2439D

Microwave Power Meter

User's Manual



Ceyear Technologies Co., Ltd.

The manual applies to the 2439D microwave power meter paired with the following models of power probes, which is designed based on the firmware version of 1.0 and higher.

- 87233 series USB CW power probe, frequency range 8 kHz to 67 GHz, power range -70 dBm to +20 dBm.
- 87235 series USB average power probe, frequency range 8 kHz~50 GHz, power range -70 dBm~+44 dBm.
- 87236 series USB peak/average power probe, frequency range 50 MHz to 67 GHz, power range -45 dBm to +20 dBm.
- 87237 series USB thermocouple power probe, frequency range DC~110 GHz, power range -35 dBm~+20 dBm.

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Foreword

Thank you for choosing and using 2439D microwave power meter developed and produced by Ceyear Technologies Co., Ltd.! Adopting advanced, sophisticated and cutting-edge technologies, the product has a high cost performance in the same kind of products.

We will take the responsibility to maximally meet your needs and provide you with high-quality measuring instruments and first-class after-sales service. We aim to provide "high quality and considerate service", and operate on the principle of making customers satisfactory with our products and services.

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Version

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Ceyear Technologies Co., Ltd.

Manual authorization

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Product warranty

The warranty period of this product is 18 months from the date of shipment. The instrument manufacturer will repair or replace the damaged components according to the user's requirements and actual conditions within the warranty period. For specific maintenance issues, refer to the contract.

Product quality certificate

Product is guaranteed to meet the metrics in this manual from the date of shipment. The calibration and measurement are completed by measuring bodies with national qualification, with relevant data to be provided for reference by users.

Quality/environmental management

Product complies with the quality and environmental management systems during R&D, manufacturing and testing. Ceyear Technologies Co., Ltd. is qualified and has passed ISO 9001 and ISO 14001 management systems.

Safety precautions

⚠ Warning

The symbol "Warning" indicates a hazard. It reminds the user to pay

attention to a certain operation process, operating instructions or the like. In case of any failure of observing the rule or maloperation, personal injury can occur. Further operation cannot be proceeded until the warning conditions are fully understood and met.

Notice

Notice mark, indicating some important information which will not cause danger. It reminds the user to pay attention to a certain operation process, operating instructions or the like. Failure to observe the rules or operate correctly may cause damage to the instrument or loss of important data. Proceed to the next step only after fully understanding and meeting the caution conditions indicated.

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1. Manual navigation

This chapter introduces the user's manual functions, chapter structure and main contents of the 2439D microwave power meter, as well as the instrument-related documents provided to users.

- About the manual.....1
- Related documents.....2

1.1. About this manual

This manual describes the basic functions and operating procedures of the 2439D microwave power meter. It describes such contents as product characteristics, basic operating instructions, configuration guide, menu description, remote control, maintenance, specifications and test methods, etc. of the instrument to help users get familiar with and master the operating instructions and key points of the instrument as soon as possible. To facilitate your skillful use of such instrument, please read carefully and follow this manual in advance for correct operation.

This manual contains the following chapters:

- Overview

This part introduces in general the main performance characteristics, typical application examples and safety precautions of operation for the 2439D microwave power meter. The purpose is to enable users to have a preliminary understanding of the main performance characteristics of the instrument and to guide users to operate the instrument safely.

- Operation guide

This guide introduces the operating instructions of various configuration functions of the instrument in detail, including: configuring the instrument, starting the configuration process and obtaining the configuration results, etc. For users who are not familiar with the 2439D microwave power meter, it introduces and enumerates each function systematically and in detail so that users can understand and master some basic usage of the power meter, such as setting trigger, horizontal scale, and frequency, etc. It introduces relatively complicated test processes and advanced operation skills for users who have basic knowledge about using the 2439D microwave power meter but are not familiar with some special usage, and guides them to implement the measurement processes. Examples include measurements of pulse modulated signals and the use of gates.

- Menu

This part introduces the menu structure and menu items according to the functions

to facilitate the users to query for reference.

- Remote control

The methods for remote control of the instrument are summarized to make users get familiar with remote control quickly. It is divided into four parts: programmed control fundamentals, introducing concepts related to programmed control, software configuration, programmed control ports, SCPI, etc; port configuration methods, introducing the connection methods and software configuration methods for programmed control ports of the 2439D microwave power meter; basic programming methods for VISA interfaces, giving basic programming examples in the form of text description and sample codes to enable users to quickly master the programming methods; I/O function library, introducing the basic concepts of instrument drivers and the basic installation and configuration instructions of IVI-COM/IVI-C drivers.

- Troubleshooting and after-sales services

This part includes the introduction of the operating principles of the instrument, troubleshooting, error message description and repair methods.

- Specifications

It introduces the product characteristics and main specifications of the 2439D microwave power meter.

1.2 Related documents

The product documentation for the 2439D microwave power meter includes:

- User's manual
- Programmed control manual

User's manual

This manual describes the functions and operating instructions of the instrument in detail, including configuration, measurement, programmed control and maintenance, etc. It is used to guide users to fully understand the functional characteristics of the product and master common test methods of the instrument. Main chapters include:

- Manual navigation
- Overview
- Operation guide
- Menu
- Remote control
- Troubleshooting and after-sales services
- Specifications

Programmed control manual

This manual introduces remote programming fundamentals, SCPI fundamentals, SCPI, programming examples and I/O driver function library in detail. The purpose is to guide the user to quickly and comprehensively master the programmed control

commands and methods of the instrument. Main chapters include:

- Remote control
- Programmed control commands
- Programming examples
- Error description
- Annex

2 Overview

This chapter introduces the main performance characteristics, main applications and main specifications of the 2439D microwave power meter. It also gives introductions on correct operation of the instrument and precautions such as electrical safety.

- Product overview.....4
- Safe operation guide.....4

2.1 Product overview

The 2439D microwave power meter has a frequency range of DC ~ 110 GHz and a power dynamic range of -70 dBm ~ +26 dBm. It is small, light, portable and hot-swappable. It can be widely used in aviation, aerospace, radar, communication, electronic countermeasures, navigation and other fields to test microwave signal average power, peak power and other parameters. The primary performance characteristics of the 2439D microwave power meter are as follows:

1) Accurate average power measurement: The 2439D microwave power meter is paired with different power probes, therefore enabling an accurate average power measurements of up to 0.2 dB. On the strength of a continuous sampling rate of 80 MS/s, high measurement speed and repeatability, a frequency range up to 110 GHz and power measurement capability down to -70 dBm, this power meter can be used for most test applications.

2) Internal zeroing: The 2439D microwave power meter is paired with different power probes and can be internally zeroed by ON/OFF control. As a result, there is no need to disconnect the power meter from the DUT during use, speeding up measurement, reducing connector wear, and lowering measurement uncertainty.

3) External trigger function: External trigger enables precise trigger of small signals near the noise floor. The 2439D microwave power meter features a built-in trigger input. The external trigger signal from the DUT can be connected to the 2439D microwave power meter via a standard BNC cable, achieving unified trigger for all connected power probes. Alternatively, independent trigger for individual power probes can be achieved by separately connecting the DUT's external trigger to each power probe using a standard BNC-to-MMCX cable.

2.2 Safe operation guide

Please read carefully and strictly observe the following precautions!

We will spare no effort to ensure that all production processes meet the latest safety standards and provide users with the highest safety guarantee. The design and test of our products and the auxiliary equipment used meet relevant safety standards, and a quality assurance system has been established to monitor the product quality and ensure the products to always comply with such standards. In order to keep the equipment in good condition and ensure operation safety, please observe the precautions mentioned in this manual. If you have any questions, please feel free to consult us.

In addition, the correct use of this product is also your responsibility. Please read carefully and observe the safety instructions before starting to use this instrument. This product is suitable for use in industrial and laboratory environments or field measurement. Always use the product correctly according to its restrictions to avoid personal injury or property damage. You will be responsible for problems caused by improper use of the product or noncompliance with the requirements, and we will not be held responsible. **Therefore, please always observe the safety instructions to prevent personal injury or property damage caused by dangerous situations.** Please keep the basic safety instructions and the product documents properly and deliver them to end users.

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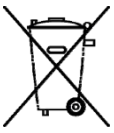
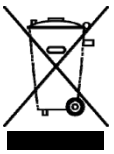
2.2.1 Safety marks

2.2.1.1 Product-related marks

Safety marks on the products are described as follows (Table 2.1):

Table 2.1 Products safety marks

Symbol	Meaning	Symbol	Meaning
	Notice, reminding users of information to be paid special attention to. It reminds users of the		Power ON/OFF

Symbol	Meaning	Symbol	Meaning
	operation information or instructions to be paid attention to.		
	Take care when handling heavy equipment.		Standby indication
	Danger! Hazard of electric shock.		DC
	Warning! Hot surface.		AC
	Protective conductive end		DC/AC
	Ground		Reinforced insulation protection of the instrument
	Ground terminal		EU mark for batteries and accumulators. Please refer to item 1 of "2.2.8 Waste disposal/environmental protection" in this section for specific instructions.
	Notice, please handle classical sensitive devices with care.		EU mark for separate collection of electronic devices. Please refer to item 2 of "2.2.8 Waste disposal/environmental protection" in this section for specific instructions.
	Warning! Radiation. Please refer to item 7 of "2.2.4 Operation precautions" in this section for specific instructions.		

2.2.1.2 Manual-related marks

In order to remind users to operate the instrument safely and pay attention to relevant information, the following safety warning marks are used in the product manual, which are explained as follows:



Danger mark, personal injury or equipment damage may be caused if not avoided.



Warning mark, personal injury or equipment damage may be caused if not avoided.



Caution mark, slight or medium personal injury or equipment damage may be caused if not avoided.



Notice mark, indicating some important information which will not cause danger.



Tips on information about the instrument and its operation.

2.2.2 Operating state and locations

Precautions before operating the instrument:

1) Unless otherwise specified, the 2439D microwave power meter shall be operated in a stable, indoor environment. The maximum altitude at which instruments are operated shall not exceed 4600 meters. The range of actual supply voltage is ±10% of the marked voltage, and the range of supply frequency is±5% of the marked frequency.

2) Unless otherwise specially stated, the instrument has not received any waterproof treatment, do not place the instrument on surfaces with water, vehicles, cabinets, tables and other objects that are not fixed and do not meet the load conditions. Please place the instrument securely and fix it on the surface of a solid object (e.g., an ESD workbench).

3) Do not place the instrument in an environment where mist is easily formed, for example, moving the instrument in a environment where cold and heat are in

alternation, where water droplets formed on the instrument may cause electric shock and other hazards.

4) Do not place the instrument on the surface of a heat-dissipating object (e.g., a radiator). The operation environment temperature shall not exceed the value specified in the description of relevant metrics of the product. Overheating of the product will lead to electric shock, fire and other risks.

5) Do not insert any object into the instrument through the opening on the instrument casing, or cover up any notch or opening on the product, which is used for internal ventilation and preventing the instrument from getting overheat.

2.2.3 Electrical safety

Precautions for electrical safety of the instrument:

1) Before the instrument is powered on, the actual supply voltage shall match the supply voltage marked on the instrument. If the power supply voltage changes, the fuse model of the instrument shall be changed synchronously.

2) According to the power requirements of the real panel of the instrument, a three-core power cord shall be adopted while ensuring reliable grounding of the ground wire during operation. Either floating ground or poor grounding may cause damage to the instrument and even cause injury to operators.

3) Do not damage the power cord, otherwise electric leakage will be caused, resulting in damage to the instrument and even injury of the operators. If an external power cord or extension socket is used, it shall be checked before use to ensure electrical safety.

4) If the power supply socket does not provide an ON/OFF switch,to cut the power of the instrument, users can just directly unplug the instrument, and therefore, it shall be ensured that the power plug can be inserted or drawn conveniently.

5) Do not use damaged power cords. Before connecting the instrument to the power cord, check the integrity and safety of the power cord, and properly place the power cord to avoid the impact due to human factors, such as, too long power cord that may trip the operator.

6) The TN/TT power supply network is required for the instrument, and the maximum rated current of its fuse is 16 A (if a fuse with higher rated current is used, it shall be discussed and determined with the manufacturer).

7) Keep the socket clean and tidy, and ensure the plug and the socket in good contact and reliable engagement.

8) Neither the socket nor the power cord can be overloaded, otherwise fire or electric shock will be caused.

9) If the instrument is tested in a circuit with the voltage Vrms>30 V, it shall be protected properly to avoid damage (e.g., by using appropriate test instruments, adding fuses, limiting current value, electrical isolation and insulation, etc.).

10) The instrument shall comply with IEC60950-1/EN60950-1 or IEC61010-1/EN 61010-1 standards to connect with PC or IPC.

11) Unless otherwise allowed, do not open the housing of the instrument, which may expose internal circuits and devices of the instrument and cause unnecessary damage.

12) If the instrument needs to be fixed at the testing site, a qualified electrician is required to install the protective ground wire between the testing site and the instrument first.

13) Take appropriate overload protections to prevent overload voltage (caused by lightning, for instance) from damaging the instrument or causing personal injury.

14) When opening the housing of the instrument, do not place objects not belonging to the interior of the instrument, otherwise, short circuit, damage to the instrument and even personal injury may be caused.

15) Unless otherwise stated, the instrument has not received any waterproof treatment, so keep the instrument from contacting with liquid to prevent damage to the instrument or even personal injury.

16) Do not place the instrument in an environment where fog is easily formed, for example, moving the instrument in a environment where cold and heat are in alternation, where water droplets formed on the instrument may cause electric shock and other hazards.

2.2.4 Operation precautions

1) Instrument operators need to have certain professional and technical knowledge, good psychological quality, and certain emergency response capabilities.

2) Before moving or transporting the instrument, please refer to the relevant instructions in "2.2.7 Transportation" of this section.

3) The inevitable use of substances (e.g., nickel) in the production process of the instrument may cause allergy to personnel. If an operator of the instrument has

allergic symptoms (e.g., rash, frequent sneezing, ophthalmia or dyspnea) during the operations, please seek medical care in time to find out the reason and solve the symptoms.

4) Please refer to the relevant instructions in "2.2.8 Waste disposal/environmental protection" of this section before disassembling this instrument for disposal.

5) RF instruments will generate high electromagnetic radiation, during which period, pregnant women and operators with cardiac pacemakers need special protection. If the radiation level is high, corresponding measures may be taken to remove the radiation sources to prevent personal injury.

6) In case of fire, the damaged instrument will release toxic substances. Therefore, the operators shall wear appropriate protective equipment (e.g., Protective masks and exposure suits) for safety.

7) Laser products shall have different warning signs according to the laser category, because the radiation characteristics of laser and such equipment have high-intensity electromagnetic power characteristics, which will cause harm to human body. If the product is integrated with other laser products (e.g., CD/DVD drive), it will not provide other functions except the settings and functions described in the product manual in order to prevent the injury of the laser beam to the human body.

8) Electromagnetic compatibility level (in accordance withEN 55011/CISPR 11, EN 55022/CISPR 22 and EN 55032/CISPR 32 standards)

— Class A equipment:

The equipment can be used except in residential areas and low-voltage power supply environment.

Note: Class A equipment is suitable for industrial operation environment, because it produces wireless communication disturbance in residential areas. Therefore, operators need to take relevant measures to reduce the impact of such disturbance.

— Class B equipment:

9) Equipment suitable for residential areas and low-voltage power supply environment.

2.2.5 Maintenance

1) Only authorized and specially trained operators are allowed to open the casing of the instrument. Before such operations, it is required to disconnect the power cord to prevent damage to the instrument or even personal injury.

2) The repair, replacement and maintenance of the instrument shall be performed by dedicated electronic engineers of the manufacturer, and the parts subject to replacement and maintenance shall receive safety tests to ensure safe use of the product in the future.

2.2.6 Batteries and power modules

Before using batteries and power modules, carefully read the relevant information to avoid explosion, fire and even personal injury. In some cases, disused alkaline batteries (e.g., lithium batteries) shall be disposed of in accordance with EN 62133. Precautions for use of batteries include the following:

1) Do not damage the battery.

2) Do not expose batteries and power modules to heat sources such as open fire; avoid direct sunlight and keep them clean and dry; clean the connection port of the battery or power module with a clean and dry soft cotton cloth.

3) Do not short circuit the battery or power module. Do not store multiple batteries or power modules in cartons or drawers because the batteries are likely to cause short circuit due to being in contact with each other or other conductors; Do not remove the original outer packaging of the battery and power module before use.

4) Batteries and power modules must not be subjected to mechanical impact.

5) If the battery fluid leaks, please do not touch the skin and eyes, otherwise wash it with a large amount of water and get medical treatment in time.

6) Please use the manufacturer's original batteries and power modules. Any incorrect replacement and charging of alkaline batteries (such as lithium batteries) is likely to cause an explosion.

7) Discarded batteries and power modules shall be recycled and disposed of separately from other wastes. Due to the toxic substances inside the battery, they shall be properly discarded or recycled according to local regulations.

2.2.7 Transportation

1) If the instrument is heavy, please handle it with care. If necessary, use tools (a crane, for instance) to move the instrument so as to prevent damaging the body.

2) The handle of the instrument is suitable for personal handling of the instrument and cannot be fixed on the transportation equipment when during the transportation of the instrument. To prevent property loss and personal injury,

please follow the manufacturer's safety regulations on the transportation of the instrument.

3) When operating the instrument on the vehicle, the driver shall drive carefully to ensure transportation safety, and the manufacturer is not responsible for any emergencies during the transportation. Therefore, please do not use this instrument during the transportation, and reinforcement and preventive measures shall be taken to ensure the transportation safety of the product.

2.2.8 Waste disposal/environmental protection

1) Do not dispose of devices marked with batteries or accumulators together with unclassified waste; Instead, such devices shall be collected separately and disposed of in a suitable collection location or through the customer service center of the manufacturer.

2) Do not dispose of waste electronic devices together with unclassified waste; Instead, such devices shall be collected separately. The manufacturer has the right and responsibility to help end users dispose of waste products. If necessary, please contact the customer service center of the manufacturer for corresponding disposal so as not to damage the environment.

3) During mechanical or thermal processing of the product or its internal components, toxic substances (dust of heavy metals, such as lead, beryllium, and nickel, etc.) may be released. Therefore, specially trained technicians with relevant experience are required to disassemble the product to avoid personal injury.

4) During the reprocessing, please refer to the safety operation rules recommended by the manufacturer to dispose of toxic substances or fuel released from the product with specific methods to avoid causing personal injury.

3 Operation guide

This chapter introduces the pre-operation precautions, front/rear panel description, basic measurement methods, and data file management of the 2439D microwave power meter. so that users can have a preliminary understanding of the instrument itself and its measurement processes. This section contains some contents consistent with the relevant sections in the quick start manual.

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- Description of front and real panels.....26
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3.1 Getting prepared

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3.1.1 Preparations before operation

This chapter outlines precautions for initial setting and use of the 2439D microwave power meter.

⚠Warning

Avoid damaging the instrument

Pay attention to the follow to avoid electric shock, fire and personal injury:

- Do not open the cabinet arbitrarily.
- Do not try to disassemble or refit any part of the instrument not mentioned in this manual. Otherwise, such consequences as reduced electromagnetic shielding property and internal component damage can occur, affecting product reliability. In this case, we will not provide any free maintenance any more even if the product is still in the warranty period.
- Read carefully relevant contents in "2.2 Safety operation instruction" of the user's manual as well as the following precautions on safe operation, and pay attention to the requirement on specific operation environment involved in the data pages.

Notice

Electrostatic protection

Take electrostatic protection measures at workplaces to avoid any damage caused by the instrument. For details, refer to relevant contents in "2.2 Safety operation instruction" of the user's manual.

Notice

Precautions for instrument operations:

Improper operating or measuring position can damage the instrument or the one connected to it. Precautions before powering on the instrument:

- Keep the instrument dry;
- Keep the instrument level, and arrange it properly;
- Make sure the environment temperature meets with the requirement noted in the data page;
- Make sure the port input signal amplitude is within the range specified;
- Make sure the signal output port is connected properly, without any overload.

Tips

Effect of electromagnetic interference (EMI):

Since EMI can affect the measurement result, pay attention to the following:

- Select proper shield cables. For example, to use the double-shielded RF/network connection cable;
- Please close any cable connection port that is enabled but temporarily unused or connect a matching load to the connection port in time;
- Please refer to the EMC level labels in the Data Page.

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3.1.1.1 Unpacking

1) Visual examination

Step 1. Check whether the outer packing box and the shockproof packing of the instrument are damaged. If there is any damage, keep the outer packing box for standby and proceed with the following examination steps.

Step 2. Unpack and check the 2439D microwave power meter articles provided in the packing box for any damage;

Step 3. Check carefully the articles mentioned above as per Table 3.1 for any problem;

Step 4. In case of any outer package damage, or damage or problem to the instrument or articles provided in the package, never power the instrument on or start it up! Please contact our service consultation center with the service hotline provided on the cover, and we will repair or change it as soon as possible accordingly.

Notice

Handling: since the instrument and packing box are heavy, it shall be handled by two persons at the same time, and placed with care.

2) Model confirmation

Table 3.1 List of articles provided together with the 2439D microwave power meter

Name	Quantity	Function
Instrument:		
✧ 2439D Microwave Power Meter	1	—
Standard:		
✧ User's manual	1	—
✧ Programming manual	1	—
✧ Power cord	1	Standard 3-core power cord
✧ Product certificate	1	—
Option:		
✧ 2439D-H05	—	Safety instrument transport case
✧ 2439D-H06	—	Rack mount kit
✧ 2439D-H12	—	English options
✧ 2439D-H13	—	Battery option

✧ 2439D-JL ✧ 2439D-EWT1	— Measurement service — An extended warranty of one year beyond the standard warranty period is provided.

3.1.1.2 Environmental requirements

The operation sites of the 2439D microwave power meter shall meet the following environmental requirements:

1) Operation environment

The operation environment shall meet the following requirements:

Table 3.2 Operating environment requirements of the 2439D microwave power meter

Operation temperature range	-10℃~50℃
Saving temperature range	-40℃~70℃

Notice

The above environmental requirements are only applicable to the operation environment factors of the instrument, and are not with the scope of specifications.

2) Heat dissipation requirements

In order to ensure that the operation environment temperature of the instrument is within the temperature range required by the operation environment, the following heat dissipation space requirements of the instrument shall be met:

Table 3.3 Heat dissipation requirements for the 2439D microwave power meter

Instrument part	Heat dissipation distance
Back	≥180 mm
Left and right sides	≥60 mm

3) Electrostatic protection

Static electricity is extremely destructive to electronic components and equipment.

Usually we take two anti-static measures: conductive table mat and wrist strap; Conductive floor mat and ankle strap. Using the above two anti-static measurements at the same time can provide good antistatic protection. If using one of them, only the former can provide antistatic protection. 1MΩ earth isolation resistor must be provided for the antistatic components at least for ensuring user safety.

- Correctly take the following antistatic measures to techniques to reduce electrostatic damages:
- Ensure all instruments are grounded properly, so as to avoid any static electricity;
- Let the internal/external conductor of the cable contact the ground shortly before connecting the coaxial cable with the instrument;
- Operators must wear anti-static wrist straps or take other antistatic measures before touching the joints, core or conducting any assembly.

Warning

Voltage range

The above-mentioned anti-static measures cannot be applied when the voltage exceeds 500 V.

3.1.1.3 Power-ON/OFF

1) Precautions before turning on the power

Pay attention to the following when turning on the power of the instrument:

a) Confirming power supply parameters

The internal power module of the 2439D microwave power meter is a 110 V/220 V adaptive AC power supply module. The 110 V/220 V adaptive AC power supply module can be powered by 110 V AC or 220 V AC power supply. In this case, the internal AC power supply module works in the adaptive operating mode, which automatically switches the operating state according to the voltage of the external AC power supply.

Table 3.4 shows the external power supply requirement for normal operation of the 2439D microwave power meter.

Table 3.4 Working power parameter requirements of the 2439D microwave power meter

Power supply parameter	Applications

Voltage, frequency	220 V±10%, 50 ~ 60 Hz		110 V±10%, 50 ~ 60 Hz	
Rated output current	>1 A		>1 A	
Power consumption (startup)	Basic configurations	All configurations	Basic configurations	All configurations
	< 25 W	< 70 W	< 25 W	< 70 W
Power consumption (standby)	< 10 W		< 10 W	

Tips

Preventing mutual interference of power supplies

To prevent mutual interference among multiple devices through power supplies, especially spike pulse interference caused by high-power devices which may cause damage to hardware, it is recommended to use a 220 V or 110 V AC stabilized power supply to power the 2439D microwave power meter.

b) Confirming and connecting the power cord

The 2439D microwave power meter adopts three-core power cord interfaces, which conform to national safety standards. Before powering on the 2439D microwave power meter, it is necessary to confirm **reliable grounding of the protective ground wire** in the power cord of the power meter. Either floating ground or poor grounding may cause the power meter and even cause injury to operators. Using a power cord without protective grounding is strictly prohibited. When the instrument is connected to a suitable power socket, the power cord connects the housing of the 2439D microwave power meter to the ground. The rated voltage value of the power cord shall be greater than or equal to 250 V, and the rated current shall be greater than or equal to 6 A.

When the power cord is connected to the 2439D microwave power meter:

Step 1. Confirm that the operation power cord is not damaged;

Step 2. Connect the power plug of the rear panel of the 2439D microwave power meter to a well-grounded three-core power socket using a power cord.

Warning

Grounding

Poor or wrong grounding may cause damage of the 2439D microwave power meter or even personal injury. Before turning on the power of the spectrum analyzer, make sure that the ground wire is in good contact with the ground wire of the power supply.

Please use a power socket with grounding protection. Do not use any external cable, power cord or autotransformer without any protective grounding as the protective grounding line. If an auto-transformer is necessary, it is required to connect the common terminal to the protective grounding of the power connector.

2) Initial power-on

Power-on/off procedures and precautions for the 2439D microwave power meter are as follows:

a) Connecting the power supply

Please confirm the power supply parameters and the power cord before power-on for the first time. For details, please refer to the section "3.1.1.3 Precautions before Turning on the Power" in the user's manual.

Step 1. Connect the power cord: Connect one end of the power cord supplied with the 2439D microwave power meter in the packing box or a compliant three-core power cord to the power socket on the rear panel of the 2439D microwave power meter (as shown in Figure 3.1). Connect the other end of the power cord to a compliant AC power supply. Observe the power switch on the front panel (as shown in Figure 3.2) until the standby indicator light turns yellow.

Step 2. Turn on the power switch on the front panel: If everything is normal, the instrument can be turned on, as shown in Figure 3.2. Then, the indicator light above the power switch on the front panel will turn green.



Figure 3.1 Power socket of the 2439D microwave power meter



Figure 3.2 Power switch on front panel of the 2439D microwave power meter

b) Turning on/off the power

i. Start up

Step 1. Turn on the power switch in the lower right corner of the front panel. At this moment, the color of the power indicator light on the power switch changes from yellow to green.

Step 2. The user interface on the front panel of the 2439D microwave power meter will sequentially display information related to the startup process.

Step 3. The system automatically runs the 2439D microwave power meter's initialization program and displays its main operating interface.

The 2439D microwave power meter enters operable state.

ii. Shutdown

Turn off the power switch in the lower right corner of the front panel to power off the 2439D microwave power meter. At this point, the power indicator light color changes from green to yellow;

The 2439D microwave power meter enters the shutdown state.

c) Power-cut

In case of emergency, in order to avoid personal injury, the 2439D microwave power meter needs to be powered off immediately. In this case, just remove the power cord (from the AC socket or the power socket on the rear panel of the 2439D microwave power meter). Therefore, sufficient operating space shall be reserved when operating the 2439D microwave power meter to facilitate direct shutdown when necessary.

3.1.1.4 Proper operation of connectors

During various tests conducted on the 2439D microwave power meter, connectors are frequently used. The service life of the connectors is always limited. Due to the inevitable wear and tear during normal use, the performance metrics of the connectors will decrease or even be unable to meet the measurement requirements. Therefore, correct maintenance and measurement connection of the connectors can not only

ensure accurate and repeatable measurement results, but also prolong the service life of the connectors and reduce the measurement costs. In actual use, the following aspects shall be paid attention to:

1) Connector check

When conducting connector inspection, anti-static wrist band shall be worn. It is recommended to use a magnifier to check the following items:

1) Whether the electroplated surface is worn or not and whether there are deep scratches;
2) Whether the thread is deformed;
3) Whether there are metal particles on the threads and the joint plane of the connector;
4) Whether the inner conductor is bent or broken;
5) Whether the screw sleeve of the connector rotates improperly.

⚠ Caution

Connector inspection prevents damage to the 2439D microwave power meter port

Any damaged connector may damage the good connector connected to it even when measuring the connection for the first time. In order to protect each interface of the 2439D microwave power meter, the connector must be checked before connector operation.

2) Connection method

Before the connection, the connectors shall be inspected and cleaned to ensure cleanness and intactness. Anti-static wrist straps shall be worn before connection. The correct connection method and steps are as follows:

Step 1. As shown in Figure 3.3, align the axes of the two interconnecting devices to ensure that the pin of the male connector slides concentrically into the socket of the female connector.



Figure 3.3 Axes of interconnected devices in a straight line

Step 2: as shown in Figure 3.4, move the two connectors leveled together so that they can be smoothly engaged. Rotate the screw sleeve of the connector (note, not the rotating connector itself) until it is tightened, and there can be no relative rotational movement between the connectors during the connection.

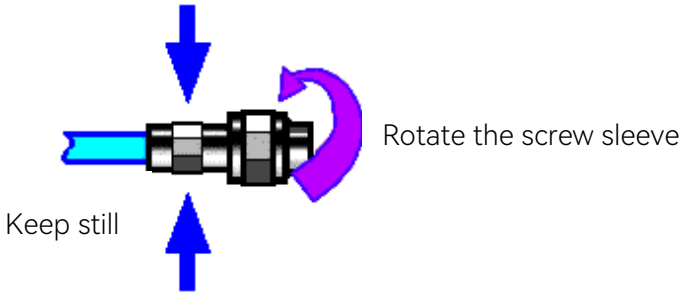


Figure 3.4 Connection method

Step 3: As shown in Figure 3.5, tighten the connectors with a torque wrench to complete the connection. Note that the torque wrench shall not exceed the initial turning point, and an auxiliary wrench can be used to prevent the connector from rotating.

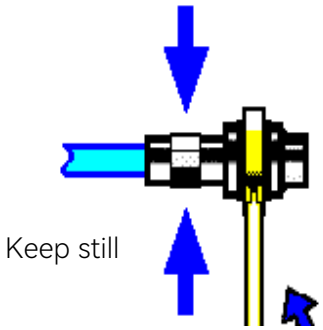


Figure 3.5 Finishing the connection with a torque wrench

3) Disconnection

Step 1. support the connectors to prevent any connector from being twisted, shaken or bent;

Step 2. An open-ended wrench can be used to prevent the connector body from rotating;

Step 3. loosen the screw sleeve of the connector with another wrench;

Step 4. Rotate the screw sleeve of the connector by hand to complete the disconnection;

Step 5. Pull the two connectors levelly apart.

