GPS LTD.

TD-6900

Automatic Capacitance and Tan Delta Tester

0.5 to 10 kV · variable-frequency anti-interference · UST, GST, CVT · printer

Operating Manual

Issue 1

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1 Safety

Read this manual before first use. The TD-6900 produces up to 10 kV. Use it only within the limits in this manual. Maintenance and repair must be carried out only by qualified personnel.

> **Warning: the input and output terminals and the test leads can carry high voltage. Plugging in or removing a test lead or the mains lead can cause a spark. Risk of electric shock: follow the operating instructions.**

- Use only the mains lead supplied, or one of the same specification.
- The instrument is earthed through the mains lead, and its earth terminal must also be connected to a sound earth. Check the earth before connecting anything to the inputs or outputs.
- Do not connect or disconnect a test lead while it is connected to a live terminal.
- Do not unplug a measuring lead during a test: the test current would flow through your body to earth.
- Under strong interference, keep the cable earthed while you disconnect it, to prevent an induced shock.
- Observe the ratings and markings on the instrument. Use only a fuse of the type and rating specified.
- Do not operate with covers or panels removed. Do not touch exposed connections or energised parts.
- If you suspect a fault or damage, stop and contact GPS.
- Do not operate in wet or damp conditions or in an explosive atmosphere. Keep the surfaces clean and dry.
- When the instrument is controlled from a computer, keep the test area in view and make sure everyone is clear before starting a test.
- In an emergency, switch MAIN POWER off at once.

Warning: death or serious injury may result if the precautions are not taken. Caution: damage to the instrument or other property may result.

Standard practice, not stated in the source manual: switch HV POWER off and earth the test object before touching it or changing connections.

2 Introduction

Dielectric loss measurement is a basic insulation test. It detects moisture, ageing and local defects in the insulation of electrical equipment, and is used in manufacturing, installation, commissioning and preventive testing of transformers, instrument transformers, reactors, capacitors, bushings and arresters.

The TD-6900 measures tan δ and capacitance automatically. Its variable-frequency source outputs a pure sine wave and filters out mains-frequency interference, so it suits substations and other sites with strong electromagnetic interference. It measures ungrounded objects by the UST (positive) connection and grounded objects by the GST (reverse) connection, and measures C1 and C2 of a capacitor voltage transformer by the self-excitation method. An external standard capacitor and external high voltage can be used for high-voltage tests, and an oil cup for insulating oil where the loss is 0.01% or more.

Protection

- High voltage: short circuit, breakdown or a sudden change in high-voltage current cuts off the output.
- Low voltage: a wrong connection to 380 V, supply fluctuation or a sudden supply failure starts the protection without causing over-voltage.
- Earth: if the instrument is not properly earthed and the case carries a dangerous voltage, the earth protection operates.
- CVT: four limits (high-voltage voltage and current, low-voltage voltage and current). With a wrong menu setting no excitation voltage is output, and no 10 kV is output in the CVT method.

- Capacitance rise: on large test objects the instrument tracks the output and keeps the test voltage constant.

3 Specification

Item	Specification
High voltage output	0.5 to 10 kV in 500 V steps (20 levels) · capacity 1500 VA
Tan δ accuracy	± (1.5% of reading + 0.06%)
Capacitance accuracy	± (1.5% of reading + 5 pF)
Resolution	Tan δ 0.001% · capacitance 0.001 pF
Tan δ range	0.01% to 100%
Capacitance, internal HV	3 pF to 60,000 pF at 10 kV · 60 pF to 1 µF at 0.5 kV
Capacitance, external HV	3 pF to 1.5 µF at 10 kV · 60 pF to 30 µF at 0.5 kV
Test frequency	Single: 45, 50, 55, 60 or 65 Hz · dual: 50D (45 and 55 Hz) or 60D (55 and 65 Hz)
CVT ratio test	Ratio 10 to 99,999, ± 1% of reading · phase 0 to 359.9°, ± 0.1°
CVT excitation output	3 to 50 V, 3 to 30 A, from CVT1 and CVT2
Input current, Cx and Cn	10 µA to 5 A
Harmonic adaptation	≤ 3%
Records	Built-in thermal printer · 100 stored results with calendar clock · RS-232
Power supply	220 V AC ± 10%, 50/60 Hz ± 1 Hz · fuse 5 A / 250 V, φ5 × 20 mm
Operating environment	−15 °C to 50 °C · relative humidity below 80%
Dimensions	460 × 345 × 345 mm
Weight	35 kg

