

# **High Voltage C-V Measurement System**

**With CV BIAS UNIT CS-603A / CS-605A**

## **Instruction Manual**

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**IWATSU**





## Preface

- ◇ Thank you for purchasing High Voltage C-V Measurement system with CV BIAS UNIT CS-603A / CS-605A. Please use IWATSU instruments regularly for a long time in future.
- ◇ Please read this manual carefully and understand its contents before using this instrument, and then keep the manual handy for future reference.



## Important Safety Precautions

To ensure safe operation of the instrument and to prevent injury to the user or damage to property, items to be observed are written in the ⚠ WARNING and ⚠ CAUTION in the manual. Be sure to read them for safe operation. In addition, marks indicating attention are attached on the panel.

### Definitions of ⚠ WARNING and ⚠ CAUTION used in this manual

 <b>WARNING</b>	Incorrect operation or failure to observe the warning may result in death or serious injury.
 <b>CAUTION</b>	Incorrect operation or failure to observe the caution may result in injury or damage to the instrument.

### Explanation of symbols on panel

 <b>ELECTRIC SHOCK</b>	Incorrect operation may cause electric shock. This symbol calls attention. To protect the user, read items in the manual before using the instrument.
 <b>WARNING</b>	To prevent injury to the user or damage to the instrument, read items in the manual before using the instrument.

## Notices

- ◇ The manual corresponds to the CV Measurement Tool version 3.1.0.
- ◇ Parts of the contents of the manual may be modified without notice for improvements in performance and functions.
- ◇ Reproduction or reprinting of the contents of the manual without prior permission from IWATSU is prohibited.
- ◇ For questions about the instrument, please contact IWATSU or our sales distributors.

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## Manual Part Number

- ◇ KMLA00411

## Revision history

- ◇ May 2021: 1st Edition



## WARNING

- **In measurement with the instrument, high voltage may be applied. Always close the cover before measurement after setting the DUT (Device under test) on the CV BIAS UNIT.**

High voltage (max. 5kV for CS-605A, max. 3kV for CS-603A) may be applied. To prevent danger, if the cover of the CV BIAS UNIT is not closed, no voltage and current can be supplied to the terminal and no power can be applied to the DUT. And, do not remodel the switch for Interlock or do not open the cover during measurement. If not, electric shock may be caused.

- **Do not open the cover of the CV BIAS UNIT during measurement.**

High voltage (max. 5kV for CS-605A, max. 3kV for CS-603A) may be applied to the terminal to which the DUT is mounted. To prevent danger or to protect the DUT, when detecting that the cover of the CV BIAS UNIT opens, the instrument immediately shuts off the voltage and current applied to the DUT. And for safety, do not open the cover of the CV BIAS UNIT during measurement.

- **After measurement, the DUT may be charged. Do not touch the DUT until discharging it through the grounding rod and confirming the safety.**

Touching the charged DUT may cause electric shock.

- **Do not use other than attached Test Lead sets**

If measurement is done without considering measurement voltage and usage rating of the cable and GND cable, fire or failures may be caused. Use the specified cables attached depending on measurement types and measurement voltage.

- **When wiring to the DUT, check the said contents of the terminals and be careful of incorrect wiring.**

If the wiring is measured incorrectly, it may cause a fire or malfunction.

- **Do not use in an environment with explosive gases.**

This may result in explosion.



## **WARNING** (Continued)

- **If you notice smoke, abnormal smell or abnormal sound, immediately take measures below and remove the power plug from the receptacle.**

- (1) Make the power switch OFF.
- (2) Remove the power plug from the receptacle.

Continued use in this situation may cause an electric shock or fire. After taking measures above, please contact IWATSU or our sales distributors for repair. Repairing the instrument is very dangerous. Do not attempt to repair the instrument under any circumstances.

- **Make sure no water gets on or inside the instrument.**

Failure to observe the precaution may result in electric shock or fire. If water gets on or inside the unit, after making the power switch OFF, and pulling out the power plug from the power outlet, please contact IWATSU or our sales distributors for repair.

- **Do not touch the plug of the power cord when your hands are wet.**

This may result in electric shock.

- **Do not place the instrument on an unstable place such as a shaky stand or inclined place.**

Letting the instrument fall or topple down may result in electric shock, fire or injury. If the instrument falls or its cover is damaged, after making the power switch OFF, and pulling out the power plug from the power outlet, please contact IWATSU or our sales distributors for repair.

- **Surely insert the power plug into the power receptacle after checking that any dust is not sticking to the power plug. Additionally, disconnect the power plug or power adaptor from the receptacle once every six months to one year, and inspect and/or clean the power plug.**

If the power plug is contaminated, this may cause an electric shock, a fire, or a malfunction.

## **WARNING** (Continued)

- **Do not put any foreign objects, such as metallic or flammable objects through the ventilation opening.**

If any foreign object of metal and the combustible one, etc. is put through the ventilation opening, this may result in electric shock, fire, and/or malfunction.

If any foreign object enters the instrument, after making the power switch OFF, and pulling out the power plug from the power outlet, please contact IWATSU or our sales distributors for repair.

- **Always use a 3-prong power cord that suits power supply voltage for the instrument.**

Using a power cord that is incompatible with the power voltage may result in electric shock, fire and/or malfunction. Additionally, using a 2-prong power cord may result in electric shock.

- If the power is supplied from the 2-prong receptacle using the 3-prong to 2-prong conversion adapter, ground the GND terminal of the adapter.
- When using the attached 3-prong power cord to supply the power from the 3-prong receptacle, grounding is made through the GND line of the power cord.

- **Use the instrument at a specified supply voltage.**

Using the instrument at a voltage other than specified may result in electric shock, fire or malfunction. Usable power supply voltage range is written on the rear panel.

- **Do not remove the case and cover**

Since there are parts with a high voltage in the instrument, touching the part may cause electric shock. When performing inspection, calibration, or repair, please contact IWATSU or our sales distributors.

- **When handling power cord, observe items below:**

If not, fire or electric shock may occur. If the power cord is damaged, it is a power cord dedicated to the instrument, so please contact and purchase it from IWATSU or our sales distributors.

- Do not attempt to fabricate the power cord.
- Do not pull the power cord.
- Do not forcibly bend the power cord.
- Do not heat the power cord.
- Do not twist the power cord.
- Avoid getting the power cord wet.
- Do not bind the power cord together.
- Do not place heavy objects on the top of the power cord.

## **WARNING** (Continued)

- **Do not modify or repair the instrument.**

Modifications or repairs made by users may result in an electric shock, a fire, or a malfunction. This instrument cannot be repaired by users. Do not open it to attempt repairs. For repairs, please contact IWATSU or our sales distributors. Note that modified products will not be accepted for repairs.

- **If a lightning occurs near the instrument operation place, immediately make the power switch OFF and remove the power plug from the power receptacle.**

A lightning may cause an electric shock, a fire, or a malfunction.

- **Do not allow metal objects, etc., to touch the metal blades of the power plug.**

Contact with a metal object, etc., may cause a fire or electric shock.

- **Do not use multiple-connection outlets.**

Power strips and other multiple-connection outlets may cause a fire or overheating.

- **Do not place containers of water or chemicals, small metal objects, etc. near the instrument.**

If the contents are spilled and enter the product, it may cause a fire or an electric shock. If water, chemicals, or metal objects enter the product, make the power switch OFF, remove the plug from the outlet, and then please contact IWATSU or our sales distributors for repair.

- **Do not use the instrument if it is not functioning correctly.**

Using a malfunctioning instrument (due to dropping, etc.) may cause an electric shock or a fire. If the instrument is not functioning correctly, make the power switch OFF, remove the plug from the receptacle, and then please contact IWATSU or our sales distributors for repair.

- **Do not place the instrument in an area where frequent vibrations or impacts occur.**

If the instrument is dropped or overturned, it may cause a physical injury.

- **If the instrument is dropped, it may result in a physical injury or property damage.**

Before transporting the instrument, remove all devices under testing, probes, and cables, and then carry it carefully by two people or more to avoid dropping.

**Read this page to ensure proper safety.** (Also read the following pages.)

## **CAUTION**

- **Set the power cord up in the place where it is pulled out easily.**

When the instrument is in a dicey situation, it is necessary to cut power off promptly. Do not attempt to place the instrument in the location where it is difficult to remove the power cord from the receptacle.

- **When disconnecting the power cord from the receptacle, hold the plug to pull it out.**

Pulling the power cord may damage it, resulting in electric shock or fire.

- **Connect or disconnect the power cord after the POWER switch has been made a OFF.**

If not, fire or overheating may be caused.

- **Do not short-circuit the blade of the power plug with metal and others.**

If touched with metal, fire or electric shock may be caused.

- **Do not use any damaged power cord, cable or adaptor.**

If any damaged power cord, cable or adaptor is used, this may result in electric shock and/or fire.

- **Do not place an object on the instrument.**

The cover comes in contact with an internal circuitry when the object is put on the instrument, and then electric shock, fire, or failures may be caused.

- **Do not place an object near the ventilation opening.**

This may cause the inside to be filled with heat, resulting in fire or failures.

- **Ensure the spaces at the both sides and rear side of the instrument.**

Otherwise, this may cause operation or performance to be failed. Open the space of about 100mm to the left side, the right side, and the back of the instrument. When mounting it on the other instrument, attention should be directed to temperature increase.

- **Do not place the instrument in the location with much moisture (bathroom, etc.) or dirt.**

If not, electric shock or fire may be caused.

- **Do not use the power cord included with the Instrument for other electrical equipment.**

The power cord included with the instrument cannot be used with electrical equipment other than the instrument.

- **Use only the power cord included with the instrument.**

Use only the specified power cord set included with the instrument. Using another power cord may cause electric shock or fire.

If the power cord is damaged, it is a power cord dedicated to the instrument, so please contact and purchase it from IWATSU or our sales distributors.



**Read this page to ensure proper safety.** (Also read the following pages.)

## **CAUTION** (Continued)

- **Do not expose the instrument to the direct sunlight.**

Direct sunlight may the inner temperature to increase, resulting in fire.

- **Do not place the instrument in a location next to a worktable or humidifier, where it may be exposed to oily smoke or steam.**

Doing so may cause an electric shock or fire.

- **Before moving the instrument, remove the power cord and external connection cables from the instrument.**

If not, the cord or the cable may be damaged, resulting in fire or electric shock.

- **When connecting the power cord or measurement cable, care should be taken so that you do not pull such cable. If such cable is pulled, this may cause the instrument to be laid down.**

If the instrument is laid down, this may cause an electric shock, a personal injury, a fire, or a malfunction.

- **Use the instrument within the specified operation and storage range.**

Using outside a regulated system requirements or keeping it outside a regulated environment may cause malfunction.

If not, an failure may be caused. Usable temperature range is as follows:

Only indoor use

Operation temperature : 0 °C to +40 °C

Operation humidity : 5% to 80% RH (at +30 °C or less) and no dew condensation allowed  
upper limit 55% RH (at +40 °C) and no dew condensation allowed

Storage temperature : -20 °C to +60 °C

Storage humidity : 5%~80% RH ( no dew condensation allowed )

- **If not used for a long term, remove the power plug of the instrument from the receptacle for safety.**

- **When transporting the instrument, detach the power code, the cable, and the adaptor, etc. and use the packing material provided at the time of purchase or packing material equivalent at least.**

Excessive vibration or shock applied to the instrument during transportation may cause it to malfunction, resulting in fire. If you do not have the proper packing material or shock absorbing material, please contact IWATSU or our sales distributors. When having the intrument transported by a shipping company, write "Precision Instrument - Handle With Care" on each side of the packing box.

- **Prior to maintenance, remove the power plug from the outlet for safety. Use a cloth to wipe away any moisture.**

Cleaning the instrument while the power plug is connected to the outlet or while the instrument is wet may cause an electric shock or a malfunction.

- **Do not use the instrument without cleaning internal for a long term.**

Long-term use of an instrument having a dirty or dusty interior may cause a fire or malfunction.

It is recommended to contact IWATSU or sales distributors to check and clean the interior, calibrate, etc., about once per year.

**Read this page to ensure proper safety.** (Also read the following pages.)

## **CAUTION** (Continued)

- **Please work carefully so that neither the hand nor the finger, etc. are placed when you handle the cover of the CV BIAS UNIT.**

It might cause the injuries such as hands and fingers when placed.

- **Please use special red Test Leads in the connection of the collector terminal when you measure high voltage.**

When the Test Leads other than red are used, the resisting voltage might damage the measurement sample and the instrument due to the insufficiency.

- **Avoid the measurements of parts other than the semiconductor device because the measurements might cause the breakdown of the instrument and the damage of the measurement device. Moreover, when you measure the device that has not been described to the manual, please contact IWATSU or our sales distributors.**

- **Do not use the instrument by method of no regulations with the instruction manual.**

If not, protection means does not function.

- **Test Adapter CS-501A (option, TO type adapter), CS-502 (option, axial type adapter), and CS-503 / CS-504 / CS-505 / CS-506 / CS-510 (option, surface mount type) Do not apply a voltage exceeding 1 kV (500 V for CS-510) to each terminal of the adapter). Do not apply a voltage exceeding 100 V to each terminal of CS-507 / CS-509 (optional, surface mount type adapter). Also, do not apply a voltage exceeding 3 kV to each terminal of CS-508 (optional, SMD CHIP type adapter).**

Exceeding the above voltage value may cause damage to the equipment and the DUT.

- **A backup battery (CR2032) is installed to memorize the settings when the power is turned off. The battery cannot be replaced by the user. In the following cases, please contact us to replace the battery.**

When the settings that have been memorized up to now are initialized, such as when the IP address returns to the default when the power is turned on.

## Items

When receiving the High Voltage C-V Measurement System, please verify items in the package.

- ◆ CV BIAS UNIT..... : 1
- ◆ CV Measurement Tool (CD-ROM) ..... : 1

### <Accessories>

- Test lead set..... : 1 set (3 wires)
  - For collector voltage ..... : 1
  - For base voltage ..... : 1
  - For emitter voltage ..... : 1
- Crocodile clip set..... : 1 set (6 wires)
  - Red large ..... : 1
  - Black large ..... : 2
  - Red small..... : 1
  - Black small ..... : 2
- CV CABLE ..... : 1
- Power cord (3-prong) ..... : 1
- Cord strap..... : 1
- Instruction Manual (This Manual) ..... : 1

### <Options>

- Test Adapter CS-500 (blank adapter) ..... : 1 set
- Test Adapter CS-501A (TO type adapter) ..... : 1 set
- Test Adapter CS-502 (axial type adapter) ..... : 1 set
- Test Adapter CS-503 (surface mount type adapter)..... : 1 set
- Test Adapter CS-504 (surface mount type adapter)..... : 1 set
- Test Adapter CS-505 (surface mount type adapter)..... : 1 set
- Test Adapter CS-506 (surface mount type adapter)..... : 1 set
- Test Adapter CS-507 (surface mount type adapter)..... : 1 set
- Test Adapter CS-508 (SMD CHIP type adapter)..... : 1 set
- Test Adapter CS-509 (surface mount type adapter)..... : 1 set
- Test Adapter CS-510 (surface mount type adapter)..... : 1 set

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## Contact Us :

