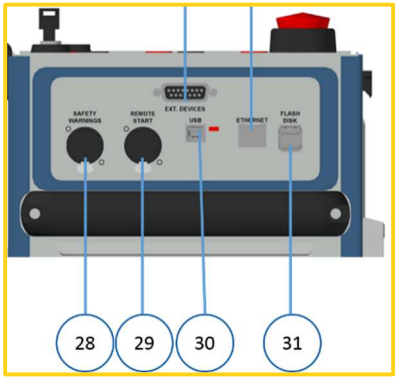


Figure 16 - Safety Warnings (28) connector

4.4 STCS Plus complete automatic windings option for power transformers (code PII33175)

This option applies to STS 5000 and STS 4000.

This option allows **with a single setup** all the typical tests that are performed on a power transformer. Moreover, only two cables (one for primary and one for secondary) are necessary to have a complete connection to the PT. Two remote heads (one with high current switches for short circuit impedance), included in the option, split the cable windings to the phase bushings. The cover of the STCS Plus it's removable.

The automatic tests performed on a PT by STCS Plus are the following:

- Ratio
- Winding resistance
- Short-circuit impedance
- OLTC dynamic test
- No Load current
- Vector group
- Demagnetization

The following image exhibits the STCS Plus option and heads, PII64175 (Head switch) and PII69175 (Junction head):

Figure 17 – STCS Plus option and heads

STCS allows performing automatically the tests.

Advantages:

- Fast measurement and single set-up for all the tests
- Low probability of connection errors

The STCS Plus option includes the following:

- The input sockets to all the STS outputs involved in the tests
- The connections of the active output to the HV or LV sides of the PT under test
- The connection to all the STS measurement inputs
- Two relays for the Tap Changer Up and Down commands up to 240 V, 1 A AC, or up to 110 V, 0.1 A DC
- The connector to the STS EXT. DEVICE connector
- The connector (on LV or HV side) for the head switches

Characteristics	Value
Weight	12,7 kg
Dimensions	480 x 380 x 230 mm
Maximum Voltage	400 V
Maximum Current	6 A

The STCS Plus option comes with the following connection cables and accessories:

Cable or accessory	Characteristics
No. 1 Ground cable	6 m long, terminated with terminator and clamp
No. 1 Multi pole cable for Head Switch	15 m long, cross section 10mm, mounted on a support wheel. Terminated with multi pole connector for the Head Switch on one side, and with 8 multi-color banana plugs and switch connector for STCS Plus module on the other side
No. 1 Multi pole cable for Junction Head	15 m long, cross section 10 mm, mounted on a support wheel. Terminated with multi pole connector for the Head Switch on one side, and with 8 multi-color banana plugs for connection with STCS Plus module on the other side
No. 8 “Kelvin” type clamps	For the connection to the PT bushings
No. 8 Cables for connecting heads to the transformer bushings	Two poles cables 5m long, for connection from the head to the transformer. Terminated with a connector on head side and two banana plugs on the other side to connect the cable to a “Kelvin” type clamp
No. 4 High current cables	Single pole cables, 4m long, to connect the Head Switch to the transformer. Cross section 50 mm^2. These cables are necessary for a correct execution of the Short Circuit Impedance test , as specified in IEEE C57-152 standard
No. 1 Multi pole cable	10m long, 4 poles, used for the connection to the tap changer device of the transformer. Terminated with four banana plugs on both sides
No. 6 adaptors	From banana to terminal
No. 2 High Voltage cables	2 m long, one red and one black, terminated on one side with the HV connector for STS 5000 output, and on the other side with 4 mm banana plugs
No. 10 Cables	2 m long, five red and five black, for the connection to: 6 A DC current generator, 70/140 V AC generator, 300 V AC meter, 10 V DC meter, 10 A meter. Cables are terminated on both sides with 4 mm banana plugs
No. 1 Data cable	To the EXT. DEVICES connector of STS, 2 m long
No. 1 PII64175 - Head switch	This head provides to connect the single cable coming from the STCS Plus module to a transformer side (HV or LV) through 4 connectors for the cables to bushings. It provides also to perform a “local” short circuit for Short Circuit Impedance test using internal high current switches and high current cables, allowing a single setup for testing transformers. The cover of the Head Switch it’s removable
No. 1 PII69175 - Junction head	This head provides to connect the single cable coming from the STCS Plus module to a transformer side (HV or LV) through 4 connectors for the cables to bushings
No. 10 Fixing straps	To fasten cables to the transformer
No. 1 Transport cases	Equipped with wheels. To transport in one set all the cables, accessories and heads

Figure 18 – STCS plus cables

	ATTENTION: The cables in the following list come as standard with STCS Plus

4.5 STCS automatic connection windings module (code PII12175)

This option applies to STS 5000 and STS 4000.

It is applicable when it is necessary to perform one of the following tests on PT:

- Ratio
- Winding resistance
- Short-circuit impedance
- OLTC dynamic test

The following image exhibits the STCS option:

Figure 19 – STCS option

STCS allows performing automatically the tests.

Advantages:

- Fast measurement set-up
- Low probability of connection errors

The STCS option includes the following:

- The input sockets to the STS outputs
- The connections of the active output to the HV or LV sides of the PT under test
- The connection to the STS measurement inputs
- Two relays for the Tap Changer Up and Down commands up to 240 V, 1 A AC, or up to 110 V, 0.1 A DC
- The connector to the STS EXT. DEVICE connector

The STCS option comes complete with the following connection cables:

Cable	Characteristics
No. 10 cable reels	Marked with different colors, 15 m long
No. 2 High Voltage cables	2 m long, one red and one black, terminated on one side with the HV connector, and on the other side with 4 mm banana plugs
No. 6 Cables	2 m long, three red and three black, for the connection to: DC current generator, 300 V AC meter, 10 V DC meter. Cables are terminated on both sides with 4 mm banana plugs
No. 1 data cable	To the EXT. DEVICES connector of STS, 2 m long
No. 6 adaptors	From banana to terminal
No. 8 “Kelvin” type clamps	For the connection to the PT bushings
No. 1 Ground cable	6 m long, terminated with terminator and clamp
No. 1 Transport cases	

Table 58 – STCS cables

	ATTENTION: The cables in the following list come as standard with STCS; they can also be ordered separately

4.6 STCS power generator Booster 20 A DC (code PII32175)

This option applies to STS 5000 and STS 4000 and must be connected to the STCS, which controls the option itself.

The STCS Booster 20 A DC allows to perform winding resistance tests up to 20 A DC on a PT.