4 The instrument

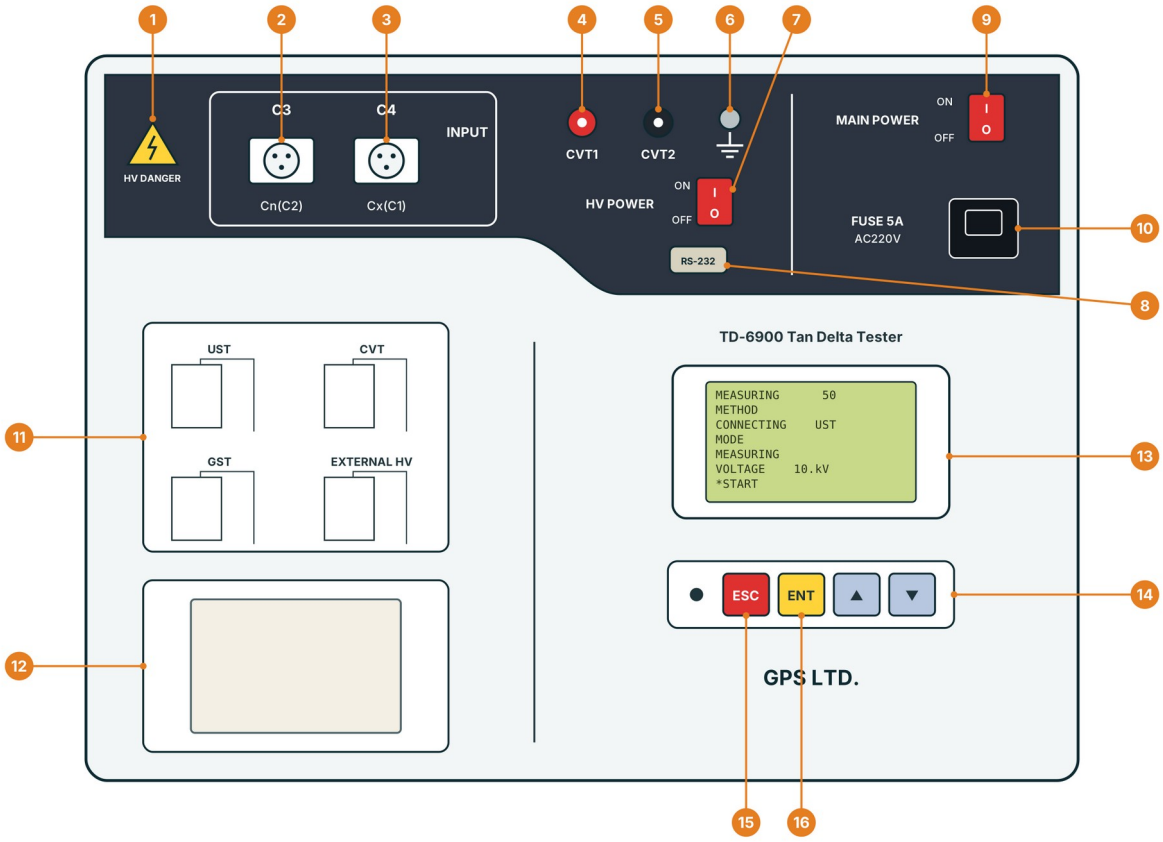


Figure 1 The TD-6900 top panel

	Item	Description
1	HV DANGER sign	Warns of the high voltage at the HV output. The HV output socket itself is on the side of the case
2	C3, Cn(C2)	Standard capacitor input, for an external standard capacitor (section 11). In the CVT method, the C2 measurement
3	C4, Cx(C1)	Measuring input: the test current from the low-voltage end of the test object in UST. In the CVT method, C1
4	CVT1	Red. Low-voltage excitation output for the CVT method, 3 to 50 V, 3 to 30 A (section 9)
5	CVT2	Black. Low-voltage excitation output, the second terminal
6	Earth terminal	Connected to the case and the mains earth. Connect to a sound earth before every test (section 5)
7	HV POWER	Internal high-voltage switch. Works only with MAIN POWER on
8	RS-232	Serial port for a computer (section 12)
9	MAIN POWER	Mains switch. In an emergency, switch it off at once
10	Mains inlet and fuse	220 V AC. Fuse 5 A / 250 V, φ5 × 20 mm
11	Wiring diagrams	UST, CVT, GST and external HV connections, as in this manual
12	Printer	Built-in thermal printer
13	LCD	Menus, settings and results (section 6)

	Item	Description
14	▲ and ▼	Move the cursor and change the value at the cursor
15	ESC	Back, or cancel
16	ENT	Select, or start and stop a test

The source manual names the keys differently (start/stop, up, down, Print). The ESC and ENT functions given here are the most likely mapping and should be confirmed on the instrument.

