# User Manual

## LCR Meter

| 6621 | |
|---|---|
| **Version** | **Date** |
| **1.04** | **SEP-2025** |

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https://www.microtest.com.tw/

Please read the following important notes carefully:

1. Before operating the LCR Meter, please read the User Manual thoroughly to ensure proper and safe use.
2. For more detailed information, refer to the LCR Meter User Manual.
3. While every effort has been made to ensure the accuracy of this manual at the time of publication, should you find any unclear descriptions or inaccuracies, please contact the MICROTEST Sales and Marketing Department. We will be pleased to assist you.
4. The contents of this manual are subject to change without prior notice due to product improvements or updates.
5. This manual is protected by copyright. No part of it may be copied, reproduced, or modified without prior permission from MICROTEST.

**Revision History**

| Date | Version |
|---|---|
| 2025-05 | 1.02 |
| 2025-08 | 1.03 |
| 2025-09 | 1.04 |

# Safety Precautions

- **Intended Use by Qualified Personnel Only**
  This product is designed for use by personnel with professional technical knowledge and training.

- **Safety Classification**
  This instrument is classified as a Category 01 instrument in accordance with the IEC safety standards.

- **General Safety Instructions**
  To ensure proper protection and safe operation, all safety instructions outlined in this manual must be strictly followed. Failure to observe these precautions may impair the safety features of the instrument. Any resulting consequences shall be the responsibility of the user.

- **Retention of Important Information**
  This manual forms an integral part of the product and contains essential information. Please store it in a secure location near the instrument for quick access when needed. Ensure that the manual is available and in good condition before operating the instrument.

# Symbols Used on This Instrument

The following symbols may appear on the instrument or in the documentation. Please understand their meanings before operating the equipment:

| | |
|---|---|
|  | Power On |
|  | Power Off |
|  | Power On State |
|  | Power Off State |

| | |
|---|---|
|  | Indicates that improper operation may result in personal injury or damage to the instrument. This symbol directs the user to consult the manual for specific operating instructions. |
| WARNING | Indicates a potentially hazardous condition that could result in serious injury or death. Instructions are provided to avoid such risks. |
| CAUTION | Indicates a condition that may cause minor injury or damage to the instrument or user data. Preventive actions are also described. |
|  | Warns of dangerous high voltage that may result in electric shock. |
|  | Indicates the terminal for connection to the protective ground of the mains power supply. |
|  | Do not dispose of this electronic equipment as unsorted municipal waste. Use designated collection facilities or contact your supplier for proper disposal methods. |
|  | Indicates that the product complies with applicable European Union directives and regulations. |
| **Note** | Provides useful information, operational tips, or supplemental instructions. |

# Safety Guidelines – WARNING

To ensure operator safety and prevent damage to the instrument or connected devices, please read and observe the following warnings carefully:

## 1. Intended Use

This LCR Meter is designed exclusively for measuring the inductance (L), capacitance (C), resistance (R), and related parameters of electronic components. It is intended for use in electronics engineering, component testing, and quality control applications.

**Do not operate the instrument in environments containing flammable gases or vapors. Doing so may result in fire or explosion.**

## 2. Usage Restrictions

- **2.1** This instrument is intended solely for testing low-voltage electronic components within the specified application scope.
- **2.2** Do not use the instrument to measure components or circuits that exceed its rated voltage or current limits.
- **2.3** This instrument is not designed for use in high-voltage circuits, for testing on human bodies, or for any medical applications.

## 3. General Handling

Do not place any heavy objects on the instrument. Electrostatic discharge (ESD) to the instrument is strictly prohibited.

## 4. Accessories

Only use dedicated MICROTEST 6621 accessories with this instrument. Do not use accessories that are damaged or have exposed conductive parts.

## 5. Servicing

If a malfunction occurs, discontinue use and return the instrument to the manufacturer for servicing by qualified personnel. Do not attempt to repair the unit yourself.

## 6. Emergency Power-Off

In the event of an emergency, unplug the power cord from the outlet immediately.

## Applicable Standards and Compliance – Note

| Category | Standard / Directive |
|---|---|
| RoHS | RoHS 3 (2015/863/EU) |
| Safety | EN 61010-1:2010 + A1:2019 |
| | EN 61010-2-030:2021 |
| UKCA (Safety) | BS EN 61010-1:2010 + A1:2019 |
| | BS EN 61010-2-030:2021 + A11:2021 |
| EMC | EN 61326-1:2021* |
| | EN 61326-2-1:2021* |
| | EN IEC 61000-3-2:2019 + A1:2021* |
| | IEC 61000-3-3:2013 + A1:2017 + A2:2021* |
| | EN 55011:2016 + A2:2021 |
| UKCA (EMC) | BS EN IEC 61326-1:2021* |
| | BS EN IEC 61326-2-1:2021* |
| | BS EN IEC 61000-3-2:2019 + A1:2021* |
| | BS EN IEC 61000-3-3:2013 + A2:2021* |
| | BS EN 55011:2016 + A2:2021 |

## Environmental Conditions

**Installation Location**

- Indoor use only
- Avoid direct sunlight, excessive dust, and conductive pollutants
- Maximum altitude: 2000 meters
- Pollution degree: 2

**Operating Environment**

- Temperature: 5°C to 40°C
- Humidity: <80% RH (non-condensing)

**Storage Environment**

- Temperature: –10°C to 70°C
- Humidity: <80% RH (non-condensing)

**Note**

To achieve optimal measurement accuracy, the instrument must be operated under the following controlled environmental conditions:

**1. Optimal Temperature and Humidity**

- The recommended ambient temperature is **23°C ± 5°C**, with **relative humidity below 70%RH** (non-condensing).
- Maintaining this temperature and humidity range ensures the instrument's measurement accuracy and stability.

**2. Electrostatic Protection in Low-Humidity Environments**

- If the instrument is installed in an environment where the **relative humidity falls below 20%**, proper anti-static measures must be implemented.
- Use electrostatic discharge (ESD) protection equipment such as **anti-static mats** to prevent measurement errors or potential damage due to electrostatic interference.

## Cleaning the Instrument

To maintain performance and appearance, clean the instrument periodically under the following guidelines:

- **Always disconnect the power cord before cleaning.**
- Use a **soft cloth, microfiber cloth, or soft brush** slightly moistened with a solution of **mild detergent and water**. Gently wipe the exterior surfaces.
- **Do not spray** any liquids directly onto the instrument.
- **Do not use organic solvents** such as **acetone, methanol, or acetic acid**, or any other aggressive chemicals, as they may damage the surface or internal components.

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# Chapter 1. Product Overview

The LCR Meter 6621 is a high-performance, multi-functional test instrument designed for precise analysis of electronic components and materials. It features a wide signal source frequency range from DC to 30 MHz, offering exceptional measurement accuracy with a basic impedance accuracy of ±0.05% and ultra-fast measurement speed as fast as 3 ms.

With its comprehensive test modes and built-in Automatic Level Control (ALC) function, the 6621 ensures accurate and stable results across a variety of applications including research and development (R&D), production process control, and laboratory evaluation.

## 1.1 Product Features

**1. Signal Source and Measurement Accuracy**

- **Frequency Range**: DC, 10 Hz to 1 / 3 / 5 / 10 / 30 MHz.
- **Measurement Accuracy**: Basic impedance measurement accuracy of **±0.05%**.
- **Automatic Level Control (ALC)**: Ensures test signal stability and consistent results.

**2. Versatile Measurement Capabilities**

- **Selectable Output Impedance**: 25 Ω and 100 Ω switchable.
- Supports **meter mode**, **multi-step test sequences**, and optional **DC bias voltage ±12 V**.
- **Ultra-fast Measurement Speed**: As fast as **< 3 ms**, suitable for production environments.

**3. Correction and Display Functions**

- Supports **open/short/load correction** to improve accuracy.
- In **meter mode**, displays up to **four component parameters** simultaneously (e.g., inductance and DCR).
- **Auto BIN sorting** with comparator function and handler interface.

**4. Communication and Interface Options**

- Equipped with multiple interfaces: **RS-232**, **GPIB (optional)**, **Handler**, **LAN**, **USB Host/Device**.
- Optional **PC software** available for automated testing and data analysis.

**5. Compatibility and Integration**

- Easily integrates into various automated systems and test setups with broad communication support and high-speed operation.

**6. Application Fields**

- Designed for **R&D**, **process control**, and **laboratory measurements**.
- The **6621 LCR Meter** combines precision, functionality, and flexibility to meet the requirements of diverse testing environments.

# 1.2 Product Specification

| Model Configuration | | | |
|---|---|---|---|
| **Model** | **Frequency Range** | **Meter Mode** | **List Mode** |
| 6621-30 | DC, 10Hz ~ 30MHz | ✓ | ✓ |
| 6621-20 | DC, 10Hz ~ 20MHz | ✓ | ✓ |
| 6621-10 | DC, 10Hz ~ 10MHz | ✓ | ✓ |
| 6621-5 | DC, 10Hz ~ 5MHz | ✓ | ✓ |
| 6621-3 | DC, 10Hz ~ 3MHz | ✓ | ✓ |
| 6621-1 | DC, 10Hz ~ 1MHz | ✓ | ✓ |

| Specification | |
|---|---|
| Basic Measurement Accuracy | ±0.05% |
| Minimum Measurement Time | < 3 ms |
| Output Impedance | Switchable between 25 Ω and 100 Ω (nominal) |
| Correction Functions | Open, Short, Load |
| Equivalent Circuit Modes | Series / Parallel |
| Multi-step Test | 50 sequences, up to 15 steps each |
| Internal Memory | 100 LCR setting files, 50 multi-step sequences |
| Display | 4.3" TFT color LCD, 800 × 480 resolution |
| Accuracy Conditions | 18 °C – 28 °C, <70% RH |
| Operating Environment | 5 °C – 40 °C, <80% RH (non-condensing) |
| Storage Environment | –10 °C – 70 °C, <80% RH (non-condensing) |
| Measurable Parameters | \|Z\|, \|Y\|, θ, X, R (series/parallel), G, B, L, D, Q, DCR, C, Vdc, Idc, ESR |
| PC Link / CPK Reporting | Optional PC software available |
| USB Host Storage | Save LCR settings, multi-step files, BMP screenshots, scanned data (FAT32 format) |

| Interface | |
|---|---|
| I/O Interface | Handler interface |
| Serial Interfaces | USB, RS-232 |
| Parallel Interface | GPIB (optional) |
| **Power Requirements** | |
| Voltage | 100 – 240 V AC |
| Frequency | 50 – 60 Hz |
| Power Consumption | 100 VA |
| Fuse | T1.6A / 250 V |
| **Physical Specifications** | |
| Dimension (W × H × D) | 300 * 89.1 * 362.8 mm |
| Weight | Approx. 3.4 kg |

## 1.3 Advantages and Value

- High Accuracy and Versatility: Designed to meet a wide range of measurement requirements for electronic components with outstanding precision and functionality.

- Support for Expanded Applications: Easily adapts to various testing scenarios with flexible configurations and optional features.

- Automated Sorting and High-Speed Measurement: Enhances production throughput and inspection efficiency.

- Comprehensive Interfaces and Data Management: Ideal for integration with modern intelligent laboratories and automated production lines.

## 1.4 About Correction

To ensure accurate measurement results within the specified accuracy range, it is **recommended to calibrate the instrument once per year**. Regular correction maintains the integrity of test data and guarantees consistent measurement performance.

## 1.5 Servicing and Repair

When your instrument requires servicing, please contact **MICROTEST** for authorized repair.
**Do not attempt to disassemble or replace any internal parts yourself**, as doing so may pose safety risks and void your warranty.

**Precautions for Shipping and Transport**

To ensure the safety of the instrument during transportation, please observe the following precautions:

- **Remove all accessories and optional attachments** from the instrument before shipping to prevent damage.
- Always use the **original packing materials** provided at the time of delivery.
  For additional protection, we recommend **double packaging** the instrument.
- Please note that **MICROTEST is not responsible for any damage incurred during transport** due to improper packaging.

If you are returning the instrument for repair, **include a clear and detailed description of the issue** to help us provide faster and more effective service.

Maintaining proper handling and packaging procedures ensures your instrument arrives safely and is serviced efficiently.

# Chapter 2. Product Introduction

The 6621 LCR Meter is a high-performance, multi-functional test instrument designed to deliver precise and flexible measurement solutions for a wide range of electronic components.
It integrates advanced capabilities and intelligent features to meet the demands of R&D, production, and quality assurance applications.

Below are the key features and functions:

- **Test Frequencies and Functional Capabilities**
  1. **Six Selectable Test Frequency Models**:
     Available frequency ranges include 10 Hz to 1 MHz, 3 MHz, 5 MHz, 10 MHz, 20 MHz, and 30 MHz to meet a variety of test requirements.
  2. **Flexible AC Signal Testing**:
     Supports LCR measurements using AC test signals. Test frequency and level can be varied continuously, enabling step-wise or swept measurements.
  3. **High-Speed Measurement**:
     Capable of performing continuous high-speed testing under various modes and conditions, ideal for automated production lines.
  4. **Advanced Measurement Features**:
     - Selectable output impedance: **25 Ω / 100 Ω**
     - **Automatic Level Control (ALC)** compensation
     - **Multi-step test sequences**
     - **BIN sorting and comparator functions** for automated pass/fail classification
- **DC Bias Function (Optional)**
  1. ±12 V DC Bias Voltage (optional)
  2. Supports measurement of DC voltage characteristics of capacitors, useful for advanced component evaluation.
- **Interfaces and System Expandability**
  1. Supports multiple communication interfaces, including:RS-232, GPIB (optional), Handler, LAN, USB Host/Device
  2. Compatible with MICROTEST 6223 or 6243H DC Bias Current Sources, enabling integration into comprehensive test systems for

inductor or power device evaluation.

- **Application Fields and Target Users**

  Thanks to its outstanding precision, multi-functionality, and adaptability, the 6621 LCR Meter is the ideal solution for high-demand test environments such as:

  - Semiconductor and electronic component manufacturers
  - R&D departments and incoming inspection operations
  - Laboratories and academic institutions

  Whether used for component testing or materials analysis, the 6621 offers an efficient and accurate solution tailored to the needs of professionals across industries.

# 2.1 Package Contents and Accessories

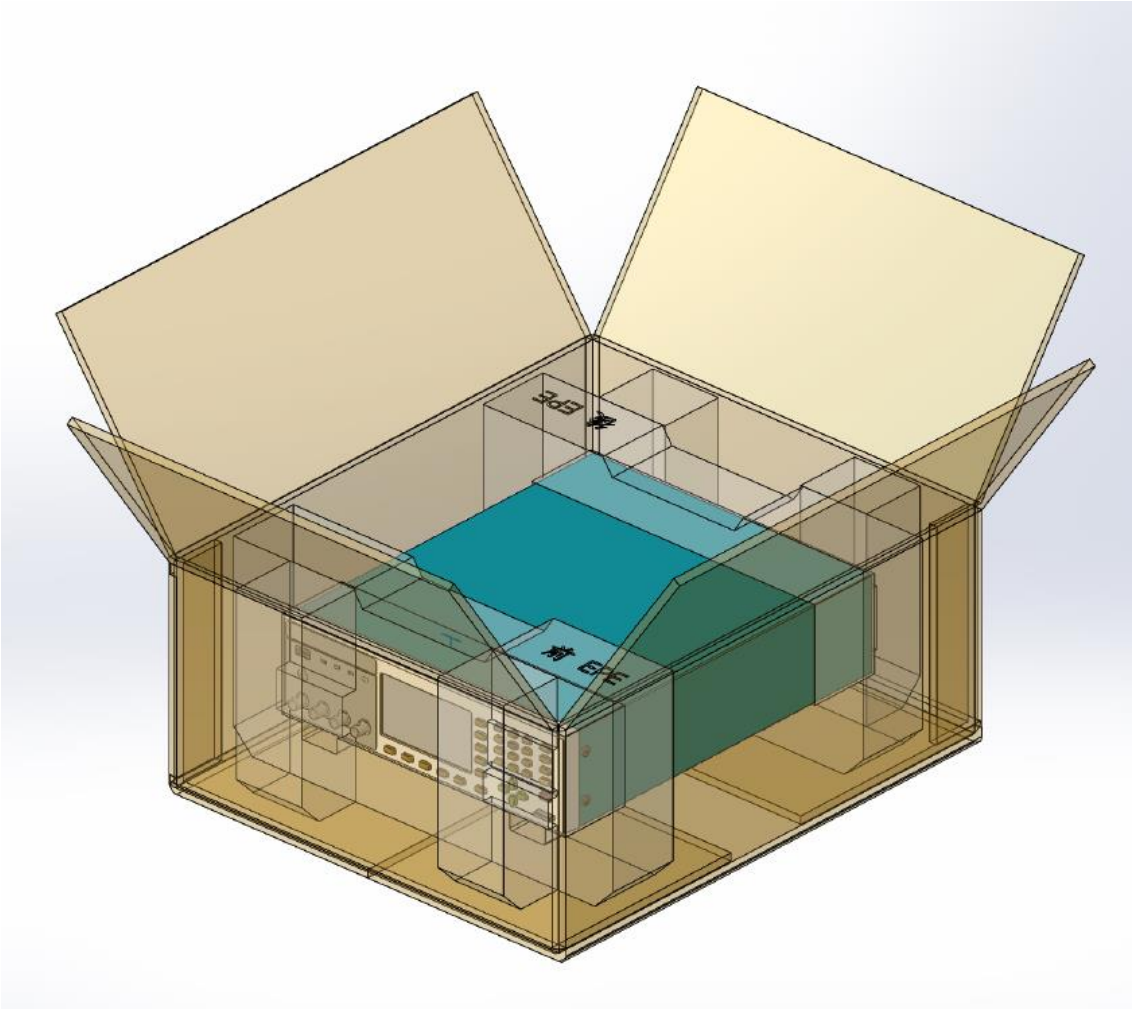


*Figure 2.1.1 Packaging Diagram*

| Standard Accessory | |
|---|---|
| ● Power Cord | |
| **Optional Accessories** | |
| ● F423906A | Kelvin clips Leads 100cm |
| ● F423906B | Kelvin clips Leads 50cm |
| ● F663001A | BNC Test Leads 50cm |
| ● F663001B | BNC Test Leads 100cm |
| ● F663001C | BNC Test Leads 200cm |
| ● F420001 | External Voltage Bias Fixture (±200V/1MHz) |
| ● F420003 | External Voltage Bias Fixture (±40V/1MHz) |
| ● F420005 | External Voltage/ Current Bias Fixture (±40V/100mA) |
| ● F420006 | External Voltage Bias Fixture (±2000V/1MHz) |
| ● FX-0000C6 | DIP Test Fixture |
| ● FX-0000C7 | Dielectric Material Test Fixture |
| ● FX-0000C8 | Magnetic Material Test Fixture |
| ● FX-0000C9 | Material Testing Fixture |
| ● FX-000C10 | Bottom Electrode SMD Test Fixture |
| ● FX-000C11 | SMD Tweezers Test Leads |
| ● FX-000C12 | SMD Test Fixture |
| ● FX-000C19 | DIP Test Fixture |
| ● FX-000C20 | Liquid Dielectric Material Test Fixture |
| ● FX-LR0001 | Automatic Level Compensation Fixture |
| ● FX-0000C4 | DIP Test Fixture |
| ● TL-000003 | RS-232 Cable (180cm) |
| ● US-26 | USB Cable (180cm USB A to mini USB B) |
| ● OP-662101 | GPIB Interface module |
| ● OP-662102 | Built-in DC Bias Voltage ±12V |
| ● 6621+ Series DC Bias Current Test System | |
| ● PC Link software | |