### IWATSU ELECTRIC CO., LTD.

Overseas Sales Sect., Sales Dept. No.2,

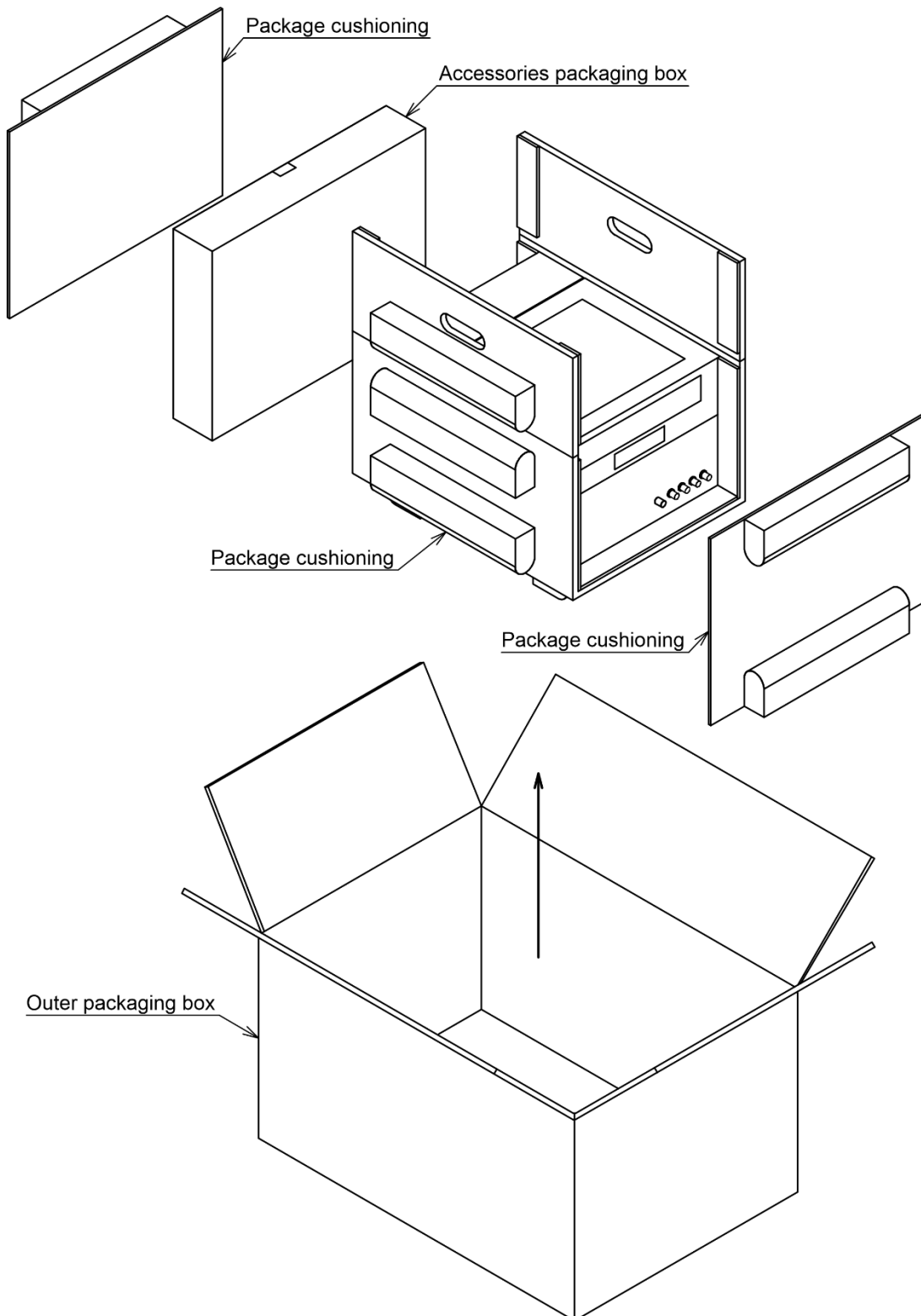
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## Unpacking Drawing

CV Measurement Tool (CD-ROM) and accessories are located in the Accessories packaging box.



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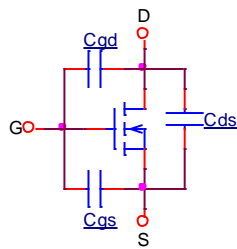
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# Chapter 1 Overview

High Voltage C-V Measurement System is configured by CV BIAS UNIT, LCR Meter and CV Measurement Tool to control their instruments. High Voltage C-V Measurement System can measure the capacitance and/or resistance of power device by changing DC bias voltage. The power devices include MOSFETs, IGBTs and Schottky Barrier Diodes. The CV BIAS UNIT sweeps drain (collector) bias voltage or gate (base) bias voltage. It is possible to measure the characteristic of change of measured values depending on DC bias voltage. In addition, C-Time measurement applies a constant DC bias voltage at a specified time and measures the time change of capacitance and resistance value. Frequency Sweep measurement that sweeps the measurement frequency is possible.

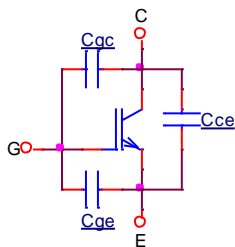
This system can measure Input Capacitance:  $C_{iss}$  ( $C_{ies}$ ), Output Capacitance:  $C_{oss}$  ( $C_{oes}$ ), Reverse Transfer Capacitance:  $C_{rss}$  ( $C_{res}$ ) and Internal Gate Resistance:  $R_g$ .  $C_{iss}$ ,  $C_{oss}$ ,  $C_{rss}$  are respectively defined by following formula.



Input Capacitance	$C_{iss} = C_{gs} + C_{gd}$
Output Capacitance	$C_{oss} = C_{ds} + C_{gd}$
Reverse Transfer Capacitance	$C_{rss} = C_{gd}$

Fig. 1.1 Three Capacitance of Power MOS FET, and Input, Output and Reverse Transfer Capacitances

$C_{ies}$ ,  $C_{oes}$ ,  $C_{res}$  are respectively defined by following formula.



Input Capacitance	$C_{ies} = C_{ge} + C_{gc}$
Output Capacitance	$C_{oes} = C_{ce} + C_{gc}$
Reverse Transfer Capacitance	$C_{res} = C_{gc}$

Fig. 1.2 Three Capacitance of IGBT, and Input, Output and Reverse Transfer Capacitances

The system can measure the capacitance of Power BJT and Power Diode as well as Power MOSFET and IGBT.

# Chapter 2 CV BIAS UNIT

This section outlines name and function of each part in CV BIAS UNIT.

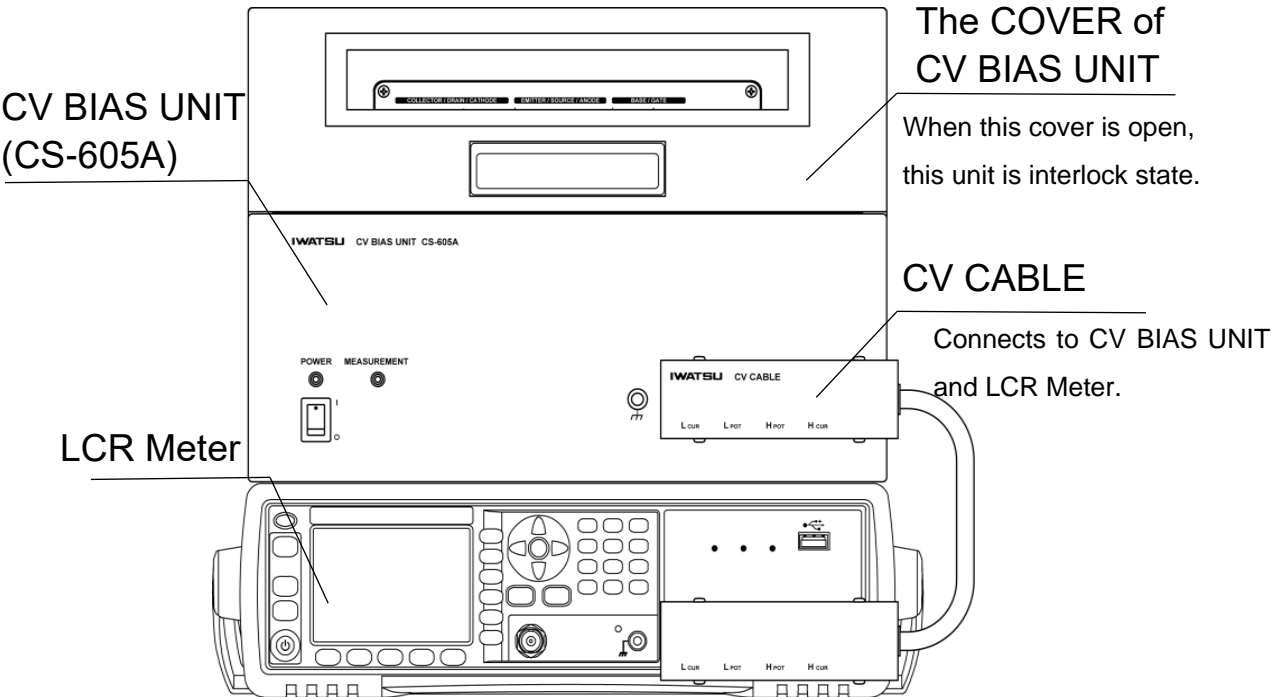


Fig. 2.1 Outer View of the High Voltage C-V Measurement System (without a PC)

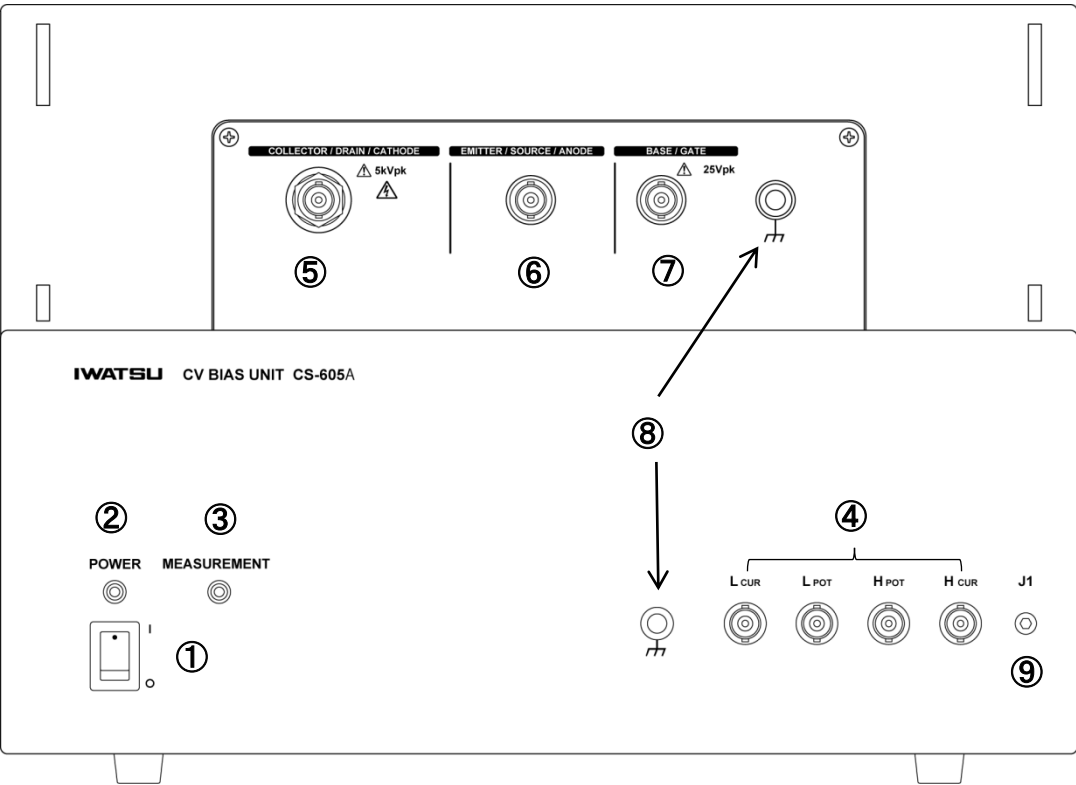


Fig. 2.2 Front View of CV BIAS UNIT without COVER (CS-605A)



Table 2.1 Descriptions of each part on Fig. 2.2

No.		Description
①	Power switch	Power On / Off.
②	POWER LED	Lights when power switch is On.
③	MEASUREMENT LED	Lights when Bias voltage is being applied during measurement.
④	Terminals of $L_{CUR}$ , $L_{POT}$ , $H_{POT}$ , $H_{CUR}$	These terminals connect to corresponding terminals of LCR Meter through the CV CABLE.
⑤	COLLECTOR / DRAIN / CATHODE	Terminal of collector / drain / cathode (List the electrode names of power devices).
⑥	EMITTER / SOURCE / ANODE	Terminal of emitter / source / anode (List the electrode names of power devices).
⑦	BASE / GATE	Terminal of base / gate (List the electrode names of power devices).
⑧	Ground Terminal	Terminal of GND.
⑨	J1 Terminal	Detects whether CV CABLE is correctly connected. If CV CABLE is not properly connected, CV BIAS UNIT is interlocked. If you don't use CV CABLE, J1 terminal is necessary to connect to earth ground (GND).

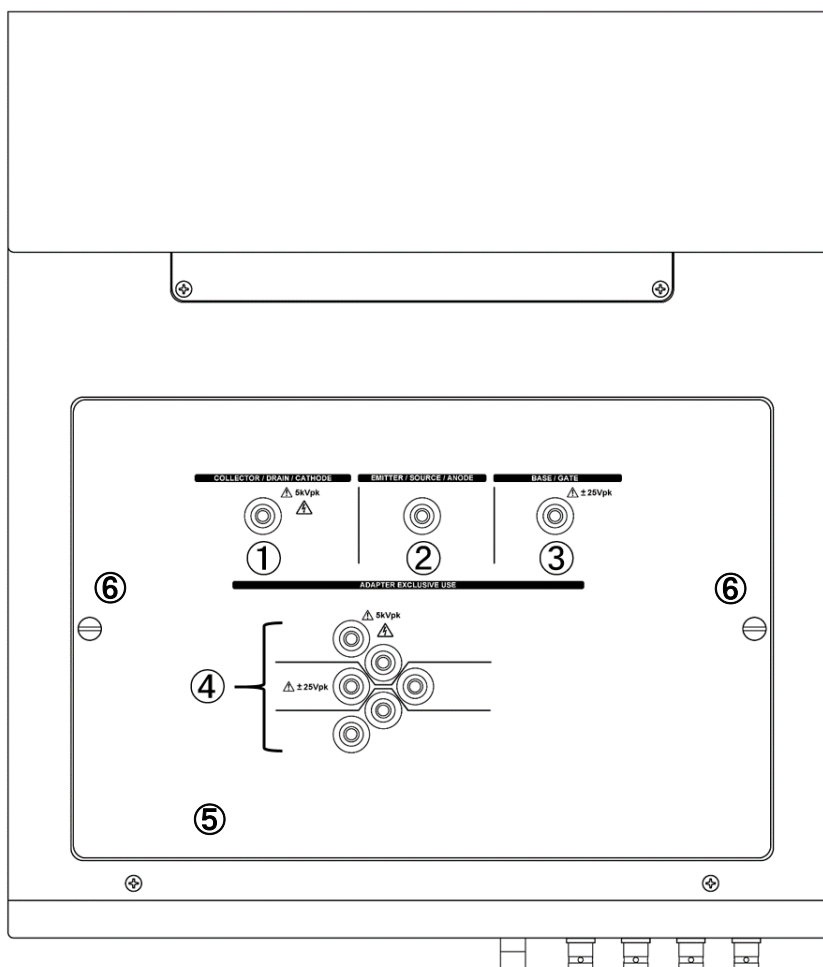


Fig. 2.3 Top View of CV BIAS UNIT (Patch Panel) without COVER (CS-605A)

Table 2.2 Descriptions of Patch Panel on Fig. 2.3

No.		Description
①	COLLECTOR / DRAIN / CATHODE	Connect to ⑤COLLECTOR / DRAIN / CATHODE on Fig. 2.2
②	EMITTER / SOURCE / ANODE	Connect to ⑥EMITTER / SOURCE / ANODE on Fig. 2.2
③	BASE / GATE	Connect to ⑦BASE / GATE on Fig. 2.2
④	Connector for the Test Adapter	Mount the Test Adapter.
⑤	Patch Panel	For large devices that do not use a Test Adapter, remove and measure.
⑥	Fixing screw	Patch Panel fixing screws