4) Operating instructions of a torque wrench

The operating instructions of a torque wrench are shown in Figure 3.6. The following points shall be paid attention to when using it:

- Confirm that the torque of the torque wrench is correct set before use;
- Ensure that the angle between the torque wrench and another wrench (used to support a connector or a cable) is within 90° before applying force;
- Grasp the end of the torque wrench handle gently, and apply force in the direction perpendicular to the handle until reaching the folding point of the wrench.

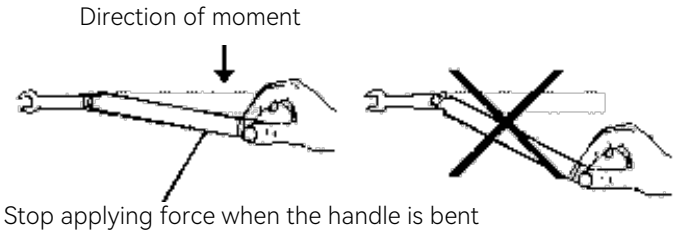


Figure 3.6 Operating instructions of a torque wrench

5) Use and storage of connectors

1) The connectors shall be covered by protective sleeves when not in use.
2) Do not mix various connectors in a box because this is one of the most common causes of connector damage.
3) Do not touch the joint plane of the connectors because the grease and dust particles on the skin are difficult to be removed from the joint plane;
4) Do not put the contact surface of a connector downward on a hard table surface. Contact with any hard surface may damage the electroplated layer and the joint surface of the connector.
5) Always wear anti-static wrist straps and work on a grounded conductive workbench pad, which can protect the 2439D microwave power meter, power probe and the connectors from electrostatic discharge.

6) Connector cleaning

When cleaning the connectors, always wear antistatic wrist straps and observe the following steps:

1) Remove loose particles on the thread and joint plane of the connectors with clean low-pressure air, and thoroughly inspect the connectors. If further cleaning treatment is required, proceed as follows:

2) Soak (but not thoroughly soak) a lint-free cotton swab with isopropyl alcohol;
3) Remove the dirt and debris from the joint plane and threads of the connectors with cotton swabs. When cleaning the inner surface of a connector, be careful not to apply external force to the central inner conductor and not to leave the fibers of cotton swabs on the central conductor of the connector.
4) Let the alcohol volatilize, then blow the surface clean with compressed air;
5) Check the connector to make sure that it is free of particles and residues.
6) If any defects of the connector is still obvious after cleaning, it indicates that the connector may have been damaged and shall not be used again. Make clear the cause of the connector damage before connection.

7) Joint plane of connectors

The reference plane is a critical concept in microwave power measurement. For microwave power meters and power probes, it serves as the benchmark for ensuring accurate measurements. A good connection depends on whether the joint planes of the connectors can achieve perfectly flat contact at every point.

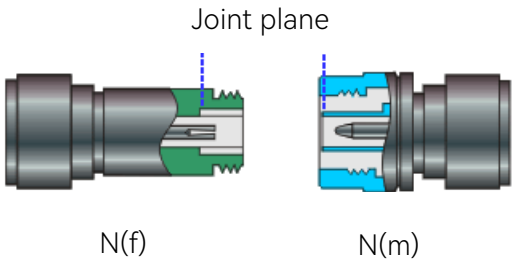


Figure 3.7 Joint plane

3.1.1.5 User check

Start the 2439D microwave power meter and allow it to warm up for at least 30 minutes. Connect the power probe to the 2439D microwave power meter via the cable and allow it to warm up for at least 30 minutes. Perform the following settings:

Step 1. Check for the power noise fluctuation in the display area, which indicates that the 2439D microwave power meter is functioning normally.

Step 2. Press the [Zero] button on the front panel to enter the zeroing menu. Click Zeroing and observe the alarm warning area of the 2439D microwave power meter. If no alarm indicators appear, the 2439D microwave power meter is functioning normally. If an alarm appears, the 2439D microwave power meter is malfunctioning. In this case, contact our service center using the contact information provided on the inside front cover of this manual or in "6.4 Method to obtain after-sales services". We will promptly repair or replace the unit as needed.

3.1.2 Routine maintenance

This section describes the daily maintenance procedures of the 2439D microwave power meter.

- Cleaning method.....25
- Test port maintenance.....26

3.1.2.1 Cleaning method

1) Clean the surface of the 2439D microwave power meter

When cleaning the surface of the 2439D microwave power meter, follow these steps:

Step 1. Shut down the 2439D microwave power meter and disconnect the power cord connected to it;

Step 2. Wipe the surface gently with dry or slightly wet soft cloth, and never wipe the inside of the 2439D microwave power meter.

Step 3. do not use chemical cleaners, such as alcohol, acetone or dilutable cleaners.

2) Cleaning the display

After a period of use, the LCD needs to be cleaned. Please follow the steps below:

Step 1. Shut down the 2439D microwave power meter and disconnect the power cord connected to it;

Step 2. Dip a piece of clean and soft cotton cloth into the cleaner and then gently wipe the display panel;

Step 3. Dry the display with a piece of clean and soft cotton cloth;

Step 4. Connect the power cord only after the cleaner is completely dried.

Notice

Display cleaning

There is an antistatic coating on the surface of the screen. Do not use cleaners containing fluoride, acid and alkaline. Do not spray the cleaner directly onto the display panel; otherwise it may penetrate into the machine and damage the 2439D microwave power meter.

3.1.2.2 Test port maintenance

Damage to power input connector of the 2439D microwave power meter or the presence of dust inside the power meter will affect the power test results. Users shall maintain such kind of connectors as follows:

- The connectors shall be kept away from dust and kept clean.
- To prevent electrostatic discharge (ESD), do not directly contact the joint surface.
- Do not use damaged connectors;
- Please use an air blower to clean the connectors instead of using tools such as sandpaper to grind the surface of the joint.

3.2 Description of front and real panels

This section introduces the composition and functions of the front and rear panels as well as operation interface of the 2439D microwave power meter.

- Description of front panel.....26
- Description of real panel.....27

3.2.1 Description of front panel

This section describes the external components and functions of the 2439D microwave power meter. The appearance is shown in Figure 3.8, and the itemized explanation is shown in Table 3.5.



Figure 3.8 Front panel of the 2439D microwave power meter

Table 3.5 Description of front panel

No.	Name	Description
1	Power button	The power button is located at the lower right corner of the front panel. It is used to turn the 2439D microwave power meter on or off.
2	Reference source output interface	N-type interface, reference source output 50 MHz, power reference 0 dBm.
3	A and B channel input interfaces	Multi-core interfaces connecting power probes, A and B channel inputs.
4	Button area	The 2439D microwave power meter has 6 function buttons and 4 directional buttons.
5	Display area	Display the current state and test results of the 2439D microwave power meter, facilitate related settings, and support touch operation.
6	Main USB port	Support connection to the power probe via cable, and channel number C.

3.2.2 Description of rear panel

The rear panel composition and functions of the 2439D microwave power meter are shown in Figure 3.9 below, and the itemized explanation is shown in Table 3.6.



Figure 3.9 Rear panel of the 2439D microwave power meter

Table 3.6 Description of rear panel

No.	Name	Description
1	220 VAC interface	AC power interface
2	C and D channel input interfaces	Multi-core interfaces connecting power probes, C and D channel inputs.
3	Optional battery port	Remove the cover plate and insert the battery through this opening.
4	U port of slave port	U port for programmed control.
5	Main USB port	Support connection to the power probe via cable, and channel number D.
6	Network port	Network port for programmed control.
7	GPIB port	GPIB port for programmed control.
8	Analogue output	Output analog voltage signals related to power measurement results of a specific channel.
9	Trigger input	Input interface of external trigger signal.
10	Grounding screw	For housing grounding.

3.3 Basic measurement methods

This section provides an overview of how to use the 2439D microwave power meter, covering the information in the window display area and the method to operate the 2439D microwave power meter using front panel buttons and other interactive controls.

- Introduction to interface.....28
- Operation example.....31

3.3.1 Introduction to interface

Figure 3.10 shows the measurement interface of the 2439D microwave power meter, which connects the power probe for numerical display. Each information area is labeled. The operating interface description is shown in Table 3.7, with detailed explanations provided below.



Figure 3.10 Numerical display interface of power probe

Table 3.7 Description of numerical display interface

No.	Name	Description
1	Frequency value	It is the carrier frequency value of the current measured signal, requiring manual user setting.
2	Data input	It indicates the source of currently displayed data. The figure shows that the current result is derived from the average value of channel A.
3	Trigger mode	Trigger mode. It is used to set the trigger mode for the current measurement. Three options are available: "Free Run", "Continuous Trigger", and "Single Trigger". Details are provided in Section 4.2.3 Trigger.
4	Window	The figure indicates one window displayed; up to four windows can be displayed simultaneously.
5	Channel indication	It indicates the channel from which the current data originates.
6	Measurement value	Power measurement value.
7	units of measurement	Support logarithmic and linear conversion.
8	Main menu	It is used to set display mode, channels, trigger, and system

		functions.
9	Softkey area	Configure different functions based on the current display mode.

When the 2439D microwave power meter connects to the peak power probe, it can simultaneously display waveforms and key parameters. The figure below is a display interface showing both waveform and power parameter.

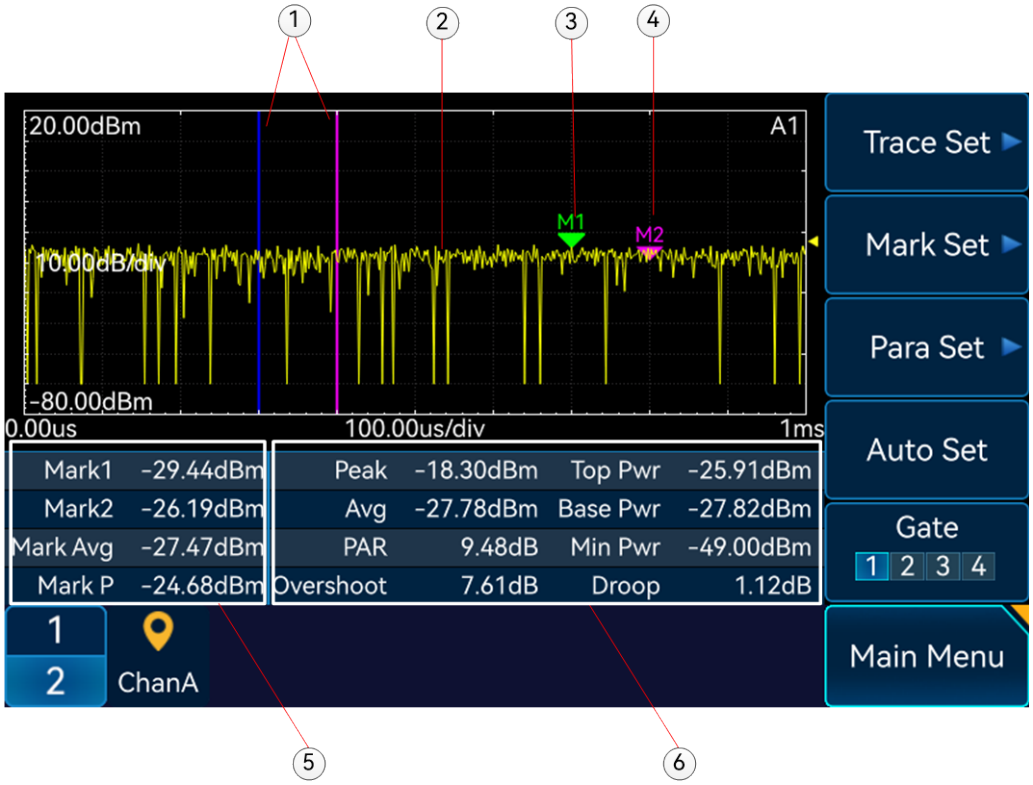


Figure 3.11 Trace display interface

Table 3.8 Description of trace display interface

No.	Name	Description
1	Gate display	It indicates the start and stop positions of the current gate. For detailed gate settings, refer to Section 4.2.2 Channel.
2	Trace	Display the pulse envelope of the signal.
3	Marker 1	Position can be set via [Marker Setting]. Detailed setting is described in Section 4.2.6 Trace.
4	Marker 2	Position can be set via [Marker Setting]. Detailed setting is described in Section 4.2.6 Trace.
5	Marker information	It indicates measurement results at marker positions. Switch between power or time parameters is possible via [Marker Setting].
6	Pulse parameter	It supports simultaneous display of up to 8 parameters.

	display area	Parameters can be selected via [Parameter Configuration], including 8 power parameters and 8 time parameters.

3.3.2 Operation examples

This section provides a detailed, step-by-step introduction to some commonly used and important basic settings and functions of the 2439D microwave power meter through examples. The aim is to enable users to quickly understand the characteristics of the power meter and master fundamental measurement methods.

First, pre-operation preparations shall be completed for the 2439D microwave power meter according to the following steps:

Step 1. Power on and start;

Step 2. Launch the application after entering the system;

Step 3. Proceed with the following operations when there are no error messages on the main operation interface of the front panel.

- Display layout.....31
- Display mode.....32
- Zeroing.....35
- Average power measurement.....36
- Peak power measurement.....37
- Usage of data input and gate.....49
- Usage of trigger function.....55
- Stable measurement method for long-period pulse signals.....62
- Power measurement statistical analysis CCDF.....64
- Web remote control.....65
- Analog output.....66

3.3.2.1 Display layout

Measurement displays can be split into up to 4 windows, each corresponding to a measurement.

1) Click [Back] to return to the top-level interface.
2) Click the layout thumbnail in the lower left corner to pop up the measurement window selection interface, as shown below:

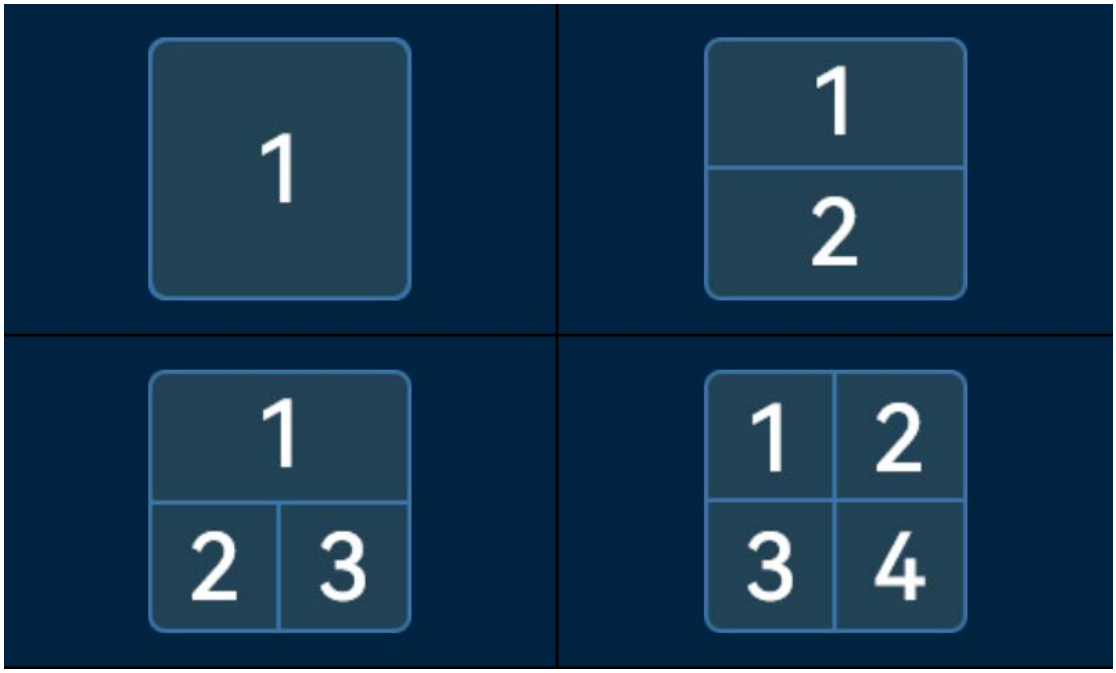


Figure 3.12 Window selection

3) Select the number of measurement windows to display. For example, when 2 windows are selected, the measurement display interface will present the following layout:



Figure 3.13 2-window interface layout

3.3.2.2 Display mode

Users can select the channel input and display mode for the current window. Display

modes support trace, numerical, and statistical views. The following example uses a single display window.

1) Click [Main Menu]>[Display Mode] to enter the display mode interface.
2) Select the channel input for this window. For example, when power probes are connected to channel A and channel B of the 2439D microwave power meter, both [Channel A] and [Channel B] become selectable. At this point, [Channel A] is highlighted, indicating that this window's input is from channel A, as shown in the following figure:



Figure 3.14 Display mode

3) Select the display mode for this window. For example, select this window as channel A trace, as shown in Figure 3.15; select this window as channel B numerical value, as shown in Figure 3.16; select this window as channel B statistics, as shown in Figure 3.17.

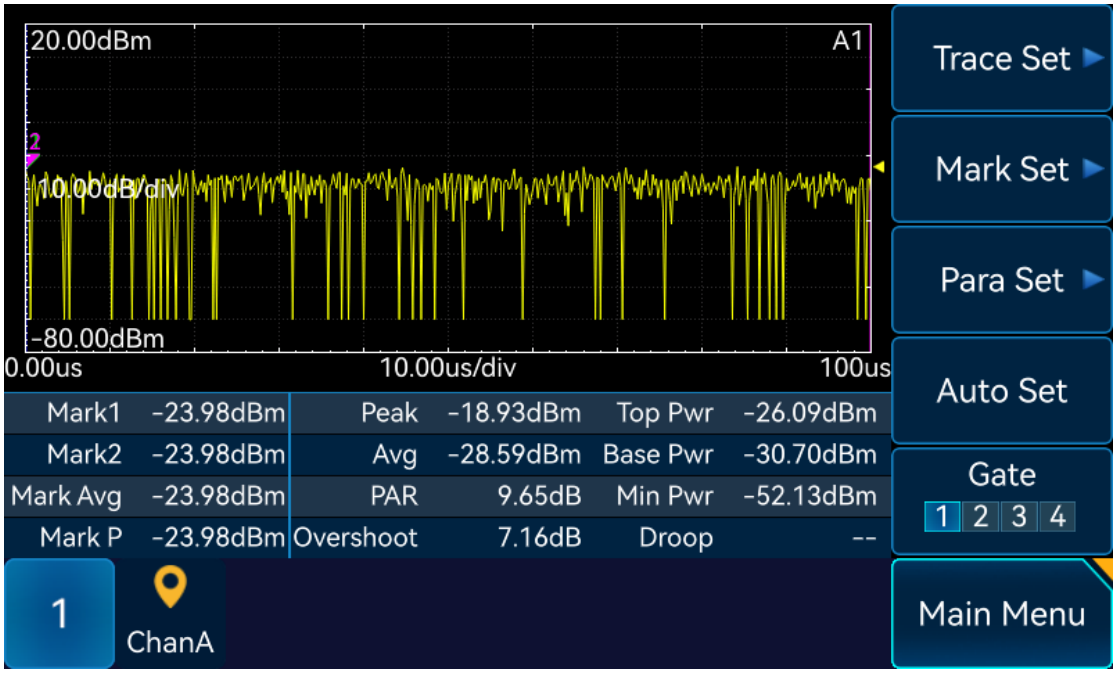


Figure 3.15 Trace display



Figure 3.16 Numerical display

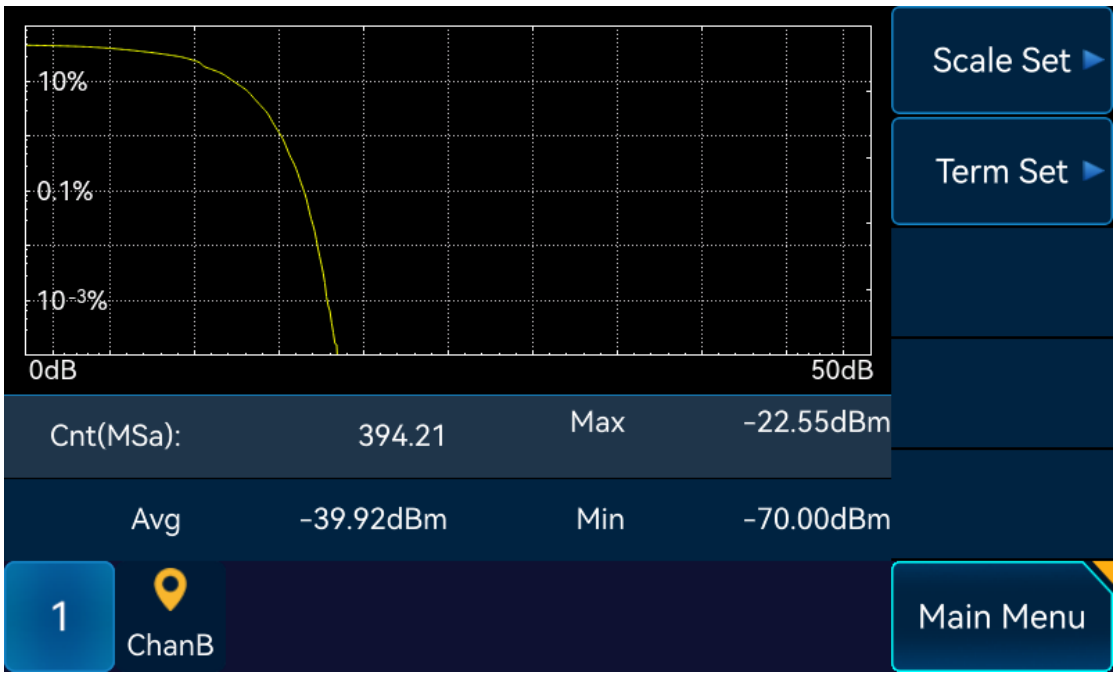


Figure 3.17 Statistics display

3.3.2.3 Zeroing

3.3.2.3.1 Scenarios requiring zeroing

To enhance power measurement accuracy, zeroing of the power probe is necessary during power measurement.

Power probe zeroing is recommended under the following conditions:

1) The power probe is replaced. The power probe requires 15 minutes of warm-up to reach a stable state.
2) The ambient temperature around the power probe changes significantly (greater than 5℃).
3) When measuring a low-power device, turn off the device's output and zero the power probe to eliminate errors caused by ground noise between the 2439D microwave power meter and the DUT.

3.3.2.3.2 Zeroing procedure

Zeroing aims to record the current noise floor that will be deducted in subsequent measurements. This ensures accuracy of measurement results. Specifically, when the zeroing type is set to External, external signal input shall be disabled before performing zeroing. The specific steps are as follows:

1) Click [Zero]>[Channel X] to select the channel requiring zeroing.

2) Select "External" in [Zeroing Type] and then click [Zero].

3) When the zeroing progress bar ends, the zeroing is finished, as shown below.

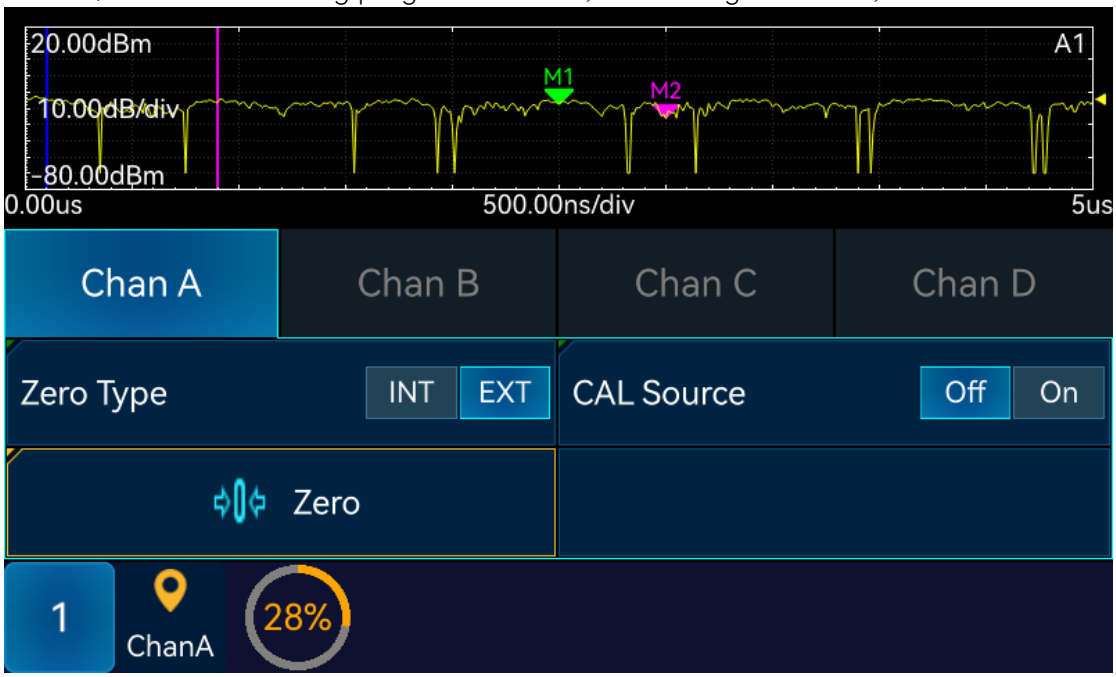


Figure 3.18 Zeroing

3.3.2.4 Average power measurement

The most common measurement task for power meters is measuring signal average power.

This section uses the A channel of the 2439D microwave power meter paired with the 87236D USB peak/average power probe as an example to provide a detailed explanation of how to perform average power measurement.

Set the frequency of the signal generator to 10 GHz and the power to +10 dBm.

The operation steps are as follows:

1) Click [Main Menu]>[Channel]>[Channel A]>[General Setting]>[Mode] and set it to "Average Only".

2) Click [Frequency]>[Channel A] and set the frequency to 10 GHz.

At this point, the measured accurate power value can be observed on the screen. as shown in the following figure.



Figure 3.19 Average power measurement

3.3.2.5 Peak power measurement

When paired with a peak power probe, the 2439D microwave power meter can measure the peak power of pulse-modulated signals and display it as an envelope graph. It enables measurement of various pulse-modulated signal envelope parameters, including peak power, average power, overshoot, rise/fall time, top power, bottom power, pulse width, pulse period, duty cycle, off time, and pulse repetition frequency.

3.3.2.5.1 Definition of pulse measurement parameter

This section details the definitions of pulse parameters in the 2439D microwave power meter.

The figure below illustrates a pulse envelope, graphically describing the parameters of the pulse envelope. Table 3.9 introduces pulse terminologies and definitions in the IEEE 194-1977 standard, while Table 3.10 provides detailed definitions for various pulse parameters.

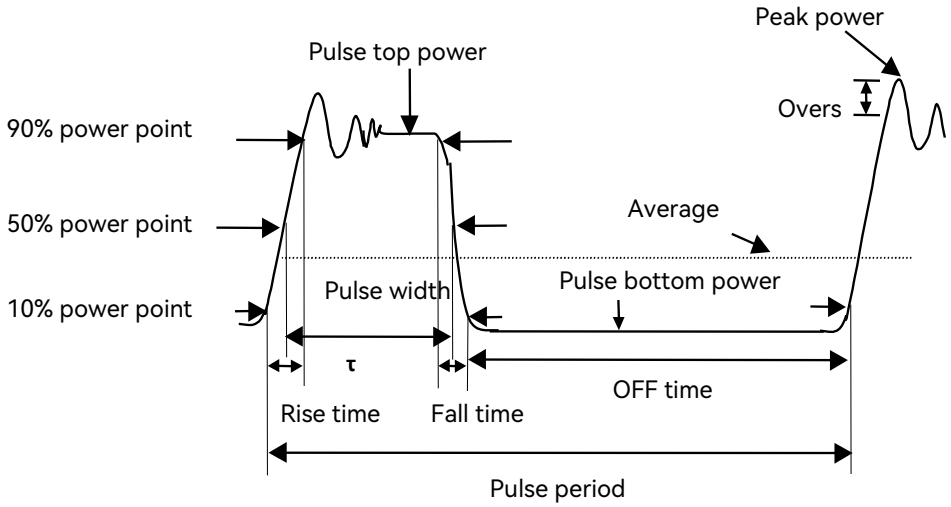


Figure 3.20 Definitions of pulse envelope amplitude and time-domain parameter

Table 3.9 IEEE pulse terminology

English term	Chinese term	Definition
Base line	Base line	A standard pulse waveform consists of two steady states—a high level and a low level. The base line represents the level at which the low-level normal state resides. It is manifested as an iso-value reference line.
Top Line	Top line	Similar to the base line definition, the top line represents the level at which the high-level normal state resides. It is manifested as an iso-value reference line. In practical applications, the base line and top line are defined using a histogram method. Specifically, the base line is defined as the power value with the highest number of power points occurring between the mesial line power of the first transition and the midpoint power of the last transition.
First Transition	First transition	The primary transition area between base line and top line of a waveform.
Last Transition	Last transition	The primary transition area between the top line and base line of a waveform.
Proximal Line	Proximal line	An iso-value reference line positioned near the base line, which represents a specified

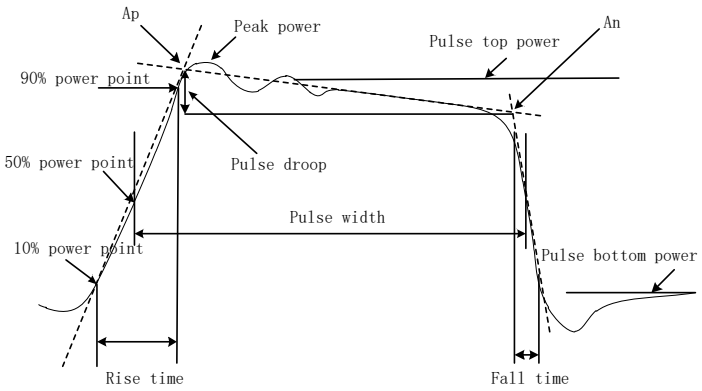
		percentage (typically 10%) of the pulse amplitude.
Distal Line	Distal line	An iso-value reference line positioned near the top line, which represents a specified percentage (typically 90%) of the pulse amplitude.
Mesial Line	Mesial line	An iso-value reference line positioned in the center of pulse, which represents a specified percentage (typically 50%) of the pulse amplitude.

The 2439D microwave power meter automatically measures 16 parameters of the pulse power envelope, which are categorized into time parameters and power parameters. Refer to Table 3.10 for specific definitions.