5 Connections and earthing

HV output

The internal high voltage, 0.5 to 10 kV and up to 200 mA, comes from the HV output socket on the side of the case. In GST it also carries the test current, and it is the high-voltage end of the internal standard capacitor. Connect both the core (big red clip) and the shield (small black clip) of the HV lead to the high-voltage end of the test object: if only the core carries the voltage, its resistance can add to the measured loss. If the HV lead has an earthed outer shield, earth it.

Cx input, C4

Input current 10 µA to 5 A, used in UST. Connect the core (red clip) to the low-voltage end of the test object. If the test object has a low-voltage shield terminal, such as a shield ring, connect the black clip to it; otherwise leave the black clip free.

- Connect the Cx lead to the low-voltage end with zero resistance, or the readings may swing or the protection may operate.
- To check accuracy against a standard capacitor or standard dielectric, use fully shielded plugs: an exposed core causes errors.

Cn input, C3

For an external standard capacitor, connected in the same way as Cx with fully shielded plugs (section 11). The standard capacitor is always connected as UST, whether the test is UST or GST.

Earth

The earth terminal is connected to the case and to the earth of the mains socket. Earth every measurement reliably and separately, even though the instrument has earth protection. The earth connection must be of zero resistance: clean any paint or rust from the earth conductor. A slightly poor earth causes errors or unstable readings; a seriously poor earth is dangerous.

Mains supply

The instrument adapts automatically to a 50 Hz or 60 Hz supply, and runs from the mains or a generator. On a generator the frequency drifts: select a fixed frequency to remove its effect. Replace the fuse only with one of the same specification. If a new fuse blows, the instrument may be faulty: contact GPS.

6 Menus and settings

1. Switch on MAIN POWER. The instrument shows its name, then the settings menu (Figure 2).
2. Switch on HV POWER.
3. Use ▲ and ▼ to move to a setting and change it, then select START to run the test.

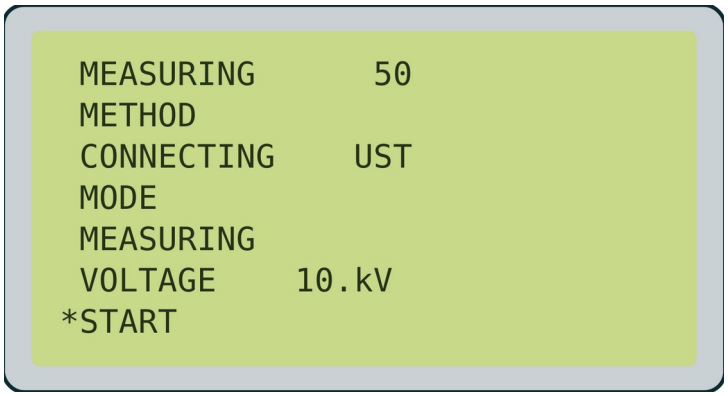


Figure 2 The settings menu

Measuring method (frequency)

50D measures at 45 Hz and 55 Hz and calculates the 50 Hz result, free of interference; 60D does the same at 55 Hz and 65 Hz for 60 Hz systems. Use a dual-frequency mode wherever there is interference. A single frequency, 45, 50, 55, 60 or 65 Hz, is for a generator supply or for a standard test at a set frequency.

Connecting mode

UST for an ungrounded test object (section 7), GST for a grounded one (section 8), CVT for the self-excitation method (section 9) and GSTg for reverse connection with low-voltage shielding (section 10). Select the mode that matches the connections.

Measuring voltage

0.5 to 10 kV in 500 V steps. Choose the voltage the test procedure specifies. In the CVT method, set the protection limits instead: 3 kV / 200 mA on the high-voltage side and 20 V / 10 A on the low-voltage side are recommended.

Standard capacitor

The internal standard capacitor serves UST, GST and CVT tests. For a high-voltage test with an external standard capacitor, select external Cn and enter its capacitance and tan δ (section 11). Do not change the factory parameters marked with an asterisk: they affect every measurement.

The source manual describes these settings on a differently laid-out screen. The order and wording of the menu items may differ slightly on the instrument.

7 UST, ungrounded test object

1. Connect the earth terminal to a sound earth.
2. Connect the HV lead core (big red clip) and shield (small black clip) to the high-voltage end of the test object (Figure 3).
3. Connect the Cx lead core (red clip) to the low-voltage end. Connect the black clip to a low-voltage shield terminal if there is one; otherwise leave it free.
4. Select UST, the frequency mode and the voltage, and start the test.