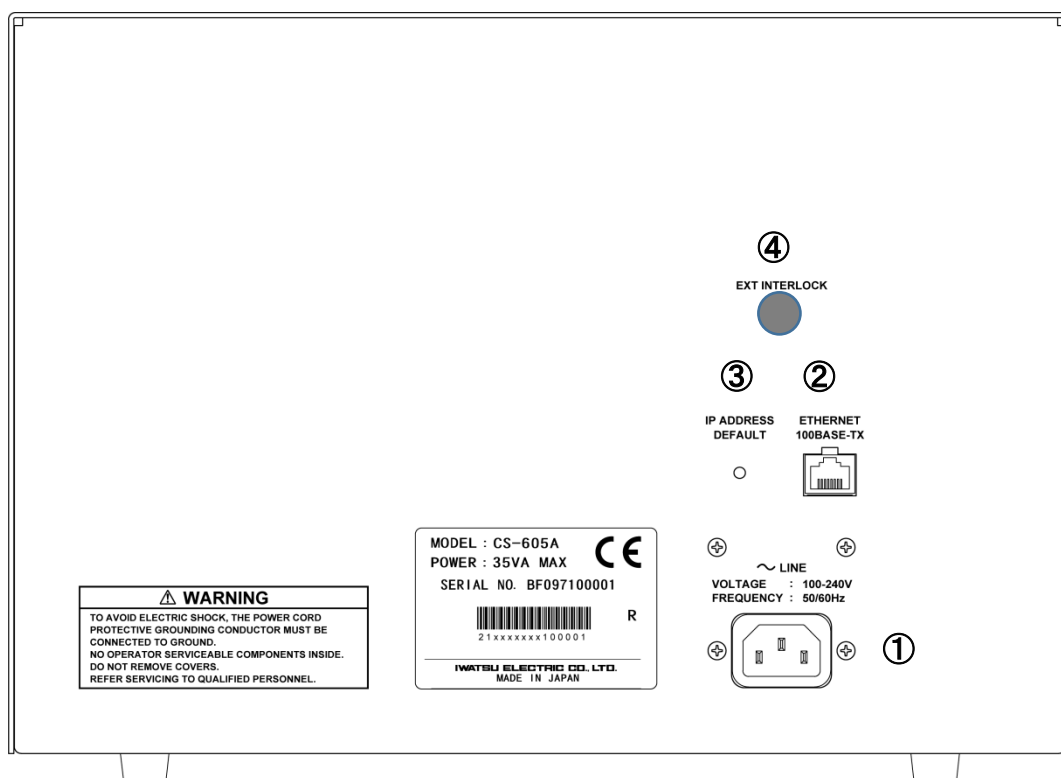


Fig. 2.4 Rear View of CV BIAS UNIT (CS-605A)

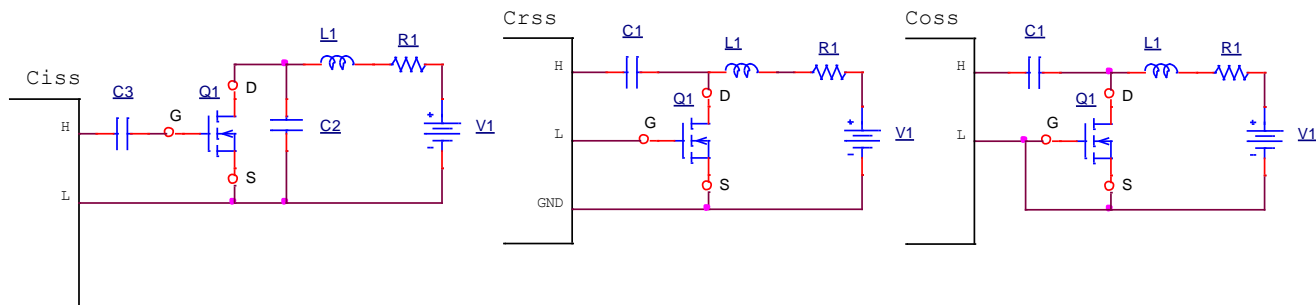
Table 2.3 Descriptions of each part on Fig. 2.4

No.		Description
①	AC LINE INPUT	AC power input connector.
②	ETHERNET Port	LAN cable connecting Port
③	IP ADDRESS DEFAULT	Resets IP address setting of CV BIAS UNIT to default.
④	EXT INTERLOCK	For custom orders. Standard product does not have this function

# 2.1 Function of CV BIAS UNIT

## 2.1.1 The Configuration of measurement equivalent circuitries

Fig. 2.5 shows the configuration of internal equivalent circuitries in CV BIAS UNIT. The device under test (DUT) is a Power MOSFET here.



$C_{iss} = C3 \parallel (C_{gs} + C_{gd} \parallel C2)$        $C_{oss} = C1 \parallel (C_{ds} + C_{gd})$        $C_{rss} = C1 \parallel C_{gd}$   
 C1, C2 and C3 are capacitors for shorting the AC measurement signal from the LCR Meter.  
 L1 is an inductor for blocking the AC measurement signal from the LCR Meter.

Fig. 2.5 Configuration of measurement equivalent circuitries

### 2.1.1.1 The Values of C1, C2, C3 and Bias Voltage Range

Each value will vary depending on the setting and collector bias voltage range.  
 For details, refer to 3.6.3.1 Collector Sweep

Select [Auto(LV :0 - 50)]: Automatically switches between LV output circuitry and HV output circuitry

Bias Voltage Range	0-50V (LV output circuitry)	More than 50V (HV output circuitry)
CS-603A	$C1, C2, C3 \geq 50\mu F$	$C1, C2 \geq 180nF$ $C3 \geq 50\mu F$
CS-605A	$C1, C2, C3 \geq 50\mu F$	$C1, C2 \geq 170nF$ $C3 \geq 50\mu F$

Select [HV] : HV output circuitry only.

Bias Voltage Range	Up to max Voltage (HV output circuitry)
CS-603A	$C1, C2 \geq 180nF$ $C3 \geq 50\mu F$
CS-605A	$C1, C2 \geq 170nF$ $C3 \geq 50\mu F$

## 2.1.2 Outputs of Collector and Gate Bias Voltage

Table 2.4 shows output voltage range and resolution of each voltage output circuitry of CV BIAS UNIT. There are two types of collector bias output circuitry: high voltage output circuitry (HV output circuitry) and low voltage output circuitry (LV output circuitry). The values and resolutions are different at each circuitry.








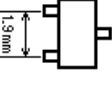
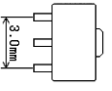

Table 2.4 Range of Bias Voltage and Resolution

		Range	Resolution
Collector bias voltage	HV output circuitry	0 ~ 3 kV (CS-603A) 0 ~ 5 kV (CS-605A)	100 mV
	LV output circuitry	0 ~ 50 V	1 mV
Gate bias voltage		-25 V ~ 25 V	1 mV

### 2.1.3 Connection with DUT

A DUT can be connected with a test lead with an alligator clip or a Test Adapter. The Test Adapter compatible with DUT is available.

Table 2.5 Test Adapter

Model name	Description	Applicable Package	Maximum voltage / current
CS-500 Blank adapter	There are 6 banana plugs on the bottom of the box insulator, which can be assembled by freely attaching sockets and lead contacts.		
CS-501A TO type	TO packages lined up in a row		1 kV / 1 A
CS-502 Axial type	Axial type with lead wire (for diode)		1 kV / 1 A
CS-503	For surface mount component TO-263 (D2PAK, 2.54 mm pitch)		1 kV / 1 A
CS-504	For surface mount component TO-252-3, 2.286 mm pitch		1 kV / 1 A
CS-505	For surface mount component TO-263-7, 1.27 mm pitch		1 kV / 1 A
CS-506	For surface mount component TO-252-5, 1.143 mm pitch		1 kV / 1 A
CS-507	For surface mount component SC-70-3 (SOT-323-3, 0.65 mm pitch)		100 V / 0.5 A
CS-509	For surface mount component SC-59A (SOT-23-3, 0.95 mm pitch)		100 V / 0.5 A
CS-510	For surface mount component SC-62 (SOT-89, 1.5 mm pitch)		500 V / 1 A
CS-508	Surface mount components for chip-shaped diodes		3 kV / 40 A

For more information on Test Adapters, see Chapter 6 Test Adapter (Option).

These Test Adapters are used by attaching them to the connector for the Test Adapter shown in Fig. 2.3, except for CS-508.

To use the Test Adapter CS-508, it must be mounted in the CV BIAS UNIT instead of the Patch Panel.

When a DUT cannot be set to the Test Adapters, a DUT connected with a test lead with an alligator clip and place the DUT in the insulation box after removing the Patch Panel from the top of CV BIAS UNIT as shown in Fig. 2.6 and measure.

In addition, although the inside is insulated, when measuring by applying a high voltage to the DUT, be careful about the insulation between the housing of the measuring instrument and the DUT. If they are in close proximity, they may discharge.

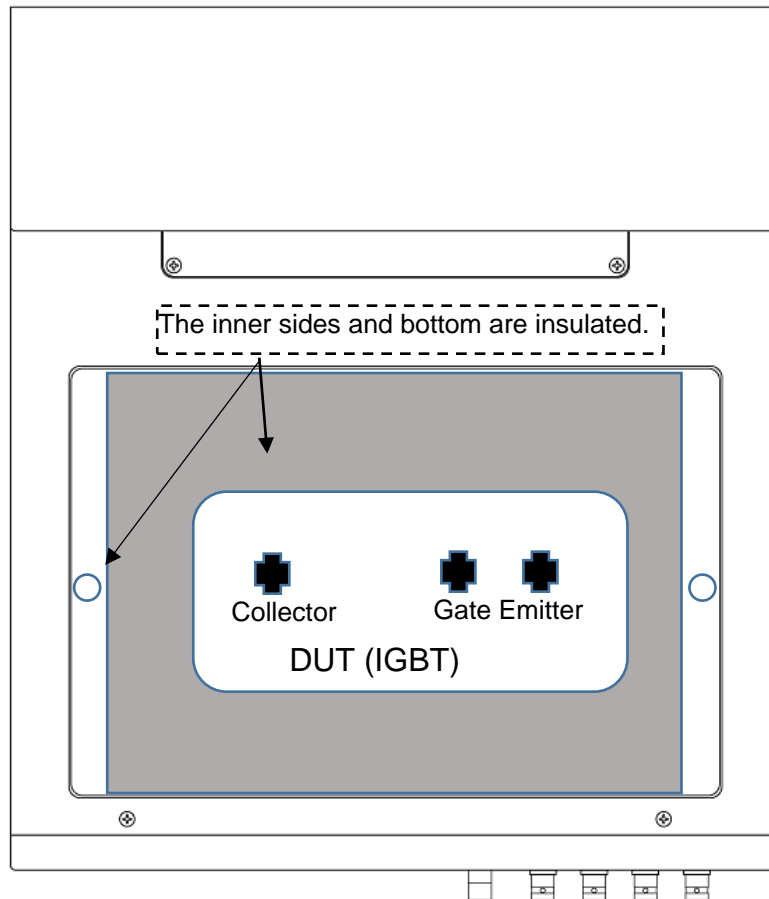


Fig. 2.6 Top View of CV BIAS UNIT without Patch Panel and a DUT.

### CAUTION !

Be sure to use the dedicated red cable when connecting the collector terminal, and be careful of incorrect wiring. It may cause damage to the DUT or malfunction of this instrument.

### CAUTION !

#### Removing and installing patch panels

When you want to measure a large DUT that cannot be set on the Test Adapter, you can remove the Patch Panel and place the DUT inside the insulation for measurement. To remove the Patch Panel, loosen the fixing screws on both ends of the Patch Panel. When installing the Patch Panel, be sure to fix it with the fixing screws. If it is insufficient, the Patch Panel may come off when setting the DUT on the Test Adapter, which is dangerous. Secure it with the fixing screws.

For the Test Adapter CS-508, remove the Patch Panel and install the Test Adapter CS-508 instead. Similarly, firmly fix it with the fixing screws.

# Chapter 3 CV Measurement Tool

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## 3.1 Overview

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CV Measurement Tool is the application software that communicates a CV BIAS UNIT and a LCR Meter to a PC with LAN interface and automatically measures characteristics of a DUT by remote control. The CV Measurement Tool is designed to measure / analyze the capacitance characteristics of the power devices such as IGBTs.

### 3.1.1 Main functions

- Remote control of CV BIAS UNIT and LCR Meter  
Measurement results are acquired from the LCR Meter while controlling the bias voltage output of CV BIAS UNIT.
- Graphical display of measured data  
Measurement results can be displayed on the PC display graphically. It is possible to display multiple results simultaneously measured at different measurement conditions.
  - Cursor function  
Cursors can be displayed on X, Y1 and Y2 axes.
  - Customization  
Measured Data settings can be customized such as title, axis label, background color, axis range, and so on.
  - Save graph image  
Graph (Measured Data) image can be saved at bmp format file basis.
  - Display Reference Data  
The specified formatted csv file can be read and displayed on the graph.
- Settings for measurement condition of LCR Meter  
LCR Meter settings can be configured such as signal frequency and/or voltage level in the application.
- Save measured data  
Measured data can be saved at csv format file basis.
- Import and Export  
Measured Data and measurement condition can be imported and exported later for display and measurement.

### 3.1.2 Prohibited matter

For using the application, follow the requirements shown in below. Otherwise, operation cannot be **ensured** properly performed.

- If the other application controls CV BIAS UNIT and / or LCR Meter at the same time during measurement, results may not be carried out properly.

## 3.2 System Requirements

This application requires as shown Table 3-1.

Table 3-1 Requirements for using the application

	Item	Requirements and specification
CV BIAS UNIT	Model	CS-603A CS-605A
Control PC	-	PC-AT compatible machine (DOS/V machine) Desktop and laptop (notebook) <ul style="list-style-type: none"><li>▪ Memory size 8GB (recommended)</li><li>▪ HDD free space (CV Measurement Tool alone) Approximately 10MB or more</li><li>▪ Display resolution 1280 x 800 or more</li><li>▪ LAN port</li></ul>
	OS	Windows 7 (English version, Japanese version) 32 bit or 64 bit Windows 8.1 (English version, Japanese version) 32 bit or 64 bit Windows 10 (English version, Japanese version) 32 bit or 64 bit
	.Net Framework	4.0 or later
	NI-VISA library	15.0.0
Recommended LCR Meter	Model	Keysight E4980AL HIOKI IM3536

- Setting of PC power mode

Since operation time will not be as specified if PC enters the system stand-by (sleep) or hibernation mode during C-Time measurement, set time to enter into sleep and hibernation to appropriate values using Power Options of Windows.

- Setting of Windows Update

Since the application may be prevented from continuing its operation due to automatic rebooting, etc., if any updates are automatically installed by Windows Update during C-Time measurement, configure Windows Update so that any updates will not be automatically installed during the automatic measurement of the application.



## 3.3 Connection

This application uses TCP/IP protocol for the communications with CV BIAS UNIT and LCR Meter, so it is necessary to make network setting such as IP address and Subnet mask. Control PC and CV BIAS UNIT and LCR Meter must be in same network.

### 3.3.1 CV BIAS UNIT network setting

IP address and subnet mask of CV BIAS UNIT is set to below as factory default.

Table 3-2 Default network settings of CV BIAS UNIT

IP address	192.168.1.102
Subnet mask	255.255.255.0

Prior to change the IP address and subnet mask of CV BIAS UNIT, it is necessary to initialize the network settings of CV BIAS UNIT once. CV BIAS UNIT network settings is initialized when you power on of CV BIAS UNIT while pressing [IP ADDRESS DEFAULT] button on the rear panel.

When clicking [Setting] → [CV BIAS UNIT IP Address Setting] on menu, dialog to set the IP address and subnet mask is shown. Enter IP address on [Set IP] and subnet mask on [Set mask]. After network cable connected to CV BIAS UNIT, check the control PC network setting and click [Apply] button. After rebooting CV BIAS UNIT, new network settings to be applied.

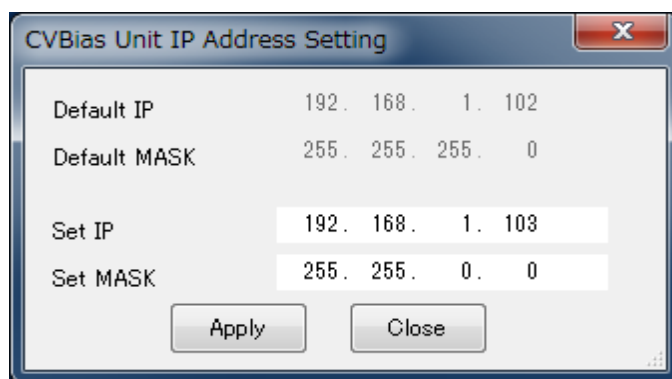


Fig. 3.1 Dialog for CV BIAS UNIT network setting

### 3.3.2 LCR Meter network setting

To set up IP address and Subnet mask of LCR Meter, please refer to your LCR Meter Instruction Manual.