Table 3.10 Definition of pulse measurement parameter

Term		Definition
Time parameter	Pulse width	The time interval between the mesial line of the pulse first transition and the mesial line of the pulse last transition. It is typically defined as the time interval between the 50% power point of the pulse first transition and the 50% power point of the pulse last transition. **Notice: If the waveform display does not show a full pulse width, the automatic measurement in the medium and large windows will be unable to display the "pulse width" value.**
	Pulse period	The time interval between two consecutive pulses is the reciprocal of the pulse repetition frequency. **Notice: If the waveform display does not show a full pulse period, the automatic measurement in the medium and large windows will be unable to display the "pulse period" value.**
	Pulse repetition frequency	The count a repetitive signal occurs per second. **Notice: If the waveform display does not show a full pulse period, the automatic measurement in the medium and large windows will be unable to display the "pulse repetition frequency" value.**
	Rise time	The time interval between the proximal line and distal line of the pulse first transition. The proximal line is typically defined as 10% of the pulse power, and the distal line is typically defined as 90% of the pulse power. Users may also define these points themselves.

		Notice: For automatic measurement of "rise time", the window must display the first transition of the waveform.
	Fall time	The time interval between the proximal line and distal line of the pulse last transition, which is defined in the same manner as "rise time". Notice: For automatic measurement of "fall time", the window must display the last transition of the waveform.
	Duty cycle	The ratio of pulse width to pulse period. Notice: If the waveform display does not show a full pulse period, the automatic measurement in the medium and large windows will be unable to display the "duty cycle" value.
	OFF time	The time during which the periodic pulse is turned off, which is equal to the pulse period minus the pulse width. Notice: If the waveform display does not show a full pulse period, the automatic measurement in the medium and large windows will be unable to display the "off time" value.
	Edge delay	The time interval on the pulse centerline, which is measured from left to right and lies between the leftmost end of screen and the first or last transition of waveform.
Power parameters	Average power	The average power value of the pulse waveform within the display window. Notice: In the trace display window, the measurement of "Average Power" requires the waveform display to cover at least one pulse period. If the displayed waveform is less than one pulse period, the average power cannot be automatically measured.
	Peak power	The maximum power value in the pulse waveform within the display window.
	Peak-to-average ratio	Ratio of peak power to average power within the display window, which is logarithmically displayed as peak power minus average power.
	Overshoot	The difference between peak power and top power.
	Top power	The power value at the top of the pulse power. The top power for pulse power is defined statistically by identifying the most frequently occurring point within a 5 dB range below the peak power level. This point is defined as the top power.
	Bottom power	The bottom power value of the pulse power.

		It follows the same calculation method as "top power". Using the minimum pulse power as the base line, the point with the highest occurrence probability within a 12 dB range above the minimum power is defined as the bottom power.
	Pulse power	The average power within the pulse width. The average power between the 50% power point of the first transition and the 50% power point of the last transition for the pulse.
	Pulse droop	This refers to the percentage of the difference between the amplitude at the intersection point with the first transition (Ap) and the amplitude at the intersection point with the last transition (An) on the extrapolated line of the smooth pulse top curve (excluding the initial "spike" or "overshoot"), relative to Ap.  Notice: The waveform shall display at least one pulse width, and the pulse width shall exceed one time base for pulse droop calculation.

3.3.2.5.2 Scale setting

This section takes the channel A of the 2439D microwave power meter paired with the 87236D USB peak/average power probe as an example to explain in detail how to quickly observe pulse envelope signals through scale setting.

Set the signal generator frequency to 10 GHz, power to +10 dBm, pulse period to 200 us, and pulse width to 100 us.

The operation steps are as follows:

1) Click [Main Menu]>[Display Mode]>[Channel A]>[Trace] to display the waveform, as shown below. By default, the horizontal start is 0 ns, horizontal scale is 10 us,

vertical center is -30 dBm, and vertical scale is 10 dB/division, which does not allow the envelope signal to be observed in its entirety.

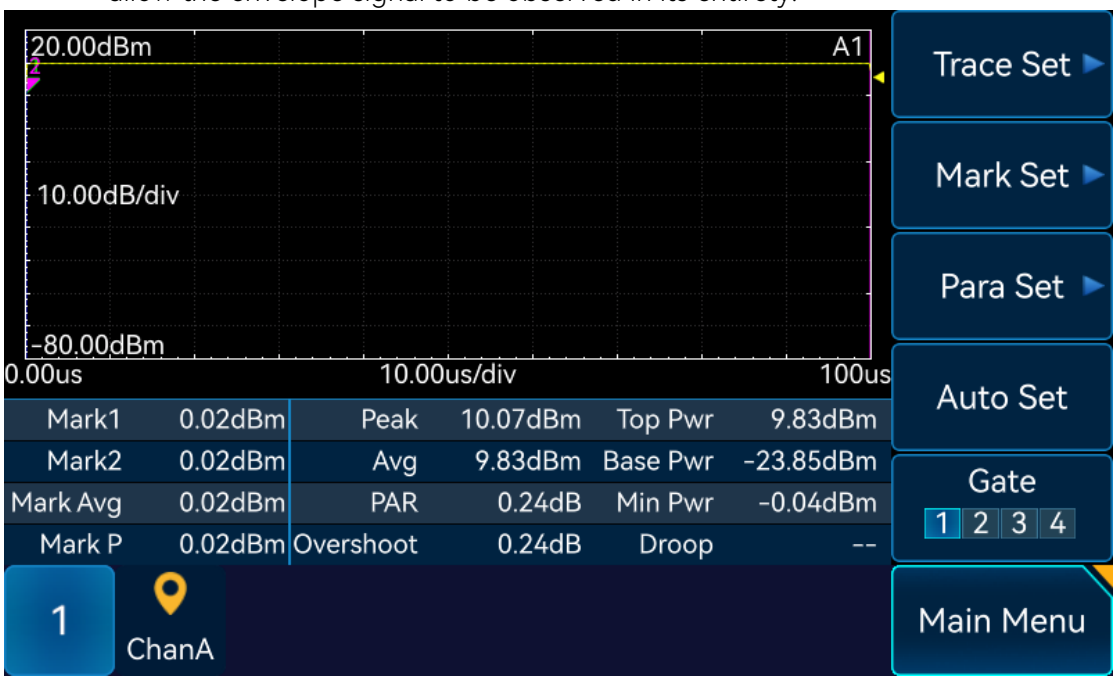


Figure 3.21 Trace display

2) Set [Scale Setting]. Set [Horizontal Scale] to 100 us/division, [Vertical Center] to -10 dBm, and [Vertical Scale] to 10 dB/division, as shown below.

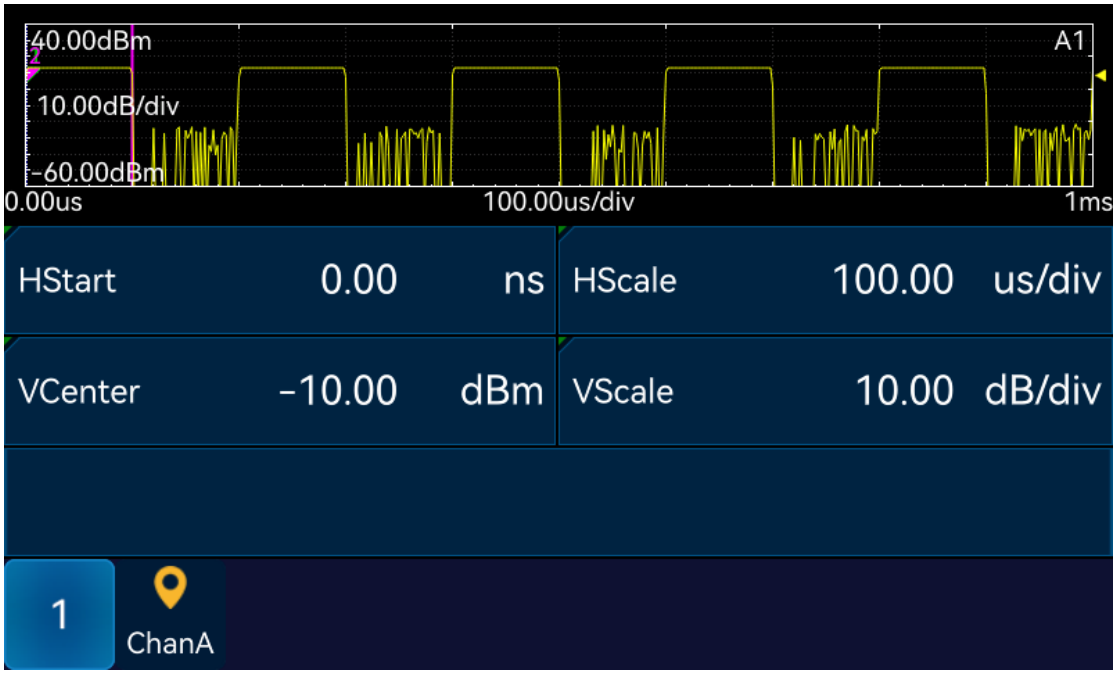


Figure 3.22 Scale setting

3) Click the waveform area to switch from small window display to medium window display, enabling multiple waveform displays and automatic power parameter measurement, as shown below.

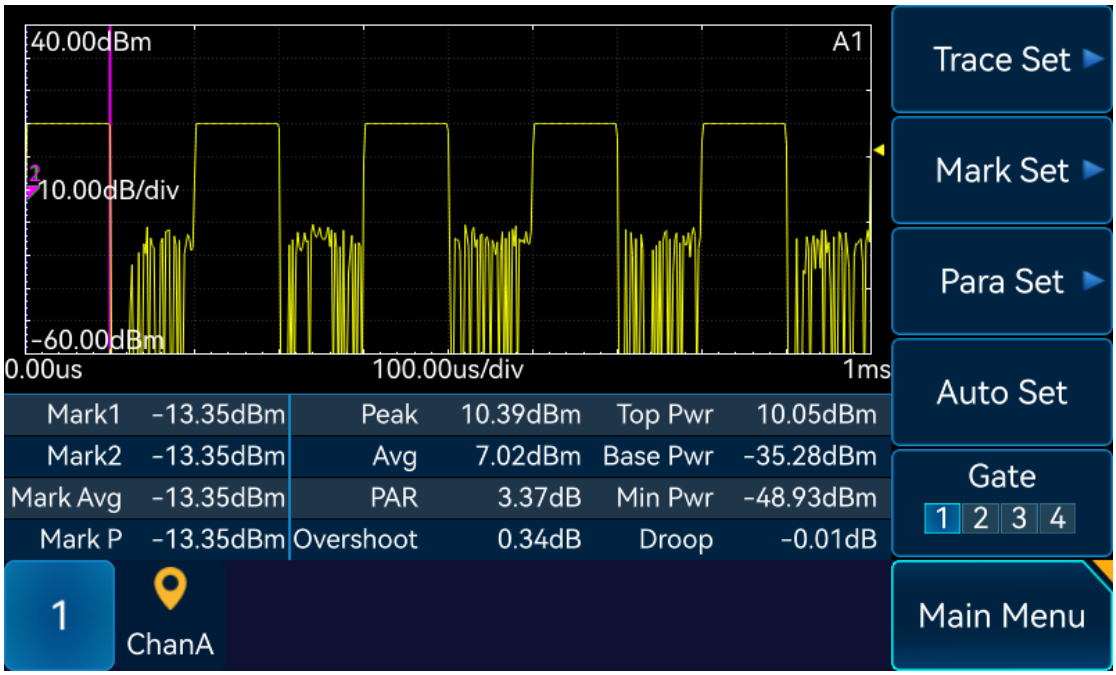


Figure 3.23 Automatic power parameter measurement for multiple periods

3.3.2.5.3 Auto setting

This section takes the channel A of the 2439D microwave power meter paired with the 87236D USB peak/average power probe as an example to explain in detail how to quickly observe pulse envelope signals through auto setting.

Set the signal generator frequency to 10 GHz, power to +10 dBm, pulse period to 200 us, and pulse width to 100 us.

The operation steps are as follows:

1) Click [Main Menu]>[Display Mode]>[Channel A]>[Trace] to display the waveform, as shown below. By default, the horizontal start is 0 ns, horizontal scale is 10 us, vertical center is -30 dBm, and vertical scale is 10 dB/division, which does not allow the envelope signal to be observed in its entirety.

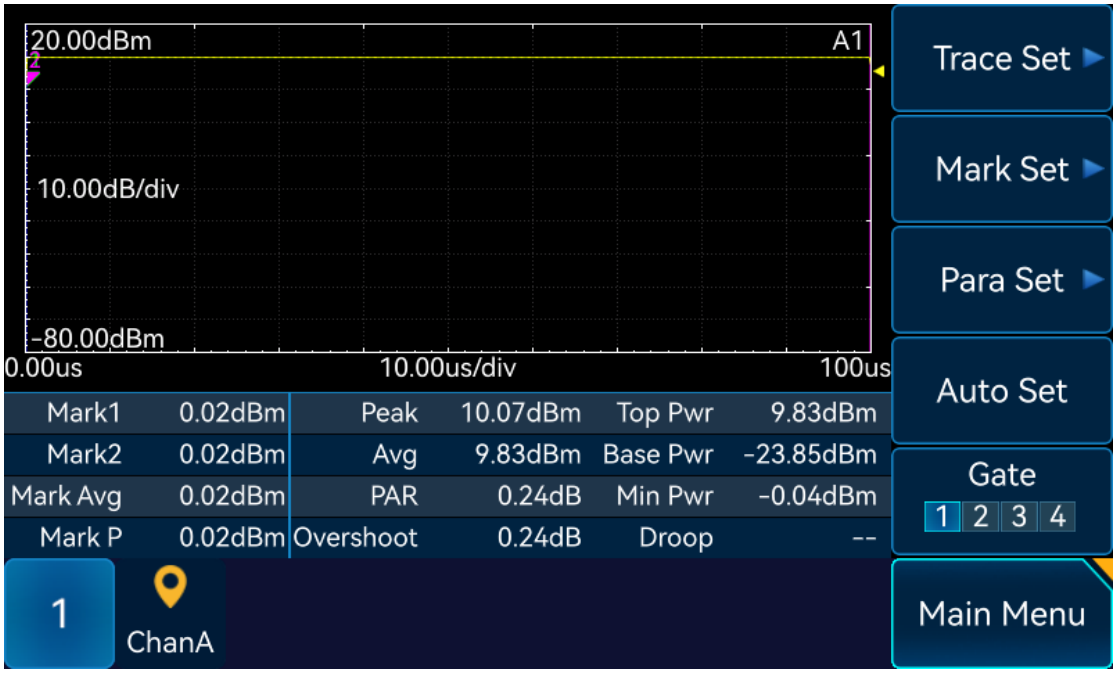


Figure 3.24 Trace display

2) After [Auto Setting] is set, an auto setting progress bar appears in the state bar, as shown below.

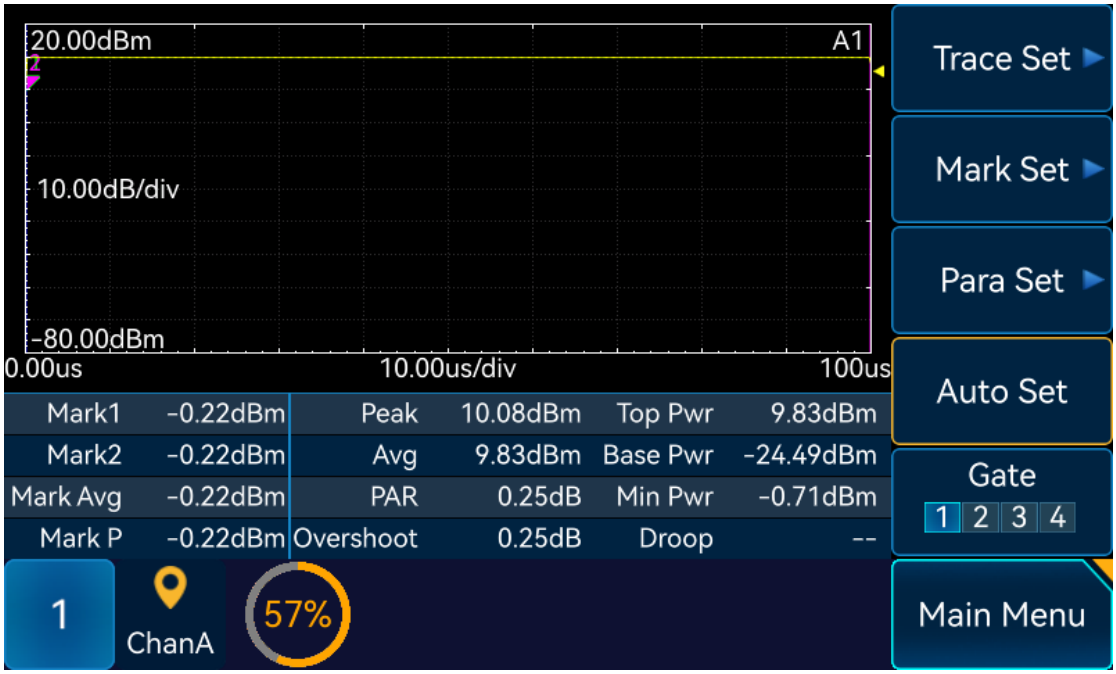


Figure 3.25 Automatic setting

3) When the auto setting progress bar ends, auto setting is finished. Multiple waveforms will be displayed, and power parameters will be automatically measured, as shown below.

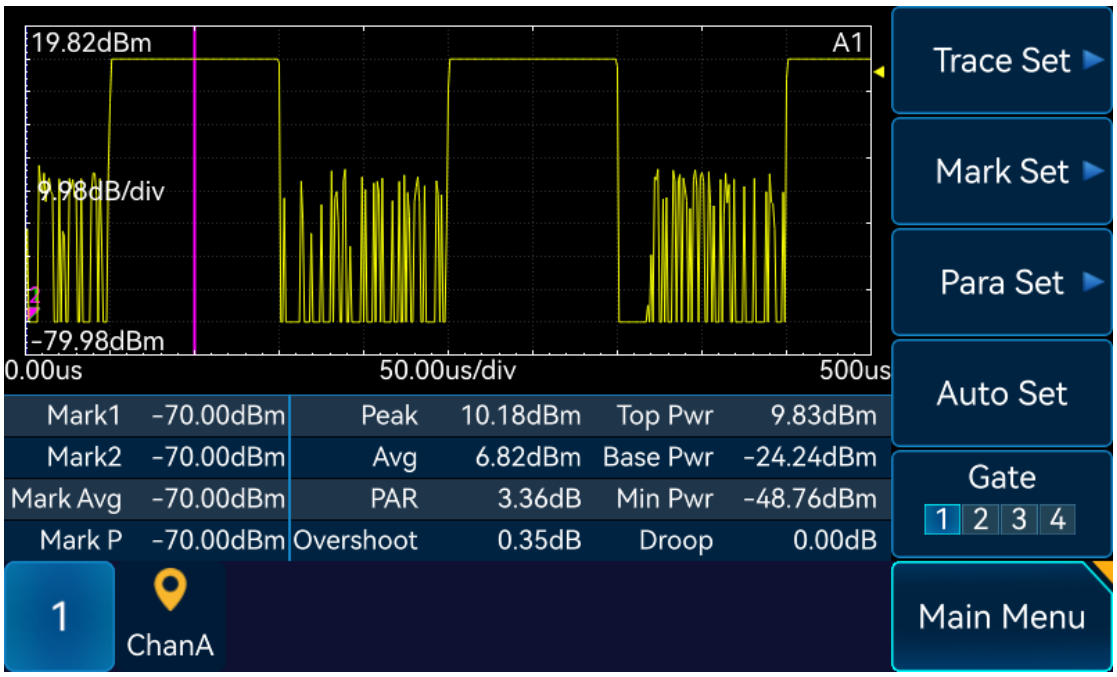


Figure 3.26 Automatic power parameter measurement for multiple periods

3.3.2.5.4 Parameter configuration

This section takes the channel A of the 2439D microwave power meter paired with the 87236D USB peak/average power probe as an example to explain in detail how to obtain the measured pulse envelope signal parameters through parameter configuration.

Set the signal generator frequency to 10 GHz, power to +10 dBm, pulse period to 200 us, and pulse width to 100 us.

The operation steps are as follows:

1) Click [Main Menu]>[Display Mode]>[Channel A]>[Trace] to display the waveform.
2) Set [Scale Setting]>[Horizontal Scale] to 100 us/division. Set [Vertical Center] to -10 dBm and [Vertical Scale] to 10 dB/division.
3) Click the waveform area to switch from small window display to medium window display. The lower-right corner of the pulse trace now displays eight pulse parameters, which default to eight power parameters, as shown below.

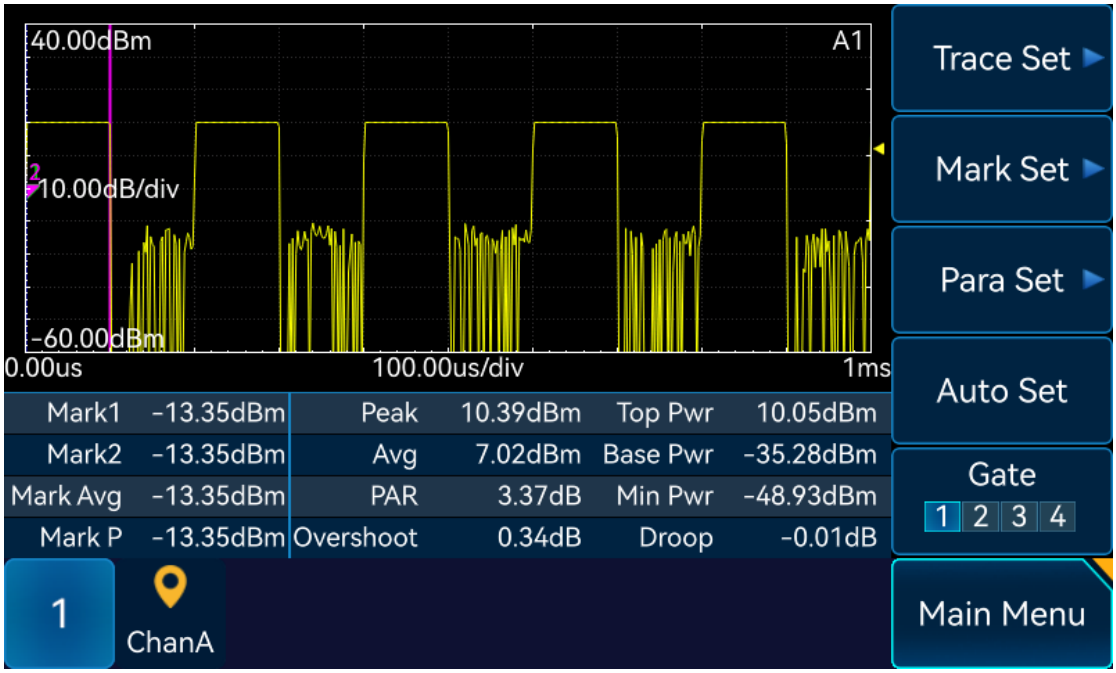


Figure 3.27 Automatic power parameter measurement for multiple periods

4) The [Parameter Configuration] is set, as shown in Figure 3.28. Up to 8 parameters can be selected for display. Users click [OK] to complete the configuration. The trace interface will then present measurement results for the 8 user-selected parameters, as shown in Figure 3.29.

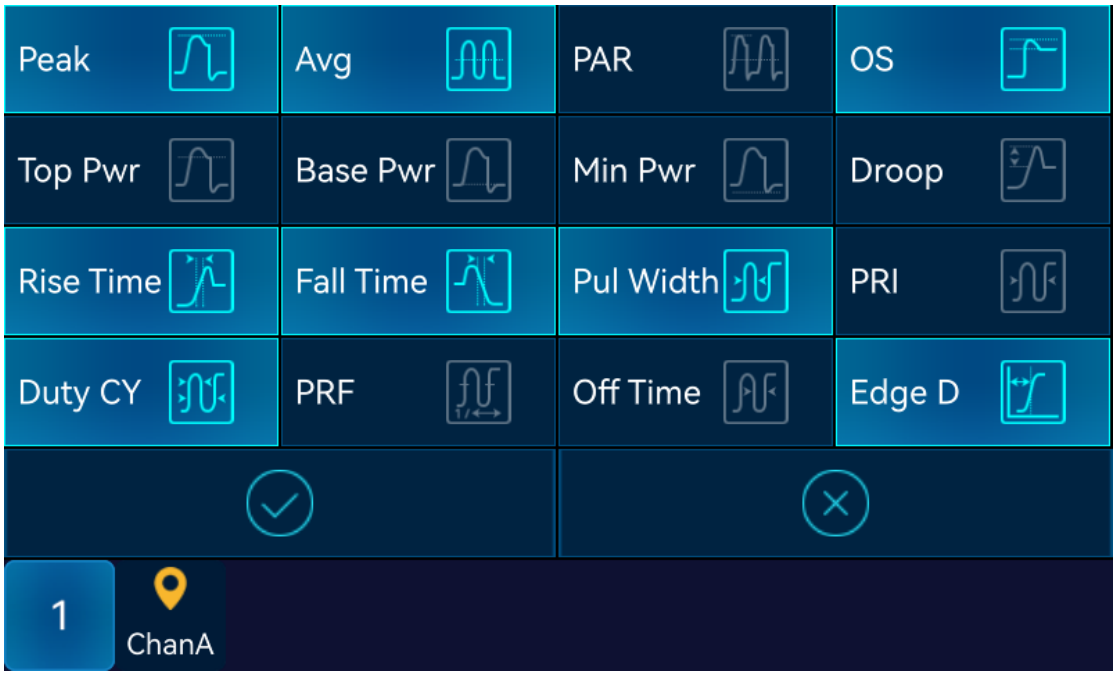


Figure 3.28 Parameter configuration

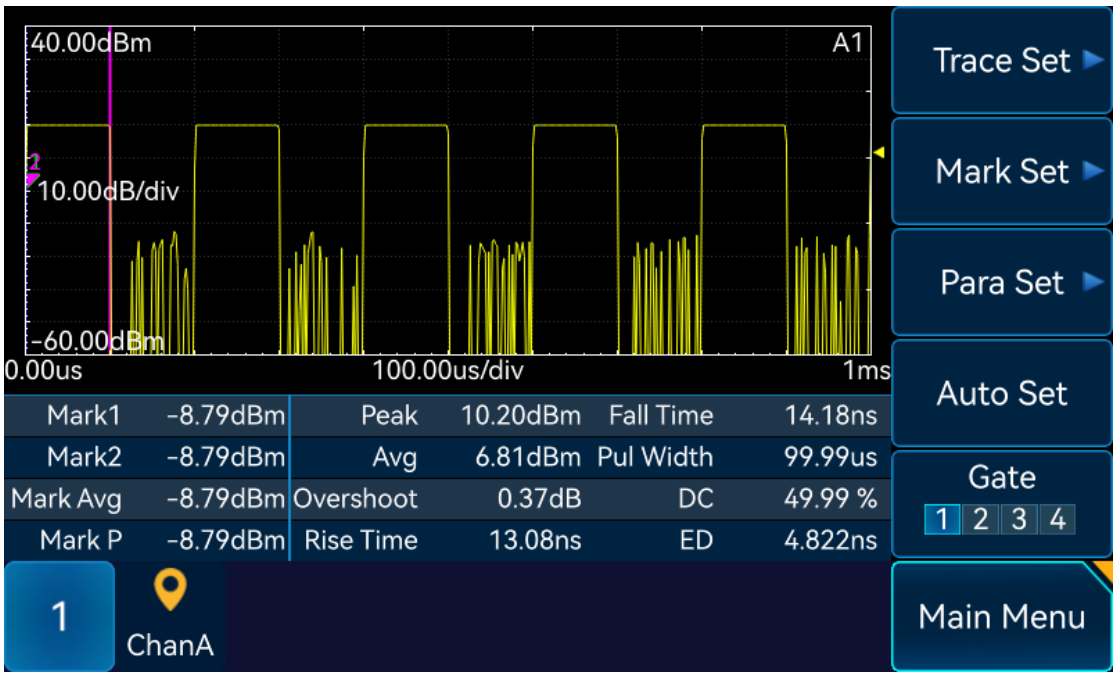


Figure 3.29 Multi-parameter test

3.3.2.5.5 Marker setting

This section takes the channel A of the 2439D microwave power meter paired with the 87236D USB peak/average power probe as an example to explain in detail how to obtain the marker parameters through marker setting.

Set the signal generator frequency to 10 GHz, power to +10 dBm, pulse period to 200 us, and pulse width to 100 us.

The operation steps are as follows:

1) Click [Main Menu]>[Display Mode]>[Channel A]>[Trace] to display the waveform.
2) Set [Scale Setting]>[Horizontal Scale] to 100 us/division. Set [Vertical Center] to -10 dBm and [Vertical Scale] to 10 dB/division to obtain multiple waveform displays.
3) Click the waveform area to switch from small window display to medium window display. The lower left corner of the pulse trace now displays four marker power parameters: marker 1 power, marker 2 power, average power between markers, and peak power between markers, as shown below.

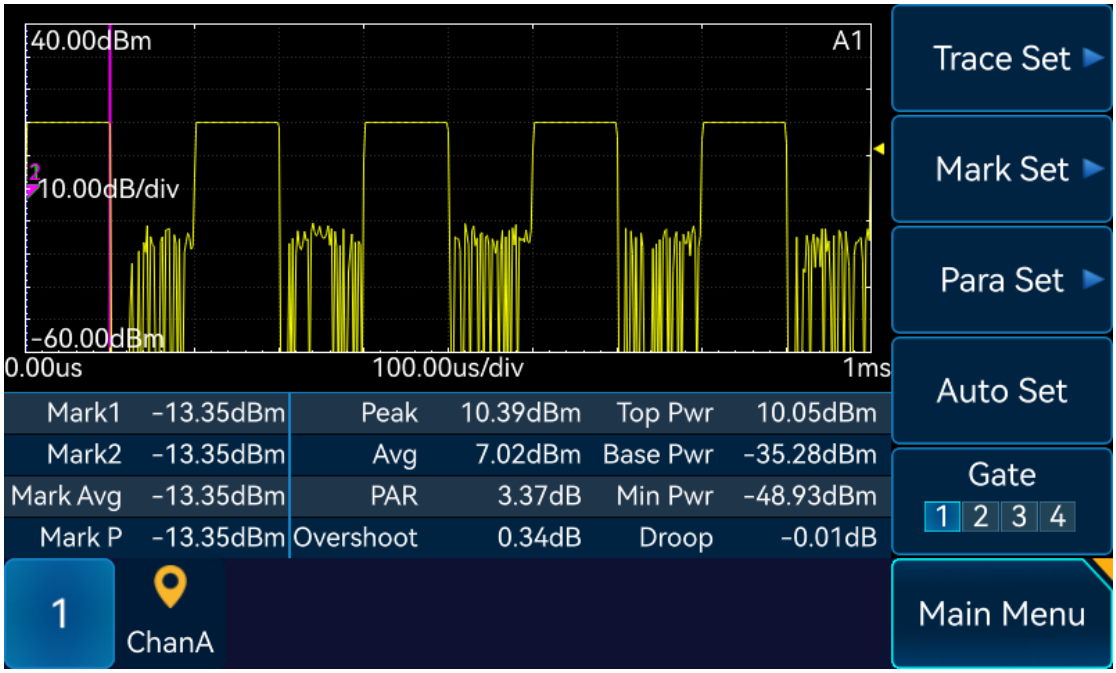


Figure 3.30 Automatic power parameter measurement for multiple periods

4) Set [Marker Setting] to enter the marker setting interface. Set [Marker 1] to 210 us and [Marker 2] to 410 us, as shown below.