The following image exhibits the STCS Booster 20 A DC option:

Figure 20 - STCS Booster 20 A DC option

The module characteristics are the following:

- Maximum output current: 20 A DC
- Maximum power on output sockets: 400 W
- Current output switch: controlled by STCS
- Current output amplitude: controlled by STS 5000 or STS 4000

The option comes complete with the following connection cables:

- No. 2 interface connection cables to STCS
- No. 1 Booster power cable, to connect the option to the STS
- No. 1 Power supply cable
- No. 2 cables, 2 m long, one red and one black

4.7 STDE residual magnetization removal module (code PII27175)

This option allows neutralizing the residual magnetization of the power transformer core after the winding resistance test. The connection to STS is mandatory.

The following image exhibits the STDE option:

Figure 21 - STDE option

The principle of the option is to apply a DC voltage with alternate polarity to the transformer winding, following the IEEE 62-1995 standard.

The following table lists the STDE main characteristics:

Characteristic	Note
Generator	Constant current, voltage limited
Maximum test current	7 A DC
Maximum test voltage	70 V DC
Current resolution	7 mA
Output current stability	Better than 0,5% of the rated value
Case	Plastic case with handle
Connections	• Connection to the STS control connector • Two sockets to the STS DC output • Two sockets to the transformer to be de-magnetized
Cables	• No 1 interface connection cable to STCS, 2 m long • No 6 Cables, 2 m long, one red and one black, for the connection to the STS • No. 2 Cables, 10 m long, for the STDE current output to the device under test

Table 59 – STDE main characteristics

4.8 STSA Surge Arrester (code PII46175)

The following image exhibits the STSA Surge Arrester:

Figure 22 - STSA Surge Arrester

This option applies to STS 5000 and STS 4000.

The option limits voltage surges generated at the DC Voltage input measurement if, during the winding resistance test, the circuit is erroneously opened. In this event, the sudden opening of a circuit involving a large inductance generates a high voltage surge, which could disturb the instrument operation, or even damage it.

The option includes a surge arrester plus two fuses. If the impulse has a normal energy, this energy is dissipated by the surge arrester, and there is no permanent damage; if, instead, the energy is too high, the arrester is short-circuited, and fuses blow.

The option has the dimensions 35 x 70 x 20 mm; it is connected to STS 10 V measure output with two 4-mm banana plugs.

4.9 BUX 2000, BUX 3000, BUX 5000 current booster (codes PII56175, PII50175, PII63175)

The optional current boosters BUX 2000, BUX 3000 and BUX 5000 allow performing tests up to respectively 2.000 A, 3.000 A and 5.000 A.

For BUX 5000 it is also possible to perform tests up to 7.000 A (without clamps and with cables short circuited), using the primary supply input called “BUX 7000” and selecting “Ext 7kA” in the “Settings/Hardware Info” panel (Ref to Chapter 13).

This option applies to STS 5000 and STS 4000.

The following images exhibit the BUX 3000 and BUX 5000 options:

Figure 23 - BUX 3000 option

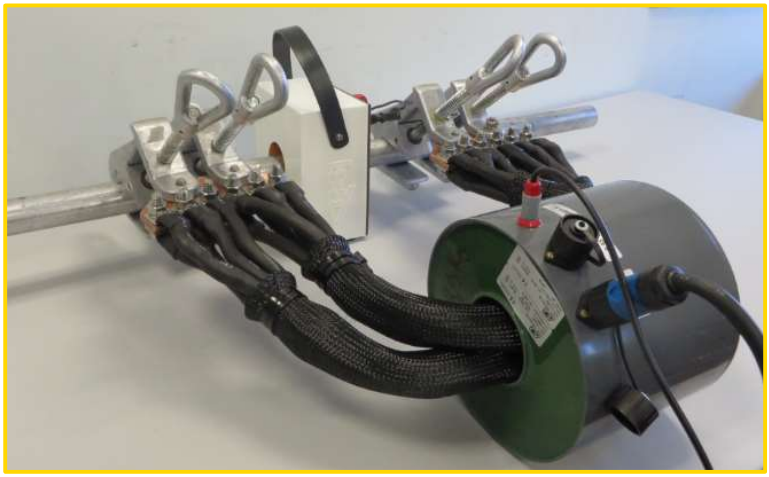


Figure 24 - BUX 5000 option connected to a CT under test

The high current booster option allows performing the following tests:

- Manual measures, whenever AC current is necessary
- CT ratio, polarity and burden
- Earth Resistance, Step and Touch and Line Impedance tests
- High current relay tests

The option includes the connection cable to the CT under test, and the connection clamps.

The option avoids 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 CTs in the field, which are some meters tall.

BUX 5000, BUX 3000 and BUX 2000 characteristics are the following:

- Output current available 20 m far from the STS control unit
- Frequency: 15÷500 Hz (The output amplitude may decrease for frequency below 50 Hz and above 60 Hz)
- Output current metering ratio: 1.000/1 A for BUX 2000 and BUX 3000, 4.000/1A for BUX 5000
- Accuracy class: typical ±0,1% of reading ±0,1% of range; guaranteed ±0,2% of reading ±0,2% of range
- High current cable, made of 4 cables, 95 mm^2, 1,2 m long, with 2 high current clamps for BUX 3000
- High current cable, made 4 cables, 95 mm^2, 2 m long, with 2 high current clamps for BUX 2000
- High current cable, made 12 cables, 95 mm^2, 0,8 m long, with 4 high current clamps for BUX 5000
- High current cables and clamps weight: 11 kg for BUX2000, 8,2 kg for BUX 3000, 14 kg for BUX 5000
- BUX 2000 output voltage (2 turns, 2.000A): 2,6 V
- BUX 3000 output voltage (1 turn, 3.000 A): 1,6 V
- BUX 5000 output voltage (1 turn, 5.000 A): 1,3 V
- BUX 5000 output voltage (2 turn, 2.500A): 2,6 V
- BUX 5000 output voltage using 7.000 A primary supply (1 turn, 7.000 A, cables short circuited without clamps): 0,95 V
- BUX 5000 weight: 19 kg
- BUX 3000 weight: 18 kg, including the 20m cable from STS to the BUX
- BUX 2000 weight: 18 kg, including the 20m cable from STS to the BUX
- BUX 2000 and BUX 3000 Dimensions: external diameter 190 mm; height 120 mm
- BUX 5000 Dimensions: external diameter 200 mm; height 170 mm

The high current clamps for the connection to the bar, have the following characteristics:

- Material: aluminum
- Opening range: from 5 to 60 mm
- Short-circuit current rating: 41 kA ÷ 1 s
- Applicable standard: EN 61230
- Hole to lift the clamp to the gate, and ring to tight from the bottom

