

# Amblyonix

## Model 6010A

Capacitance and Tan/Delta Test Set

### User Manual



Foreword

Dear Customer,

Thank you for purchasing a Model 6010A Tan Delta Test Set. Please read this manual in detail prior to first use, as it will acquaint you with the product and help you to use it skillfully.

Our goal is to continuously improve our products, so there may be slight differences between the product you purchased and its original instruction manual. If changes in this manual occur, you will find them in the appendix. If you have questions or would like to discuss a unique testing application, please contact us.

This product is covered by a one-year limited warranty from the date of shipment. If it is found to be defective due to parts or workmanship during the warranty period, we will repair it free of charge.

Should this product require repair either in or out of warranty please return it to us at:

Amblyonix Industrial Instrument Company

20 Republic Road  
North Billerica, MA 01862

Phone: 1-800-447-4020  
Fax: 1-978-667-8901  
Email: [service@amblyonix.com](mailto:service@amblyonix.com)  
Website: [www.amblyonix.com](http://www.amblyonix.com)



**Amblyonix**  
Industrial Instrument Company

20 Republic Road, North Billerica, MA 01862  
800-447-4020 [WWW.AMBLYONIX.COM](http://WWW.AMBLYONIX.COM)

Table of Contents

Foreword . . . . . 2

Safety Requirements . . . . . 4

    To avoid fire hazards or personal injury: . . . . . 4

    Grounding . . . . . 4

    Before You Test . . . . . 5

Overview . . . . . 5

Theory of Operation . . . . . 8

Specifications . . . . . 9

Front Panel Description . . . . . 10

Operating Instructions . . . . . 12

    GST/UST Testing . . . . . 13

    CVT Testing . . . . . 14

    CVT Ratio Testing . . . . . 15

    GSTg Testing . . . . . 16

    Data . . . . . 16

    Settings . . . . . 16

Caution . . . . . 16

Reference Wiring . . . . . 17

    Straight Polarity Method . . . . . 17

    Reverse Polarity Method . . . . . 18

    CVT Transformation Ratio Test . . . . . 19

    CVT TEST . . . . . 20

    GSTgTest . . . . . 21

Please visit our website for technical updates and news concerning this and other products available in our continuously expanding product offering.

This product is designed to be connected to electrical equipment that has been disconnected from electrical service. Only properly trained personnel should operate this instrument. Prior to first use please read this manual entirely. Familiarize yourself with all aspects of this products' features and functions. Always use best testing practices when using this instrument.

## Safety Requirements

Please read the following safety precautions carefully to avoid the risk of personal injury, and to prevent damage from occurring to this instrument and/or other devices that are connected to it. To avoid possible danger to equipment or personnel, never use this product outside of the scope of its intended use.

If this product should appear to malfunction, never attempt to perform repairs yourself. Only qualified technicians that are completely familiar with every aspect of its operation should perform repairs.

### To avoid fire hazards or personal injury:

Keep unqualified and/or unauthorized personnel away from the testing area.

Always use the proper power cord. If you are new to this piece of equipment, inspect the power cord for any damage. If the ground connection and/or any of the power cord's other electrical connections appear to be damaged do not connect it to this instrument. Call us at 1-800-447-4020 for a suitable replacement to a damaged power cord.

Always use the proper interconnecting and ground cables.

Never touch the energized surfaces and/or output of this device and/or any equipment connected to it during a test.

Always use this product by connecting and disconnecting it properly to the equipment being measured. Never connect or disconnect the test connections during a test.

### Grounding

The Model 6010A is grounded through the dedicated ground terminal located on the front panel of the instrument. To prevent electric shock, good testing practice dictates that the case ground connection must be connected to a good earth ground. Grounding the Model 6010A is an important first consideration and must be done regardless of the types of testing to be done. Before making any other connections from this device to the device being tested in GST (Grounded Sample Test), UST (Ungrounded Sample Test), or CVT (Capacitor Voltage Transformer) test modes, please ensure that your Model 6010A is properly grounded. Allow your test set-up to be inspected and verified by a competent observer.

Do not operate this product when its covers or panels have been removed.

Avoid contact with the output connections or the device under test during or after a test until the output, and the device under test have been fully de-energized.

Do not operate this device if you suspect faulty operation. If you suspect faulty operation, stop immediately. Contact our repair department for technical assistance.

Do not operate in wet/damp conditions. Do not operate in explosive atmospheres. Ensure that this Tan Delta Test Set remains clean and dry during use.

### Before You Test

Before performing any test, always make sure that your Model 6010A is well grounded via the front-panel ground connection. Ensuring that this device is properly grounded is the first step in creating a safe testing environment. Only use this instrument to test de-energized equipment that has been electrically isolated and removed from service.

## Overview

For many reasons, a considerable amount of the maintenance testing of electrical equipment has been done by performing measurements on electrical insulation. There are a variety of different tests that can be employed to determine the integrity of electrical insulation, and many others that are designed to pin-point insulation faults.

