



87230 Series USB CW Power Sensor User Manual



China Electronics Technology Instruments Co., Ltd

This manual applies to the following types of USB continuous wave power sensors:

- 87230: 9kHz~6GHz.
- 87231: 10MHz~18GHz.
- 87232: 50MHz~26.5GHz.
- 87233: 50MHz~40GHz.

Options other than standard accessories are as follows:

- English options: English menu, English panel, etc. for export.

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Foreword

Thank you very much for choosing 87230 series USB continuous wave power sensor developed and produced by China Electronics Technology Instruments Co., Ltd.(CETIC)! Our products integrate high-quality, precision and high-tech in one, with higher cost performance among the products of the same category.

We will do our utmost to meet your needs to provide you with high-quality measuring instruments and first-class after-sales service. Our consistent aim is "excellent quality and considerate service". Providing satisfactory products and services is our commitment to customers.

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AV2.984.1215SS

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China Electronics Technology Instruments Co., Ltd.(CETIC)

Manual authorization

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legal liability for the infringer.

Product warranty

The product has a warranty period of 18 months from the date of shipment. During the warranty period, the instrument manufacturer will repair or replace the damaged parts according to the user's requirements and actual conditions. The specific maintenance operation matters should be subject to the contract.

Product quality certification

The product is guaranteed to meet the specifications defined in the manual from the date of shipment. Calibration measurement is completed by a nationally qualified measurement organization, and relevant information is provided for user review.

Quality/Environmental management

The product complies with the quality and environmental management system during the R&D, manufacturing and testing processes. CETIC has been qualified and passed the ISO 9001 and ISO 14001 management systems.

Safety precautions



The warning sign indicates that there is a danger. It prompts the user to pay attention to a certain operation procedure, operation method, or the like. Failure to follow the rules or incorrect operation may result in personal injury. Only after fully understanding and satisfying the warning conditions indicated can the next step be continued.



The note sign indicates an

important message tip, but it does not pose a danger. It prompts the user to pay attention to a certain operation procedure, operation method, or the like. Failure to follow the rules or incorrect operation may result in damage to the instrument or loss of important data. Only after fully understanding and satisfying the cautionary conditions indicated can the next step be continued.

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1 Manual navigation

This chapter introduces the functions, chapter structure, and main contents of the User Manual for 87230 Series USB Continuous Wave Power Sensor (AV2.984.1215SS), as well as the instrument-related documents provided to the user.

- [About the manual.....1](#)
- [Related documents.....2](#)

1.1 About the manual

This manual describes the basic functions, operation methods, features, basic usage, measurement configuration manual, remote control, maintenance, technical specifications, etc. of 87230 series USB continuous wave power sensors, so as to help you familiarize and master the instrument's operating methods and use points. To facilitate your familiarity with the use of the instrument, please read this manual carefully before operating the instrument, and then follow the instructions in the manual for proper operation.

The chapters included in the user manual are as follows:

- **Overview**

It summarizes the main functions, performance characteristics, typical applications and safety instructions for operating the instrument of 87230 series USB continuous wave power sensor, and aims to make the user understand the main performance characteristics of the instrument and guide the user to operate the instrument safely.

- **Getting started**

This chapter introduces pre-operation checks, instrument browsing, basic measurement methods, data management, etc. of 87230 series USB continuous wave power sensor, so as to help the user to understand the instrument itself and the measurement process, and to make preliminary preparations for the comprehensive introduction of the instrument measurement operation manual. The content contained in this chapter is consistent with the relevant sections of the Quick Start Guide.

- **Operation manual**

It describes in detail the operation methods of the instrument's various measurement functions, including setting up the instrument, starting the measurement process, and obtaining the measurement results. It mainly consists of two parts: function operation manual and advanced operation manual. The function operation manual is tailored for the users who are not familiar with the method of using 87230 series USB continuous wave power sensor. It systematically describes and lists each setting in detail, so that the user can understand and master some basic usages of 87230 series USB continuous wave power sensor. The advanced operation manual is tailored for the users who know the basic common sense for use but are not familiar with specific usages of 87230 series USB continuous wave power sensor. It introduces relatively complex test procedures and advanced usage techniques.

- **Remote control**

It outlines the remote control operation method of the instrument, and aims to enable the user to quickly start the remote control operation. It is divided into four parts: the remote control basis, which introduces the remote control-related concepts, software configuration, remote control interfaces, SCPI command, etc.; the instrument port configuration method, which introduces the connection method and software configuration method of the remote control interface of 87230 serial USB continuous wave power sensors; the VISA interface basic programming method, which gives the basic programming examples by way of text description and sample code, and enables the user to quickly master the remote control programming method; the I/O function library, which introduces the basic concept of the instrument driver and the basic installation configuration of the IVI-COM/IVI-C driver.

1 Manual navigation

1.2 Related documents

- **Fault diagnosis and repair**

It introduces the working principle of the whole machine, fault diagnosis and solution, error message description and repair method.

- **Technical specifications**

It introduces the product features and key technical specifications of 87230 series USB continuous wave power sensor.

1.2 Related documents

The product documents for 87230 series USB continuous wave power sensor include:

- Quick use guide
- User manual
- Remote control manual

Quick use guide

This guide describes the basic operation methods for configuration and start-up measurement of the instrument, and aims to make the user quickly understand the characteristics of the instrument, master the basic settings and basic local and remote control operation methods. The main chapters included are:

- Manual navigation
- Ready to use
- Typical application
- Get help

User manual

This manual describes in detail the functions and operation and use methods of the instrument, including configuration, measurement, remote control and maintenance, and aims to guide the user how to fully understand the product features and master the commonly used instrument testing methods. The main chapters included are:

- Manual navigation
- Overview
- Getting started
- Operation guide
- Remote control
- Fault diagnosis and repair
- Technical specifications

Remote control manual

This manual describes in detail the remote control programming basics, SCPI basics, SCPI command, programming examples, I/O driver library, etc., and aims to guide the user how to quickly and comprehensively master the instrument's remote control commands and methods. The main chapters included are:

- Manual navigation
- Remote control
- Remote control command
- Programming example
- Error description

- Appendix

2 Overview

This chapter introduces the main performance characteristics, main purposes and application fields of 87230 series USB continuous wave power sensor, and also explains how to properly operate the instrument and power safety precautions.

- [Product overview.....5](#)
- [Safe use guide.....5](#)

2.1 Product overview

The 87230 series USB continuous wave power sensors (USB continuous wave power sensors) are a new generation of diode-detection power sensors based on USB 2.0 interface developed by China Electronics Technology Instruments Co., Ltd.(CETIC), with the internal use of high-performance DSP processing chip, and is enabled with the advantages such as wide frequency range, wide power dynamic range, fast measurement speed, and high measurement accuracy through multi-dimensional calibration technology.