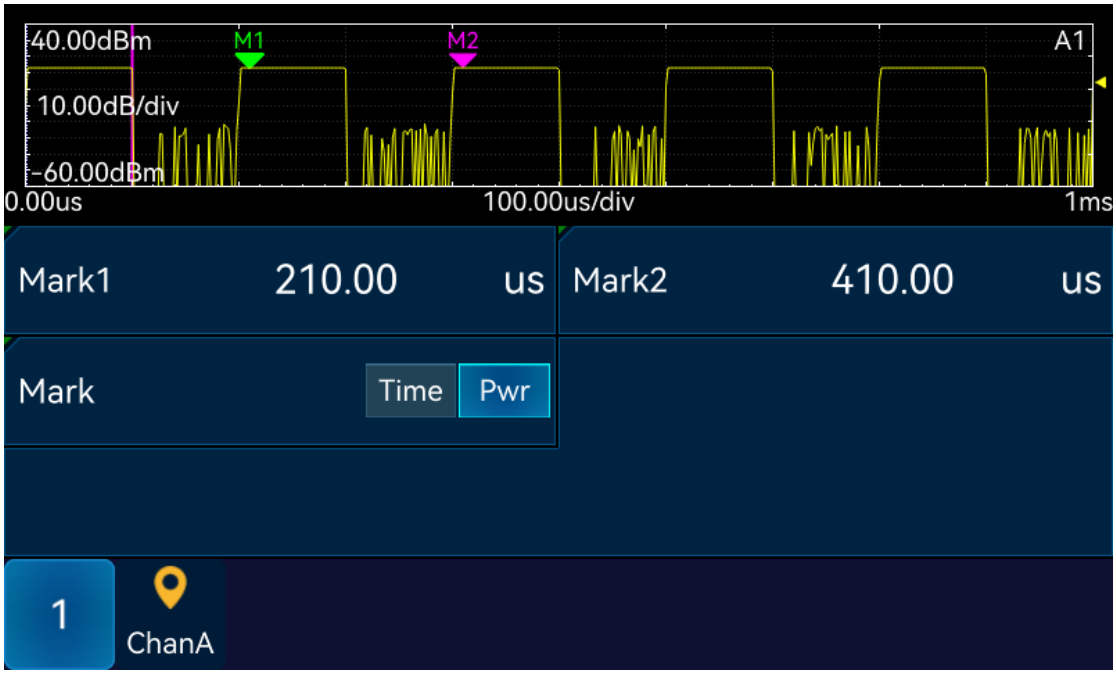


Figure 3.31 Marker setting

5) Click the waveform area to switch from small window display to medium window display. Marker power parameters can now be viewed in the lower left corner of the pulse trace, as shown below.

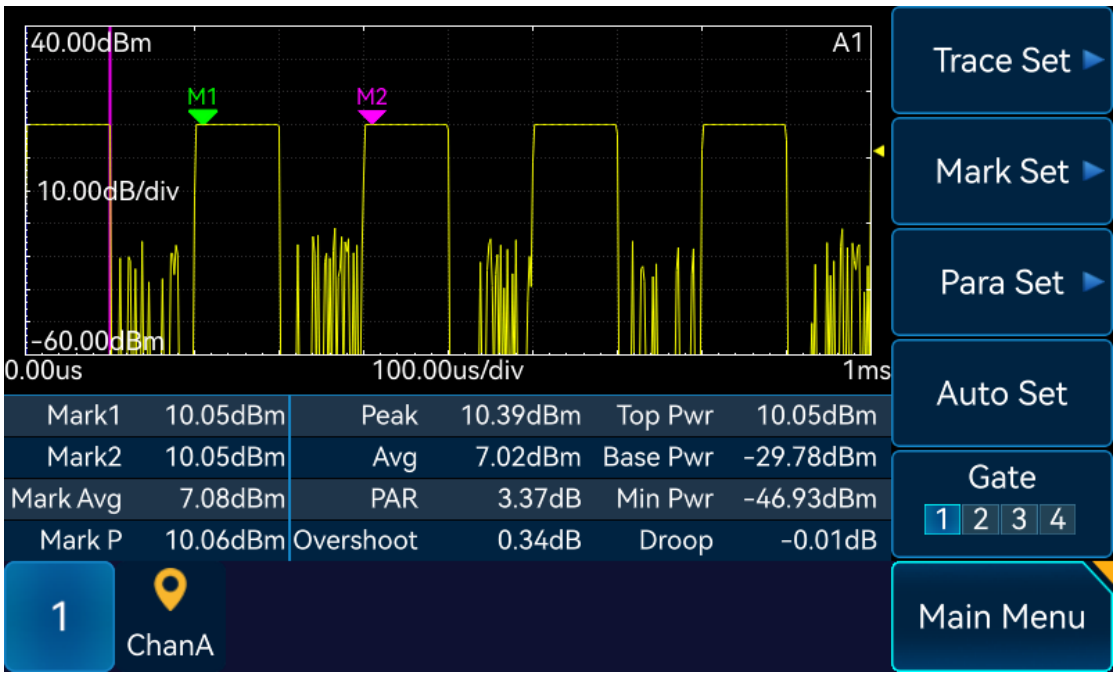


Figure 3.32 Marker parameters

6) Set [Marker Setting]>[Marker Type] to "Time". The marker time parameters can be viewed in the lower left corner of the pulse trace, as shown below.

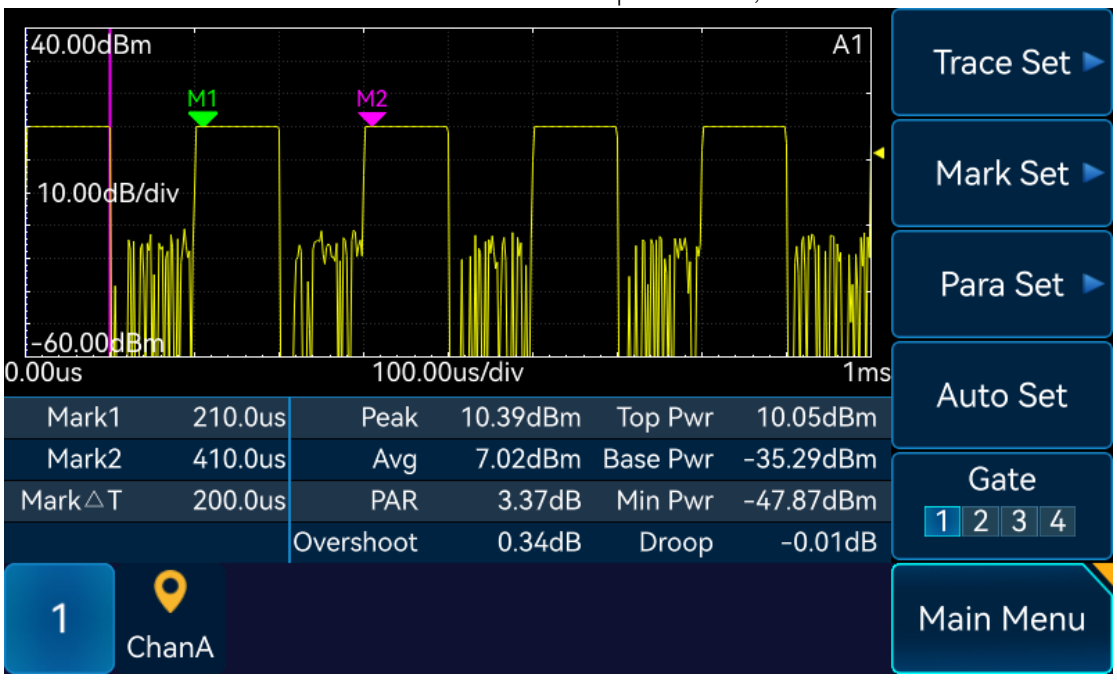


Figure 3.33 Marker time parameters

3.2.3.6 Usage of data input and gate

In the 2439D microwave power meter, the "Gate" serves as a crucial auxiliary measurement tool. When combined with "Data Input", the "Gate" enables convenient test

of numerous pulse parameters.

3.2.3.6.1 Basic concepts of measurement gate

The "gate" function is exclusively used for measurement relaying on peak power probes. Measurement gates are relative to the trigger position, which is used for displaying trace measurement data within specific time intervals. Up to four gates can be set for each peak measurement channel, with each gate supporting four measurement types: "Average Power", "Peak Power", "Peak-to-Average Ratio", and "Minimum Power".

The definition is detailed below:

Average power: The average power within the current gate.

Peak power: The maximum power value within the current gate.

Peak-to-average ratio: The ratio of peak power to average power within the current gate.

Minimum power: The minimum power value within the current gate.

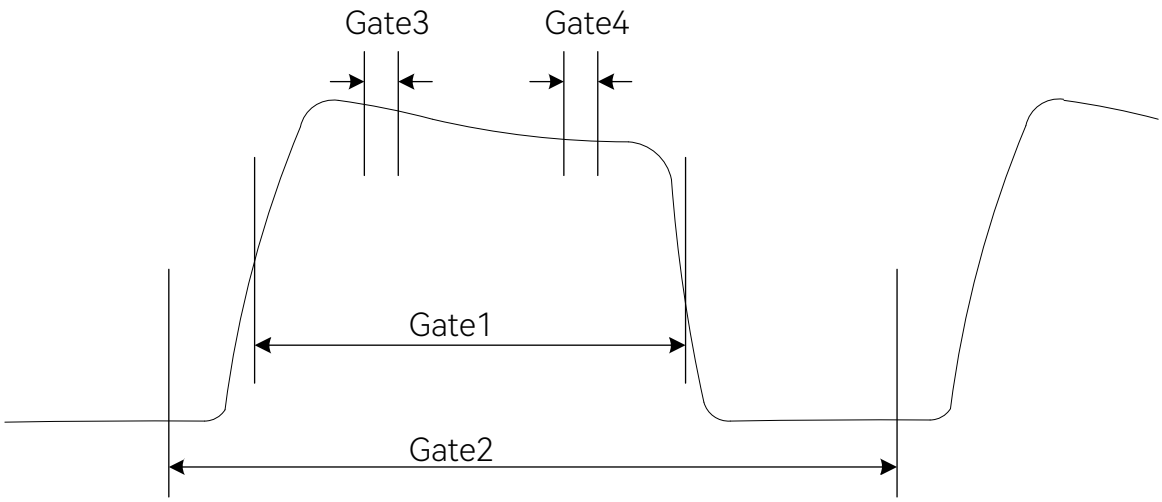


Figure 3.34 Measurement gate

For example, by setting a measurement gate as shown above, the following measurements can be performed:

1） Pulse power: Average power within gate 1.

2） Average power of pulse: Average power in gate 2.

2) Peak-to-average ratio: Peak power within gate 2/average power.

3) Pulse dropout: Average power in gate 3/average power in gate 4.

3.2.3.6.2 Usage of data input

The 2439D microwave power meter can configure up to four windows via its display layout function. Each window supports data input configuration. The following uses one window as example to demonstrate data input usage.

1) Click Window 1 to enter the window. Click [Data Input] to access the data input interface, as shown below. Since the power probe is currently in "Average Only" mode, [Gate] and [Type] are disabled.

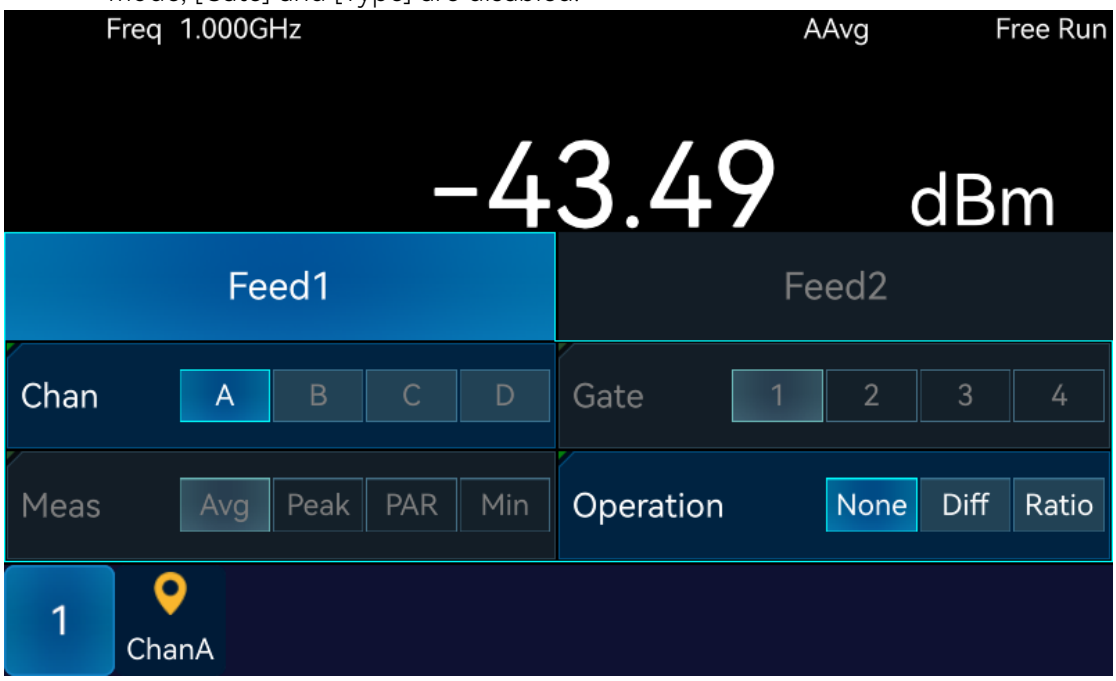


Figure 3.35 Data input in "Average Only" mode

2) Set [Main Menu]>[Channel]>[Channel A]>[General Setting]>[Mode] to "Normal". Click [Data Input] to enter the data input interface, where all functions can be set as shown in the figure below.

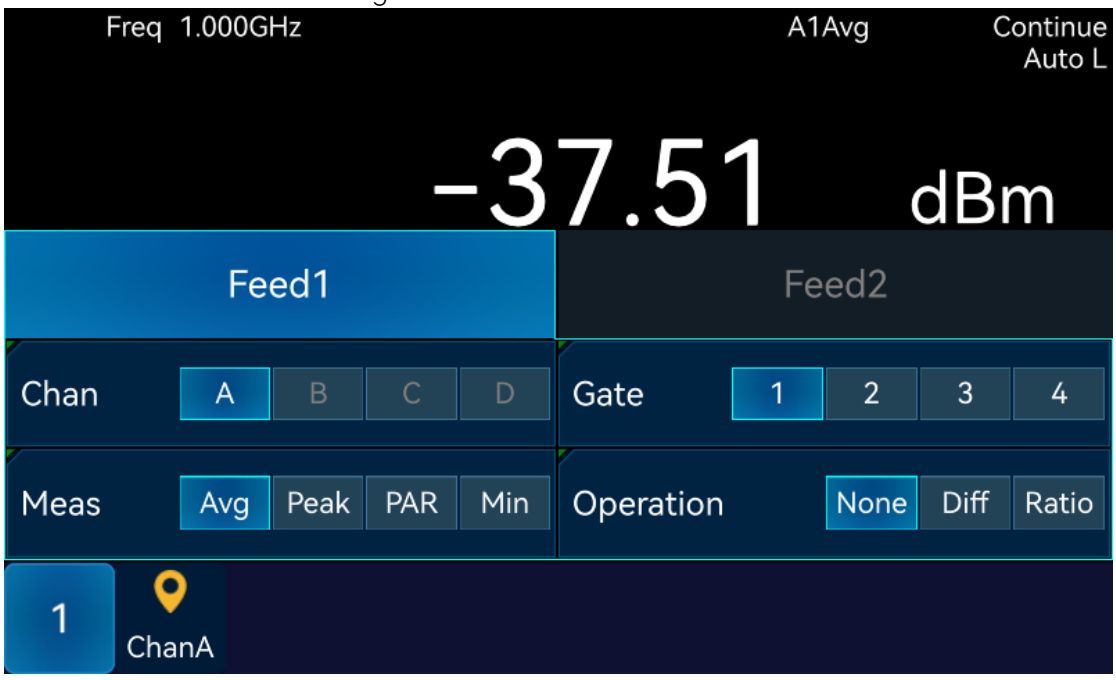


Figure 3.36 Data input in "Normal" mode

3) [Input 1] includes [Channel], [Gate], [Type], and [Operation]. Among them, [Channel] can be set to assign the current measurement to a specific channel; [Gate] can be set to assign the current measurement to a specific gate; [Type] can be set to define the current measurement as "Average", "Peak", "Peak-to-average ratio", or "Minimum" within the gate; [Operation] can be set to "None", "Difference", or "Ratio". When it is set to "None", [Input 2] cannot be set. When it is set to 'Difference' or "Ratio", [Input 2] can be set. As shown below, [Input 2] includes [Channel], [Gate], and [Type].

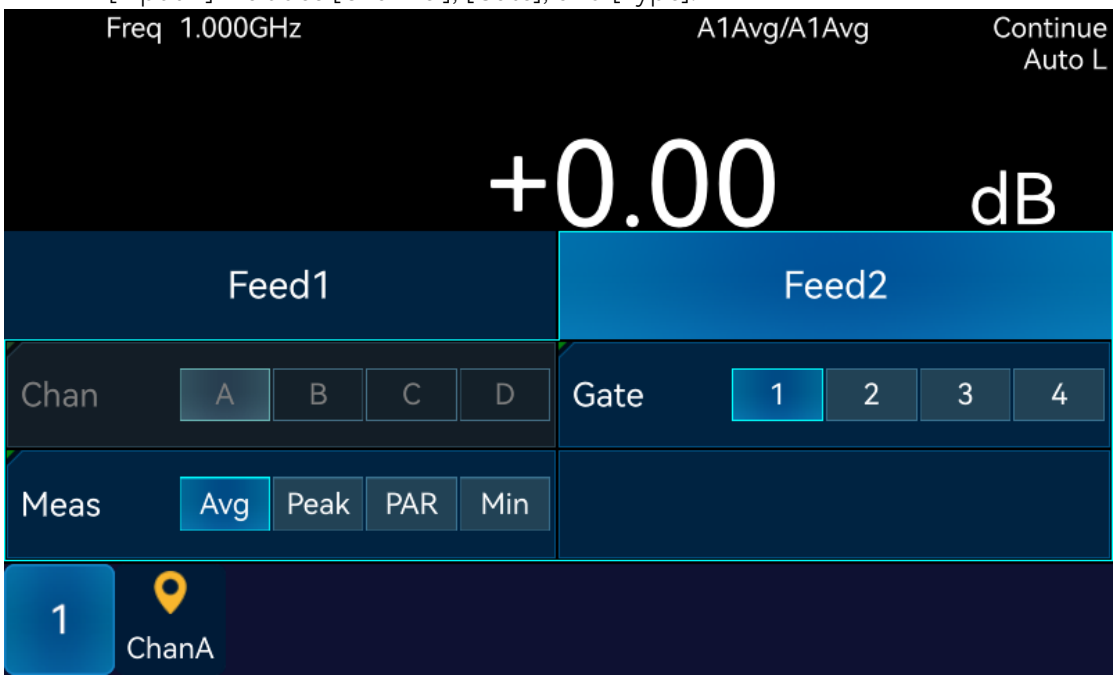


Figure 3.37 Input 2 in data input

3.2.3.6.3 Pulse power measurement

This section takes the channel A of the 2439D microwave power meter paired with the 87236D USB peak/average power probe as an example to explain in detail how to measure pulse power by gate.

Set the signal generator frequency to 1 GHz, power to 10 dBm, period to 100 us, and pulse width to 70 us.

The operation steps are as follows:

1) Click the layout thumbnail in the lower left corner to pop up the measurement window selection interface. Select 2 windows.
2) Click Window 1 to enter the window. Set [Main Menu]>[Display Mode]>[Channel A]>[Trace] to display the trace.
3) Click the waveform area to switch from small window display to medium window display. Set [Scale Setting]>[Horizontal Scale] to 30 us.
4) Set [Main Menu]>[Channel A]>[Gate Setting]. Set [Gate] to 1, [Gate Start] to 100

us, and [Gate Duration] to 70 us.

5) Press [Back] to return to the top-level interface. Click the second window to enter it.
6) Set [Data Input]>[Input 1]; set [Channel] to A, [Gate] to 1, [Type] to "Average", [Operation] to "None".
7) Press [Back] to return to the top-level interface. At this point, the measurement result in Window 2 is the average power of gate 1, i.e. the pulse power of the signal, as shown below.

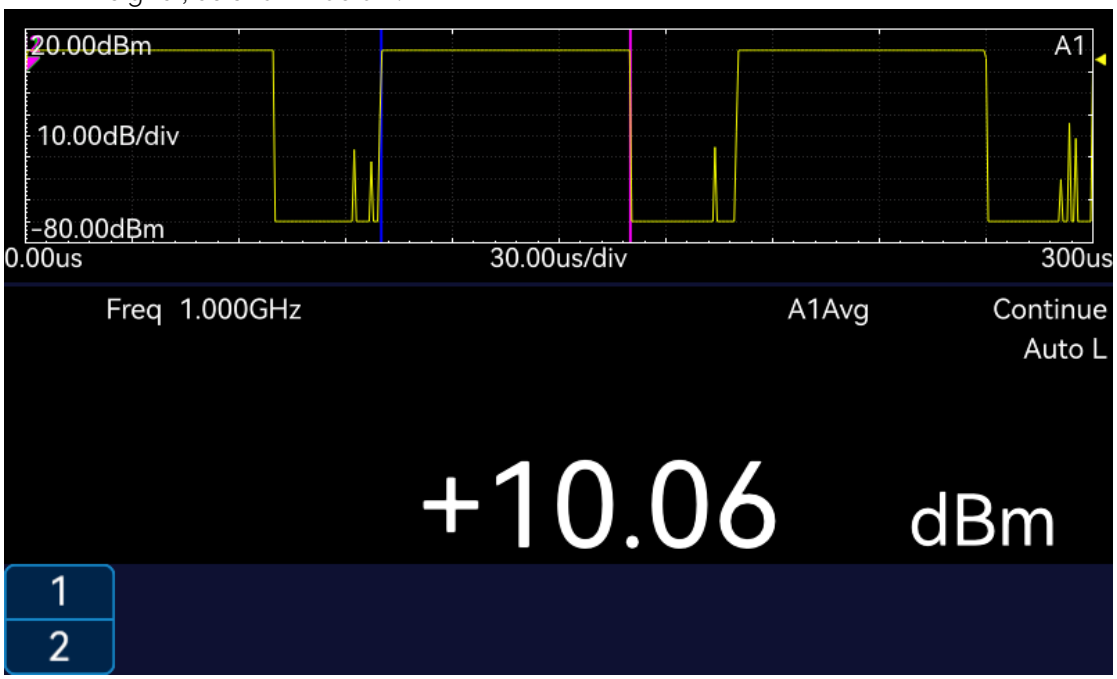


Figure 3.38 Pulse power measuring result

3.2.3.6.4 Peak-to-average ratio measurement

This section takes the channel A of the 2439D microwave power meter paired with the 87236D USB peak/average power probe as an example to explain in detail how to measure pulse power by gate.

Set the signal generator frequency to 1 GHz, power to 10 dBm, period to 100 us, and pulse width to 70 us.

The operation steps are as follows:

1) Click the layout thumbnail in the lower left corner to pop up the measurement window selection interface. Select 2 windows.
2) Click Window 1 to enter the window. Set [Main Menu]>[Display Mode]>[Channel A]>[Trace] to display the trace.
3) Click the waveform area to switch from small window display to medium window display. Set [Scale Setting]>[Horizontal Scale] to 30 us, and set [Gate] to 2.
4) Set the gate. Set [Main Menu]>[Channel A]>[Gate Setting]. Set [Gate] to 2, [Gate

Start] to 100 us, and [Gate Duration] to 100 us.

5) Press [Back] to return to the top-level interface. Click the second window to enter it.
6) Set [Data Input]>[Input 1]; set [Channel] to A, [Gate] to 2, [Type] to "Peak", [Operation] to "Ratio".
7) Set [Input 2]>[Channel] to A, [Gate] to 2, [Type] to "Average".
8) Press [Back] to return to the top-level interface. At this point, the measurement result in Window 2 is the peak/average power of gate 2, i.e. the peak-to-average ratio of the signal, as shown below.

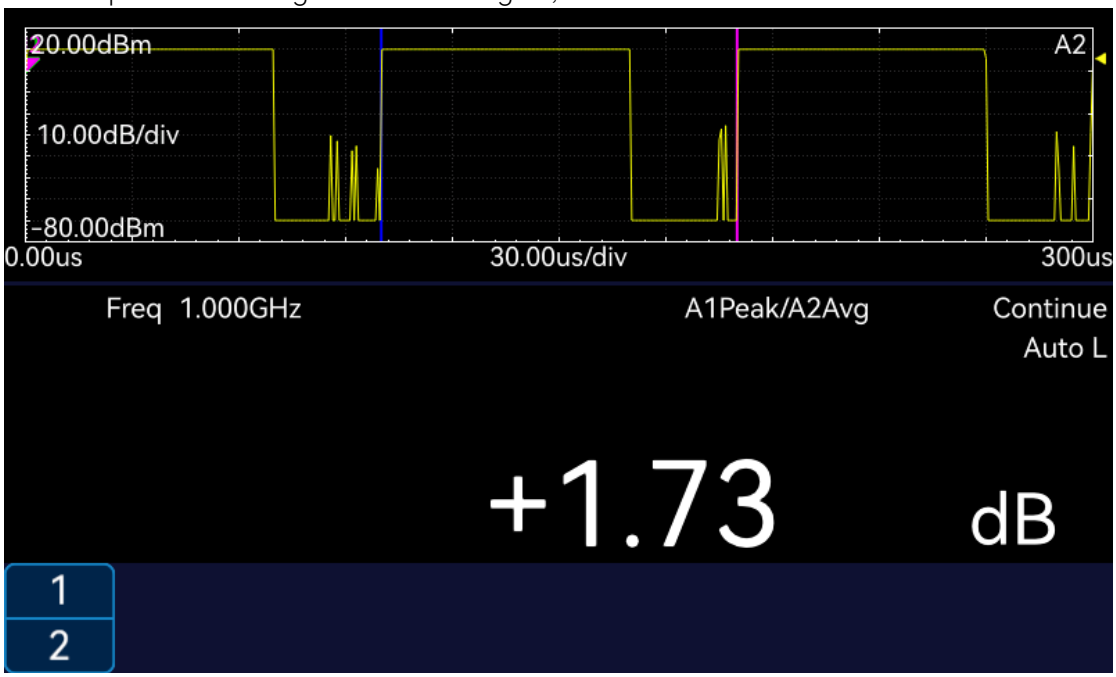


Figure 3.39 Measurement results of peak-to-average ratio

3.2.3.6.5 Pulse dropout measurement

This section takes the channel A of the 2439D microwave power meter paired with the 87236D USB peak/average power probe as an example to explain in detail how to measure pulse dropout by gate.

Set the signal generator frequency to 1 GHz, power to 10 dBm, period to 100 us, and pulse width to 70 us.

The operation steps are as follows:

1) Click the layout thumbnail in the lower left corner to pop up the measurement window selection interface. Select 2 windows.
2) Click Window 1 to enter the window. Set [Main Menu]>[Display Mode]>[Channel A]>[Trace] to display the trace.
3) Click the waveform area to switch from small window display to medium window display. Set [Scale Setting]>[Horizontal Scale] to 30 us.

4) Set the gate 3. Set [Main Menu]>[Channel A]>[Gate Setting]. Set [Gate] to 3, [Gate Start] to 107 us, and [Gate Duration] to 1 us.
5) Set the gate 4. Set [Main Menu]>[Channel A]>[Gate Setting]. Set [Gate] to 4, [Gate Start] to 162 us, and [Gate Duration] to 1 us.
6) Press [Back] to return to the top-level interface. Click the second window to enter it.
7) Set [Data Input]>[Input 1]; set [Channel] to A, [Gate] to 3, [Type] to "Average", [Operation] to "Ratio"".
8) Set [Input 2]>[Channel] to A, [Gate] to 4, [Type] to "Average".
9) Press [Back] to return to the top-level interface. At this point, the measurement result in Window 2 is the average power of gate 3 and gate 4, i.e. the pulse dropout of the signal, as shown below.

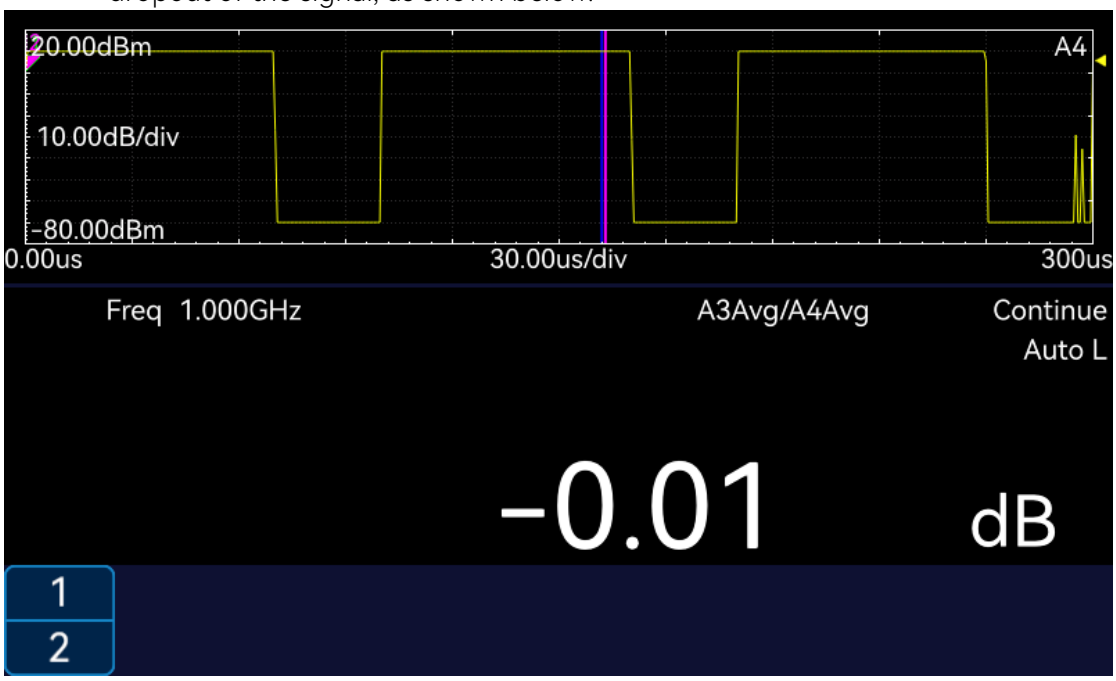


Figure 3.40 Pulse dropout measuring result

3.3.2.7 Usage of trigger function

The 2439D microwave power meter enables envelope parameter measurements for various modulated signals, including pulse modulation signals. It displays the power envelope waveform of the signal and provides corresponding amplitude and time parameters, offering users an intuitive visualization of the power variation in the measured signal. The trigger function is fundamental to stable measurement of pulse signals. Both stable waveform display and accurate amplitude/time measurements rely on a stable trigger.