Note: When using HIOKI's LCR Meter, please set as follows. Port number is 3500, Delimiter is CR + LF and Gateway is OFF.

### 3.3.3 Cable connection

After setting LCR Meter network properly, turn OFF power supply of CV BIAS UNIT and LCR Meter, then connect PC in which the application is installed and CV BIAS UNIT and LCR Meter with a network cable. For the connection via network, make a connection to the network terminal such as hub using a straight cable.

### 3.3.4 Caution on the first connection

When connecting for the first time, Windows Firewall function displays a Windows Security Alert screen (Fig. 3.2).

Access needs to be permitted for the communication between application and CV BIAS UNIT and LCR Meter. Mark the network for which communication is to be allowed in accordance with the communication environment of use, and click [Allow access] on the application name to be permitted to communicate with network through firewall. After setting the permission, connect the communication again.



Fig. 3.2 Windows Security Alert dialog

### 3.3.5 Check connection

This function can confirm whether network setting for control PC, LCR Meter and CV BIAS UNIT correctly.

- Check connection between LCR Meter and control PC
  1. Enter IP address of LCR Meter in [LCR Meter IP Address] on main Window (Fig. 3.5 ②)
  2. Select menu [Settings] → [LCR Meter Connect Test]
- Check connection between CV BIAS UNIT and control PC
  1. Enter IP address of CV BIAS UNIT in [CV Bias Unit IP Address] on main Window (Fig. 3.5 ②)
  2. Select menu [Settings] → [CV Bias Unit IP Address Setting]

When network setting is made properly, below dialog (Fig. 3.3) is shown. When dialog (Fig. 3.4) is shown, network setting is not made correctly. Please check the network settings again.

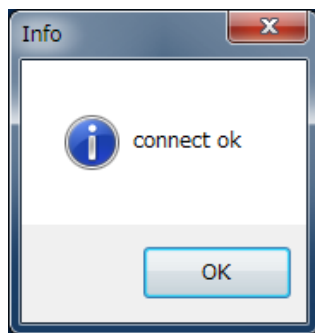


Fig. 3.3 Case of correct connection

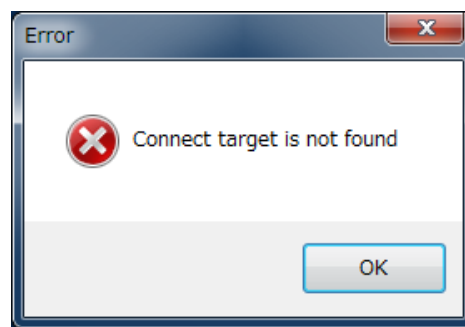


Fig. 3.4 Case of incorrect connection

### 3.4 Operations and Settings in Window

When the application is started, two Windows are displayed (Fig. 3.5, Fig. 3.6).

The explanation uses the measurement of IGBT as an example.

#### 3.4.1 Main Window

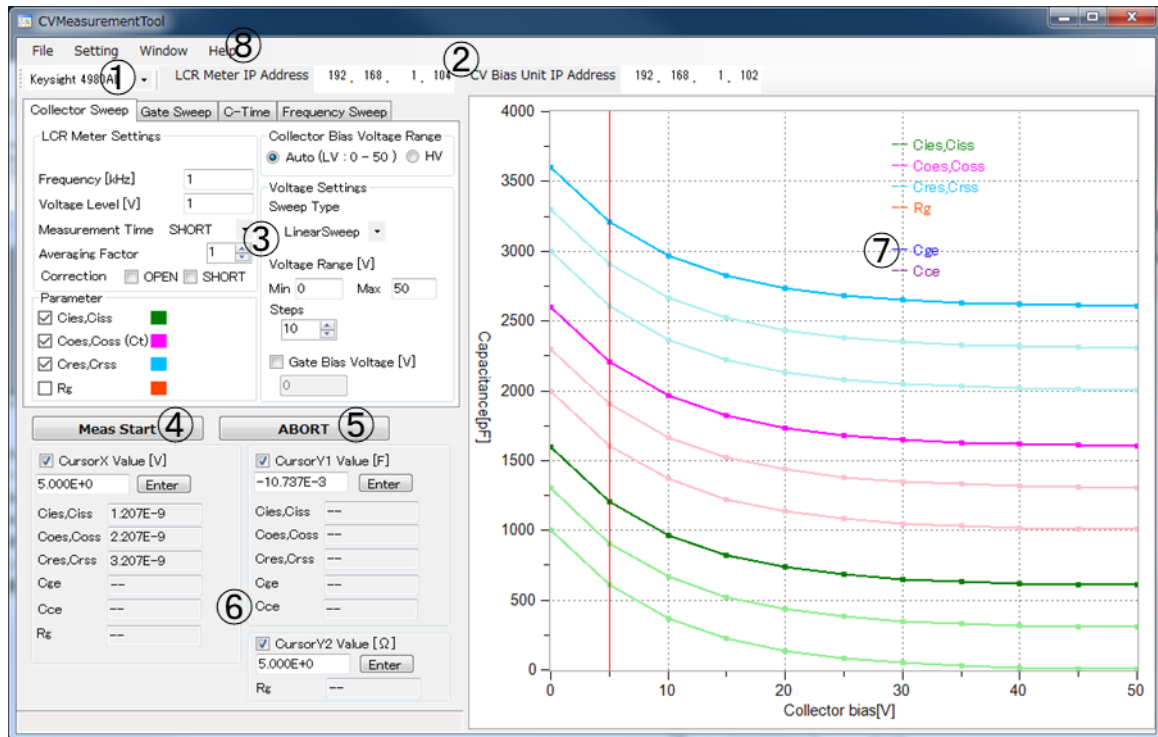


Fig. 3.5 Main Window

Table 3.3 Main Window

No.	Item	Description
①	LCR Meter model	Display LCR Meter model and specifies it.
②	IP address	Display and Enter IP address of LCR Meter and CV BIAS UNIT.
③	Sweep mode tab	Specify measurement condition of each sweep mode. See 3.5 Sweep mode and 3.6 Settings of measurement condition.
④	Meas Start button	When clicking the button, measurement is started.
⑤	ABORT button	When clicking the button in measuring, measurement is cancelled.
⑥	Cursor setting area	Show or hide cursors and displays values indicated by cursors. See 3.10.3 Cursor.
⑦	Graph area	Display measured Data. See 3.10.1 Graph area
⑧	Menu	See 3.12 Menu.

### 3.4.2 Measured Data Table Window

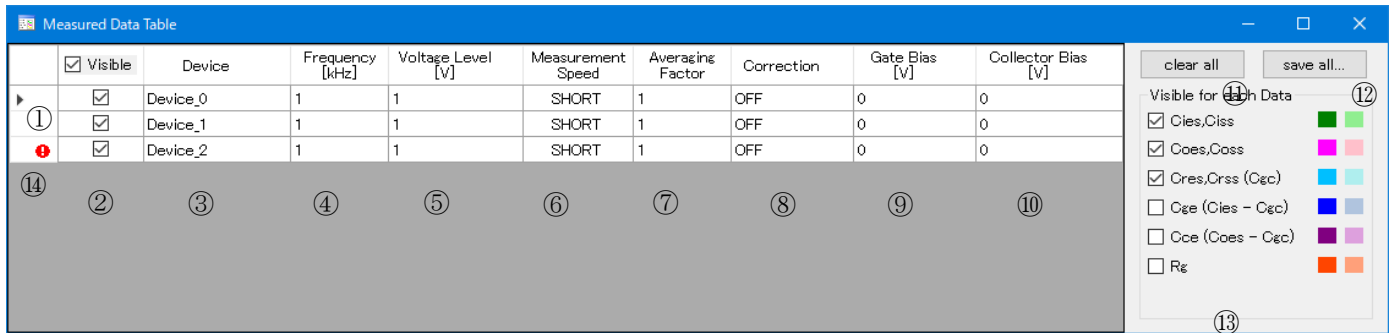


Fig. 3.6 Measured Data Table Window

Table 3.4 Measured Data Table Window

No.	Item	Description
①	Selected cursor	Indicate currently selected data. The cursor can be switched by clicking the line of Measured Data Table you want to select.
②	Visible column	Show or hide each data. When clicking box in the left of [Visible], display or no-display setting is applied for all data.
③	Device column	Display the device name. Device name can be renamed by clicking.
④	Frequency column	Display the measurement frequency. (No-display in Frequency Sweep mode.)
⑤	Voltage Level column	Display the signal voltage level.
⑥	Measurement Time column (Keysight) / Measurement Speed column (HIOKI)	Display mode of the measurement time.
⑦	Averaging Factor column	Display averaging factor.
⑧	Correction column	Display whether the correction was enable.
⑨	Gate Bias column	Display the gate voltage value at fixed gate voltage. (No-display in Gate Sweep mode.)
⑩	Collector Bias column	Display the collector voltage value at fixed collector voltage. (No-display in Collector Sweep mode.)
⑪	clear all button	Clear all data.
⑫	save all button	Save displayed data. See 3.10.4.2 Save for all .
⑬	Visible for each Data	Show or hide each data configuration of measurement. Color sample shown in the side of each check corresponds to color of plot point and line displayed in graph. Left: color of selected Data. Right : color of non-selected Data
⑭	Measured value error display	This error is displayed when either the capacitance value or resistance value of the displayed waveform contains a negative value.

	<input checked="" type="checkbox"/> Visible	Device	Frequency [kHz]	Voltage Level [V]	Measurement Time	Averaging Factor	Correction	Gate Bias [V]	Collector Bias [V]
	<input checked="" type="checkbox"/>	Device_0	1	1	MED	1	OFF	0	0
▶	<input checked="" type="checkbox"/>	Device_1	1	1	MED	1	OFF		
	<input checked="" type="checkbox"/>	Device_2	1	1	MED	1	OFF		

⑮ Save to CSV File...  
 ⑯ Remove  
 ⑰ Add Reference Data...

Fig. 3.7 Dialog box opens when Measured Data Table Window is right clicked

Table 3.5 Dialog box from Measured Data Table Window

No.	Item	Description
⑮	Save to CSV File	Save selected Measured Data. See 3.10.4.1 Save each .
⑯	Remove	Remove selected Data.
⑰	Add Reference Data	Add Reference Data. See 3.11.3 Add Reference Data.

## 3.5 Sweep mode

---

Sweep mode is determined by currently displayed sweep mode tab on main Window (Fig. 3.5 ③).

- Collector Sweep

It sweeps collector voltage. Gate voltage and measurement frequency values are fixed.

X-Axis of the graph shows collector voltage values.

- Gate Sweep

It sweeps gate voltage. Collector voltage and measurement frequency values are fixed.

X-Axis of the graph shows gate voltage values.

- C-Time

Collector voltage, gate voltage and measurement frequency values are fixed.

X-Axis of the graph shows elapsed time from the start of measurement.

- Frequency Sweep

It sweeps measurement frequency. Collector voltage and gate voltage values are fixed.

X-Axis of the graph shows measurement frequency.

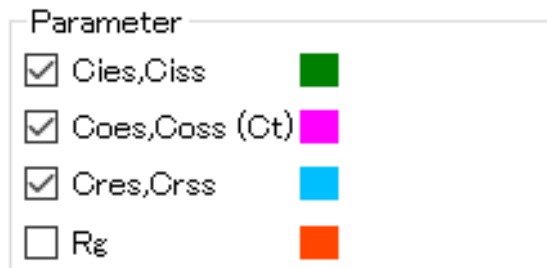
It is not supported when using HIOKI's LCR Meter.

## 3.6 Settings of measurement condition

### 3.6.1 Parameter

[Parameter]

Select the parameters to measure. Check selectable checkboxes of parameter to measure. The configuration of each circuitry is shown in Fig. 2.5. [Rg] is resistance measurement when Cies (Ciss) measurement circuitry configuration is used. When Rg measurement is performed, the value of reactance X is also acquired. It is not displayed in the graph.



A dialog box titled "Parameter" with a list of four items, each with a checkbox and a colored square to its right:

Parameter	Color
<input checked="" type="checkbox"/> Cies,Ciss	Green
<input checked="" type="checkbox"/> Coes,Coss (Ot)	Magenta
<input checked="" type="checkbox"/> Cres,Crss	Cyan
<input type="checkbox"/> Rg	Orange

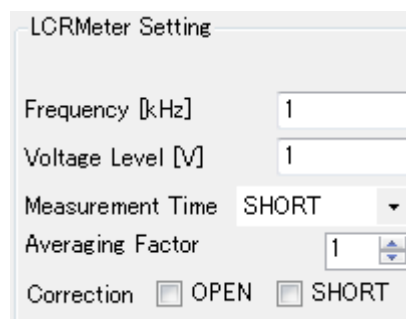
Fig. 3.8 Parameters

The capacitance values Cgc (Cgd), Cge (Cgs) and Cce (Cds) are calculated value from the measured values Cies (Ciss), Coes (Coss) and Cres (Crss). See Fig. 1.2 Three Capacitance of IGBT, and Input, Output and Reverse Transfer Capacitances and Fig. 1.1 Three Capacitance of Power MOSFET, and Input, Output and Reverse Transfer Capacitances.

### 3.6.2 LCR Meter Setting

[LCR Meter Setting]

Measurement condition settings of LCR Meter can be configured. Each setting item and description are as follows.



A dialog box titled "LCRMeter Setting" with the following settings:

Frequency [kHz]	1
Voltage Level [V]	1
Measurement Time	SHORT
Averaging Factor	1
Correction	<input type="checkbox"/> OPEN <input type="checkbox"/> SHORT

Fig. 3.9 LCR Meter Setting



Table 3.6 Items and descriptions of [LCR Meter Setting]

Item	Description
Frequency	Set measurement frequency. Unit is [kHz]. For the value of range and resolution, please refer to LCR Meter manual.
Voltage Level	Set the signal voltage level. Unit is [V]. For the value of range and resolution, please refer to LCR Meter manual.
Measurement Time (Keysight) / Measurement Speed (HIOKI)	Set the Measurement Time Mode. For the setting mode, please refer to LCR Meter manual.
Averaging Factor	Set averaging factor. It can be specified within range of 1 to 256 in steps of 1.
Correction	Enable or disable each correction. When using correction data on LCR Meter manually, uncheck both OPEN and SHORT.

### 3.6.3 Measurement condition at each sweep mode

#### 3.6.3.1 Collector Sweep

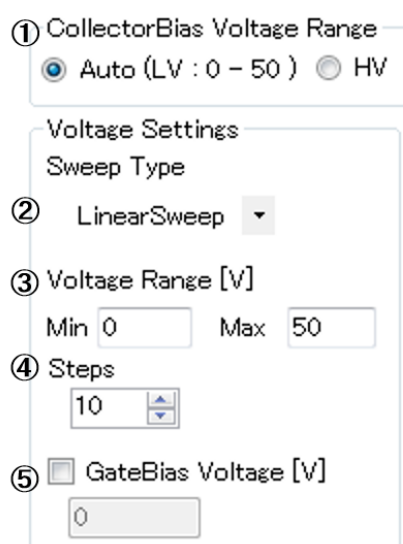


Fig. 3.10 [Collector Sweep] tab

#### ① [Collector Bias Voltage Range]

Specifies collector output circuitry.

When [Auto (LV : 0 - 50) ] is checked, the output circuitry automatically switches according to output voltage setting.

When [HV] is checked, HV output circuitry is only used in measurement.

## ② [Sweep Type]

Specifies sweep type of collector voltage.

- [Single]

Output voltage specified in [Max] once.

- [LinearSweep]

Linearly increases output voltage with respect to the step. Output voltage is given by below.

$$V_{\text{out}} = \frac{V_{\text{max}} - V_{\text{min}}}{\text{Steps}} \times \text{step} + V_{\text{min}}$$

Where

$V_{\text{out}}$  output voltage

$V_{\text{max}}$  voltage specified in [Max]

$V_{\text{min}}$  voltage specified in [Min]

Steps number of steps specified in [Steps]

step present step ( = 0, 1, . . . , Steps)

- [LogSweep]

Output voltage is given by below.

$$V_{\text{out}} = \left( \frac{V_{\text{max}}}{V_{\text{min}}} \right)^{\frac{\text{step}}{\text{Steps}}} \times V_{\text{min}}$$

Where

$V_{\text{out}}$  output voltage

$V_{\text{max}}$  voltage specified in [Max]

$V_{\text{min}}$  voltage specified in [Min]

Steps number of steps specified in [Steps]

step present step ( = 0, 1, . . . , Steps)

- [List Sweep]

Determine collector voltage according to the list in which step and collector voltage value are defined by csv file.