The BUX options are provided with the following cables:

- No. 1 Voltage supply cable, 20 m long, 2 wires. Terminated on one side with a connector for the eKAM EXT. BOOSTER output and on the other side with a connector for the BUX module
- No. 1 Metering cable, 20 m long, 2 wires. Terminated on one side with a connector for the 3 V AC input of eKAM and on the other side with the connector for current measurement of the BUX module. The cable includes a shunt, which converts the output current into voltage

The following table lists the maximum test currents and durations for power supply of 110 V for BUX 2000:

Test current [A]	Output power [VA]	On duration [s]
500	700	Infinite
1.000	1.500	600
1.300	2.400	200

Table 60 - Max test currents and durations (110 V) for BUX 2000

The following table lists the maximum test currents and durations for power supply of 230 V for BUX 2000:

Test current [A]	Output power [VA]	On duration [s]
500	700	Infinite
1.000	1.500	60
2.000	5.000	25

Table 61 - Max test currents and durations (230 V) for BUX 2000

The following table lists the maximum test currents and durations for power supply of 110 V for BUX 3000:

Test current [A]	Output power [VA]	On duration [s]
500	300	Infinite
1.000	900	Infinite
1.500	1.500	1.200
2.000	2.400	300

Table 62 - Max test currents and durations (110 V) for BUX 3000

The following table lists the maximum test currents and durations for the power supply of 230 V for BUX 3000:

Test current [A]	Output power [VA]	On duration [s]
500	300	Infinite
1.000	900	Infinite
1.500	1.500	1.200
2.000	2.400	300
2.500	3.400	120
3.000	4.800	60

Table 63 - Max test currents and durations (230 V) for BUX 3000

The following table lists the maximum test currents and durations for power supply of 110 V for BUX 5000:

Test current [A]	Output power [VA]	On duration [s]
500	300	Infinite
1.000	900	> 30 min.
1.500	1.800	1.200
2.000	2.400	300

Table 64 - Max test currents and durations (110 V) for BUX 5000

The following table lists the maximum test currents and durations for the power supply of 230 V for BUX 5000:

Test current [A]	Output power [VA]	On duration [s]
500	600	Infinite
1.000	1.200	> 30 min.
1.500	1.800	1.200
2.000	2.400	300
2.500	3.000	120
3.000	3.600	30
4.000	4.800	20
5.000	6.300	10

Table 65 - Max test currents and durations (230 V) for BUX 5000

4.10 Current Clamp (code PII16102)

The following image exhibits the Current Clamp option:

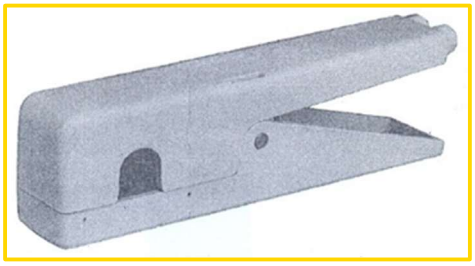


Figure 25 - Current Clamp

This option applies to STS 5000.

The current clamp avoids opening the secondary current circuit when performing the primary test of CT burden.

The following table lists the Current Clamp main characteristics:

Characteristic	Value
Ratio	1 A//1 mA
Maximum primary current	100 A
Maximum cable diameter	12 mm

Table 66 - Current Clamp main characteristics

4.11 PLCK Polarity Checker (code PII41175)

This option applies to STS 5000 and 4000 models.

The following image exhibits the PLCK option:

Figure 26 - PLCK option

The PLCK Polarity Checker has three colored LED:

- Pass (GREEN).Indicates the right polarity
- Fail (RED).Indicates the wrong polarity
- Low Battery (BLUE). If it blinks, the battery has reached the first low voltage threshold; the fixed light indicates the second low voltage threshold, in this case the battery should be changed

The detection range of the PLCK Polarity Checker is from 40 mV to 300 V. If a low or distorted signal is detected, both Pass and Fail LEDs blink. To check the polarity on a very low impedance (e.g. the current terminals of a numeric relay), is possible that the voltage drop is much less than 40 mV even when the maximum possible current is generated; in this case check the polarity including the connection cables to the relay, in order to increase the voltage drop.

4.12 STLG current injection power transformer for ground tests (code PII70175)

This option applies to STS 5000 and 4000 models.

The following image exhibits the STLG option:

Figure 27 - STLG option

It is a high power, five taps transformer, which acts as an impedance adaptor, increasing the impedance at high test currents. A high current switch allows selecting the desired current range. A voltage meter displays the generated voltage or the voltage on the line due to the inductive couplings.

Output current and voltage are measured and sent back to STS measuring inputs; a third output allows STS to understand which one is the selected range.

The STLG option characteristics are the following:

- Input: form STS 5000, via the booster connector
- Output current ranges: 11, 22, 35, 55, 105 A AC. Corresponding no-load voltages: 540, 270, 160, 108, 55 V
- Output current connection: via high current sockets
- Output power: 1.800 VA steady; 5.500 VA peak for 5 s, 5.200 VA on the 105 A range
- High current selector switch, to connect the selected tap to the output current sockets
- Analogue voltage meter, to display the voltage at the output sockets. Range: 600 V AC
- Outputs to STS XXXX:
    - Selected current output range, to the 10 V voltage input
    - Output current, to the 10 A current input
    - Output voltage, to the 300 V voltage input
- Transport case: black plastic case, with handles
- Weight: 25 kg
- Dimensions: 23 x 33 x 44 cm

All the followings connection cables are included in the option:

- No. 1 Cable, 6 m long, for the connection of the STS BOOSTER connector
- No. 2 Cables, 6 m long, for the current output connection, terminated with “Kelvin” type clamps
- No. 6 cables, red and black, 6 m long
- No. 1 cable for the connection of the STLG voltage meter output to the STS 300 V meter
- No. 1 bridge, to short circuit the current meter output if it is not connected to STS XXXX
- Cable transport case

	ATTENTION: For safety reasons, STLG must always acts together with the STSG option

4.13 Power factor correction module (code PII85175)

This option is applicable only the STLG option. It is a module to increase the current in the grounding and step and touch tests; the module has many capacitors and it allows to reduce the reactive component of the line, to obtain the increasing of the STLG test generated current.