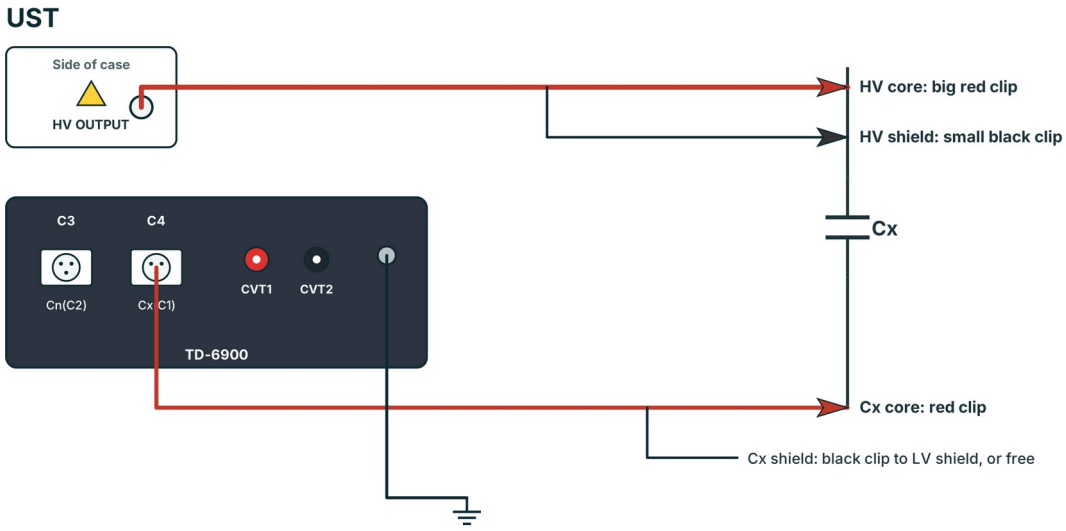


Figure 3 UST connection

8 GST, grounded test object

1. Connect the earth terminal to a sound earth.
2. Connect the HV lead core (big red clip) to the high-voltage end of the test object (Figure 4).
3. Use the HV shield (small black clip) to shield a branch that should not be measured. If no shielding is needed, leave it free.
4. Select GST, the frequency mode and the voltage, and start the test.

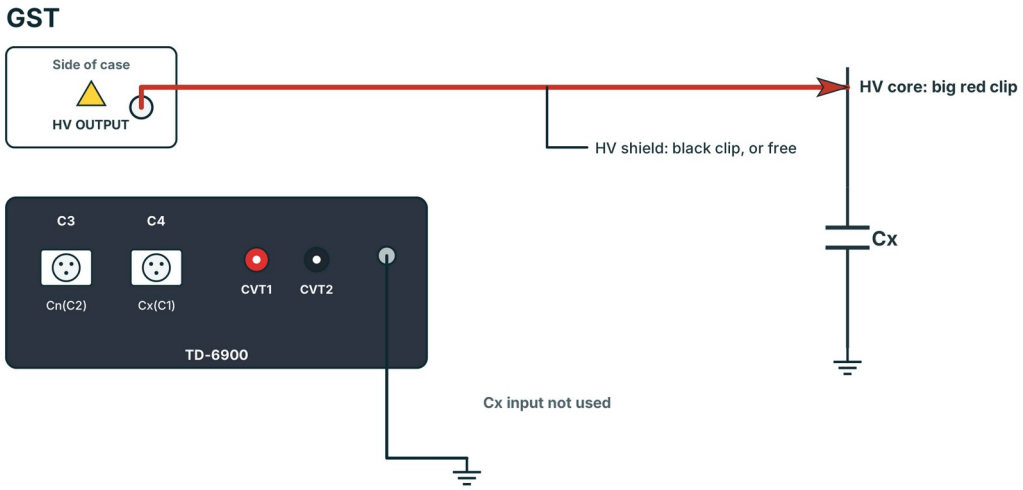


Figure 4 GST connection

9 CVT self-excitation

The self-excitation method measures C1 and C2 of a capacitor voltage transformer in one connection, and compensates automatically for an earthed bus and for the voltage division of the standard capacitor. The instrument outputs a low-voltage excitation from CVT1 and CVT2 to a secondary winding, and the CVT itself produces the test voltage.

1. Remove the earth link from the δ end of C2.
2. Connect the HV lead core (big red clip) to the δ end of C2, and its shield (small black clip) to the X end (Figure 5).
3. Connect the Cx lead core (red clip) to the top of C1. Leave the Cx black clip free.
4. Connect CVT1 and CVT2 to the da and dn terminals, or to any secondary winding. There is no polarity.
5. Connect the earth terminal to a sound earth. Switch on HV POWER: the excitation comes from inside the instrument.
6. Select CVT, set the protection limits (3 kV / 200 mA and 20 V / 10 A recommended) and start the test. One test gives C1 and C2 with their tan δ.