Using a megohmmeter to measure insulation resistance has always been the most common way to evaluate electrical insulation. A megohmmeter produces a high-voltage DC test signal and measures the resultant current flow through the insulation being tested. From this, a DC resistance measurement can be obtained. This is the simplest insulation test that can be made, as it is a practical application of Ohm's Law and DC circuit theory. Another way to test insulation is to perform a Tan Delta test, often also referred to as a Power Factor test although this is a bit misleading. If you are new to Tan Delta testing, take this moment to clear your mind and consider other testing possibilities.

Tan Delta testing is like insulation resistance testing, in that it does perform an insulation test. The most significant difference between insulation resistance testing and Tan Delta testing is that Tan Delta testing is performed using an AC test signal instead of a DC test signal. By using an AC signal, the effects of capacitance can also be used to determine the health of electrical insulation. As this is true, even more information becomes available if the AC test signal can change frequency during the test. With this added information, a skilled operator can quickly determine the cause of insulation failures, such as those caused by excessive moisture, or from those caused by the effects of carbonization, corona, or partial discharge.

As we know, every physical thing can be described as having attributes such as weight, mass, and density. These very same physical things (whatever they may be), also have electrical resistance and capacitance. We know this to be true when we experience an electric shock caused by static electricity. Any object that can be electrically charged exhibits what is called self-capacitance. As we begin this conversation, let us ask an important question: What role does capacitance play in our understanding of electrically insulated systems? Consider the capacitor illustrated in Figure 1.

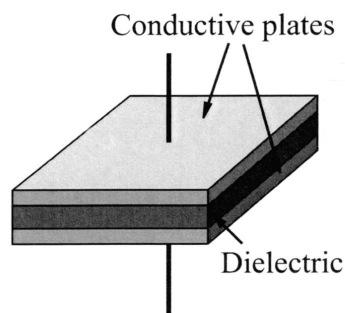


Figure 1

Its capacitive value is determined by the surface area of its plates and the insulating material of its dielectric. In a theoretically perfect capacitor (none of which exist), the dielectric would completely insulate one plate from the other. The greater the dielectric's insulation resistance value, the more perfect the capacitor would be. When a capacitor is connected into an AC circuit path, current is electro-magnetically transferred from one plate to the other through the insulating dielectric. The capacitor's effect on the circuit will cause the current in the circuit to be shifted 90° from the applied voltage.

A less than perfect capacitor would result if current were able to resistively leak directly from one plate to the other through the dielectric. When this happens the capacitors' phase-shifting qualities will change as well. Over time, the detrimental effects of heat and prolonged environmental exposure can cause a degradation of the components of the capacitor—most specifically its dielectric. As the dielectric begins to degrade it will become less of an insulator over time. As its insulation value becomes compromised, electrons will begin to leak through the dielectric and result in an increase of heat, and what are called watt-losses. These watt losses are observed in all types of electrically insulated systems and equipment. Over time, as insulating materials in motors, generators, and cables degrade, their capacitive-system values also change in a corresponding way. These changes can be quantified through Tan Delta testing. The Tan Delta component of an AC circuit is best defined as the ratio between resistive and capacitive currents.

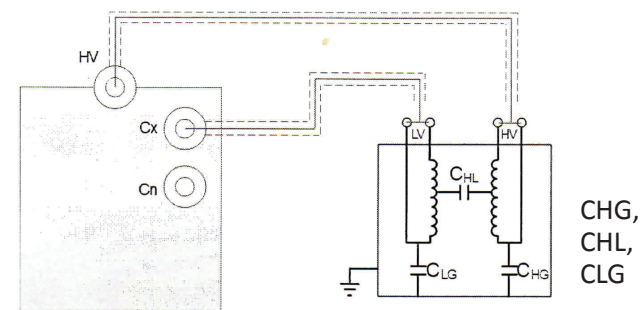


Figure 2

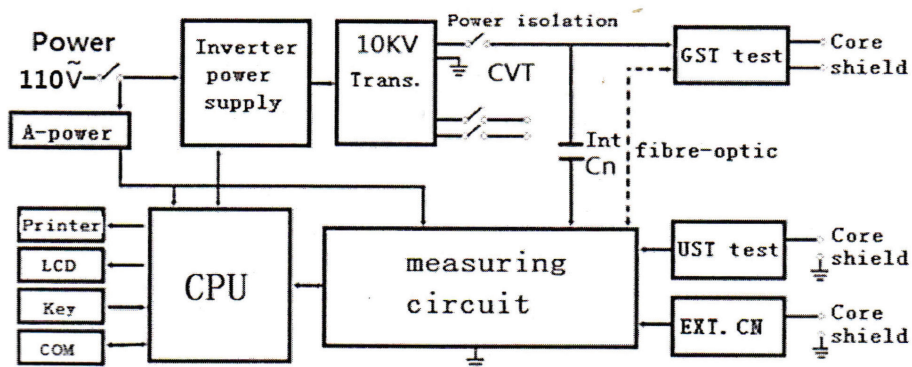
Consider the transformer depicted in Figure 2.