- Dimensions: 325L, 295A, 285P. Aluminum case with handles
- Weight: 12 kg
- Selectable capacitance nominal values: 600 µF, 400 µF, 200 µF, 150 µF and 100 µF
- Maximum voltage: 600 V (range 100 µF and 150 µF) , 450 V on the others
- Maximum current: 60 A

4.14 STLG large station (code PII88175)

The following image lists the kit elements:

Element	Description	Photo
STLG PII80175	• Transport case with wheels PII19175 • Standard cable kit PII75175 with case	
STSG PII71175	• No. 3 cable connection studs (diameter 20 mm) PII72175 • No. 3 surge arresters (N°3x PII77175 • Transport case with wheels	
RCLG PII85175	• Cable for series connection to STLG • Transport case with wheels	
Transport trolley	No. 1 Stainless steel transport trolley **PII18175** for the handling of the test set and of the STLG option	
Portable Handheld Multimeter	No. 1 Mod. KEYSIGHT U1271A • Count up to 30,000 (4 digits 3/4) • Analogue scale display • Impedance 10MR • Measures TRUE RMS and CC of A, V; it measures Hz, Ω, mΩ, mA, capacitance and temperature • Operating temperature (-20÷+55) °C; humidity 0÷80% • CAT III 1000 V; CAT IV 600 V • Accuracy V CA 0.7% + 20 counts • Accessories: probes, thermocouple, 4 AAA batteries, calibration certificate, quick start guide	
Step and touch resistive selector with active filter	No. 1 Box with resistances 1kR for multimeter which includes an active filter to make the measurements of step and touch voltage at 80 Hz. Code PII87175	
Clamp meter with multimeter	No. 1 Mod. Chauvin Arnoux F203 • Measures CA TRUE RMS, MISURA CC • Voltage measure CAT III 1000V • Scale 60 A e 600 A AC; 60 A, 600 A e 900 A in CC Accuracy 1% up to 599.9 A AC e 900 A CC • Opening 34mm	
Power cable	No. 1 Power cable for control units, 2,5 mm^2 section, 50 m long, mounted on cable reel with wheels	

Table 67 – Kit elements (1/2)

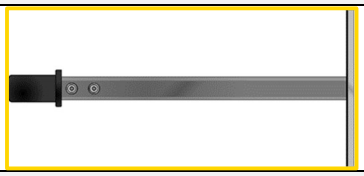
Element	Description	Photo
Additional power cables	No. 2 flexible cables, cross section 10 $mm^{2,}$ 50 m long, for the connection of the power output, mounted on the cable-winding with wheels	
Measure cables	No. 10 cables, 2,5 mm^2, 100 m long, each mounted on its reel; terminated with banana and with securing sleeve 4 mm	
250 N electrodes	No. 2 probes platform, with weights up to 250 N	
Tip electrodes	No. 2 tip electrodes, 0,5 m, with 4 mm sockets	
Grounding cable	No. 1 cable, 16 $mm^{2,}$ 25 m long, yellow green, mounted on its reel with wheels	
Clamps	• No. 3 phase clamps in light alloy with clamping up to 65 mm, with stem ring for laying and removal of cylindrical conductors from 5 mm to 65 mm (diameter) • No. 1 Grounding clamp, with tightening capacity up to 35 mm on cylindrical conductors	
Switching Stick Kit	No. 1 Kit compliant to CEI EN 61230, CEI EN 61235, CEI EN 60855, CEI EN 50508; in three parts, for voltages ≤380 kV	
Connection cables for phase clamps	No. 3 Cable 10 m, section 10 mm^2; terminated on one side with lugs for connection to phase clamps and the other side with clamps suitable for the connection with STSG	
Stabilized power supply	No. 1 stabilized power supply, input voltage 230 V 50 Hz, output voltage 0÷30 V CC 0÷20 A PII86175	
Power cable reels	No. 2 flexible cables 50 m long, section 2,5 mm^2. Lug 2P+T 16A 230V IP44; 2 sockets 2P+T 16A 230V IP44; 1 German/bi-pass socket 2P+T 16A IP44 + circuit breaker	
Line synchronization	No. 1 Line synchronization PII24156	

Table 68 – Kit elements (2/2)

4.15 STSG safety grounding module (code PII71175)

This option applies to STS 5000 and STS 4000; it is used with the STLG option, to increase the operator safety.

The following image exhibits the STSG option:

Figure 28 - STSG option

During tests, STLG is connected to the out of service overhead line to be tested. The purpose of the STSG device is to protect the operator against possible high voltage spikes during the operations.

STSG incorporates three voltage suppressors (one for each line) and one high current switch, to connect the three lines in parallel when necessary.

The STSG option characteristics are the following:

- Nominal AC spark-over voltage : <1.000 V_{rms}
- Impulse spark-over voltage : <2.000 V_{peak}
- Short-circuit proof with 25 kA_{eff}/100 ms; 36 kA_{eff}/75 ms
- Connection via three cylindrical studs 16, 20 or 25 mm diameter, for the clamps connection. Each stud is connected to the voltage suppressor. The stud dimensions must be specified at order
- Tightening torque: ≥15 Nm
- Metallic aluminum box with handle
- Weight: 9,1 kg (with grounding cable)
- Dimensions: 41 x 21 x 13,5 cm
- Grounding cable, included: 95 mm^2, 2m; terminated with a universal clamp

The device must be connected to the ground and to the HV line.

	ATTENTION: Connection cables to the HV line are not included in the option

4.15.1 Cylindrical studs

The following table lists the studs for the STSG option:

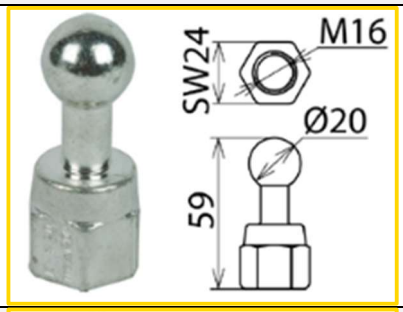
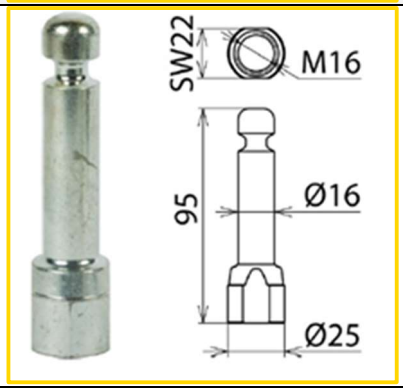
Stud code	Drawing	Characteristics
PII72175		max short circuit current: 0,5 s: 33,5 kA max short circuit current: 1,0 s: 23,7 kA
PII73175		max short circuit current: 0,5 s: 42,0 kA max short circuit current: 1,0 s: 29,6 kA
PII74175		max short circuit current: 0,5 s: 42,0 kA max short circuit current: 1,0 s: 29,6 kA

Table 69 - Studs characteristics

4.15.2 Surge arrester for STSG (code PII77175)

If a high voltage spike occurs on the line during the execution of the tests, the STSG surge arresters must be replaced.
Technical characteristics:

- Nominal AC spark-over voltage : < 940 Vrms
- Impulse spark-over voltage : < 1.600 Vpeak
- Short-circuit proof with 25 kAeff/100 ms; 36 kAeff/75 ms

4.16 Ground Grid Test Accessories Kit (code PII76175)

The following image exhibits the Ground Grid Test Accessories Kit:

Figure 29 - Ground Grid Test Accessories Kit

This option applies to STS 5000 and STS 4000 models.

