87236 Series USB Peak/Average Power Sensor

User's manual



Ceyear Technologies Co., Ltd.

This manual applies to the following models of the USB peak/average power Sensor based on the firmware version of 1.0 and higher.

- 87236D USB Peak/Average Power Sensor
- 87236E USB Peak/Average Power Sensor
- 87236F USB Peak/Average Power Sensor
- 87236L USB Peak/Average Power Sensor

Version: A.1 March 2026, Ceyear Technologies Co., Ltd.
Address: No. 98, Xiangjiang Road, Huangdao District, Qingdao, Shandong Province
Service consultation: 400-1684191
Quality supervision: 0532-86886614
Website: www.ceyear.com
Email: techbb@ceyear.com
Postal code: 266555

Foreword

Thank you for choosing and using the USB peak/average power Sensors 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

.A.1 2026.3

Ceyear Technologies Co., Ltd.

Manual authorization

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Product warranty

The warranty period of this product is 12 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

This 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

This 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.

Calibration cycle

The calibration cycle of this product is 1 years.

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1. Manual navigation

This chapter introduces the user's manual functions, chapter structure and main contents of the USB peak/average power Sensor, as well as the instrument-related documents provided to users.

- About the manual.....1
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1.1. About this manual

This manual introduces the basic functions and operating instructions of the USB peak/average power Sensor produced by Ceyear Technologies Co., Ltd. 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 USB peak/average power Sensor. 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 section introduces the pre-operation checks, instrument browse, and operating instructions for various measurement functions of the USP peak/average power Sensor, including instrument connection, initiating measurement processes, and acquiring measurement results. It primarily consists of two parts: basic operating instructions and function operation guide. The "basic operating instructions" section systematically and comprehensively introduces and lists each function for users unfamiliar with operating instructions of the USP peak/average power Sensor, enabling them to understand and master basic operating instructions of this Sensor . The operation guide introduces relatively complicated test processes and advanced operation skills for users who have basic knowledge about using the USB peak/average power Sensors but are not familiar with some special usage, and guides them to implement the measurement processes.

- 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 commands, etc; port configuration methods, introducing the connection methods and software configuration methods for programmed control ports; 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 library, introducing the basic concepts of instrument drivers and the basic installation and configuration instructions of IVI-COM/IVI-C drivers.

- Troubleshooting and repair

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

- Specifications and test methods

  This part introduces the product characteristics, main specifications and recommended test methods of the USB peak/average power Sensors.

1.2 Related documents

The product documentation for the USB peak/average power Sensors includes

- User's manual
- Programmed control manual
- Quick start guide
- Online help

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
- Menus
- Remote control
- Troubleshooting and repair
- Specifications and test methods
- Annex

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

Quick start guide

This manual introduces the basic operating instructions for configuration and start-up measurement of the instrument to enable users to quickly understand the characteristics of the instrument, and master the basic settings and basic operating instructions. Main chapters include:

- Get prepared
- Typical applications
- Get help

Online help

Online help is integrated in the instrument, providing fast text navigation help to make it convenient for users in local and remote control operation. The instrument user interface tool bar offers corresponding shortcut keys to activate this function. Main chapters are identical to those of the user's manual.

2. Overview

This chapter outlines the primary performance characteristics, main application scope, and main specifications of the USP peak/average power Sensor. It also details precautions, including proper instrument operation and electrical safety.

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2.1 Product overview

The 87236 series USB peak/average power Sensor has a frequency range of 50 MHz ~ 67 GHz and a power dynamic range of -45 dBm ~ +20 dBm. It is small, light, portable and hot-swappable and therefore can be widely used in tests of parameters such as average power and peak power. The main performance characteristics of the 87236 series USB peak/ power Sensor are as follows:

1) Accurate average power measurement: The 87236 series USB peak/average power Sensors enable accurate average power measurements of up to 0.2 dB, using a continuous sampling rate of 80MS/s for high measurement speed and repeatability, with a frequency range up to 67 GHz and power measurement capability down to -45 dBm to cover most test applications.
2) Dynamic range of ultra wide pulse power: The 87236 series USB peak/average power Sensors have a peak power measurement range of -35 dBm ~ +20 dBm, enabling measurement and analysis of very small signals at high bandwidths. It also supports external triggering in Average Mode, enabling pulse power measurements down to -45 dBm.
3) Fast rise and fall time: The pulse power and time parameters can be measured in the development, production, installation and maintenance of related components. The 87236 series USB peak/average power Sensor has a video bandwidth of up to 30 MHz and a rise/fall time of less than or equal to 13 ns, allowing signals with a 50 ns pulse width to be measured.
4) Internal/external zeroing: Each 87236 series USB peak/average power Sensor can be internally zeroed by switch control, so there is no need to disconnect the power Sensor from the DUT during use, speeding up measurement, reducing connector wear, and lowering measurement uncertainty.
5) Internal/external trigger: The external trigger can accurately trigger small signals close to the lower noise limit. The 87236 series USB peak/average power Sensor has built-in trigger input and trigger output, which can connect the external trigger of the DUT to the power Sensor via standard BNC to MMCX cables.
6) Automatic measurement: The automatic measurement function can help users in complex measurements without tedious menu settings, and the pulse measurement

results can be obtained with one click, improving user test efficiency.

7) Statistical Measurement: The 87236 series USB peak/average power Sensor can realize two CCDF statistical functions. The normal CCDF performs statistical analysis of waveforms in free-run and continuous trigger modes; the gated CCDF is used in conjunction with the gate signal and performs statistical analysis of waveforms within the gated signal only.
8) Built-in wireless applications: The 87236 series USB peak/average power Sensor features built-in wireless presets, including GSM, EDGE, CDMA, WCDMA, BLUETOOTH, WiMAXTM and LET.
9) Compact and portable: The 87236 series USB peak/average power Sensor does not require a power host and can be powered and communicated via the USB 2.0 interface, thus allowing for a portable and lightweight solution for field testing.

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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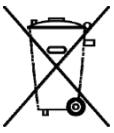
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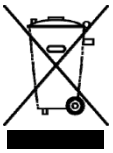
2.2.1 Safety marks

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 operation information or instructions to be paid attention to.		Power ON/OFF
	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

Symbol	Meaning	Symbol	Meaning
			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

Please note before operating the instrument:

1) Unless otherwise specified, the USP peak/average power Sensor must be operated in a stable, indoor environment. The maximum altitude for operating the instrument shall not exceed 4,600m, and the maximum altitude for transporting the instrument shall not exceed 4,500m. 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 16A (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 earth 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:

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 outlines pre-use precautions and common basic measurement methods for the USP peak/average power Sensor, enabling users to gain an initial understanding of the instrument and measurement process. The USP peak/average power Sensor can be operated via the host computer's power measurement and display software or through programmed control. This chapter uses the host computer's power measurement and display software as an example to explain basic setting and measurement methods of the USP peak/average power Sensor. Detailed operating instructions for the power measurement and display software are provided in the User's Manual for the Power Measurement and Display Software that is accessible via the software's Help menu. This section contains some contents consistent with the relevant sections in the quick start manual.

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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 USP peak/average power Sensor.

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. If the product is under warranty, we will no longer provide free maintenance.
- 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

Pay attention to the following when operating the instrument:

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

- To ensure that the fan blades and heat radiation holes are unobstructed, the instrument shall be at least 10cm away from the wall, and ensure that all fan vents are unobstructed;
- 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 package and the shockproof packing of the instrument are damaged. If there is any damage, keep the outer package for standby and
proceed with the following examination steps.

Step 2. Unpack and check the Sensor and articles provided in the package 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.

2) Model confirmation

Table 3.1 List of articles provided

Name	Quantity	Function
Oscilloscope:		
✧87236D/E/F/L	1	—
Standard:		
✧USB cable	1	—
✧Trigger cable	2	—
✧CD	1	—
✧Product certificate	1	—

3.1.1.2 Environmental requirements

The operation sites of the USB peak/average power Sensors shall meet the following environmental requirements:

1) Operation environment

The operation environment shall meet the following requirements:

Table 3.2 Environmental requirements of operations

Temperature	10℃~40℃
Temperature range during error adjustment	23℃ ±5℃ (allowable temperature deviation during error adjustment < 1 ° C)
Humidity	Hygrometer measurement range at <+29 ℃: 20% - 80% (non-condensed)
Elevation	0-2000 meters (0-6561 feet)
Vibration	Max. 0.21 G, 5Hz~500Hz

注 意

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

2) 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

The 87236 series USB peak/average power Sensor is powered by the USB2.0 interface of the host computer, with a supply voltage of +5 V and a supply current of 500 mA. During operation, the USB peak/average power Sensor is connected to the USB interface of the host computer via the USB cable; and the USB cable is unplugged after use to power off the instrument.

3.1.1.4 Proper operation of connectors

Connectors are often used in various tests of the USB peak/average power Sensor. Although the connectors of calibration pieces, test cables and analyzer measurement ports are designed and manufactured according to the highest standards, the service life of all these connectors is still 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:

a) Whether the electroplated surface is worn or not and whether there are deep scratches;
b) Whether the thread is deformed;
c) Whether there are metal particles on the threads and the joint plane of the connector;
d) Whether the inner conductor is bent or broken;
e) Whether the screw sleeve of the connector rotates improperly.

⚠ Caution

Checking the connector to prevent damaging ports of the instrument

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 USB peak/average power Sensor, 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 3.1, 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 3.1 Axes of interconnected devices in a straight line

Step 2: as shown in Figure 3.2, 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.

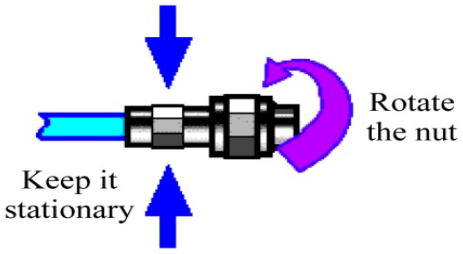


Figure 3.2 Connection method

Step 3: As shown in Figure 3.3, 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.

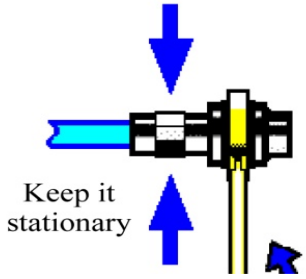


Figure 3.3 Finishing the connection with a torque wrench

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 3.4. 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.

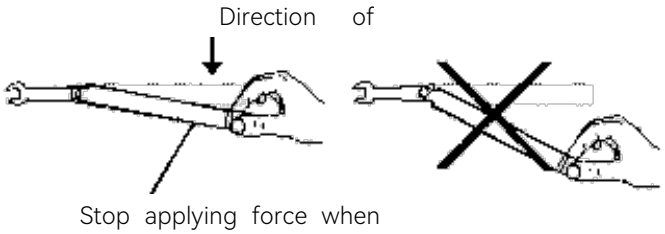


Figure 3.4 Operating instructions of a torque wrench

5) Use and storage of connectors

a) The connectors shall be covered by protective sleeves when not in use.
b) Do not mix various connectors, air lines and calibration kits in a box because this is one of the most common causes of connector damage.
c) Keep the connectors and the analyzer at the same temperature. Holding a connector by hand or cleaning a connector with compressed air will significantly change its temperature. The connectors shall be calibrated after its temperature is stable.
d) 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;
e) 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.
f) Always wear anti-static wrist straps and work on a grounded conductive workbench pad, which can protect the analyzer and the connectors from electrostatic discharge.