The list is csv file and format is as follows. Enter “Step”, “Volt” on the first line.

Step	,	Volt
0	,	voltage value on the step0
1	,	voltage value on the step1
:	,	:

Note: Specify voltage increment positively. The unit is [V].

When [List Sweep] is checked, name of csv file is shown.

CollectorBias Voltage Range  
☒ Auto (LV : 0 - 50 ) ☐ HV

Voltage Settings  
Sweep Type  
ListSweep

File Name

☐ GateBias Voltage [V]

Fig. 3.11 [ListSweep]

Enter csv file path in [File Name] by typing or drag and drop. When clicking [Browse], dialog to open the csv file. When clicking [View File], the csv file entered in [File Name] opens.

- [Manual]

When [Manual] is selected for [Sweep Type] and measurement is started and slider is shown in below of graph area. Collector voltage is set in real time by moving the value of the slider. The range of slider is specified in [Min], [Max].

③ [Min], [Max]

Specifies the range of collector voltage. When you enter out of range of voltage values or resolution shown in Table 2.4, it will be automatically rounded to nearest possible value before measurement.

④ [Steps]

Specifies measurement step as an integer. The number of steps that can be set is 1 to 5000.

⑤ [Gate Bias Voltage]

When [Gate Bias Voltage] is checked, Gate voltage value can be specified. If you uncheck [Gate Bias Voltage],

Gate voltage is set to the same voltage of emitter (source).

When entering the value out of range of voltage values or resolution shown in Table 2.4, it will be automatically rounded to nearest possible value before measurement.

### 3.6.3.2 Gate Sweep

GateBias Voltage Settings

Sweep Type

① LinearSweep ▼

Voltage Range [V]

② Min 0 Max 25

③ Steps

10

④ CollectorBias Voltage [V]

0

Fig. 3.12 [Gate Sweep] tab

#### ① [Sweep Type]

Specifies sweep type of gate voltage.

- [Single]

Output gate voltage specified in [Max] once.

- [Linear Sweep]

Linearly increase output voltage with respect to the step. Refer to 3.6.3.1 Collector Sweep at [Linear Sweep] for output voltage.

- [List Sweep]

Determine gate voltage according to the list in which step and gate voltage value are defined by csv file. For the list file format, refer to 3.6.3.1 Collector Sweep at [ListSweep].

- [Manual]

When [Manual] is selected for [Sweep Type] and measurement is started and slider is shown in below of graph area. Gate voltage is set in real time by moving the value of the slider. The range of slider is specified in [Min], [Max].

#### ② [Min], [Max]

Specifies range of gate voltage. When you entering out of range of voltage values or more than the resolution shown in Table 2.4, it will be automatically rounded to nearest possible value before measurement.

#### ③ [Steps]

Specifies measurement step as an integer. The number of steps that can be set is 1 to 5000.

#### ④ [Collector Bias Voltage]

Specifies collector bias voltage. When you entering out of range of voltage values or resolution shown in Table 2.4, it will be automatically rounded to nearest possible value before measurement. When output voltage value is in LV Range, LV output circuitry is used.

### 3.6.3.3 C-Time

Time Settings

① Steps  
100

② Intervals [s]  
0.0

Voltage Settings

③ Collector Bias Voltage [V]  
0

④ ☒ Gate Bias Voltage [V]  
0

Fig. 3.13 [C-Time] tab

#### ① [Steps]

Specifies measurement step as an integer. The number of steps that can be set is 1 to 5000.

#### ② [Intervals]

Specifies the time intervals to trigger LCR Meter. The intervals can be set from 0.0 to 5000.0 in step of 0.5 seconds. If the intervals is specified in a time shorter than single measurement time, the next measurement is started immediately once the measurement is completed. (Refer to Fig 3.15.)

#### ③ [Collector Bias Voltage]

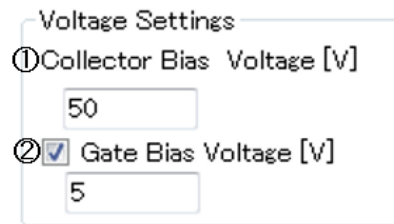
Specifies collector bias voltage. When you entering out of range of voltage values or resolution shown in Table 2.4, it will be automatically rounded to nearest possible value before measurement. When output voltage value is in LV Range, LV output circuitry is used.

#### ④ [Gate Bias Voltage]

When [Gate Bias Voltage] is checked, Gate voltage value can be specified. If you uncheck [Gate Bias Voltage], gate voltage is set to the same voltage of emitter (source).

When entering the value out of range of voltage values or resolution shown in Table 2.4, it will be automatically rounded to nearest possible value before measurement.

### 3.6.3.4 Frequency Sweep



Voltage Settings

① Collector Bias Voltage [V]  
50

② ☒ Gate Bias Voltage [V]  
5

Fig. 3.14 [Frequency Sweep] tab

#### ① [Collector Bias Voltage]

Specifies collector bias voltage. When you entering out of range of voltage values or resolution shown in Table 2.4, it will be automatically rounded to nearest possible value before measurement. When output voltage value is in LV Range, LV output circuitry is used.

#### ② [Gate Bias Voltage]

When [Gate Bias Voltage] is checked, Gate voltage value can be specified. If you uncheck [Gate Bias Voltage], gate voltage is set to the same voltage of emitter (source).

When entering the value out of range of voltage values or resolution shown in Table 2.4, it will be automatically rounded to nearest possible value before measurement.

### 3.7 LCR Meter OPEN / SHORT correction (Collector Sweep / Gate Sweep / C-Time measurement)

#### 3.7.1 Compensation of test lead inductance and the parasitic capacitance of circuitry

After constructing measurement circuitry utilizing Open / Short correction techniques appropriate compensation should be performed. At Collector Sweep, Gate Sweep, and C-Time measurement, the correction is performed for only one specified frequency point. When using LCR Meter from Keysight, SPOT No.1 to No.12 are used to compensation values. For HIOKI, PANEL No. 1 to No. 12 are used.

The relationship between SPOT / PANEL to be used and the measurement circuitry configuration inside CV BIAS UNIT is shown in Table 3.7. When correction is enabled on the application, measurement values are corrected by enabling only SPOT / PANEL number corresponding to the Circuit currently used for measurement.

Table 3.7 SPOT / PANEL and measurement circuitries (See Fig. 2.5)

SPOT / PANEL	Measurement circuitries
No 1	Cies(Ciss) + LV output circuitry
No 2	Coes(Coss) + LV output circuitry
No 3	Cres(Crss) + LV output circuitry
No 4	Cies(Ciss) + HV output circuitry
No 5	Coes(Coss) + HV output circuitry
No 6	Cres(Crss) + HV output circuitry
No 7	Cies(Ciss) + LV output circuitry + gate voltage output circuitry
No 8	Coes(Coss) + LV output circuitry + gate voltage output circuitry
No 9	Cres(Crss) + LV output circuitry + gate voltage output circuitry
No 10	Cies(Ciss) + HV output circuitry + gate voltage output circuitry
No 11	Coes(Coss) + HV output circuitry + gate voltage output circuitry
No 12	Cres(Crss) + HV output circuitry + gate voltage output circuitry

### 3.7.2 Execution of LCR Meter correction

LCR Meter correction is executed in the following two ways.

- ① Select Menu [Setting] → [LCR Meter Correction].
- ② Execute measurement when the following conditions in Table 3.8 for Keysight or 3.9 for HIOKI are satisfied.

Either ways, correction at the frequency point specified in [Frequency] on [LCR Meter Setting] is executed.

OPEN and SHORT correction for all measurement circuitries are performed in one execution of correction regardless of whether or not it will be used. When execution of LCR Meter correction completed correctly, the application holds the value of frequency and each correction data when correction is executed.

When changing configuration of external measurement circuitry without changing measuring frequency, correction will not be executed before measurement. In this case, please execute correction manually by the method

Table 3.8 Correction execution condition at measurement for Keysight E4980AL

Correction [OPEN] / [SHORT] Checkbox	Frequency	Compensation values held by LCR Meter and values held by the appli- cation	Process
Either or both checked	Different from previous measurement	—	Execute correction using from SPOT No.1 to No.12. This application holds correction values.
	Not different from previous measurement	Different	Compensation values held by the appli- cation are set on SPOT No.1 to No.12.
		Same	Measurement is started using correction values held by LCR Meter.
Both unchecked	—	—	Correction settings are not changed.

Table 3.9 Correction execution condition at measurement for HIOKI IM3536

Correction [OPEN] / [SHORT] Checkbox	Frequency	Compensation values held by LCR Meter and values held by the appli- cation	Process
Either or both checked	Different from previous measurement	—	Execute correction using from PANEL No.1 to No.12. This application holds correction values.
	Not different from previous measurement	different	Measurement is started using correction values held by LCR Meter.
		same	
Both unchecked	—	—	Correction settings are not changed.



### 3.7.3 Procedure of LCR Meter correction

Each correction is performed in the following order. Execute correction following displayed dialog.

1. OPEN correction of Cies (Ciss), Coes (Coss) and Cres (Crss) + LV and HV output circuitry + gate voltage output circuitry is performed. (SPOT / PANEL No.1~No.12 OPEN)

Messages in the dialog box are Click [OK] button on the dialog after unloading DUT.

2. SHORT correction of Cies (Ciss) + LV and HV output circuitry + gate voltage output circuitry is performed. (SPOT / PANEL No.1, No.4, No.7, No.10 SHORT)

Messages in the dialog box are Click [OK] button on the dialog after making sure to short emitter-gate.

3. SHORT correction of Coes (Coss) + LV and HV output circuitry + gate voltage output circuitry is performed. (SPOT / PANEL No.2, No.5, No.8, No.11 SHORT)

Messages in the dialog box are Click [OK] button on the dialog after making sure to short collector-emitter.

4. SHORT correction of Cres (Crss) + LV and HV output circuitry + gate voltage output circuitry is performed. (SPOT / PANEL No.3, No.6, No.9, No.12 SHORT)

Messages in the dialog box are Click [OK] button on the dialog after making sure to short collector-gate.

### **3.8 LCR Meter OPEN / SHORT correction (Frequency Sweep measurement)**

---

In Frequency Sweep measurement, the correction is performed for all frequency points of LCR Meter.

When correction is enabled, correction is executed every time once the combination of measurement circuitries shown in Table 3-7 used for Frequency Sweep measurement is changed. When continuous measurement is performed under the condition that the combination of measurement circuitries is not changed, the previous correction value can be used.

### 3.9 Measurement

Measurement starts by clicking [Meas Start] button in the Main Window. After entering the device name, the current measurement condition is added to the list of Measured Data Table Window and the data under measurement is plotted to graph area. [ABORT] button is only enabled during measurement. The measurement can be cancelled by clicking the button.

#### Collector Sweep and Gate Sweep measurement

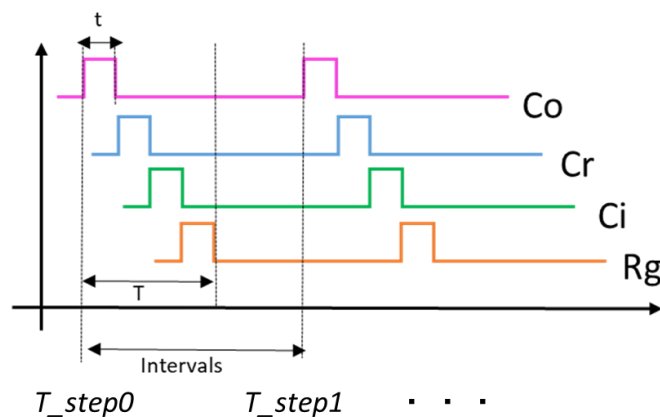
This measurement sweeps voltage. Measurement frequency value is fixed. Measurement is performed for checked configuration in specified voltage range. If the voltage does not reach the specified value, measurement will be canceled. When the sweep of the specified range is completed, sweep of the next configuration starts.

#### C-Time measurement

Measurement is performed for checked configuration in the order of Coes (Coss), Cres (Crss), Cies (Ciss) and Rg. Collector voltage, gate voltage and measurement frequency values are fixed. In case of  $Intervals \leq T$ , the time specified in [Intervals] is ignored and measurement is performed with  $Intervals = T$ .

In this case, the time specified in "Intervals" is ignored, and after the measurement for that step is completed, the measurement for the next step begins.

Note: When "Pause before measuring Cres, Crss" is checked in the menu, Cres (Crss) measurement cannot be performed at the same time as other configurations. If you want to measure Cres (Crss), check only Cres (Crss) and measure, or uncheck "Pause before measuring Cres, Crss".



$t$ :	Measurement time per Configuration
$T$ :	Total of $t$
$Intervals$ :	Time specified in [Intervals]
$T\_step0, T\_step1 \dots$ :	Values plotted on the X-axis

Fig. 3.15 Sequence of C-Time measurement

### **Frequency Sweep measurement**

Frequency Sweep measurement is performed for checked configuration in following frequency points. Collector voltage, gate voltage are fixed. When the sweep of the range is completed, sweep of the next configuration starts.

Frequency Sweep measurement performed at the following frequency points.

<Frequency points>

5 kHz	6 kHz	8 kHz	10 kHz	12 kHz	15 kHz
20 kHz	25 kHz	30 kHz	40 kHz	50 kHz	60 kHz
80 kHz	100 kHz	120 kHz	150 kHz	200 kHz	250 kHz
300 kHz	400 kHz	500 kHz	600 kHz	800 kHz	1000 kHz

#### **3.9.1 Device name**

Before measurement is started, enter device name in order to distinguish for each data.

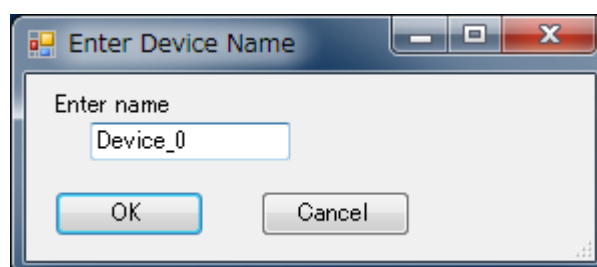


Fig. 3.16 Input form for device name

When there is a number at the end of the device name which entered at previous measurement, the default device name, which is currently displayed, is incremented by one automatically.

Example of increment of number

Device name at the last time	Default device name
Device1	Device2
Device009	Device010

The device name that already exists in the Measured Data Table can not be used.

The device name can be renamed by clicking Device column in Measured Data Table.

### 3.9.2 Interlock

CV BIAS UNIT becomes to interlock state when the cover is open or CV CABLE is incorrectly connected. When not using CV CABLE, earth J1 terminal to GND.

When CV BIAS UNIT is change to interlock state during measurement, below dialog is shown. If you want to continue to measure, click [OK] button after interlock is released. Click [ABORT] button to cancel measurement.

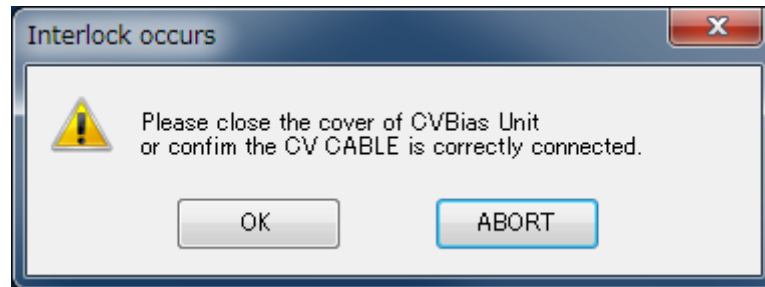


Fig. 3.17 Interlock dialog

When the application detects interlock state when output voltage is being applied during measurement, measurement is aborted.