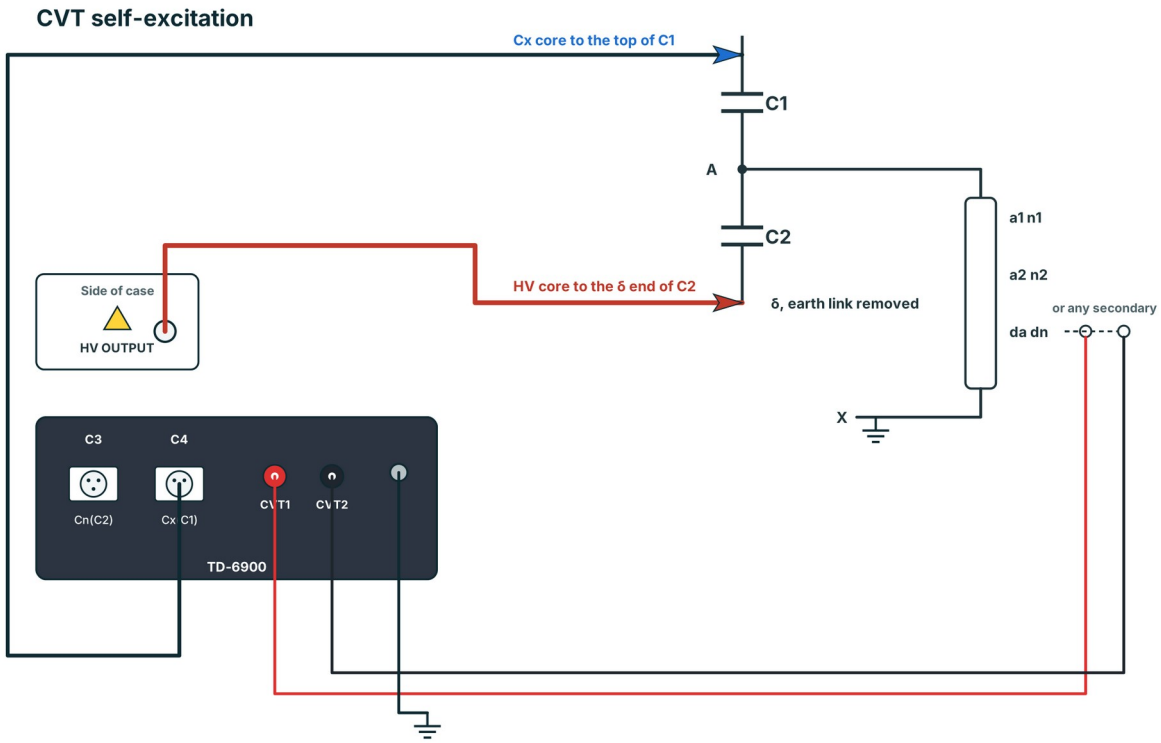


Figure 5 CVT self-excitation, C1 in one section

- Do not connect Cx to C2 and the high voltage to C1: the error is larger.
- If C1 is a single section, the bus must not be earthed, or the Cx core is shorted to earth.
- If C1 has several sections, the bus can be earthed. C11 and C12 are measured by UST or GST, and C13 and C2 by self-excitation, with the Cx core at the top of C12 (C1 is then the result for C13).
- Keep a non-dedicated HV lead off the ground: stray capacitance and loss to earth cause errors. A dedicated CVT lead can lie on the ground.