6) Connector cleaning

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

a) 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:
b) Soak (but not thoroughly soak) a lint-free cotton swab with isopropyl alcohol;
c) 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.
d) Let the alcohol volatilize, then blow the surface clean with compressed air;
e) Check the connector to make sure that it is free of particles and residues.
f) 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) Use of adapters

When the measurement port of the USB peak/average power Sensor and the connector type used are different, suitable adapters must be used for measurement connection. In addition, even if the measurement port of the USB peak/average power Sensor is the same as the connector type of the DUT port, it is also advisable to use adapters. Both cases can protect the measurement port, prolong its service life and reduce the maintenance cost. Before connecting an adapter to the measurement port of the USB peak/average power Sensor, it is required to carefully check and clean the adapter. And a high-quality adapter shall be used to reduce the influence of mismatching on measurement accuracy.

8) Joint plane of connectors

An important concept in microwave measurement is reference plane. Regarding a USB peak/average power Sensor, it is the benchmark reference plane for all measurements. During the calibration or zeroing, the reference plane is defined as the plane where the measurement port and the calibration standard are engaged. Good connection and calibration depend on thorough and level contact between the connectors on the joint plane.

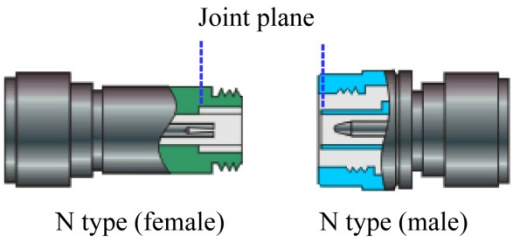


Figure 3.5 Calibration plane

3.1.1.5 User check

Connect the USP peak/average power Sensor to a computer via USB cables and allow it to warm up for at least 30 minutes. Set the instrument as follows:

Step 1. Initiate the power measurement and display software, click "Connect Device", select the equipment in the pop-up window, and confirm it.

Step 2. Observe the power noise fluctuations in the display area. Click "External Zeroing". Pay close attention to the alarm indication area in the power measurement and display software. If no alarms appear, the instrument is functioning normally. If an alarm appears, the instrument is malfunctioning.

Contact our service center using the contact information provided on the inside front cover of this manual or in "5.4 Method to obtain after-sales services". We will promptly repair or replace the unit as needed.

3.1.2 Routine maintenance

This section describes daily maintenance procedures of the USP peak/average power Sensor.

- Cleaning method.....23
- Test port maintenance.....23

3.1.2.1 Cleaning method

Please follow the steps below when cleaning the surface of the instrument:

Step 1. Power off the device and disconnect the network cable.

Step 2: wipe the surface gently with dry or slightly wet soft cloth, and do not wipe the inside of the instrument.

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

3.1.2.2 Test port maintenance

Damage to the RF input port of the USB peak/average power Sensor or the presence of dust inside the power Sensor will affect the test results of RF band. 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.

Notice

Port impedance matching

The RF port of the USP peak/average power Sensor is a 50 ohm connector (male). If the connection does not match the impedance connector, the connector will be damaged.

3.2 Appearance interface description

This section describes the external components and functions of the USP peak/average power Sensor, as shown in Figure 3.6. The itemized explanation is shown in Table 3.3.

Table 3.3 Description of Sensor appearance and interface

No.	Name	Description
1	Power input interface	It is used to receive power signal input
2	USB interface	It is used for power supply and communication of USB peak/average power Sensor
3	Trigger input interface	For external trigger signal input
4	Trigger output interface	For pulse modulated signal synchronous output
5	Indicator light	It is used to indicate the working state of the instrument



Figure 3.6 Sensor appearance and interface

3.3 Basic operating instructions

This section introduces the main characteristics of the operating interface of the USB peak/average power Sensor power measurement and display software and the basic measurement setting methods. These basic measurement setting methods will be applied in subsequent measurement tasks. This section includes:

- Power measurement and display software.....24

- Sensor connection.....27

3.3.1Power measurement and display software

The power measurement and display software of the USP peak/average power Sensor features a new intuitive graphical user interface that clearly displays the average power measurement window, pulse trace window, statistical measurement window, and data statistics window. The operating interface of the power measurement and display software is divided into different areas according to the function modules, and multiple function modules can be operated at the same time. The left side of the screen is Sensor parameter display area and its right side is the instrument menu setting area, which can be operated by the user via mouse. This section primarily introduces the partitioned composition and functions of the power measurement and display software's user interface. Detailed operating instructions are available in the User's Manual for the Power Measurement and Display Software that is accessible via the software's Help menu. The software operating interface is shown in Figure 3.7, and the itemized explanation as shown in Table 3.4:



Figure 3.7 Main interface of power measurement and display software

Table 3.4 Operating interface description

No.	Name	Description
1	Menu bar	Function setting menu
2	Tool bar	Shortcuts to common tools
3	Parameter display area	Display pulse measurement parameters, gate parameters, marker parameters, and statistical parameters.
4	Navigation bar	Display all connected devices
5	Central window display area	Display power measurement data and support adding 1 to 4 sub-windows, including pulse trace, statistical trace, numerical values, and data statistics.
6	Menu setting area	Set the function menu

3.3.2Sensor connection

To use a USB peak/average power Sensor, at least the following conditions shall be met:

1) The host computer has a USB 2.0 interface;

2) The host computer has the VISA library and power measurement and display software installed.

Notice

VISA library installation

To run the power measurement and display software, the VISA library shall be installed to the computer. Note: Only one kind of VISA library may be installed in the computer. Installing two kinds of VISA libraries will cause programmed control conflicts or errors. At this time, users shall uninstall all libraries and reinstall only one kind of VISA library.

Step 1. Connect the device as shown in Figure 3.8. Use a USB cable to connect the Sensor to the computer;

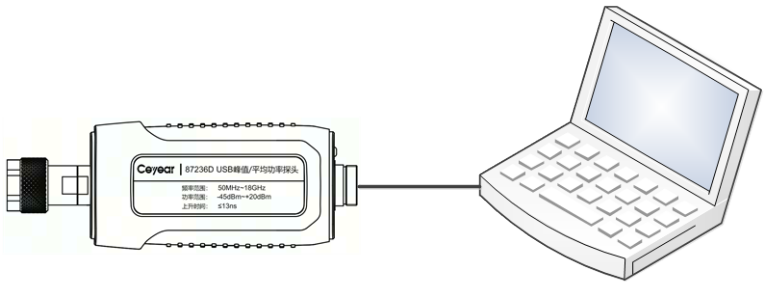


Figure 3.8 Use and connection of the USB peak/average power Sensor

Step 2. Open the power measurement and display software. Click [Connect Device] on the toolbar to pop up the Connect Device dialog box, as shown in Figure 3.9. The dialog box lists all USB peak/average power Sensors that can be connected to the computer. Users can select one or more Sensors to connect. After selection, users click the "Connect" button. The software automatically creates a value window for each Sensor in the central window display area, as shown in Figure 3.10;

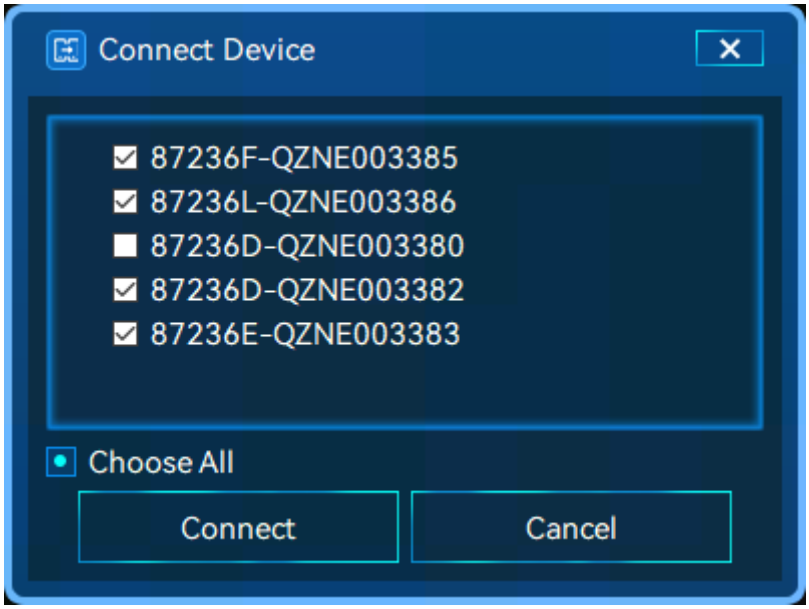


Figure 3.9 Device connection dialog box



Figure 3.10 Software interface after connection confirmation

Notice

Multi-Sensor connection

When more than 4 USB peak/average power Sensors are connected, the power measurement and display software can locate all Sensors in the connected devices window. However, it supports displaying measurement results from a maximum of 4 USB peak/average power Sensors simultaneously.

Step 3 Click the [Disconnect Device] button in the toolbar to pop up the device disconnection dialog box, as shown in Figure 3.11. The dialog box lists all currently connected USB peak/average power Sensors. Users may select one or more Sensors to disconnect. After selection, users click the "Disconnect" button to disconnect the chosen devices. The software will automatically close the corresponding functional windows for the devices and display a device disconnection prompt window, as shown in Figure 3.12.

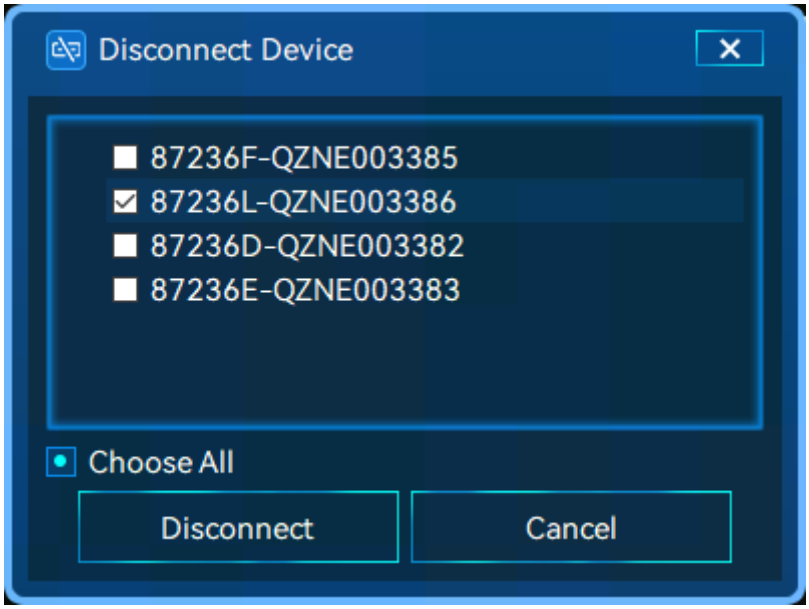


Figure 3.11 Device disconnection dialog box

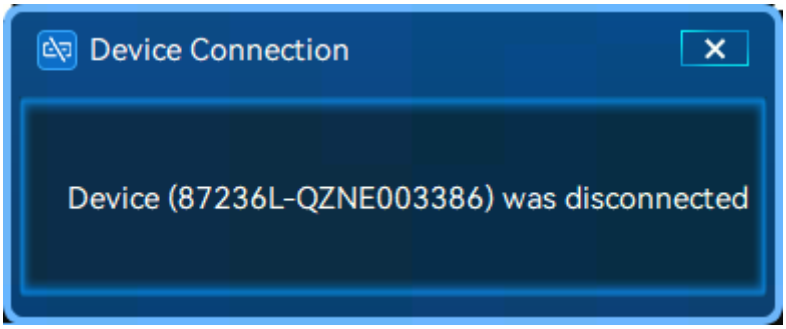


Figure 3.12 Device disconnection prompt box

3.4 Function operation guide

This section describes the operating instructions of basic setting functions for the USB peak/average power Sensor, including: average power measurement, pulse power measurement, etc. The setting steps are detailed using examples.