When both windings are shorted as shown, it is easy to imagine the conductors of each winding as the plates of a capacitor. The insulation of the windings can now be considered as the dielectric. The effects of the insulation on the circuit are illustrated as CHG, CHL and CLG. Current passing through the resistive element of the circuit would generate heat and create watt losses in a way similar to the previous discussion regarding the capacitor in Figure 1. As the insulation in this system degrades, the resistive element of the capacitive circuit will become more prominent (lower) and cause the current flowing in the circuit to shift phase in relation to the source in a small but perceivable way.

## Theory of Operation

The Model 6010A compares the device under test to an internal standard circuit of precisely known qualities. This standard circuit is composed of a built in high-stability standard capacitor and a measuring circuit. During the test, a voltage is applied to the device under test and the resultant current amplitudes and phase are compared to those of the standard circuit. From these measurements the digital signal processor performs a real-time vector analysis and calculates capacitance and dielectric loss tangent values. Touch screen controls allow the operator to select different test modes, change test voltages, currents, and frequencies. Tests can be performed at above and below 50Hz or 60Hz powerline frequencies, providing for more comprehensive results.

The Model 6010A will not produce a test signal unless both front panel safety switches are closed. Other safety features include input voltage fluctuation stabilization, output short circuit protection, over voltage and current sensing, and thermal overload protection.



## Specifications

### Capacitance Range

**Internal HV:** 3pF-60000pF/10kV  
60pF-1uF/0.5kV

**External HV:** 3pF-1.5uF/0.5kV  
60pF-30uF/0.5kV

**Maximum Resolution:** 0.0001pF

**Tan/Delta Range:** Unlimited,  
0.001% resolution Automatically  
displays Capacitance, Inductance,  
and Resistance values.

### Tan/Delta Test Current

**Range:** 10uA-1A

**Internal HV selectable  
voltage range:** 0.5-10kV

**Maximum output current:** 200mA

### Selectable Test Frequencies:

45, 50, 55, 60, 65Hz

### Automatic, Dual variable frequencies:

45/55Hz, 55/65Hz, 47.5/52.5Hz

**Power Supply:** 120VAC 60Hz

### Operating Environment:

14°F to 104°F @≤90%RH

**Dimensions:** 18.1 x 14.2 x 13.8 inches

Weight: 51.75lbs



## Front Panel Description

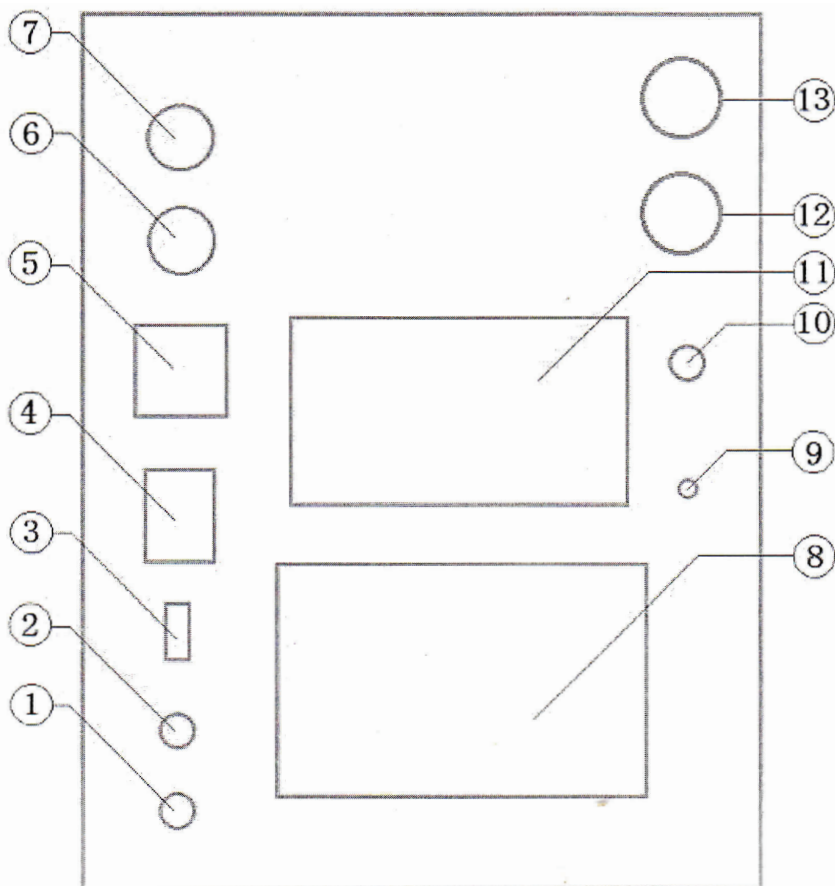


Figure 3

- |                                  |  |
|----------------------------------|--|
| 1. <b>Emergency Stop Button</b>  | 8. <b>Touch-Screen LCD</b>                     |
| 2. <b>Reset Button</b>           | 9. <b>Grounding Terminal</b>                   |
| 3. <b>U Disk interface</b>       | 10. <b>ES Self-Excited Connection Terminal</b> |
| 4. <b>Power Switch</b>           | 11. <b>Printer</b>                             |
| 5. <b>Power Input Receptacle</b> | 12. <b>Safety Interlock 1</b>                  |
| 6. <b>Cn Connector</b>           | 13. <b>Safety Interlock 2</b>                  |
| 7. <b>Cx Connector</b>           | 14. <b>High Voltage Output</b>                 |