The 2439D microwave power meter offers two trigger modes based on trigger source: internal trigger and external trigger. Regarding the internal trigger, the trigger

signal is generated internally by the peak power meter through analysis of its actual measurement data. Both waveform display and parameter calculations are referenced to this trigger signal. Regarding the external trigger, the peak power meter uses an external signal as the trigger signal for data processing. This is typically a TTL-level signal provided by the signal generating device, which is synchronized with the measured signal.

3.3.2.7.1 Usage of trigger menu

The trigger menu can be accessed via the [Main Menu] and is organized by channel. Each channel corresponds to a set of trigger function setting parameters. Users can switch between channel A and channel D by tapping the corresponding tab. The following uses channel A as an example to provide descriptions:

When [Trigger Mode] in the trigger menu is set to "Free Run", the power meter samples at a fixed rate, which is unaffected by trigger. Therefore, no additional trigger functions need to be configured, and other settings in the trigger menu are unavailable. Simultaneously, "Free Run" is displayed in the upper right corner of the numerical window. It is worth noting that trace measurement is not supported in "Free Run" mode. If the trace window is displayed in the screen, "Stop" appears in its upper right corner.



Figure 3.41 Trigger menu in "Free Run" mode

When [Trigger Mode] in the trigger menu is set to "Continuous Trigger/Single Trigger", the power meter's sampling is controlled by the trigger signal. Proper configuration of trigger parameters is required to achieve accurate measurements. Simultaneously, the upper right corner of the numerical window will display either

"Continuous Trigger" or "Single Trigger", which matches the current setting. At this point, by coordinating with [General Setting]>[Mode] in the channel menu, different measurement schemes can be implemented:

- When [Mode] is set to "Average Only", only [Extended Trigger] and its submenus—including [Trigger Edge], [Trigger Source], [Trigger Delay], and [Trigger Holdoff]—are available. This enables measurement of low-power signals in conjunction with an external trigger. Specific measurement methods are detailed in 3.3.2.7.2 Usage of trigger input function.It is worth noting that trace measurement is not supported. If the trace window is displayed in the screen, "Stop" appears , in its upper right corner.



Figure 3. 42 Trigger menu available only in average mode and "Continuous/Single Trigger" state

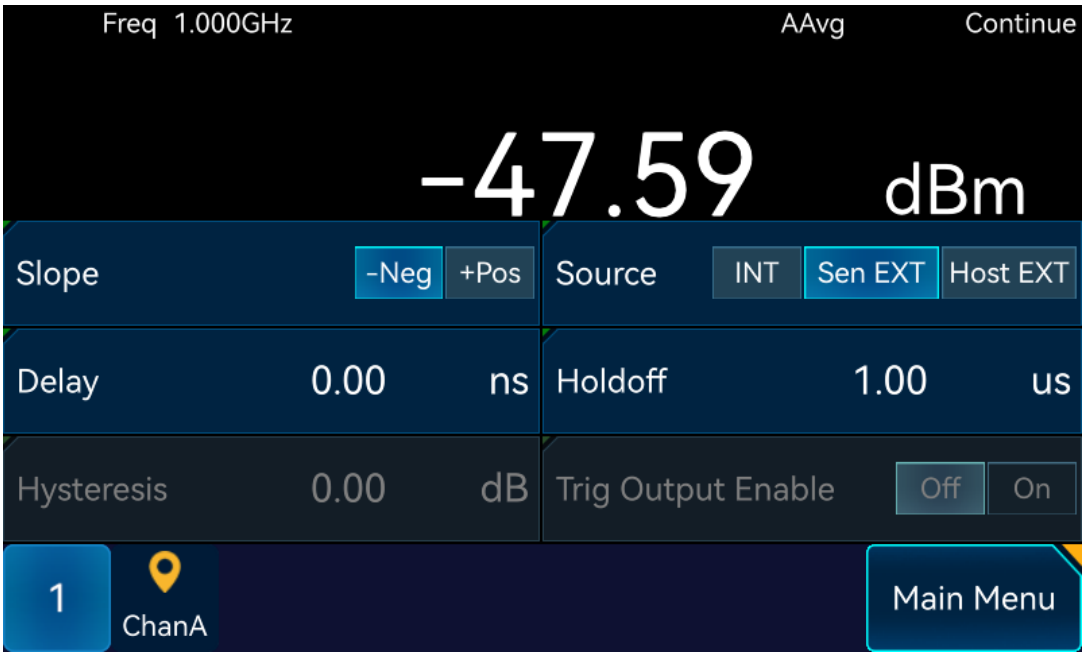


Figure 3. 43 Trigger menu-extended trigger menu available only in average mode and "Continuous/Single Trigger" state

- When [Mode] is "Normal", all trigger menus are available. This enables waveform display of pulse signals while acquiring power amplitude and timing parameters. Specific measurement methods are detailed in3.3.2.5 Peak power measurement.



Figure 3.44 Trigger menu available in normal mode and "Continuous/Single Trigger" state



Figure 3.45 Trigger menu-extended trigger menu available in normal mode and "Continuous/Single Trigger" state

The difference between continuous trigger and single trigger is that when "Single Trigger" is set, each press of the [Single Trigger] button or two presses of the [Run/Stop] button on the front panel of the 2439D microwave power meter will trigger one sampling upon receiving a trigger signal. After one measurement is completed, the measurement result is returned and then "Stop" mode is maintained for awaiting the next operation. During this waiting period, the word "Stop" is always displayed in the upper right corner of the window on the screen. Without a trigger signal, pressing [Single Trigger] yields no response. In this state, if users press the [Run/Stop] button, the power probe's operational state will be switched between "active" and "inactive" only.

[Trigger Level] is used to select the threshold level for trigger signals. When pulse-modulated signals are measured, the trigger level must be between the top power and the bottom power to achieve effective trigger. [Trigger Mode] is used to control the [Trigger Level]. When the trigger mode is set to "Auto-Level", the trigger level cannot be input. The power meter automatically sets the trigger level to 3 dB lower than the top power based on the measured pulse amplitude and updates the display in the [Trigger Level] field. When the trigger mode is set to "Normal/Auto", the trigger level must be manually entered. Generally, the trigger level shall be set 3 to 5 dB lower than the peak power of the measured signal to ensure stable trigger.

3.3.2.7.2 Usage of trigger input function

When users apply the 2439D microwave power meter paired with a power probe to measure pulse-modulated signals, if the measured signal power is low and the internal trigger level is insufficient for trigger, a pulse envelope signal synchronized with the measured signal can be input to the 2439D microwave power meter via the trigger input interface. By selecting an external trigger as the trigger source, stable trigger is achieved, enabling measurement of the pulse envelope signal.

The 2439D microwave power meter features two trigger input ports with identical function. Users can switch between them by clicking [Trigger Setting]>[Extended Trigger]>[Trigger Source] to provide greater operational flexibility. One trigger input port is located on the rear panel of the 2439D microwave power meter, corresponding to the "Outside of Instrument" option in [Trigger Source]. The other is positioned on the cable interface side of the power probe, corresponding to the "Outside of Probe" option in [Trigger Source].

3.3.2.7.2.1 Trace measurement of pulse signals in external trigger mode

When paired with the 87236 series USB peak/average power probes, the 2439D microwave power meter enables trace measurement of pulse signals. If the measured signal power is too low and the internal trigger level is insufficient for trigger, the trigger input function must be used for measurement.

The following takes the channel A of the 2439D microwave power meter paired with the 87236D USB peak/average power probe as an example to provide functional description. Set the signal generator to pulse modulation mode, the amplitude to -20 dBm, the frequency to 1 GHz, the pulse period to 100 us, and pulse width to 50 us. The specific operations of the power meter are as follows:

1) Connect the 87236D USB peak/average power probe to channel A of the 2439D microwave power meter, so that the power probe will be automatically recognized and connected.
2) Set the frequency for channel A power probe: Press the [Frequency] softkey on the right side of the 2439D microwave power meter, select [Channel A], and set the frequency to 1 GHz.
3) Set the mode for the channel A power probe: Press [Main Menu]>[Channel]>[Channel A]>[General Setting], and then select "Normal" for [Mode].
4) Set the trigger method and trigger source for the channel A power probe: Click [Main Menu]>[Trigger]>[Channel A], select "Continuous " for [Trigger Mode], and then click [Extended Setting] and select "Outside of Instrument" for [Trigger Source].
5) Set the display mode for channel A power probe: Click [Main Menu]>[Display Mode]>[Channel A], and then select "Trace" for the display mode.

6) Configure trace scale: Click the trace window to display the quick access toolbar on the right. Click [Scale Setting], and then modify [Horizontal Scale] to 20 us/division, [Vertical Center] to -30 dBm, and [Vertical Scale] to 10 dB/division.
7) Connect the power probe to the signal generator's output port. Connect the signal generator's pulse to the trigger input port of rear panel on the 2439D microwave power meter.
8) Activate the signal generator output. The pulse envelope signal now displays stably in the trace window.

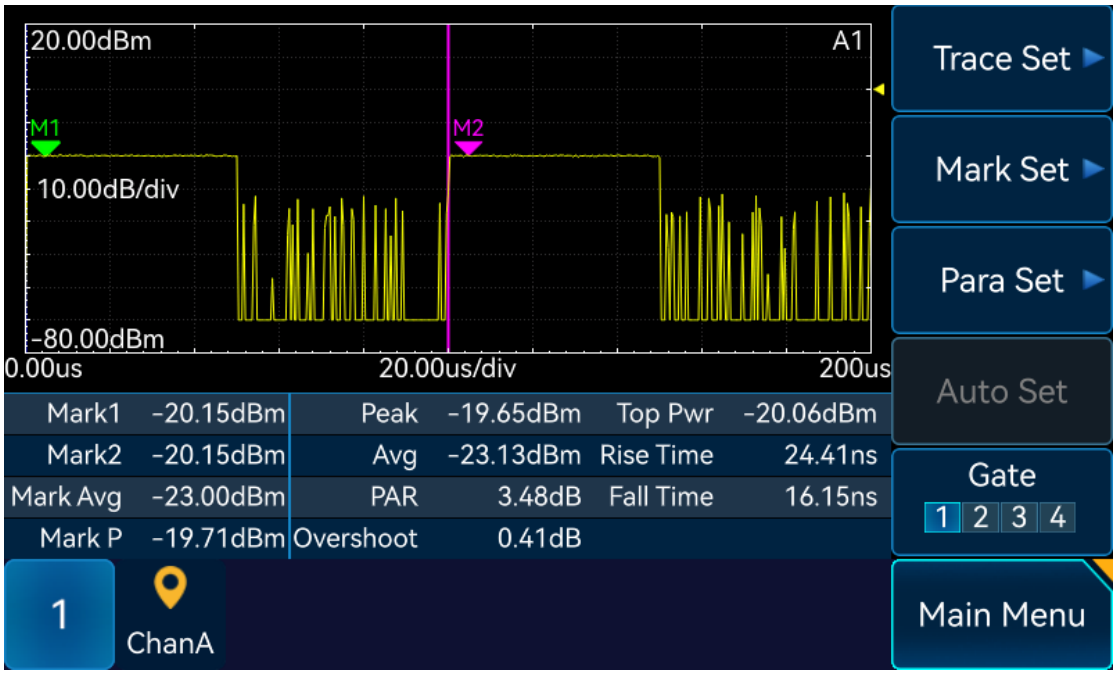


Figure 3. 46 Trace measurement of pulse signal in external trigger mode

3.3.2.7.2.2 Average power measurement of pulse signals in external trigger mode

The 2439D microwave power meter is paired with power probe. It can measure the average power of pulse-modulated signals using the trigger input function and aperture parameters. This refers to the average power over a period starting from the first transition of trigger, with the duration of this period being aperture-dependent.

The following takes the channel A of the 2439D microwave power meter paired with the 87235D USB average power probe as an example to provide functional description. Set the signal generator to pulse modulation mode, the amplitude to -40 dBm, the frequency to 1 GHz, the pulse period to 100 us, and pulse width to 50 us. The specific operations of the power meter are as follows:

1) Connect the 87235D USB average power probe to channel A of the 2439D microwave power meter, so that the power probe will be automatically

recognized and connected.

2) Set the frequency for power probe: Press the [Frequency] softkey on the right side of the 2439D microwave power meter, select [Channel A], and set the frequency to 1 GHz.
3) Set the mode and aperture for channel A power probe: Click [Main Menu]>[Channel]>[Channel A]>[General Setting]. Select "Average Only" for [Mode] and set [Aperture] to 50 ms.
4) Set the trigger method and trigger source for the channel A power probe: Click [Main Menu]>[Trigger]>[Channel A], select "Continuous " for [Trigger Mode], and then click [Extended Setting] and select "Outside of Instrument" for [Trigger Source].
5) Connect the 87235D USB average power probe to the signal generator's output port. Connect the signal generator's pulse to the trigger input port of rear panel on the 2439D microwave power meter.
6) Users activate the signal generator output. The measured signal power value will be visible in the value window. At this time, the power value represents the average power over 50 ms (aperture) starting from the first transition of trigger.



Figure 3 .47 Average power measurement of pulse signals in external trigger mode

3.3.2.8 Stable measurement method for long-period pulse signals

The 2439D microwave power meter can measure long-period pulse signals when it is paired with the 87236 series USB peak/average power probe. Due to the limited duration of the power meter's one sampling cycle, if the measured pulse signal period

exceeds 100 ms, the power meter requires manual trigger level setting to ensure stable trigger and stable display of the pulse envelope signal.

The following takes the channel A of the 2439D microwave power meter paired with the 87236D USB peak/average power probe as an example to provide functional description. Set the signal generator to pulse modulation mode, the amplitude to 0 dBm, the frequency to 1 GHz, the pulse period to 200 us, and pulse width to 10 ms. The specific operations of the power meter are as follows:

1) Connect the 87236D USB peak/average power probe to channel A of the 2439D microwave power meter, so that the power probe will be automatically recognized and connected.
2) Set the frequency for channel A power probe: Press the [Frequency] softkey on the right side of the 2439D microwave power meter, select [Channel A], and set the frequency to 1 GHz.
3) Set the mode for the channel A power probe: Press [Main Menu]>[Channel]>[Channel A]>[General Setting], and then select "Normal" for [Mode].
4) Set the trigger mode and trigger source for channel A power probe: Click [Main Menu]>[Trigger]>[Channel A], select "Continuous " for [Trigger Mode], select "Normal" for [Trigger Type], and set [Trigger Level] to -3 dBm.
5) Set the display mode for channel A power probe: Click [Main Menu]>[Display Mode]>[Channel A], and then select "Trace" for the display mode.
6) Configure trace scale: Click the trace window to display the quick access toolbar on the right. Click [Scale Setting], and then modify [Horizontal Scale] to 20 ms/division, [Vertical Center] to -20 dBm, and [Vertical Scale] to 10 dB/division.
7) Connect the power probe to the signal generator's output port. Turn on the signal generator output. A pulse envelope signal will now stably display in the trace window.

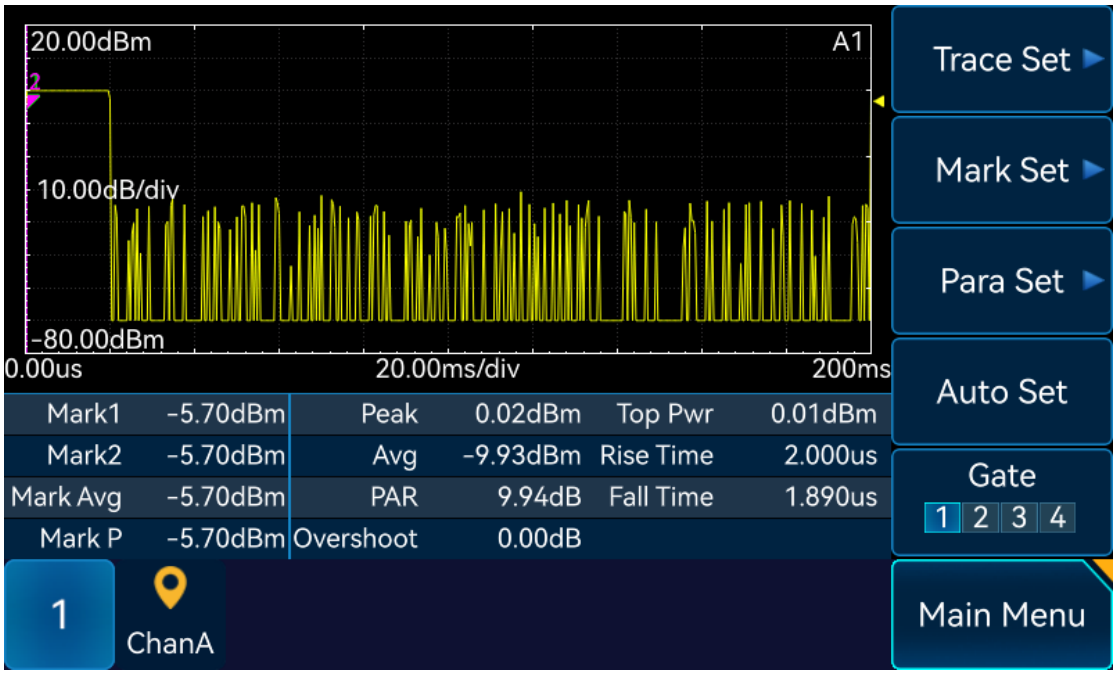


Figure 3. 48 Stable measurement of long-period pulse signals

3.3.2.9 Power measurement statistical analysis CCDF

CCDF indicates the percentage of sampling points within a given sample whose power level is greater than or equal to a specific value, relative to the total number of points in the sample. In the CCDF graph, **the X-axis represents the peak-to-average power ratio in dB; the Y-axis indicates the probability of occurrence of power levels greater than or equal to a given dB value.** For example, when the x-coordinate indicates 2 dB, the probability of occurrence is 50.00%. This means that the probability of a peak-to-average power ratio exceeding 2 dB is 50.00%. CCDF is primarily applied in communication systems for signal mixing, power amplification, and signal decoding. It can be used to evaluate modulation scheme effectiveness, signal mixing quality, spread spectrum systems, and for designing and manufacturing RF/microwave components.

The following takes channel A as an example to demonstrate how to display the CCDF waveform. The operation steps are as follows:

1) Click [Main Menu]>[Display Mode]>[Channel A]>[Statistics] to enter the CCDF statistical measurement window;
2) Set the scale. Click [Scale Setting]>[Horizontal Length] and set it to 12, namely the horizontal length of 12 dB;
3) Set stop operation. Set the operation to be performed after a specified duration or a specified number of statistical samples has been reached. Click [Stop Setting]>[Stop Action] and set it to "Clear".
4) End count. Click [Stop Setting]>[Stop Counting] and set it to 1000 MSa. In other

words, set [Stop Operation] when 1000MSa is reached. In this case, it is set to "Clear".

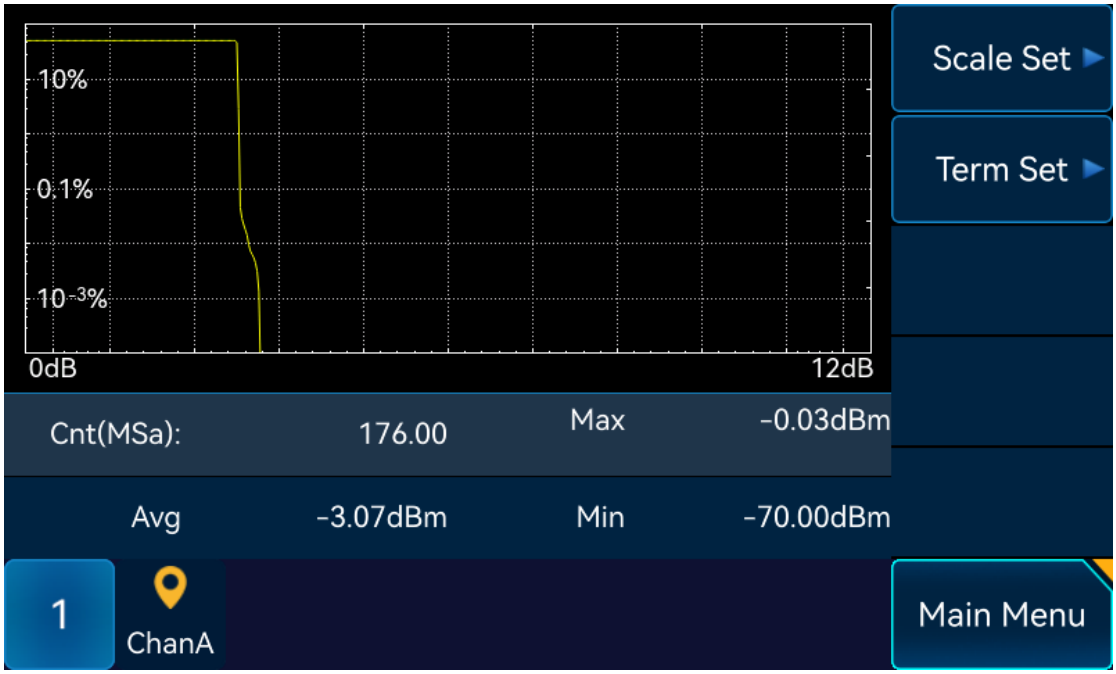


Figure 3.49 Statistical measurement

3.3.2.10 Web remote control

The 2439D microwave power meter supports remote access to its interface via a web browser.

The operation steps are as follows:

1) Click [Main Menu]>[System]>[Service]>[Next Page]>[Web Remote Control] and set it to "ON";
2) Connect the upper computer to the 2439D microwave power meter using an Ethernet cable.
3) Enter the IP address of the 2439D microwave power meter via a web browser to access the welcome interface, as shown in the figure. The default IP address is 192.168.1.101.

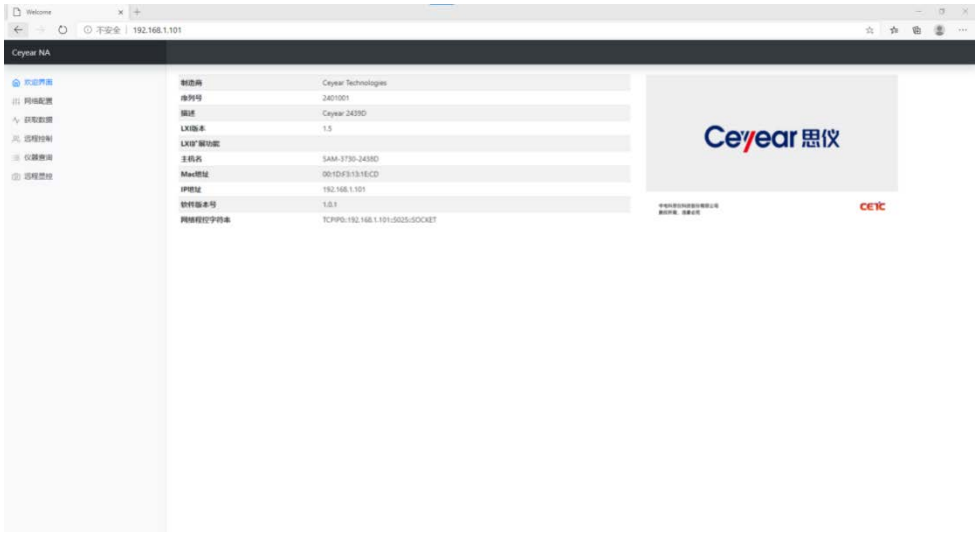


Figure 3.50 Web remote control welcome interface

4) Via a web browser, click [Remote Display Control]>[Display Control] to enter the display control interface. This allows real-time display of the 2439D microwave power meter interface and enables interface operation via a mouse, as shown in the figure.

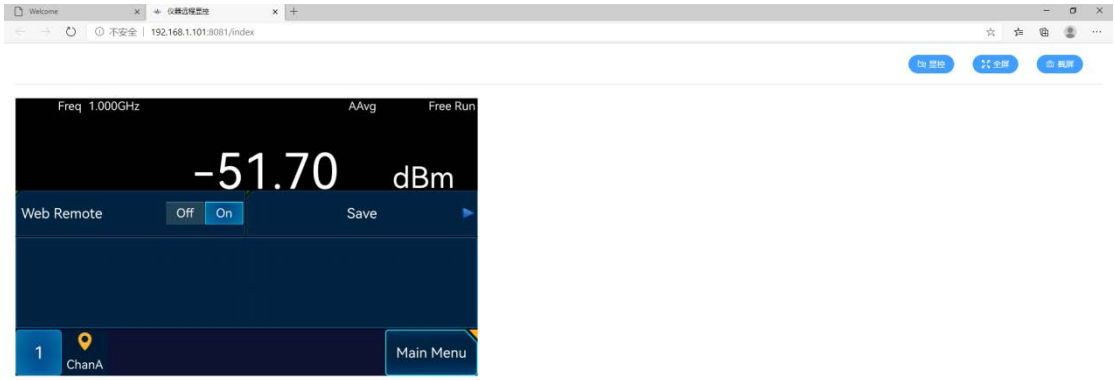


Figure 3.51 Display and control interface

3.3.2.11 Analog output

Through settings, the analog output interface generates an analog voltage signal corresponding to the power value measured by the power probe. Typically, the upper power limit corresponds to 5 V, the lower power limit corresponds to 0 V, and

intermediate power values are linearly mapped to voltage values between 5 V and 0 V. This signal can serve as amplitude stabilization reference for other instruments such as signal generators.

This section uses the A channel of the 2439D microwave power meter paired with the 87236D USB peak/average power probe as an example to provide a detailed explanation of how to use analogue output.

Set the frequency of the signal generator to 10 GHz and the power to 0 dBm.

The operation steps are as follows:

1) Click Window 1 to enter the window. Click [Extended Measurement] to enter the extended measurement interface. Click [Analog Output], set the state to "ON", and set the [Upper Limit] to 10 dBm and the [Lower Limit] to -5 dBm, as shown in the figure.



Figure 3.52 Analog output

2) When the signal generator output is greater than or equal to 10 dBm, the analog output interface outputs 5 V. When the signal generator output is less than or equal to -5 dBm, the analog output interface outputs 0 V. When the signal generator output is equal to 7dBm, the analog output interface outputs 2.5 V.

3.4 Data management

This section describes operating state storage/recall and programmed control recording file output of the 2439D microwave power meter.

- Storing/recalling operating state.....68

- Programmed control recording file output.....71

3.4.1 Storing/recalling operating state

- Reset state.....68
- Storing/recalling user state.....69

3.4.1.1 Reset state

The 2439D microwave power peter provides the user with the option of resetting state upon power-on as the initial state during power-on measurement. Typically, when the 2439D microwave power meter encounters a measurement error, its initial state during normal operation can be restored by resetting the 2439D microwave power meter. The reset state for the 2439D microwave power meter is set as follows:

Step 1. Open the reset configuration interface:

Press [Reset] on the front panel to enter the reset configuration interface.

Step 2. Execute the reset operation:

Press [Reset] to execute the reset operation.

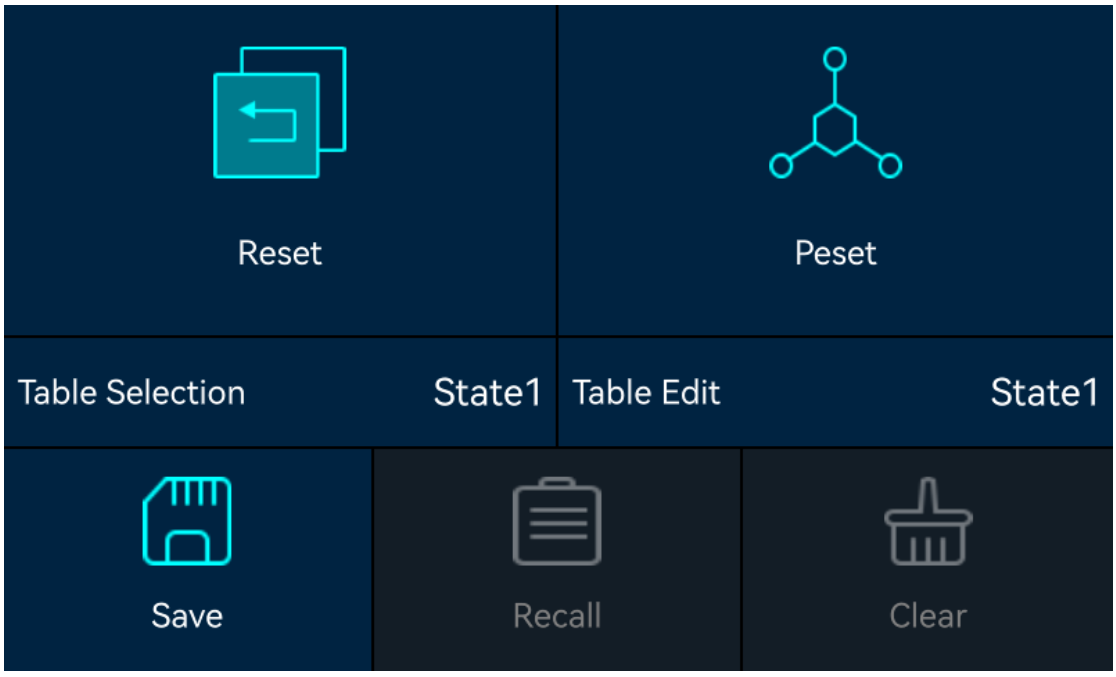


Figure 3.53 Reset configuration interface

3.4.1.2 Storing/recalling user state

The 2439D microwave power meter is capable of storing/recalling its measurement states, enabling users to restore required measurement states for further analysis.

Step 1. Open the storage/recall configuration interface:

Press [Reset] on the front panel to access the storage/recall configuration interface.

Step 2. Set the current storage/recall table:

Press [Storage/Recall Table Selection] to enter the storage/recall table selection interface as shown in Figure 3.54. Select the current storage/recall table. Press [State2] to set the current storage/recall table to "State2" as shown in Figure 3.55.