The 87230 series USB continuous wave power sensors include four product types, namely 87230, 87231, 87232 and 87233, with the frequency range of 9kHz ~ 6GHz, 10MHz ~ 18GHz, 50MHz ~ 26.5GHz, and 50MHz to 40GHz, respectively. The main features are as follows:

- 1) The continuous wave signal absolute power accurate measurement function;
- 2) Internal zero calibration and external zero calibration function;
- 3) Single sensor volume, light weight, easy to carry;
- 4) Support USB remote control function, provide interchangeable virtual instrument (IVI) driver, and support USBTMC (USB test measurement) protocol;
- 5) Compatible with other computers or measuring instruments with USB host interface, and can quickly set up a microwave power test system.

2.2 Safe use guide

Please read carefully and strictly observe the following precautions!

We will ensure that all production processes meet the latest safety standards and provide the user with the highest security. The design and testing of our products and their auxiliary equipment are all in compliance with relevant safety standards, and a quality assurance system has been established to monitor the quality of products, so as to ensure that the products consistently comply with such standards. In order to keep the equipment in good condition and ensure safe operation, please observe the precautions defined in this manual. If you have any questions, please feel free to contact us.

In addition, the correct use of the product is your responsibility. Before you start using this instrument, please carefully read and follow the safety instructions. The product is suitable for use in industrial and laboratory environments or on-site measurement. Remember to use the product properly in accordance with its limitations to avoid personal injury or property damage. If the product is used improperly or not used as required, you will be responsible for the problem and we will not be responsible for it. **Therefore, in order to prevent personal injury or property damage caused by dangerous conditions, please always observe the safe use instructions.** Please properly keep the basic safety instructions and product document and deliver them to the end user.

2.2.1 Safety sign

2.2.1.1 Product-related signs

The safety warning signs on the products are as follows (Table 2.1):

Table 2.1 Product Safety Signs

Symbol	Significance	Symbol	Significance
	Note, particularly remind the user of the information. Remind the user of the operating information or instructions that should be noted.		Power on/off
	Pay attention to handling heavy equipment.		Standby instructions
	Danger! Be careful of electric shock.		Direct current (DC)
	Warn! Be careful of the surface heat.		Alternating current (AC)
	Protective conductive end		Direct current/Alternating current (DC/AC)
	Ground		Instrument reinforcement insulation protection
	Ground terminal		EU sign for batteries and storage batteries. For details, refer to Item 1 in "2.2.8 Disposal/Environmental Protection" of this section.
	Note, be careful of handling the electrostatic sensitive devices.		EU sign for separately collected electronic devices. For details, refer to Item 2 in "2.2.8 Disposal/Environmental Protection" of this section.
	Warn! Radiation. For details, refer to Item 7 in "2.2.4 Operation Precautions" of this section.		

2.2.1.2 Manual-related signs

In order to remind the user to operate the instrument safely and to pay attention to relevant information, the following safety warning signs are used in the product manual:



Danger sign, if not avoided, can cause personal injury and equipment damage.



Warning sign, if not avoided, can cause personal injury and equipment damage.

 **Take Care**

Careful sign, if not avoided, can result in minor or moderate personal injury and equipment damage.

Note

Note sign, represents an important information tip, but does not pose a danger.

Prompt

Prompt sign, instrumentation, represents an instrument or instrument operating information.

2.2.2 Operational status and position

Before operating the instrument, please note:

- 1) Unless otherwise stated, the operating environment of 87230 series USB continuous wave power sensors must meet the following requirements: stable placement of the instrument, and indoor operation. The altitude at which the instrument is operated and transported should not exceed 4,600 m. The actual supply voltage is allowed to vary within $\pm 5\%$ of the marked supply voltage.
- 2) Unless otherwise stated, the instrument has not been subjected to water repellent treatment. Do not place the instrument on surfaces with water, vehicles, cabinets, and tables that are not fixed and do not meet the load carrying conditions. Place the instrument securely on the surface of a solid object (e.g., an antistatic workbench).
- 3) Do not place the instrument in an environment that is prone to fogging, for example, moving the instrument in an environment with alternate cooling and heating. The water droplets formed on the instrument can cause electrical shock and other hazards.
- 4) Do not place the instrument on the surface of a heat-dissipating item (for example, a heat sink). The operating environment temperature should not exceed that defined in the description of the product-related indicators. Overheating of the product can result in electric shock, fire, and other hazards.
- 5) Do not insert anything into the inside of the instrument through the opening in the instrument housing, or shield the notches or openings in the instrument.

2.2.3 Electricity safety

Electricity considerations for the instrument:

- 1) Before the instrument is powered on, it must be ensured that the actual supply voltage matches the marked supply voltage of the instrument.
- 2) Unless given special permission, you should not open the instrument housing at will, as this will expose internal circuits and components, thus causing unnecessary damage.
- 3) Take appropriate overload protection to prevent overload voltage (such as caused by lightning) damaging the instrument or causing personal injury.
- 4) Unless otherwise stated, the instrument has not been subjected to water repellent treatment, so the instrument should not be exposed to liquids to prevent damage to the instrument or even personal injury.
- 5) The instrument should not be in an environment that is prone to fogging, for example, moving the instrument in an environment with alternate cooling and heating. The water droplets formed on the instrument can cause electrical shock and other hazards.

2.2.4 Operation precautions

- 1) The instrument operator needs to have certain professional and technical knowledge, good psychological quality, and a certain ability to respond to emergency response.
- 2) Before moving or transporting the instrument, refer to the relevant instructions in "[2.2.7 Transport](#)" of this section.
- 3) Inevitably use the substances that are allergic to the person (for example, nickel) in the production process of the instrument. If the instrument operator shows allergic symptoms (such as rashes, frequent sneezing, red eyes, or breathing difficulties) in the operation process, please promptly seek medical advice to resolve the symptoms.
- 4) Before disassembling the instrument for disposal, refer to the relevant instructions in section "[2.2.8 Disposal/Environmental protection](#)" of this section.
- 5) As radio frequency instruments produce high levels of electromagnetic radiation, pregnant women and operators with cardiac pacemakers need special protection. If the radiation levels are high, appropriate measures can be taken to remove radiation sources to prevent personal injury.
- 6) In the event of a fire, the damaged instrument releases toxic substances. For this reason, the operator must be equipped suitable protective articles (such as protective masks and protective clothing) just in case.
- 7) Electromagnetic compatibility rating (in compliance with Standards EN 55011/CISPR 11, EN 55022/CISPR 22 and EN 55032/CISPR 32)
 - Class A equipment:

Except residential areas and low-voltage power supply environments, this equipment can be used.

Note: Class A equipment is suitable for use in industrial operating environments, as it generates disturbances in wireless communication in residential areas, thus operators must take relevant measures to reduce the impact of such disturbances.
 - Class B equipment:

Class B equipment is suitable for use in residential areas and low-voltage power supply environments.

2.2.5 Maintenance

- 1) Only authorized operators undergoing special technical training can open the instrument. Before opening the instrument, disconnect the power cord to prevent damage to the instrument or even personal injury.
- 2) The instrument should be repaired and replaced by special electronic engineers of the manufacturer. The repaired and replaced part must undergo safety test to ensure the subsequent safe use of the product.