$V_H (\leq 12KV)$



Figure 4

- Emergency Stop Button:** By pressing this button during a test, the High-Voltage test signal is immediately disabled. During a test, this button will illuminate indicating the presence of high voltage.
- Reset Button:** By pressing this button, the Model 6010A will revert to the main system set-up screen. This can be very helpful if test modes or connection configurations need to be changed before a test is initiated.
- U Disk Interface:** Test results can be downloaded to a thumb drive and stored for future analysis via this port. Avoid removing an inserted thumb drive during the storage process, as this may damage the thumb drive.
- Power Switch:**
- Power Input Receptacle:** A standard EIC input power connector, this receptacle is used to connect the instrument to line power.
- Cn Connector:** This connection is used in UST and GST test modes when an external standard capacitor is used during a test.
- Cx Connector:** This connection is used to complete the low-voltage side of the test circuit. A shield connection is provided for connection to cable shields and/or for guarding connections.

- Touch-Screen LCD:** This is the Model 6010A's human/machine interface. It is used to program the instrument to perform tests, display test results, and to alert the operator of failures that may occur during the test. The LCD will also display abnormal test conditions such as improper grounding before a test can be initiated. Maintain your display by avoiding long-term exposure to direct sunlight. Never store power cables or test leads inside the front cover of your Model 6010A as this may damage the display.
- Grounding Terminal** A primary safety feature, this connection should be established before connecting the Model 6010A to line power and before any other connections are made. Be certain that this connection is made to a good, known earth ground.
- ES Terminal:** This is the Electro-Static Voltmeter connection used in the self-excitation test method for CVTs, and is connected to the da terminal of a CVT under test.
- Printer:** A convenient front-panel thermal printer that uses standard 55mm thermal printing paper, allows the operator to quickly and easily print tests results.
- Safety Interlock 1:** See 13.
- Safety Interlock 2:** These safety features ensure that the high-voltage test signal cannot be initiated until both safety interlocks are closed. If either of these safety interlocks are open when the Model 6010A is powered up an error message is displayed informing the operator that either or both interlocks are open, and the output signal will be disabled until both interlocks are closed.
- High Voltage Output Connector:** Located inside an access hatch at the top of the Model 6010A, this connector is used to connect the red high-voltage test lead to the de-energized device to be tested.

# Operating Instructions

As with all industrial testing applications, safety must be the first consideration. Always connect the Model 6010A to a well-established earth ground via the front panel ground connector, and through the ground connection of the line cord supplied with your unit. Do not use any other line cord than the one provided with your unit at the time of purchase. Contact us for a replacement line cord should the one supplied become damaged or missing.

Refer to the wiring diagrams in Reference Wiring Section of this manual when connecting the Model 6010A to equipment under test. Make all test connections to de-energized equipment only. Never attempt to touch or remove cables during a test. When the test connections are made to the de-energized device under test, the connections are then validated and the test site has been inspected and cleared of personnel, proceed as follows:

Turn the unit on. If a good ground is not detected by the Model 6010A via the line cord, or through the front panel ground connector, an UNGROUNDED error message will appear on the display and the unit will be disabled. Make sure a good ground has been established before proceeding. With a good ground established and sensed, the Model 6010A will sense if SAFETY INTERLOCKS 1 and 2 are closed. These interlocks are safety features that are designed to be used to secure a test site, or to interrupt a test remotely in the case of an emergency. Make certain that these interlocks are closed, as this will allow you to advance from this screen and begin to set up and perform tests. With these safety considerations met, proceed as follows:

After the introductory screen appears the Model 6010A will advance to its main menu as depicted in Figure 5. This screen will allow the operator to change global settings (such as date and time), select archived test results from memory, and enter the various testing screens.