## 3.10 Graphical display / Analysis of measured data

### 3.10.1 Graph area

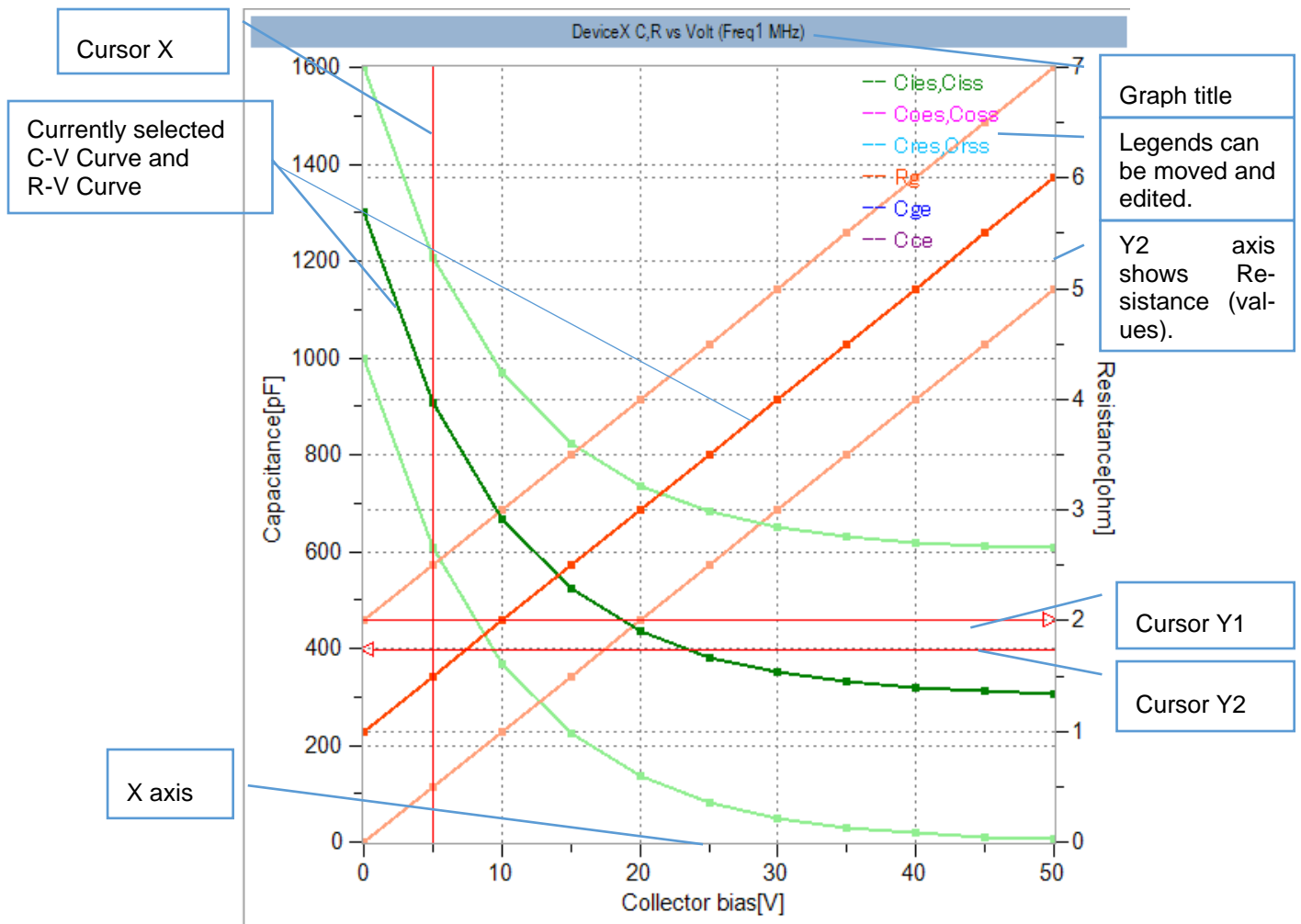


Fig. 3.17 Description of graph

Each displayed legend can be edited or moved. When double-clicking on any position in graph area, legend is appeared in the current position.

When clicking the cursor, the line becomes dashed. The cursor can be moved by dragging and also rolling mouse wheel.

### 3.10.2 Graph Setting

Graph settings can be made by right clicking on graph area.

- X-Axis

The screenshot shows the 'GraphSetting' dialog box with the 'X-Axis' tab selected. The 'Caption' field contains 'Collector bias'. The 'Unit' checkbox is checked, and the unit is set to 'non' with a 'V' in a separate box. The 'Measurement' dropdown is set to 'V'. The 'Scale' section has 'Log' unselected and 'Linear' selected. The 'Range' section has 'Auto' checked and '1-2-5 step (Start from Zero)' unchecked. The 'Min' field is '0' and the 'Max' field is '10'. The 'Grid' section has 'Visible' checked and a 'Color' button. 'OK' and 'Cancel' buttons are at the bottom.

Table 3.10 Graph Setting X-Axis

Item	Description	
Caption	X-Axis label setting. The caption is displayed in the bottom edge of graph.	
Unit	Collector Sweep / Gate Sweep / Frequency Sweep	Enable or disable SI-prefix and unit character. Checked : Formats X-Axis value with SI-prefix. [SI-prefix unit character] is followed in the caption.
		SI-prefix Symbol      p, n, u, m, non, k, M, G (non = 10 <sup>0</sup> )
		Unit character      Specify any string.
	C-Time	Specify X-Axis value format. Unchecked : format is [hour:min:sec].
Measurement	Measurement type setting. The Measurement type for X-Axis is displayed.	
Scale	Axis scale setting. Log / Linear can be selected. In C-Time measurement, the scale is fixed at Linear.	
Range	Axis range setting. Sets X-Axis range.	
	Auto	Determine the range including all visible Data automatically.
	1-2-5step (Start from Zero)	Axis range is determined at 1-2-5steps basis and minimum (maximum) value is set to zero automatically. This setting is available when Range is set at Auto.
	Min	Set minimum value of the range when Range is not set at Auto.
	Max	Set maximum value of the range when Range is not set at Auto.
Grid	Grid display setting.	
	Visible	Set the grid shown or hidden.
	Color	Set the grid color.

- Y-Axis

GraphSetting

X-Axis Y-Axis Y2-Axis Options

Caption  ☒ Unit [   ]

Measurement

Scale ☐ Log ☒ Linear

Range ☒ Auto ☐ 1-2-5 step (Start from Zero)

Min  Max

Grid ☒ Visible

Table 3.11 Graph Setting Y-Axis

Item	Description	
Caption	Y-Axis label setting. The caption is displayed in the left edge of graph.	
Unit	Enable or disable SI-prefix and unit character. Checked : Formats Y-Axis value with SI-prefix. [SI-prefix unit character] is followed in the caption.	
	SI-prefix Symbol	p, n, u, m, non, k, M, G (non = 10 <sup>0</sup> )
	Unit character	Specify any string.
Measurement	Measurement type setting. The Measurement type for Y-Axis is displayed.	
Scale	Axis scale setting. Log / Linear can be selected.	
Range	Axis range setting. Set Y-Axis range.	
	Auto	Determine the range including all visible Data automatically.
	1-2-5step (Start from Zero)	Axis range is determined at 1-2-5steps basis and minimum (maximum) value is set to zero. This setting is available when Range is set at Auto.
	Min	Set minimum value of the range when Range is not set at Auto.
	Max	Set maximum value of the range when Range is not set at Auto.
Grid	Grid display setting	
	Visible	Set the grid shown or hidden.
	Color	Set the grid color.



- Y2-Axis

GraphSetting

X-Axis Y-Axis **Y2-Axis** Options

Caption  ☒ Unit [   ]

Measurement

Scale ☐ Log ☒ Linear

Range ☒ Auto ☐ 1-2-5 step (Start from Zero)

Min  Max

Grid ☒ Visible

Table 3.12 Graph Setting Y2-Axis

Item	Description	
Caption	Y2-Axis label setting. The caption is displayed in the right edge of graph.	
Unit	Enable or disable SI-prefix and unit character. Checked : Formats Y2-Axis value with SI-prefix. [SI-prefix unit character] is followed in the caption.	
	SI-prefix Symbol	p, n, u, m, non, k, M, G (non = 10 <sup>0</sup> )
	Unit character	Specify any string.
Measurement	Measurement type setting. The Measurement type for Y2-Axis is displayed.	
Scale	Axis scale setting. Log / Linear can be selected.	
Range	Axis range setting. Set Y2-Axis range.	
	Auto	Determine the range including all visible Data automatically.
	1-2-5step (Start from Zero)	Axis range is determined at 1-2-5steps basis and minimum(maximum) value is set to zero. This setting is available when Range is set at Auto.
	Min	Set minimum value of the range when Range is not set at Auto.
	Max	Set maximum value of the range when Range is not set at Auto.
Grid	Grid display setting	
	Visible	Set the grid shown or hidden.
	Color	Set the grid color.

When [Range] is set at Auto, axis range is automatically determined by Measured Data, and [Min] / [Max] setting is disabled.

When [Range] is set to both [Auto] and [1-2-5 Step (Start from Zero)], axis range is determined from interval of 1, 2, or 5. In this case, minimum value of the axis is set to zero. However, when data with negative values exist among displayed data, and the range of data with negative value is larger than maximum positive value, maximum positive value of axis is set at zero.

When [Scale] is set to Log scale, the values of Measured Data are displayed as absolute values.

When [Unit] is checked, [Min] / [Max] setting values are converted according to specified SI-prefix (ex. “4,000pF” calculated into “4nF” automatically when changing from p to n of suffix).

- Options

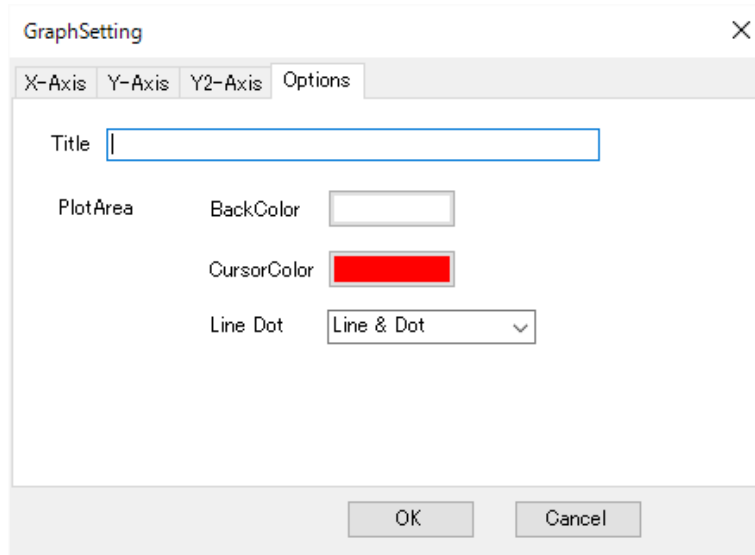


Table 3.13 Graph Setting Options

Item	Description
Title	Set Measurement title. The title is displayed in the top of graph.
Back Color	Set color of Plot area background.
Cursor Color	Set Cursor color.
Line Dot	Set plotting points and Line. Line & Dot : Display plotting points and Line. Dot : Display only plotting points. Line : Display only Line.

### 3.10.3 Cursor

Cursor shown / hidden can be set in this area and displays the value indicated by each cursor. The values of currently selected data are displayed.

The screenshot shows a software interface for setting cursors. It is divided into two main sections: 'CursorX Value [V]' and 'CursorY1 Value [F]'. The 'CursorX Value [V]' section has a checked checkbox, a text input field with '5.000E+0', an 'Enter' button, and a list of data points (Cies,Ciss, Coes,Coss, Cres,Crss, Cge, Cce, Rg) with corresponding values. The 'CursorY1 Value [F]' section has a checked checkbox, a text input field with '398.000E-12', an 'Enter' button, and a list of data points (Cies,Ciss, Coes,Coss, Cres,Crss, Cge, Cce, Rg) with corresponding values. Below these is a 'CursorY2 Value [Ω]' section with a checked checkbox, a text input field with '2.000E+0', an 'Enter' button, and a list of data points (Cies,Ciss, Coes,Coss, Cres,Crss, Cge, Cce, Rg) with corresponding values. Callouts point to various elements: 'Show or hide the cursor.' points to the checkboxes; 'Moves cursor X to entered value.' points to the 'Enter' button in the X section; 'Displays the value of intersection between cursor X and each Data.' points to the data list in the X section; 'Move cursor Y1 to entered capacitance value.' points to the 'Enter' button in the Y1 section; 'Displays the value of intersection between cursor Y1 and each Data.' points to the data list in the Y1 section; 'Moves cursor Y2 to entered resistance value.' points to the 'Enter' button in the Y2 section; and 'Displays the value of intersection between cursor Y2 and each Data.' points to the data list in the Y2 section.

CursorX Value [V]  
☒ 5.000E+0 Enter  
Cies,Ciss 906.531E-12  
Coes,Coss --  
Cres,Crss --  
Cge --  
Cce --  
Rg 1.500E+0

CursorY1 Value [F]  
☒ 398.000E-12 Enter  
Cies,Ciss 23.506E+0  
Coes,Coss --  
Cres,Crss --  
Cge --  
Cce --  
Rg 10.000E+0

CursorY2 Value [Ω]  
☒ 2.000E+0 Enter  
Cies,Ciss --  
Coes,Coss --  
Cres,Crss --  
Cge --  
Cce --  
Rg 10.000E+0

Show or hide the cursor.

Moves cursor X to entered value.

Displays the value of intersection between cursor X and each Data.

Move cursor Y1 to entered capacitance value.

Displays the value of intersection between cursor Y1 and each Data.

Moves cursor Y2 to entered resistance value.

Displays the value of intersection between cursor Y2 and each Data.

Fig. 3.19 Cursor setting area

In C-Time measurement, X-Axis value format is [hour : minute : second].

Ex.) To set 12 min 34 s → Set as 0:12:34.

### 3.10.4 Save from Measured Data Table

#### 3.10.4.1 Save each measured data from the Measured Data Table

To save measured data as csv file, right click the row of Measured Data Table.

Enter file name in the dialog box once clicking [Save to CSV File] on menu, then currently selected data are output as csv file. The format of csv is as follows.

Line#	Description
1	Sweep Mode , X-Axis data header*1
2	Measurement Title, The name of graph title
3	Frequency [kHz]*2, The value of frequency*2, Signal Voltage Level [V], The value of signal voltage level, Measurement Time*3 ,The value of measurement time, Averaging Factor ,The number of averaging factor, Correction, The choice of correction enabled or not, Gate Bias[V]*4, The value of gate voltage*4, Collector Bias[V]*5 , The value of collector voltage*5 Measurement Parameter (Ci / Co / Cr), each measurement function setting value
4	X-Axis data header*1, Ci, Co, . . .
5 or later	X-Axis value*6, Capacitance and/or Resistance values at each X-Axis value, . . . *7

#### 3.10.4.2 Save for all measured data on the Measured Data Table

To save all displayed data as csv file, click [save all] button on the Measured Data Table Window.

The output data are values of X-Axis values of capacitance and/or resistance at each X-Axis value. The range and interval of X-Axis value can be specified by following two ways.

Note: Data measured with [Sweep Type] set to [Manual] may not be output correctly.

##### 1. [Auto]

Outputs X-Axis value and capacitance and/or resistance on the X-Axis value of each Data in the same range and interval of currently selected Data.

The format of csv is as follows.

Line#	Description
1	Sweep Mode, X-Axis data header*1
2	Measurement Title, The name of graph title
3	Frequency [kHz]*2, The frequency value of currently selected Data*2, Signal Voltage Level [V], The value of currently selected Data,

	Measurement Time*3, The value of currently selected Data, Averaging Factor, The value of currently selected Data, Correction, The value of currently selected Data, Gate Bias[V]*4, The value of currently selected Data*4, Collector Bias[V]*5, The value of currently selected Data*5 Measurement Parameter (Ci / Co / Cr), each measurement function setting value currently selected
4	X-Axis data header*1, Device1 Ci, Device1 Co", . . . ,Device2 Ci, . . .
5 or later	X-Axis value*6, Ci values of Device1 on the X-Axis value, Co values of Device1 on the X-Axis value, . . . Ci values of Device2 on the X-Axis value, . . . *7

## 2. [Manual]

Range and constant interval of X-Axis value and capacitance and/or resistance can be specified. The format of csv is as follows.

Line#	Description
1	X-Axis data header*1, Device1 Ci, Device1 Co", . . . , Device2 Ci, . . .
2 or later	X-Axis value*6, Ci values of Device1 on the X-Axis value, Co values of Device1 on the X-Axis value, . . . Ci values of Device2 on the X-Axis value, . . . *7

\*1 : X-Axis data header is one of "Vc", "Vg", "Time", or "Frequency" and corresponds to X-Axis value of Collector Sweep, Gate Sweep, C-Time and Frequency Sweep measurement.