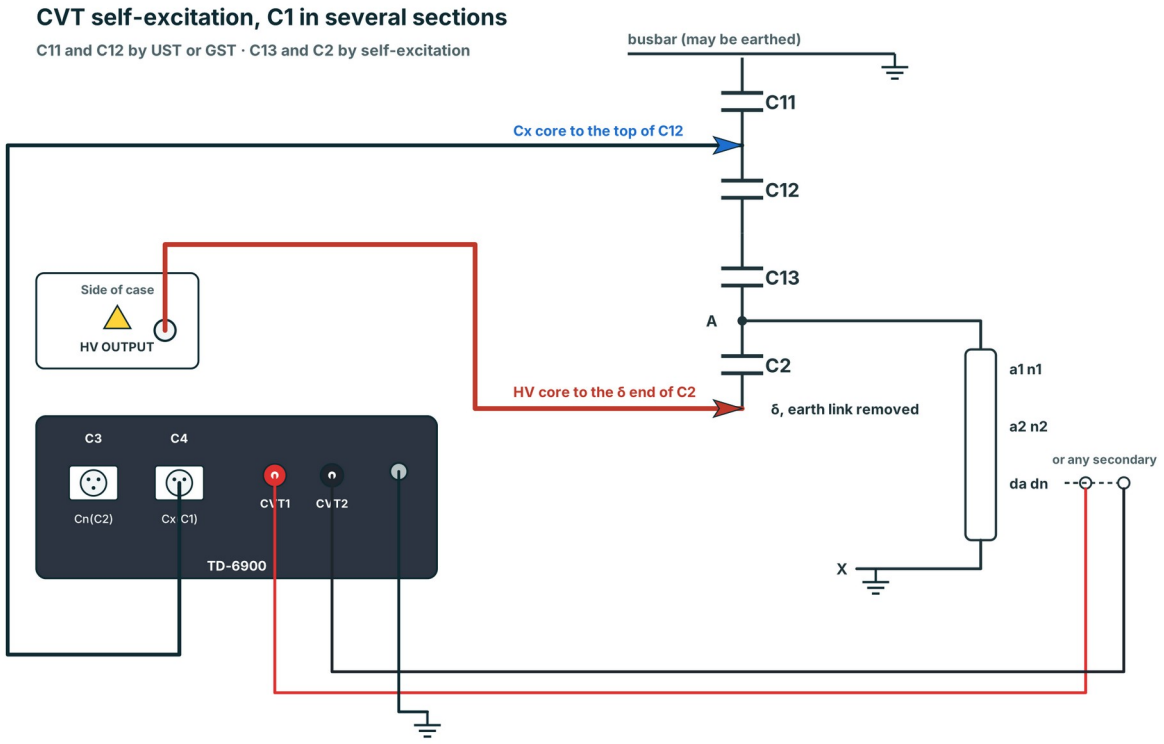


Figure 6 CVT self-excitation, C1 in several sections

The source manual draws the Cx and HV connections this way round; the panel marks C3 as Cn(C2) and C4 as Cx(C1). Confirm which lead each terminal takes in the CVT method on the instrument.

10 GSTg, reverse connection with low-voltage shielding

Use GSTg where the low-voltage terminal of a capacitor that must be shielded cannot withstand high voltage, so the usual 10 kV high-voltage shield of a reverse connection cannot be used. For example, with a 220 kV CVT bus earthed, C11 can be measured by a 10 kV reverse connection without disconnecting: the bus stays earthed, the top of C11 stays connected, the HV core goes to the bottom of C11, and the Cx core to the J and X ends of C2. C12 and C2 are then shielded at low voltage.

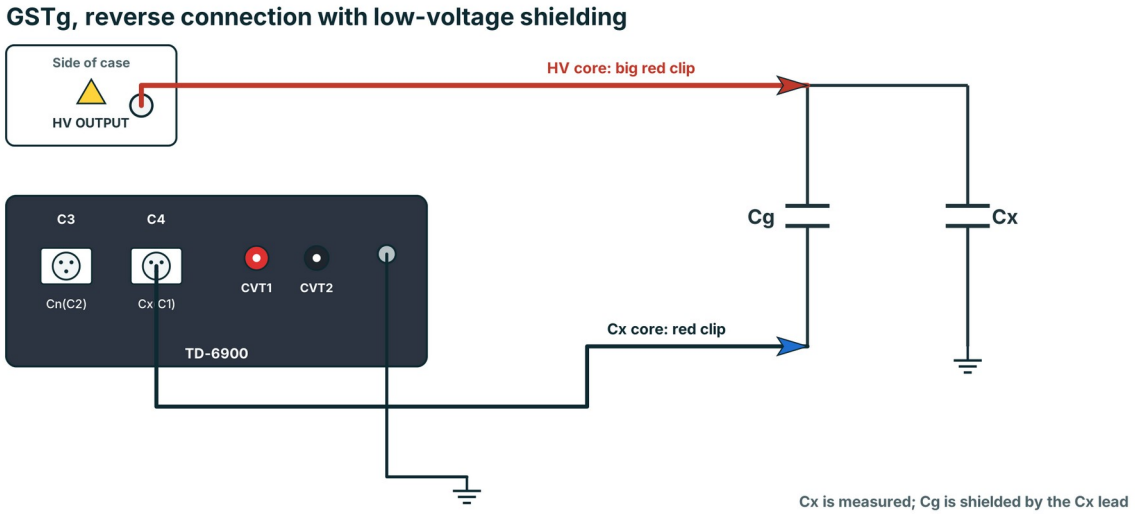


Figure 7 GSTg connection

11 External high voltage and standard capacitor

For tests above 10 kV or on large capacitance, use an external high-voltage supply with an external standard capacitor (Figure 8). The instrument tracks the frequency of the external supply from 40 to 70 Hz, including a series resonant supply. Up to 5 A test current, 40 to 70 Hz, in UST; up to 10 kV, 5 A, 40 to 70 Hz in reverse connection.