- Average power measurement.....31
- Pulse power measurement.....33
- "Gate" setting and its usage.....39
- "Offset setting and its usage".....44

Warning

Preventing Sensor burnout

If the signal output power of the DUT may exceed the upper limit of power range of the USB peak/average power Sensor, an appropriate power attenuator must be connected to the Sensor input. Failure to do so will burn out the Sensor.

3.4.1 Average power measurement

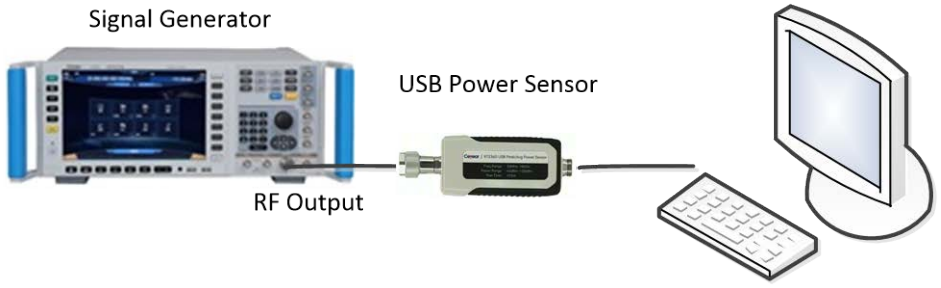


Figure 3.13 Connection of test

Connection is performed as shown in Figure 3.13. The specific procedure is as follows:

Step 1: Set the signal generator output power to 0 dBm, frequency to 1 GHz and modulation mode to OFF;

Step 2: Connect the USB peak/average power Sensor and run the power measurement and display software. The measurement mode defaults to Average Only. Set the frequency to 1 GHz, as shown in Figure 3.14;

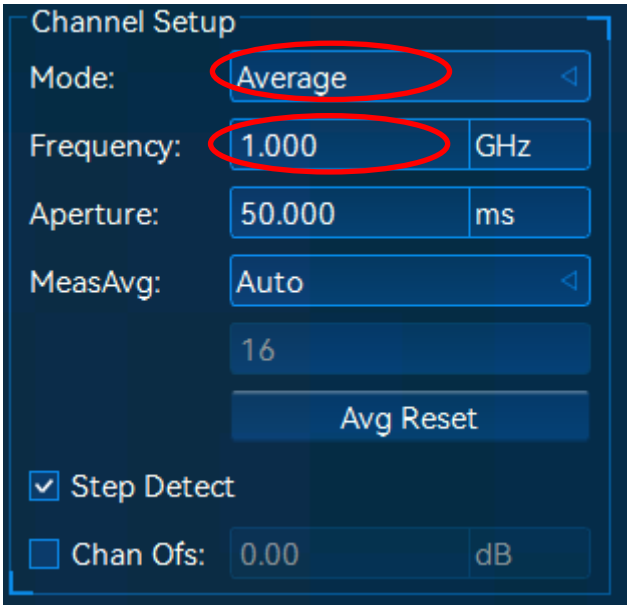


Figure 3.14 Measurement mode

Step 3: Conduct internal zeroing (when the measured signal is small and almost equal to the lower limit of Sensor power range, the signal source output needs to be turned off for external zeroing), as shown in Figure 3.15;



Figure 3.15 Zeroing setting

Step 4: At this time, the measured signal power value can be observed in the average power display window, as shown in Figure 3.16.



Figure 3.16 Power display window

注 意

When measuring low-level signals, it is necessary to conduct external zeroing first. When conducting external zeroing, it is necessary to turn off the output of the signal source, and then conduct the measurement, so as to ensure the accuracy of the measurement.

3.4.2 Pulse power measurement

3.4.2.1 Definition of pulse measurement parameter

This section details the definitions of pulse parameters within the power measurement and display software.

Figure 3.17 illustrates a pulse envelope schematic, graphically describing its parameters. Table 3.5 presents pulse terminology and definitions in the IEEE 194-1977 standard, while Table 3.6 provides detailed definitions for various pulse parameters.

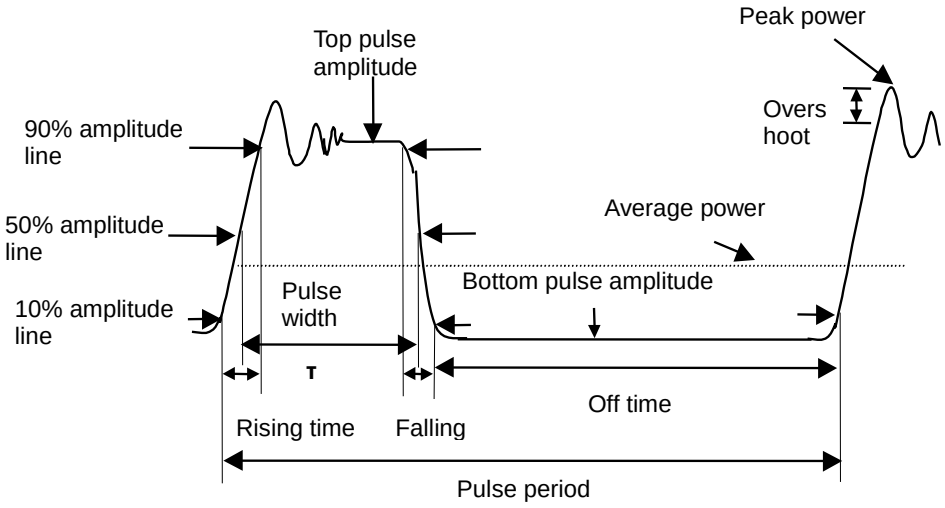


Figure 3.17 Definitions of pulse envelope amplitude and time-domain parameter

Table 3.5 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.

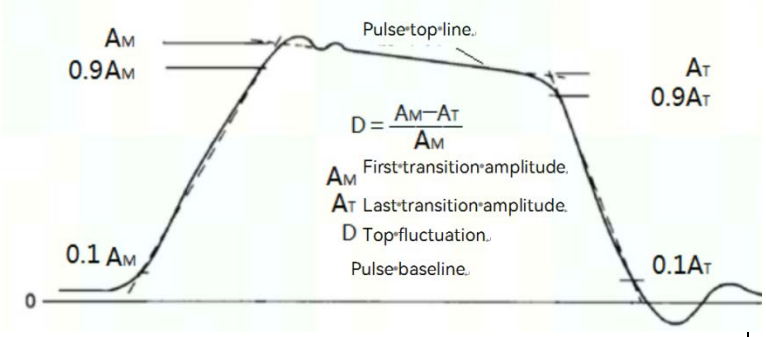
		The base line represents the level at which the low-level normal state resides. It is manifested as an iso-value reference line.
Top Line	Top line	Similar to the base line definition, the top line represents the level at which the high-level normal state resides. It is manifested as an iso-value reference line. In practical applications, the top line is defined as the power value with the highest number of power points occurring between the midpoint power of the first transition and the midpoint power of the last transition.
First Transition	First transition	The primary transition zone between base line and top line of a waveform.
Last Transition	Last transition	The primary transition zone 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 power measurement and display software automatically measures 16 parameters of the pulse power envelope, which are categorized into time parameters and power parameters. Refer to Table 3.6 for specific definitions.

Table 3.6 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 "pulse width" value cannot be displayed in the left parameter display area.**

	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 "pulse period" value cannot be displayed in the left parameter display area.**
	Pulse repetition frequency	The number of times a repetitive signal occurs per second. **Notice: If the waveform display does not show a full pulse period, the "pulse repetition frequency" value cannot be displayed in the left parameter display area.**
	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.
	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".
	Duty cycle	The ratio of pulse width to pulse period.
	OFF time	The time during which the periodic pulse is turned off, which is equal to the pulse period minus the pulse width.
	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.
	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 must display at least one pulse width.

3.4.2.2 Pulse power measurement and waveform display

Connection is performed as shown in Figure 3.13. The specific procedure is as follows:

Step 1: Set the signal generator output power to 0 dBm and the frequency to 1 GHz. Turn on pulse modulation mode, and set the pulse period to 100 us and pulse width to 50 us;

Step 2: Connect the USB peak/average power Sensor and run the power measurement and display software. The measurement mode defaults to Average Only. Set the frequency to 1 GHz.

Step 3: Click the toolbar [Pulse Trace] to open the trace display window in the test panel. The measurement mode is set to Normal and the trigger mode is set to Continuous Trigger;

Step 4: Conduct internal zeroing operation (when the measured signal is small, the source output needs to be turned off for external zeroing);

Step 5: Set the display position of the pulse waveform in the trace window via the trace menu, as shown in Figure 3.18;

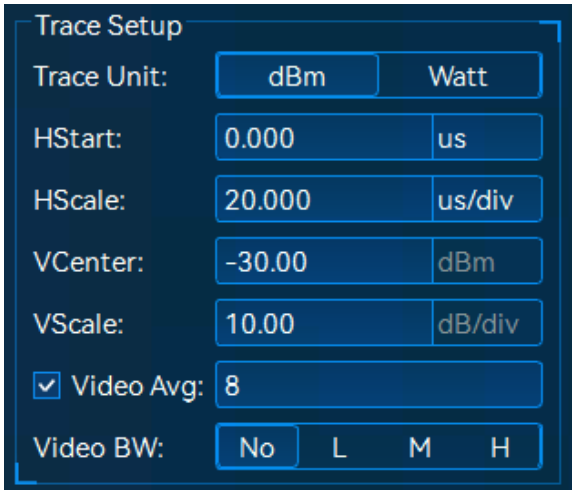


Figure 3.18 Trace setting

Step 6: Set the start position and duration of gate 1. The average power, peak power and peak to average ratio in the gate can be observed and measured in the parameter display area, and the automatic gate can also be used to measure the gate parameters, as shown in Figure 3.19;



Figure 3.19 Gate measurement

Step 7: The numerical display window shows the gate measurement value, while the trace display window shows the pulse trace, as shown in Figure 3.20;

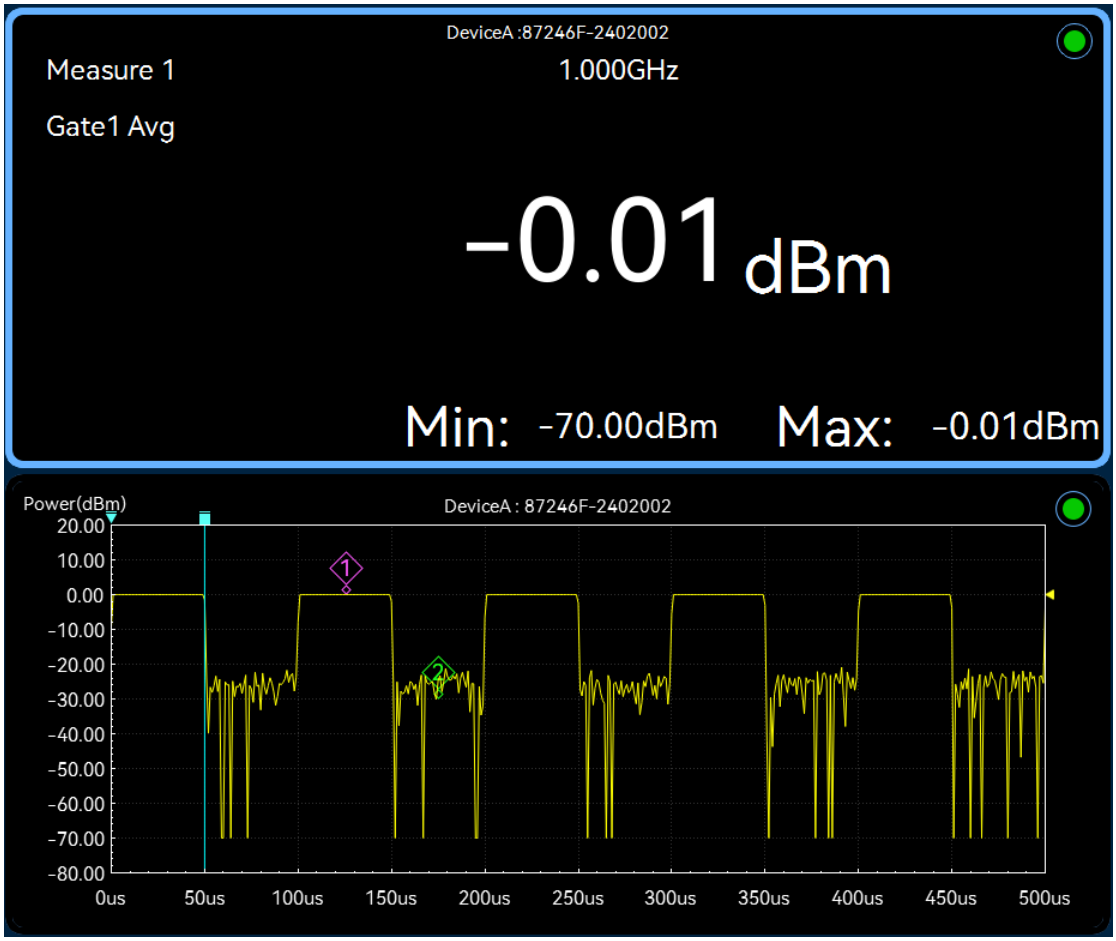


Figure 3.20 Gate measurement

Step 8: At this time, the pulse amplitude and time parameters can be observed in the pulse parameters of the parameter display area, as shown in Figure 3.21.