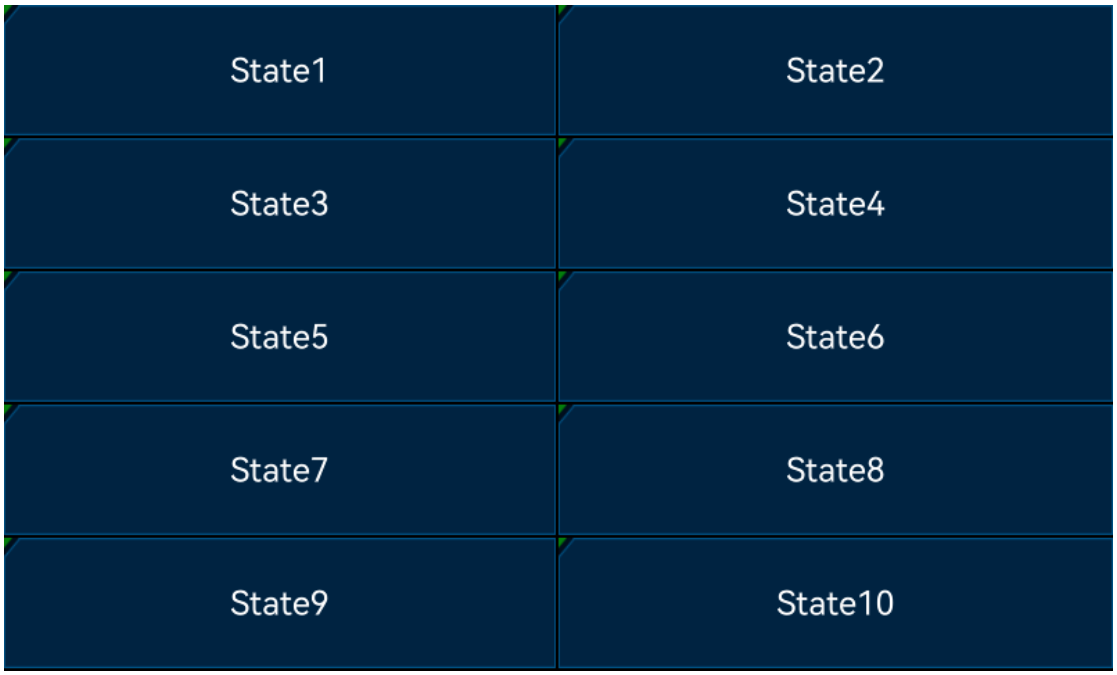


Figure 3.54 Storage/recall table selection

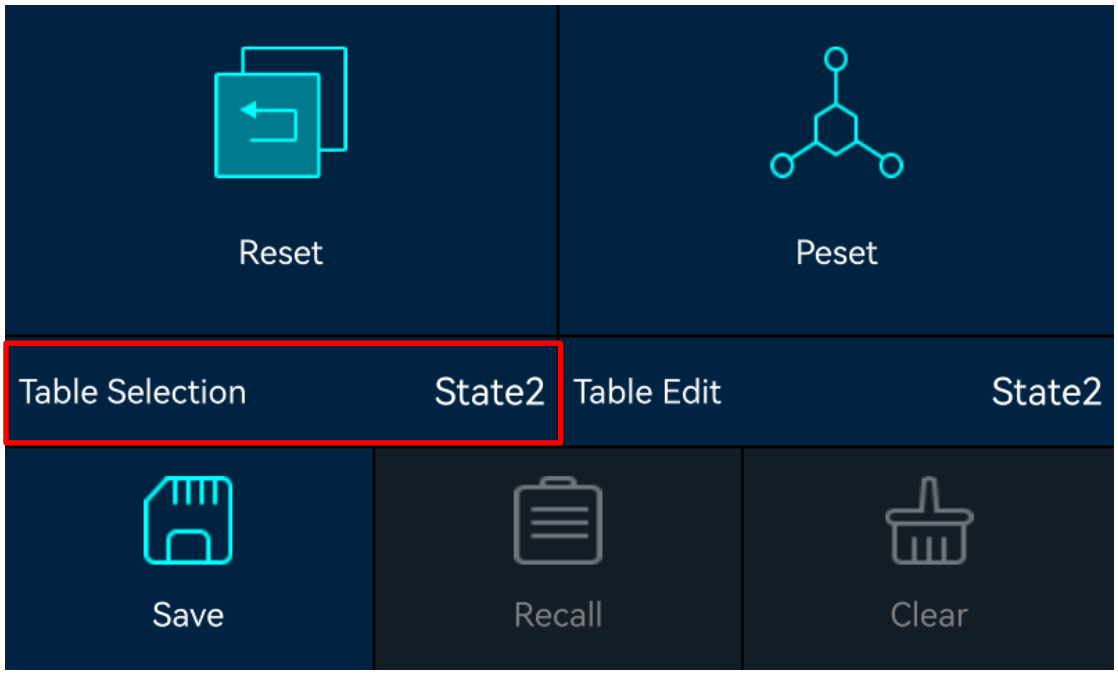


Figure 3.55 Current storage/recall table

Step 2. Store/recall/clear current storage/recall table:

Press [Store] to store the current measurement state of the 2439D microwave power meter to the current storage/recall table. At this point, the [Recall] and [Clear] buttons become settable, as shown in Figure 3.56. Press [Recall] to recall the measurement state from the current storage/recall table. Press [Clear] to clear the measurement state from the current storage/recall table.

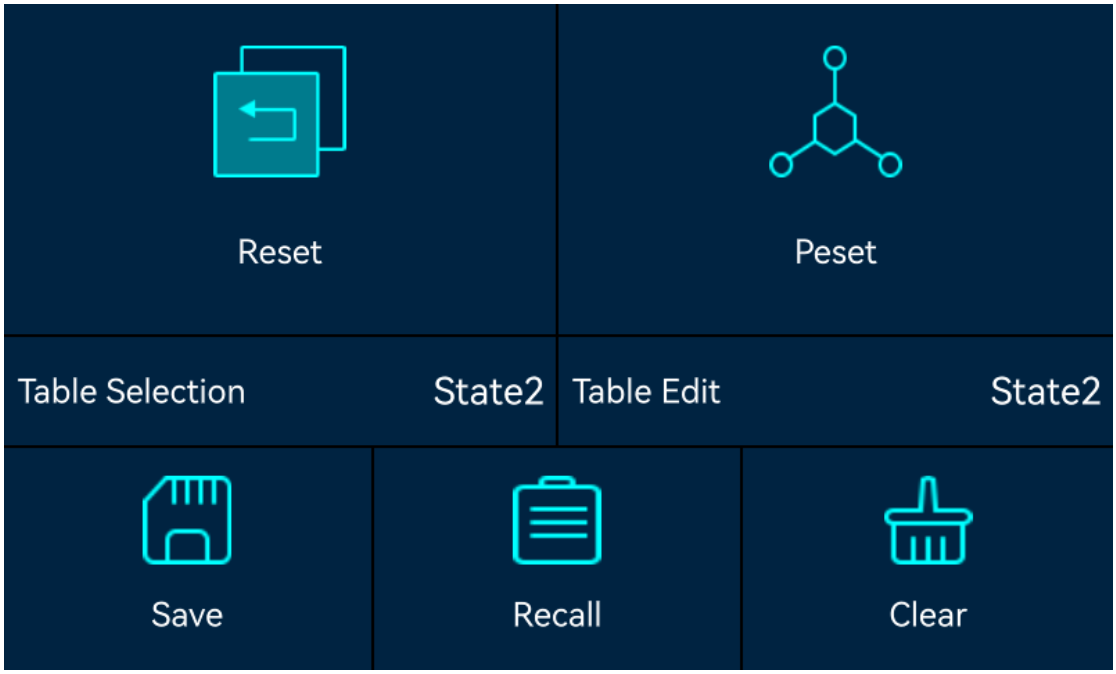


Figure 3.56 Storage/recall table storage

3.4.2Programmed control recording file output

The 2439D microwave power meter provides programmed control recording file output functionality, allowing users to store programmed control commands to a USB flash drive for convenient analysis and use.

Step 1. Open the programmed control recording configuration interface:

Press [Main Menu]>[System]>[Service]>[Programmed Control Recording] to enter the programmed control recording configuration interface.

Step 2. Enable programmed control recording and record programmed control commands:

Press 

to activate the programmed control recording function. All subsequent users' operations on the 2439D microwave power meter will be recorded as programmed control commands and displayed in the programmed control recording configuration interface, as shown in Figure 3.57.

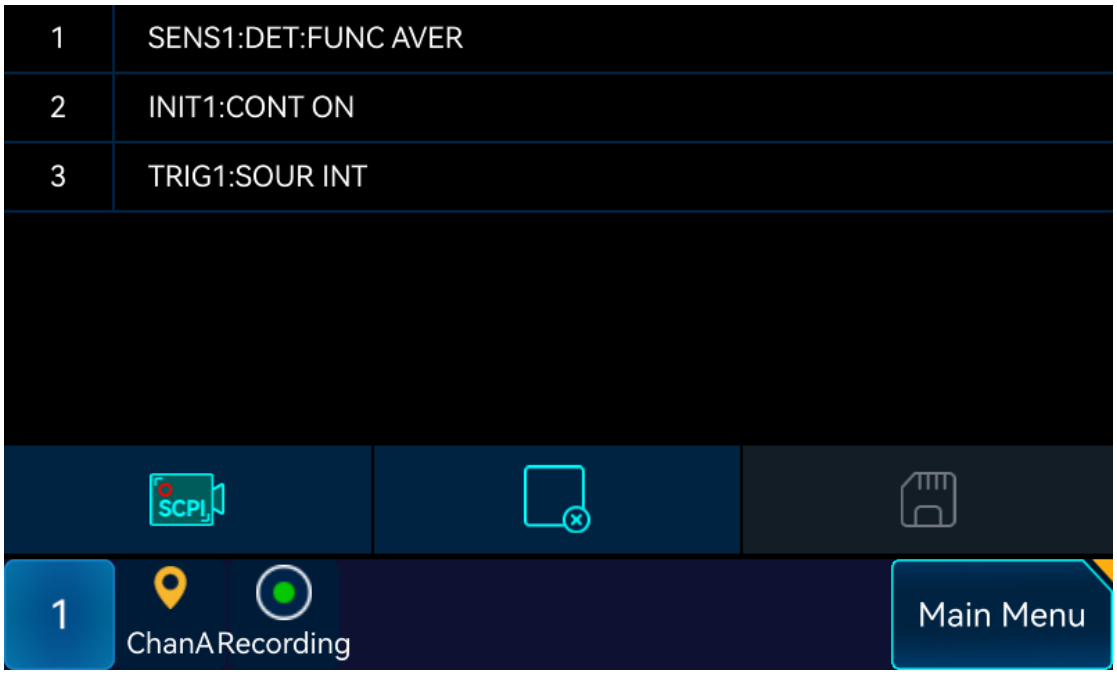


Figure 3.57 Programmed control recording configuration

Step 3. Store recorded programmed control commands to a USB flash drive:

Press  to clear the current programmed control recording commands. Press  to store the current programmed control recording commands to the USB flash drive.

4 Menu

The 2439D microwave power meter menu includes: Display Mode, Channel, Trigger, System, Numerical, Trace, Statistics, Zeroing, Frequency, Reset. All menu structures included in the 2439D microwave power meter and their detailed menu descriptions are listed in order below.

- Menu structure.....73
- Menu description.....73

4.1 Menu Structure

- Display mode.....73
- Channel.....74
- Trigger.....77
- System.....79
- Numerical.....82
- Trace.....84
- Statistics.....85
- Zeroing.....86
- Frequency.....87
- Reset.....87

4.2 Menu description

This section details menu items, functions, parameters and other information.

- Display mode.....73
- Channel.....74
- Trigger.....77
- System.....79
- Numerical.....82
- Trace.....84
- Statistics.....85
- Zeroing.....86
- Frequency.....87
- Reset.....87

4.2.1Display mode

Press [Main Menu]>[Display Mode] to pop up the display mode menu, which is used

to set the current window's display mode. Options include: Channel, Trace, Numerical, Statistics. The operation interface is shown in Figure 4.1, and the menu item description is shown in Table 4.1:

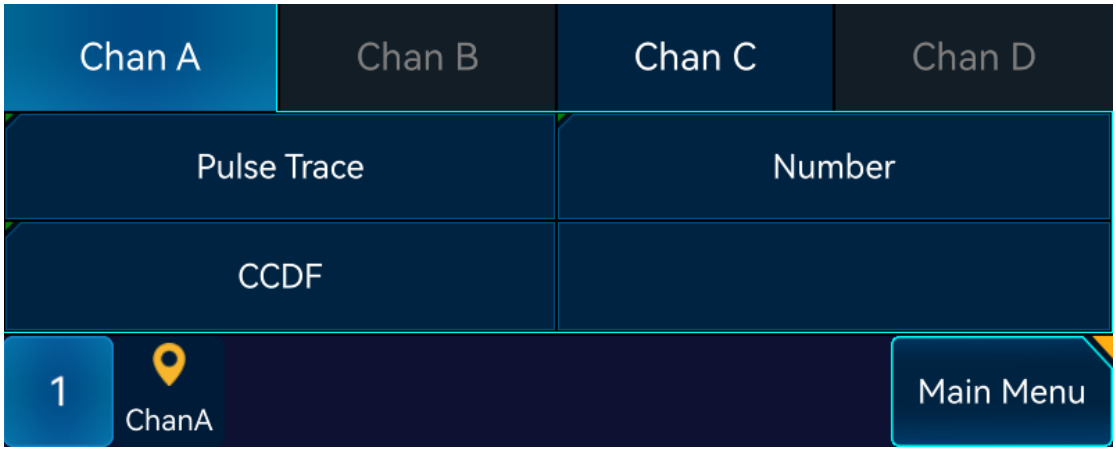


Figure 4.1 Display mode setting

Table 4.1 Display mode menu

Display mode	
Channel	Set the channels displayed in the current window, including [Channel A], [Channel B], [Channel C], and [Channel D].
Trace	Set the current window display to pulse trace.
Numerical Value	Set the current window display to power value.
Statistics	Sets the current window display to statistical traces.

注 意

Channel settings are only available when a power probe is connected to the channel.

4.2.2 Channel

Press [Main Menu]>[Channel] to pop up the channel menu for setting the channel of the 2439D microwave power meter. Specific menus include General Setting, Trace Setting, Gate Setting, and Offset. Menus are shown in Tables 4.2, 4.3, and 4.4. Menu item descriptions are provided in Tables 4.5, 4.6, 4.7, 4.8, and 4.9.

Table 4.2 Channel setting

Menu	Submenu
✧ Channel	
✧ Common Setting>>	Mode
	Aperture
	Step detection
	Average state
	Average count
	Average reset
✧ Trace Setting>>	Trace unit
	Trace average state
	Trace average
	VBW
	Pulse Definition>>
✧ Gate Setting>>	Gate
	Gate start
	Gate duration
	Auto gate
	Gate left reference
	Gate right reference
✧ Offset>>	Channel offset state
	Channel offset
	Frequency Response Offset>>

Table 4.3 Channel setting - pulse definition

Menu	Submenu
✧ Pulse Definition>>	Pulse definition
	Proximal line
	Mesial line
	Distal line

Table 4.4 Channel setting - frequency response offset

Menu	Submenu
✧ Frequency Response Offset>>	Frequency response offset
	Selection of frequency response offset table
	Name of frequency response offset table
	Edit>>

Table 4.5 Description of channel setting menu

Channel	
Channel	Set the affiliated channels under the channel setting, including [Channel A], [Channel B], [Channel C], and [Channel D].

Table 4.6 Description of general setting menu

Channel setting	
Mode	Set the detection measurement mode to Normal or Average Only.
Aperture	Set aperture size (i.e. measurement duration).
Step detection	The initialization filter increases the measurement speed when there is a large change in the measured power.
Average state	Turn off, or set the average count automatically or manually.
Average count	Setting range is 1-262144. Increasing the measurement average count reduces measurement noise, but increases measurement time.
Average reset	Average reset clears the measurement results in the buffer and re-caches and calculates them, effectively reducing the measurement time when the average count is high.

Table 4.7 Description of trace setting menu

Trace Setting	
Trace unit	Set the trace units to logarithmic and linear, respectively.
Trace average state	OF/OFF. Control ON/OFF state of trace average.
Trace average	The average count the signal has been triggered, to smooth the display trace and reduce noise.
VBW	Digital filtering is used to achieve different video bandwidths.
Pulse definition	Set definition mode to power or voltage.
Distal line	Set distal line value.
Mesial line	Set mesial line value.
Proximal line	Set proximal line value.

Table 4.8 Description of gate setting menu

Gate setting	
Gate selection	Select the current gate and set the start time and length of the current gate.
Gate Start	Current gate start time.
Gate duration	Current gate duration.
Auto gate	Enable or disable Auto Gate for the current gate.
Gate left reference	Current gate left reference percentage (available only when Auto Gate is enabled).
Gate right reference	Current gate left reference percentage (available only when Auto Gate is enabled).

Table 4.9 Description of offset setting menu

Offset setting	
Channel offset state	Turn channel offset on or off.
Channel offset	Set the channel deviation applied to the measured power before the mathematical operation.
Frequency response offset ON/OFF	Current gate start time.
Frequency response offset selection	Enable or disable frequency response offset.
Name of frequency response offset table	Edit the name of the current frequency response offset table.
Edit	Edit the current frequency response offset table to insert frequencies and gains.

4.2.3 Trigger

Press [Main Menu]>[Trigger] to pop up the trigger menu. Trigger forms the foundation for stable measurement of pulse signals. The pulse envelope is shaped to generate a trigger signal synchronized with the measured signal. The first or last transition of this trigger signal is used as the trigger position, enabling accurate power measurements and stable trace waveforms.

This section primarily covers the trigger setting menu for the 2439D microwave power meter, including trigger type, trigger mode, trigger level, trigger edge, trigger source, trigger delay, trigger holdoff, trigger hysteresis, and trigger output enable. The menu is shown in Table 4.10. Menu item descriptions are shown in Table 4.11.

Table 4.10 Trigger setting

Menu	Submenu
✧ Channel	
✧ Trigger mode	
✧ Trigger Mode	
✧ Trigger level	
✧ Extended Trigger>>	Trigger edge
	Trigger Source
	Trigger delay
	Trigger Holdoff
	Trigger Hysteresis
	Trigger output enable

Table 4.11 Description of trigger setting menu

Trigger setting	
Channel	Set the affiliated channels under the trigger setting, including [Channel A], [Channel B], [Channel C], and [Channel D].
Trigger mode	Set free-run, continuous trigger or single trigger mode. Free run: Sampling is performed at a fixed rate, which is unaffected by trigger. Continuous trigger: Sampling is controlled by the trigger signal. At the time of measuring pulse-modulated signals, setting an appropriate trigger level generates a trigger signal synchronized with the pulse modulation envelope, enabling accurate and stable measurements. Single trigger: When a trigger signal is present, pressing [Single Trigger] once triggers one sampling; when no trigger signal is present, pressing [Single Trigger] will not trigger sampling.
Trigger mode	Set to Auto-Level, Normal or Auto.
Trigger level	Set the trigger level manually in normal and auto trigger mode.
Trigger edge	Set to trigger on the or last transition of the signal.
Trigger source	Set internal trigger or external trigger.
Trigger delay	Set the delay time between the trigger event and the gating start event, applied to all gates.
Trigger holdoff	Set the trigger holdoff time, and disable the trigger within this time.

Trigger hysteresis	Set the trigger hysteresis value.
Trigger output enable	Enable a TTL level synchronized with the input signal.

4.2.4 System

Press [Main Menu]>[System] to pop up the system menu, which applies to settings related to the 2439D microwave power meter system. Specific functions include Remote Interface, Error List, About, Service, Chinese/English Switch, and Probe Information. Menus are detailed in Tables 4.12 to 4.17. Menu item descriptions are shown in Tables 4.18 to 4.25.

Table 4.12 System setting

Menu	Submenu
✧ Remote Interface>>	GPIB
	Address mode
	IP address
	Subnet
	Gateway
	Interface information
✧ Error List>>	Local error
	Programmed control error
✧ About	
✧ Service>>	Time>>
	Instrument software update
	Commissioning Mode>>
	Programmed Control Recording>>
	Version Information>>
	Page Down>>
✧ Chinese/English Switch	
✧ Probe Information	

Table 4.13 System setting-service-time

Menu	Submenu
✧ Time>>	Time of this run
	Accumulated runtime
	Clear current data

Table 4.14 System setting-service-programmed control recording

Menu	Submenu
✧ Programmed Control Recording>>	Record ON/OFF
	Clear
	Store to USB flash drive

Table 4.15 System setting-service-version information

Menu	Submenu
✧ Version Information>>	Hardware version information
	Software version information
	CPU board version information

Table 4.16 System setting- services - page down

Menu	Submenu
✧ Page Down>>	Web remote control
	Overload>>

Table 4.17 System setting- services - page down- overload

Menu	Submenu
✧ Overload>>	Overload ON/OFF
	Overload list

Table 4.18 System menu description

System	
About	It is used to display basic information of the 2439D microwave power meter, including model, version number, manufacturer, and contact details.
Chinese/English switch	Set Chinese and English display for the 2439D microwave power meter
Probe information	It is used to display connection state for each channel of the 2439D microwave power meter, including power probe model, serial number, and version number.

Table 4.19 Description of remote interface menu

Remote Interface	
GPIB	Set the GPIB address for the 2439D microwave power meter.
Address mode	Set the IP address acquisition method for the 2439D microwave power meter to Static or Dynamic.
IP address	Set the IP address for the 2439D microwave power meter.
Subnet	Set subnet mask of the 2439D microwave power meter.
Gateway	Set default gateway of the 2439D microwave power meter.
Interface information	Display interface information for the 2439D microwave power meter, including Socket, HISLIP, VXI-11, USBTMC, and GPIB.

Table 4.20 Description of error list menu

Error List	
Local error	Display local errors for the 2439D microwave power meter.
Programmed control error	Display errors generated by programmed control of the 2439D microwave power meter.

Table 4.21 Description of service list menu

Service	
Instrument software update	Update the 2439D microwave power meter software via USB flash drive.
Commissioning mode	Enter the 2439D microwave power meter commissioning menu, which is not accessible to users.

Table 4.22 Description of time setting menu

Time	
Time of this run	Display the runtime since the last power-on of the 2439D microwave power meter.
Accumulated runtime	Display the cumulative runtime since delivery of the 2439D microwave power meter.
Clear current data	Clear runtime since the last power-on of the 2439D microwave power meter.

Table 4.23 Description of programmed control recording menu

Programmed Control Recording	
Record ON/OFF	Enable or disable programmed control recording of the 2439D microwave power meter
Clear	Clear the programmed control commands for this recording from the 2439D microwave power meter.
Store to USB flash drive	Store the programmed control commands for this recording from the 2439D microwave power meter to a USB flash drive.

Table 4.24 Description of version information menu

Version Information	
Hardware version information	Display hardware-related information of the 2439D microwave power meter, including the CPU board, keyboard board, and rear panel.
Software version information	Display software-related information of the 2439D microwave power meter, including software name, serial number, and version number.
CPU board version information	Display CPU board information for the 2439D microwave power meter, including FPGA version number.

Table 4.25 Description of page-down menu

Page Down	
Web remote control	Enable or disable the web remote control function for the 2439D microwave power meter.
Overload ON/OFF	Enable or disable overload protection of the 2439D microwave power meter.
Overload list	Display overload-related information for the 2439D microwave power meter.

4.2.5 Numerical

Press [Main Menu]>[Display Mode]>[Numerical] to switch the current window to numerical display. The numerical menu is located on the right side of the numerical display window. This menu is used to set the numerical display window, such as switching power units within the numerical window. It primarily includes measurement units, resolution, relative measurement, extended measurement, and data input. The menu is shown in Table 4.26. Menu item descriptions are shown in Table 4.27.

Table 4.26 Value measurement setting

Menu	Submenu
✧ Unit	
✧ Resolution	
✧ Relative Measurement>>	Relative measurement ON/OFF
	Relative power
✧ Extended Measurement>>	Measurement limit ON/OFF
	Measurement upper limit
	Measurement lower limit
	Analogue output ON/OFF
	Analog output upper limit
	Analog output lower limit
✧ Data input	Input 1
	Input 1 channel
	Input gate 1
	Input 1 type
	Input 1 operation
	Input 2
	Input 2 channel
	Input gate 2
	Input 2 type

Table 4.27 Description of value measurement setting menu

Measurement setting	
Unit	Set the current measurement to logarithmic or linear measurement units.
Resolution	Set the measurement result display resolution of the current measurement.
Relative measurement ON/OFF	Enable relative mode for the current measurement.
Relative power	Click relative power to calculate the relative measurement result of the current measurement value and the reference value.
Measurement limit ON/OFF	Set the ON/OFF state for the measurement limit of the current measurement.
Upper limit	Set the upper limit value for the current measurement.
Lower limit	Set the lower limit value for the current measurement.

Analogue output ON/OFF	Set the ON/OFF state of analog output for the current measurement.
Analog output upper limit	Set the upper limit value of analogue output for the current measurement.
Analog output lower limit	Set the lower limit value of analogue output for the current measurement.
Input 1	Switch the input 1 display, including channel, gate, type, and operation.
Input 1 channel	Set the input 1 channel, including channel A, channel B, channel C, and channel D. It is only active when a channel is connected to a power probe.
Input gate 1	Set the input 1 gate, including gates 1 to 4.
Input 1 type	Set the input 1 type, including average, peak, peak-to-average ratio, and minimum.
Input 1 operation	Set the input 1 operation, including none, difference, and ratio.
Input 2	Toggle the input 1 display, including channel, gate, and type.
Input 2 channel	Set the input 2 channel, including channel A, channel B, channel C, and channel D. (setting not supported)
Input gate 2	Set the input 2 gate, including gates 1 to 4.
Input 2 type	Set the input 2 type, including average, peak, peak-to-average ratio, and minimum.

4.2.6 Trace

Press [Main Menu]>[Display Mode]>[Trace] to switch the current window to trace display. The trace menu is located on the right side of the trace display window. This menu is used to set pulse trace display modes, including scale setting, marker setting, parameter configuration, auto setting, and current gate. The menu is shown in Table 4.28. Menu item descriptions are shown in Table 4.29.

Table 4.28 Trace setting

Menu	Submenu
✧ Scale Setting>>	Horizontal start
	Horizontal scale
	Vertical center
	Vertical scale
✧ Marker Setting>>	Marker 1
	Marker 2
	Marker type

✧ Parameters Configuration	
✧ Auto setting	
✧ Gate	

Table 4.29 Description of trace setting menu

Trace Setting	
Horizontal start	Set the start time on the leftmost part of the trace window.
Horizontal scale	Set the time represented by each division in the horizontal direction of the trace window.
Vertical center	Set the power value represented by the center in the vertical direction of the trace window.
Vertical scale	Set the power represented by each division in the vertical direction of the trace window.
Marker 1	Set the horizontal position of the marker 1.
Marker 2	Set the horizontal position of the marker 2.
Marker type	Set the marker time parameters or marker power parameters in the marker information display area.
Parameters Configuration	Set the displayed pulse parameter types in the pulse parameter display area, with up to 8 types selected.
Auto setting	Automatically set the horizontal start, horizontal scale, vertical center, and vertical scale of pulse trace.
Gate	Set the gate currently displayed for the pulse trace.

4.2.7 Statistics

Press [Main Menu]>[Display Mode]>[Statistics] to switch the current window to trace display. The trace menu is located on the right side of the trace display window. This menu is used to set pulse trace display modes, including scale setting, marker setting, parameter configuration, auto setting, and current gate. The menu is shown in Table 4.30. Menu item descriptions are shown in Table 4.31.

Table 4.30 Statistics setting

Menu	Submenu
✧ Scale Setting>>	Horizontal length
✧ Stop Setting>>	Capture settings
	End operation
	End count

Table 4.31 Description of statistics setting menu

Statistics Setting	
Horizontal length	Set the horizontal length of statistical trace display.
Capture settings	Set to run or stop the current capture.
End operation	Set the current post capture state.
End count	Set the current capture end count condition.

4.2.8 Zeroing

Press [Zero] on the front panel to pop up the zeroing menu. This menu is used to set zeroing for the 2439D microwave power meter. The specific menu includes Channel, Zeroing Type, Reference Source, and Zeroing. The menu is shown in Table 4.32. Menu item descriptions are shown in Table 4.33.

Table 4.32 Zeroing setting

Menu	Submenu
✧ Channel	
✧ Zeroing Type	
✧ Reference source	
✧ Zeroing	

Table 4.33 Description of zeroing setting menu

Zeroing Setting	
Channel	Set the affiliated channels under the current zeroing, including [Channel A], [Channel B], [Channel C], and [Channel D].
Zeroing type	Zeroing types are categorized as Internal or External. Internal: Using an internal switch, zeroing can be performed without turning off the signal generator output. External: Signal generator output must be turned off to perform zeroing. Additionally, external zeroing is required, particularly for small signal measurements.
Reference source	Turn on the reference source to output a 0 dBm, 50 MHz signal.
Zero	Execute zeroing once.

4.2.9 Frequency

Press [Frequency] on the front panel to pop up the frequency menu. Thismenu is used to set the frequency for the 2439D microwave power meter. Specific menus include Channel and Frequency. The menu is shown in Table 4.34. Menu item descriptions are shown in Table 4.35.

Table 4.34 Frequency setting

Menu	Submenu
✧ Channel	
✧ Frequency	

Table 4.35 Description of frequency setting menu

Frequency setting	
Channel	Set the affiliated channels under the current zeroing, including [Channel A], [Channel B], [Channel C], and [Channel D].
Frequency	Set measurement frequency.

4.2.10 Reset

Press [Reset] on the front panel to pop up the reset menu, which is part of the reset and storage/recall functions of the 2439D microwave power meter. Main functions include: Reset, Preset, Storage/Recall Table Selection, Storage/Recall Table Editing, Store, Recall, Clear. The menu is shown in Table 4.36. Menu item descriptions are shown in Table 4.37.

Table 4.36 Reset setting

Menu	Submenu
✧ Reset	
✧ Preset	
✧ Storage/Recall Table Selection	
✧ Storage/Recall Table Editing	
✧ Storage	
✧ Recall	
✧ Clear	

Table 4.37 Description of reset setting menu

Trace Setting	
Reset	Reset the 2439D microwave power meter measurements to factory defaults.
Preset	Preset include 24 options. Users can select the appropriate preset state based on the test object to quickly configure parameters such as "Display Type", "Horizontal Scale", "Vertical Scale", "Measurement Gate", and "Frequency". This facilitates accurate and rapid measurement of various power and time parameters.
Storage/recall table selection	Select the current storage/recall table from 10 available options.
Storage/Recall Table Editing	Edit the name of the current storage/recall table.
Storage	Store the current state of the 2439D microwave power meter into thecurrent storage/recall table.
Recall	Recall the state from the current storage/recall table into the 2439D microwave power meter.
Clear	Clear the storage state of the current storage/ recall table.

5. Remote control

This chapter introduces the programmed control fundamentals, programmed control interface and configuration methods of the 2439D microwave power meter, and briefly introduces the concept and classification of I/O instrument driver library. The purpose is to facilitate users to start to achieve remote control. Specific contents include:

- Remote control fundamentals.....89
- Instrument programmed control port and configuration.....109
- Basic VISA interface programming 112
- I/O library.....115

5.1 Remote control fundamentals

5.1.1 Programmed control interface

Instruments with remote control function generally support three kinds of remote control interface: LAN, GPIB and USB, and the type of port supported by the specific model of instrument is determined by the function of the instrument.