The following table lists the elements of the Ground Grid Test Accessories Kit:

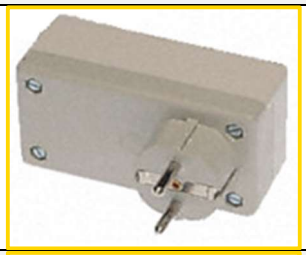
Quantity	Element	Characteristic
2	Earth Screw	0,95 m long, with 4 mmm sockets
1	Spanner	To screw the spike into the ground
4	Earth electrode	0,5 m long, with 4 mmm sockets
1	Transport bag	To carry earth spikes, electrodes and spanner
3	Cable	1,5 mm^2, 200 m long, mounted on reel, terminated on one side with safety 4 mm socket and on the other side with safety 4 mm banana plug
2	Rectangular probe	With shaft 0.8 m long, with safety 4 mm sockets. Material: zinc-plated iron, dimensions 250 x 120 mm, thickness 10 mm, with rubber protection on the foot, on the rod and on the handle, and two safety sockets. The surface in touch with the ground is limited to 300 cm^2
1	Line synchronizer	
1	Digital multimeter CAT III 600V, TRUE RMS, Accuracy AC ±1 % +3 digits	
1	Resistance selector for Step and Touch test	

Table 70 - Elements of the Ground Grid Test Accessories Kit

4.17 Current Clamp Meter (code PII79175)

The following image exhibits the current clamp meter:

Figure 30 – Current Clamp Meter

When it is necessary to use the STSG and STLG options to execute the test, the options are connected to a transmission line. The line is put out of service, and connected to earth on both sides. Before connection to the HV line, it is necessary to measure the current flowing into the ground connections, using a clamp meter, to evaluate the residual voltage coupling.

The following table lists the Current Clamp Meter main characteristics:

Characteristic	Value
Maximum current	400 A AC
Digits	4
Accuracy	± 2 % + 5 digits
Clamp opening	37 mm

Table 71 - Current Clamp Meter main characteristics

4.18 Foldable Trolley (code PII18175)

The following image exhibits the Foldable Trolley:

Figure 31 - Foldable Trolley

This option applies to all STS XXXX models.

The trolley eases the handling of STS XXXX + TD 5000. The trolley hosts both instruments and the HV cable for TD 5000.

When not used, it can be folded, to minimize the volume.

The following table lists the main characteristics:

Characteristic	Value
Material	Stainless Steel
Weight	19 kg
Dimensions (closed)	68 x 34 x 106 cm
Wheel dimensions	Ø 25 x 9 cm

Table 72 - Trolley characteristics

4.19 SFRA 5000 Sweep Frequ. Resp. Analyzer (code PII90175)

SFRA 5000 is a standalone sweep frequency response analyzer for the high accuracy transformer analysis and integrates the STS XXXX + TD 5000 family test sets. The SFRA 5000 offers both high precision and portability in a single package, providing all the accessories required for fast, easy to use, reliable and repeatable measurements.

SFRA 5000 is provided with its own embedded software, giving the possibility to the engineer to zoom into a portion of the sweep in order to inspect any differences in the plot in more detail during or after a sweep.

The following image exhibits a SFRA 5000:

Figure 32 – SFRA 5000

Optionally, it is possible to use the PADS software (in the TDMS suite).

4.20 TD 5000 module for the Tan(δ) loss angle factor measure (code PII11175)

This option applies to all STS XXX models. The following image exhibits the TD 5000:

Figure 33 - TD 5000

The basic TD5000 function is to generate voltages to test the quality of insulation.

The High Voltage generator TD 5000 performs the measurement of the Tan(δ), of the dissipation factor and of the capacitance of on CT, VT, PT (transformer or bushings) ,CB, motors and generators (RCTD needed) at the frequency of the mains or in a wide frequency range. The measurement is performed by the module, which is equipped with a patented measurement circuitry; the result is sent to STS Family.

The measurement circuitry incorporates a reference high voltage capacitor, rated 200 pF, with the following: a variation better than 0.05%/year, a temperature factor better than and 0.01%,/°, and a Tan(δ) better than 0.005%, and a reference resistor bridge, with accuracy better than 0.01% and thermal drift less than 1 ppM/°C. The patented circuitry and the variable frequency output make test results immune from external noise, even in the very highly noisy environment. The noise it is suppressed using a narrow bandwidth numerical filter. In case of a test frequency equal to the line frequency, the measurements are automatically performed at different frequencies (F_{line} ± 4 Hz).

Before each test the TD5000 automatically checks and calibrates itself with the internal reference capacitor.

The maximum interference conditions at line are the following:

- Electromagnetic: 500 µT, at 50 or 60 Hz in any direction
- Electrostatic: 15 mA rms of the interference current into any lead or cable with no loss of measurement accuracy. Applicable to a maximum ratio of interference current to specimen current 20:1

The module has two panels on the sides, and one below: one for the connection to the power supply, the other for the IN-A (UST-A) and IN-B (UST-B) measurements, and the other for the output connection.

The following image exhibits the power supply on the side:

Figure 34 - Power supply on the side

The following image exhibits the IN-A (UST-A) and IN-B (UST-B) measurements on the side:

Figure 35 - IN-A (UST-A) and IN-B (UST-B) measurements on the side

The following image exhibits the HV output on the front panel:

Figure 36 - HV output on the front panel

It is possible to see that there is one HV connector, and there are two metering inputs. This allows the Tan(δ) measurements of all points with one connection. Besides, the IN-A (UST-A) and IN-B (UST-B) can be used as control points to avoid the measure of parasitic capacitances.

TD 5000 is powered and automatically controlled by STS. During tests, the high power, not isolated STS voltage output is connected to TD 5000.