*Table 2.1.1 Table Accessories*

# 2.2 Panel Overview

- **Front panel**

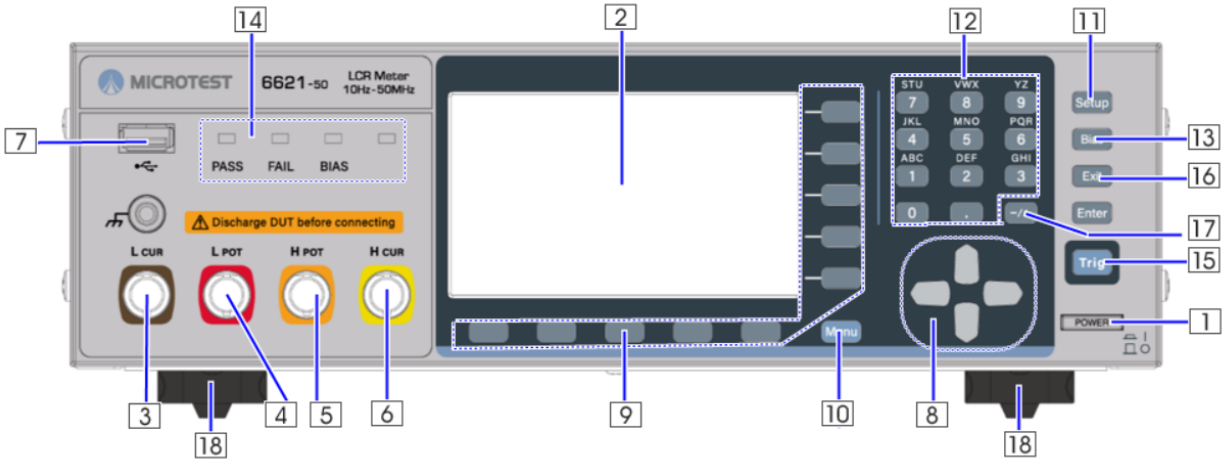



*Figure 2.2.0.1 Front panel*

| No. | Name | Description |
|---|---|---|
| 1 | Power Switch | Turns the power on or off. |
| 2 | LCD Display | Displays various settings, test values, and other information. |
| 3 | L CUR | BNC terminal for connecting DUT (Device Under Test) through 4-terminal test fixture or test leads. |
| 4 | L POT | |
| 5 | H POT | |
| 6 | H CUR | |
| 7 | USB Socket | For connecting USB storage devices to save data (not for PC communication); only FAT32 format is supported. |
| 8 | Direction Keys | Moves the cursor up, down, left, or right. |
| 9 | Operation Key | Functional keys corresponding to the on-screen display functions. |
| 10 | Menu Key | Used to switch between Measure, List Set, and List Run modes. |
| 11 | Setup Key | Accesses the Setup screen. Use the left and right keys to select Measure, System, or List setup. |
| 12 | Numeric Keys | Used for entering numeric values (0–9). |
| 13 | Bias Key | Turns bias output on. |
| 14 | LED | Indicates PASS, FAIL, or BIAS status. |
| 15 | Trig Key | Performs manual triggering or holds the measurement. |

| | | |
|---|---|---|
| 16 | EXIT Key | Cancels input, returns to the previous menu, or exits remote control mode (panel lock release). |
| 17 | – / ← Key | Backspace key. When a USB drive is inserted, pressing this key opens the USB menu, which includes the screenshot function. |
| 18 | Foot Pads | Provide friction to stabilize the unit on the surface. |

Table Front panel components and functions

- **Rear panel**

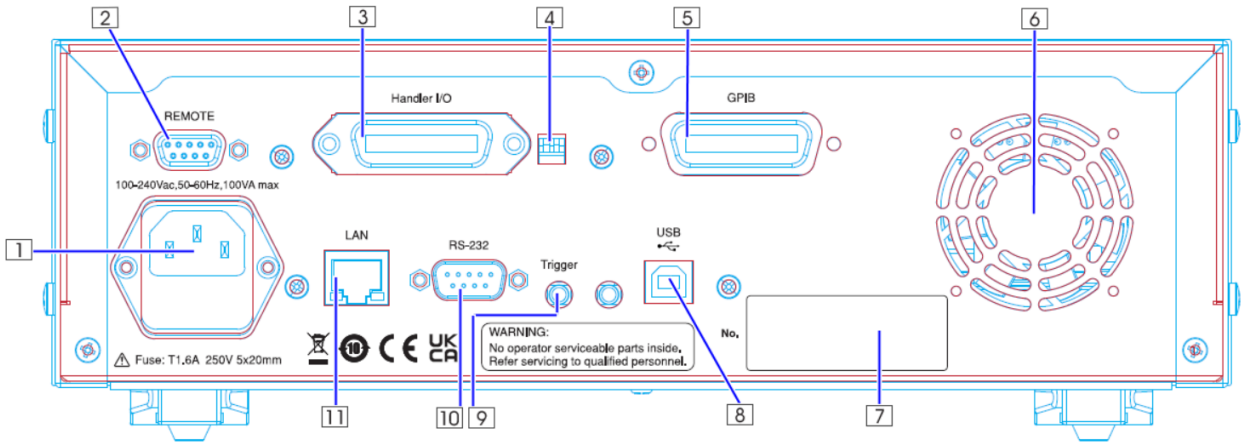



*Figure2.2.0.2 Rear panel*

| No. | Name | Description |
|---|---|---|
| 1 | Power Inlet | Connects to the power cord (AC 100–240V, 50/60Hz). |
| 2 | REMOTE | Connects to fixtures or external current source instruments. |
| 3 | Handler I/O | Used to connect I/O signals. |
| 4 | DIP Switch | Set to UP for isolation; set to DOWN for conduction. |
| 5 | GPIB (Optional) | Used for GPIB communication. |
| 6 | Fan | Cooling fan for internal temperature control. |
| 7 | Serial Number Label | Displays the unit's serial number. |
| 8 | USB Device Port | Used for USB communication. |
| 9 | External Trigger | Connects to external trigger fixtures. |
| 10 | RS-232 | Used for RS-232 communication. |
| 11 | LAN | Used for LAN communication. |

*Table2.2.1 Rear panel components and functions*

# 2.3 REMOTE Interface

## 6621 Connection and Setup with DC Bias Current Sources

### 1. Hardware Connection

- Connect a 9-pin male to RJ45 adapter cable to the REMOTE connector located on the rear panel of the 6621.
- Insert the RJ45 connector into the LAN port on the rear panel of the 622X, 6243, or 6243H parallel current source.
- Set the DIP switch of each unit to the correct ID number.

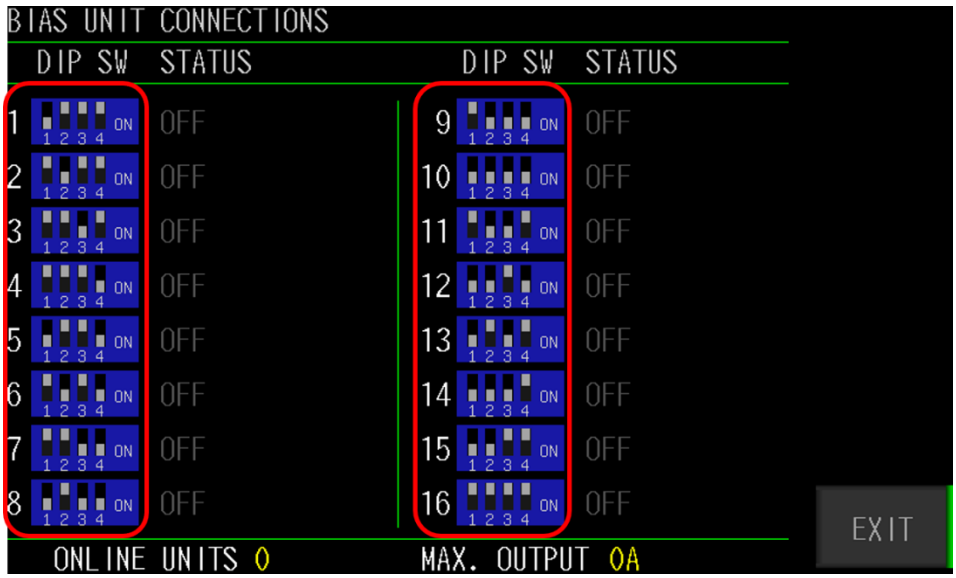



*Figure2.3.0.1 DIP switch setting*

**Note:** The 6621 cannot be used simultaneously with both 6223 and 6243.

### 2. Setup Procedure

- Press the Setup key on the 6621 to enter the setup screen.
- Use the direction keys to navigate to the "SYSTEM" page.
- Use the direction keys to navigate to the "BIAS" option and select 622x/4x.

### 3. Function Key Descriptions

- MEASURE: Enters the Meter mode.
- Mode: Set the output mode to either Sequence or All on.

  **Sequence mode**: The connected current sources supply output current one by one until the target current is reached.
  Example:
  Three 6243 units with a target current of 60A.

Unit 1 outputs 40A, Unit 2 outputs 20A, Unit 3 outputs 0A.
**All on mode**: The target current is evenly distributed among the connected current sources.
Example:
Three 6243 units with a target current of 60A.
Unit 1 outputs 20A, Unit 2 outputs 20A, Unit 3 outputs 20A.

- Details: Displays connection details, including version and model information.
- Status: Displays whether the 6621 is successfully connected to the DC bias current sources.

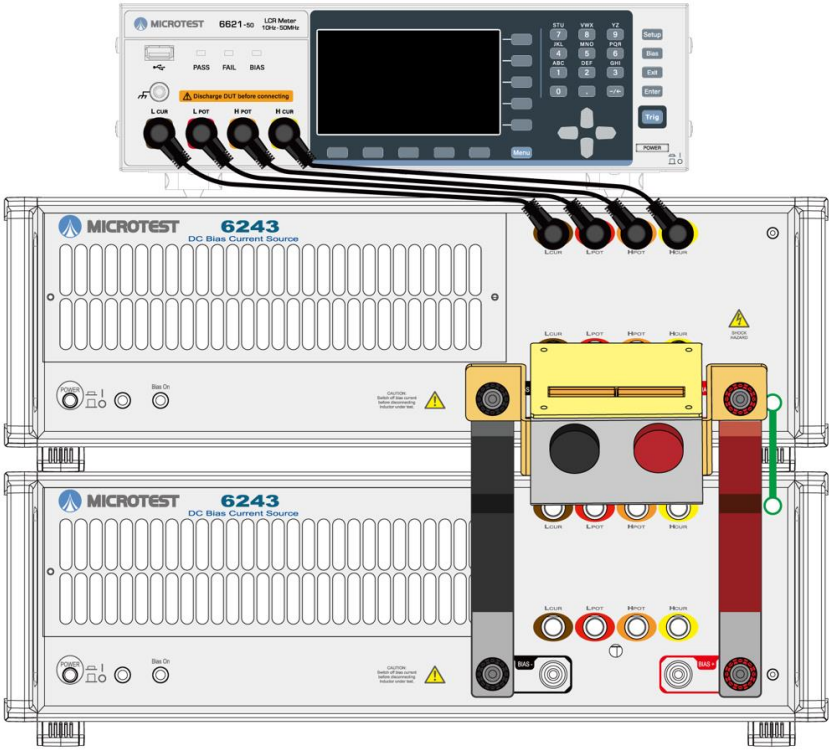



*Figure2.3.0.2 Front view*

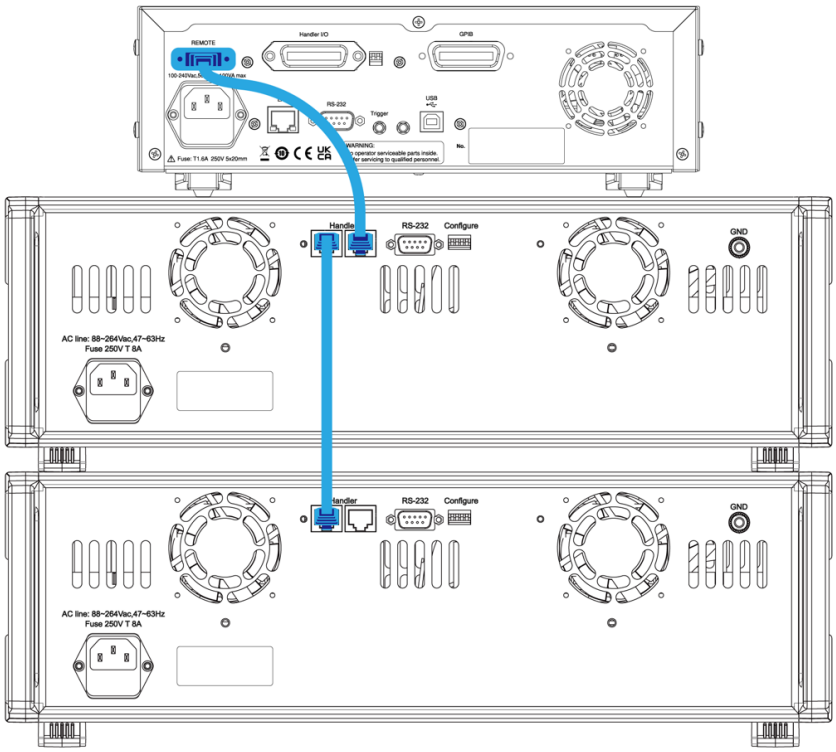



*Figure2.3.0.3 Rear view*

**Note:**

- When BIAS current output is active, the BIAS LED will light up. Please operate with caution.
- Before replacing the DUT (Device Under Test), ensure that the BIAS output is turned off and the BIAS LED has turned off completely to avoid any safety hazards.
- Before testing the DUT, always verify its specifications. Do not apply BIAS current exceeding the DUT's rated limits, as this may cause damage to the DUT or the test fixture.

# 2.4 Handler Interface

The Handler Interface allows external signals to control the instrument via the **Handler I/O connector** located on the rear panel.
Follow the steps below to enable remote control functionality:

**1. Check the DIP Switch**

- Locate the DIP switch on the rear panel of the unit.
- Set the DIP switch UP for isolation, or DOWN for conduction.

**2. Open System Settings**

- On the 6621 front panel, press the [Setup] key to enter the Setup page.

- Used direction keys to navigate to the System page.
- Use the direction keys to navigate to the Handler.

### 3. Enable Handler Interface

- Set the **Handler Interface** option to **ON** to activate remote control functionality.




*Figure2.4.0.1 Enable Handler I/O*

## Handler I/O pin define

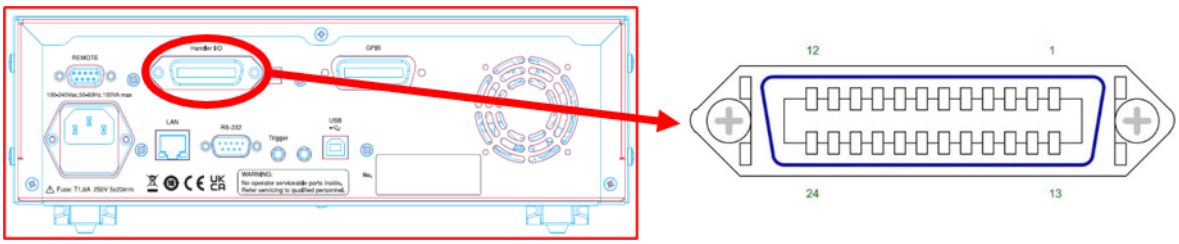



*Figure2.4.0.2 Handler I/O connector*

| Signal | | | | I/O | | Description |
|---|---|---|---|---|---|---|
| PIN | Meter | List | Meter/List | | | |
| 1 | /EXT_TRIG | | | I | Negative-edge Trigger | Test starts when shorted to Pin 5 (Trig Return) |
| 2 | /EOM | | | O | Negative-level Signal | End of Measurement |
| 3 | /PASS | | | O | Negative-level Signal | PASS result |
| 4 | /FAIL | | | O | Negative-level Signal | FAIL result |
| 5 | Trig Return | | | | GND | Trigger return ground |
| 6 | COM | | | | Common Ground | |
| 7 | COM | | | | Common Ground | |

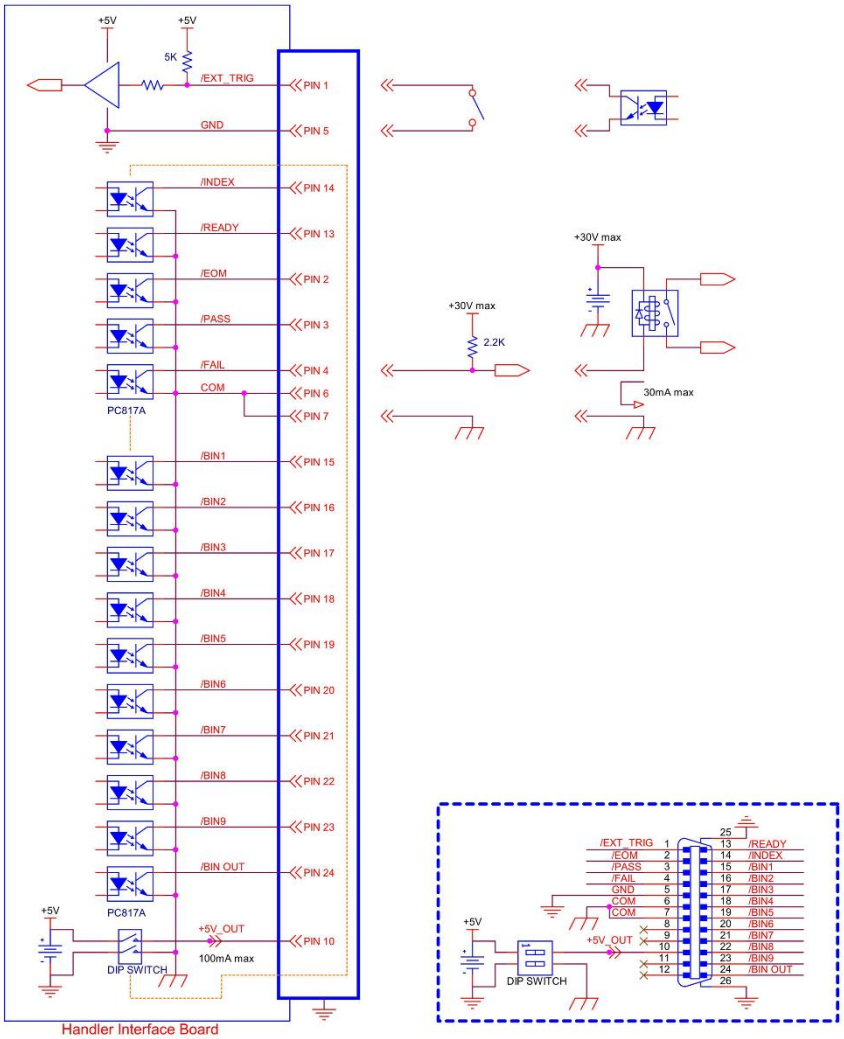
| | | | | | |
|---|---|---|---|---|---|
| 8 | | | | | |
| 9 | | | | | |
| 10 | +5V out | | | O | DC Output |
| 11 | | | | | |
| 12 | | | | | |
| | | | | | |
| 13 | /Ready | | | O | Negative-level Signal |
| 14 | /Index | | | O | Negative-level Signal |
| 15 | /PARA-1 OK | /STEP-1 OK | /BIN1 | O | Negative-level Signal |
| 16 | /PARA-2 OK | /STEP-2 OK | /BIN2 | O | Negative-level Signal |
| 17 | /PARA-3 OK | /STEP-3 OK | /BIN3 | O | Negative-level Signal |
| 18 | /PARA-4 OK | /STEP-4 OK | /BIN4 | O | Negative-level Signal |
| 19 | /PARA-1 NG | /STEP-1 NG | /BIN5 | O | Negative-level Signal |
| 20 | /PARA-2 NG | /STEP-2 NG | /BIN6 | O | Negative-level Signal |
| 21 | /PARA-3 NG | /STEP-3 NG | /BIN7 | O | Negative-level Signal |
| 22 | /PARA-4 NG | /STEP-4 NG | /BIN8 | O | Negative-level Signal |
| 23 | - | - | /BIN9 | O | Negative-level Signal |
| 24 | - | - | /BIN out | O | Negative-level Signal |

*Table2.4.1 Handler I/O Pin Definitions*

**Description:**

1. Applying a low signal to PIN 1 (/EXT_TRIG) by shorting it to PIN 5 (Trig Return) will initiate a single measurement. The trigger pulse width must be greater than 100 μs.
2. All other signal pins are opto-isolated open-collector outputs. When active, the output is pulled to ground; when inactive, the output is in high-impedance state.
3. The /EOM and /INDEX signals are reset after each trigger input.