1. Connect the external supply to the high-voltage ends of the test object and the standard capacitor.
2. Connect the test object low-voltage end to C4, Cx(C1), and the standard capacitor low-voltage end to C3, Cn(C2), with fully shielded plugs.
3. Select external Cn and enter the capacitance and tan δ of the standard capacitor. These values are saved.
4. Start the test. The internal HV output is not used.

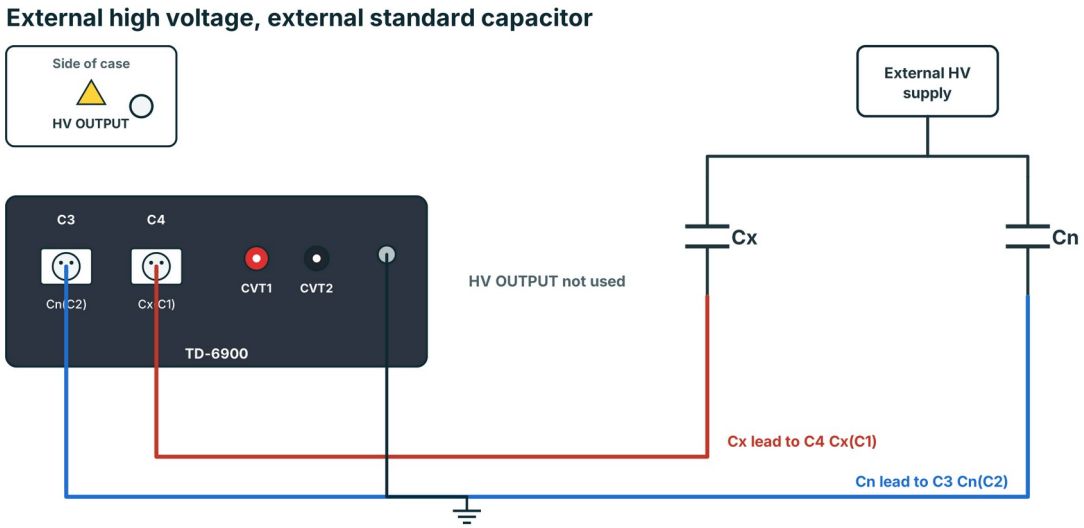


Figure 8 External high voltage with an external standard capacitor

12 Results, printing and computer control

At the end of a test the instrument shows the result (Figure 9). Use ▲ and ▼ to see the other values. It identifies the test object as capacitive, inductive or resistive automatically and chooses the units.

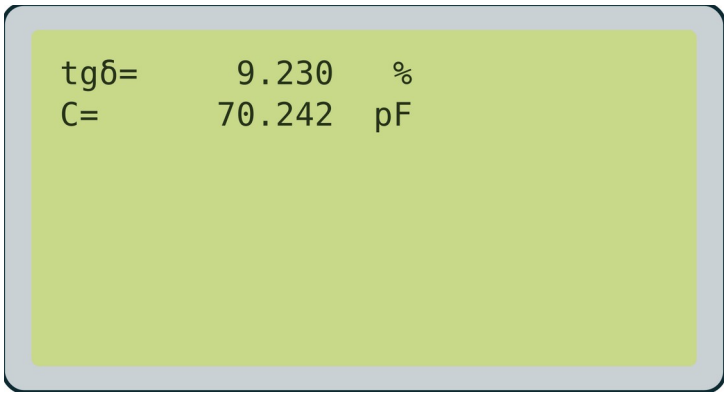


Figure 9 A result

Test object	Values shown	Note
Capacitive	Cx, tan δ, U, I, Φ, P, F, t	If |tan δ| > 1, capacitance and series or parallel resistance are shown
Inductive	Lx, Q, U, I, Φ, P, F, t	If |Q| < 1, inductance and series resistance are shown
Resistive	Cx (or Lx), Rx, U, I, Φ, P, F, t	
CVT self-excitation	C1, tan δ, C2, tan δ, U1, U2, F, t	U1 is the voltage when C1 is measured, U2 when C2 is measured
CVT ratio	K, Φ, F, t, U, I, Cx, tan δ	Cx and tan δ are from the high-voltage terminal, GST connection