The HV generator (maximum power 3.6 kVA) has an electronic control not dependent from the mains and the following table lists its main characteristics:

Maximum output voltage [V]	Output current [mA]	Maximum output duration	Frequency [Hz]
12.000	300	240 s	1÷500
	125	> 1 h	
	100	steady	

Table 73 - HV generator main characteristics

	ATTENTION: At 10 kV, the output (current value and duration) has the same characteristic

The following table lists the voltage and current output measurement accuracy and resolution:

Internal measure	Resolution	Typical accuracy		Guaranteed accuracy	
		± % (rdg)	± % (rg)	± % (rdg)	± % (rg)
12.000 V AC	1 V	±0,2%	±0,5 V	< 0,3%	+1 V
5 A AC (@ inputs A or B> 10 mA)	0,1 mA	±0,2%	±0.1 mA	< 0,5%	< 0,5%
<10 mA AC (@ inputs A or B)	0,1 µA	±0,2%	±0,1 µA	< 0,3%	+0,1 µA

Table 74 - voltage and current output measurement accuracy and resolution

The following table lists the frequency characteristics of TD 5000:

Range	Accuracy
1÷500 Hz	50 ppM typical; 100ppM maximum

Table 75 - Frequency characteristics of TD 5000

The connections of the TD 5000 are the following:

- HV panel for the connection of the double shielded safety cable
- TD 5000 Ground socket
- Two measurement sockets (IN A and IN B)

The available test selections are the following:

- Ungrounded: UST-A; UST-B; UST A+B
- Grounded: GST; GSTg-A; GSTg-B; GSTg-A+B

The following table lists the derived measurements from the measurements of V and I:

Measurement	Characteristics
Capacitance	Measurement range 1: from 0 pF to 5 µF. Resolution: 6 digits. Accuracy, typical: ±0,03% of the value ±0,1 pF; guaranteed: <0,1% of the value +1 pF (from 45 to 70 Hz) Measurement range 2: from 5 µF to 200 µF. Resolution: 6 digits; accuracy, typical: ±0,1% of the value ±0,1 nF; guaranteed: <0,5% of the value ±1 nF
Tan(δ) (dissipation factor DF)	• Measurement range 1: from 0 to 10% (capacitive). Resolution: 5 digits; accuracy, typical: 0,05% of the value ±0,005 %; guaranteed: 0,1% of the value ±0,005 % (from 45 to 70 Hz, current < 10 mA) • Measurement range 2: from 0 to 100%. Resolution: 5 digits; accuracy, typical: 0,3% of the value ±0,01 %; guaranteed: 0,5% of the value ±0,02 % • Measurement range 3: over 100%. Resolution: 5 digits; accuracy, typical: 0,5% of the value ±0,03 %; guaranteed: 0,8% of the value ±0,05 %
Power factor PF (cos(ϕ))	• Measurement range 1: from 0 to 10% (capacitive). Resolution: 5 digits; accuracy, typical: 0,05% of the value ±0,005 %; guaranteed: 0,1% of the value ±0,005 % (from 45 to 70 Hz, current < 10 mA) • Measurement range 2: from 0 to 100%. Resolution: 5 digits; accuracy, typical: 0,3% of the value ±0,02 %; guaranteed: 0,5% of the value ±0,02 %
Impedance	From 1 kΩ to 1.400 MΩ. Accuracy, typical 0,3% of the value ±0,1%, guaranteed <0,5% of the value. Resolution: 6 digits
Power (Dielectric Losses)	Measurement ranges: from 0 to 10 kW or 100 kW or 1 MW. Resolution (6 digits): 0,1 mW; accuracy: <0,5% of the value ±1 mW
Inductance	• Measurement range 1: from 1 H to 10 kH. Resolution (6 digits): 0,1 mH; accuracy, typical: 0,3% of the value ±0,5 mH; guaranteed: 0,5% of the value • Measurement range 2: from 100 H to 10 MH. Resolution (6 digits): 1 H; accuracy, typical: 0,3% of the value; guaranteed: <0,5% of the value

Table 76 - Derived measurements from the measurements of V and I

The same ranges and accuracies are applied to reactive and apparent power measurements.

Other characteristics:

- Dimensions: 440 (W) X 345 (H) X 210 (D) mm
- Weight: 25 kg

The following image exhibits the “PTs – Power Factor, Capacitance and Tan δ” page:

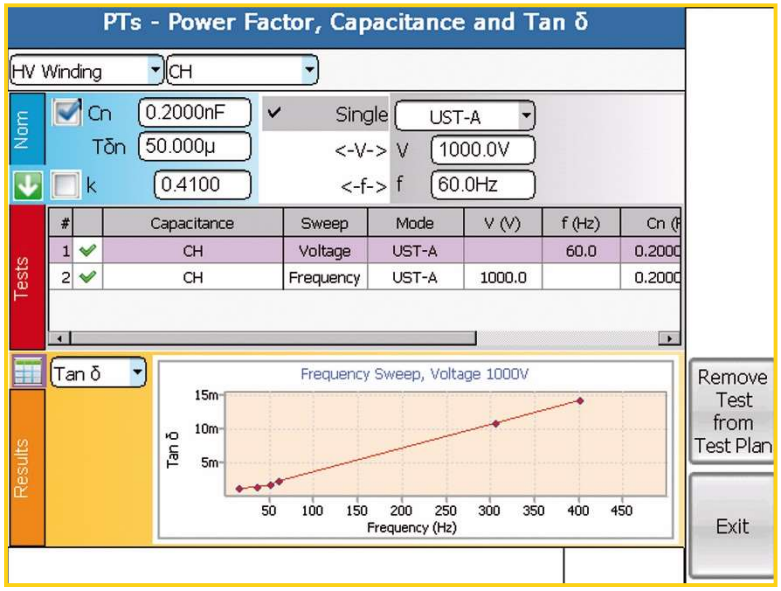


Figure 37 - "PTs – Power Factor, Capacitance and Tan δ" page

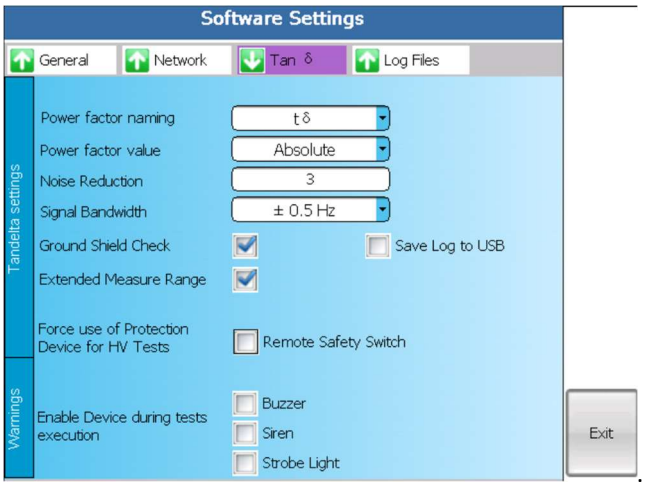
Customer can set different test, single shot, voltage sweep and frequency sweep. Selecting the test row and pressing start the test is automatically executed. At the end is possible to see directly on the screen numerical results and, for sweep test a graph of Tan δ or Capacitance as shown in picture. At the end is possible to save the test result inside the instrument memory or on an USB pen drive.