2.2.6 Battery and power module

The precautions for using the battery are as follows:

- 1) Do not damage the battery.
- 2) Do not expose the battery and power module to a heat source such as an open flame. When stored, avoid direct sunlight, and keep it clean and dry. Clean the connection port of the battery or power module with a clean, dry and soft cotton cloth.
- 3) Do not short-circuit the battery or power module. Do not store multiple batteries or power modules in the paper cassette or drawer due to short circuit caused by contact with each other or with other conductors. Do not remove the original packaging before using the battery and power module.
- 4) Do not subject the battery and power module to mechanical impact.

2.2 Safe use guide

- 5) If the battery leaks liquid, do not contact it with the skin and eyes. If there is a contact, rinse the skin and eyes with plenty of water and timely seek medical advice.
- 6) Please use the batteries and power modules that are standardly equipped by the manufacturer. Any incorrect replacement and charging of alkaline batteries (such as lithium batteries) can cause explosions.
- 7) Waste batteries and power modules need to be recycled and handled separately from other waste products. Due to the toxic substances inside the battery, it must be properly discarded or recycled according to local regulations.

2.2.7 Transportation

- 1) If the instrument is heavy, please move it carefully. If necessary, use a tool (such as crane) to move the instrument so as not to damage the body.
- 2) The handle of the instrument is suitable for use when personally transporting the instrument, and cannot be fixed on the transported equipment when transporting the instrument. To prevent property damage and personal injury, follow the manufacturer's safety regulations for transporting instruments.
- 3) To operate the instrument on a transport vehicle, the driver must drive carefully to ensure the transport safety. The manufacturer is not responsible for emergencies during the transportation process. Therefore, please do not use the instrument during the transportation process, and reinforcement and preventive measures should be taken to ensure the safety of product transportation.

2.2.8 Disposal/Environmental protection

- 1) Do not dispose of the equipment marked with a battery or storage battery along with unsorted waste, but collect it separately and dispose of it at a suitable collection site or through the manufacturer's customer service center.
- 2) Do not dispose of the waste electronic devices along with unsorted waste, but collect it separately. The manufacturer has the right and responsibility to help the end user dispose of discarded products. When necessary, please contact the manufacturer's customer service center to deal with them in order to avoid destroying the environment.
- 3) When the product or its internal devices are subjected to mechanical or thermal reprocessing, toxic substances (heavy metal dust, such as lead, bismuth, nickel, etc.) may be released. Thus, the technicians undergoing special training with relevant experience are required to perform disassembly so as not to cause personal injury.
- 4) During the reprocessing process, the toxic substances or fuels released from the product should be treated by special methods after referring to the safe operating rules recommended by the manufacturer, so as to avoid personal injury.

3 Getting started

This chapter introduces the pre-use precautions and routine maintenance of 87230 series USB continuous wave power sensors, so that the user can preliminarily understand the instrument itself. The content contained in this chapter is consistent with the relevant sections of the Quick Start Guide.

- [Pre-use precautions](#).....11
- [Routine maintenance](#).....18

3.1 Pre-use precautions

This chapter describes the precautions for 87230 series USB continuous wave power sensors before it is used for the first time.

Warn

Prevent damage to the instrument

To avoid electric shock, fire, and personal injury:

- Do not open the chassis without authorization;
- Do not attempt to disassemble or modify any part not described in this manual. If disassembling without authorization, it may cause the electromagnetic shielding effectiveness to decline and the internal parts of the machine to be damaged, which will affect the reliability of the product. If the product is within the warranty period, we will no longer provide unpaid maintenance;
- Carefully read the relevant contents in "[2.2 Safe use guide](#)" of this manual, and the following operational safety precautions. Also pay attention to the specific operating environment requirements involved in the data page.

Note

When operating the instrument, please note:

Inappropriate application locations or measurement settings can damage the instrument or its connected instruments. Please note the following items before powering on the instrument:

- Keep the instrument dry;
- Place and lay the instrument horizontally and reasonably;
- The ambient temperature meets the requirements defined in the data page;
- The power level of the port input signal conforms to the marked range;
- The signal output port is properly connected and not overloaded.

Note

Electrostatic protection

Pay attention to the anti-static measures in the workplace to avoid damage to the instrument. For details, please refer to the relevant content in "[2.2 Safe use guide](#)" of the manual.

Prompt

Electromagnetic interference (EMI) effects:

Electromagnetic interference can affect the measurement results, for this purpose:

- Select the appropriate shielded cable, for example, using dual shielded RF/network connection cables;
- Please promptly close the opened and temporarily unused cable connection port or connect the matching load to the connection port;
- Refer to the electromagnetic compatibility (EMC) level sign in the user manual.

3.1.1 Unpacking

1) Visual inspection

- Step 1** Check whether the outer packing box and the instrument's shockproof packaging are damaged or not. If there is any damage, store the outer packaging for backup and follow the following steps to proceed with the check;
- Step 2** Unpacking, check whether the host and its accompanying items in the box are damaged or not;
- Step 3** Check carefully whether the above items are faulty against Table 3.1.
- Step 4** If the outer package is damaged, or the instrument and its accompanying items in the box are damaged or faulty, it is forbidden to power on and start the instrument! Please contact our service consulting center by the service consulting hotline listed on the cover, and we will promptly repair or exchange it according to the situation.

2) Model confirmation

Table 3.1 List of Accompanying Items in the Box of 87230 Series USB Continuous Wave Power Sensors

Item	Quantity	Features
Host:		
✧ 87230 Series	1	Host
Standard configuration:		
✧ USB cable	1	Lockable dedicated USB cable, 2m long
✧ CD	1	Contain virtual panel, remote control manual, driver, and programming example
✧ User manual	1	—
✧ Certificate	1	Affixed to the body

3.1.2 Environmental requirements

The operating environment of 87230 series USB continuous wave power sensors should meet the following environmental requirements.

1) Operating environment

The operating environment should meet the following requirements:

Table 3.2 Requirements for the Operating Environment of 87230 Series USB Continuous Wave Power Sensors

Temperature	10°C ~ 40°C
Temperature range during error adjustment	23°C ±5°C (allowable temperature deviation during error adjustment is <1°C)
Humidity	Hygrometer measurement range: 20% to 80% (not condensed) when <+29 °C
Altitude	0 to 4,600 m
Vibration	Maximum:0.21G, 5 Hz to 500 Hz

Note

The above environmental requirements are only tailored for the operating environment of the instrument and do not fall into the scope of the technical specifications.

2) Electrostatic protection

Static electricity is extremely destructive to electronic components and equipment. Usually we take two kinds of anti-static measures: a combination of a conductive desk mat and a wrist strap; a combination of a conductive mat and an ankle strap. When taken together, they provide good anti-static protection. If taken alone, only the former can provide protection. To ensure user safety, anti-static components must be provided with at least 1 MΩ of ground isolation resistance.

Please take the following anti-static measures to reduce static damage:

- Ensure that all instruments are properly grounded to prevent static electricity generation;
- Before connecting the coaxial cable with the instrument, the inner and outer conductors of the cable should be temporarily contacted with the ground separately;
- Workers must wear an anti-static wrist strap or take other anti-static measures before touching the connectors, cores or performing any assembly operations.