## { Connections to Handler Interface Board }



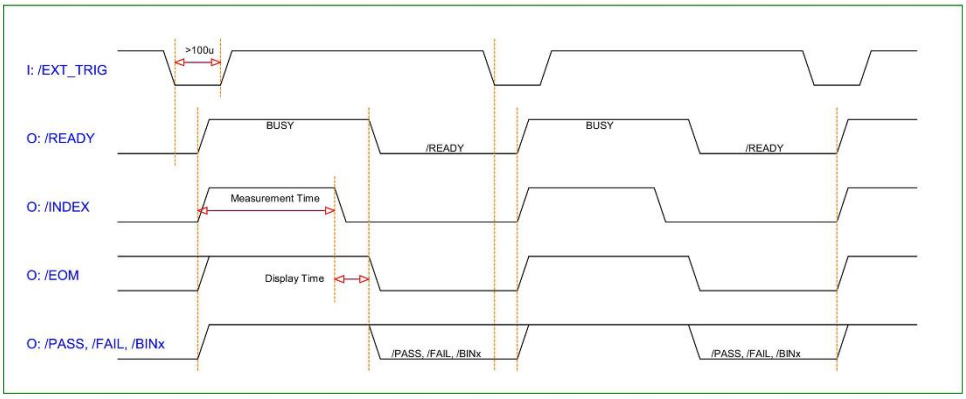




*Figure2.4.0.3 Timing Diagram*

# 2.5 GPIB Interface (Optional)

The computer can be connected to the GPIB connector on the rear panel of the 6621 using a GPIB (General-Purpose Interface Bus) cable. The instrument can then be controlled by the computer via GPIB.

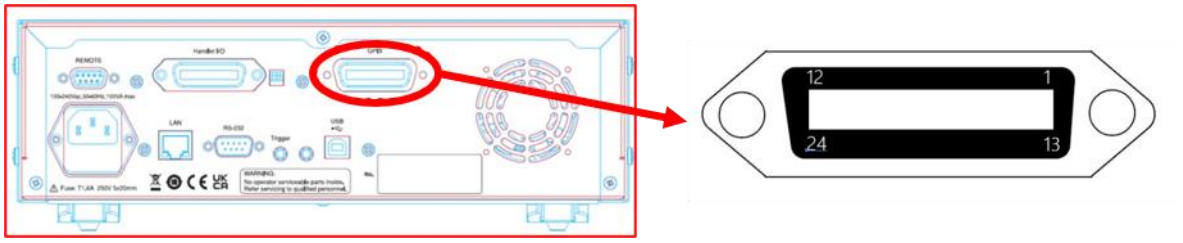



*Figure2.5.0.1 GPIB connector*

| Pin | Definition | Pin | Definition | Pin | Definition |
|---|---|---|---|---|---|
| 1 | Data line 1 | 9 | IFC | 17 | REN |
| 2 | Data line 2 | 10 | SRQ | 18 | Ground |
| 3 | Data line 3 | 11 | ATN | 19 | Ground |
| 4 | Data line 4 | 12 | Shield | 20 | Ground |
| 5 | EOI | 13 | Data line 5 | 21 | Ground |
| 6 | DAV | 14 | Data line 6 | 22 | Ground |
| 7 | NRFD | 15 | Data line 7 | 23 | Ground |
| 8 | NDAC | 16 | Data line 8 | 24 | Signal ground |

*Table2.5.1 GPIB Pin Definitions*

**Open System Settings**

- On the 6621 front panel, press the [Setup] key to enter the Setup page.
- Used direction keys to navigate to the System page.
- Use the direction keys to navigate to **GPIB Address** and set an address from **1 – 30**.

1. A GPIB bus can connect up to **15 instruments in total** (1 controller + 14 devices).
2. Each device must be assigned a **unique address**, enabling data and command exchange among all connected devices.

# 2.6 RS-232 Interface

Use an RS-232 cable to connect your computer to the RS-232 connector on the rear panel of the 6621.

Once connected, the computer can control the instrument via RS-232 for

testing.

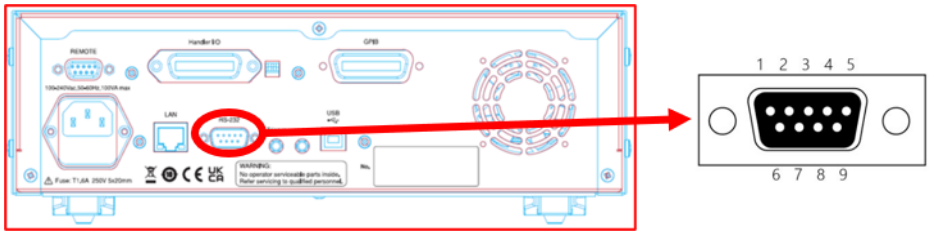



*Figure2.6.0.1 RS-232 Connector*

| Pin | Definition | Pin | Definition |
|---|---|---|---|
| 1 | NC | 6 | NC |
| 2 | RXD | 7 | NC |
| 3 | TXD | 8 | NC |
| 4 | NC | 9 | NC |
| 5 | GND | | |

*Table2.6.1 RS-232 Pin Definitions*

**Open System Settings**

- On the 6621 front panel, press the [Setup] key to enter the Setup page.
- Used direction keys to navigate to the System page.
- Use the direction keys to navigate to RS232 BAUD and Select a baud rate of 9600, 19200, 38400, 57600, or 115200 bps.

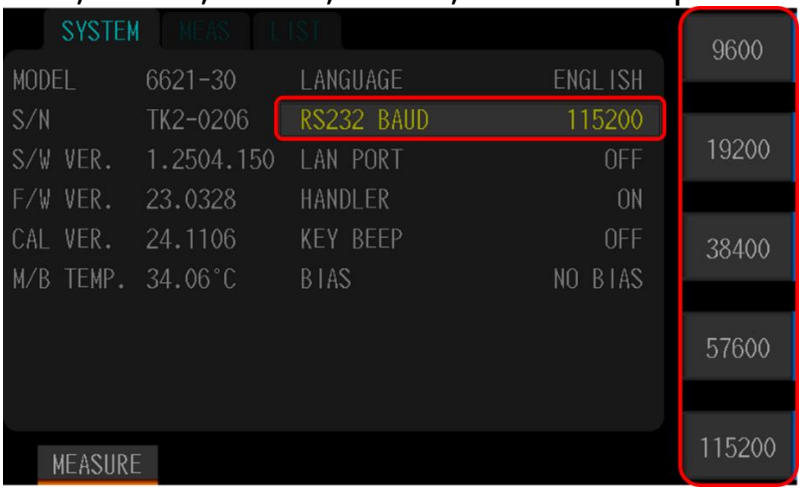



*Figure2.6.0.2 RS232 Baud Rate Setting*

# 2.7 LAN Interface

Use a network (Ethernet) cable to connect your computer (or network switch/router) to the LAN port on the rear panel of the 6621.

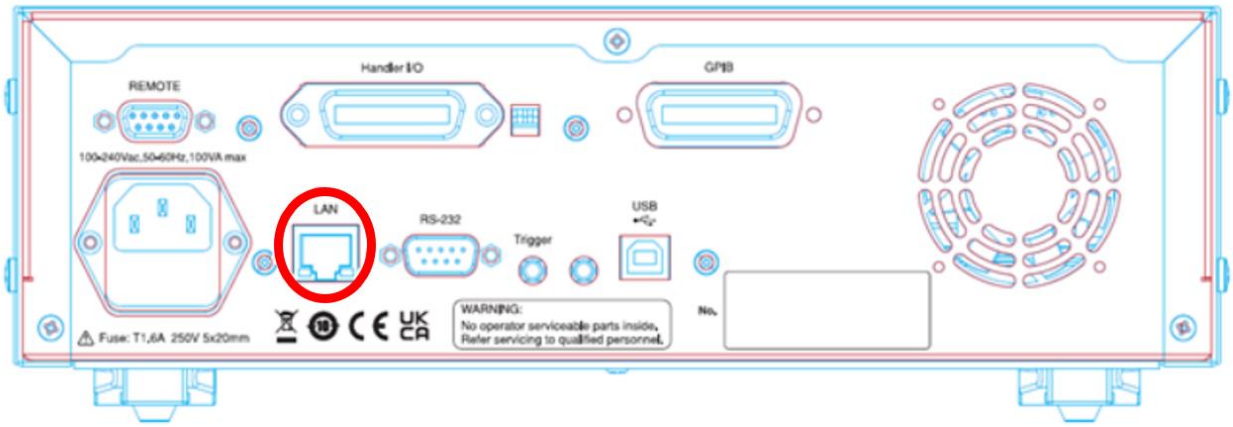



*Figure2.7.0.1 LAN Connector*

## Open System Settings

- On the front panel of the 6621, press the [Setup] key to enter the [System] page.
- Use the arrow keys to navigate to the Network Interface option.

## Enable the Network Interface

- Set LAN PORT to On.

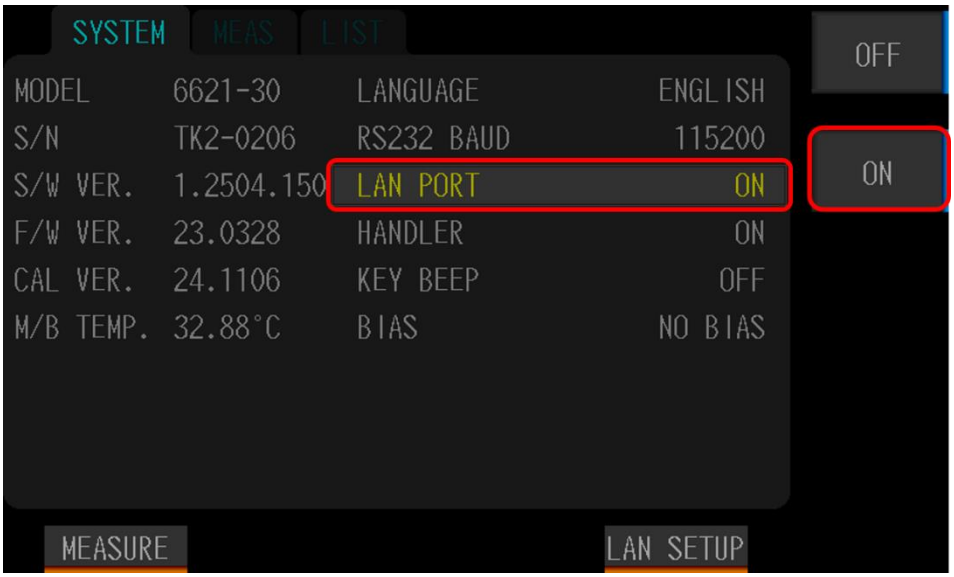



*Figure2.7.0.2 LAN Port Setting*

## Configure Network Settings

- For IP Configuration, select MANUAL or AUTO (DHCP).
- If MANUAL is chosen, enter the required parameters: IP Address, Subnet Mask, Gateway, DNS Server, etc.
- Status: Online or Offline indicates the current network state.

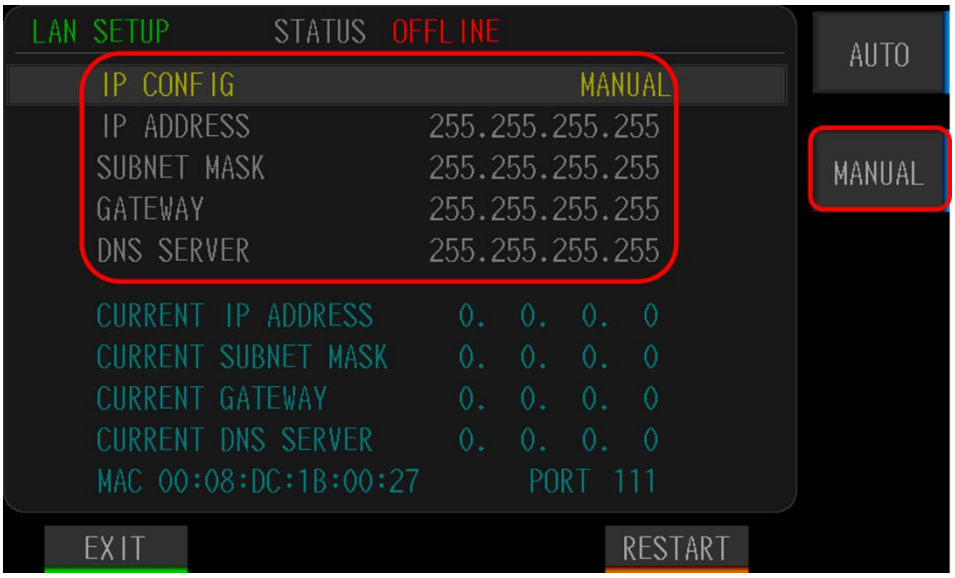



*Figure2.7.0.3 LAN-Manual setting*

# 2.8 Connect the Trigger Connection Port

When using the Trigger connection port, first go to the System Settings screen, select <Handler>, and set it to "ON".




*Figure 2.8.1 Handler ON*

The diagram below shows the structure of a 3.5mm audio jack terminal. When the Handler Interface is set to "ON", shorting GND and SW1 will activate the trigger.

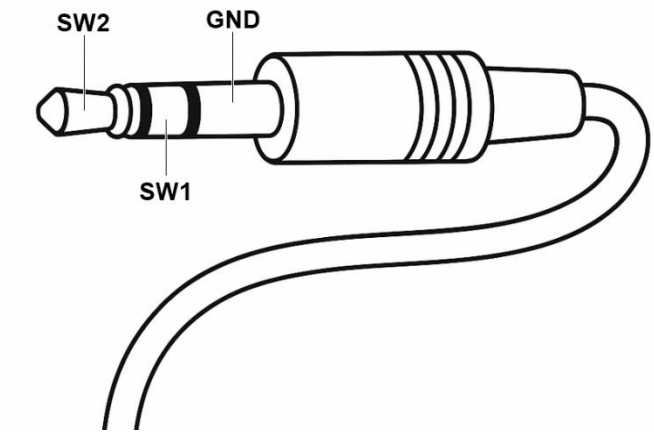



Figure 2.8.2 Structure description

# 2.9 Power-On Procedure

**Before you begin:**

Verify that the AC line voltage is within 100 – 240 V AC.

**Connect the Power Cord**

- Insert the power cord firmly into the AC inlet on the rear panel of the 6621.

**Press the POWER Key**

- On the front panel, press the POWER key.

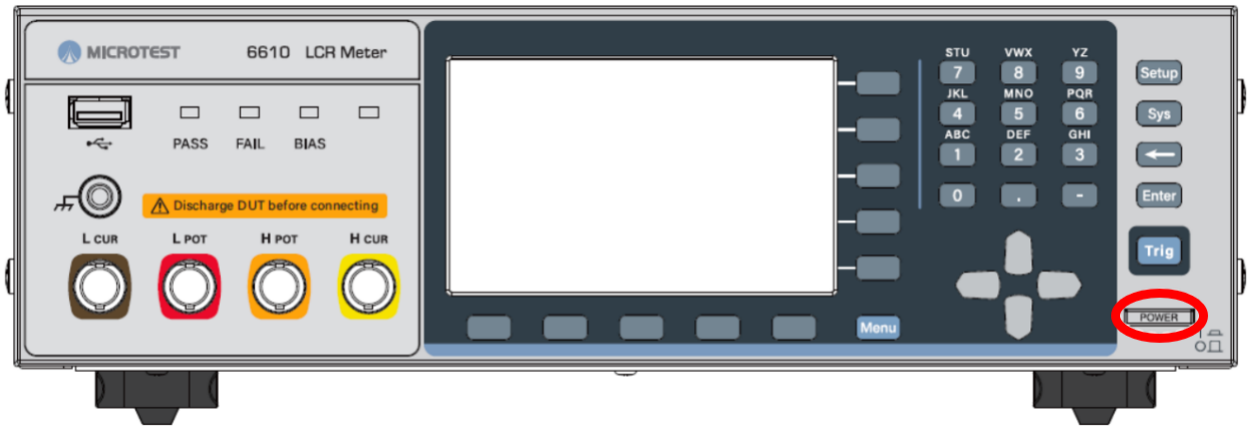



*Figure2.9.0.1 6621 Power key*

**Confirm the Startup Screen**

- The LCD will display the startup screen shown below.




*Figure2.9.0.2 Startup screen*

- Once the screen appears, the instrument has completed its power-on self-test and is ready for use.

**Maintenance & Safety Notes**

1. **Power Isolation**
   - Always unplug the power cord before performing any maintenance or cleaning.
2. **Dry-Hand Operation**
   - Do not plug in or unplug the power cord with wet hands to avoid electric shock.
3. **Power-Cord Inspection**
   - If the power cord or plug is damaged or loose, discontinue use immediately. A faulty cord can cause electric leakage, fire, short-circuit, or electric shock.

Operate the instrument properly to ensure the safety of both personnel and equipment.

# 2.10 BNC Connector Precautions

1. **Proper Connection**
   - Ensure the BNC plug is firmly mated to both the instrument and the DUT to prevent intermittent contact and inaccurate readings.
   - Align the connector correctly before mating; never force or overtighten the coupling ring.
2. **ESD Protection**
   - Before testing, make sure the DUT and test leads are properly

grounded to avoid electrostatic discharge (ESD) that could damage the instrument or the DUT.