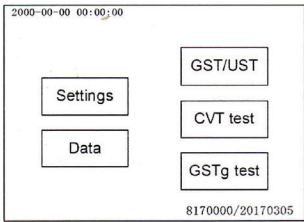


Figure 5

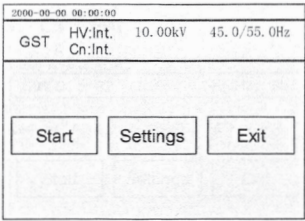


Figure 6

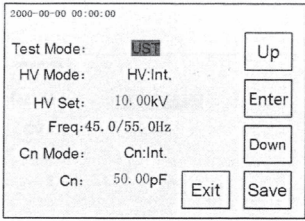


Figure 7

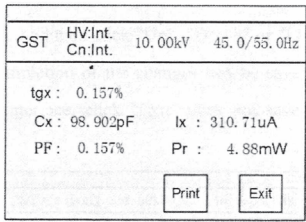


Figure 8

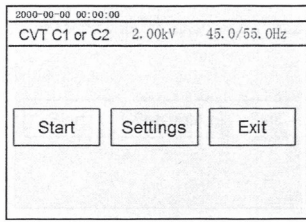


Figure 9

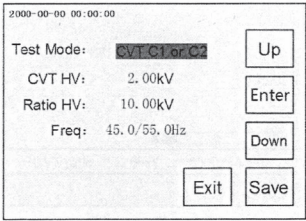


Figure 10

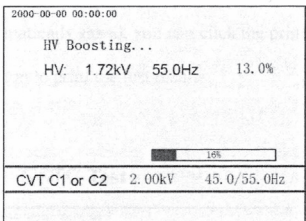


Figure 11

## GST/UST Testing

The Model 6010A has a variety of test modes for specific testing applications. Each mode is configurable so that the proper testing parameters are set for each individual test. All test modes are programmed in the same way. The most commonly used test profile is the GST/UST test mode, located at the top of the column of available testing options. GST is an abbreviation for Grounded Sample Test, whereas UST stands for Ungrounded Sample Test. By touching the GST/UST icon the display will advance to the test set-up screen, (see Figure 6) where you may START a test, change test SETTINGS, or EXIT back to the main screen. Press the SETTINGS icon to advance to the test set-up screen shown in Figure 7, and edit/modify the test parameters to suit your application. Press and highlight the MODE or SETTING to be changed. Use the UP and DOWN icons to scroll to the desired settings for your test. SAVE your test set-up before exiting this screen or your changes will not be saved. After saving your test set-up, exit this screen and the Model 6010A will revert to the previous screen. Make certain that the test parameters you have selected are now updated and appear on this screen. When all safety considerations met and when all personnel are cleared from the testing area, press the START icon softly but deliberately, and the test will begin.

During a test the Model 6010A will display the test in progress. The operator will observe the test as it ramps and dwells at the previously programmed frequencies and voltage levels. The display will also indicate the type of test being conducted as well as the voltage source, capacitive reference, and the applied voltage and frequencies. The date and time of each test is also recorded and saved along with the test results.

When the test has been completed the results will be displayed as depicted in Figure 8. The test will automatically be saved into memory and can be printed by pressing the PRINT icon.

CVT Testing

As with the previously mentioned test example, first make sure that good grounding and safety practices are in order. Next, follow the wiring instructions for the CVT test to be performed. Turn the Model 6010A on and select the CVT Test icon. The display will advance to the test screen shown in Figure 9. Press the SETTINGS icon to enter the test set-up screen (Figure 10) and modify the test parameters as has been previously described in GST/UST Testing. Save your set-up and the Model 6010A will revert to the previous screen and display any newly changed programming parameters. Verify that the test parameters are correct. Make certain that the test connections have been verified, and the testing area has been inspected and cleared of personnel. Press the START icon softly but deliberately and the test will begin.

The Model 6010A will display the test in progress as shown in Figure 11. The operator will observe the test as it ramps and dwells at the previously programmed frequencies and voltage levels. The display will also indicate the type of test being conducted as well as the applied voltage and frequencies. The date and time of each test is also recorded and saved along with the test results.

When the test has been completed the results will be displayed as depicted in Figure 12. The test will automatically be saved into memory and can be printed by pressing the PRINT icon.

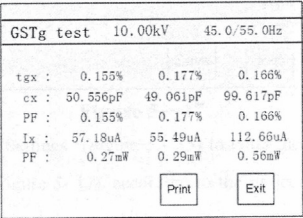


Figure 17

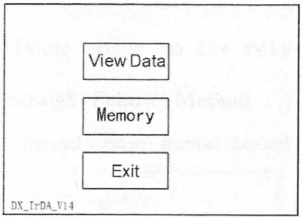


Figure 18

CVT Ratio Testing

When the CVT Test icon is selected from the main test screen, press the SETTINGS icon to advance to the test step-up screen depicted in Figure 13. Press and highlight the Test Mode options and scroll UP or DOWN to select the CVT RATIO test routine. Modify the test parameters to your requirement as has been previously described in GST/UST Testing. Save your set-up and the Model 6010A will revert to the previous screen and display any newly changed programming parameters. Verify that the test parameters are correct. Make certain that the test connections have been verified, and the testing area has been inspected and cleared of personnel. Press the START icon softly but deliberately and the test will begin.

The Model 6010A will display the test in progress as shown in Figure 14. The operator will observe the test as it ramps and dwells at the previously programmed frequencies and voltage levels. The display will also indicate the type of test being conducted as well as the applied voltage and frequencies. The date and time of each test is also recorded and saved along with the test results.

When the test has been completed the results will be displayed as depicted in Figure 15. The test will automatically be saved into memory and can be printed by pressing the PRINT icon.