Table 5.1 Remote control interface type and VISA addressing string

Programmed control interface	VISA address string (Note 1)	Description
LAN (local area network)	● VXI-11 protocol TCPIP::host address[::LAN device name][::INSTR] VISA ● HiSLIP protocol TCPIP::host address::hislip0[::INSTR] VISA ● Original socket protocol TCPIP::host address[::LAN device name]::<port>::SOCKET	The controller realizes remote control by connecting the instrument with the network port on the rear panel of the instrument. For details of the protocol, please refer to: "5.1.1.1 LAN interface".
GPIB (IEC/IEEE Bus Interface)	GPIB::primary address[::INSTR]	The controller realizes remote control by connecting the instrument with the port on the rear panel

		of the instrument. The bus interface standard IEC 625.1/IEEE 418 is met. For details, please refer to: "5.1.1.2 GPIB interface".
USB (Universal Serial Bus)	USB::<vendor ID>::<product_ID>::<serial_number>[::INSTR]	Instrument rear panel port. For details, please refer to: "5.1.1.3 USB interface"

Note 1: VISA, that is, virtual instrumentation software architecture, is a set of standard software interface function library. Users can use this function library to control instruments via GPIB, LAN, USB and other interfaces. Users shall first install the VISA library on the control computer and use the VISA library to achieve remote instrument control. Please refer to the user's manual of the installed VISA library for details.

5.1.1.1 LAN interface

It can be controlled remotely by computers in LAN 10Base-T or 100Base-T. Various instruments are combined into a system in LAN and controlled uniformly by computers in it. In order to realize the remote control in the LAN, the 2439D microwave power meter shall be installed with port connector, network card and relevant network protocol in advance, and provided with relevant network services. Meanwhile, the controller computer in the network shall also be equipped with instrument control software and VISA library in advance. The three operating modes of the network card are:

- 10Mbit/s Ethernet IEEE802.3;
- 100Mbit/s Ethernet IEEE802.3u;
- 1Gbit/s Ethernet IEEE802.3ab.

The controller computer and the 2439D microwave power meter shall be connected to the common TCP/IP protocol network through the network port. The cable between the computer and the 2439D microwave power meter is a commercial RJ45 cable (category 5 twisted pair cable with or without shielding). During data transmission, the transmission speed of LAN is faster when data packet transmission is applied. Generally, the length of the cable between the computer and the 2439D microwave power meter shall not exceed 100 m (100Base-T and 10Base-T). For more information about LAN communication, please refer to: http://www.ieee.org. Knowledges about the LAN interface are introduced below:

1) IP address

Physical connection of the network shall be guaranteed for remote control on the 2439D microwave power meter via the LAN. For example, if the IP address of the master computer is 192.168.1.10, the IP address of the 2439D microwave power meter shall be set to 192.168.1.XXX, whereas XXX is the figure between 1~255.

When establishing a network connection, only the IP address is required. The VISA addressing string is as follows:

TCPIP::host address[::LAN device name][::INSTR]

Where:

- TCPIP represents the network protocol used;
- host address represents the IP address or name of the instrument, and is used for identifying and controlling the controlled instrument;
- LAN device name defines the handle number of the protocol and subset (option);
- INSTR represents the instrument resource type (option);

VXI-11

TCPIP::<IP address or instrument name>[::inst0][::INSTR]

inst0: LAN device name, representing using VXI-11 protocol (optional)

HISLIP

TCPIP::<IP address or instrument name>::hislip0[::INSTR]

hislip0: HISLIP device name, indicating use of the HISLIP interface protocol (mandatory).

SOCKET

TCPIP::<IP address or instrument name>::port::SOCKET

- port identifies the socket port number;
- SOCKET represents the raw network socket resource class.

Socket communication requires specifying a port (commonly referred to as a port number) and "SOCKET". The default port number for socket communication is 5025.

Example:

The instrument's IP address is 192.168.1.101, and the instrument name is 2439D-00001

- The valid resource strings for the VXI-11 protocol are:
  TCPIP::192.168.1.101
  TCPIP::192.168.1.101::INSTR
  TCPIP::192.168.1.101::inst0
  TCPIP::192.168.1.101::inst0::INSTR
  TCPIP::2439D-00001.local
  TCPIP::2439D-00001.local::INSTR

TCPIP::2439D-00001.local::inst0
TCPIP::2439D-00001.local::inst0::INSTR

- The valid resource strings for the HISLIP protocol are:
  TCPIP::192.168.1.101::hislip0
  TCPIP::192.168.1.101::hislip0::INSTR
  TCPIP::2439D-00001.local::hislip0
  TCPIP::2439D-00001.local::hislip0::INSTR
- The valid resource string during original socket connection is:
  TCPIP::192.168.1.101::5025::SOCKET
  TCPIP::2439D-00001.local::5025::SOCKET

Tips

Method of recognizing multiple instruments in the programmed control system

If multiple instruments are connected in the network, the individual IP address and related resource string are used to distinguish. The host computer applies its own VISA resource string for instrument identification.

2) VXI-11 protocol

The VXI-11 standard is based on the ONC RPC (Open Network Computing Remote Procedure Call) protocol, which is the network/transport layer of the TCP/IP protocol. The TCP/IP network protocol and associated network services are pre-configured for communication. Such connection-oriented communication, which follows the sequential exchange and can identify the interruption of the connection, ensures no loss of information.

3) HISLIP protocol

HISLIP (high-speed LAN instrument protocol) is the successor to the VXI-11 protocol for TCP-based instruments, as specified by the IVI. According to the protocol, two TCP sockets are used for a single connection:

1) The first socket is used for rapid data transmission.

2) The second socket is used for non-sequential control commands (e.g., device clearing or SRQ).

HISLIP has the following characteristics:

- It offers the same high performance as the original socket network connection.
- It is compatible with IEEE 488.2 and supports message exchange protocol, device clearing, serial polling, remote/local control, trigger and service request.
- It employs a single IANA-registered port (4880) to simplify firewall configuration.

- It provides a multifunctional locking mechanism to enable multiple users to access at the same time.
- It is compatible with both IPv6 and IPv4 networks.

4) Socket communication

According to the TCP/ IP protocol, the 2439D microwave power meter is connected to the network via LAN sockets. As a basic method used in computer network programming, the socket allows applications using different hardware and operation systems to communicate over a network. Based on this method, two-way communication between the 2439D microwave power meter the computer is realized through ports.

As a software class programmed specially, the socket defines the IP address, device port number and other necessary information for network communication, and integrates some basic operations in network programming. Sockets can be used after installing packaged libraries in the operation system. Two commonly used socket libraries are the Berkeley socket library for UNIX the Winsock library for Windows.

Sockets in the 2439D microwave power meter are compatible with Berkeley sockets and Winsock through the application program interface (API). In addition, it is compatible with the API of other standard sockets. When SCPI are used to control the 2439D microwave power meter, the socket program established in the program issues the command. Before using a LAN socket, the socket port number of the 2439D microwave power meter must be set. The socket port number for the 2439D microwave power meter is 5025.

5.1.1.2 GPIB interface

As an instrument programmed control interface widely used at present, GPIB interface is connected to different types of instruments through GPIB cable, so as to build a test system with the host computer. In order to realize remote control, the host computer shall be equipped with GPIB bus card, driver and VISA library in advance. During communication, the host computer first addresses the controlled instrument through the GPIB bus address. The user may set the GPIB address and ID query string, and the GPIB communication language may be in the form of SCPI by default.

GPIB and its associated interface operations are defined and described in detail in ANSI/IEEE Standard 488.1-1987 and ANSI/IEEE Standard IEEE Standard 488.2-1992. For details of the standards, please refer to the IEEE website: http://www.ieee.org.

GPIB processes information in bytes at the data transmission speed of up to 8MBps, which is fast. Since the data transmission rate is limited by the distance between the device/system and the computer, the following points shall be noted when connecting GPIB:

- Up to 15 instruments may be built through GPIB interface.
- The total length of the transmission cable shall not be more than 15 m or twice the number of instruments in the system. In general, the maximum length of the transmission cable between the devices shall not exceed 2 m;
- If multiple instruments are connected in parallel, a "live" cable is required.
- The end of the IEC bus cable shall be connected to the instrument or controller computer.

5.1.1.3 USB interface

To implement USB programmed control, a computer and the 2439D microwave power need to be connected via a USB B-type port, with the VISA library installed in advance. VISA automatically detects and configures the instrument to establish a USB connection without the need to enter the instrument address string or install a separate driver.

USB address:

Addressing string format: USB::<vendor ID>::<product ID>::<serial number>[::RAW]

Where:

- <vendor ID> represents the manufacturer code;
- <product ID> represents the instrument code;
- <serial number> represents the serial number of the instrument;

Example:

USB::0x0AAD::0x00C6::100001::INSTR

0x0AAD: Manufacturer code;

0xC6: Instrument code;

100001: serial number of the instrument.

5.1.2 Message

The messages transmitted on the data cable are divided into the following two categories:

1) Interface message

During communication between the instrument and the host computer, the attention cable shall be pulled down first, and then the interface message will be transmitted to the instrument through the data cable. Only instruments with GPIB bus function can send interface message.

2) Instrument message

For the detailed structure and syntax of the instrument message, see Section "5.1.4 SCPI". The instrument message can be divided into two types as per the transmission direction, namely, command and instrument response. Unless otherwise stated, all programmed control interfaces apply instrument message in

the same way.

a) Commands:

Commands (programming messages) are messages sent by the host computer to the instrument for the remote control of instrument functions and the query of state information. Commands are divided into the following two categories:

- Based on the impact on the instrument:

-- Setting commands: change the set state of the instrument, such as reset or setting frequency.

-- Query commands: query and return data, for example: identify the instrument or query the parameter value. Query commands end with the suffix question mark.

- Based on the definition in the standard:

- Common commands: with functions and syntax to be defined by IEEE488.2, they are applicable to all types of instruments (if realized)

It is used for management of standard state register, resetting, self-detection, etc.

-- Instrument control commands: instrument characteristic commands, used to realize instrument functions, such as setting frequency.

The syntax also follows the specifications of SCPI.

b) Instrument responses:

Instrument responses (response message and service request) are the query result information sent by the instrument to the computer. Such information includes measurement results, instrument state, etc.

5.1.3 SCPI

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- Description of SCPI.....96

5.1.3.1 Introduction to SCPI

SCPI (standard commands for programmable instruments) are a command set for all instruments established based on Standard IEEE488.2. The main purpose is to make the same function have the same programmed control command to achieve the universality of programmed control commands.

SCPI consist of a command header and one or more parameters. The command header is separated from the parameters by spaces and contains one or more key fields. A command with direct suffix question mark is a query command. Commands are divided into common commands and instrument commands that have different syntactic structures. SCPI have the following characteristics:

1) Programmed control commands are oriented to test function rather than describing instrument operation;
2) Programmed control commands reduce the repetition of similar test function realization process, and ensure the compatibility of programming.
3) Programed control messages are defined in layers that are hardware independent of the communication physical layer.
4) Programmed control commands are independent of programming methods and languages. The test program of SCPI is easy to transplant.
5) Programmed control commands are scalable and can adapt to different scale of measurement control.
6) The extensibility of SCPI makes it a "living" standard.

If you are interested in learning more about SCPI, please refer to:
IEEE Standard 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation. New York, NY, 1998.
IEEE Standard 488.2-1987, IEEE Standard Codes, Formats, Protocols and Comment. Commands for Use with ANSI/IEEE Std488.1-1987. New York, NY, 1998.
Standard Commands for Programmable Instruments(SCPI) VERSION 1999.0.

For programmed control command set, classification and description of the 2439D microwave power meter, please refer to:

1) Annex B Zoom table of SCPI of this manual.
2) "3 Programmed control commands" of the programmed control manual;
3) "Annex A Zoom table of SCPI classified as per subsystems" of the programmed control manual;
4) "Annex B Zoom table of SCPI classified as per menus" of the programmed control manual.

5.1.3.2 Description of SCPI

- General terms.....96
- Command type.....98
- Instrument command syntax.....98
- Command tree.....100
- Command parameters and responses.....101
- Numeration system of commands.....104
- Command line structure.....105

1) General terms

The following terms apply to this section. To better understand the chapters, you shall understand the exact definitions of the terms.

Controller

A controller is any computer used to communicate with the SCPI device. A controller may be a PC, minicomputer, or a plug-in card on a cage. Some AI devices can also be used as controllers.

Device

A device is any device that supports SCPI. Most of the devices are electronic measurement or excitation devices that use GPIB interfaces for communication.

Programmed control message

A programmed control message is the combination of one or more SCPI that have been correctly formatted. Programmed control messages tell the devices how to measure and output the signals.

Response message

A response message is a set of data of specified SCPI formats. Response messages always come from the devices to controllers or listening devices. Response messages tell the controllers about the internal state or measurement values of the devices.

Command

A command is an instruction that satisfies the SCPI standard. The combination of commands controlling the devices forms a message. In general, a command includes keywords, parameters, and punctuation.

Event command

Event-type programmed control commands cannot be queried. An event command generally has no corresponding front panel button setting, and its function is to trigger an event at a specific time.

Query

A query is a special type of command. When a control device is queried, a response message appropriate to the controller syntax requirements is returned. A query statement always ends with a question mark.

2) Command type

There are two types of SCPI: common commands and instrument commands. Figure 5.1 shows the difference between the two commands. Common commands, defined by IEEE 488.2, are used to manage macros and state registers and for synchronization and data storage. Because common commands all start with an asterisk, they are easy to be recognized. For example, *IDN? *OPC, *RST are all common commands. Common commands are not part of any instrument commands, and the instrument interprets them in the same way regardless of the current path setting of the commands.

Instrument commands are easy to be recognized because they contain a colon (:). A colon is used in the beginning of an expression or between two keywords, for example: FREQuency[:CW?]. According to the internal function module of the instrument, instrument commands are divided into sub-sets of corresponding subsystem commands. For example, the power subsystem (:POWer) contains power-related commands, while the state subsystem (:STATus) contains commands for the state control register.

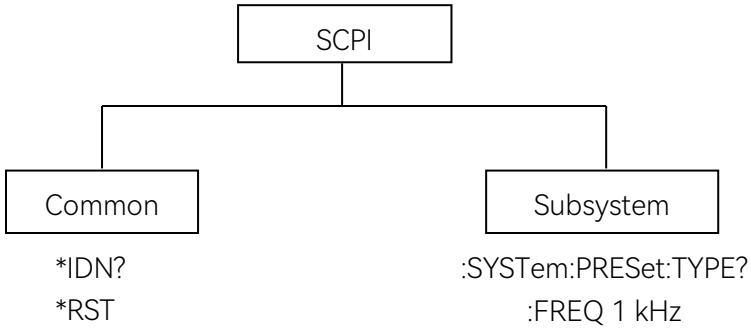


Figure 5.1 Types of SCPI

3) Instrument command syntax

Table 5.2 Special characters in command syntax

Symbol	Meaning	Example
|	The vertical bar between the keyword and the parameter represents multiple options.	[:SENSe]:BANDwidth|BWIDth HIGH|LOWer BANDwidth and BWIDth are optional; HIGH and LOWer are optional.
[]	A square bracket indicates that the contained keyword or parameter is optional when forming a command. The command will	[:SENSe]:BANDwidth? SENSe is optional.

	be executed even when such implied keyword or parameter is ignored.	
< >	The portion enclosed in angle brackets is not used literally in the command in the literal sense. They represent the part that must be contained.	[:SENSe]:FREQency[:CW|FIXed] <val>[unit] In this command, <val> must be replaced with actual frequency. [unit] is an omittable unit. For example: FREQ 3.5 GHz FREQ 3.5e+009
{ }	The part in braces indicates that the parameter is optional.	MEMory:TABLe:FREQuency <val>{,<val>} For example: MEM:TABL:FREQ 5e7

Table 5.3 Command syntax

Characters, keywords and syntax	Example
Uppercase characters represent the minimum set of characters required to execute a command.	[:SENSe]:FREQuency[:CW|FIXed]?, FREQ is the short format part of the command.
Lowercase character of the command is optional; such flexible format is called "flexible listening". Refer to the section "Parameters and responses of commands" for more information.	:FREQuency :FREQ,:FREQuency or or :FREQUENCY Either of them is correct.
When a colon is between the two command mnemonics, it moves the current path in the command tree down by one level. For more information, please refer to the command path part in section "Command tree".	:TRIGger:MODE? TRIGger is the topmost keyword of this command.
If the command contains more than one parameter, adjacent parameters are separated. The parameter is not part of the command path, so it does not affect the path layer.	MEMory:TABLe:FREQuency <val>{,<val>}
The semicolon is used to separate 2 adjacent commands, without affecting current command path.	:FREQ 2.5GHZ; :POW 10DBM
Blank characters, such as <space> or <tab>, are usually ignored as long as they do not appear between keywords or in keywords. However, you	:FREQ uency or :POWer :LEVel6.2 is not allowed. :LEVel and 6.2 must be separated

must separate the commands and parameters with blank characters, which does not affect the current path.	by a space, namely, :POWer:LEVel 6.2.

A typical command consists of a keyword prefixed with a colon. The keyword is followed by parameters. The following is an example of a syntax declaration:

[:SOURce]:POWer[:LEVel] MAXimum|MINimum

In the example above, the [:LEVel] in the command follow: POWer closely without any space. MINimum|MAXimum immediately following [:LEVel] is the parameter. There is a space between the command and the parameter. Other parts of the syntax expression are described in Table 5.2 and Table 5.3.

4) Command tree

Most remote control programs apply instrument commands. When parsing such commands, SCPI apply a file system-like structure called command tree, as shown in Figure 5.2:

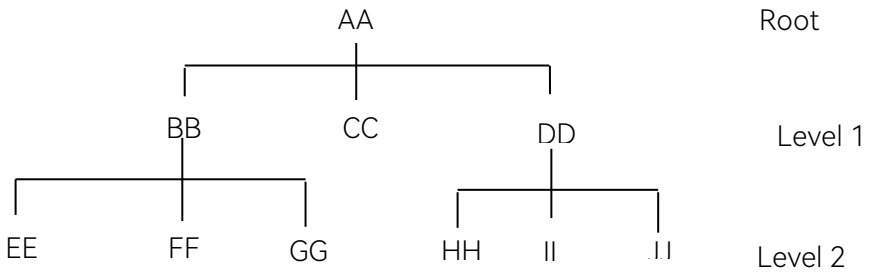


Figure 5.2 Simplified command

The top command is the root command, or "root" for short. When a command is parsed, follow a specific path to the next level of command according to the tree structure. For example, in :POWer:ALC:SOURce?, : POWer stands for AA, :ALC stands for BB, :SOURce stands for GG, and the entire command path is (:AA:BB:GG).

A software module in instrument software - command interpreter, is responsible for parsing each received SCPI. The command interpreter breaks commands into individual command elements by using a series of rules that distinguish the path of the command tree. After parsing the current command, keep the current command path unchanged. The advantage of this is to parse subsequent commands more quickly and efficiently since that the same command keyword may appear in different paths. After starting or *RST (reseting) the instrument, current command path is reset to root.

5) Command parameters and response

Table 5.4 Parameter and response types of SCPI

Parameter type	Response data type
Numerical	Real number or integer
Extended numerical	Integer
Discrete	Discrete
Boolean	Digital boolean
String	String
Blocks	Finite-length blocks
	Infinite-length blocks
Non-decimal numeric types	Hexadecimal
	Octal
	Binary

SCPI define different data formats in the use of programmed control and response messages to comply with the principles of "flexible listening" and "precise speaking". For more information, please refer to IEEE488.2. "*Flexible listening*" means that the formats of the commands and parameters are flexible.

For example, to set the frequency offset state command for the power probe: FREQuency:OFFSet:STATe ON|OFF|1|0,

The following command formats are all used to set the frequency offset function to on:

:FREQuency:OFFSet:STATe ON, :FREQuency:OFFSet:STATe 1,

:FREQ:OFFS:STAT ON, :FREQ:OFFS:STAT 1

Each parameter type has one or more corresponding response data types. During query, a data type will be returned for a numerical parameter, and the response data is precise and strict, known as "**precise speaking**".

For example, during query of the power state (:POWer:ALC:STATe?), when it is ON, the response data returned is always 1 during query, regardless of whether the previously sent setting command is :POWer:ALC:STATe 1 or :POWer:ALC:STATe ON.

a) Numerical parameters

Numeric parameters can be used in both instrument-specific commands and common commands. A numeric parameter receives all the usual decimal counting methods, including signs, decimals, and scientific notation. If a device only accepts a specified numeric type, such as an integer, it will automatically round up the received numeric parameters.

Examples of numeric parameters:

0 No decimal point

100 Optional decimal point
1.23 Signed bit
4.56e<space>3 Index marker e can be followed by a space
-7.89E-01 Index marker e can be uppercase or lowercase
+256 Positive lookahead allowed
5 Decimal points can be used first

b) Extended numerical parameters

Most measurements related to instrument commands use extended numeric parameters to specify physical quantities. Extended numerical parameters receive all numeric parameters and additional special values. All the extended numeric parameters receive MAXimum and MINimum as parameter values. Whether other special values, such as UP and DOWN, will be received is determined by the ability of the instrument to parse. All effective parameters will be listed in the table of SCPI.

Notice: Extended numeric arguments do not apply to common commands or STATus subsystem commands.

Examples of extended numeric parameters:

101 Numeric parameter
1.2GHz GHz can be used as an index (E009)
200 MHz MHz can be used as an index (E006)
-100mV -100 millivolt
10DEG 10°
MAXimum Maximum effective setting
MINimum Minimum effective setting
UP Increase by a step
DOWN Reduce by a step

c) Discrete parameters

When the number of parameter values to be set are finite, they are identified by discrete parameters. Discrete parameters use mnemonics to represent each valid setting. Like programmed control command mnemonics, discrete parameter mnemonics have two formats, long and short, and allow for mixture of upper and lower cases.

In the following examples, discrete parameters and commands are used together.
:TRIGger[:SEQuence]:SOURce BUS|IMMediate|EXTernal
BUS GPIB, LAN, RS-232 trigger
IMMediate Trigger immediately
EXTernal Trigger externally

d) Boolean parameters

A Boolean parameter represents a true or false binary condition, which can only have four possible values.

Boolean parameter examples:

ON	Logically true
OFF	Logically false
1	Logically true
0	Logically false

e) String parameters

String parameters allow ASCII strings to be sent as parameters. Single quotes and double quotes are used as separators.

The following are example of string parameters:

'This is Valid' "This is also Valid" 'SO IS THIS'

f) Real response data

Most of the test data are of real number type, and their formats can be basic decimal notation or scientific notation, which are supported by most advanced programmed control languages.

Examples of real number response data:

1.23E+0
-1.0E+2
+1.0E+2
0.5E+0
0.23
-100.0
+100.0
0.5

g) Integer response data

An integer response data is a decimal expression of an integer value containing signed bit. When querying the state register, most of the response data returned are of integer type.

Examples of integer response data:

0	Sign bit optional
+100	Positive lookahead allowed
-100	Negative lookahead allowed
256	No decimal point

h) Discrete response data

Discrete response data are basically the same as discrete parameters, only that the return format of discrete response data is only a short form in uppercase.

Examples of discrete response data:

INTernal	Amplitude stabilization mode: internal
EXTernal	Amplitude stabilization mode: external
MMHead	Amplitude stabilization mode: millimeter wave source module

i) Digital bool response data

A binary value 1 or 0 is returned as Boolean response data.

j) String response data

String response data and string parameters are alike. The main difference is that the separators of string response data are double quotes instead of single quotes. Double quotes can also be embedded in string response data, and there may be no characters between the double quotes. Here are some examples of string response data:

"This is a string"

"one double quote inside brackets: ("")"

6) Numeration system of commands

The value of the command can be entered in binary, decimal, hexadecimal or octal format. When using binary, hexadecimal or octal format, a proper identifier is required before the value. Decimal format (the default format) does not require an identifier, and when a value is entered without a representation, the device will ensure that it is in decimal format. The following list shows the required representations for each format:

#B indicates that the number is a binary number;

#H indicates that the number is a hexadecimal number;

#Q indicates that the number is an octal number.

The following are various representations of the decimal number 45 in SCPI:

#B101101

#H2D

#Q55

The following example sets the RF output power to 10 dBm (or a value of the equivalent value of the currently selected unit, such as DBUV or DBUVEMF) with a hexadecimal value of 000A.

:POW #H000A

When using a non-decimal format, a measurement unit, such as DBM or mV, is not

used with the value.

7) Command line structure

A command line may contain multiple SCPI. To indicate the end of the current command line, the following methods may be used:

- Enter;
- Enter and EOI;
- EOI and the last data byte.

Commands on the command line are separated by semicolons, and commands belonging to different subsystems begin with a colon. For example:

MMEM:COPY "Test1", "MeasurementXY";:HCOP:ITEM ALL

The command line contains two commands: the first one belongs to the MMEM subsystem, and the second belongs to the HCOP subsystem. If adjacent commands belong to the same subsystem with repeated command path, they can be expressed in abbreviation. For example:

HCOP:ITEM ALL;:HCOP:IMM

The command line contains two commands: both of them belong to the HCOP subsystem, with the same first level. Therefore, the second command can start from the next level of HCOP, and the colon for starting the command can be omitted. It can be abbreviated as follows:

HCOP:ITEM ALL;IMM

5.1.4 Command sequence and synchronization

IEEE488.2 defines the difference between overlapping and sequential commands:

- Sequential commands are sequences of commands that are executed continuously. Each command is usually executed faster.
- An overlapping command is one that is not executed automatically before the next command is executed. It usually takes longer to process overlapping commands, and programs are allowed to process other events synchronously during the period.

Even if there are multiple setting commands on a command line, they may not be executed in the order they were received. To ensure that commands are executed in a certain order, each command must be sent on a separate command line.

Example: the command line contains setting and query commands

If multiple commands on a command line contain query commands, the query results are unpredictable. A fixed value is returned for the following command:

:FREQ:STAR 1GHZ;SPAN 100;:FREQ:STAR?

Returned value: 1000000000 (1 GHz)

The following command returns an unfixed value:

:FREQ:STAR 1 GHz;STAR?;SPAN 1000000

The returned result can be current start frequency value of the instrument before such command is sent, since the instrument program will not execute the commands one by one until all command messages are received. If the instrument program executes a command upon its reception, the returned result may also be 1 GHz.

Tips

Setting commands are sent separately from query commands

General rules: the setting command and query command shall be sent in different programmed control messages, so as to ensure the returned result of the query command is correct.

5.1.4.1 Prevention of overlapping execution of commands

In order to prevent overlapping execution of commands, multithreading or commands *OPC, *OPC? or *WAI may be applied, which are executed only after the hardware settings are completed. During programming, the computer may force a period of time to synchronize certain events. The descriptions are shown below:

- **Controller program using multi-threading**
  Multi-threading is used to wait for command completion and synchronization between the user interface and programmed control, that is, to wait for *OPC? Completion in separate threading without interfering GUI or programmed control threading execution.
- The application of the three commands in synchronous execution is shown in the table below:

Table 5.5 Command syntax

Method	Action	Programming method
*OPC	After the command is executed, set it in the operation completion bit of the ESR register.	Set to ESE BIT0; Set to SRE BIT5; Send overlapping commands and *OPC; Wait for service request (SRQ) Service request represents that the overlapping command has been executed.
*OPC?	Stop executing the current command until 1 is returned . The command is returned only when it is in the operation completion bit of	Terminate processing of the current command before executing other commands, and send the command directly after the current command.

	the ESR register, indicating that the previous command has been processed.	
*WAI	Before the execution of *WAI, wait for all commands to be sent before proceeding with unfinished commands.	Terminate the processing of the current command before executing other commands, and send the command directly after the current command is implemented.

5.1.5 State reporting system

The state report system stores all operating state information and error information of current instrument. They are stored in state registers and error queues respectively, and can be queried through a programmed control interface.

5.1.5.1 Structure of state register

State registers are described by classification below:

1) STB, SRE

The state byte (STB) register and its related mask register – service request enable register (SRE), comprise the top register of the state reporting system. STB saves the general operating state of the instrument by collecting the information of lower registers.

2) ESR, SCPI state register

STB receives information from the following registers:

- The value resulting from the AND operation between the event state register (ESR) and the event state enable (ESE) mask register.
- SCPI state register includes: STATus:OPERation and STATus:QUEStionable registers (SCPI definition),

which contain the specific operation information of the instrument. All SCPI state registers have the same internal structure

(For details, see 2.1.5.2 "SCPI state register structure", please refer to Section 2.1.5.2 "Structure of SCPI State register"

of the programmed control manual).

3) IST,PPE

Similar with SRQ, IST ("Individual STatus") marks a separate bit consisting of all states of the instrument. The associated parallel poll enable register (PPE) determines the STB data bits for IST marking.

4) Output buffer zone

It stores the messages returned by the instrument to the controller. It does not belong to the state report system, but determines the MAV position value of the STB.

For details on the registers mentioned above, see "2.1.5 Status report system" of the programmed control manual.

Please refer to the hierarchical structure of state register shown in Figure 5.1.

Tips

SRE, ESE

SRE may be used as the enable part of STB. Similarly, ESE may be used as the enable part of ESR.

5.1.5.2 Application of state reporting system

The state reporting system is used to monitor the state of one or more instruments in a test system. In order to correctly realize the function of the state reporting system, the controller in the test system must receive and evaluate the information of all instruments. Standard methods used include:

1) Service request (SRQ) initiated by the instrument.
2) Serial query of all instruments in the bus system, initiated by the controller in the system, in order to find the initiator of the service request and the reason.
3) Parallel query of all instruments.
4) Programmed control command to query the state of specific instruments.

For specific operation methods, refer to "2.1.5 State report system application" of the programmed control manual.

5.1.6 Precautions for programming

1) Please initialize the instrument state before changing settings

When setting the instrument remotely, first initialize the instrument state (for example, send "*RST"), and then implement the required state setting.

2) Command sequence

In general, setting commands and query commands shall be sent separately. Otherwise, the returned value of query commands will change with the current

order of instrument operation.

3) Fault response

Service requests can only be initiated by the instrument. The controller program in the test system shall guide the instrument to initiate service request actively when there is an error, and then enter corresponding interrupt service program for processing.

4) Error queue

Each time the controller program processes a service request, it shall query the error queue of the instrument instead of the state register for a more precise cause of the error. Especially in the test phase of the controller program, the error queue shall be frequently queried to obtain the error command sent by the controller to the instrument.

5.2 Instrument programmed control port and configuration

- LAN.....109
- GPIB.....110
- USB.....111

5.2.1 LAN

SICL-LAN is used by LAN programmed control system to control the 2439D microwave power meter.