Warn

Voltage range

The above anti-static measures cannot be used in applications where the voltage exceeds 500V.

3.1.3 Power on/off

1) Host system requirements

The 87230 series USB continuous wave power sensors adopts a standard USB mini-AB receptacle. Power display or direct remote control must be performed on a computer or other test instrument that has a USB host interface.

Before using 87230 series USB continuous wave power sensor, please make sure that the host meets the following requirements:

3 Getting started

3.1 Pre-use precautions

- Computer or any hardware device with a USB host interface;
- Support Windows 98SE/ME/XP/2000/2003/Win7/WIN10 or higher versions;
- Equipped with VISA 3.0 or higher versions and accompanied power test virtual panel
- Can also be programmed with remote control programming software such as Microsoft® Visual Basics, C++, LabVIEW, etc.

2) USB cable selection

The 87230 series USB continuous wave power sensors are equipped with a dedicated USB cable which can be fastened to the body, as shown in Figure 3.1. The user can also use their own USB cable, but should ensure that the cable meets international safety standards.



Prevent personal injury and instrument damage

Poor contact or incorrect wiring may cause instrument damage or even personal injury. Therefore, users are recommended to use the USB cable provided by the Company. If you need to use other non-standard cables, please contact our technical staff.

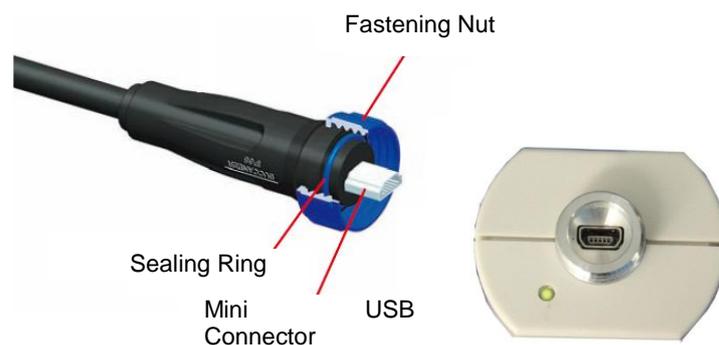


Figure 3.1 Fastenable USB Cable

3) Power on the instrument

The 87230 series USB continuous wave power sensors adopts the computer standard USB interface. Table 3.3 lists the power supply requirements for 87230 series USB continuous wave power sensors during normal operation.

Table 3.3 Working Power Supply Variation Range of 87230 Series USB Continuous Wave Power Sensors

Power parameter	Application range
Output voltage	+5V \pm 5% DC
Rated current	0.5A

The 87230 series USB continuous wave power sensor has a normal power consumption of 1.8W. When the USB interface of the computer is connected with multiple USB devices, it cannot guarantee that each

3.1 Pre-use precautions

interface can be provided with 0.5A output current. At this time, the computer may prompt that individual sensors cannot be found. In this case, please use the USB HUB with external power supply.

Use a USB cable that meets the requirements to connect the sensor to the host's USB interface and observe whether the green indicator light of the sensor is on.

- Step 1** Connect the small end of the USB cable to 87230 series USB continuous wave power sensor and screw it tightly. Then connect the large end of the USB cable to the USB host interface of the computer or the measuring instrument. The green indicator light of the sensor will light up later;
- Step 2** The "Device Manager" of the host can find new "USB Test and Measurement Devices".



Figure 3.2 Connection of 87230 Series USB Continuous Wave Power Sensor to a Computer

4) Shutdown of the instrument

Unplug the USB cable to turn off the USB continuous wave power sensor, then the green indicator light of the sensor goes out.

3.1.4 Using the connector correctly

In the test process of the USB continuous wave power sensor, it is necessary to connect the USB continuous wave power sensor to the USB cable, and then connect to the source to be tested. The 1.85mm, 2.4mm, and 3.5mm male connectors are needed, and even all types of adapters are needed, although these connectors are designed and manufactured to the highest standards, the service life of all these connectors is limited. Due to the inevitable wear and tear during normal use, the performance index of the connector is degraded or even fails to meet the measurement requirements. Therefore, proper connector maintenance and measurement connections can not only obtain accurate and repeatable measurement results, but also extend the service life of the connector, and reduce the measurement cost. In the actual use process, the following aspects must be noted:

1) Connector check

When carrying out the connector inspection, an antistatic wrist strap should be worn. It is recommended to use a magnifying glass to check the following items:

- 1) Whether the surface of the plating is worn or not, whether there is a deep scratch?
- 2) Whether the thread is deformed;
- 3) Whether there are metal particles on the thread and the joint surface of the connector;
- 4) Whether the inner conductor is bent or broken;
- 5) Whether the screw sleeve of the connector rotates poorly.



Connector check to prevent damage to instrument port

Any damaged connector may damage the good connector connected to it even when the first measurement is made. To protect the interfaces of the USB continuous wave power sensor, check the connector before performing the connector operation.

2) Connection method

The connector should be inspected and cleaned before measuring the connection to ensure that the connector is clean and not damaged. Wear an antistatic wrist strap when connecting. The correct connection methods and procedures are as follows:

- Step 1** As shown in Figure 3.3, align the axes of the two interconnected devices to ensure that the pins of the male connector slide concentrically into the socket of the female connector;



Figure 3.3 The Axes of the Interconnected Devices Are on A Straight Line

- Step 2** As shown in Figure 3.4, move the two connectors straightly together so that they can smoothly engage with each other. Rotate the connector sleeve (note not the connector itself) until it is tightened. There should be no relative rotational motion between the connectors during connecting;

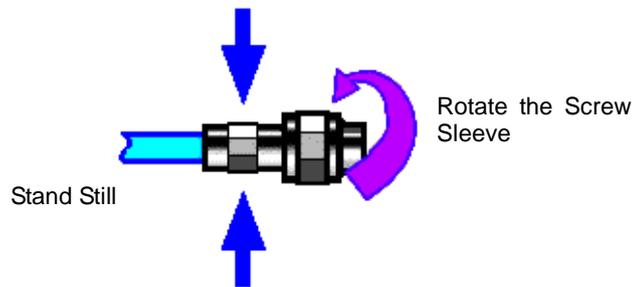


Figure 3.4 Connection Method

- Step 3** As shown in Fig. 3.5, tighten with a torque wrench to complete final connection. Note that the torque wrench should not exceed the initial breakpoint. Use an auxiliary wrench to prevent the connector from rotating.

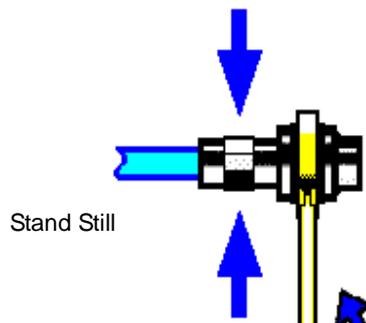


Figure 3.5 Tighten with A Torque Wrench to Complete Final Connection

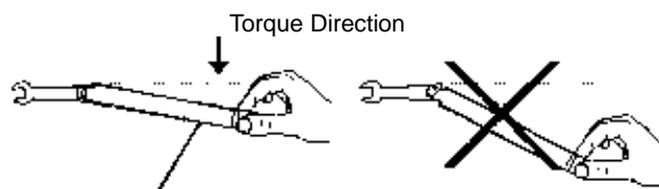
3) Disconnection method

- Step 1** Support the connector to prevent imposing a twisting, shaking or bending force on any connector;
- Step 2** An open wrench can be used to prevent the connector body from rotating;
- Step 3** Use another wrench to loosen the screw sleeve of the connector;
- Step 4** Rotate the screw sleeve of the connector by hand to complete the final disconnection;
- Step 5** Pull the two connectors apart in a straight manner.