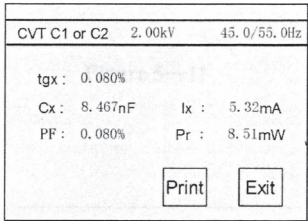


Figure 12

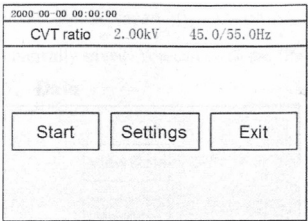


Figure 13

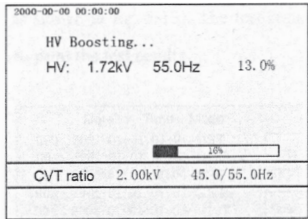


Figure 14

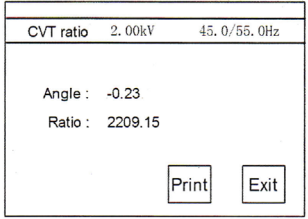


Figure 15

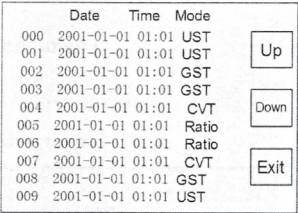


Figure 19

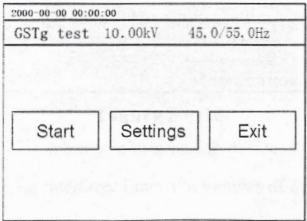


Figure 16

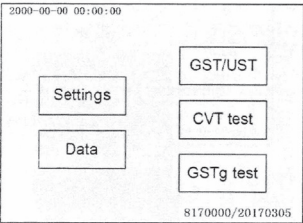


Figure 20

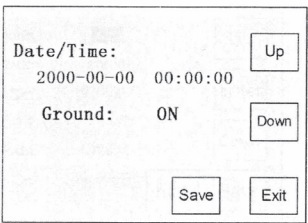


Figure 21



## GSTg Testing

When the GSTg Test icon is selected from the main test screen, press the SETTINGS icon to advance to the test set-up screen depicted in Figure 16. Modify the test parameters to your requirement. Save your set-up and the Model 6010A will revert to the previous screen and display any newly changed programming parameters. Verify that the test parameters are correct. Make certain that the test connections have been verified, and the testing area has been inspected and cleared of personnel. Press the START icon softly but deliberately and the test will begin.

The Model 6010A will display the test in progress as shown in Figure 17. The operator will observe the test as it ramps and dwells at the previously programmed frequencies and voltage levels. The display will also indicate the type of test being conducted as well as the applied voltage and frequencies. The date and time of each test is also recorded and saved along with the test results.

When the test has been completed the results will be displayed as depicted in Figure 17. The test will automatically be saved into memory and can be printed by pressing the PRINT icon.

## Data

In the main menu select the DATA icon. The Model 6010A will enter the data management interface screen depicted in Figure 18. Select the View Data icon and a data tabulation screen will appear (see Figure 19). Tests are saved by test number, data and time, and by the type of test that was performed. Highlight any test that has been stored in memory and that specific test will be re-displayed to be printed. Two hundred tests can be saved to the on-board memory. Test number 000 will be the last test saved, and the highest number test will be the oldest test in memory.

## Settings

When the Model 6010A is turned on it will display an introductory screen and then automatically advance to the main test screen. Select the SETTINGS icon to change the global setting for date and time. The Model 6010A is shipped from the factory with the GROUND ALARM feature enabled. Although it is not recommended, this feature may be disabled by highlighting this feature and by selecting the UP and DOWN icons this feature may be turned off. All selections or improper settings may be changed by pressing the CANCEL icon to return to the previous screen so that the proper settings may be established. Always select the SAVE icon to save your changes.

All steps in the case of improper settings or want to change again, you can press the Cancel button to return to the previous step, if you cannot return by pressing the cancel button. You can press the reset button to return to the main menu.

## Caution

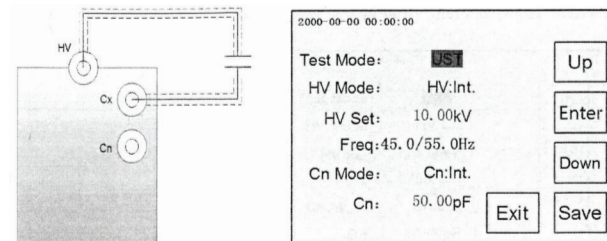
All the dashed lines are of the shielding layer of cables and the solid lines are of the core wire of cables. Please use the associated test cable supplied together with the product. Generally test cables can be used commonly, but this instrument is a highly-precise measuring instrument and please use the associated test cable as possible, otherwise the precision of measuring result might be affected by the self-attribute difference of the cable. Please refer to the Front Panel Description (figure 3) for the cable use of each socket and terminal.