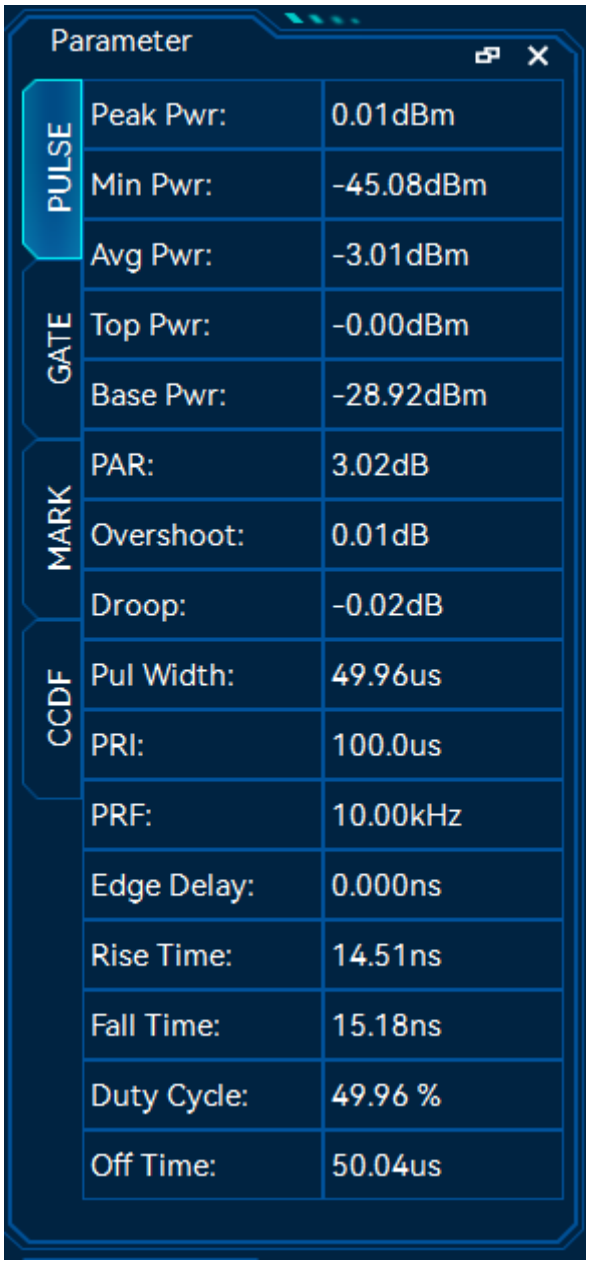


Figure 3.21 Pulse parameter

3.4.3 "Gate" setting and its usage

In power measurement and display software, "gate" serves as essential auxiliary measurement tools. Users familiar with gate setting can test numerous pulse parameters easily.

3.4.3.1 Basic concepts of measurement gate

The "gate" function is exclusively used for measurement relaying on peak power Sensors. 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", "peak", "peak-to-average ratio", and "minimum".

The definition is detailed below:

Average: The average power value within the current gate.

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

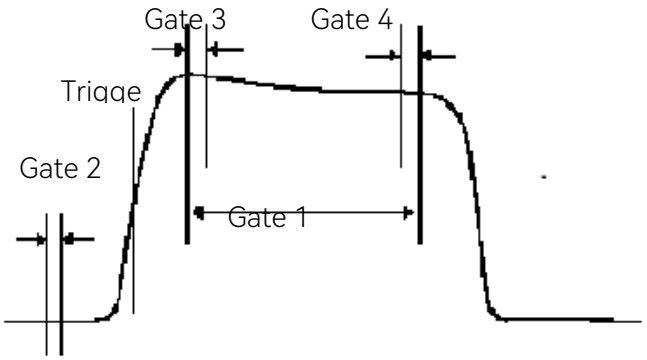


Figure 3.22 Measurement gate

For example, by setting a measurement gate as shown in Figure 3.22, the following measurements can be performed:

- Average power of pulse: Average measurement in gate 1;
- Ratio of peak to average: Peak-to-average measurement in gate 1;
- Pulse dropout: Average measurement in gate 3 minus the average measurement in gate 4;
- Noise average: Average measurement in gate 2.

注 意

The concept of "gate" applies only to the 87236 series USP peak/average power Sensor. Other Sensor types do not support gate-related operations;

The 87236 series USB peak/average power Sensor can only perform "gate"-related operations in trace measurement mode. Therefore, when setting gates, users shall set [Mode] in [Channel Setting] to "normal" and set [Trigger Mode] in [Trigger Setting] to "continuous trigger".

During the measurements with a gate, gate position and duration can be modified via "gate setting". Only one gate position can be displayed in the pulse trace window. The numeric window supports combined test with two gates, offering two combination modes: "ratio" and "difference". Users can freely define the measurement types for gate 1 and gate 2 via [Operation], [Input 1], and [Input 2] in the [Measurement Setting], and freely combine various measurement types.

3.4.3.2 Setting positions of measurement gate

Up to four distinct gates can be set. For more intuitive gate setting, it can be used in conjunction with the pulse trace window to visually adjust gate start time and duration. As shown in Figure 3.23, the procedures for setting gates relative to the trigger position are as follows:



Figure 3.23 Gate setting

Step 1: Set the drop-down box in [Gate Setting] to select the current gate. There are 4 gates available. If "gate 1" is selected, the following settings apply to "gate 1";

Step 2: Set the start position of gate 1 via [Gate 1 Start]. The start vertical line of the corresponding gate will appear in the pulse trace window.

Step 3: Set the duration of gate 1 via [Gate 1 Duration], which is defined as the time span between the start and stop vertical lines of corresponding gate in the pulse trace window.

Step 4: Set start position and duration of gate 1 via [Auto Gate]. The left/right reference ratio for gate 1 is set to 10%. In other words, the start vertical line is set to 10% of the first pulse and the stop vertical line to 90% of the first pulse, as shown in Figure 3.24.



Figure 3.24 Automatic gate setting

3.4.3.3 Measurement gate setting in the numerical window

When the Sensor is in trace measurement mode, the value displayed in the numeric window corresponding to the Sensor represents a setting within the measurement gate. The numerical display presents two types of measurement results: First, measurements for individual parameter settings, such as "average power" or "peak power" within a single gate; Second, combined calculations and measurements of results from two gates, such as the ratio of "average power of gate 1" to "average power of gate 2",

The procedures for setting individual gates and combination doors in the numerical display mode are detailed below.



Figure 3.25 Individual gate setting

As shown in Figure 3.25, the procedures for setting a single door are as follows:

Step 1: Set [Measurement Setting] > [Operation] to "None" to select single-door measurement mode.

Step 2: Set [Input 1] > [Gate] > [1] to designate the current gate as gate 1. In this case, gate 1 will appear in the upper-left corner of the numerical window, indicating that gate 1 is the active measurement gate.

Step 3: Set [Input 1] > [Type] > [Average]. The upper-left corner of the numerical window will display the average, and the window will show the average power in gate 1.

Step 4: Set [Type] to "peak", "peak-to-average ratio", or "minimum". In this case, the numerical display window will show all kinds of measurement values.

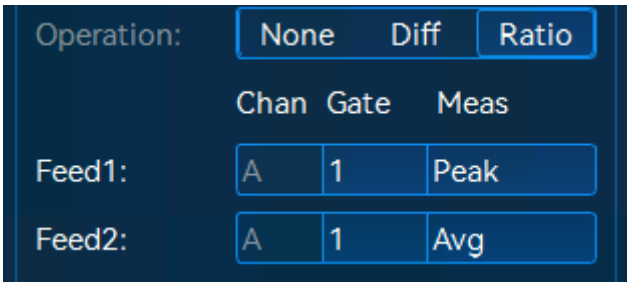


Figure 3.26 Combination gate setting

As shown in Figure 3.26, the steps for setting a combination door are as follows:

Step 1: Follow the "procedures for setting a single door" to set [Input 1] to the "average power" of "measurement gate 1";

Step 2: Set [Operation] to [Compare]. In this case, [Input 2] will light up, enabling [Input 2] operation;

Step 3: Set [Input 2] > [Gate] > [2] to set the second data for "combined measurement" to gate 2. In this case, the top-left corner of the numeric window will display gate 1 average/gate 2 average, indicating the measurement result is the ratio of gate 1 to gate 2;

Step 4: Set [Input 2] > [Type] > [Peak] and set the measurement type for "gate 2" to "peak". In this case, the measurement result in the numeric window will be the ratio of "gate 1 average power" to "gate 2 peak power" (unit: dB).

Step 5: If [Operation] is set to [Difference], the upper-right corner of the numeric window displays gate 1 average - gate 2 average. In this case, the measurement result in the numeric window is the difference between "gate 1 average power" and "gate 2 average power" (unit: dBm).

3.4.4 Setting and using "offset"

The USP peak/average power Sensor can compensate for signal attenuation or gain in the test path. Offset can be set at two distinct positions within the measurement channel: "channel offset" and "frequency response offset". They apply to the entire channel and enable independent Sensor compensation.

3.4.4.1 Setting channel offset

If the measurement path includes amplification or attenuation circuits, the gain and attenuation are inherent to the measurement channel. Channel offset is measured in dB, ranging from 100 dB to +100 dB. Positive values compensate for the attenuation of attenuators, while negative values compensate for the gain of amplifiers.

Steps to set channel offset:

Step 1: Select [Channel Setting] > [Channel Offset]. Click the checkbox to select and enable the channel offset function. "channel offset" will appear in the upper-right corner of the numerical window, indicating the channel setting is active.

Step 2: Set [Channel Setting] > [Channel Offset]. Enter the offset value via keyboard.

If the entered offset value is positive, the measurement result plus the offset value is displayed. If the entered offset value is negative, the measurement result minus the offset value is displayed.

3.4.4.2 Setting frequency response offset

Frequency response offset varies with frequency, providing a rapid and effective compensation method for frequency-dependent variations in test system response. It is applied to the power Sensor. The USP peak/average power Sensor can store up to 10 frequency response offset tables, each supporting a maximum of 4000 frequency points.

After activating the frequency response offset function, the power Sensor automatically sets correction factors based on the Sensor calibration table and frequency response offset table during power measurements. This ensures measurement accuracy by adjusting the measurement results.