3. **Cleaning & Maintenance**
   - Inspect BNC plugs regularly for oxidation or contamination. Wipe with a lint-free cloth as needed to maintain good contact.
   - Do not use corrosive liquids or sharp tools to clean the connector.
4. **Avoid Excessive Pulling**
   - During measurements, avoid excessive tension on the BNC cable to prevent connector damage or poor contact.
5. **Shielded Test Leads**
   - Use well-shielded test leads and ensure the ground connection is secure to minimize electromagnetic interference.
6. **Pre-test Check**
   - Before each measurement, verify that all cables and connectors are free of damage or looseness.
   - Avoid touching exposed contact points during testing to prevent measurement errors or electric shock.
7. **High-Frequency Measurements**
   - For high-frequency applications, use BNC cables rated for the required frequency range and confirm that the connectors are suitable for the target bandwidth.

# Chapter 3. Mode Overview

## 3.1 Meter Mode

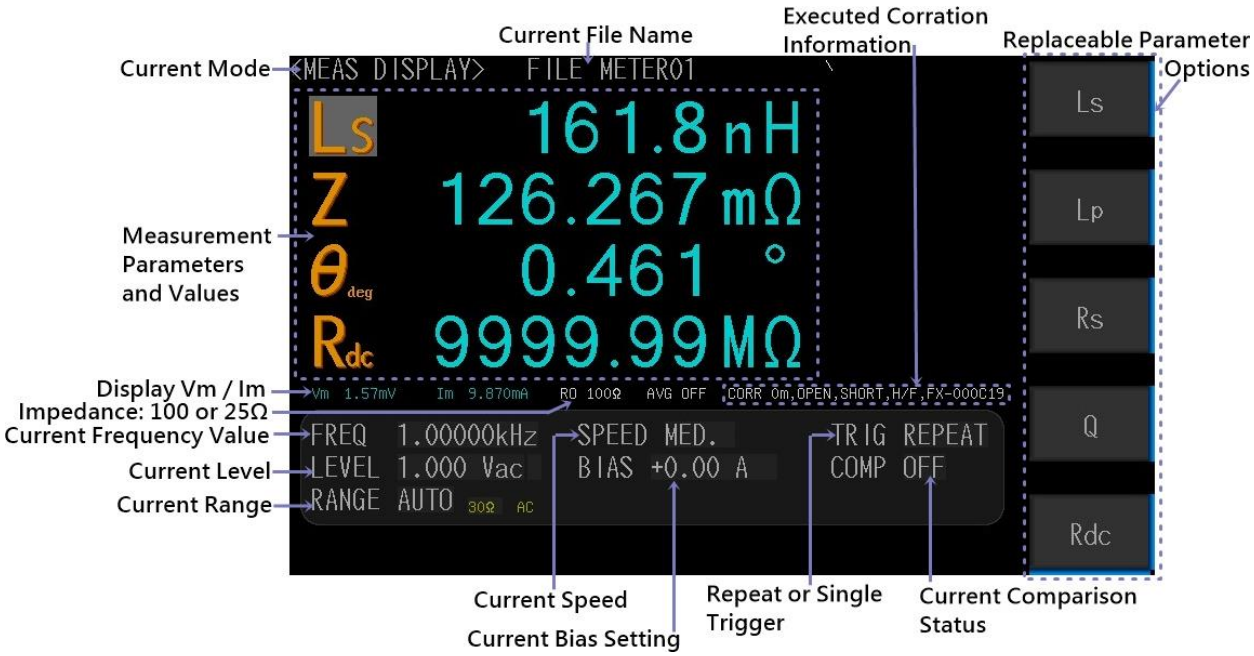



*Figure 3.1.1 Part Introduction*

1. Mode
   Press the Menu key. On the right side of the LCD, the modes include Meter, List Set, List Run, and Correction. Press the corresponding soft key to switch between pages freely.

2. File
   Use the arrow keys to highlight a file name, at which point the soft-keys below the LCD change to file functions; press the corresponding soft-key to enter the File page, where you can recall, create new, save as, delete, or save to USB (when a USB drive is inserted).

   Press the USB Files soft-key below the LCD to browse files on the USB drive. You can store parameter sets in the instrument's non-volatile memory—Meter Mode allows up to 100 setups, and Multi-Step List Test Mode allows up to 50 setups (each with up to 15 measurement steps).
   **Recall**
   Use the arrow keys to select the file you want to open, then press the <Recall> soft key to load it.

**New**

Press the <New> soft key to create a blank file, enter a filename and press Enter, then return to the main screen to configure parameters.

**Save As**

After configuring parameters, press the <Save As> soft key, enter a filename and press Enter to save the current settings as a new file.

**Delete**

Use the arrow keys to highlight the file, press the <Delete File> soft key, and in the confirmation dialog press <Confirm> to delete it — files in use cannot be deleted.

**Copy > USB**

When a USB drive is inserted, press the <Save to USB> soft key to copy the selected file to the USB drive (Meter Mode files go to LCR6621\METER, Multi-Step Mode files go to LCR6621\LIST).

**USB Files**

When a USB drive is inserted, press the <USB Files> soft key to browse folders containing LCR6621 setup files on the USB drive.

3. Parameter

Use the arrow keys to move the cursor to the parameter (LS), at which point the soft-keys on the right side of the LCD will display available replacement parameters. You can also use the function key below the LCD to cycle through the options, and once the desired parameter appears, press the corresponding soft-key to select it.

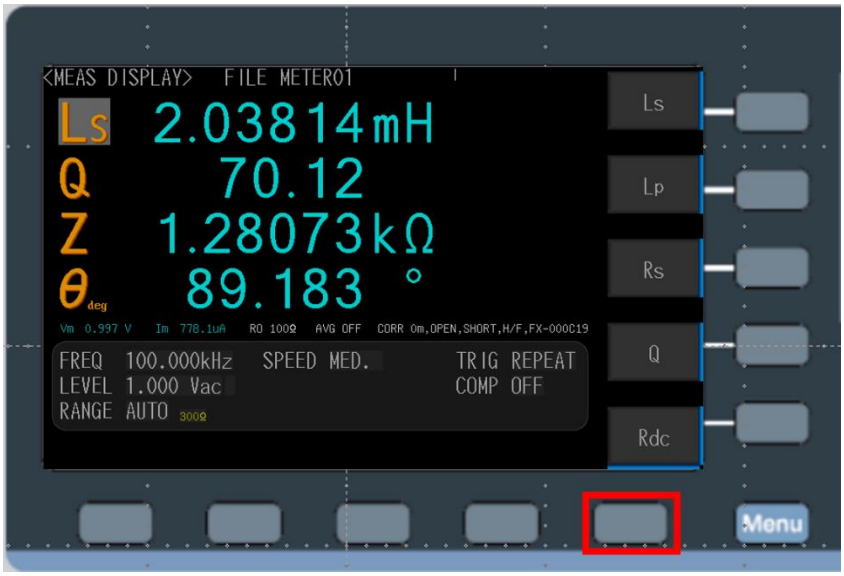



*Figure 3.1.2 Function key for cycle through the options*

| Parameter | Description | Parameter | Description |
|---|---|---|---|
| RDC | DC Resistance | R | Resistance |
| Ls | Series Inductance | X | Reactance |
| Lp | Parallel Inductance | Y | Admittance |
| Cs | Series Capacitance | G | Conductance |
| Cp | Parallel Capacitance | B | Susceptance |
| Q | Quality Factor | εr* | Complex relative permittivity |
| D | Dissipation Factor | εr′ | Relative permittivity– Real part |
| Rs | Series Resistance | εr″ | Relative permittivity – Imaginary part |
| Rp | Parallel Resistance | μr* | Complex relative permeability |
| Z | Impedance | μr′ | Relative permeability – Real part |
| θd | Phase Angle | μr″ | Relative permeability – Imaginary part |
| θr | Phase Angle (in radians) | | |

*Table 3.1.1 Parameters*

Note:
About Dielectric Constant (εr): When switching to **εr***, **εr′**, or **εr″** parameter, the screen will display the **FIXTURE** option. This option is used to configure the parameters required for calculation formulas, including **diameter, thickness, and fixture coefficient**.
This function is mainly intended for use with fixtures **FX-0000C7** and **FX-000C20**. For detailed instructions, please refer to the **FX-0000C7** or **FX-000C20** user manual.

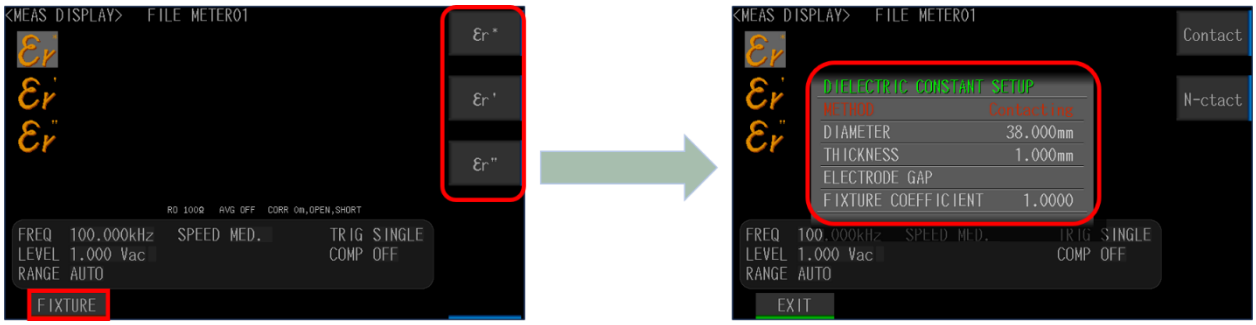



*Figure 3.1.2 About Dielectric Constant*

About Permeability (μr): When switching to **μr***, **μr′**, or **μr″** parameter, the screen will display the **FIXTURE** option. This option is used to configure the parameters required for calculation formulas, including **height, inner diameter, outer diameter, and fixture coefficient**.
This function is mainly intended for use with the **FX-0000C8** fixture. For detailed instructions, please refer to the **FX-0000C8** user manual.

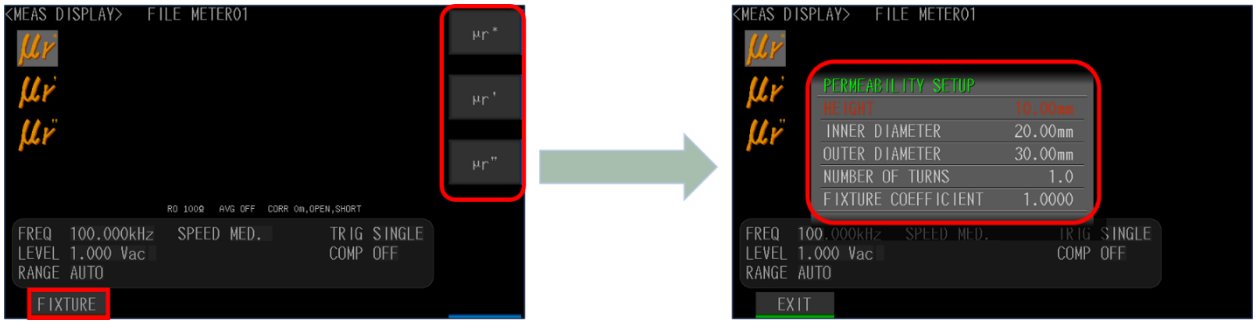



*Figure 3.1.3 About Permeability (μr)*

4. Frequency

Use the arrow keys to move the cursor to Frequency; the setting range is 10 Hz to 30 MHz (depending on the model specifications). Enter numeric values using the keypad, then press the corresponding soft key for Hz, kHz, or MHz. The symbols ↑↑, ↑, ↓, ↓↓ indicate coarse or fine adjustment; press the corresponding soft key to make adjustments.

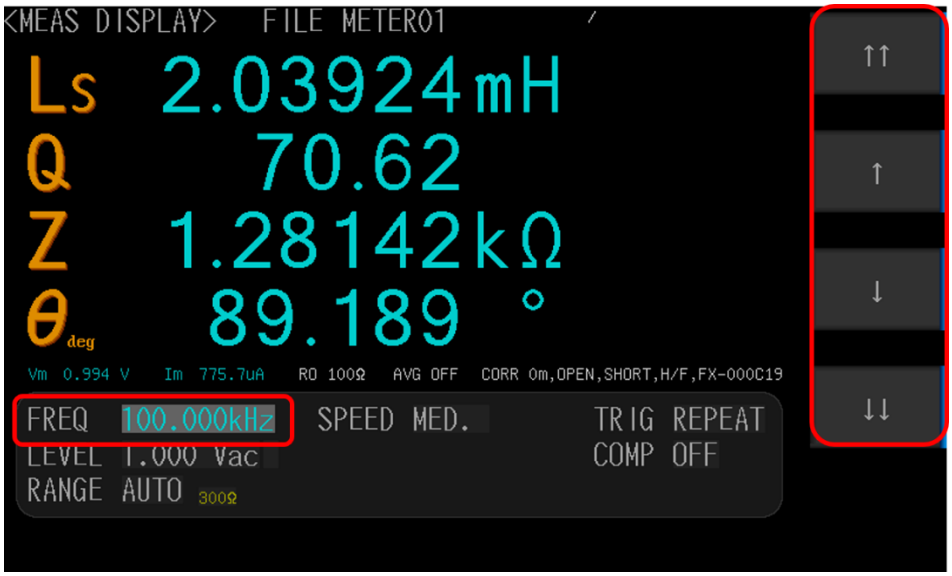



*Figure 3.1.3 Frequency setting*

5. Level

Use the arrow keys to move the cursor to Level; on the right side of the LCD, ALC ON/OFF and impedance settings of 100 Ω or 25 Ω will appear. Press the corresponding soft key to configure. After entering a numeric value, select mV, V, μA, or mA using the appropriate soft key.

Selecting <ALC ON> ensures that the voltage across the DUT or the current through it matches the configured values. When ALC is ON, the instrument adjusts the output based on measured voltage or current,

which slightly increases the test time. If the ALC control cannot reach the set range, an ALC FAIL message will appear. When the test voltage is 2 V or ALC FAIL occurs, consider turning ALC off. While ALC is on, the instrument continuously measures and adjusts, which can affect test speed.

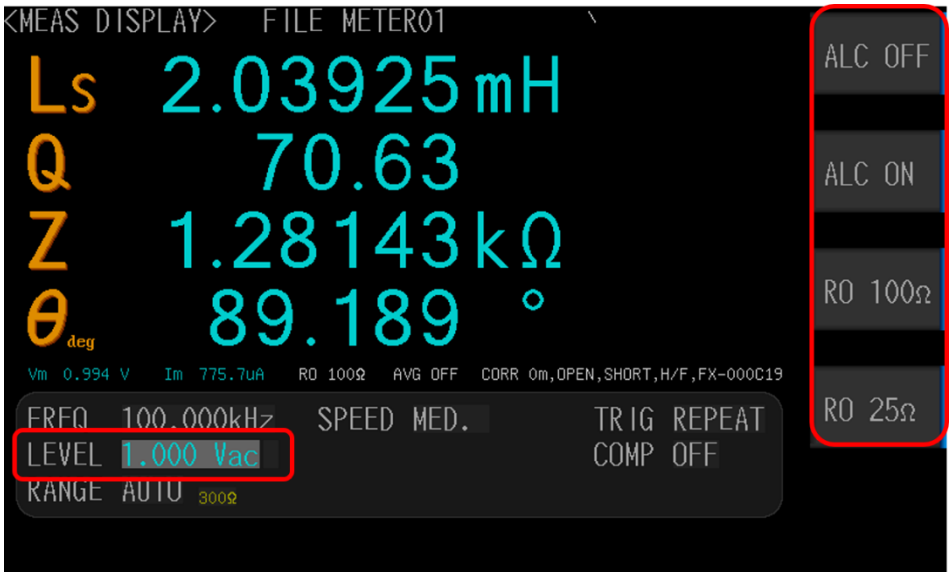



*Figure 3.1.4 Level setting*

| RO (Output impedance) | Frequency Range | Voltage range (Vac) | Current Range (mAac) |
|---|---|---|---|
| 100Ω | ≤1MHz | 0.010V to 2.000V | 0.10mA to 20.00mA |
| 100Ω | ≥1MHz | 0.010V to 1.000V | 0.10mA to 10.00mA |
| 25Ω | ≤1MHz | 0.010V to 1.000V | 0.40mA to 40.00mA |
| 25Ω | ≥1MHz | 0.010V to 1.000V | 0.40mA to 40.00mA |

*Table 3.1.2 Level limits*

6. Range (AC)

Use the arrow keys to move the cursor to Range. The range options include Auto, 1, 2, 3, and 4, where levels 1–4 correspond to <1=30 Ω>, <2=300 Ω>, <3=3 kΩ>, and <4=30 kΩ>. Ranges 1–4 are related to frequency; Please refer to the table below:

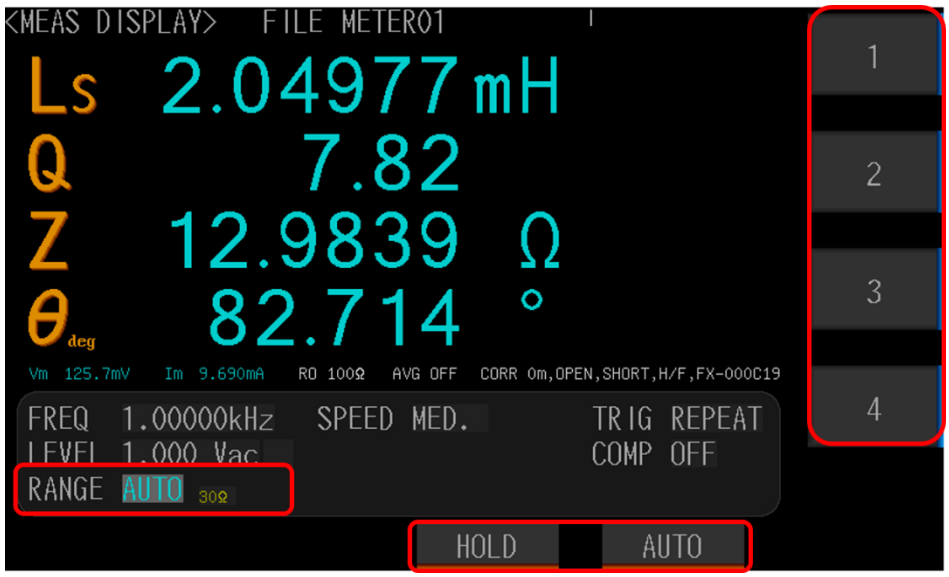



*Figure 3.1.5 Range*

| Frequency | Range 1 | Range 2 | Range 3 | Range4 |
|---|---|---|---|---|
| 10Hz to 12kHz | ✓ | ✓ | ✓ | ✓ |
| 12.001kHz to 120kHz | ✓ | ✓ | ✓ | |
| 120.001kHz to 1.2MHz | ✓ | ✓ | | |
| 1.20MHz to 30MHz | ✓ | | | |

*Table 3.1.3 Range limits*

7. Speed

Use the arrow keys to move the cursor to Speed. Available options include <Max>, <Fast>, <Med>, <Slow>, and <Slow2>. Select the desired option by pressing the corresponding soft key.