\*2 : It is not output in Frequency Sweep measurement.

\*3 : When using HIOKI's LCR Meter, it is "Measurement Speed".

\*4 : It is not output in Gate Sweep measurement.

\*5 : It is not output in Collector Sweep measurement.

\*6 : "Vc", "Vg" unit is [V], Time is [sec], and Frequency is [Hz].

\*7 : Capacitance unit is [F] and resistance is [ $\Omega$ ].

## 3.11 Export / Import

It is possible to save Measured Data and measurement condition and recall them later. With recall function, measurement can be continued at the same conditions as previously.

### 3.11.1 Export (Save)

To open the dialog for file name input, click Menu [File] → [Settings File] → [Export]. Measured Data and measurement condition can be saved in this file.

The file and directory for Export are created automatically as below.

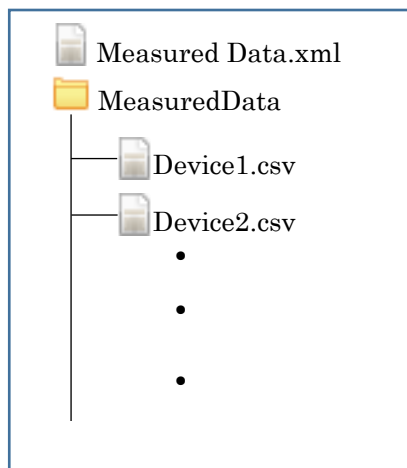


Fig.3.20 Created Files and folder

Table 3.14 Measured Data.xml file

Item	Descriptions
Measured Data.xml file	This is measurement condition file. The file name is what you entered when this file is exported.
Measured Data folder	It contains Measured Data. This folder is automatically created at the same as measurement condition file name.
Device1.csv 、 Device2.csv 、 ・ ・ ・ files	These are Measured Data files. This file name is the same as Device name.

### 3.11.2 Import (Recall)

To open dialog selecting file to import, click Menu [File] → [Settings File] → [Import], then select measurement condition file (Table 3.14 Measured Data xml file) to open.

Do not read files which edited by different software.

### 3.11.3 Add Reference Data

The specified formatted csv file can be read in the following ways and displayed on the graph.

- Click menu [File]→[Add Reference Data]
- Right click the Measured Data Table and click [Add Reference Data] .
- Drag and drop the csv files to the Measured Data Table or graph area.

The csv files which can be read are as follows.

- The csv file output by [Save to CSV File] on the Measured Data Table.
- The csv file output by menu [File]→[Settings File]→[Export].
- The csv file of the following format.

Line#	Description
1	Sweep Mode, X-Axis data header
2	Frequency [kHz], The value of frequency, Signal Voltage Level [V], The value of signal voltage level, Measurement Time or Measurement Speed, The value of measurement time, Averaging Factor, The value of averaging factor, Correction, The choice of correction enabled or not, Gate Bias[V], The value of gate voltage, Collector Bias[V], The value of collector voltage
3	X-Axis data header, Y-Axis data headers
4 or later	X-Axis value, Y-Axis values

When the first line is omitted, Sweep Mode is specified as "Vc"

The second line is optional. The value is displayed in the corresponding column of Measured Data Table.

X-Axis data header must be one of "Vc", "Vg", "Time", or "Frequency" . The unit of X-Axis value can be set as "Vc", "Vg" is [V], Time is [sec], and Frequency is [Hz].

Y-Axis data header must be one of "Ci", "Co", "Cr", "Rg", "X", "Cge" or "Cce". The unit of Y-Axis value can be set as capacitance is [F] and resistance is [ $\Omega$ ].

Ex). Reading “Ref Sample.csv”

1	SweepMode	Vc			
2	Frequency [kHz]	100			
3	Vc	Cl	Co	Cr	
4		0	1.00E-09	2.00E-09	3.00E-09
5		5	6.07E-10	1.61E-09	2.61E-09
6		10	3.68E-10	1.37E-09	2.37E-09
7		15	2.23E-10	1.22E-09	2.22E-09
8		20	1.35E-10	1.14E-09	2.14E-09
9		25	8.21E-11	1.08E-09	2.08E-09
10		30	4.98E-11	1.05E-09	2.05E-09
11		35	3.02E-11	1.03E-09	2.03E-09
12		40	1.83E-11	1.02E-09	2.02E-09
13		45	1.11E-11	1.01E-09	2.01E-09
14		50	6.74E-12	1.01E-09	2.01E-09
15					

Fig.3.21 Ref Sample.csv

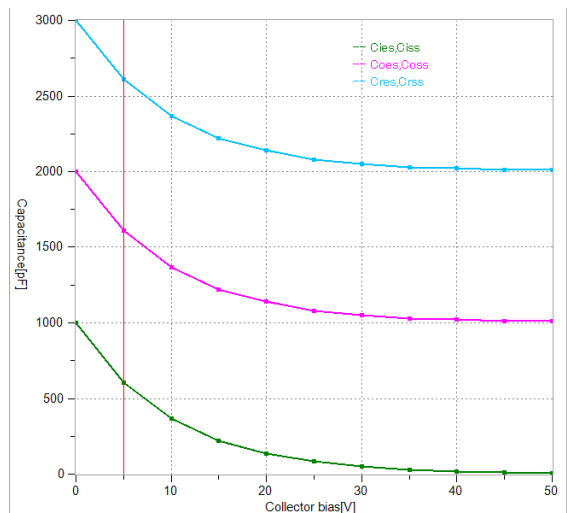


Fig3.22 Result of reading Ref Sample.csv (graph area)

	<input checked="" type="checkbox"/> Visible	Device	Frequency [kHz]	Voltage Level [V]	Measurement Time	AveragingFactor	Correction	Gate Bias [V]
►	<input checked="" type="checkbox"/>	RefSample	100					

Fig 3.23 Result of reading Ref Sample.csv (Measured Data Table)



## 3.12 Menu

Menu on the Main Window is shown in below table.

### • File

Menu item		Description
Settings File	Import	Recall measurement condition file and Measured Data file. See 3.11.2 Import (Recall)
	Export	Save measurement condition file and Measured Data file. See 3.11.1 Export (Save).
Save Data Image		Save graph image into BMP file.
Add Reference Data		Add Reference Data. See 3.11.3 Add Reference.
Exit		Close the application.

### • Settings

Menu item	Description
CV BIAS UNIT Connect Test	Test connection between control PC, LCR Meter and CV BIAS UNIT. See 3.3.5 Check connection.
CV BIAS UNIT IP Address Setting	Set up IP address of CV BIAS UNIT. See 3.3.1 CV BIAS UNIT network setting.
LCR Meter Connect Test	Test connection to LCR Meter. See 3.3.5 Check connection.
LCR Meter Correction	Execute LCR Meter correction. See 3.7 LCR Meter OPEN / SHORT correction.
Measurement Parameter	The measurement parameter setting screen opens. On the setting screen, you can set the measurement function Cp or Cs of the LCR meter at the time of capacity measurement.
Pause before measuring Cres, Crss	When measurement is performed with this item checked, semi-automatic measurement will be enabled to obtain more accurate measurement values.
Application Initialize	Initialize all settings of the application.

### • Window

Menu item	Description
Show Measured Data Table	Show Measured Data Table Window.

▪ Help

Menu item	Descriptions
Help	Show this Instruction Manual (pdf file).
About	Show the version information of this application software.

## Chapter 4 Daily Maintenance and Calibration

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### ◆ Daily Maintenance

Since electric shock may be generated, be sure to remove the power cord before cleaning.

To clean the exterior, use a soft cloth including a small amount of water and gently wipe it.

Use of solvent or detergent may cause discoloration or unexpected failures.

Do not use the following solvent and the detergent.

- Alcohol, gasoline, acetone, lacquer, ether, thinner, detergent including ketone.

### ◆ Calibration

It is recommended that CS-603A / 605A be calibrated regularly for accurate measurement.

For regular calibration of the entire instrument, contact IWATSU or our sales distributors.

**Regular calibration once per year** is recommended.

### ◆ Repair and sending

If a failure occurs, contact IWATSU or our sales distributors. If an unexpected failure by our fault occurs during the warranty period, it can be repaired without charge.

When sending the instrument, please write the instrument name, instrument number, failure, name, place, and telephone number of the person in charge clearly.

To avoid an accident during transportation when sending it, use the corrugated carton box used for delivery or equivalent: i.e. having shock absorbing materials. If a proper packing box is not found, contact IWATSU or our sales distributors.

## Chapter 5 Specifications

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### ◆ Collector bias voltage

Collector voltage range	Setting resolution	Voltage accuracy
0~+50 V (Low Voltage Circuit)	1 mV	Set voltage $\pm 5\% \pm 1$ mV
0~+3 kV (CS-603A)	100 mV	Set voltage $\pm 5\% \pm 100$ mV
0~+5 kV (CS-605A)	100 mV	Set voltage $\pm 5\% \pm 100$ mV

### ◆ Gate bias voltage

Gate voltage range	Setting resolution	Voltage accuracy
-25 V~+25 V	1 mV	Set voltage $\pm 5\% \pm 1$ mV

### ◆ Measurement frequency range

10 kHz~100 kHz

### ◆ Measurement / accuracy

Condition Cgd:Cds:Cgs=1:1:1

Frequency Measurement range Accuracy (additional error)

10 kHz 100 pF~10 nF  $\pm 5\%(\pm 50\text{pF})$

100 kHz 10 pF~1 nF  $\pm 5\%(\pm 2\text{pF})$

Condition Cgd:Cds:Cgs=1:10:100

Frequency Measurement range Accuracy (additional error)

10 kHz 100 pF~10 nF  $\pm 5\%(\pm 50\text{pF})$

100 kHz 10 pF~1 nF  $\pm 5\%(\pm 2\text{pF})$

### ◆ Range of measurement signal levels of LCR Meter

100 mV~1 V

### ◆ General specifications (CS-603A / CS-605A)

- |                |                   |  |
|----------------|-------------------|--|
| • Power source | Input voltage     | AC 100 – AC 240 V, Max. fluctuation: $\pm 10\%$                            |
|                | Frequency         | 50 / 60 Hz   |
|                | Power consumption | 35 VA  |
| • Dimensions   |                   | 330 mm(W) x 230 mm(H) x 370 mm(D)<br>(Excluding attachment and projection) |
| • Weight       |                   | Approx. 8.0 kg   |

◆ Environment conditions

Performance ensured temperature range	+10 °C to + 35 °C
Operation ensured temperature range	0 °C to +40 °C
Operation humidity range	5% to 80% RH (at +30 °C or less) and no dew condensation allowed upper limit 55% RH (at +40 °C) and no dew condensation allowed
Operation Altitude	Up to 2,000m

Pollution degree	2
Overvoltage category (installation category)	II

## ◆ Compliance information

## Safety Standard

Compliant standard EN 61010-1: 2010+A1: 2019

## EMC Standard

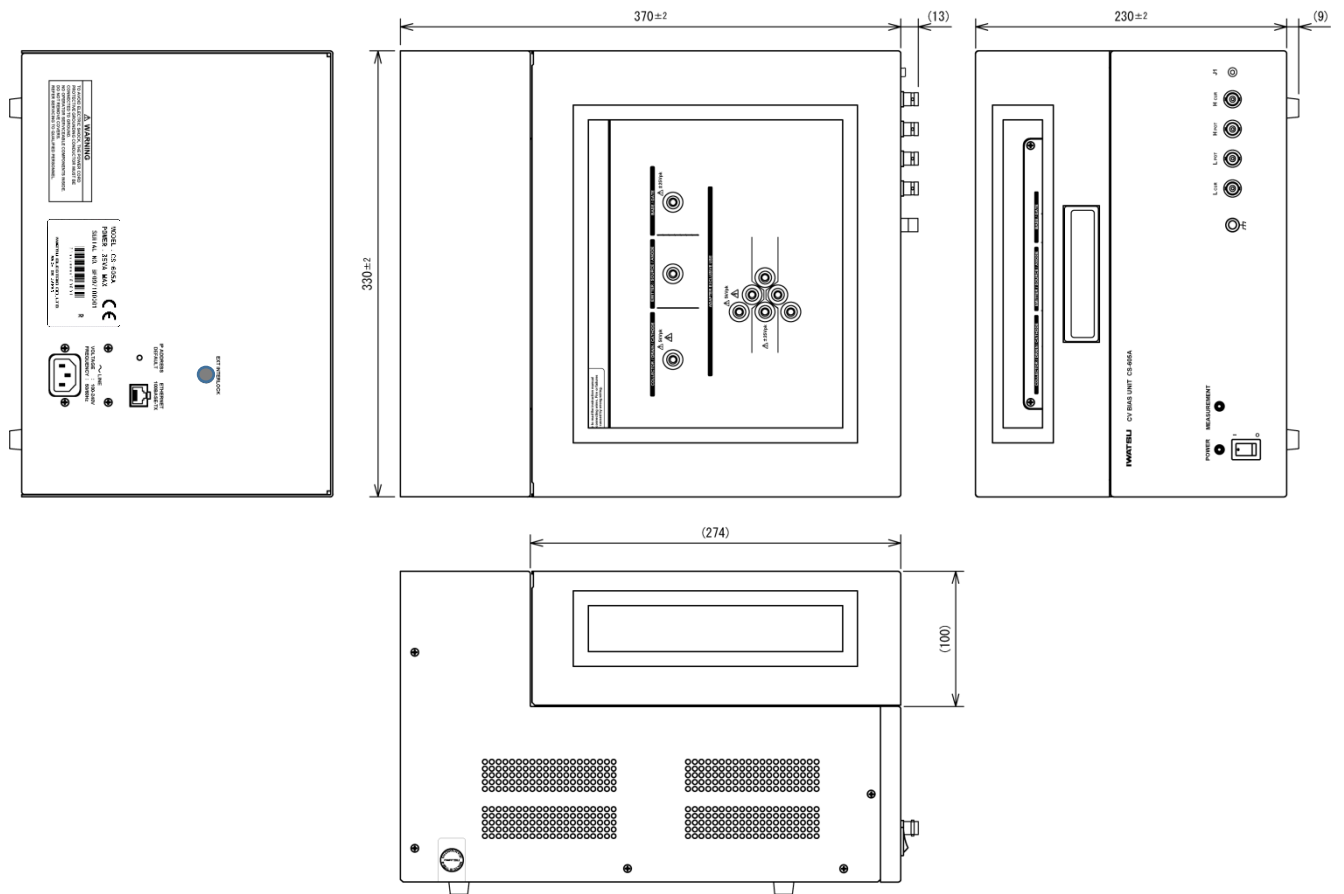
Compliant standard EN 61326-1: 2013 (Class A)

This instrument is a Class A (for industrial environments) instrument.

## Environmental Standard

Compliant standard EN IEC 63000: 2018 Monitoring and instruments

## ◆ External dimensions



Unit: mm

Fig 5.1 Example of CS-605A

# Chapter 6 Test Adapter (Option)

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## 6.1 Set the DUT in the Test Adapter

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This section describes how to attach the DUT to each applicable Test Adapter. A Test Adapter is available according to the package of the device to be measured. If there is no applicable Test Adapter, use the Test Adapter CS-500.

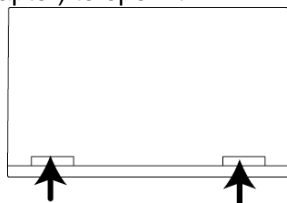
Since it is attached to the Test Adapter manually, take measures such as using an antistatic sheet or static electricity elimination wristband to prevent damage to the DUT due to static electricity that charges the operator.

Also, after installing the DUT, be sure to correct the LCR meter before starting the measurement for the first measurement.

### 6.1.1 Set the DUT in the Test Adapter CS-500

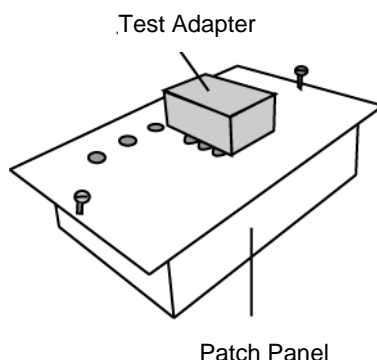
[DUT Installation procedure]

- ① Open the lid of the Test Adapter CS-500.
- ② Insert a flat-blade screwdriver, etc. into the part indicated by the arrow in the figure below (the lid of the Test Adapter) to open it.