4) How to use a torque wrench

The method of using the torque wrench is shown in Figure 3.6. Please pay attention to the following points when using it:

- Make sure the torque of the torque wrench is set correctly before use;
- Ensure that the torque wrench and the other wrench (used to support the connector or cable) are within an included angle of 90° before applying the force;
- Grasp the end of the handle of the torque wrench slightly and apply force in the direction perpendicular to the handle until the breaking point of the wrench is reached.



Stop the force when the handle is bent

Figure 3.6 How to Use a Torque Wrench

5) Connector use and preservation

- 1) When the connector is not in use, a protective sheath should be added;
- 2) Do not put the connectors, tools, etc. in a box. This is the most common cause of connector damage.
- 3) Keep the connector and analyzer at the same temperature, and holding the connector by hand or cleaning the connector with compressed air will significantly change the temperature, thus we should wait until the temperature of the connector stabilizes before using it for calibration.
- 4) Do not touch the joint plane of the connector, as the skin grease and dust particles are difficult to be removed from the joint plane;
- 5) Do not place the contact surface of the connector down on a hard surface. Contact with any hard surface may damage the plating and bonding surfaces of the connector.
- 6) Wear an antistatic wrist strap and work on a grounded conductive workbench pad to protect the analyzer and connector from being affected by electrostatic discharge.

6) Connector cleaning

When cleaning the connector, wear an anti-static wrist strap and clean the connector as follows:

- 1) Use clean low-pressure air to clear the connector threads and loose particles on the connecting surface. Inspect the connector thoroughly. If further cleaning is required, follow the steps below.
- 2) Soak (but not soak totally) lint-free cotton swabs with isopropyl alcohol;

3 Getting started

3.2 Routine maintenance

- 3) Use a cotton swab to remove the dirt and debris from the connector's connecting surface and thread. When cleaning the inner surface, be careful not to apply external force to the inner conductor of the center, and do not leave the fibers of the cotton swab on the center conductor of the connector;
- 4) Allow the alcohol to evaporate and then blow the surface clean with compressed air;
- 5) Check the connector to confirm that there are no particles and residues;
- 6) If the defect of the connector is still visible after cleaning, it indicates that the connector may be damaged and should not be used again, and confirm the cause of the connector damage before making the measurement connection.

7) Use of adapter

When the analyzer's measurement port differs from the type of connector used, an adapter must be used to make the measurement connection. It is also a good idea to use the adapter even if the analyzer's measurement port and the port of the device to be measured have the same connector type. Both of these conditions can protect the measurement port, extending its service life and reducing maintenance costs. The adapter should be carefully inspected and cleaned before being connected to the analyzer's measurement port. A high-quality adapter should be used to reduce the effect of mismatch on the measurement accuracy.

8) Connecting surface of the connector

An important concept in microwave measurement is the reference plane. For the analyzer, it is the basic reference plane for all measurements. During calibration, the reference plane is defined as the plane where the measurement port and the calibration standard are joined. The good connection and calibration depend on whether the connectors can be completely straightly contacted at each point of the connecting surface to ensure the minimum power standing-wave ratio (PSWR), thus ensuring the measurement accuracy.

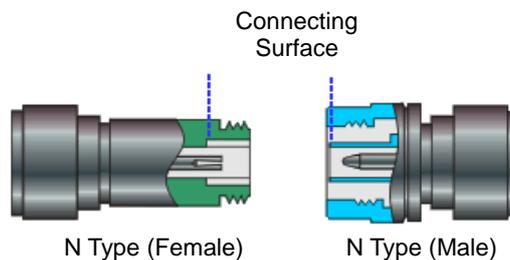


Figure 3.7 Calibration Plane

3.2 Routine maintenance

This section describes the routine maintenance methods for 87230 series USB continuous wave power sensor.

3.2.1 Cleaning methods

When cleaning the surface of the instrument, follow the steps below:

- Step 1** Shut down the instrument, disconnect the power cord from the instrument.
- Step 2** Wipe the surface gently with a dry or slightly moistened soft cloth. Do not wipe the inside of the instrument.
- Step 3** Do not use chemical cleaners such as alcohol, acetone, or dilutable cleaners.

3.2.2 Test port maintenance

The 87230 series USB continuous wave power sensor is equipped with a USB cable connector and a microwave power signal input port. If the USB cable connector is damaged or there is dust present inside it, it will affect the test results of the RF band. Please maintain the connector as follows:

- The connector should be kept away from dust and kept clean;

3.2 Routine maintenance

- To prevent electrostatic discharge (ESD), do not directly contact the connector surface;
- Do not use damaged connector;
- Use a hair dryer to clean the connector. Do not use a tool such as sandpaper to abrade the connector surface.

4 Operation guide

This chapter describes the selection of 87230 series USB continuous wave power sensor and detailed operation methods and measurement procedures for different measurement functions.

- [Power sensor selection](#).....21
- [Power measurement virtual panel](#).....21
- [Zero calibration and calibration before measurement](#).....23
- [Continuous wave power measurement function](#).....24

4.1 Power sensor selection

The 87230 series USB continuous wave power sensors include four product types, namely 87230, 87231, 87232 and 87233, as shown in the table below.

Table 4.1 87230 Series USB Continuous Wave Power Sensors

No.	Model	Power range	Frequency range	Interface form
1	87230	-50dBm~+20dBm	9kHz ~ 6GHz	N(m)
2	87231	-60dBm~+20dBm	10MHz ~ 18GHz	N(m)
3	87232	-60dBm~+20dBm	50MHz ~ 26.5GHz	3.5mm(m)
4	87233	-60dBm~+20dBm	50MHz ~ 40GHz	2.4mm(m)



Figure 4.1 87230 Series USB Continuous Wave Power Sensor

The 87230 series USB continuous wave power sensors can measure the continuous wave power, and its performance indicators are different. The user can select the appropriate sensor according to the characteristics and measurement requirements of the measured signal and the index parameters of each sensor. The basic functions of the sensor are shown in Table 4.1. Refer to “[7.3 Technical specifications](#)” for the description of the specific indicators of each sensor.

4.2 Power measurement virtual panel

The USB interface of 87230 series USB continuous wave power sensors conforms to the USBTMC (USB Test and Measurement) protocol and is an enumerable device (that is, it can be found through the VISA library's viFindRsrc function). The manufacturer's ID and device ID (decimal) are 1204 and 4100, respectively. See the serial number on each sensor.