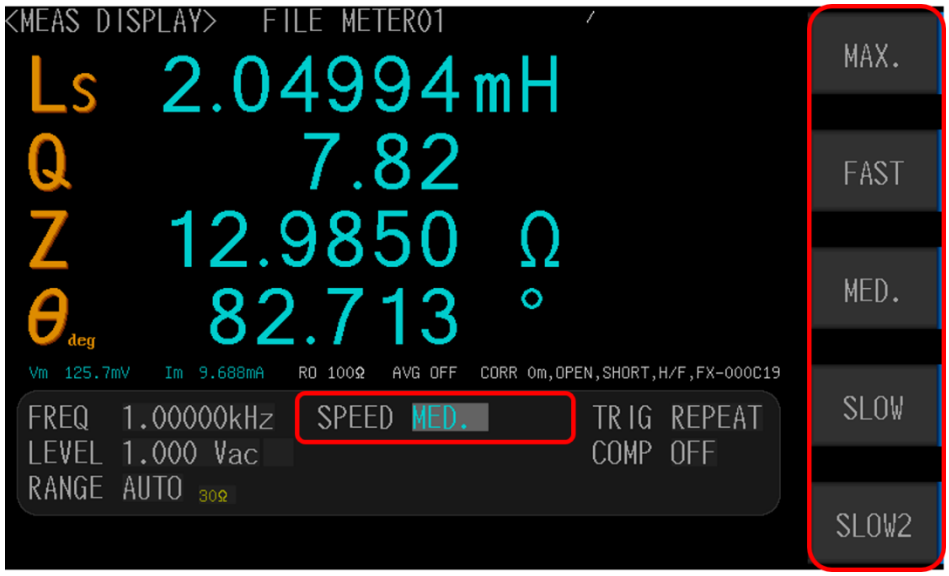



*Figure 3.1.6 Speed setting*

8. Bias

Use the arrow keys to move the cursor to Bias. The right side of the LCD will display ↑↑, ↑, ↓, ↓↓ for coarse or fine tuning. The bias value depends on the <Bias Source> setting. To set the bias source, press the Setup key, use the left arrow key to move the cursor to the System page, then use the down arrow key to move to Bias Source. The LCD will display options including <None>, <12V> (optional), <40V/0.1A>, and <622x/4x>. Configure based on user requirements. When <None> is selected, the Bias option will not be available in Meter Mode. <40V/0.1A> requires fixture F420005, and <622x/4x> must be used with models 6220, 6223, 6243, or 6243H.




*Figure 3.1.7 Bias setting*

9. Trig

Use the arrow keys to move the cursor to Trigger; the right side of the LCD will display <Repeat> and <Single>. When set to <Repeat>, the instrument performs continuous measurements. If <Single> is selected, you must press the Trig key to initiate each measurement—each press of the Trig key triggers a new measurement.




*Figure 3.1.8 Trig mode*

10. Comparator

    Use the arrow keys to move the cursor to Comparator; the <Compare Category> option will appear at the bottom of the LCD. Press the corresponding soft key to enter the comparator grading settings and configure conditions according to your requirements.

    You can set it to <Measured Value>, <Delta Value>, <Delta %>, or <Off>. Depending on your choice, enter the standard value, upper limit, and lower limit as needed. If <Measured Value> is selected, only the upper and lower limits are required. If <Delta Value> or <Delta %> is selected, a standard value must also be entered as a reference. When the test result passes, it is displayed in green text; when it fails, it is shown in red text.

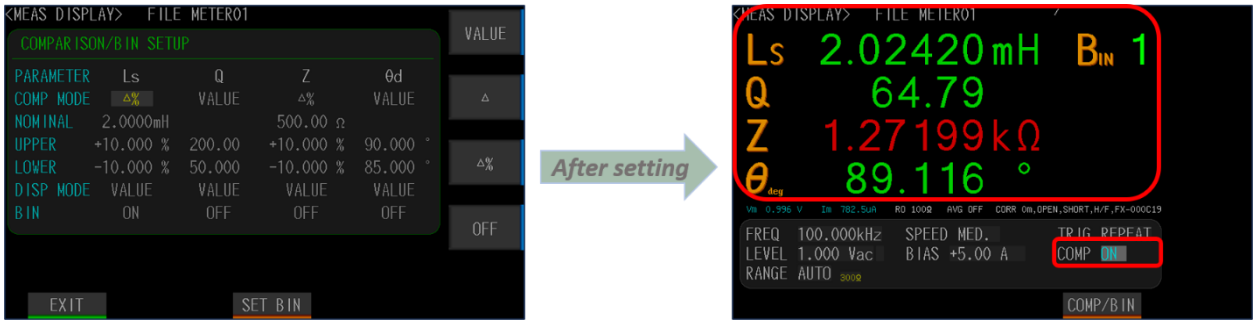



*Figure 3.1.9 Comparator Setting*

## Bin Function

The DUT (Device Under Test) can be categorized based on test results.

Binning parameters are selected from the four measurement items configured in Meter Mode. Up to 9 bin categories can be defined, and the range for each bin can also be customized.




*Figure 3.1.10 Bin Setting*

## Bin Classification Methods

- **Equal**:
  After setting the upper and lower limits, the system automatically calculates evenly spaced reference values for each bin. The value mode can be set to Measured Value, Offset Value, or Offset Percentage.

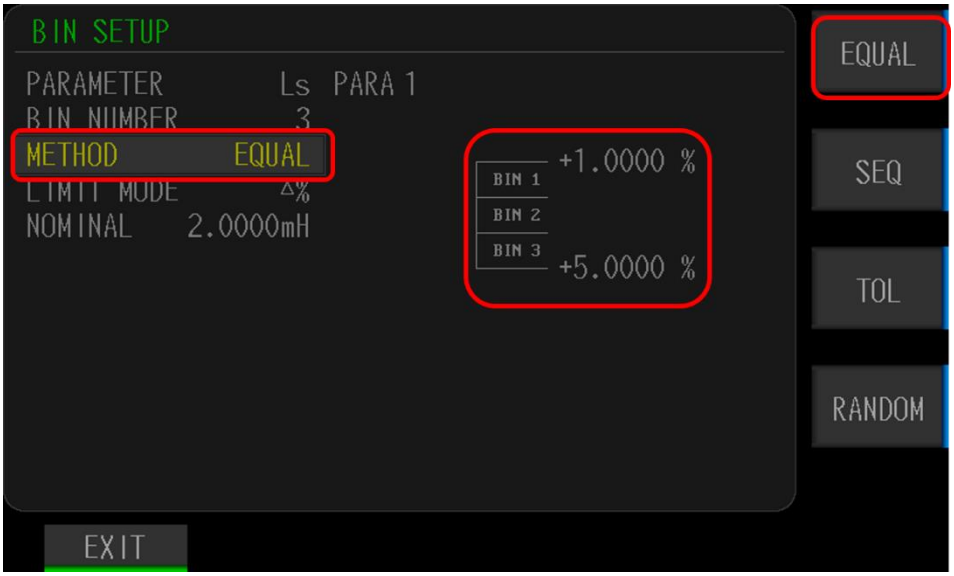



*Figure 3.1.11 Bin Equal*

- **Sequential**:
  Users manually set each bin's value in ascending or descending order. The system directly classifies the DUT based on the preset values for each bin. Value modes available: Measured Value, Offset Value, or Offset Percentage.

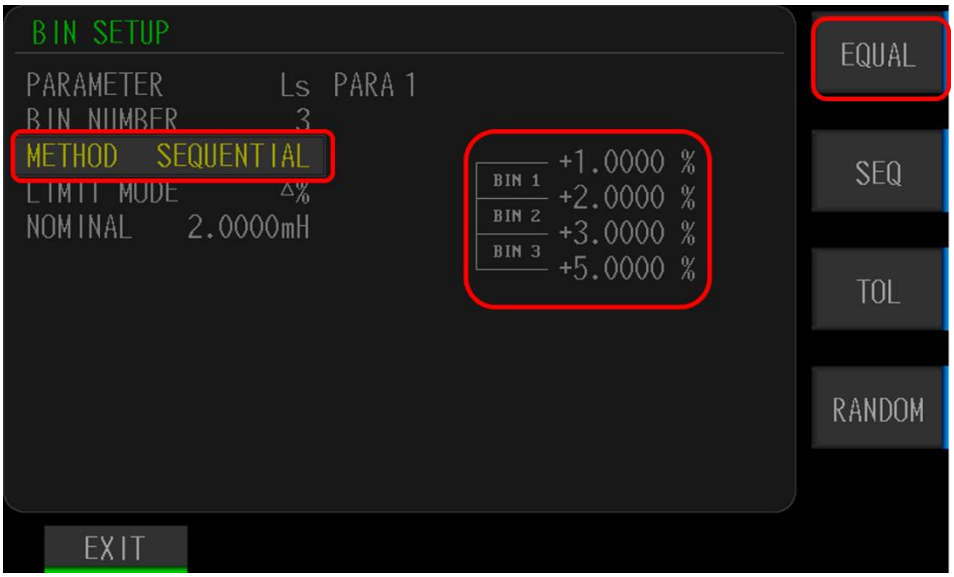



*Figure 3.1.12 Bin Sequential*

- **Tolerance**:
  This method uses error tolerance as the classification criteria. A standard value must be set first, then each bin is defined by allowable positive and negative deviations. Only Offset Value and Offset Percentage can be selected as value modes in this method.

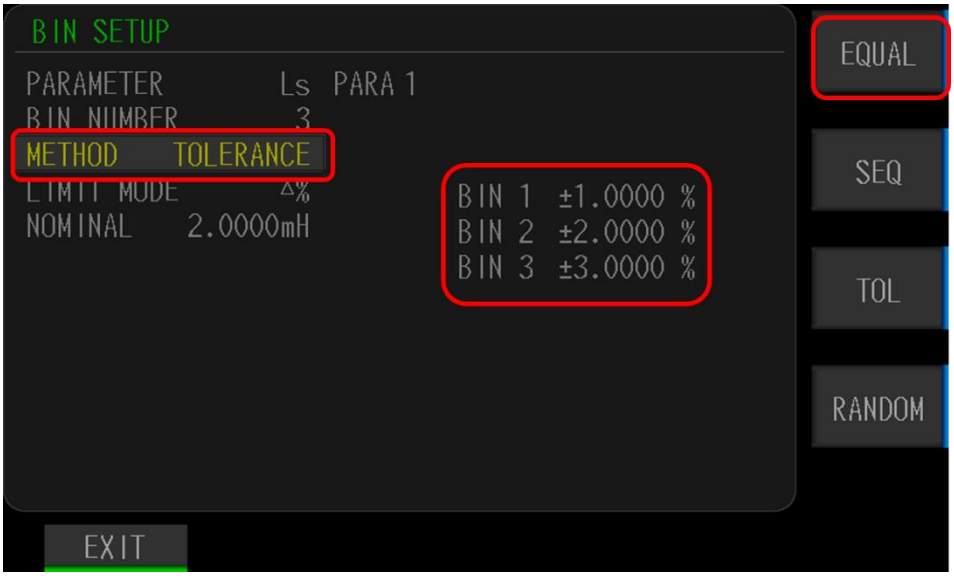



*Figure 3.1.13 Bin Tolerance*

- **Random**:
  Users can define upper limits for each bin freely. The system classifies according to the manually entered bin limits. Value modes available: Measured Value, Offset Value, or Offset Percentage.




*Figure 3.1.14 Bin Random*

**Value Modes**:

You can choose between Measured Value, Offset Value, and Offset Percentage based on your needs. If using Offset Value or Offset Percentage, a reference standard value must be entered. Negative deviations should be prefixed with a minus sign when inputting the value.

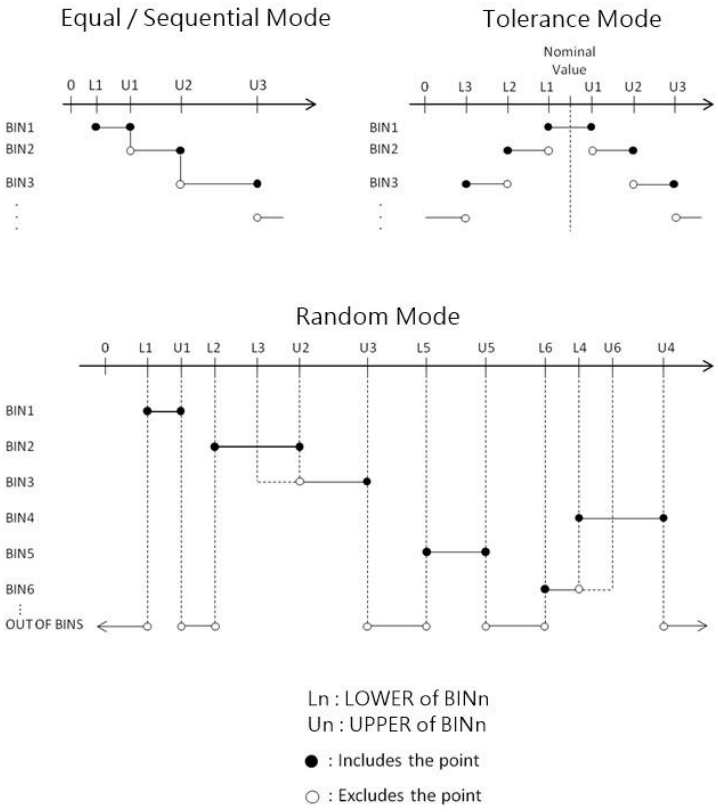



Figure 3.1.15 Upper and Lower Limit Criteria for Each Bin

# 3.2 LIST Mode

**List Mode** is designed for production lines and automated measurements. It allows you to configure multiple parameters and test conditions, and then execute them in sequence with a single operation.

**Key Features**

- Supports up to **15 test steps** (Step 1–15).
- Each step can have independent settings for:
  - **FREQUENCY**
  - **LEVEL**
  - **DC BIAS**
  - **SPEED**
  - **DELAY**
  - **COMP (Comparison) MODE**
  - **NOMINAL, UPPER, LOWER** limits
  - **BIN** sorting (Detail refer to BIN function)

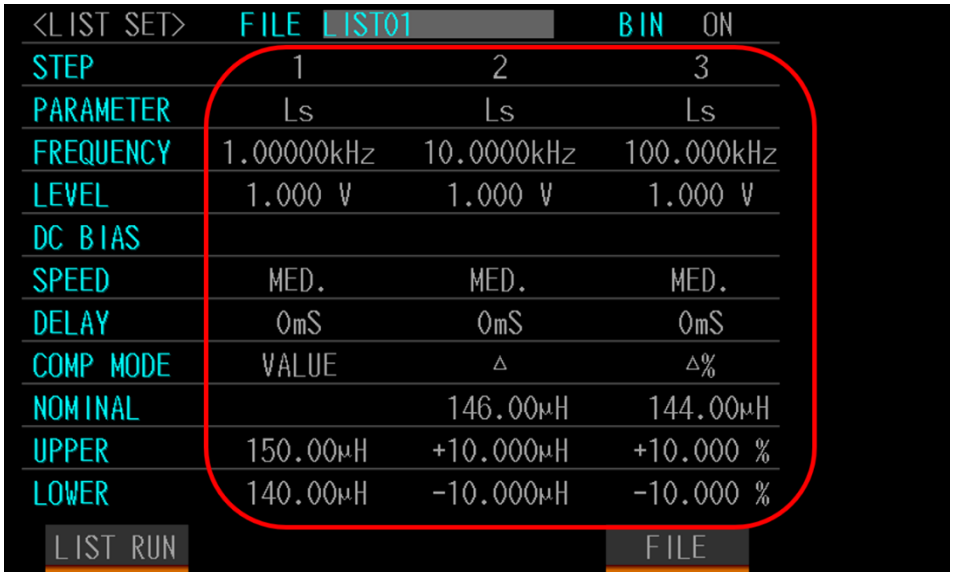



*Figure 3.2.1 List Mode setting*




*Figure 3.2.2 Bin function location*

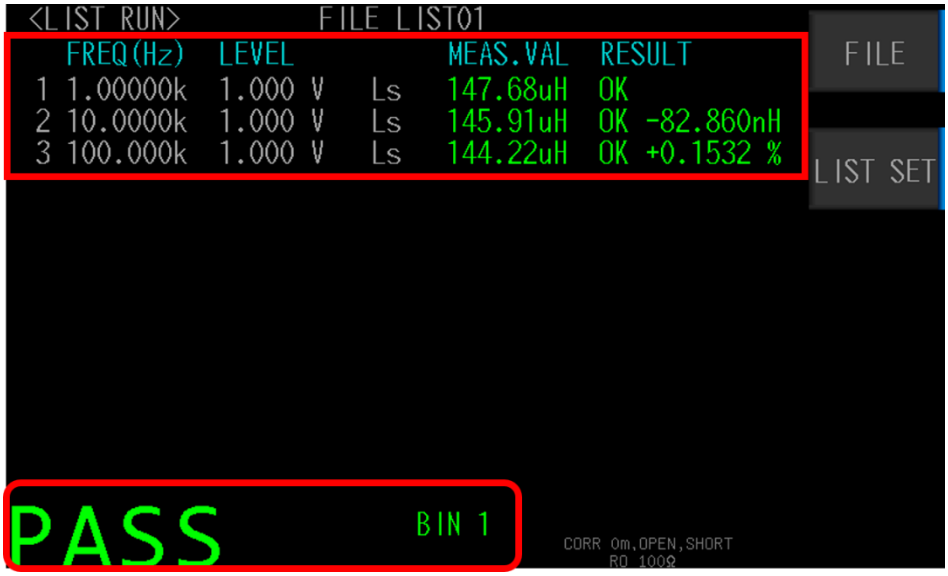



*Figure 3.2.3 Test Result*

# Chapter 4. Setup Overview

## 4.1 Measure

Press the Setup key and move the cursor to the MEAS. The screen will display as shown in Figure 4.1.1.

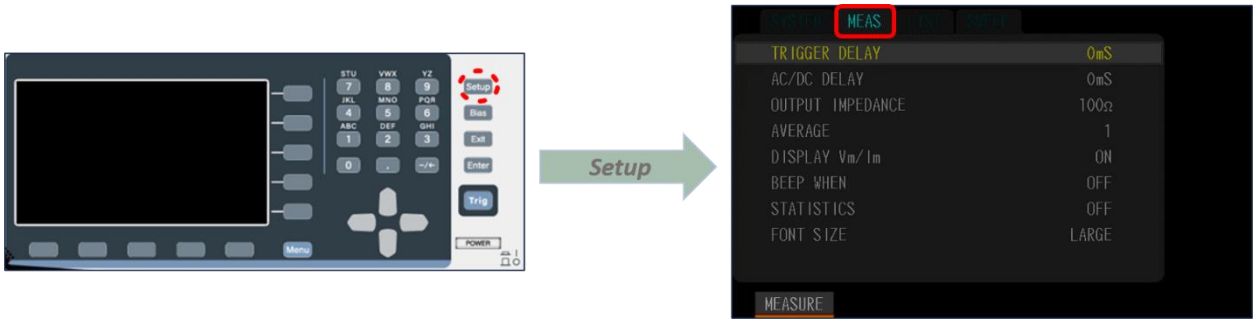



*Figure 4.1.1 Setup-Measure page*

**1. TRIGGER DELAY:**

Set the trigger delay time. This function is commonly used in automated equipment.

**Cautions**： The trigger delay time ranges from 0~5000mS. If the value exceeds the maximum limit, the system will automatically reset it to 5000mS.