At the end of the tests, settings and results can be downloaded to a PC, with PADS program included in the TDMS suite, which comes with the device. The software allows saving test results into a file, examining them, printing them.

Optionally, PADS allows controlling the device from the PC. It is also possible to edit settings with PADS, and to upload them to STS.

In the picture above “k” is the temperature coefficient (5°C to 60°C , reference temperature 20°C) used to compensate the measures C and TD accordingly to the ANSI/IEEE C57.12.90 standard.
In the same test are calculated some equivalent parameters at different voltages (i.e. watt loss and current at 10 kV).

The Tan δ result can be displayed and calculated also as Power Factor, as absolute or percentage values ((% value = abs value * 100), depending upon the selections in Software Settings panel:



The following table lists the connection cables supplied with TD 5000 (they come as standard with the test set; however, they can also be ordered separately):

Cable	Characteristics
No. 1 yellow-green connection cable	6 m long, for the ground connections. Terminated with terminator on one side, and with a clamp on the other side
No. 2 yellow-green connection cables	1 m long, for the ground connections. Terminated with terminators
No. 1yellow-green connection cable	2 m long, for the ground connections. Terminated with terminators
No. 1 power cable	To the BOOSTERS connector of STS XXXX, 1 m long
No. 1 power cable	To the BOOSTERS connector of STS XXXX, 2 m long
No. 1 High voltage connection cable	20 m long, 25 kV, with earth screen, for the connection to the device under test. Terminated on the device side with an isolated banana plug, and on the TD 5000 side with two plugs: one for the HV and the other one for the ground
No. 1 clamp	25 mm opening, with a connector which mates with the HV cable with 6 mm plug
No. 1 bigger clamp	60 mm min. opening, with a connector which mates with the HV cable with 6 mm plug
No. 2 Shielded connection cables	20 m long, for the connection to the metering points. Terminated on the TD 5000 side with the metering connector, and on the device side with a 4 mm banana plug. Cables are mounted on wheels
No. 2 clamps	25 mm opening, terminated with 4 mm sockets, which allow connecting to the metering point
No. 2 Kelvin type clamps	60 mm opening, terminated with 4 mm sockets, which allow connecting to the metering point
No. 1 signals connection cable	To the EXT. DEVICES connector of STS XXXX, 1 m long
No. 1 signals connection cable	To the EXT. DEVICES connector of STS XXXX, 2 m long
No. 1 Transport Case	

Table 77 - Cables supplied with TD 5000

The following table lists the parasitic capacitances which exist in a three winding (two secondary) power transformer, in a two winding (one secondary) power transformer and in a bushing transformer:

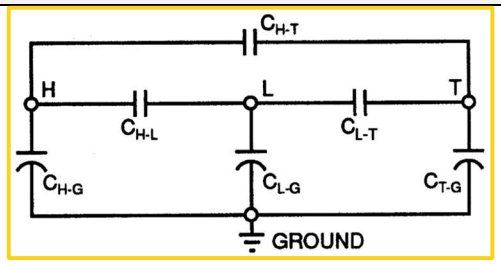
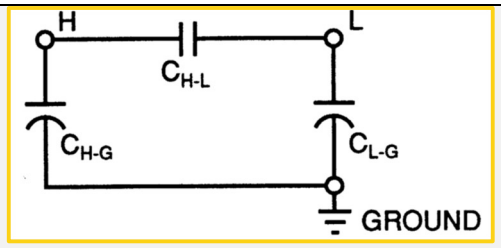
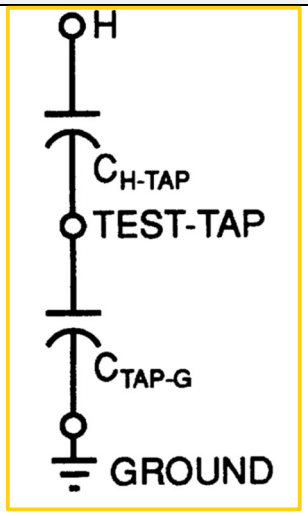
Transformer	Scheme	Terms
Three winding (two secondary) power transformer		• H = high voltage terminal • L = low voltage terminal • T = third winding • G = Ground • C(H-T): parasitic capacitance between High voltage and T • C(H-L): parasitic capacitance between High voltage and Low voltage • C(H-G): parasitic capacitance between High voltage and Ground • C(L-G): parasitic capacitance between Low voltage and Ground • C(L-T): parasitic capacitance between Low voltage and T • C(T-G): parasitic capacitance between T and Ground • C(H-Tap): parasitic capacitance between High voltage and Tap • C(Tap-G): parasitic capacitance between Tap and Ground • Test tap = test terminal
Two winding (one secondary) power transformer		
Bushing transformer		

Table 78 - Parasitic capacitances

4.21 CAP-CAL reference capacitor (code PII40175)

The following image exhibits the CAP-CAL reference capacitor:

Figure 38 - CAP-CAL reference capacitor

Purpose of the reference capacitor is to check the actual calibration of TD 5000 for the measures of the capacitance and Tan(δ).

The CAP-CAL includes an extremely high accuracy high voltage and low Tan(δ) capacitor. The device includes also 4 resistances to be connected to the capacitor in series mode, to generate some known Tan(δ) values.