Steps to enable frequency response offset:

Step 1: Verify the power measurement and display software is connected to the power Sensor;

Step 2: Click the [Advanced] menu in the [Menu Bar], and then select [Frequency Response Offset Table] from the dropdown options to enter the frequency response offset window. This window displays a list of all available frequency response offset tables, as shown in Figure 3.27. The window includes columns for serial number, frequency response offset table name, number of points, and enable state;

Step 3: Click the checkbox corresponding to a specific table in enable state" column.

For example, click the checkbox corresponding to the No.1 frequency response offset table to enable that table. Simultaneously, "frequency response offset (1)" will appear in the upper-right corner of the numerical window, indicating that frequency response offset table 1 is active.

It is worth noting that the power measurement and display software can only open the frequency response offset table for the currently selected power Sensor in the operation navigation bar. The "frequency response offset (1)" will only appear in numerical window corresponding to that power Sensor, as shown in Figure 3.28.

Additionally, only one entry in the "enable state" column of the window may be "selected" at a time. This means only one frequency response offset table can be active for a single power Sensor.



Figure 3.27 Frequency response offset table window



Figure 3.28 Frequency response offset ON/OFF marker

Steps to edit the frequency response offset table:

Step 1: As per the **frequency response offset enabling procedure**, first open the frequency response offset table window;

Step 2: Use the mouse to select the desired frequency response offset table within the window. The selected table will display a light blue background;

Step 3: Click the "Edit" button to open the editing window and modify the table contents, as shown in Figure 3.29. Alternatively, double-click any frequency response offset table to edit it;

Step 4: Check the [FDO Enable] checkbox to activate the frequency response offset table;

Step 5: Click the [Frequency Response Offset Table Name] input box to modify the table's name;

Step 6: Click the [Add]/[Delete]/[Edit]/[Clear] buttons to perform operations on individual data entries within the table;

Step 7: Click the [File Import] button to load data stored in spreadsheets (e.g., .csv files) with a single click;

Step 8: Click the [File Export] button to save the data in the current window to a spreadsheet. When it is used in conjunction with [File Import], convenient batch editing of data in the frequency response offset table is possible.

Step 9: Click the [OK] button to set the frequency response offset table. Clicking [Cancel] will discard all the above settings.

It is worth noting that steps 4) to 6) take effect only after users click [OK]. Any setting will be discarded if users close the window.



Figure 3.29 Editing window of frequency response offset table

If a frequency entered in the frequency response offset table exceeds the frequency range defined in either the Sensor calibration table or the frequency response offset table, the USB peak/average power Sensor will use the highest or lowest frequency point in the corresponding table to set the calibration factor and offset.

In practical applications, if the frequency of the signal under test differs from the frequency points in the Sensor calibration table or the valid frequency response offset table, the USB peak/average power Sensor will use linear interpolation to calculate the calibration factor and offset for that frequency point.

4. Remote control

This chapter briefly introduces the programmed control fundamentals, programmed control interface and configuration method, and basic VISA interface programming method of the USB peak/average power Sensor, as well as the concept and classification of I/O instrument driver library. The purpose is to facilitate users to start to achieve remote control. Due to the product's characteristics, only USB programmed control is supported. Specific details include:

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- Instrument programmed control port and configuration.....64
- Basic VISA interface programming method.....65
- I/O library.....68

4.1 Remote control fundamentals

- Programmed control interface 48
- Message.....49
- SCPI command 50
- Command sequence and synchronization 59
- State reporting system 61
- Precautions for programming 64

4.1.1 Programmed control interface

The USD programmed control interface and related VISA addressing string are described in the table below:

Table 4.1 Remote control interface type and VISA addressing string

Programmed control interface	VISA addressing string	Description
USB (Universal Serial Bus)	USB::<vendor ID>::<product_ID>::<serial_number>[::INSTR]	The controller realizes remote control by connecting the instrument through its USB interface.

To implement USB programmed control, a computer and signal generator need to be connected via a USB interface 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>[::INSTR]

Where:

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

Example:

USB:: 0x3399:: 0x3800::QWNI006688::INSTR

0x3399: Manufacturer code;

0x3800: Instrument code;

QWNI006688: serial number of the instrument.

4.1.2 Message

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 "4.1.3 SCPI command". 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.

4.1.3 SCPI

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4.1.3.1 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 repeat typeof 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 USB peak/average power Sensor, please refer to:

1) "3 Programmed Control Commands" of the Programmed Control Manual;
2) "Annex A Zoom table of SCPI commands classified as per subsystems" of the Programmed Control Manual;

4.1.3.2 Description of SCPI

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- Command type.....52
- Instrument command syntax.....53
- Command tree.....54
- Command parameters and responses.....55
- Number system of commands.....58
- Command line structure.....59

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 SCPIs 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 key 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 4.1 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.

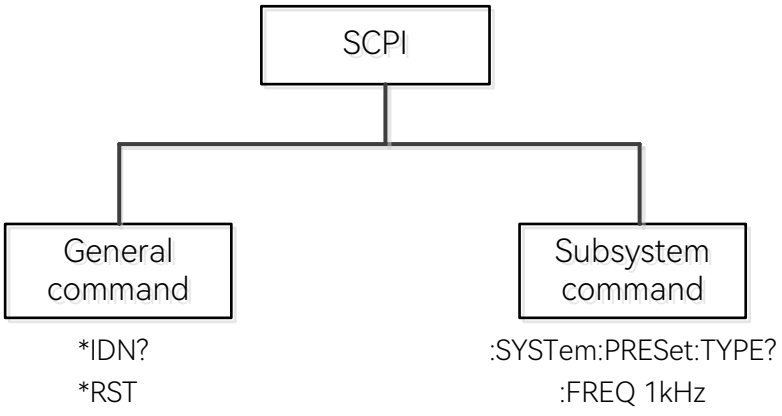


Figure 4.1 Types of SCPI

3) Instrument command syntax

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 4.2 and Table 4.3.

Table 4.2 Special characters in command syntax

Symbol	Meaning	Example
|	The vertical bar between the keyword and the parameter represents multiple options.	[:SOURce]:AM: SOURce EXTernal|INTernal EXTernal and INTernal are optional
[]	A square bracket indicates that the contained keyword or parameter is optional when forming a command. The command will be executed even when such implied keyword or parameter is ignored.	[:SOURce]:AM[:DEPTh]:EXPon ential? SOURce and DEPTh are optional.
< >	The portion enclosed in angle brackets is not used literally in the command . It represents the part that must be contained.	[:SOURce]:FREQ:STOP <val><unit> In this command, <val> and <unit> must be replaced with actual frequency and unit. For example: :FREQ:STOP 3.5 GHz
{ }	The part in braces indicates that the parameter is optional.	[:SOURce]:LIST:POWer <val>{,<val>} For example: LIST:POWer 5

Table 4.3 Command syntax

Characters, keywords and syntax	Example
Uppercase characters represent the minimum	[:SOURce]:FREQuency[:CW]?,

set of characters required to execute a command. .	FREQ is the short format part of the command.
The lower case part of the command is optional; such flexible format is loaded called "flexible listening". For details, refer to "Command Parameters and Responses".	:FREQuency :FREQ,:FREQuency or or :FREQUENCY Either of them is correct.
When a colon is between two command mnemonics, it will move the current path down a level in the command tree. Please refer to the command path of "Command Tree" for more information.	:TRIGger:OUTPut:POLarity? TRIGger is the top-level keyword for the command.
If the command contains more than one parameter, adjacent parameters are separated by commas. The parameter is not part of the command path, so it does not affect the path layer.	[:SOURce]:LIST:DWELl <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 or within keywords. However, you must separate the commands and parameters with blank characters, which does not affect the current path.	:FREQ uency or :POWer :LEVel6.2 is not allowed. :LEVel and 6.2 must be separated by a space, namely, :POWer:LEVel 6.2.

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 4.2:

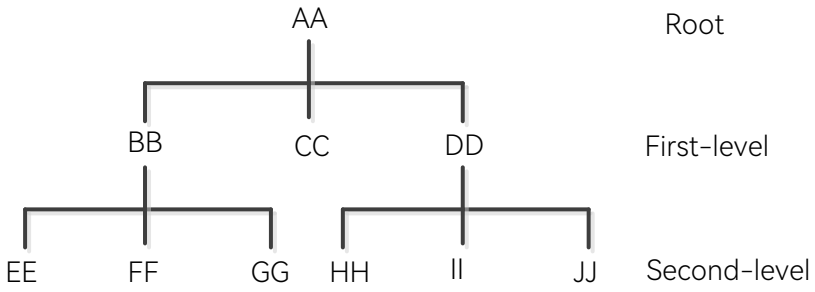


Figure 4.2 Simplified command tree

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

SCPI defines 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 USB peak/average power Sensor: 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.

Table 4.4 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

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

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

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

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

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

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'

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

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

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 Stabilization mode is internal
EXTernal Stabilization mode is external
MMHead Stabilization type is millimeter wave source module

Digital bool response data

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

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

Since one command line can contain multiple SCPI commands, the following methods can be used to indicate the end of current command line:

- 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

4.1.4 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 1GHz;STAR?;SPAN 1000000

The returned result can be current start frequency value of the instrument before such command is sent, since the power Sensor program will not execute the commands one by one until all command messages are received. If the command is executed after the power Sensor receives a command, 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.

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 4.5 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 the ESR register, indicating that the previous command has been processed.	Terminate processing of the current command before executing other commands, and send the command directly after the current command.
*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.

4.1.5 State reporting system

The state report system stores all operation 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.

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- Application of state reporting system.....63

4.1.5.1 Structure of state register

As shown in the following figure, the status information is of hierarchical structure.