**2. AC/DC DELAY:**

If the measurement includes both AC parameters and RDC, you can set a delay time between the AC and DC measurements. The range is 0~5000mS. Can be used when the measured value is unstable during switching between AC and DC.

**3. OUTPUT IMPEDANCE:**

Set the impedance to 100Ω or 25Ω. You can select either <100Ω> or <25Ω> according to user requirements. Different output impedances of the signal source will result in different current levels or measurement values, mainly due to voltage division effects during testing.

**4. AVERAGE:**

If the measurement value is unstable, you can set the number of averaging counts. The setting range is 1-64 times. The higher the averaging count, the more stable the measurement value will be; however, the measurement speed will be relatively slower.

**5. DISPLAY Vm/Im:**

To display Vm/Im values, select <ON>. The screen will show both AC and DC Vm/Im values. It is recommended to set this option to <OFF> to avoid affecting the measurement speed.

**6. BEEP WHEN:**

Selecting <Fail> will cause the buzzer to sound when the test result is Fail or NG. Selecting <PASS> will cause the buzzer to sound when the test result is PASS or OK.

**7. STATISTICS:**

Selecting <ON> will display the statistics count. Selecting <OFF> will hide the statistics count.

**8. Meter Font Size:**

Select <LARGE> or <SMALL> to change the font size on the screen.

# 4.2 LIST

Press the Setup key, move the cursor to the LIST page, and the screen will display as shown in Figure 4.2.2.

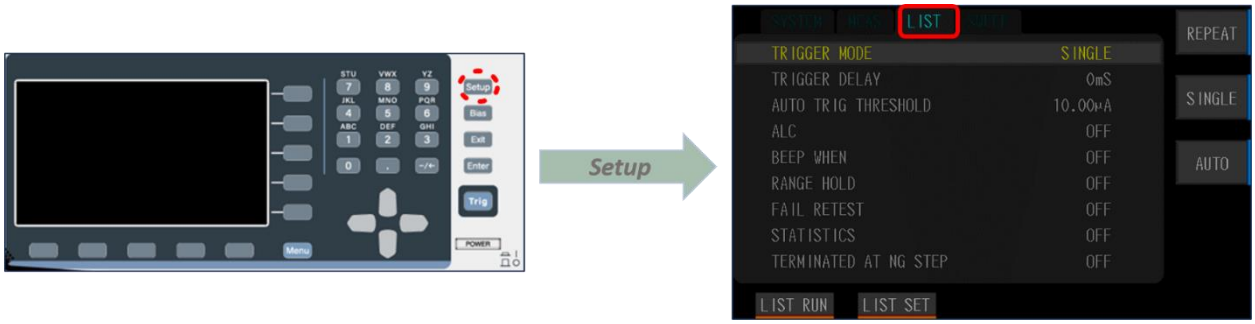



*Figure 4.2.1 Setup-List page*

1. **TRIGGER MODE:**
   TRIGGER MODE include <REPEAT>, <SINGLE>, and <AUTO>. <REPEAT> triggers measurements continuously without interruption. <SINGLE> requires a trigger (Trig) for each test. <AUTO> automatically triggers when the device under test and the 6621 form a measurement loop.
2. **TRIGGER DELAY:**
   Set the delay time for each triggered test. The setting range is 0~5000mS.
3. **AUTO TRIG THRESHOLD:**
   When the TRIGGER MODE is set to AUTO, the AUTO TRIG THRESHOLD can be set from 0.01uA ~ 20000.00uA. If the measured current is greater than the threshold, it indicates that the device under test is connected. If it is lower than the threshold, it indicates that the device under test has been disconnected.
4. **ALC (Automatic Level Control):**
   Same as in the meter mode, this setting enables or disables ALC. If the voltage compensation fails, ALC FAIL will be displayed in the lower right corner.
5. **BEEP WHEN:**

When the <FAIL> option is selected, the buzzer will sound when the test result is Fail or NG. When the <PASS> option is selected, the buzzer will sound when the test result is PASS or OK.

6. **RANGE HOLD:**
   Sets whether to fix the measurement range. When <ON> is selected, the range used will be the one determined during the first completed test. When <OFF> is selected, the most suitable range will be selected for each measurement. Using a fixed range results in slightly faster measurement speed.
7. **FAIL RETEST:**
   When a failed step is encountered, it will be remeasured until the test result passes before proceeding to the next step. The setting options are <OFF>, <Step 1>, and <ALL>. <OFF> means the retest function is disabled. <Step 1> means only the first step will be remeasured if it fails. This is commonly used in automated testing systems to prevent errors when the device under test is not yet properly positioned. <ALL> means any failed step will be repeatedly tested until it passes, before moving on to the next step.
8. **STATISTICS:**
   This setting enables or disables the count statistics function. When set to <ON>, the system will keep track of the number of PASS and FAIL results. When set to <OFF>, the count statistics function will not be executed.

9. **TERMINATED AT NG STEP:**
   When this setting is set to <ON>, the test will be stopped immediately if any step results in a failure.

# 4.3 System

Press the <Setup> key and move the cursor to the SYSTEM. The screen will display as shown in Figure 4.3.1. The information on the left side of the LCD shows the current model, serial number, firmware version, correction version, and internal temperature of the device.

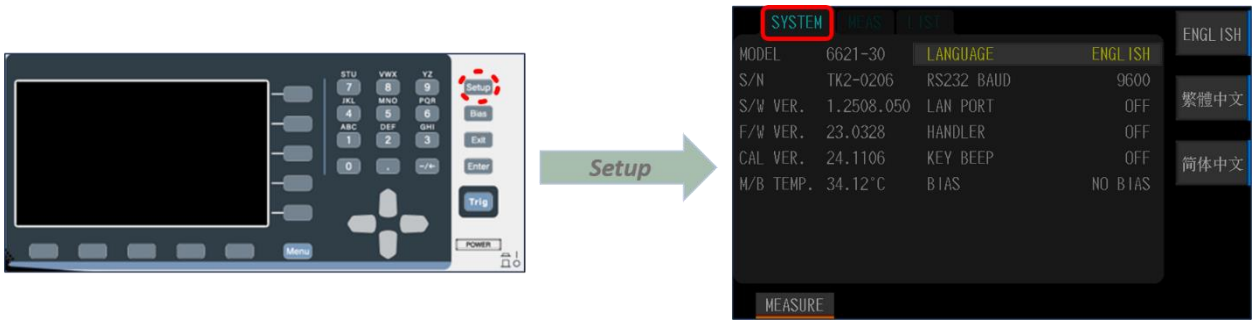



*Figure 4.3.1 Setup-System page*

**1. LANGUAGE:**

Use the arrow keys to move the cursor to LANGUAGE. You can select from <ENGLISH>, <繁體中文>, or <简体中文>. Set the language according to the user's preference.

⚠ Cautions : For certain proprietary terms or font-related items, <English> will still be used.

**2. GPIB ADDRESS:**

Use the arrow keys to move the cursor to GPIB ADDRESS, where you can set the GPIB address from 1~30.

**3. RS232 BAUD:**

Use the arrow keys to move the cursor to RS232 BAUD, where you can select from the available options <9600>, <19200>, <38400>, <57600>, <115200>.

**4. LAN PORT:**

Use the arrow keys to move the cursor to LAN PORT, where you can select <OFF> or <ON>.

Press the corresponding function key for LAN SETUP to choose between <AUTO> or <MANUAL>.

This allows the user to control the instrument via the network function.

**5. HANDLER:**

Use the arrow keys to move the cursor to HANDLER, where you can select <OFF> or <ON>. Press the corresponding function key for Contact Description to view the function information of each pin. This allows the user to remotely control the instrument, monitor signal inputs, and view PASS/FAIL output results.

**6. KEY BEEP:**

Use the arrow keys to move the cursor to KEY BEEP, where you can select <OFF> or <ON>. This turns the key operation sound on or off.

**7. BIAS:**

Use the arrow keys to move the cursor to BIAS, where you can select <NO BIAS>, <12V> (optional), <40V/0.1A>, or <622x/4x>. If using <40V/0.1A>, the optional fixture F420005 must be selected. If using <622x/4x>, an additional 622x or 624x device must be purchased. For wiring connections, please refer to 2.3 REMOTE Interface .

# Chapter 5. Correction

Press the <Menu> key and select <CORR.> to enter the correction page.
It is recommended to perform fixture or test lead correction (balancing) before each measurement.
Correction helps eliminate stray capacitance, series impedance, and other parasitic effects introduced by the fixture or test leads, ensuring the accuracy of measurement results. This is especially important for high-precision or high-frequency testing.
Always perform correction when changing the test environment or fixtures.
When the equipment is moved to a new environment or when test accessories (such as fixtures or test leads) are replaced, changes in external conditions may alter the system's parasitic parameters. Recalibrating is a critical step to ensure the measurement equipment continues to meet accuracy requirements.




Figure 5.0.1 Correction page

## 1. OPEN:

Use the arrow keys to move the cursor to OPEN. Connect the fixture or test leads to the 6621 BNC interface, following the method shown in Figure 5.0.2 or 5.0.3. After securing the fixture contacts or clamping the test leads properly, press the OPEN soft key (bottom function key)

to begin the open correction process. A pop-up window will appear showing "OPEN CORRECTION…"

If the open correction fails, the screen will display "CORRECTION ERROR". If the correction is successful, the open correction option will become active, as shown in Figure 5.0.4.

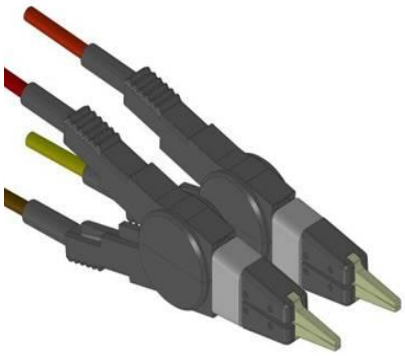


Figure 5.0.2 Test Lead Open Correction Method

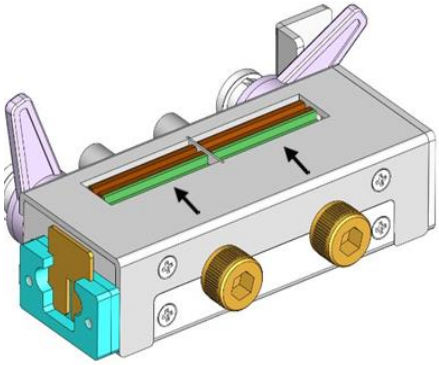


Figure 5.0.3 Fixture Open Correction Method (Be sure to lock the contact pins securely)

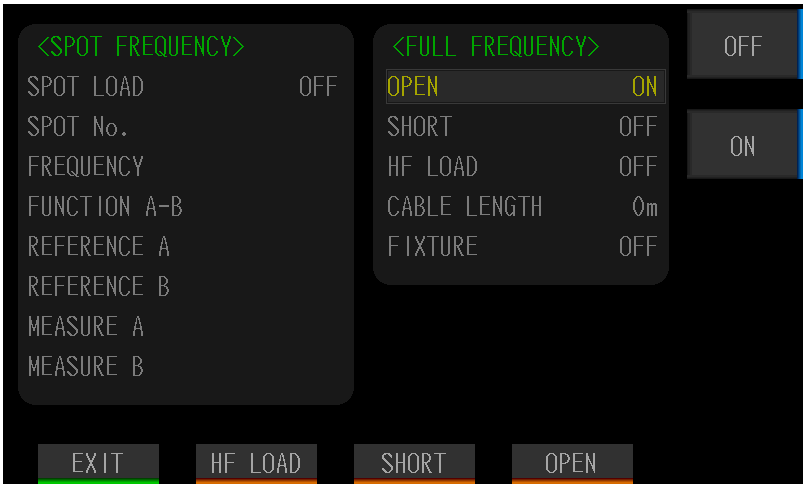



Figure 5.0.4 Open Correction Successful

## 2. SHORT:

Use the arrow keys to move the cursor to SHORT. Connect the fixture or test leads to the 6621 BNC interface, following the method shown in Figure 5.0.5 or 5.0.6. After the fixture securely clamps the shorting

plate, or the test leads are clamped together to form a short circuit, press the SHORT soft key (bottom function key) to start the short correction process. A pop-up window will appear showing "SHORT CORRECTION…"

If the correction fails, the screen will display "CORRECTION ERROR". If the correction is successful, the short correction option will become active, as shown in Figure 5.0.7.

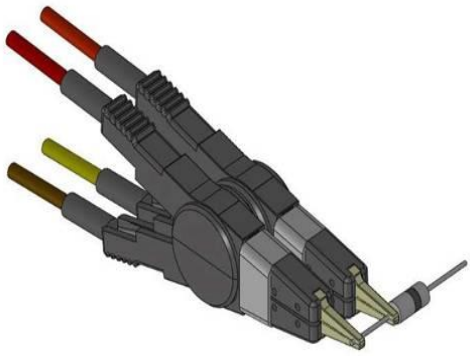


Figure 5.0.5 Test Lead Short Correction Method

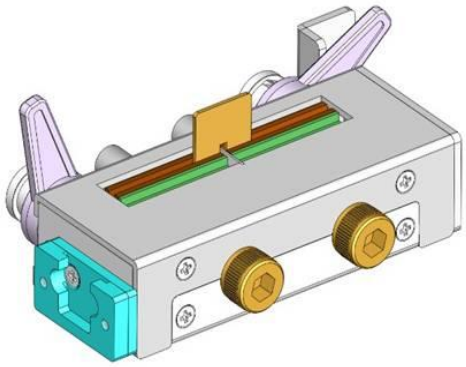


Figure 5.0.6 Fixture Short Correction Method (After inserting the shorting plate, please securely lock the contact pins)




Figure 5.0.7 Short Correction Successful

3. **HF LOAD:** (Perform high-frequency load correction when the test frequency is above 1 MHz)

Use the arrow keys to move the cursor to HF LOAD. Connect the fixture to the 6621 BNC interface, following the method shown in Figure 5.0.8. Securely clamp the fixture to the STD-LOAD, then press the HF LOAD soft key (bottom function key) to start the correction. A pop-up window will appear showing "HF CORRECTION…" …

If the correction fails, the screen will display "CORRECTION ERROR". If the correction is successful, the high-frequency load correction option will become active, as shown in Figure 5.0.9.

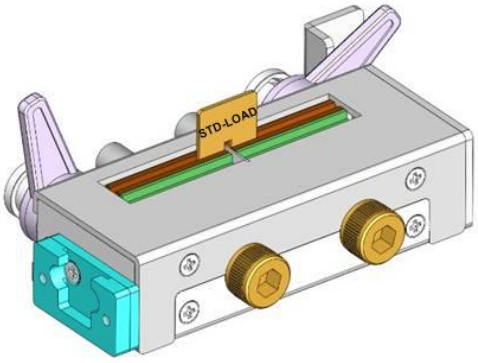



Figure 5.0.8 Clamp the STD-LOAD securely




Figure 5.0.9 HF LOAD Successful

## 4. CABLE LENGTH:

If the 6621 BNC interface is connected to test leads, use the arrow keys to move the cursor to CABLE LENGTH, and set it according to the length of the test leads. Available options are: <0m>, <0.5m>, <1m>, and <2m>.




*Figure 5.0.10 Cable Length Setting*

## 5. FIXTURE:

If the 6621 BNC interface is connected to a fixture, use the arrow keys to move the cursor to FIXTURE, and select the appropriate setting based on the fixture model. Available options include <F42001>, <FX-000C20>, <FX-000C19>, <FX-000C12>, <FX-000C10>, <FX-0000C8>, <FX-0000C7>, <FX-0000C6>.

**Note: Only one of Fixture Compensation or Cable Length can be selected at a time.**




*Figure 5.0.11 Fixture compensation setting*

## 6. SPOT LOAD:

Use the arrow keys to move the cursor to SPOT LOAD, and set the option to "On" to enable the "SPOT No.". The available setting range is from1~16. Move the cursor to FREQUENCY and set it to "On", then enter the frequency and the FUNCTION A-B and REFERENCE A-B based on the known specifications of the device under test. Press MEASURE (the fixture has already been clamped to the device under test), as shown in Figure 5.0.12.

Available parameter options include <Ls-Q>、<Ls-Rs>、<Lp-Q>、<Lp-Rp>、<Cs-D>、<Cs-Rs>、<Cp-D>、<Cp-Rp>、<R-X>、<G-B>、<Z-Deg>、<Y-Deg>.




*Figure 5.0.12 Frequency, correction parameters, and reference values*




*Figure 5.0.13 MEAS Mode*

**Note:** If the SPOT LOAD is not required, please set this function to "OFF".

# Chapter 6. Specification Sheet

| **6621 Series** | |
|---|---|
| 6621-30 | 10Hz ~ 30MHz |
| 6621-20 | 10Hz ~ 20MHz |
| 6621-10 | 10Hz ~ 10MHz |
| 6621-5 | 10Hz ~ 5MHz |
| 6621-3 | 10Hz ~ 3MHz |
| 6621-1 | 10Hz ~ 1MHz |
| **Frequency** | |
| Frequency Range | Resolution |

| | |
|---|---|
| 10.0~99.9Hz | 0.1Hz |
| 100.0~999.9Hz | 0.1Hz |
| 1.0000k~9.9999kHz | 0.1Hz |
| 10.0000k~99.9999kHz | 0.1Hz |
| 100.000k~999.999kHz | 1Hz |
| 1.00000M~9.99999MHz | 10Hz |
| 10.0000M~30.0000MHz | 100Hz |
| Frequency Accuracy | ±0.01% |
| Display Range | |
| DCR | 0.00mΩ to 99.9999MΩ |
| \|Z\| | 0.000mΩ to 9999.99MΩ |
| R, X | ±0.000mΩ to 9999.99MΩ |
| \|Y\| | 0.00000μS to 999.999kS |
| G, B | ±0.00000μS to 999.999kS |
| Cs, Cp | ±0.00000pF to 9999.99F |
| Ls, Lp | ±0.00nH to 9999.99kH |
| Q | 0.00 to 9999.99 |
| D | 0.00000 to 9999.99 |
| θDEG | ±0.000° to 180.000° |
| θRAD | ±0.00000 to 3.14159 |
| Δ% | ±0.000% to 9999.999% |
| **Voltage Signal Level (*f: frequency [MHz])** | |
| Range | 10mVrms ~ 2Vrms (f≦1 MHz)<br>10mVrms ~ 1Vrms (f> 1MHz or f≦1 MHz and RO=25Ω) |
| Resolution | 1mV |
| **Accuracy** | |
| At 4-Terminal test fixture | ± [(10 + 0.05 × f )% + 1 mV] |
| At Cable length > 0m | ± [(15 + 0.1 × f )% + 1 mV] |
| **Current Signal Level (*f: frequency [MHz])** | |
| Range | 100μA ~ 20mArms (RO=100Ω)<br>400μA ~ 40mArms (RO=25Ω) |
| Resolution | 10μA |
| **Accuracy** | |
| Accuracy at 4-Terminal test fixture | |
| Frequency ≤ 10MHz | $+[10\% + 50\text{uA}], -[(10 + 0.2 * f^2)\% + 50\text{uA}]$ |
| Frequency > 10MHz | $\pm[(10 + 0.3 * f)\% + 50\text{uA}]$ |
| Accuracy at Cable length > 0m | |
| Frequency ≤ 5MHz | $+[10\% + 50\text{uA}], -[(15 + 1.5 * f^2)\% + 50\text{uA}]$ |
| Frequency > 5MHz | $\pm[(20 + 0.3 * f)\% + 50\text{uA}]$ |
| **DCR Signal Level** | |
| Signal Level | DC 1V, 40mA max |

| | |
|---|---|
| Accuracy | ±1% |
| Output Impedance | 25Ω(nominal) |
| **Internal DC Bias** | |
| Range | 0 to ±12V |
| Resolution | 1mV |
| Accuracy | ±( 0.3%± 2mV) |
| **Measurement Speed** | |
| Max | 2.5ms (Frequency >10kHz) |
| Fast | 50ms (Frequency >20kHz) |
| Med | 100ms |
| Slow | 300ms |
| Slow2 | 600ms |
| **Display Time** | |
| 1.6 ~ 5.6ms (depend on the contents) | |