The following image exhibits the connection of the CAP-CAL to the TD 5000:

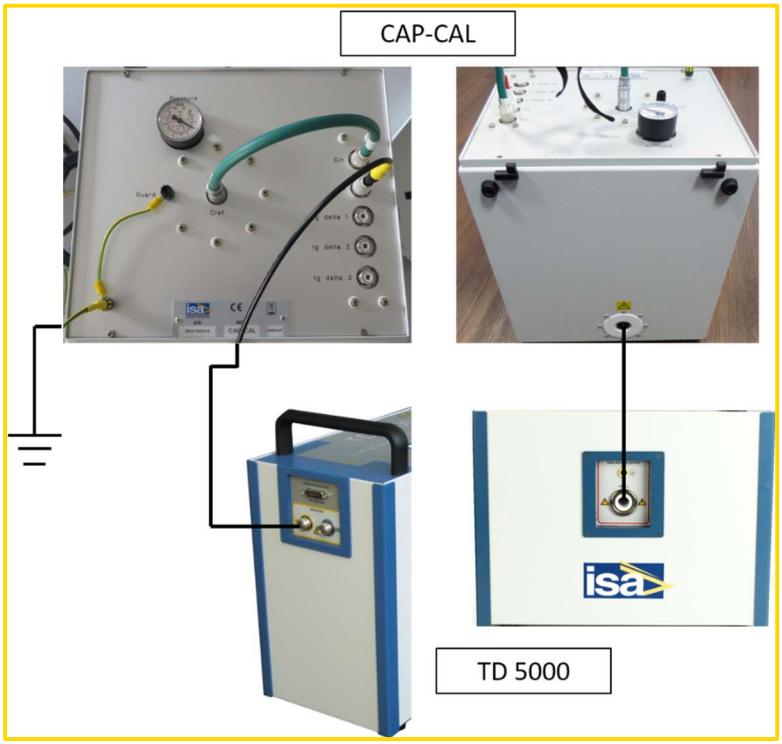


Figure 39 - Connection of the CAP-CAL to the TD 5000

A calibration certificate is issued by ISA laboratory and it is supplied together the CAP-CAL.

4.22 STOIL cell for the insulating oil check (code PII13175)

This option applies to TD 5000, to perform Tan(δ) test of the PT oil.

The following image exhibits the STOIL option:

Figure 40 - STOIL option

Cell characteristics are the followings.

- Maximum test voltage: 12 kV
- Cell volume: 1 l
- Empty cell capacity: (60±10) pF

The option comes complete with the following connection cables: No. 2 HV connection cables, 2 m long, terminated on the TD 5000 side with the HV connector, and on the other side with the proper termination for the cell.

4.23 Digital Thermo Hygrometer (code PII44175)

The following image exhibits the Digital Thermo Hygrometer:

Figure 41 - Digital Thermo Hygrometer

Some tests performed by STS, such as Tan(δ), are influenced by temperature and humidity. The option allows measuring these parameters, and to input them into the test settings.

The following table lists the main characteristics:

Characteristic	Value
Temperature range	(-10÷+60) °C (-50÷+250) °C with an external sensor
External temperature sensor	RTD Ni1000/6180 ppM, not included
Temperature measurement accuracy	±0.4 °C
Humidity measurement range	(5÷95)% RH
Resolution of humidity measurement	0.1%
Accuracy of humidity measurement	±2.5% RH over the whole range
Battery	9 V
Battery life	Typically 9 months
Dimensions	(141x71x27) mm
Weight	150 g

Table 79 - Digital Thermo Hygrometer main characteristics

4.24 RCTD reactor for motors and generators measures (Code PII47175)

This option applies to TD 5000 and allows increasing the test current and getting the maximum test voltage on high capacitive burdens.

The following image exhibits the RCTD option:

Figure 42 - RCTD option

Each RCTD is composed by two inductors with a nominal value of 40 H and a steady current of 0.6 A.

The maximum current on each inductor can be up to 1 A for more a limited time.

The inductors can be connected in parallel on the load in order to increase the test frequency.

It is possible to connect two RCTD in parallel in order to have three or four inductors connected in parallel.

The following table lists the RCTD characteristics:

Characteristic	Value
Weight	39 kg
Dimensions	23 x 44 x 28 mm

Table 80 – RCTD characteristics

The reactor has a standard cable kit (code PII48175) and the following table lists them:

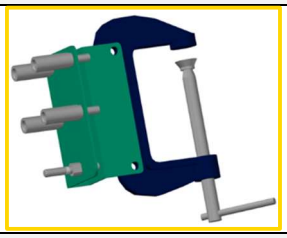
Cable	Characteristics	Scheme
No. 1 ground cable	6 m long, 6 mm^2 terminated with terminator and clamp	
No. 1 safety cable	To STS; 10 m long, 2x0,5 mm^2	
No. 1 “Safety IN” connector	For the safety loop closure	
No. 1 Safety cable	To connect another RCTD; 2 m long, 2x0,5 mm^2	
No. 1 clamp	Screw terminal, with plate for the HV connection	
No. 2 HV cables	5 m long, not shielded, terminated with 6 mm male connectors	

Table 81 – RCTD cables

4.25 RTD Capacitance for transformer ratio at high voltage (Code PII41185)

This option allows using high voltage generator TD 5000 to measure the turn ratio of the transformers.

Voltage values up to 12 kV can be generated and turn ratio precision is 0.1 %

5 PROTECTIONS

The protections of the STS XXXX are the following:

- 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 and a fixed led light
- Fuse on the mains supply
- Fuse on the low power current and voltage outputs
- Fuse on the current meter input
- The STS XXXX is protected against short circuit, overload and overvoltage
- 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
- Thermal sensor on the main transformer. In case of over-temperature, an alarm message is displayed
- Thermal sensor on the active electronic devices. 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
- The current measurement input is protected against wrong connections

REVISIONS

The following table lists the revisions of the document:

No.	Date	Description
1	January 2011	First issue
2	October 2011	Modified HV outputs, Tan(δ), low voltage, STCS
3	February 2012	Revised all options Added the oil test cell
4	January 2013	Final revision
5	April 2013	Improved the description of TD 5000
6	February 2014	Added the PLCK and the RCTD options
7	June 2014	Improved description of RCTD
8	July 2014	Added STCS Booster 20 A Winding Resistance Module option
9	October 2014	Added STSA images and STSA3V option
10	December 2014	Added STLG ground grid testing module Added STSG safety grounding module Revised
11	January 2015	Added the STDE demagnetizer option
12	February 2015	Added BUX 2000 option Added IEC61850-9-2LE function description Added long cables kit PII57175 Trigger options revised
13	July 2015	TD5000 option revised STOIL option revised
14	October 2015	Complete layout revision
15	July 2016	Added BUX 5000 option Added ALF/ISF test Added Vector Group test
16	September 2016	Minor edits
17	September 2016	Minor edits
18	October 2016	Ref. to ANSI/IEEE C57.12.90 standard
19	May 2018	Added STCS Plus Option
20	Mar 2020	Some details revised in chapter 2, LV Directive
21	September 2020	TD5000 characteristics update
22	September 2020	RTD option added

Table 82 - Revisions

LIST OF FIGURES

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S P E C I F I C A T I O N

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