## Reference Wiring

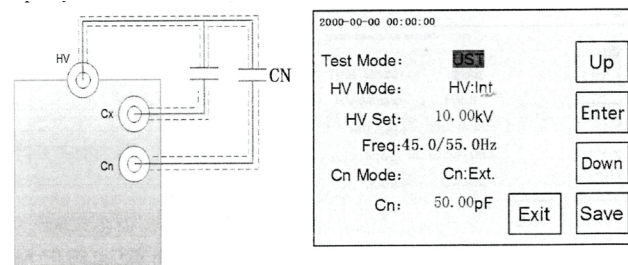
(Please refer to the relevant procedures)

### Straight Polarity Method

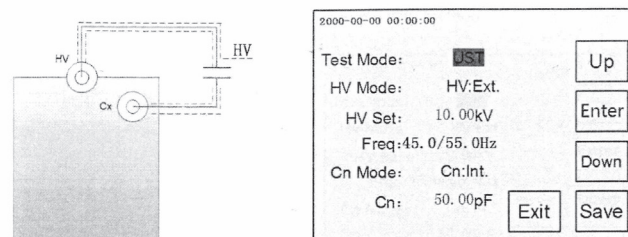
#### 1. Internal voltage - internal standard - straight polarity method



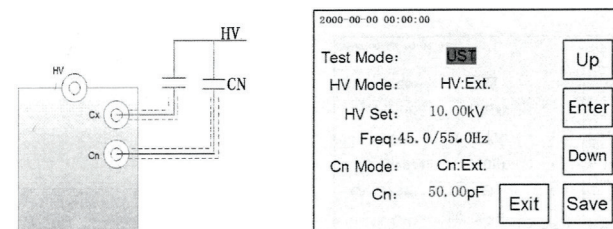
#### 2. Internal voltage - external standard reverse polarity method (must firstly set up the capacity of external standard)



#### 3. External voltage - internal standard - straight polarity method

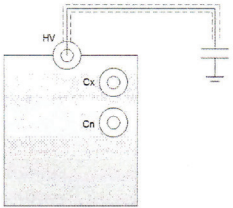


#### 4. External voltage - external standard - straight polarity method (must firstly set up the capacity of external standard)



Reverse Polarity Method

1. Internal voltage - internal standard - reverse polarity method



2000-00-00 00:00:00

Test Mode: **GST**

HV Mode: HV:Int.

HV Set: 10.00kV

Freq:45.0/55.0Hz

Cn Mode: Cn:Int.

Cn: 50.00pF

Up

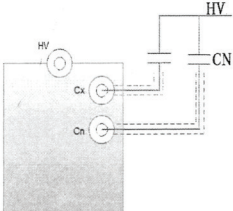
Enter

Down

Exit

Save

4. External voltage - external standard - reverse polarity method  
(must firstly set up the capacity of external standard)



2000-00-00 00:00:00

Test Mode: **UST**

HV Mode: HV:Ext.

HV Set: 10.00kV

Freq:45.0/55.0Hz

Cn Mode: Cn:Ext.

Cn: 50.00pF

Up

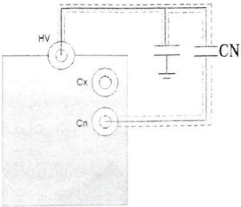
Enter

Down

Exit

Save

2. Internal voltage - external standard - reverse polarity method  
(must firstly set up the capacity of external standard)



2000-00-00 00:00:00

Test Mode: **GST**

HV Mode: HV:Int.

HV Set: 10.00kV

Freq:45.0/55.0Hz

Cn Mode: Cn:Ext.

Cn: 50.00pF

Up

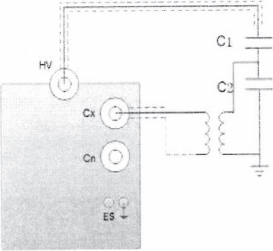
Enter

Down

Exit

Save

CVT Transformation Ratio Test



2000-00-00 00:00:00

Test Mode: **CVT:ratio**

Ratio HV: 2.00kV

Freq: 45.0/55.0Hz

Up

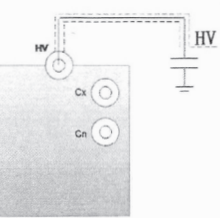
Enter

Down

Exit

Save

3. External voltage - internal standard - reverse polarity method



2000-00-00 00:00:00

Test Mode: **GST**

HV Mode: HV:Ext.

HV Set: 10.00kV

Freq:45.0/55.0Hz

Cn Mode: Cn:Int.