- Connection establishment.....109
- Interface configuration.....109

5.2.1.1 Connection establishment

An Ethernet cable is used to connect the 2439D microwave power meter and an external controller (computer) to a LAN. Special attention shall be paid to the IP address settings that may cause address conflicts. So users shall check with your network administrator before setting to prevent conflicts from occurring.

5.2.1.2 Interface configuration

Physical connection of the network shall be guaranteed for remote control on the 2439D microwave power meter via the LAN. Click [System] >[Remote Interface] to enter the menu shown in Figure 5.3. When the address mode is set to Static, set "IP Address", "Subnet Mask" and "Default Gateway" to the subnet where the master controller is located. When the address mode is set to Dynamic, the 2439D microwave power meter

will dynamically obtain the "IP Address", "Subnet Mask", and "Default Gateway", and display them on the interface.

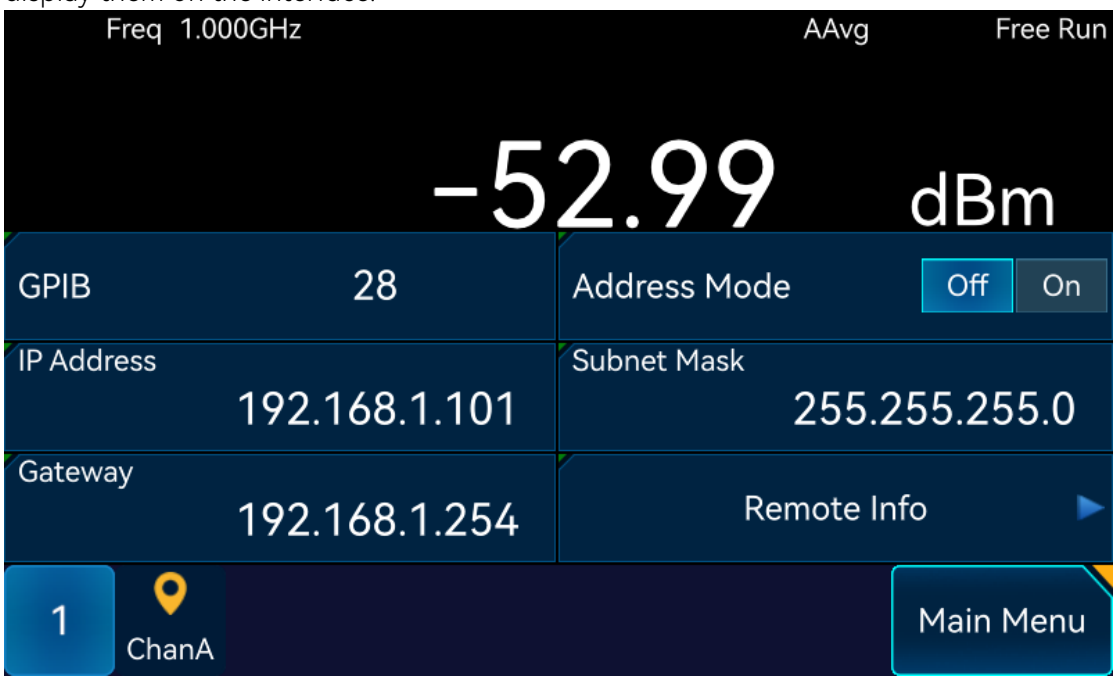


Figure 5.3 LAN interface setting

5.2.2 GPIB

- Connection establishment.....110
- Interface configuration.....110

5.2.2.1 Connection establishment

A GPIB cable is used to connect the 2439D microwave power meter with external controller (computer).

5.2.2.2 Interface configuration

Users may need to modify the GPIB address when using the 2439D microwave power meter to establish the system. The default GPIB address of the machine is 28. Methods for modification of the GPIB address are described below:

Press [System]>[Remote Interface] to enter the interface shown in Figure 5.4. Press the [GPIB] input box to modify the local GPIB address.

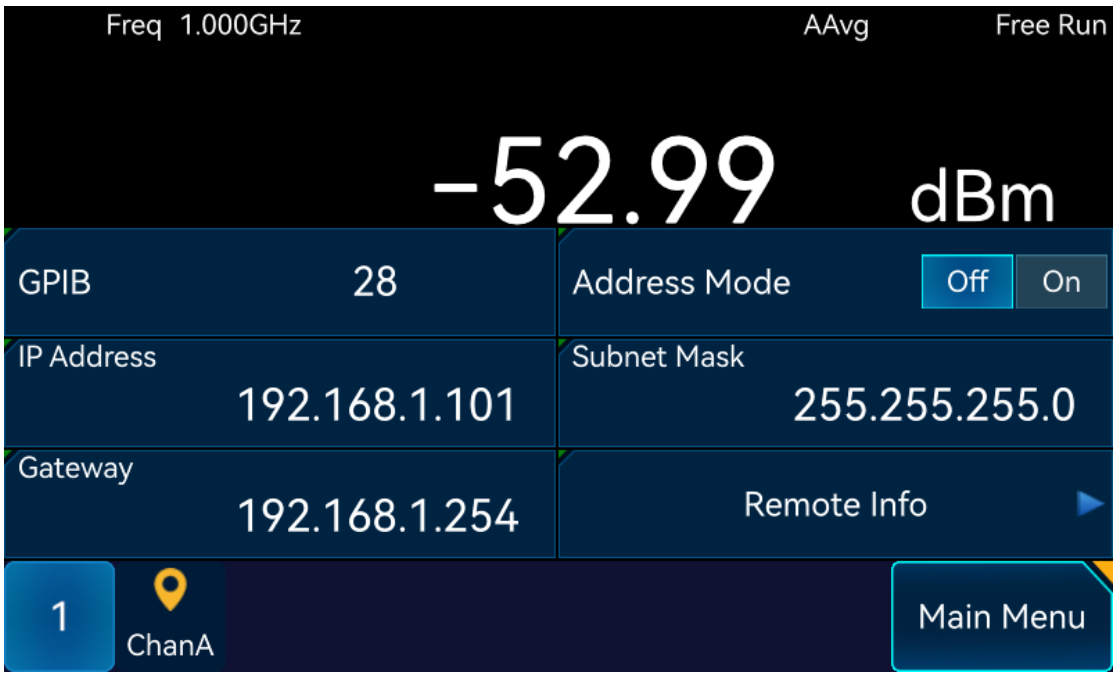


Figure 5.4 GPIB interface setting

5.2.3 USB

The USB programmed control system controls the 2439D microwave power meter using the USBTMC protocol.

注 意

Application of the connector at the master control port of front-panel USB

Type-A connector on the front panel is the connector at the master control port of USB. In the 2439D microwave power meter, the port is used to connect the flash disk of USB 1.1 interface to upgrade resident software of the 2439D microwave power meter. It may also be connected to the USB keyboard and mouse to control the power meter. It fails to control the 2439D microwave power meter through this port.

- Connection establishment.....111
- Interface configuration.....112

5.2.3.1 Connection establishment

A USB cable is used to connect the 2439D microwave power meter with external

controller (computer).

5.2.3.2 Interface configuration

The VID and PID of the 2439D microwave power meter are 0x3399 and 0x3900, respectively. The serial number is marked on the interface. These three interface information are fixed and not user configurable.

5.3 Basic VISA interface programming

Take the following as an example to describe the basic method for realizing instrument programming via the VISA library. Take the C++ language as an example.

5.3.1 Installing VISA library

VISA is the generic name for the standard I/O function library and its associated specifications. VISA library function is a set of functions that can be easily recalled. Its core function can control various types of devices without considering the interface type of devices and the operating instructions of different I/O interface software. These library functions are used to write the driver program of the instrument and complete the command and data transmission between the computer and the instrument, so as to realize programmed control of the instrument. By initializing the addressing string ("VISA resource string"), a connection to an instrument with a programmed control port (LAN, USB, GPIB and RS-232, etc.) can be established.

To realize remote control, the VISA library must be installed first. The VISA library is encapsulated with the transmission function at the bottom layer with VXI, GPIB, LAN and USB interfaces, so as to facilitate users' direct recall. The 2439D microwave power meter supports the following programming interfaces: GPIB, LAN, and USB. These interfaces, combined with the VISA library and programming language, allow remote control of the 2439D microwave power meter. At present, Agilent I/O Library provided by Agilent is often used as the underlying I/O library.

5.3.2 Generation of global variables

Start by generating global variables that other program modules will recall, such as instrument handle variables. The following example programs shall contain the following global variables:

```
ViSession iDevHandle;
ViSession iDefaultRM;
const char rgcDevRsc[MAX_RSC_LEN] = "USB0::04B4::1010::2019001::0::INSTR";
```

const int iTmo = 5000;

Where, the constant rgcDevRsc represents the instrument descriptor, "USB0" represents the controller, "04B4" represents the vendor ID of the instrument, 1010 is the product ID, and 2020001 is the product serial number.

If the instrument is controlled via the GPIB interface and the GPIB address is "20", then the value of the variable is

const char rgcDevRsc[MAX_RSC_LEN] = "GPIB0::20::INSTR";

If the instrument is controlled via a LAN socket interface with IP address 192.168.1.1 and port number 5025, then the value of the variable is

const char rgcDevRsc[MAX_RSC_LEN] = "TCPIP0::192.168.1.1::5025::SOCKET";

If the instrument is controlled via the LAN interface with IP address 192.168.1.1, then the value of the variable is

const char rgcDevRsc[MAX_RSC_LEN] = "TCPIP0::192.168.1.1::INSTR";

5.3.2 Initializing controller

/**

The following examples show how to open and establish a communication connection between the VISA library and the instrument (as specified by the instrument descriptor).

//Initialize the controller: open the default resource manager and return the instrument handle iDevHandle.

**/

```
void InitController()
{
    ViStatus iStatus;
    iStatus = viOpenDefaultRM(&iDefaultRM);
    iStatus = viOpen(iDefaultRM, rgcDevRsc, VI_NULL, VI_NULL, &iDevHandle);
}
```

5.3.3 Initializing the instrument

/**/

The following example shows how to initialize the default state of the instrument and empty the state register.

/**/

```
void InitDevice()
{
    ViStatus iStatus;
    ViUInt32 uiRetCnt;
    iStatus = viWrite(iDevHandle, "*CLS\n", strlen("*CLS\n"), &uiRetCnt); //Status
```

```
    Reset
    iStatus = viWrite(iDevHandle, "*RST\n", strlen("*RST\n"), &uiRetCnt); //Instrument
    Reset
}
```

5.3.4 Sending setting command

```
/*************************************************************************/
```

The following example shows how to set the frequency of the 2439D microwave power meter.

```
/*************************************************************************/
void SimpleSettings()
{
    ViStatus iStatus;
    ViUInt32 uiRetCnt;
    //Set the frequency to 128MHz
    iStatus = viWrite(iDevHandle, "FREQ 1.2e8\n", strlen("FREQ 1.2e8\n"),
    &uiRetCnt);
}
```

5.3.5 Reading the state of measuring instrument

```
/*************************************************************************/
```

The following examples show how to read the set state of the instrument.

```
/*************************************************************************/
void ReadSettings()
{
    ViStatus iStatus; //Status
    ViUInt32 uiRetCnt; //read the returned bytes
    char rgcBuf[256]; //Temporary buffer
    char* pcCmd = NULL; //Command pointer

    //QueryFreq
    pcCmd = "FREQ?\n";
    iStatus = viWrite(iDevHandle, pcCmd, strlen(pcCmd), &uiRetCnt);
    Sleep(10);
    iStatus = viRead(iDevHandle, rgcBuf, sizeof(rgcBuf), &uiRetCnt);
    //Print debugging information
    printf("frequency %s", rgcBuf);
}
```

5.3.6 Command synchronization

```
/*************************************************************************/
```

The following examples illustrate the methods for command synchronization with sweep process.

```
/*************************************************************************/
void SweepSync()
{
    ViStatus iStatus; //Status
    ViUInt32 uiRetCnt; //read the returned bytes
    ViEventType eType; //Event Type
    ViEvent eEvent; //Event
    int iStat; //State word
    char rgcOpcOk[256]; //OPC string
    char* pcCmd = NULL; //Command pointer

    /*************************************************************************/
    /* The command INITiate[:IMMediate] is used to start single sweep (when continuous sweep is OFF, INIT:CONT OFF)*/
    /* Only at the end of single sweep can the next command in the command buffer be executed                */ */
    /*************************************************************************/
    pcCmd = "INIT:CONT OFF\n";
    iStatus = viWrite(iDevHandle, " pcCmd ", strlen(pcCmd), &uiRetCnt);
    //Method 1 for waiting for the sweep to end: use *WAI
    pcCmd = "ABOR;INIT:IMM;*WAI\n";
    iStatus = viWrite(iDevHandle, " pcCmd ", strlen(pcCmd), &uiRetCnt);
    //Method 2 for waiting for the sweep to end: use *OPC?
    pcCmd = "ABOR;INIT:IMM; *OPC?\n";
    iStatus = viWrite(iDevHandle, " pcCmd ", strlen(pcCmd), &uiRetCnt);
    iStatus = viRead(iDevHandle, rgcOpcOk, 2, &uiRetCnt); //wait for *OPC to return "1"
    //Main program continues……
}
```

5.4 I/O library

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5.4.1 Overview of I/O library

I/O library is a pre-written software library for instruments, known as instrument driver. As a software between the computer and the instrument hardware, it consists of the function library, utility program, tool kit, etc. It is a combination of a series of software code modules and corresponds to operation of a plan, such as configuring the instrument, reading from the instrument, writing to the instrument and trigger the instrument, etc. Residing in the computer, it is the bridge and link between the computer and the instrument. By providing a high-level modular library for convenient programming, users no longer need to learn the complex low-level programming protocol for a specific instrument. Application of instrument driver is the key to develop test and measurement applications quickly.

Functionally, a universal instrument driver generally consists of five parts: functor, interactive developer interface, programmer interface, subprogram interface and I/O interface, as shown in Figure 5.5.

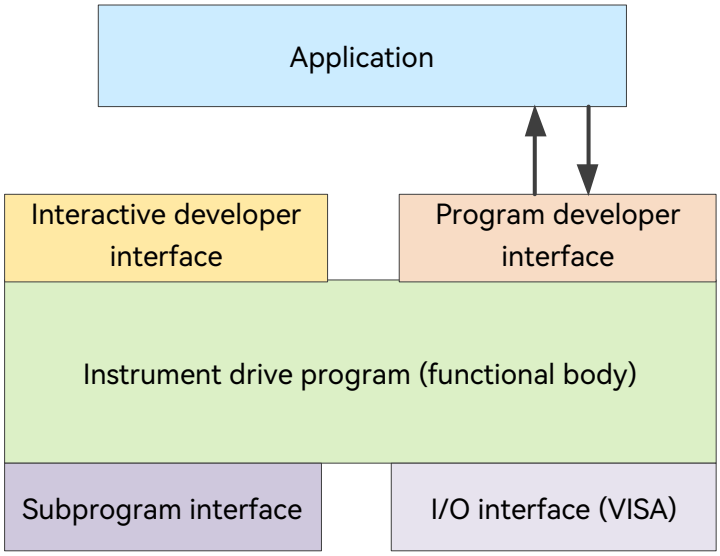


Figure 5.5 Structure model of instrument driver

The details are as follows:

1) Functor. As the main function part of the instrument driver, it may be understood as its framework program.
2) Interactive developer interface. Application development environment that supports instrument driver development is usually provided with graphical interactive developer interface for user convenience. For example, in Labwindows/CVI, the function panel is an interactive developer interface. In the function panel, each parameter of the instrument driver function is represented as a graphical control.
3) Programmer interface. It is a software interface for the application to recall

instrument driver function, such as dynamic link library file.dll of instrument driver in Windows system.

4) I/O interface. It completes the actual communication between the instrument driver and the instrument. The bus-specific I/O software, such as GPIB and RS-232, or the common standard I/O software applied cross multiple buses (VISA I/O) can be used.
5) Subprogram interface. It is a software interface for the instrument driver to access other support libraries, such as databases, FFT functions, etc. The subprogram interface is used when the instrument driver needs to recall other software modules, operation systems, programmed control code libraries and analysis function libraries to complete its task.

5.4.2 Installation and configuration of I/O library

Along with the application in test field, it has gone through different development stages from traditional instrument to virtual instrument. In order to solve the interchangeability of instruments and reusability of test program in automatic test system, instrument driver has gone through different development processes. IVI (Interchangeable Virtual Instruments) driver is relative popular and common at present. Based on IVI specification, it defines a new instrument programming interface, inserts the class driver and VPP architecture onto the VISA to make the test application and instrument hardware completely independent, adds such unique functions as instrument simulation, range sensing and state cache, improves the operation efficiency of the system, and realizes instrument exchange.

There are two types of IVI driver: IVI-C and IVI-COM, where the latter adopts the form of COM API based on the component object model (COM) of Microsoft, and the former adopts the form of C API based on ANSI C. Both types are designed according to the instrument class defined in the IVI specification and have the same application development environment, including Visual Studio, Visual Basic, Agilent VEE, LabVIEW, CVI/LabLinux, etc.

Two types of driver shall be provided at present to meet the needs of different users in different development environments. IVI driver of the 2439D microwave power meter is developed with Nimbus Driver Studio and directly generates IVI-COM and IVI-C driver and program installation package. For specific installation and configuration, you can refer to the attached documentation of the control card and I/O library you selected.

IVI driver after installation are divided into IVI inherent function group and instrument function group (basic function group and extended function group). Specific function classification, functions and attributes are shown in the help document of the driver.

Tips

Port configuration and IO library installation

Before using the computer to control the 2439D microwave power meter, please make sure you have the necessary ports and I/O libraries installed and configured correctly.

Tips

Use of I/O library

The driver function panel, help document and driver function examples will be installed automatically when installing the attached IVI-COM/C driver installation package, so as to facilitate users to develop integrated programmed control functions.

6 Troubleshooting and after-sales services

This chapter will show you how to find problems and accept after-sales service. and explain error message of the instrument.

If you encounter any problem when operating the 2439D microwave power meter or want to buy relevant components or accessories, we can provide you with complete after-sales services.

Generally, causes of problems include hardware, software or user maloperation. In case of any problem, please contact us in time. If the 2439D microwave power meter is within the warranty period, we will repair it for free as per the provisions specified in the warranty bill. Otherwise, we will charge maintenance costs as per the contract requirement.

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6.1 Operating principle

The section introduces the basic operating principle and hardware principle block diagram of the 2439D microwave power meter, so as to let users understand the functions of the power meter and solve problems encountered during operation.

The principle block diagram of the 2439D microwave power meter developed in this project is shown in Figure 6.1.

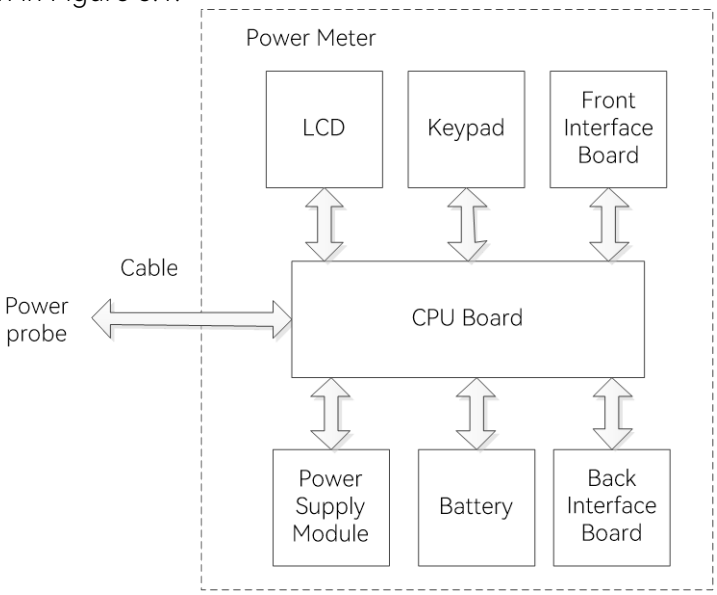


Figure 6.1 Principle block diagram of the 2439D microwave power meter

The primary function of the 2439D microwave power meter is to display measurement results from the power probe and set the power probe via the power meter. The 2439D microwave power meter primarily consists of the following unit modules: CPU board, front interface board, LCD display, keypad, rear interface board, power supply module, and battery. The hardware principle of the 2439D microwave power meter is shown in Figure 6.1. The power probe measures signal power parameters and time parameters. The 2439D microwave power meter reads the measurement results to be displayed via a cable. Therefore, the 2439D microwave power meter in this project primarily handles power supply, data read/write operations, and display for the power probe, without participating in the calculation of power results.

6.2 Fault diagnosis and troubleshooting

Tips

Fault diagnosis and instructions

This section introduces the way on how to judge and handle failures (if any) of the 2439D microwave power meter, and feed them back to the manufacturer as accurately as possible if necessary for quick solution.

The following failures and troubleshooting are listed as per function types.

6.2.1 Power probe not found

If the power probe is not detected by the 2439D microwave power meter after power-on, perform the checks according to the steps below:

Step 1. Verify the cable is undamaged and the USB interface on the 2439D microwave power meter is intact;

Step 2. Verify the cable is properly connected;

Step 3. Verify whether the power probe indicator light is flashing.

6.2.2 State Indicator light not ON

Check if the channel interface of the 2439D microwave power meter is functioning normally. Try connecting the power probe to another channel and observe if the indicator light operates. Alternatively, connect the power probe via its cable to a functional computer USB interface. If it is abnormal, the power probe is faulty and users shall return it for repair. If it is normal, it is recommended to connect another cable to test the probe. If the probe functions correctly, the cable is defective; otherwise, the 2439D microwave power meter fails. Return the defective unit to the manufacturer for repair.

6.2.3 Unexpected phenomenon

In the process of use, there are many reasons for the unexpected phenomenon. Refer to the following test procedures to determine the cause of the problem with the instrument. Usually these tests can solve the problem or determine the cause of the problem clearly.

- Check whether the mechanical connection of the cable is correct and whether the electrical characteristics are compatible;
- When problems occur after certain settings, check the actions taken to make sure all settings are correct. If the test is completed, check that the measurement results match the signal under test and that the performance specifications of the instrument are met.
- When the instrument shows unexpected results, if you are not sure whether the settings made are correct, replug it and then set it according to the signal under test and test requirements.

6.3 Error message

During actual use, the system will automatically provide error messages if it is not operated properly or configured correctly. Users can roughly determine the type of problem based on error prompts and take appropriate measures to troubleshoot or decide to return for repair.

On the 2439D microwave power meter interface, click [Main Menu]>[System]>[Error List] to view recent error messages.

6.4 Method to obtain after-sales services

6.4.1 Contacting us

In case of any failure to the 2439D microwave power meter, check and store the error message, analyze possible causes, and refer to the methods provided in "6.2 Fault diagnosis and troubleshooting" for preliminary troubleshooting. If the problem cannot be solved, contact the service and consultation center of the Company as per the contact information provided below and provide us with the error collected. We will coordinate with you to solve the problem as soon as possible.

Contact information:

Service consultation: 400-1684191

Website: www.ceyear.com

Email: techbb@ceyear.com

Postal code: 266555

Address: No. 98, Xiangjiang Road, Huangdao District, Qingdao, Shandong Province, China

6.4.2 Package and mailing

In case of any failure to the 2439D microwave power meter that is difficult to be eliminated, contact us by phone or fax. If it is confirmed that the 2439D microwave power meter has to be returned for repair, pack it with the original packing materials and packing box by following the steps below:

1) Prepare a detailed description of the failure of the power meter and put it into the packing box along with the power meter.
2) Pack the power meter with the original packing materials, so as to minimize possible damage;
3) Place cushions at the four corners of the outer packing box, and place the instrument in the outer packing box.
4) Seal the opening of the packing box with adhesive tape and reinforce the packing box with nylon tape.
5) Specify text like "Fragile! Do not touch! Handel with care!" and so on.
6) Please check by precision instrument.
7) Keep a copy of all shipping documents.

Notice

Packaging precautions for the 2439D microwave power meter

Using other materials for packing the 2439D microwave power meter may damage the instrument. Users shall never use polystyrene beads as packing materials because they cannot provide sufficient protection on the instrument and may result in instrument damage.

Tips

Instrument package and transportation

Please follow carefully the precautions described in "3.1.1.1 Unpacking" when transporting or handling the instrument (for example, damage occurred during delivery).

7 Specifications

The section introduces the specifications and main test methods of the 2439D microwave power meter.

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7.1 Statement

The test conditions for all metrics are under the temperature of 23℃±5℃ (half hours after startup), unless otherwise specified. The additional instrument information is to facilitate users to understand more clearly the instrument performance that is not contained in the range of specifications. Key word descriptions are shown below:

Technical specification (spec): Place the calibrated instrument in the working environment of -10℃ - 50℃ for at least 2h, and then warm it up for 30 min., so as to ensure its performance (including the measurement uncertainty), unless otherwise specified. All data in the document are specifications, unless otherwise specified.

Typical value (Typ): It indicates 80% of the instruments can reach typical performance, which is not a guarantee, and excludes uncertainty factors during the measurement. It is valid only at the room temperature (about 25℃).

Nominal value (nom): It indicates such performances as the expected average performance, designed performance features or those that cannot be tested by limited test means, for example, the 50 Ω connector. Products marked with nominal values are not included in the warranty, and such values are taken at the room temperature (about 25℃).

Measurement value (meas): It indicates the performance characteristic measured during the design phase for comparing with the expected performance, for example, amplitude drifting change with time. It worth noting that such data is not a guarantee, which is also taken at the room temperature (about 25℃).

7.2 Product features

7.2.1 Structure and size

Overall dimensions: 231 mm×106 mm×251 mm

Nominal Dimensions: 213 mm × 88 mm × 214 mm.

7.2.2 Weight

2.4 kg (excluding built-in battery)
3.0 kg (with battery).

7.2.3 Color

Black.

7.2.4 Function

7.2.4.1 Functional integrity

After powering on the instrument, the indicator light near the power switch glows orange, indicating the standby power supply is functioning normally. After the power switch is pressed, the indicator light at the power switch turns green. Once the display enters the instrument interface, the buttons and touchscreen shall operate smoothly.

7.2.4.2 Main function

a) Probe recognition function;
b) Pulse trace display function;
c) Average power measurement function;
d) USB, LAN, GPIB programmed control function;
e) Trigger input function
f) Analog output function.

7.3 Specifications

Table 7.1 Specifications of the 2439D microwave power meter

Item	Basic metrics
Instrument model	2439D
Number of channels	4

Frequency range	DC to 110 GHz (depending on the power probe used)
Power range	-70 dBm to +44 dBm (depending on the power probe used)
Maximum measurement display resolution	Logarithmic mode: 0.001 dB; Linear mode: 4 digits
Channel offset range	±100.00 dB
Horizontal scale range	2 ns/division to 3600 s/division
Reference source frequency	50 MHz±0.5 MHz (23℃±5℃)
Reference source power	1.000mW (1±1.0%) (23℃±5℃)
Display	5-inch color LCD Display resolution: 800 x 480
Power supply	100 V_{AC} to 240 V_{AC} 50 Hz~60 Hz; including battery option
Max. power consumption	25 W (paired with 2 power probes，without battery)
Battery working time	5 h (paired with 2 power probes)
Structural characteristics	Benchtop
Size (W × H × D)	Overall dimensions: (231.0±2.5)mm×(105.6±1.5)mm×(251.0±2.5)mm Nominal dimensions: (231.0±1.2)mm ×(88.1±0.8) mm × (213.5±1.2)mm
Max. weight of instrument	2.4 kg (excluding built-in battery) 3.0 kg (with battery)
Operation/storage temperature	-10℃ ~ 50℃/-40℃ ~ +70℃
Communication Interface	U port of slave port :U port for programmed control Main USB port :Support connection to the power probe via cable, and channel number D Network port :Network port for programmed control GPIB port :GPIB port for programmed control
Other Interface	Analogue output :BNC(f) ,Output analog voltage signals related to power measurement results of a specific channel
	Trigger input :BNC(f) ,Input interface of external trigger signal

Table 7.2 Specifications of compatible probe

Probe type	Probe model	Basic metrics
87233 Series USB CW power probe	87233C	Frequency range: 8 kHz to 12 GHz, power range: -60 dBm to +20 dBm
	87233D	Frequency range: 10 MHz to 18 GHz, power range: -70 dBm to +20 dBm
	87233E	Frequency range: 50 MHz to 26.5 GHz, power range: -70 dBm to +20 dBm

	87233F	Frequency range: 50 MHz to 40 GHz, power range: -70 dBm to +20 dBm
	87233L	Frequency range: 50 MHz to 67 GHz, power range: -55 dBm to +20 dBm
87235 Series USB Average Power Probe	87235B	Frequency range: 8 kHz to 8 GHz, power range: -70 dBm to +26 dBm
	87235C	Frequency range: 10 MHz to 8 GHz, power range: -60 dBm to +23 dBm
	87235D	Frequency range: 10 MHz to 18 GHz, power range: -70 dBm to +26 dBm
	87235F	Frequency range: 10 MHz to 33 GHz, power range: -65 dBm to +26 dBm
	87235FA	Frequency range: 10 MHz to 40 GHz, power range: -65 dBm to +26 dBm
	87235H	Frequency range: 10 MHz to 50 GHz, power range: -65 dBm to +23 dBm
	87235L	Frequency range: 50 MHz to 67 GHz, power range: -60 dBm to +23 dBm
	87235DG	Frequency range: 10 MHz to 18 GHz, power range: -50 dBm to +44 dBm
87236 Series USB Peak/Average Power Probe	87236D	Frequency range: 50 MHz to 18 GHz, power range: -45 dBm to +20 dBm
	87236E	Frequency range: 50 MHz to 26.5 GHz, power range: -45 dBm to +20 dBm
	87236F	Frequency range: 50 MHz to 40 GHz, power range: -45 dBm to +20 dBm
	87236L	Frequency range: 500 MHz to 67 GHz, power range: -45 dBm to +20 dBm
87237 Series USB Thermocouple Power Probe	87237D	Frequency range: DC to 18 GHz, power range: -35 dBm to +20 dBm
	87237L	Frequency range: DC to 67 GHz, power range: -35 dBm to +20 dBm
	87237P	Frequency range: DC to 110 GHz, power range: -30 dBm to +20 dBm

7.4 Options

Sequence number	Part number	Option name	function
1	2439D-H05	Safety instrument transport case	Portable packaging box with handle which can carry two sets

			of probes
2	2439D-H06	Rack mount kit	Mount kit for rack
3	2439D-H12	English options	Panels,signs,manuals,and software for English
4	2439D-H13	Battery option	Li-ion Battery option 14.4V,91.67Wh
5	2439D-JL	Measurement service	Provide Commercial Calibration Certificate.
6	2439D-EWT1	An extended warranty of one year beyond the standard warranty period is provided.	An extended warranty of one year beyond the standard warranty period is provided. For a 2-year extension, you can choose 2 items.This pattern continues. the services does not include calibration,but only one-way freight for the goods.