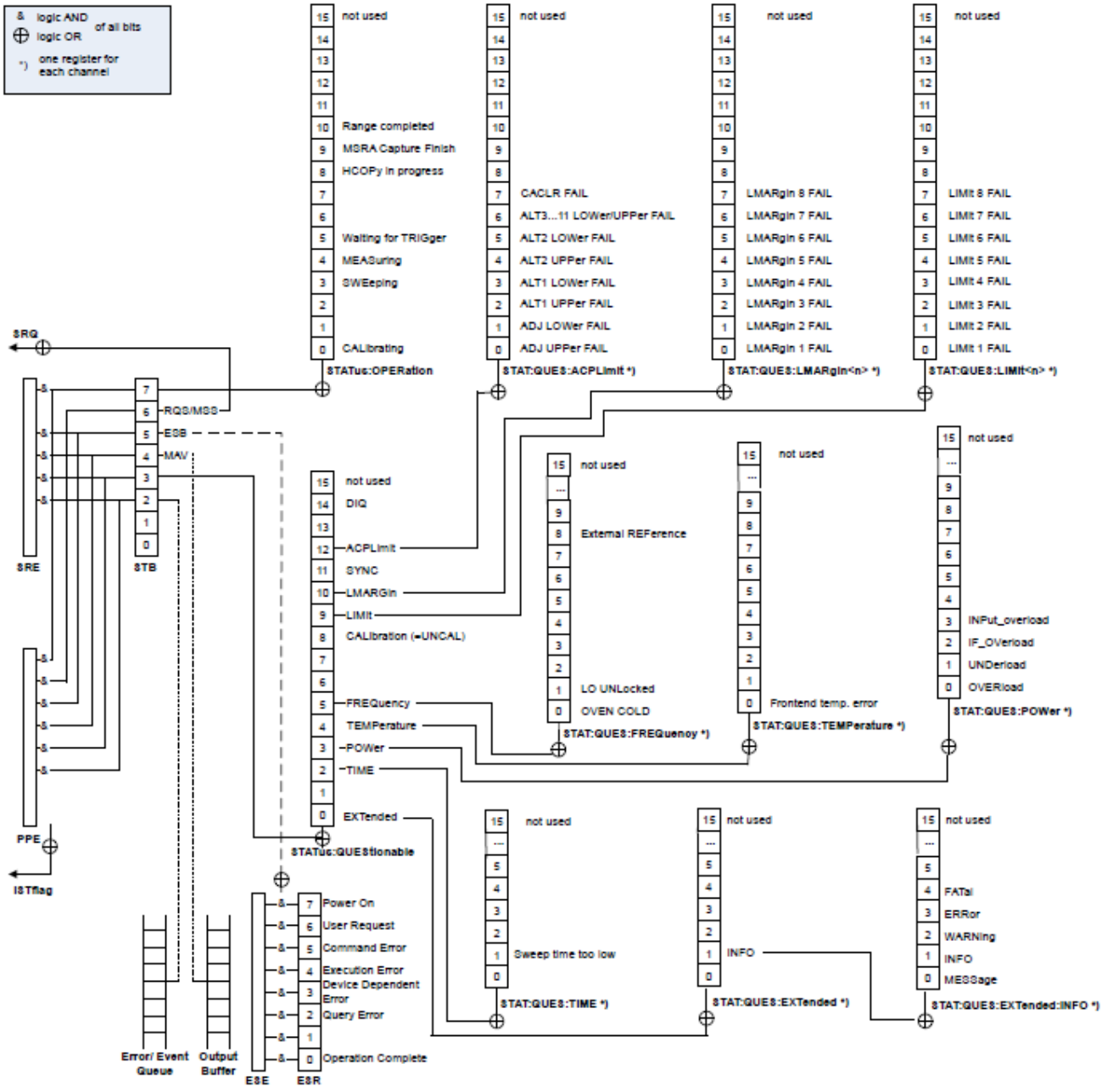


Figure 4.3 Hierarchical structure of the state register

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 operation 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 of 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, refer to 2.1.5.2 "SCPI state register structure"
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 is not part of the state reporting system, but determines the value of the M bit of STB.

For details on the registers mentioned above, refer to "2.1.6 State reporting system" of the programmed control manual.

Tips

SRE, ESE

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

4.1.5.2 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 operating instructions, refer to "2.1.5 State report system application" of the programmed control manual.

4.1.6 Programming precautions

1) Please initialize the instrument state before changing settings

During remote instrument setting, initialize the instrument state (for instance, to send "*RST") first before realizing 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.

4.2 Instrument programmed control port and configuration

The USB programmed control system controls the instrument based on the USBTMC protocol.

4.2.1 Connection Establishment

Use the USB cable to connect the 87236 series USB peak/average power Sensor to an external controller (computer).

4.2.2 Interface Configuration

The VID and PID of this instrument are 0x3399 and 0x3800 respectively, and the serial number is marked on the instrument. These three interface information are fixed and not user configurable.

4.3 Basic VISA interface programming

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

- VISA library.....65
- Initializing and setting default state.....65
- Sending setting command.....67
- Reading the state of measuring instrument 67
- Reading frequency marker.....67
- Command synchronization.....68

4.3.1 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 called. 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 calling. The programming interface supported by the USB peak/average power Sensor is USB. These interfaces, combined with the VISA library and programming language, allow remote control of the USB peak/average power Sensor.

4.3.2 Initializing and setting default state

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

language as an example.

1) Installing VISA library

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 calling. The programming interface supported by the USB peak/average power Sensor is USB. These interfaces, combined with the VISA library and programming language, allow remote control of the USB peak/average power Sensor.

2) Generating global variables

Start by generating global variables that other program modules will call, 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::3399::3800:: QWNI006688::0::INSTR";
const int iTmo = 5000;
```

Among them, the constant rgcDevRsc represents the instrument descriptor, "USB0" represents the controller, "3939" represents the vendor ID of the instrument, 3800 is the product ID, and QWNI006688 is the product serial number.

3) 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);
}
```

4) 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
}
```

4.3.3 Sending setting command

```
/*****************************************************************************/
The following example shows how to set the frequency of the USB peak/average
power Sensor.
/*****************************************************************************/
void SimpleSettings()
{
    ViStatus iStatus;
    ViUInt32 uiRetCnt;
    //Set the frequency to 128MHz
    iStatus = viWrite(iDevHandle, "FREQ 1.2e8\n", strlen("FREQ 1.2e8\n"),
&uiRetCnt);
}
```

4.3.4 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);
```

```
}
```