The user can use the VISA library to remotely control the USB sensor. For specific configuration, refer to the *Remote Control Manual for 87230 Series USB Continuous Wave Power Sensor*. You can also use the power measurement virtual panel to perform the power test. The user need to install the version higher than VISA 3.0, and run the power measurement virtual panel provided by the CD. After opening it, the power measurement virtual panel is as shown in Figure 4.2.

4 Operation guide

4.2 Power measurement virtual panel

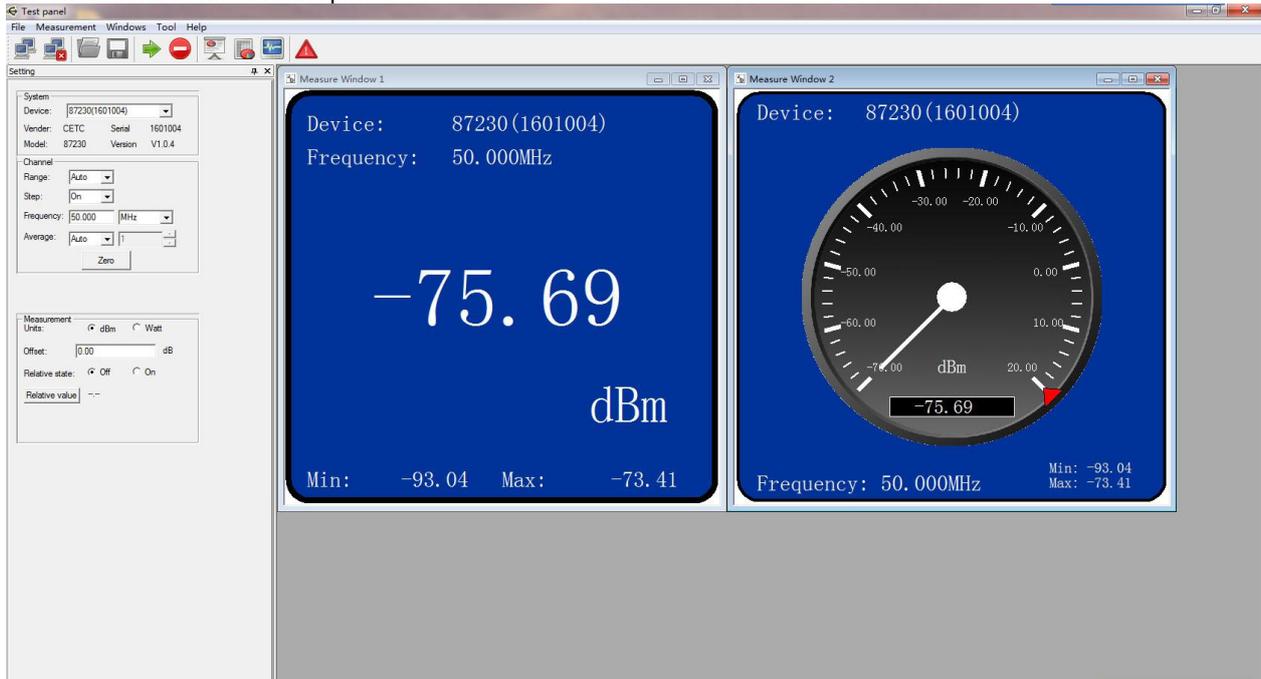


Figure 4.2 Power Measurement Virtual Panel

The connection and use procedures for 87230 series USB continuous wave power sensor:

Step 1 Connect the USB power sensor to the computer, open the power measurement virtual panel, select the USB device to be connected in the "Instrument Connection" window popped up by the system, and click the "Connect" button, as shown in Figure 4.3, then the measurement process normally operates;

Step 2 The user can view the model, serial number, and firmware version number of the USB continuous wave power sensor in the "System" tab on the left side of the window.

Step 3 Click on the  or  button on the toolbar. The system will automatically display the measurement result or stop the measurement process in the opened value window.

Step 4 The user can set the measurement frequency, average number of times, range selection, etc. in the "Channel" tab window;

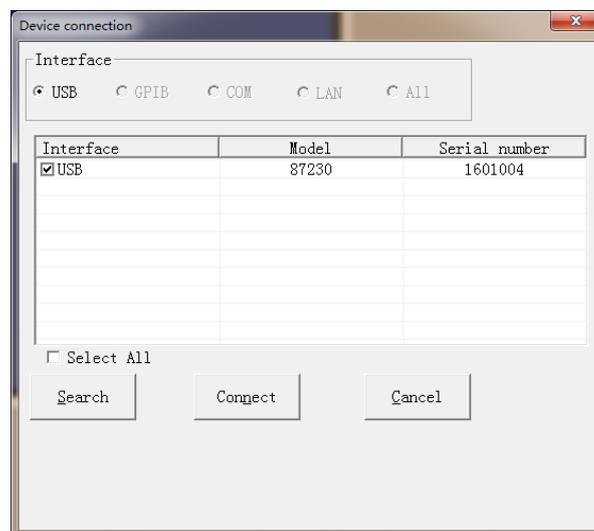


Figure 4.3 Connecting Device Window

4.3 Zero calibration and calibration before measurement

Step 5 In the "Measurement" tab window, settings such as unit selection, offset, and relative measurement can be performed;



Step 6 Click the  and  buttons on the toolbar to create a new numeric display window and an analog display window.



Step 7 Click the  button on the toolbar to re-search and connect the newly connected USB power sensor.

4.3 Zero calibration and calibration before measurement

In order to improve the measurement accuracy of the instrument, it is necessary to perform zero calibration of the instrument before performing small-signal power measurement with 87230 series USB continuous wave power sensor.

The 87230 series USB continuous wave power sensor has been calibrated before shipment from the factory. The calibration source used for calibration is traceable to the national standards. Therefore, the user is not recommended to perform calibration operations.

4.3.1 Zero calibration

The zero calibration operation refers to measuring and storing the noise of the entire measurement channel. During the measurement process, the zero calibration value needs to be deducted from the actual measured value, that is, the channel noise is deducted, and the reading at this time is the true channel input signal level.

If the sensor is connected to another device, first turn off the signal output of the device and then perform the zero calibration operation.

Specific steps are as follows:

Step 1 Connect the sensor to the output port of the source to be measured and turn off the source output.

Step 2 Use the remote control command or the [Zero Calibration] button on the power measurement panel to perform an external zero calibration operation. The green indicator light flashes during the zero calibration operation.

It is recommended to perform an zero calibration operation 87230 series USB continuous wave power sensor in the following situations:

- When the temperature changes more than 5 °C;
- After 24 hours
- Before measuring a low power continuous wave signal. For example, measuring a small signal which is within 10 dB of the lowest measurable power of the power sensor used.

Note

For 87230 series USB continuous wave power sensor with the frequency range from 9kHz to 6GHz, as the detection components are DC-coupled, some of the signal sources may also have DC or low frequency leakage when the RF output is "off", and may cause the measured signal level to be too high, thus zero calibration cannot be performed.

4.3.2 Internal zero calibration

Internal zero calibration means that switches are added at the front end of the measurement channel.