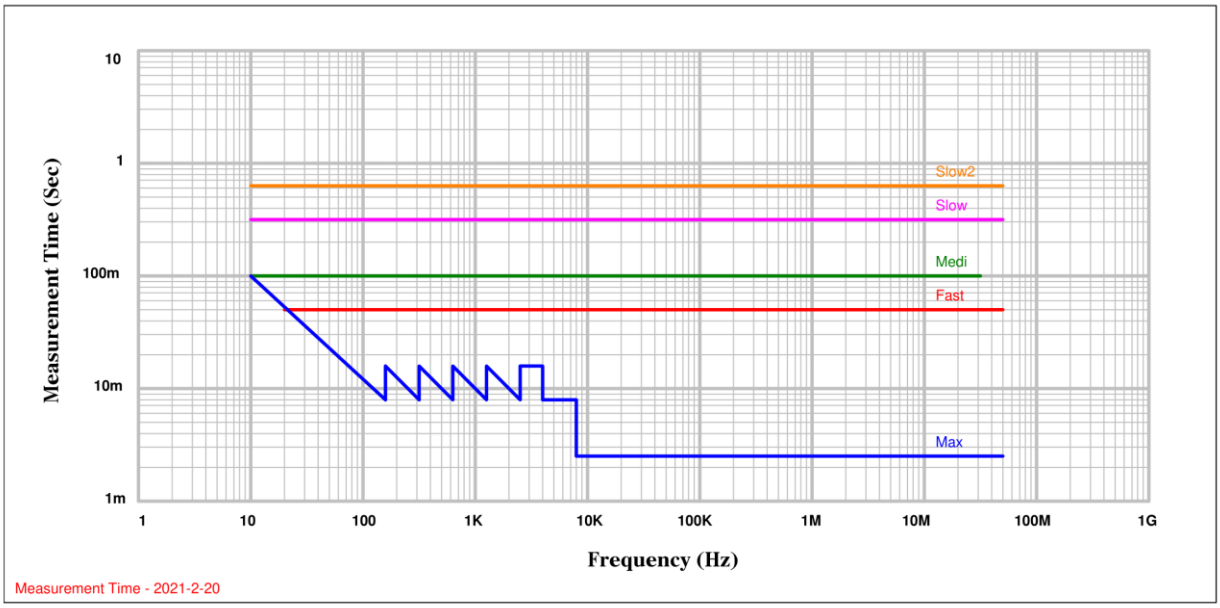



*Figure 4.3.1 Test Speed vs. Frequency Relationship*

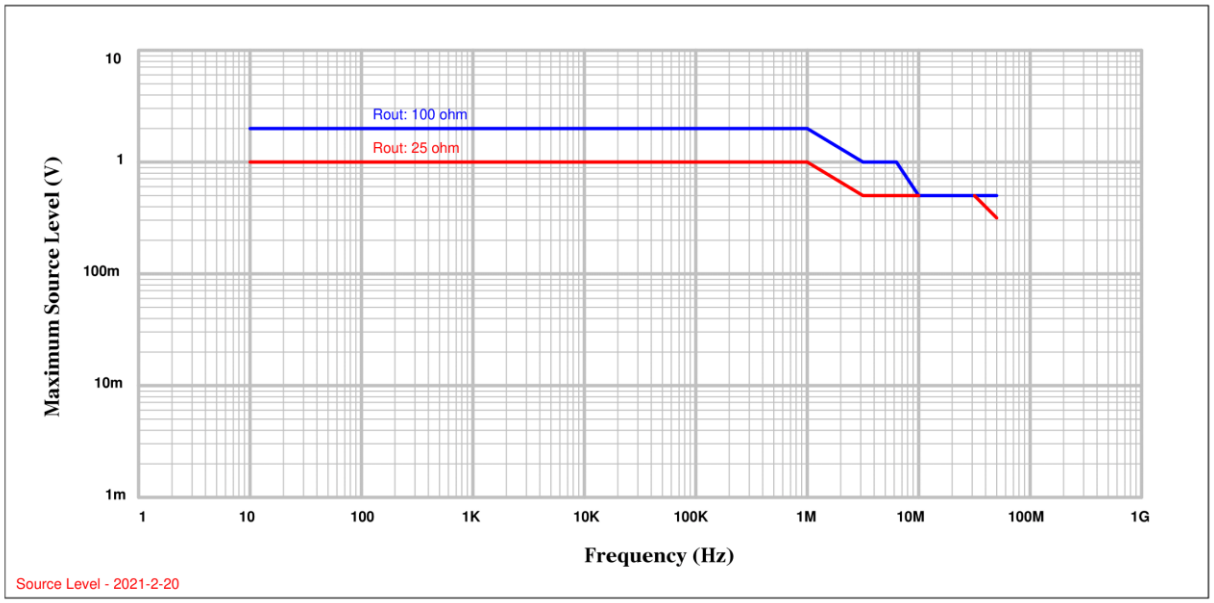



*Figure 4.3.2 Output Impedance vs. Frequency Relationship*

## 4-Terminal Kelvin Fixture Measurement:

When using a 4-terminal Kelvin fixture for resistance measurements, if shielding is not applied, the DC resistance (RDC) that can be measured up to a maximum 10 MΩ.

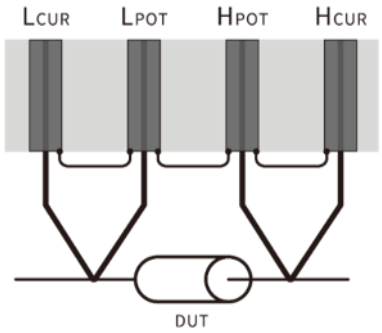



*Figure 4.3.3 4-Terminal Measurement*

## When measuring high resistance with a 4-terminal Kelvin fixture:

When performing high-resistance measurements using a 4-terminal Kelvin fixture, external noise interference can reduce measurement stability. Therefore, proper shielding is required to effectively eliminate external noise and ensure accurate results. It is recommended to follow the connection method shown in the diagram below. The DC resistance (RDC) that can be measured up to a maximum 100 MΩ.

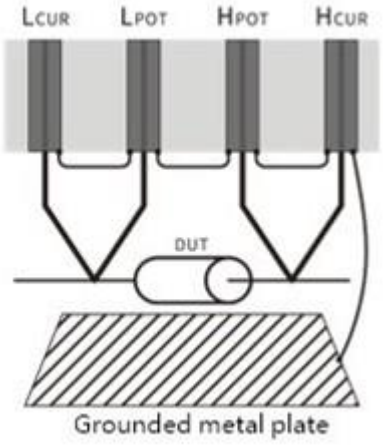
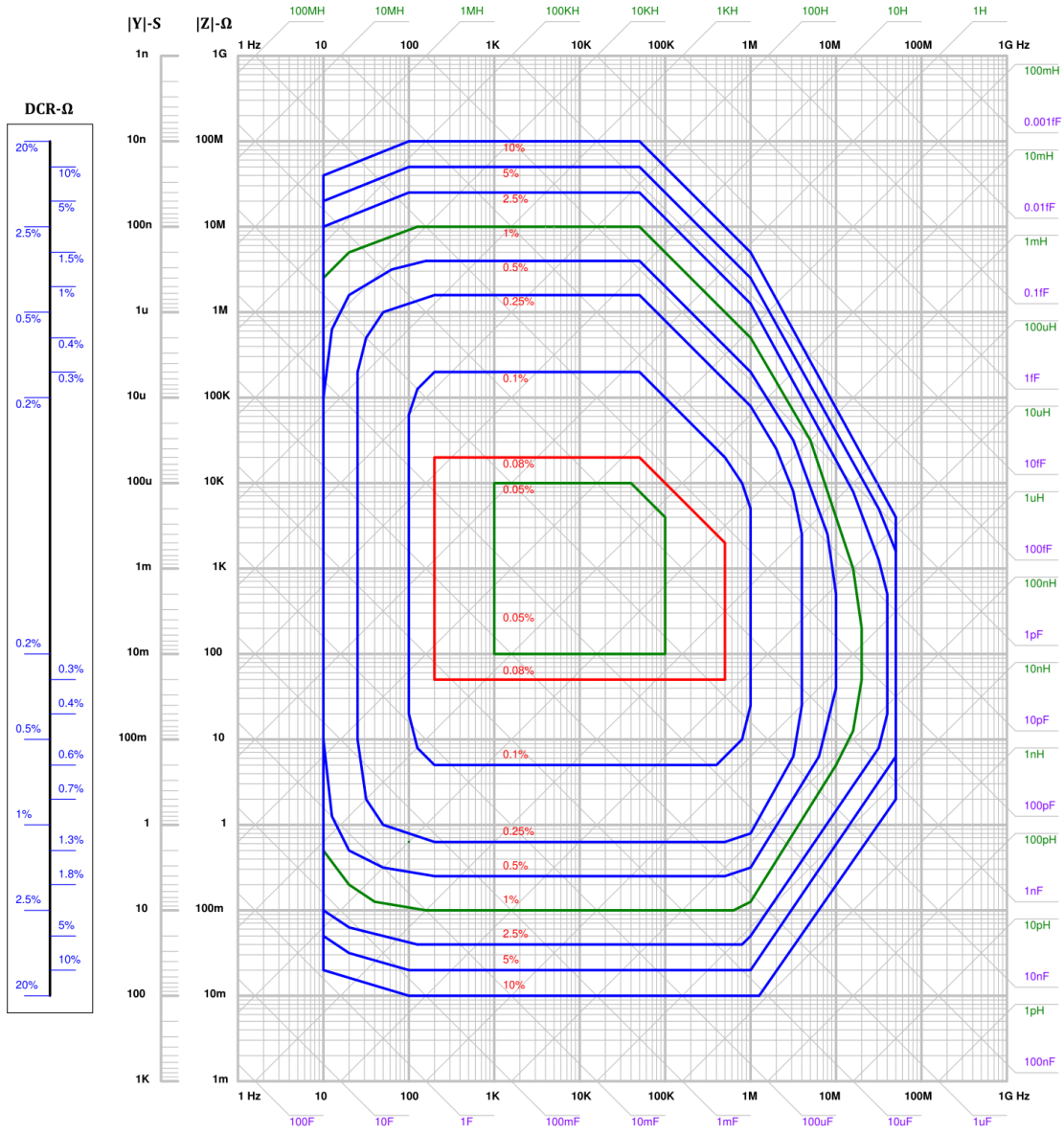



*Figure 4.3.4 4-Terminal Measurement for high impedance*

# 6.1 |Z| Accuracy Table




Impedance measurement accuracy[Ae]: 10% range at BNC port of front panel
(Signal 0.5V,Slow mode, Cable 0m), update:2021/2/20

# 6.2 Measurement Accuracy:

## Conditions of accuracy

All specifications apply at 23 ± 5 °C, and 60 minutes after the instrument has been turned on.

Impedance measurement accuracy at 4-terminal test fixture (Typical at > 10 MHz)

| | |
|---|---|
| \|Z\|, \|Y\| accuracy | ± Ae [%], Where Relative accuracy Ae = ( Ab + Az + Av + Ad+ Ac ) × Kt [%] |
| θ accuracy | ± Ae / 100 [rad] |
| L, C, X, B accuracy | |
| at Dx ≤ 0.1 | ± Ae [%] |
| at Dx > 0.1 | ± Ae × $\sqrt{1+Dx^2}$ [%] |
| R accuracy | |
| at Dx ≥ 10, (Qx ≤0.1) | ± Ae [%] |
| at 0.1 < Dx < 10, (10 > Qx>0.1) [%] | Rs: ± Ae × $\sqrt{1+Dx^2}$ / Dx [%], Rp: ± Ae × $\sqrt{1+Dx^2}$ / ( Dx ∓ Ae /100 × $\sqrt{1+Dx^2}$ ) |
| at Dx ≤ 0.1, (Qx ≥ 10) | Rs: ± Ae / Dx [%], Rp: ± Ae / ( Dx ∓ Ae /100 ) [%] |
| G accuracy | |
| at Dx > 0.1 | ± Ae × $\sqrt{1+Dx^2}$ / Dx [%] |
| at Dx ≤ 0.1 | ± Ae / Dx [%] |
| D accuracy | |
| at Dx ≤ 0.1 | ± Ae / 100 |
| at 0.1 < Dx ≤ 1 | ± Ae × (1+ Dx) / 100 |
| Q accuracy (at Qx × Da < 1) | |
| at Qx > 10, (Dx < 0.1) | ± ($Qx^2$ × Ae /100) / (1 ∓ Qx × Ae /100) |
| at Qx ≤ 10, (Dx ≥ 0.1) | ± ($Qx^2$ × Ae (1+ Dx) / 100) / (1 ∓ Qx × Ae (1+ Dx) / 100) |

NOTE: Da : measurement accuracy of D, Dx : measurement value of D, Qx : measurement value of Q

Ae = ( Ab + Az + Av + Ad + Ac ) × Kt [%]

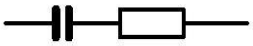
| | |
|---|---|
| Ab [%] | Frequency: F[Hz], Fm[MHz]<br>F < 200Hz: 0.08 + (200 / F - 1) × 0.0222<br>200Hz ≤ F ≤ 500kHz: 0.08<br>F > 500KHz: 0.08 + (Fm - 0.5) x 0.0472 |
| Az [%] | Impedance Range [Ω]<br>Zx ≤ 100Ω : (100 / Zx - 1) x 0.001 x Km<br>F < 100Hz: Km = 1 + (100/F - 1) x 0.112, 100Hz ≤ F ≤ 1MHz: Km = 1, F > 1MHz: Km = 1 + (Fm - 1) x 3<br>Zx > 100Ω : (Zx/100 - 1) x 0.00001 x Kn x Kp<br>F < 100Hz: Kn = 1 + (100/F - 1) x 0.112, 100Hz ≤ F ≤ 50KHz: Kn = 1, F > 50KHz: Kn = F/50000<br>F ≤ 1MHz: Kp = 1, F > 1MHz: Kp = 1 + (Fm-1) x 0.5 |
| Av [%] | Signal Level [V]<br>Vac > 0.5V: $(Vac - 0.5)^2$ x 0.45 x (1 + Fm/30)<br>Vac ≤ 0.5V: (0.5/Vac - 1) x 0.25 |
| Ad [%] | Measurement Speed<br>(5) SLOW2: 0<br>(4) SLOW : 0<br>(3) MED : 0.1<br>(2) FAST : 0.2<br>(1) MAX : 0.4 |
| Ac [%] | Cable length [m]<br>0 m: 0 Fm: 0 to 50 [MHz]<br>0.5 m: 0.02 + 0.01 × Fm Fm: 0 to 20 [MHz]<br>1 m: 0.02 + 0.02 × Fm Fm: 0 to 10 [MHz]<br>2 m: 0.02 + 0.03 × Fm Fm: 0 to 5 [MHz] |
| Kt | Temperature [°C]<br>8 - 18°C: 4<br>18 - 28°C: 1 + $(T - 23)^2$ x 0.0139<br>28 - 38°C: 4 |

# 6.3 Introduction to Basic Measurement Principles

When measuring AC resistance, capacitance, inductance, reactance, and admittance, series or parallel equivalent circuit models can be used.

**C**：Capacitance

Series：

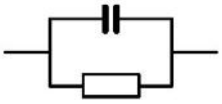


Series Circuit Formulas：

$$C_s = C_p\left(1+D^2\right)$$

D = dissipation factor

Parallel：



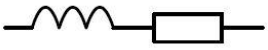
Parallel Circuit Formulas：

$$C_p = \frac{C_s}{(1+D^2)}$$

D = dissipation factor

**L**：Inductance

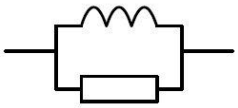
Series：



$$L_s = \frac{L_p}{\left(1+\frac{1}{Q^2}\right)}$$

Q = Quality Factor

Parallel：

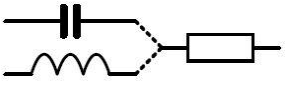


$$L_p = L_s\left(1+\frac{1}{Q^2}\right)$$

Q = Quality Factor

**X**：Reactance

Series：

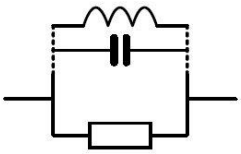


Series Circuit Formulas：

$$R_s = \left(\frac{R_p}{1+Q^2}\right)$$

Q = Quality Factor

Parallel：



Parallel Circuit Formulas：

$$R_p = R_s\left(1+Q^2\right)$$

Q = Quality Factor

## Resistance and Conductance

Resistance is a physical quantity that represents the opposition to the flow of electric charge within a material, commonly referred to as the resistance value. Its unit is the ohm (Ω).
Conductance is a measure of how well an object or circuit can transmit electric current from one point to another. Its unit is the siemens (S), which is the reciprocal of resistance, expressed as G=1/R.

- Resistance（R）

  Measurement Type：Series → Rs / Parallel → Rp / DC Resistance → Rdc

  Relevant Formulas：

  $$R = \frac{V}{I} = \frac{1}{G} = Z_s - jX = Z_s - j\omega L = Z_s + \frac{j}{\omega C}$$

  $$|Z_s| = \sqrt{(R^2 + X^2)}$$

  $$|Z_p| = \frac{RX}{\sqrt{(R^2 + X^2)}}$$

  $$R_s = |Z|\cos\theta$$

- Conductance（G）

  Measurement Type：Parallel → Gp

  (Conductance applies only to parallel equivalent circuit models)

  Relevant Formulas：

  $$G_p = \frac{I}{V} = \frac{1}{R} = Y_p - jB = Y_p - j\omega C = Y_p + \frac{j}{\omega L}$$

  $$|Y_s| = \frac{GB}{\sqrt{(G^2 + B^2)}}$$

  $$|Y_p| = \sqrt{(G^2 + B^2)}$$

  $$G_p = |Y|\cos\theta$$

## Capacitance

Capacitance refers to the amount of electric charge stored at a given electric potential difference. It is commonly represented by the letter C, and its SI unit is the farad (F).

Measurement Type：Series → Cs / Parallel → Cp

Relevant Formulas：

$$Z_s = R + jX = R + j\omega L = R - \frac{j}{\omega C}$$

$$Y_p = G + jB = G + j\omega C = G - \frac{j}{\omega L}$$

$$Q = \frac{\omega L_s}{R_s} = \frac{1}{\omega C_s R_s} \qquad (\text{series R , L , C values})$$

$$Q = \frac{R_p}{\omega L_p} = \omega C_p R_p \qquad (\text{parallel R , L , C values})$$

$$D = \frac{R_s}{\omega L_s} = \omega C_s R_s \qquad (\text{series R , L , C values})$$

$$D = \frac{G_p}{\omega C_p} = \omega L_p G_p \qquad (\text{parallel G , L , C values})$$

## Inductance

Inductance is one of the properties of electronic circuits or devices. It refers to the electromotive force (EMF) generated by electromagnetic induction that opposes changes in current when the current varies. The unit of inductance is the henry (H).