4.3.5 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……
}
```

4.4 I/O library

- Overview of I/O library ……69
- Installation and configuration of I/O library ……70

4.4.1 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 4.4.

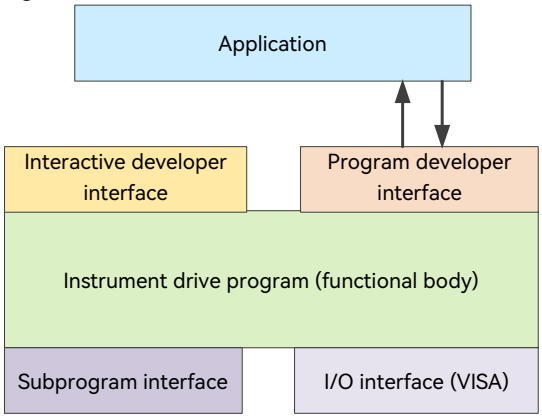


Figure 4.4 Structure model of instrument driver

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 call 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 call other software modules, operation systems, programmed control code libraries and analysis function libraries to complete its task.

4.4.2 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 USB peak/average power Sensor is developed with Nimbus Driver Studio and directly generates IVI-COM and IVI-C driver and program installation package. For specific installation and configuration, please 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.

5 Troubleshooting and after-sales services

This chapter will show you how to find problems and accept after-sales service. It also describe the error messages for the USP peak/average power Sensor.

If you encounter any problem when operating the USB peak/average power Sensor 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 USB peak/average power Sensor 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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- Fault diagnosis and troubleshooting.....73
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5.1 Operation principles

The section introduces the basic operating principle and hardware function block diagram of the USB peak/average power Sensor, so as to facilitate users to understand the functions of the USB peak/average power Sensor and solve problems encountered during operation.

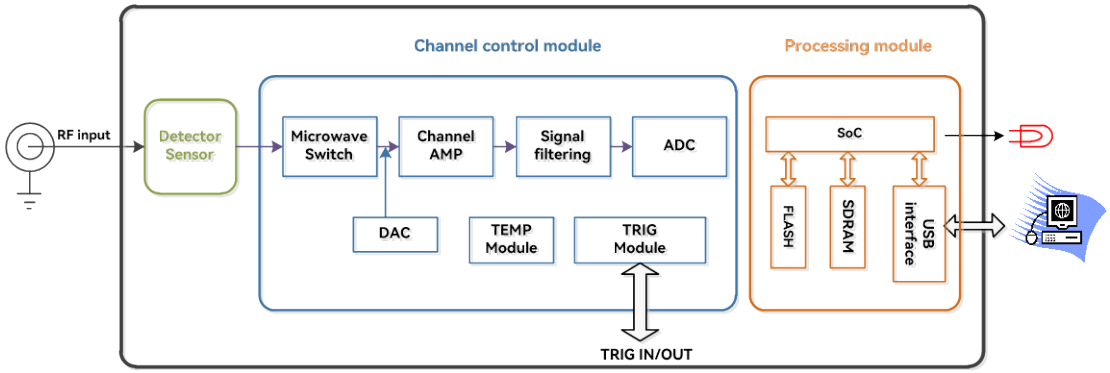


Figure 5.1 Principle block diagram of the USB peak/average power Sensor

In this project, diode is used as the power sensor. When the USB peak/average power Sensor is used to measure the peak envelope of pulse power, its internally balanced dual diode detector first detects the input microwave pulse modulation signal and converts it into two-way pulse modulation envelope signal. Two microwave switches

on the front of the channel conditioning board control the USB peak/average power Sensor to either a measurement state or an internal zeroing state. When the switch is turned on for power measurement, the positive and negative detector signals are linearly amplified and enter two differential amplifiers with high and low ranges, respectively, and then enter the dual-channel ADC for sampling. Internal zeroing is performed when the switch is turned off. In this project, the real-time sampling technology is used to realize data acquisition. The 16-bit dual-channel ADC performs analog-to-digital conversion at the rate of 80Msample/s of the master clock, and the rate at which the converted data is latched and written into DDR3 is controlled by the sampling clock given by the sampling rate generator of the time base unit circuit. The sampled data stored in DDR3 is read out by the main processor at the end of each acquisition cycle and further processed by digital filtering, rapid calibration and compensation to obtain waveform data for display. The USB peak/average power Sensor supports a high data transmission rate of up to 480 Mb/s through the universal serial bus conforming to the USBTMC standard, and uploads the measured results to the host computer for display.

In this project, the function of desktop peak power meter is implemented in one USB peak/average power Sensor, so the compensation of power data is directly for the instrument, which will not produce the error generated by the use of the Sensor and power meter in the traditional power measurement solution. Therefore, the calibration source is no longer needed and the calibration operation is no longer required, which can reduce the size and power consumption, make the use more convenient and test more efficient. The calibration data performed on the instrument is stored in FLASH. In the implementation of temperature compensation algorithm, the processor uses a thermistor located near the diode sensor to continuously monitor the product temperature.

The USB peak/average power Sensors developed in this project are divided into four frequency bands, which are 50 MHz-18 GHz, 50 MHz-26.5 GHz, 50 MHz-40 GHz and 500 MHz-67 GHz, respectively, with the same circuit board and structural parts of the instrument. The frequency bands are divided through the detector components to realize the serialization of products, and make the products easy to produce and maintain, with high reliability and stability.

5.2 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 USB peak/average power Sensor, 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.

5.2.1 Device not found

If the USB device is not found in the computer's Device Manager after power-up, please follow the steps listed below for checking:

Step 1. Confirm whether the USB cable is connected properly and check whether the USB power supply is working properly;

Step 2. Confirm whether multiple USB devices are connected, using a USB HUB with an external power supply if necessary;

Step 3. Confirm whether the power Sensor have the device VISA library and drivers correctly installed.

5.2.2 State Indicator light not ON

Check whether the USB2.0 interface of the host computer is working properly, replace other USB interfaces to observe whether the indicator light is working, or use other devices such as mouse, keyboard, U disk, etc. to verify that the USB interface is powered properly. If it is abnormal, check the external lines for any failure. After troubleshooting, power on the instrument again. If it is confirmed that it is caused by the power supply of the instrument itself, the product shall be sent back to the manufacturer for repair.

5.2.3 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 USB 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.

5.3 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.

In the User Power Test panel, click the Error List icon to view the recent error messages.

For detailed descriptions of error messages, please refer to the Programmed Control Manual of the USB Peak/Average Power Sensor.

5.4 Method to obtain after-sales services

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5.4.1 Contacting us

In case of any failure to the USB peak/average power Sensor, check and save the error message, analyze possible causes, and refer to the methods provided in "5.2 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 message collected. We will coordinate with you to solve the problem as soon as possible.

Contact information:

Version: A.1 Marcj 2026, Ceyear Technologies Co., Ltd.

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

Service consultation: 400-1684191

Quality supervision: 0532-86886614

Website: www.ceyear.com

Email: techbb@ceyear.com

Postal code: 266555

5.4.2 Package and mailing

In case of any failure to the USB peak/average power Sensor that is difficult to be eliminated, contact us by telephone. If it is confirmed that the USB peak/average power Sensor has to be returned for repair, pack it with the original packing materials and case by following the steps below:

1) Prepare a detailed description of the USP peak/average power Sensor fault symptoms and place it in the packing box alongside the Sensor.
2) Pack the USB peak/average power Sensor with the original packing materials to minimize possible damage.
3) Place cushions at the four corners of the outer packing carton, and place the instrument in the outer packing carton.
4) Seal the opening of the packing carton with adhesive tape and reinforce the packing carton 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

Precautions for packaging the USB peak/average power Sensor

Using other materials for packing the USB peak/average power Sensor may damage the instrument. Never use polystyrene beads as packing materials because on the one hand, they cannot provide sufficient protection on the instrument, and on the other hand, they can be sucked in to the instrument fan by the static electricity generated, resulting in instrument damage.

Tips

Instrument package and transportation

Please follow the precautions described in "3.1.1 Preparation before operation" when transporting or handling the instrument.

6. Specifications and test methods

The section introduces the specifications and test methods of the USB peak/average power Sensor.

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- Technical specifications.....76
- Option information.....80
- Test of main performance characteristics.....82

6.1 Statement

The testing condition for all metrics is: The temperature of 23℃±5℃ half an hour after start, 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:

Specifications: Place the calibrated instrument in the operation environment of 0℃ – 40℃ for at least 2 h, and then warm it up for 45 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 characteristics or those that cannot be tested by limited testing means, for example, the 50 ohm 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. Such data is not a guarantee, which is also taken at the room temperature (about 25℃).

6.2 Specifications

Table 6.1 Specifications of the USP peak/average power Sensor

Specifications		
Frequency range	87236D	50 MHz~18 GHz

	87236E	50 MHz~26.5 GHz
	87236F	50 MHz~40 GHz
	87236L	500 MHz~67 GHz
Power range(note 1)	87236D/F	Normal@ModeMode -30 dBm ~ +20 dBm (50 MHz≤f < 500 MHz) -35 dBm ~ +20 dBm (f≥500 MHz)
		Average mode -45 dBm ~ +20 dBm
	87236L	Normal@ModeMode -35 dBm ~ +20 dBm (500 MHz≤f≤40 GHz) -30 dBm ~ +20 dBm (40 GHz < f≤67 GHz)
		Average mode -45 dBm ~ +20 dBm (500 MHz≤f≤40 GHz) -40 dBm ~ +20 dBm (40 GHz < f≤67 GHz)
Max. input power	+23 dBm (average power); +30 dBm (peak power, duration < 1 μs)	
Rise/fall time(note 2)	13ns	
Maximum sampling rate	80MSamples/sec, continuous sampling	
VBW	≥30 MHz	
Single capture bandwidth	≥30 MHz	
Min. pulse width	50ns	
Average power measurement accuracy(note 3)	87236D	±0.20 dB (±4.7%)
	87236E	±0.25 dB (±5.9%)
	87236F	±0.30 dB (±7.2%)
	87236L	±0.33 dB (±7.9%)
Maximum capture length	1 s (down frequency)	
	1.2ms (maximum sampling rate)	
Maximum pulse repetition frequency	10 MHz	
Max Voltage Standing Wave Ratio	87236D	1.20 (50 MHz≤f≤2 GHz)
		1.26 (2 GHz<f≤18 GHz)

	87236E	1.20 (50 MHz≤f≤2 GHz)
		1.26 (2 GHz<f≤18 GHz)
		1.35 (18 GHz<f≤26.5 GHz)
	87236F	1.20 (50 MHz≤f≤2 GHz)
		1.26 (2 GHz<f≤18 GHz)
		1.35 (18 GHz<f≤26.5 GHz)
		1.50 (26.5 GHz<f≤40 GHz)
	87236L	1.20 (500 MHz≤f≤2 GHz)
		1.26 (2 GHz<f≤18 GHz)
		1.35 (18 GHz<f≤26.5 GHz)
		1.50 (26.5 GHz<f≤40 GHz)
		1.70 (40 GHz<f≤67 GHz)
Calibration uncertainty	87236D	0.17 dB (4.0%) (50 MHz ≤ f ≤ 10 GHz)
		0.19 dB (4.5%) (10 GHz < f ≤ 18 GHz)
	87236E	0.18 dB (4.2%) (50 MHz ≤ f ≤ 1 GHz)
		0.19 dB (4.5%) (1 GHz < f ≤ 18 GHz)
		0.22 dB (5.2%) (18 GHz < f ≤ 26.5 GHz)
	87236F	0.18 dB (4.2%) (50 MHz ≤ f ≤ 1 GHz)
		0.19 dB (4.5%) (1 GHz < f ≤ 18 GHz)
		0.22 dB (5.2%) (18 GHz < f ≤ 26.5 GHz)
		0.24 dB (5.7%) (26.5 GHz < f ≤ 40 GHz)
	87236L	0.19 dB (4.5%) (500 MHz ≤ f ≤ 18 GHz)
		0.22 dB (5.2%) (18 GHz < f ≤ 26.5 GHz)
		0.24 dB (5.7%) (26.5 GHz < f ≤ 40 GHz)
		0.29 dB (6.9%) (40 GHz < f ≤ 67 GHz)
Connector	87236D	N-Type(m)
	87236E	3.5mm(m)
	87236F	2.4mm(m)
	87236L	1.85mm(m)
Time base and trigger		
Horizontal scale	2 ns/div-100 ms/div	
Internal trigger (typical)	-20 dBm ~ +20 dBm	

Trigger delay	± 1.0s (maximum)	
Trigger Holdoff	1 μs ~ 1 s	
Trigger Hysteresis	0 dB–10 dB	
Input and output		
Trigger input interface	MMCX connector is TTL-compatible and used for external trigger input	
Trigger output interface	MMCX connector is TTL-compatible and used for trigger sync output	
Programmed control interface	USB2.0 interface, USB-TMC compatible	
Maximum measurement speed	50,000 readings per second	
Product characteristics		
Display	Host computer display	
Operating interface language	Chinese/English	
Power supply requirement	+5 V, 500 mA	
Operating temperature range	-10℃~50℃	
Saving temperature	-40℃~+70℃	
Weight	≤0.30 kg (excluding accessories and packaging)	
Boundary dimension (Width×Height×Depth)	87236D	141.1mm×52.0mm×34.0mm
	87236E	133.9mm×52.0mm×34.0mm
	87236F	124.7mm×52.0mm×34.0mm
	87236L	124.7mm×52.0mm×34.0mm
Recommended calibration cycle	12 months	
Host computer		
Operating system	Windows 11 64-bit Windows 10 32-bit and 64-bit Windows 7 32-bit and 64-bit	
Hardware	Processor: 1 GHz or more (2 GHz or more recommended)	

	Memory: 2 GB or more (4 GB or more recommended) Hard disk space: 1.0 GB or more Display: 1280 x 1024 or better

Note 1. It is recommended to conduct zeroing after startup, significant temperature change or a long time since the last zeroing. External zeroing shall be performed in Average Only mode, and it shall be ensured that the output of the DUT is turned off;

Note 2. It is effective when the frequency is greater than or equal to 500 MHz and the video bandwidth is turned off.

Note 3. It is effective when the power range is -15 dBm ~ +20 dBm, the frequency is greater than or equal to 500 MHz, and the SWR of the DUT is less than 1.20. In the free operation mode, the average is set to 32.

6.3 Option information

Table 6.2 Option information of the USP peak/average power Sensor

No.	Option No.	Option name	Function
1	87230-H01	USB cable	Length: 2.0m
2	87230-H02	USB cable	Length: 4.5m
3	87230-H03	Trigger cable	Length: 1.5m
4	87230-H04	Trigger cable	Length: 4.5m
5	87230-H05	Safety instrument transport case	High-strength portable packing box with handle is used for transport purpose and can accommodate one Sensor set
6	87230-H06	Safety instrument transport case	High-strength portable packing box with handle is used for transport purpose and can accommodate two Sensor sets
7	87236D-H12	English options	English label, manual, power measurement and display software, etc.
8	87236E-H12	English options	English label, manual, power

			measurement and display software, etc.
9	87236F-H12	English options	English label, manual, power measurement and display software, etc.
10	87236L-H12	English options	English label, manual, power measurement and display software, etc.
11	87236D-JL	Measurement service	Measurement and calibration services and measurement reports are provided
12	87236E-JL	Measurement service	Measurement and calibration services and measurement reports are provided