4.4 Continuous wave power measurement function

The user does not need to disconnect the sensor from the device to be measured to test the measurement and store the channel noise. In the internal zero calibration process, the RF signal is always applied to the power sensor, which can reduce the wear of the sensor connector and shorten the measurement time. It is especially suitable for the applications where it is not convenient to turn off the power signal output.

In general, normal zero calibration usually has a good zero effect. It should be based on the actual needs of the measurement to select the internal zero calibration and normal zero calibration functions. During programming by the user, the internal zero calibration and normal zero calibration functions can be selected by calling the CALibration[1]:ZERO:TYPE command. For specific operation, refer to the *Remote Control Manual for 87230 Series USB Continuous Wave Power Sensor*.

Note

When measuring low-level signals, it is necessary to perform automatic zero calibration and then perform measurement again to ensure the accuracy of the measurement.

When measuring a low-power signal with amplitude lower than -40 dBm, the step detection is set to the "off" state, and more accurate measurement results can be obtained, but the measurement speed is slower.

4.3.3 Calibration

Calibration refers to connecting the power sensor to a known standard calibration source output port for power tracing under current measurement conditions (current temperature, current power reference, etc.).

The 87230 series USB continuous wave power sensor has been calibrated before shipping, so the user is not recommended to perform calibration operation. However, advanced users can perform automatic calibration of the sensor in the following cases:

- The user use the custom 0dBm power standard for measurement comparison;
- Beyond the one-year calibration period, the user believes that the measurement is in error and does not meet the factory calibration condition.

4.4 Continuous wave power measurement function

The 87230 series USB continuous wave power sensor can measure the average power of continuous wave signals. The power measurement dynamic ranges from -60dBm to +20dBm, and the frequency ranges from 9kHz to 40GHz.

The user can use the power measurement panel or remote control command provided by the Company to measure the continuous wave power. For details, please refer to the *Remote Control Manual for 87230 Series USB Continuous Wave Power Sensor* in the CD. Generally, it is divided into the following three steps:

Step 1 Zero calibration of the USB continuous wave power sensor;

Step 2 Set the frequency of the signals to be measured.

Step 3 Use the sensor for continuous wave power measurement.

When multi-channel measurements are required, the user can connect multiple USB continuous wave power sensors directly to the computer, or use USB HUBs to set up a multi-channel power measurement system, as shown in Figure 4.4.

4.4 Continuous wave power measurement function



Figure 4.4 Multi-Channel Power Measurement by Using USB HUB

The specific operation steps are as follows:

Step 1. Open the virtual power measurement panel, and the system automatically finds multiple USB continuous wave power sensors that are connected. Select all the power sensors that are connected, and click the "Connect" button, as shown in Figure 4.5, the system automatically displays the USB continuous wave power sensor which is first found and display the measurement result;

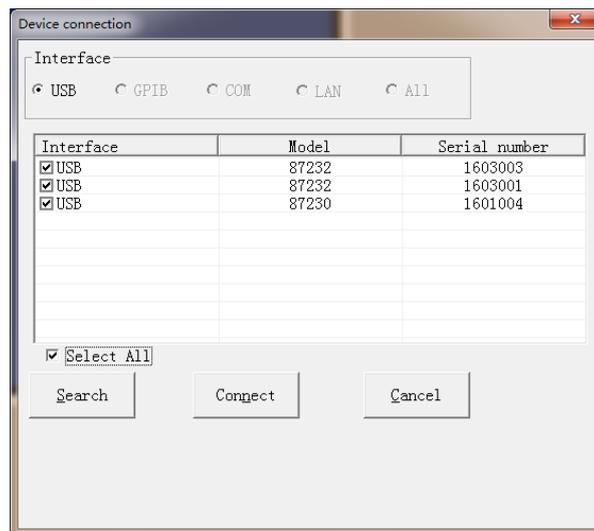


Figure 4.5 Devices Connected with Multiple USB Continuous Wave Power Sensors



Step 2. Click the  or  button on the toolbar to open the measurement results of other power sensors with numeric display or analog display, as shown in Figure 4.6;

Step 3. Click certain measurement window with the mouse, and the system will indicate the currently selected measurement window in the form of a yellow border. Select the "Device" drop-down menu under the "System" tab to assign this window to other devices.

Step 4. Click certain measurement window with the mouse. The system indicates the currently selected measurement window in the form of a yellow border. You can perform operations such as zero calibration, measurement frequency setting, and offset setting for the channel.

Step 5. When more USB continuous wave power sensors are connected, the window/tiling or cascaded commands can be used to automatically arrange the opened measurement window.

4 Operation guide

4.4 Continuous wave power measurement function

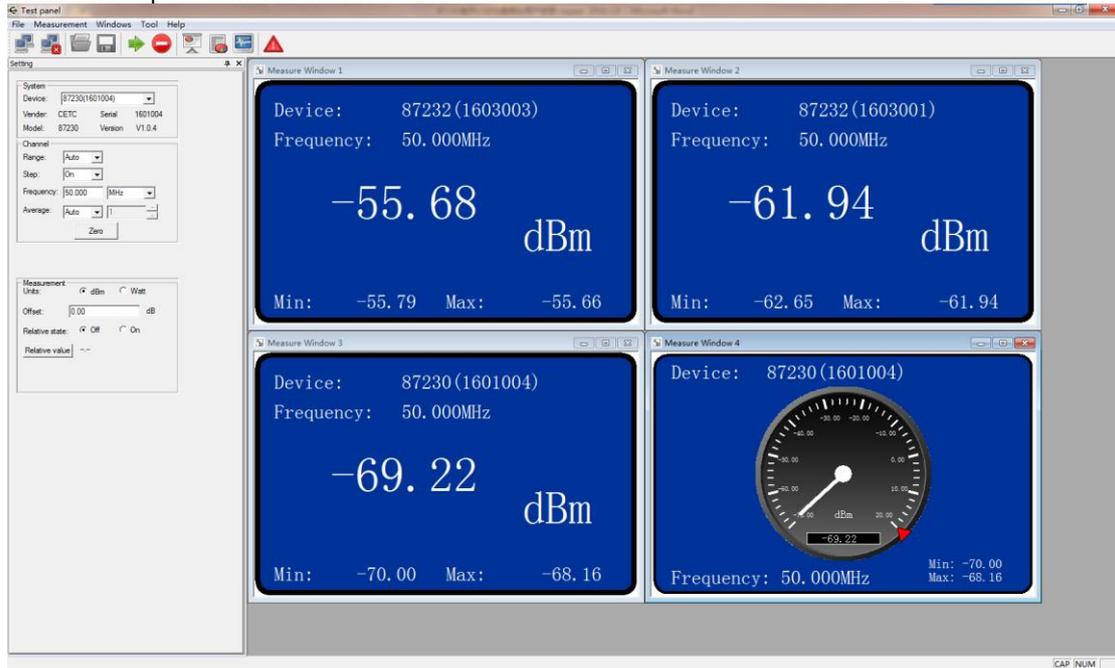


Figure 4.6 Measurement Window Connected with Multiple USB Continuous Wave Power Sensors

The 87230 series USB continuous wave power sensor can be connected to a computer to achieve microwave power measurement by using the virtual panel or user programming. It can also be connected to some of our electronic measuring instruments to achieve microwave power measurement by using the power option of the instrument. For specific operations, please refer to the relevant instrument instruction manual.