Measurement Type：Series → Ls / Parallel → Lp

Relevant Formulas：

$$Z_s = R + jX = R + j\omega L = R - \frac{j}{\omega C}$$

$$Y_p = G + jB = G + j\omega C = G - \frac{j}{\omega L}$$

$$Q = \frac{\omega L_s}{R_s} = \frac{1}{\omega C_s R_s} \qquad (\text{series R , L , C values})$$

$$Q = \frac{R_p}{\omega L_p} = \omega C_p R_p \qquad (\text{parallel R , L , C values})$$

$$D = \frac{R_s}{\omega L_s} = \omega C_s R_s \qquad (\text{series R , L , C values})$$

$$D = \frac{G_p}{\omega C_p} = \omega L_p G_p \qquad (\text{parallel G , L , C values})$$

## Reactance and Susceptance

Reactance, denoted by X in AC circuit analysis, is the imaginary part of complex impedance. It represents the opposition that inductors and capacitors present to the flow of current, similar to how resistance opposes current in DC circuits. In AC circuits (such as series RLC circuits), capacitors and inductors impede current flow, and this effect is called reactance. Its unit is the ohm (Ω).
Susceptance is defined in power electronics as the reciprocal of reactance and is the imaginary part of admittance. It can be classified into capacitive susceptance and inductive susceptance based on its nature. Susceptance is the reciprocal of reactance (B=1/X) and its unit is the siemens (S).

- Reactance （X）

  Measurement Type：Series → Xs

  (Reactance is only applicable to series equivalent circuit models)

  Relevant Formulas：

$$X = \frac{1}{B} = |Z| \sin\theta$$

$$|Z_s| = \sqrt{(R^2 + X^2)}$$

$$|Z_p| = \frac{RX}{\sqrt{(R^2 + X^2)}}$$

$$X_s = |Z| \sin\theta$$

- Susceptance（B）

  Measurement Type：Parallel → Bp

  (Susceptance is only applicable to parallel equivalent circuit models)

  Relevant Formulas：

$$B = \frac{1}{X} = |Y| \sin\theta$$

$$|Y_s| = \frac{GB}{\sqrt{(G^2 + B^2)}}$$

$$|Y_p| = \sqrt{(G^2 + B^2)}$$

$$B_p = |Y| \sin\theta$$

## Impedance and Admittance

Impedance is a general term that refers to the opposition to AC current flow caused by resistance, inductance, and capacitance in a circuit. Its unit is the ohm (Ω).
Admittance is a general term that includes both conductance and susceptance. In power electronics, admittance is defined as the reciprocal of impedance. Its unit is the siemens (S).

- Impedance（Z）

Relevant Formulas：

$$Z = \frac{E}{I} = \frac{1}{Y}$$

$$Z_s = R + jX = R + j\omega L = R - \frac{j}{\omega C}$$

$$|Z_s| = \sqrt{(R^2 + X^2)}$$

$$|Z_p| = \frac{RX}{\sqrt{(R^2 + X^2)}}$$

$$R_s = |Z|\cos\theta$$

$$X_s = |Z|\sin\theta$$

- Admittance（Y）

Relevant Formulas：

$$Y = \frac{I}{E} = \frac{1}{Z}$$

$$Y_p = G + jB = G + j\omega C = G - \frac{j}{\omega L}$$

$$|Y_s| = \frac{GB}{\sqrt{(G^2 + B^2)}}$$

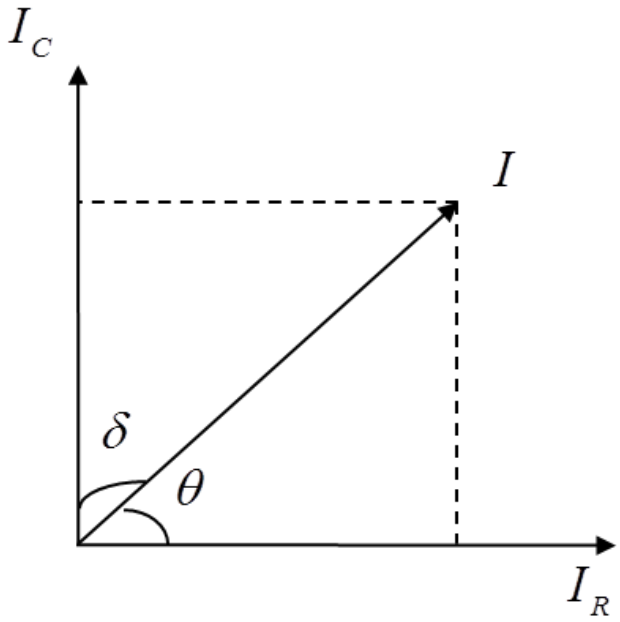
$$|Y_p| = \sqrt{(G^2 + B^2)}$$

$$G_p = |Y|\cos\theta$$

$$B_p = |Y|\sin\theta$$

## Quality factor and Dissipation factor

Quality Factor (Q) is used to measure the energy consumed relative to frequency. In general, the higher the quality factor of a circuit, the better its selectivity. The dissipation factor is the reciprocal of the quality factor. It refers to the angular loss of signal in a capacitor (or inductor) at a given operating frequency and constant temperature. The phase shift caused by the time delay between the applied voltage and the resulting current leads to loss current and energy dissipation. At this point, the current consists of two components: one is the charging current (Ic), which is 90 degrees out of phase with the voltage; the other is the loss current (IR), which is in phase with the voltage. The total current (I) is the sum of these two components. The angle δ between the total current and the charging current is called the loss angle. The tangent of this angle, tan δ, is known as the dissipation factor (D). The diagram below shows the actual phase relationship of a real capacitor.



- Quality Factor（Q）

  Relevant Formulas：

$$Q = \frac{R_p}{\omega L_p} = \omega C_p R_P \qquad (\text{series R , L , C values})$$

$$Q = \frac{\omega L_s}{R_s} = \frac{1}{\omega C_s R_s} \qquad (\text{series R , L , C values})$$

$$Q = \frac{1}{\tan(90-\theta)^\circ} = \frac{1}{D}$$

- Dissipation factor（D）

  Relevant Formulas：

$$D = \frac{R_s}{\omega L_s} = \omega C_s R_s$$

$$D = \frac{G_p}{\omega C_p} = \omega L_p G_p$$

$$D = \tan(90-\theta)^\circ = \frac{1}{Q}$$

## Angle(θ)

When measuring impedance (Z), admittance (Y), quality factor (Q), and dissipation factor (D), their phase angles are measured.

Relevant Formulas：

$$Z_s = R + jX = R + j\omega L = R - \frac{j}{\omega C}$$

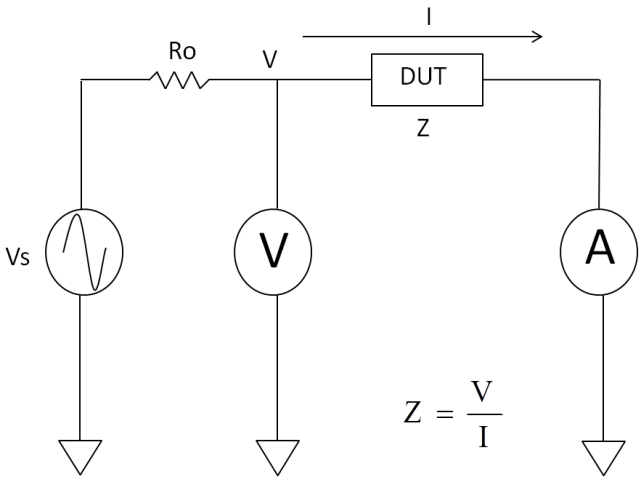
$$Y_p = G + jB = G + j\omega C = G - \frac{j}{\omega L}$$

$$Q = \frac{1}{\tan(90-\theta)^{\circ}} = \frac{1}{D} \qquad D = \tan(90-\theta)^{\circ} = \frac{1}{Q}$$

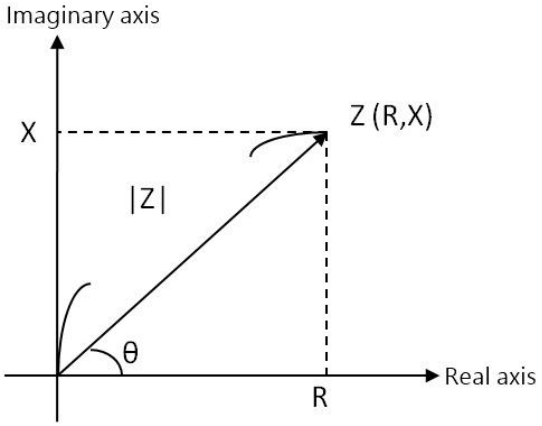
$$R_s = |Z|\cos\theta \qquad X_s = |Z|\sin\theta$$

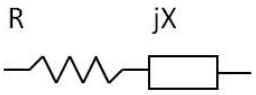
$$G_p = |Y|\cos\theta \qquad B_p = |Y|\sin\theta$$

## Impedance Measurement Theory




This is a simplified model for impedance measurement using the 6621. Vs is the test signal level, and Ro is the internal resistance of the signal source. When the test signal voltage V is applied and the current flowing through the DUT is I, the impedance Z of the DUT is expressed as Z=V/I. Impedance (Z) consists of a real part and an imaginary part. The diagram shows the vector representation of impedance.



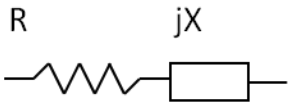

$$Z = R + jX = |Z| \angle \theta$$

$$\begin{cases} R = |Z|\cos\theta \\ X = |Z|\sin\theta \end{cases}$$

$$\begin{cases} |Z| = \sqrt{R^2 + X^2} \\ \theta = \tan^{-1}\left(\frac{X}{R}\right) \end{cases}$$

R : Resistance
X : Reactance
|Z| : Magnitude of Impedance
θ : Phase of Impedance

Admittance (Y) can also be used to represent impedance (Z), where Y = 1/Z

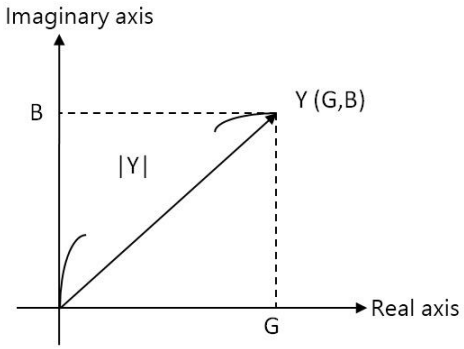


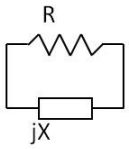

$$Y = \frac{1}{Z} = \frac{1}{R+jX} = \frac{R}{R^2+X^2} - j\frac{X}{R^2+X^2}$$

OR

$$Y = \frac{1}{Z} = \frac{1}{|Z|\angle\theta} = |Y|\angle(-\theta)$$

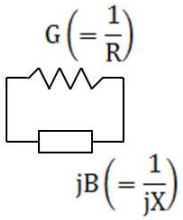
When dealing with parallel circuits, using the admittance (Y) equation simplifies the analysis.




$$Z = \frac{jRX}{R+jX} = \frac{RX^2}{R^2+X^2} + j\frac{R^2X}{R^2+X^2}$$

(Impedance makes the analysis more complex)



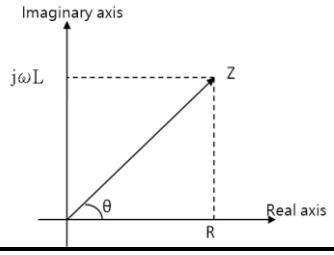
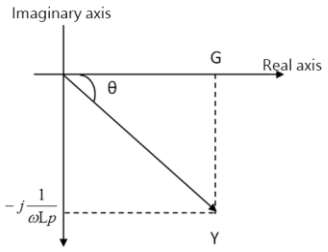
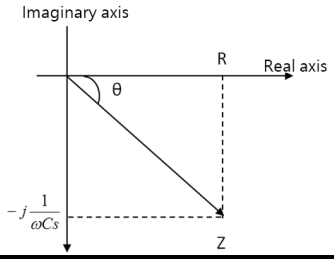
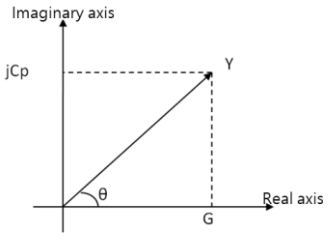

$$Y = G + jB$$

G : Conductance

B : Susceptance

|Y|: Magnitude of admittance

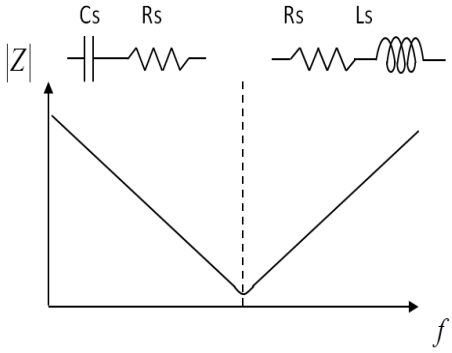
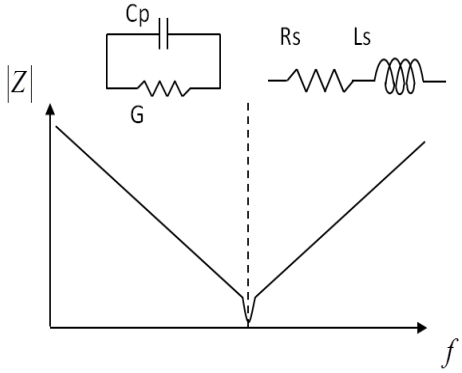
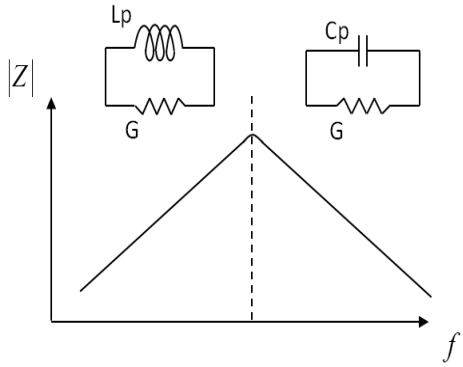
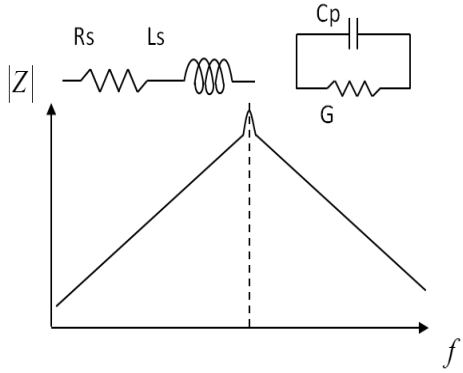
The 6621 measures the impedance of the DUT, where Z is a vector quantity. The result is represented using the following equivalent circuit models

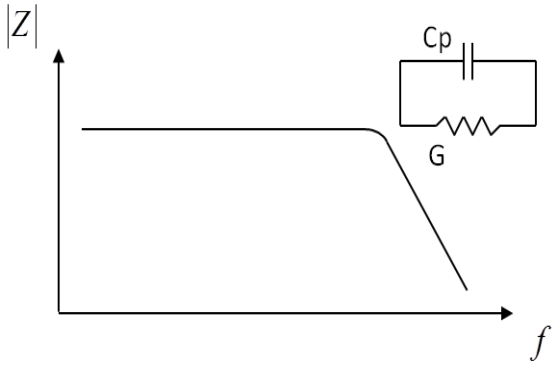
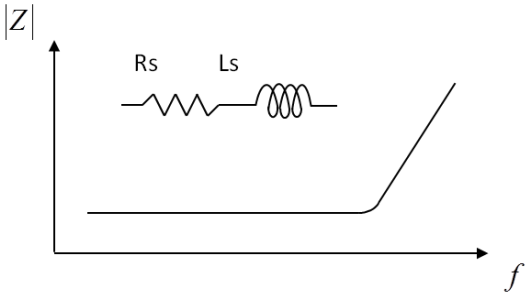
| | | |
|---|---|---|
| Rs Ls |  | $Z = Rs + jX = \lvert Z\rvert \angle \theta$<br>$X = \omega Ls$<br>$Z = Rs + j\omega Ls$<br>Where $\omega = 2\pi f$<br>( f : test frequency ) |
| G<br>Lp |  | $Z = Rs + jX = \lvert Z\rvert \angle \theta$<br>$X = \omega Ls$<br>$Z = Rs + j\omega Ls$<br>Where $\omega = 2\pi f$<br>( f : test frequency ) |
| Rs Cs |  | $Z = Rs + jX = \lvert Z\rvert \angle \theta$<br>$X = -j\frac{1}{\omega Cs}$<br>$Z = Rs - j\frac{1}{\omega Cs}$<br>Where $\omega = 2\pi f$<br>( f : test frequency ) |
| G<br>Cp |  | $Y = G + jB$<br>$B = \omega Cp$<br>$Y = G - j\omega Cp$<br>Where $\omega = 2\pi f$<br>( f : test frequency ) |
| $Q = \frac{1}{D} = \frac{1}{\tan\delta} = \frac{X_L}{R} = \frac{-X_C}{R} = \frac{-B_L}{G} = \frac{B_C}{G}$ | | |

Lp : Equivalent Parallel Inductance
Ls : Equivalent Series Inductance
Q : Quality factor
Cp : Equivalent Parallel Capacitance
Cs : Equivalent Series Capacitance
D : Dissipation factor

## Component Characteristic Curve

The diagram below shows the ideal characteristic curves of various passive components. Each component exhibits different behaviors at different operating frequencies. By selecting appropriate measurement parameters, values closer to those in actual applications can be obtained.

| DUT | Characteristic curves | Measurement Parameters |
|---|---|---|
| High C |  | Cs-Rs<br>Cs-D<br>Cs-Q<br>R-X<br>\|Z\|-∠θ |
| Low C |  | Cp-G<br>Cp-D<br>Cp-Q<br>G-B<br>Y-∠θ |
| High L |  | Lp-G<br>Lp-D<br>Lp-Q<br>G-B<br>Y-∠θ |
| Low L |  | Ls-Rs<br>Ls-D<br>Ls-Q<br>R-X<br>\|Z\|-∠θ |

| DUT | Characteristic curves | Measurement Parameters |
|---|---|---|
| High R |  | Cp-G<br>G-B<br>Y-∠θ |
| Low R |  | Ls-Rs<br>R-X<br>\|Z\|-∠θ |

## Selection of Series and Parallel Equivalent Parameters

This diagram shows the applicable range of series and parallel equivalent circuits. For low impedance values (Z) below 1 kΩ, the series equivalent circuit is appropriate. For high impedance values above 100 kΩ, the parallel equivalent circuit is recommended. When the impedance falls between 1k~100kΩ, the measured values from the series and parallel equivalent circuits are the same.