13	87236F-JL	Measurement service	Measurement and calibration services and measurement reports are provided
14	87236L-JL	Measurement service	Measurement and calibration services and measurement reports are provided
15	87236D-EWT1	An extended warranty of one year beyond the standard warranty period is provided.	Extended warranty options are available for purchase after the standard warranty expires: one year, two years, and so forth. The service does not include calibration and covers only one-way shipping costs.
16	87236E-EWT1	An extended warranty of one year beyond the standard warranty period is provided.	Extended warranty options are available for purchase after the standard warranty expires: one year, two years, and so forth. The service does not include calibration and covers only one-way shipping costs.
17	87236F-EWT1	An extended warranty of one year beyond the standard warranty period	Extended warranty options are available for purchase after the standard warranty expires: one

		is provided.	year, two years, and so forth. The service does not include calibration and covers only one-way shipping costs.
18	87236L-EWT1	An extended warranty of one year beyond the standard warranty period is provided.	Extended warranty options are available for purchase after the standard warranty expires: one year, two years, and so forth. The service does not include calibration and covers only one-way shipping costs.

6.4 Primary performance metrics test

The testing condition for all metrics is: The temperature of 23℃±5℃ half an hour after start, 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:

- Frequency range test.....82
- Power range test.....82
- Test on rise/fall time.....84
- Minimum pulse width test.....86
- Test of average power measurement accuracy.....87
- Maximum pulse repetition frequency test.....88
- Calibration uncertainty test.....88

6.4.1 Frequency range test

Description: The calibration uncertainty of the USB peak/average power Sensor within its frequency range shall meet the requirements. In this case, it can be judged that the frequency range metrics are satisfied. See 6.4.7 Test for calibration uncertainty for specific test methods.

6.4.2 Power range test

Description: In this test, a standard power meter is used for comparison to verify whether the power range metrics of the USB peak/average power Sensor meet the

requirements.

Test block diagram: as shown in Figure 6.1.

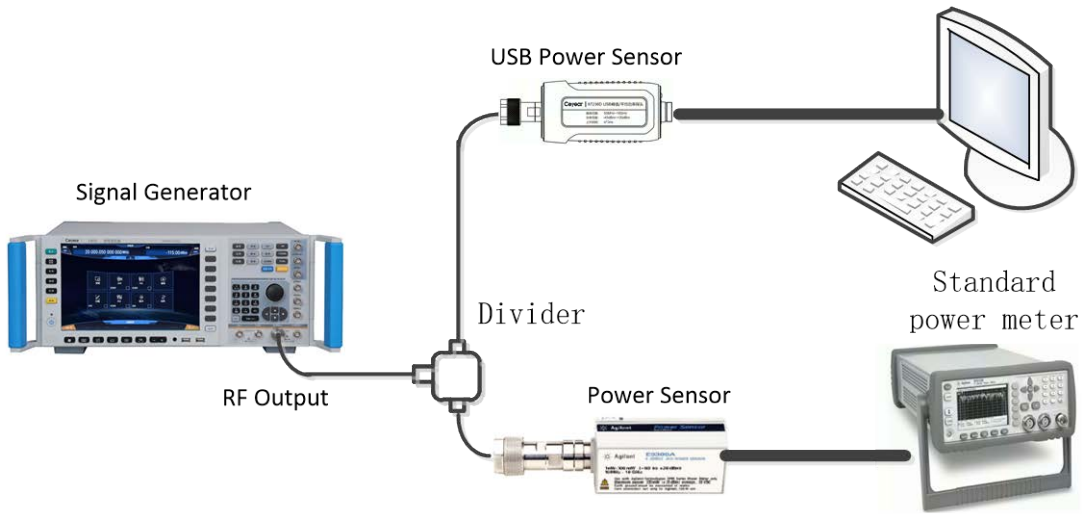


Figure 6.1 Power range test

Test step:

1) The USB peak/average power Sensor under test is connected to the computer via USB cable, and the standard power meter is mated to a power Sensor covering the frequency band, warmed up for at least 30 minutes and then zeroed, and connected in accordance with Figure 6.1;
2) The signal generator is set to continuous wave mode at 50 MHz, with output power set per Table 6.3; Average power is measured using the USB peak/average power Sensor under test and a standard power meter, respectively, with the 87236D/E/F frequency set to 50 MHz. The average power is -30 dBm ~ +20 dBm in the normal mode, or -45 dBm ~ -35 dBm in average mode. The number of averages is set appropriately, and the measurement values P1 from the USB peak/average power Sensor under test and P0 from the standard power meter are recorded; The frequency of both the signal generator and the 87236L is set to 500 MHz. The average power is -35 dBm ~ +20 dBm in the normal mode, or -45 dBm ~ -35 dBm in average mode. The number of averages is set appropriately, and the measurement values P1 from the USB peak/average power Sensor under test and P0 from the standard power meter are recorded. The measurement error is △P (dB) = P1-P0, and its value shall meet the allowable error value required by the metrics in Table 6.3.
3) The signal generator is set to continuous wave mode at 1 GHz, with output power set per Table 6.3; Average power is measured using the USB peak/average power Sensor under test and a standard power meter, respectively, with the 87236D/E/F frequency set to 1 GHz. The average power is -35 dBm ~ +20 dBm in the normal mode, or -45 dBm ~ -35 dBm in average

mode. The number of averages is set appropriately, and the measurement values P1 from the USB power Sensor under test and P0 from the standard power meter are recorded; The measurement error is defined as ΔP (dB) = P1 - P0, which shall be within the permissible error specified in Table 6.3.

4) The signal generator is set to continuous wave mode. The output power is set according to the requirements in Table 6.3. The average power is measured using both the USB peak/average power Sensor under test and the standard power meter. The frequency of both the signal generator and the 87236D/E/F is set to 18 GHz, 26.5 GHz and 40 GHz. The average power is -35 dBm ~ +20 dBm in the normal mode, or -45 dBm ~ -35 dBm in average mode. The number of averages is set appropriately, and the measurement values P1 from the USB peak/average power Sensor under test and P0 from the standard power meter are recorded. The frequency of both the signal generator and the 87236L is set to 67 GHz. The average power is -30 dBm ~ +20 dBm in the normal mode, or -40 dBm ~ -30 dBm in average mode. The number of averages is set appropriately, and the measurement values P1 from the USB peak/average power Sensor under test and P0 from the standard power meter are recorded. The measurement error is △P (dB) = P1-P0, and its value shall meet the allowable error value required by the metrics in Table 6.3.

Note: When measuring a power below -20 dBm, users shall set the power Sensor number of averages to 512, disable "step detection" and turn off the signal generator. After "external zeroing" of the power Sensor is performed, users shall turn on the signal generator and observe the power Sensor measurement value, which shall be within the permissible error in Table 6.3.

Table 6.3 Power range test table of the 87236 series

	Power point (dBm)	Standard power meter Measurement value P0 (dBm)			Power meter under test Measurement value P1 (dBm)			Error value △P(dB)			Allowable error value (dB)
		Lower frequency limit	1 GHz	Frequency cap	Lower frequency limit	1 GHz	Frequency cap	Lower frequency limit	1 GHz	Frequency cap	
87236D	+20										±0.20
	0										±0.20
	-15										±0.20
	-30										±1.65

	-35										±1.65
	-45										±2.47
87236E	+20										±0.25
	0										±0.25
	-15										±0.25
	-30										±1.65
	-35										±1.65
	-45										±2.47
87236F	+20										±0.30
	0										±0.30
	-15										±0.30
	-30										±1.65
	-35										±1.65
	-45										±2.47
87236L	+20										±0.33
	0										±0.33
	-15										±0.33
	-30										±1.65
	-35										±1.65
	-40										±1.65
	-45										±2.47

6.4.3 Test on rise/fall time

Description: This test uses the pulse modulated signal from the test signal generator of the USB peak/average power Sensor under test to verify that the rise/fall time of the USB peak/average power Sensor meets the requirements.

Test block diagram: as shown in Figure 6.2.

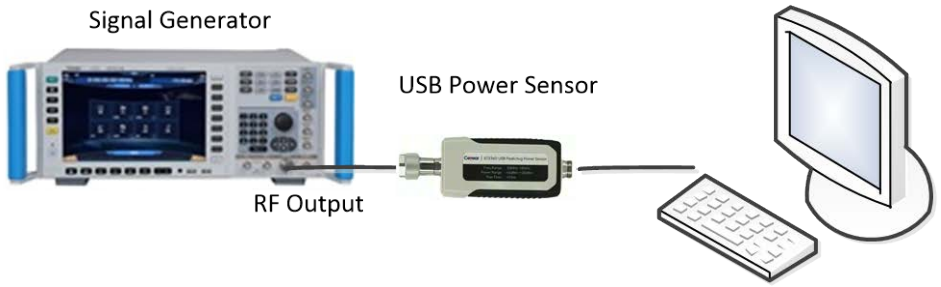


Figure 6.2 Test on rise/fall time

Test step:

1) The USB peak/average power Sensor under test is connected to the computer

via USB cable, started and warmed up for at least 30 minutes, and then connected in accordance with Figure 6.2;

2) Set the signal generator to Pulse Modulation mode, with pulse period of 10 us, and pulse width of 5 us, set the frequency to 1 GHz, and set the output power to 0 dBm;
3) Open the trace display window for the USB peak/average power Sensor under test. Set the frequency to 1 GHz, adjust the horizontal scale appropriately, select internal trigger mode for the trigger source, enable Auto Level, set the number of averages as needed, and record the pulse first/last transition readings t_R automatically measured by the USB peak/average power Sensor under test.
4) The rise/fall time of the USB peak/average power Sensor under test is calculated by the following formula, and the actual value t_r(ns) is recorded. The actual value shall meet the requirements of the rise/fall time metrics.

$$t_r = \sqrt{t_R^2 - t_S^2} \times (1 - 30\%)$$

where, t_r – the actual rise/fall time of the USB peak/average power Sensor under test, in ns;

t_R – the reading of the rise/fall time of the USB peak/average power Sensor under test, in ns;

t_s – the rise/fall time of the signal generator output pulse, in ns.

Notes: When the rise time of USB peak/average power Sensor is 13 ns, the error is 30%.

Table 6.4 Rise/ fall time test

Model	Signal generator Rise/fall time (ns)	Reading value t_R(ns)		Actual value t_r(ns)		Metric requirements
		Rise	Fall	Rise	Fall	
87236D						13ns
87236E						13ns
87236F						13ns
87236L						13ns

6.4.4 Minimum pulse width test

Description: This test verifies whether the minimum pulse width metric of the pulse envelope signal measured by the USB peak/average power Sensor under test meets the requirements.

Test block diagram: as shown in Figure 6.2.

Test step:

1) The USB peak/average power Sensor under test is connected to the computer via USB cable, started and warmed up for at least 30 minutes, and then connected in accordance with Figure 6.2;
2) Set the signal generator to pulse modulation mode, the pulse period to 100 us, the pulse width to 50 us, the frequency to 1 GHz, and the output power to 20 dBm;
3) Open the trace display window of the USB peak/average power Sensor under test, set the frequency to 1 GHz, set the horizontal scale properly, enable the auto level mode, and set the number of averages properly;
4) After the measurement is stable, users shall read the pulse width measured by the USB peak/average power Sensor under test. The automatic measurement error of pulse width shall not exceed ±13 ns.

6.4.5 Average power measurement accuracy test

Description: In this test, a standard power meter is used for comparison to verify whether the average power range metrics of the USB peak/average power Sensor meet the requirements.

Test block diagram: as shown in Figure 6.1.

Test step:

1) The USB peak/average power Sensor under test is connected to the computer via USB cable, and the standard power meter is connected to the power Sensor of the corresponding frequency band, zeroed after warming up for at least 30 minutes, and is connected in accordance with Figure 6.1;
2) The signal generator is set to continuous wave mode, and the frequency is set to 1 GHz, and the output power is set as required in Table 6.5 Average power measurement accuracy test;
3) Continuous wave average power is measured using both the USB peak/average power Sensor under test and a standard power meter. The measurement value P1 of the USB peak/average power Sensor under test and the measurement value P0 of the standard power meter are recorded. The measurement error is △P (dB) = P1-P0, and its value shall meet the allowable error value required by the metrics in Table 6.5.

Note: It is valid when signal generator SWR is < 1.20. The number of averages is set to 32 in Average Only mode.

Table 6.5 Average power measurement accuracy test

	Power point (dBm)	Standard power meter Measurement P0 (dBm)	Power meter under test Measurement P1 (dBm)	Error △P(dB)	Allowable error value (dB)
87236D	+20				±0.20
	0				±0.20
	-15				±0.20
87236E	+20				±0.25
	0				±0.25
	-15				±0.25
87236F	+20				±0.30
	0				±0.30
	-15				±0.30
87236L	+20				±0.33
	0				±0.33
	-15				±0.33

6.4.6 Maximum pulse repetition rate test

Description: This test verifies whether the repetition rate metrics of the pulse envelope signal measured by the USB peak/average power Sensor under test meet the requirements.

Test block diagram: as shown in Figure 6.2.

Test step:

1) The USB peak/average power Sensor under test is connected to the computer via USB cable, started and warmed up for at least 30 minutes, and then connected in accordance with Figure 6.2;
2) Set the signal generator to pulse modulation mode with a pulse frequency of 10 MHz and a duty cycle of 50%. Set the frequency to 1 GHz and the output power to 20 dBm.
3) Open the trace display window of the USB peak/average power Sensor under test, set the frequency to 1 GHz, set the horizontal scale properly, enable the auto level mode, and set the number of averages properly;
4) After the measurement is stable, read the pulse signal frequency measured by the USB peak/average power Sensor under test. The measurement error of pulse repetition frequency shall not exceed ± 0.2 MHz.

6.4.7 Calibration uncertainty test

Description: In this test, a standard power meter is used for comparison to verify whether the metrics meet the requirements.

Test block diagram: as shown in Figure 6.1.

Test step:

1) The USB peak/average power Sensor under test is connected to the computer via USB cable, and the standard power meter is connected to the power Sensor of the corresponding frequency band, zeroed after warming up for at least 30 minutes, and is connected in accordance with Figure 6.1;
2) Set the signal generator to continuous wave mode, set the output power to 0 dBm, and set the frequency as required in Table 6.6 Calibration uncertainty test table;
3) Measure the signal generator output using a standard power meter, record the measurement value P0, connect the USB peak/average power Sensor under test to a computer via USB cable, measure the signal generator output, record the measurement value P1, calculate the deviation △P = P1 - P0 and record it;
4) The final calibration uncertainty is selected as the maximum value of deviation, which shall be within the metrics requirements.

Note: The logarithmic and linear conversion equation of calibration uncertainty is

$$U = (10^{\Delta P/10} - 1) \times 100\%$$

where, U is the linear error and ΔP is the logarithmic error.

Table 6.6 Calibration uncertainty test

	Test frequency point	Standard power meter Measurement P0 (dBm)	Power meter under test Measurement P1 (dBm)	Error △P(dB)	Allowable error value (dB)
87236D	50 MHz				±0.17
	1 GHz				±0.17
	5 GHz				±0.17
	10 GHz				±0.17
	15 GHz				±0.19
	18 GHz				±0.19
87236E	50 MHz				±0.18
	1 GHz				±0.18
	5 GHz				±0.19
	10 GHz				±0.19
	18 GHz				±0.19

	20 GHz				±0.22
	26.5 GHz				±0.22
87236F	50 MHz				±0.18
	1 GHz				±0.18
	10 GHz				±0.19
	18 GHz				±0.19
	26.5 GHz				±0.22
	30 GHz				±0.24
	40 GHz				±0.24