- ③ Connect the DUT and the Test Adapter.
  - For Transistors: Connect the collector, base and emitter of the transistor to the collector, base, and emitter terminals of the Test Adapter.
  - For FET: Connect the FET drain, gate and source to the collector, base and emitter terminals of the Test Adapter.
  - For Diode: Connect the anode and cathode of the diode to the collector and emitter terminals of the Test Adapter.
- ④ Mount the Test Adapter to the Patch Panel.

When installing the Test Adapter, push it straight in from above, parallel to the Patch Panel.



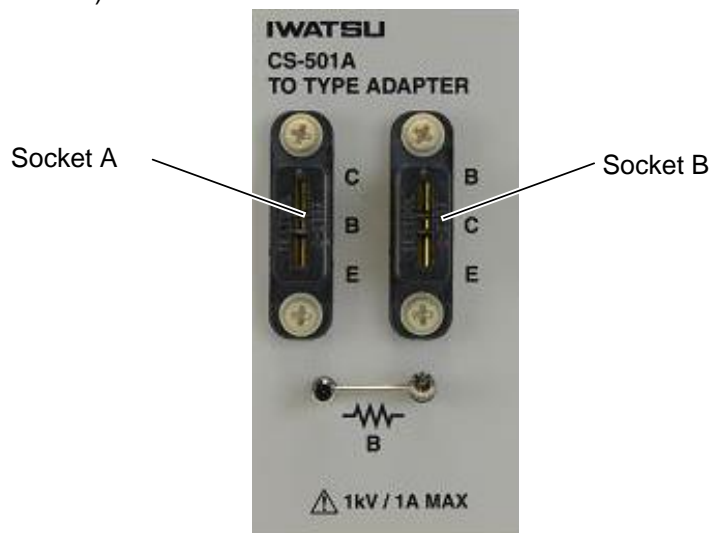
## 6.1.2 Set the DUT in the Test Adapter CS-501A

Two types of DUT can be mounted to this adapter, but measurements cannot be made at the same time. Mount one DUT and an insulating tab for measurement.

[DUT Installation procedure]

① Mount the DUT to the Test Adapter CS-501A

- 1) Select sockets A and B according to the type of device to be measured as shown in the figure below.
- 2) Insert the terminal of the DUT into the connection groove of the terminal of the socket. Insert an insulation tab into the vacant socket (At the time of purchase, the insulation tab is inserted in socket A or B).



### CAUTION !

#### Base resistor and insulation tab

The Test Adapter CS-501A comes with a jumper wire for the base resistor as an accessory. Both ends can be screwed. For High Voltage C-V Measurement System, be sure to attach the attached jumper wire.

For accurate measurement, insert the accessory insulation tab into socket A or B to which the measuring element is not connected during measurement.

- For Transistors: Insert the collector, base and emitter of the transistor to the collector, base, and emitter terminals of the Test Adapter.
- For FET: Insert the FET drain, gate and source to the collector, base and emitter terminals of the Test Adapter.
- For Diode: Insert the anode and cathode of the diode to the collector and emitter terminals of the Test Adapter.

② Mount the Test Adapter to the Patch Panel.

When installing the Test Adapter, push it straight in from above, parallel to the Patch Panel.

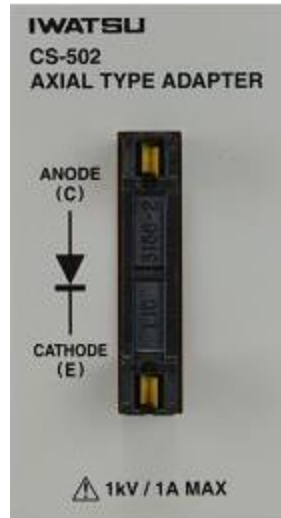


### 6.1.3 Set the DUT in the Test Adapter CS-502

[DUT Installation procedure]

Mount the DUT to the Test Adapter CS-502.

- ① Insert the terminal of the DUT into the connection groove of the terminal of the socket.



For Diode: Insert the anode and cathode of the diode into the anode and cathode terminals of the Test Adapter.

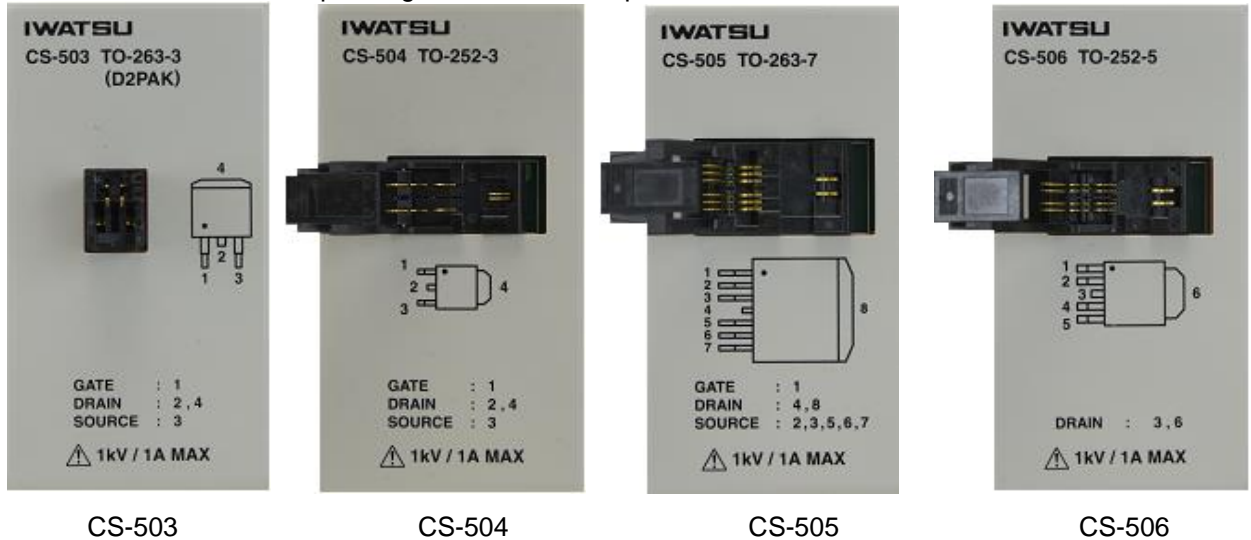
- ② Mount the Test Adapter to the Patch Panel.

When installing the Test Adapter, push it straight in from above, parallel to the Patch Panel.

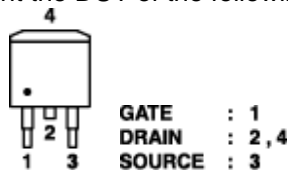
## 6.1.4 Set the DUT in the Test Adapter CS-503 / CS-504 / CS-505 / CS-506

[DUT Installation procedure]

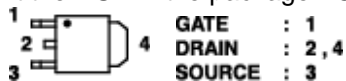
- 1) Mount the device to be measured to the Test Adapter CS-503 (or CS-504, CS-505, CS-506).
- 2) Mount the DUT corresponding to each Test Adapter in the socket.



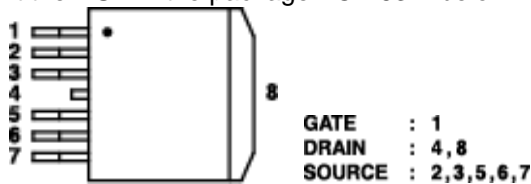
- For CS-503 : Mount the DUT of the following package TO-263-3 (2PAK) in the socket.



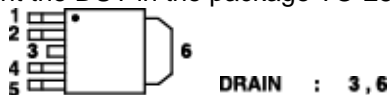
- For CS-504 : Mount the DUT in the package TO-252-3 below into the socket.



- For CS-505 : Mount the DUT in the package TO-263-7 below into the socket.



- For CS-506 : Mount the DUT in the package TO-252-5 below into the socket.



Pin assignments for gate terminals and source terminals are supported at the time of shipment from the factory.

- ① Mount the Test Adapter to the Patch Panel.

When installing the Test Adapter, push it straight in from above, parallel to the Patch Panel.

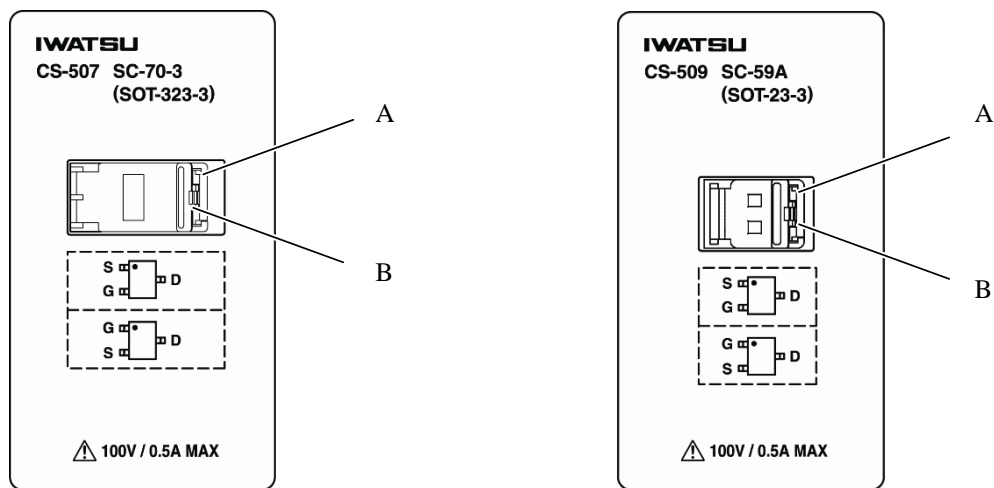
### 6.1.5 Set the DUT in the Test Adapter CS-507 / CS-509

Two types of DUT can be Mounted to this adapter, but measurements cannot be made at the same time. Install and measure only one type of DUT.

[DUT Installation procedure]

- ① Mount the DUT to the Test Adapter CS-507 or CS-509.

- 1) Select A or B in the socket according to the type of device to be measured as shown in the figure below.
- 2) Mount the DUT in package SC-70-3 (SOT-323-3) on CS-507 and SC-59A (SOT-23-3) on CS-509 in the socket.



Mount the DUT of the following package SC-70-3 (SOT-323-3) or SC-59A (SOT-23-3) in the socket.

- A in the socket
- B in the socket

- ② Mount the Test Adapter to the Patch Panel.

When installing the Test Adapter, push it straight in from above, parallel to the Patch Panel.

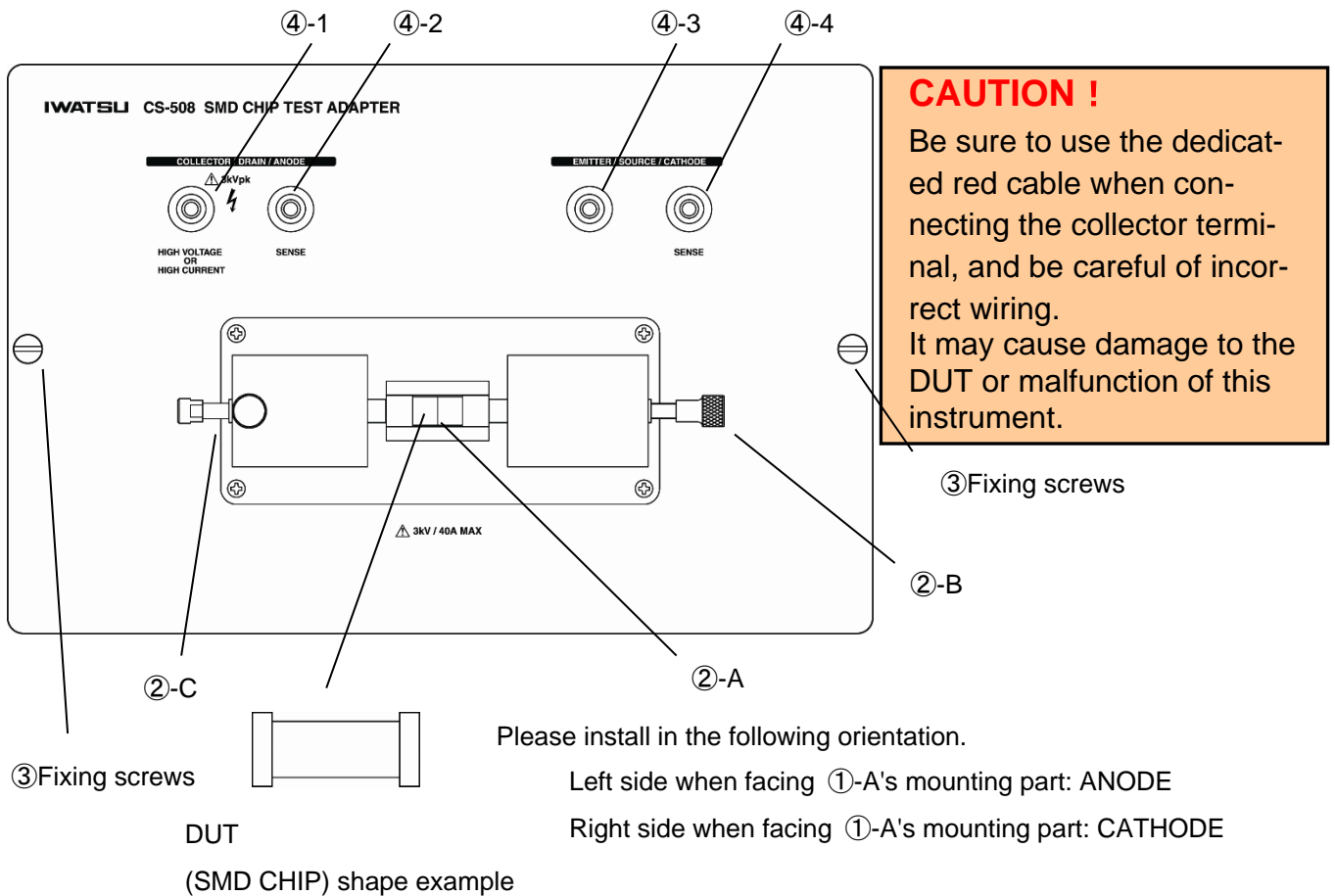
## 6.1.6 Set the DUT in the Test Adapter CS-508

[DUT Installation procedure]

① Mount the DUT to the Test Adapter CS-508.

- 1) Pull the knob of ②-B to the right and set the device to be measured to ②-A.
- 2) If the DUT cannot be set to ②-A with only the ②-B knob, loosen the ②-C fixing screw.

Pull the knob of ② -C to the left to widen the mounting part of ②-A. After installing the device to be measured, tighten the fixing screw ②-C to fix it.



Example) For diode: Set the anode and cathode of the diode to the anode and cathode of the Test Adapter.

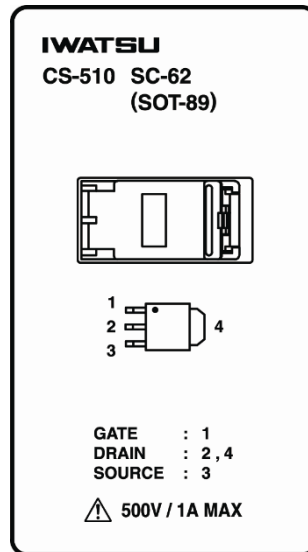
- ② Mount the Test Adapter with the fixing screw instead of the Patch Panel.
- ③ Connect the terminals ④-1 to ④-4 in the above figure to the terminals corresponding to COLLECTOR / DRAIN / ANODE of CV BIAS UNIT and the terminals corresponding to EMITTER / SOURCE / CATHODE.

### 6.1.7 Set the DUT in the Test Adapter CS-510

[DUT Installation procedure]

- ① Mount the DUT to the Test Adapter CS-510.

Mount the DUT corresponding to the Test Adapter in the socket.



- For CS-510: Mount the following package SC-62 type DUT in the socket.



- ② Mount the Test Adapter to the Patch Panel.

When installing the Test Adapter, push it straight in from above, parallel to the Patch Panel.

Memo



CS-603A / 605A

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