Cn: 50.00pF

Up

Enter

Down

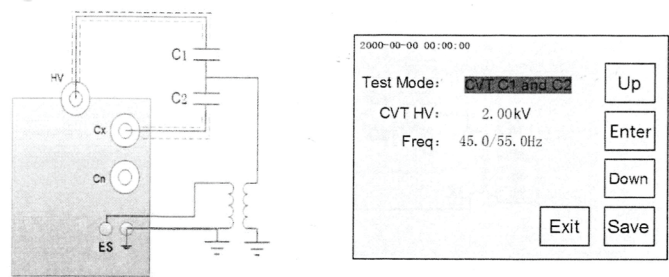
Exit

Save

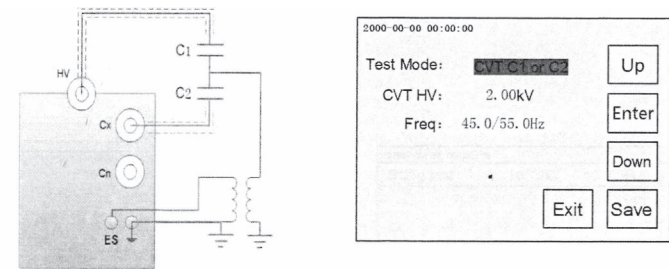
CVT TEST

**Test Note:** During CVT test, the high voltage line should be suspended and cannot contact the ground otherwise its additional dielectric loss to the ground will cause errors.

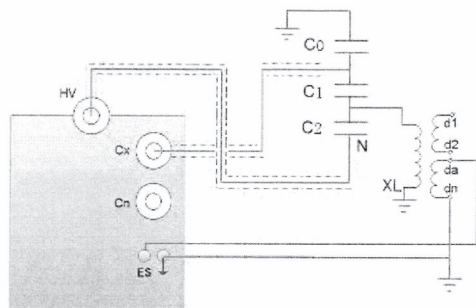
1. CVT Simultaneous Test



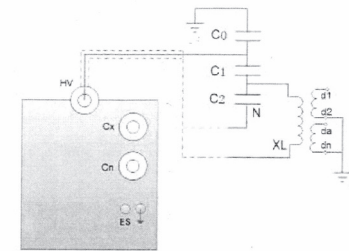
2. CVT Separate Test



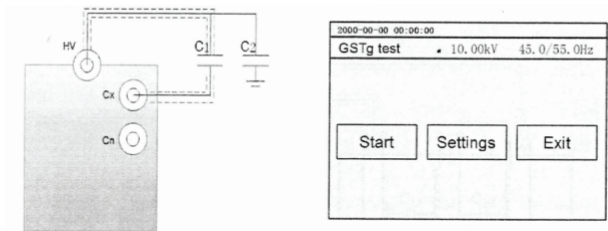
3. CVT capacitance value and dielectric loss measurement mode without removing high voltage lead: CVT self-excitation method. Voltage < 2kV



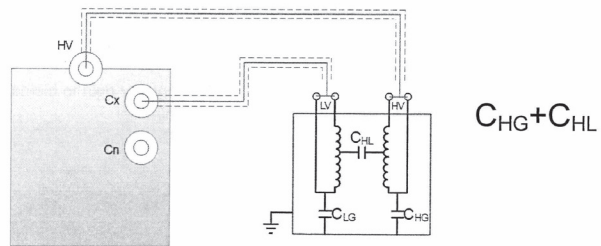
4. The capacitance value and dielectric loss measurement mode of CVT upper end C0 are measured by reverse connection shielding method: reverse connection method. Voltage < 2kV



GSTgTest

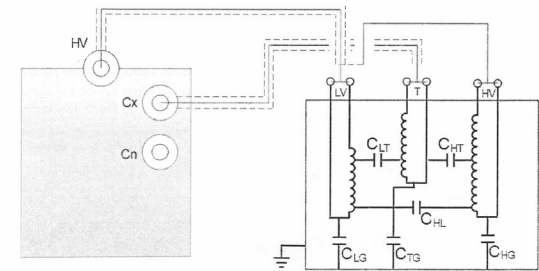


Two-winding transformer CHG+CHL



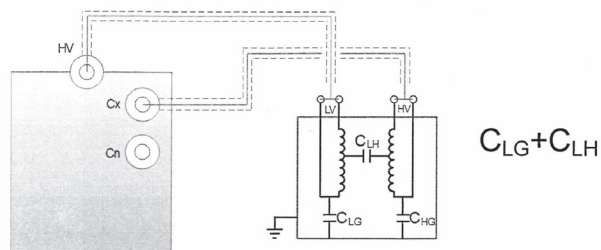
GST 2A CHG+CHL

Two-winding transformer CLG+CLH



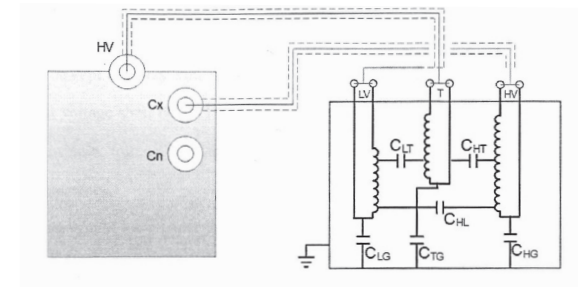
Three-winding transformer CrG+CHr

(Shield of high voltage line connected to LV winding)



Three-winding transformer CHG+CHL

(Shield of high voltage line connected to T winding)



Three-winding transformer CLG+CL

(Shield of high voltage line connected to HV winding)