Symbol	Meaning
Cx	Capacitance of the test object (1 µF = 1000 nF, 1 nF = 1000 pF)
tan δ	Dielectric loss factor (1% = 0.01)
Lx, Q	Inductance of the test object; quality factor (no unit)
Rx	Resistance of the test object
U, I	Test voltage and current
K	CVT ratio: primary to secondary voltage
Φ	Phase by which the voltage (0°) lags the current
P	Dissipated power
F	Frequency. In a dual-frequency mode, the average
t	Temperature measured inside the instrument. It can read high because the instrument warms up, and results are not corrected for it

"over" means the value is out of range. The results can be printed on the built-in printer, and the instrument can print automatically after each test. 100 results are stored with the date and time.

Computer

With a computer on the RS-232 port, the instrument can be controlled and the results processed. Use the same baud rate and address on both. For the PC software, contact GPS.

The source does not say which key prints a result or sets automatic printing on this panel. Confirm on the instrument.

13 Field test advice

If a result is clearly unreasonable, check the following.

Cause	What to do
Poor contact at a hook	The hook must make good contact with the test object, or discharge at the contact causes large swings in the readings. Watch for a thick oxide layer on a lead, or a lead moving in the wind
Poor earth	Causes instrument protection or large swings in the readings. Scrape paint and rust from the earth point: the earth connection must be of zero resistance

Cause	What to do
Negative tan δ on a CVT or PT	Measuring the lower coupling capacitor of a CVT directly gives negative tan δ: use the self-excitation method. Measuring an electromagnetic PT by the end-shielding method can give negative tan δ when damp: dry the bottom three sheds and the terminal block, or use a conventional method
High humidity	Can make tan δ abnormally high, low or negative, and unstable. A shielding ring can be added, but it changes the field around the test object, so follow the relevant regulations
Generator supply	The frequency is unstable: work at a fixed 50 Hz
Test leads	Long use can leave a hidden open circuit, a core-to-shield short or a poor plug. Check the leads regularly. Use fully shielded plugs when testing a standard capacitor, and keep a non-dedicated HV lead off the ground in the CVT method
Wrong mode	Select the mode that matches the connections. Under interference, use a dual-frequency mode

Is it the instrument?

- Tan δ measurement depends strongly on the test method: check the connections before suspecting the instrument.
- With a multimeter, check the leads for an open circuit or a core-to-shield short, check the supply is not too high or low, and check the earth.
- Measure a standard capacitor, or a capacitor of known capacitance and loss, by UST and GST. If the results are right, the instrument is working.
- Unplug all the leads and run an empty test. If it does not raise the voltage normally, the instrument may be faulty.
- After starting a CVT test, measure the low-voltage output: 2 to 5 V should appear.

Checking the anti-interference performance

Set up a loop that injects a known interference current into the instrument. The loop may become part of the test object. Once a test starts, the supply wiring carries the measuring frequency; if that reaches the instrument through the interference loop, the test is not valid. Do not use a nearby high-voltage conductor to create interference: short-gap discharge is non-linear and produces same-frequency interference.

14 About variable-frequency measurement

Under severe interference, measuring at a frequency other than the mains frequency gives reliable results. At 55 Hz, for example, the measuring system passes only the 55 Hz signal and rejects 50 Hz interference, because it can separate the two frequencies, using tens of thousands of points on each waveform.

Dielectric loss follows two ideal models: in the series RC model tan δ = 2πfRC, rising with frequency; in the parallel model tan δ = 1/(2πfRC), falling with it. A real capacitor mixes many such elements, so the effect of frequency is small. Apart from low-frequency resonance in circuits of several components, the loss near the mains frequency changes steadily with frequency.

The dual-frequency modes therefore measure one point either side of the interference frequency, 45 and 55 Hz for 50 Hz, and calculate the 50 Hz value. This brings no significant error: the two values before averaging are very close, and each is a valid result on its own.

15 Supplied with the instrument

- TD-6900 tester
- Dedicated test cables, including the CVT excitation lead
- Mains lead and earth lead
- Spare printer paper and fuses
- This manual and certificate

Model	Description	Part number
TD-6900	Automatic capacitance and tan delta tester, 0.5 to 10 kV, built-in printer	806900

16 Warranty and service

One year from the date of purchase, subject to product registration with GPS at www.gpslimited.com/register-product. Service and technical support are available for the life of the instrument.

To keep the specified accuracy, we recommend recalibration by GPS or an authorised GPS agent every year. For service, calibration or technical support contact GPS at sales@gpslimited.com or +44 (0) 203 093 0914, quoting the model, part number and serial number.