Some of the measuring instruments that support 87230 series USB continuous wave power sensor are shown in Table 4.2.

Table 4.2 Some of Our Measuring Instruments that Support 87230 Series USB Continuous Wave Power Sensor

No.	Model	Item
1	2442	Handheld peak power analyzer
2	2,443A	Peak power analyzer
3	4,942B	Microwave comprehensive tester
4	4957/4958	Handheld RF comprehensive tester
5	4023/4024	Handheld microwave spectrum analyzer
6	3,680A	Handheld antenna feeder ester

Note: Whether other instruments are supported or not, please consult the technical support personnel.

5 Remote control

This chapter introduces the remote control basis, remote control interface and configuration methods of 87230 series USB continuous wave power sensor, and briefly introduces the concept and classification of the I/O instrument driver library. To facilitate the user to start remote control operation, the specific content includes:

- Remote control basics.....27
- Remote control interface and configuration40
- Basic programming method of VISA interface.....41
- I/O instrument driver library.....43

5.1 Remote control basics

5.1.1 Remote control interface

The instrument with remote control function generally supports three remote control interfaces: LAN, GPIB, and USB. The type of the interface supported by the instrument is determined by the functions of the instrument itself.

Table 5.1 Remote Control Interface Types and VISA Addressing Strings

Remote control interface	VISA address string (Note 1)	Description
LAN (Local Area Network)	Original socket protocol: TCPIP::host_address::port::SOCKET	The controller performs remote control through connecting the instrument's rear panel network port with the instrument. For specific protocol, refer to " 5.1.1.1 LAN interface ".
GPIB (IEC/IEEE Bus Interface)	GPIB::primary address[::INSTR]	The controller performs remote control through connecting the instrument's rear panel network port with the instrument. Compliance with the IEC 625.1/IEEE 418 bus interface standard. For details, refer to " 5.1.1.2 GPIB interface ".
USB (Universal Serial Bus)	USB::<vendor ID>::<product_ID>::<serial_number>[::INSTR]	Instrument rear panel port. For details, refer to " 5.1.1.3 USB interface ".

Note 1: VISA refers to the Virtual Instrumentation Software Architecture. It is a set of standard software interface function library, and the user can use such library to control the instrument through GPIB, RS232, LAN, USB interfaces, etc. The user should first install the VISA library on the control computer and use the VISA library to implement remote control of the instrument. For details, refer to the User Manual for the Installed VISA Library.

5.1.1.1 LAN Interface

RJ45 communication cable (shielded or unshielded Category 5 twisted pair) can be used to access the 10Mbps/100Mbps/1000Mbps Ethernet, and to realize remote control f through a LAN control computer.

5.1 Remote control basics

In order to implement remote control within the LAN, the interface adapter and TCP/IP network protocol have been installed, and corresponding network services based on the TCP protocol have been configured.

In general, the installed network interface adapter has the following three operating modes:

- 10Mbps Ethernet (IEEE802.3);
- 100Mbps Ethernet (IEEE802.3u);
- 1000Mbps Ethernet (IEEE802.3ab).

The interface adapter automatically matches the appropriate network speed based on link conditions. In general, the length of the cable connecting the instrument should not exceed 100 m. For more information on Ethernet, please refer to <http://www.ieee.org>.

The following describes the LAN interface knowledge:

1) IP address

When the instrument is remotely controlled through the LAN, the physical connection of the network should be ensured. Set the IP address of the instrument to the subnet where the host computer is located. For example, if the IP address of the host computer is 192.168.12.0, then the IP address of the instrument should be set to 192.168.12.XXX, where XXX is 1 to 255.

Only the IP address is needed to establish a network connection. The form of the VISA addressing string is as follows:

TCPIP::host address::port::SOCKET

Among which:

- TCPIP stands for the network protocol used;
- Host address represents the instrument's IP address or host name used to identify and control the instrument being controlled;
- Port represents the socket port number;
- SOCKET represents the original network socket resource class.

For example:

When establishing an original socket connection, TCPIP::192.1.2.3::5000::SOCKET can be used

Prompt

Multi-instrument identification method in the remote control system

If more than one instrument is connected to the network, use the instrument's separate IP address and the associated resource strings to distinguish them. The host computer uses the respective VISA resource string to identify the instrument.

2) Socket communication

The TCP/IP protocol connects the instrument to the network via a LAN socket. The socket is a basic method used in the computer network programming, which allows the applications using different hardware and operating systems to communicate in the network. This method enables two-way communication between the instrument and the computer through the port.

The socket is a specialized software class that defines the necessary information for network communications such as IP address and device port number, and integrates some basic operations in network programming. The socket can be used by installing a packaged library in the operating system. Two commonly used socket libraries are the Berkeley socket library for applications in UNIX and the Winsock library for applications in Windows.

5.1 Remote control basics

The sockets in the instrument are Berkeley socket and Winsock compatible through the application program interface (API). In addition, other standard socket APIs are also compatible. When the instrument is controlled via SCPI command, the socket program established in the program issues a command. The instrument's socket port number is fixed at 5,000.

5.1.1.2 GPIB interface

GPIB is the only bus designed specifically for instrument control and is still widely used in the automatic test system. To realize remote control, the host computer needs to install the GPIB bus card, driver, and VISA library first. During communication, the host computer addresses the controlled instrument through the GPIB address. The user can change the GPIB address of the controlled instrument to prevent communication failures caused by address conflicts in the entire system.

GPIB and its associated interface definitions are described in detail in the ANSI/IEEE 488.1-1987 Standard and the ANSI/IEEE 488.2-1992 Standard. Please refer to IEEE website: <http://www.ieee.org> for specific standard details.

When GPIB is connected, please note the following points:

- Through the GPIB bus component test system, up to 15 devices;
- The total length of the transmission cable does not exceed 20 m or does not exceed twice the number of instruments in the system;
- In general, the maximum length of the transmission cables between devices is no more than 2 m;
- If you connect multiple instruments in parallel, you need to use the "or" cable;
- The terminal of the IEC bus cable should be connected to the instrument or the controlling computer.

5.1.1.3 USB interface

In order to implement USB remote control, it is necessary to connect the computer and instrument through the USB type B port and install the VISA library in advance. VISA automatically detects and configures the instrument to establish the USB connection without inputting the instrument address string or installing a separate driver.

USB address:

Format of addressing string: `USB::<<vendor ID>::<<product ID>::<<serial number>[:INSTR]`

Among which:

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

Example:

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

0x0AAD: manufacturer code;

0xC6: instrument code;

100001: serial number of the instrument.

5.1.2 Messages

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

1) Interface message

The interface message is a GPIB bus-specific message, and only the instrument with the GPIB bus function responds to the interface message. When the host computer sends an interface message to the instrument, it first needs to pull down the attention line, and then the interface message can be

5.1 Remote control basics

transmitted to the instrument through the data line.

2) Instrument message

For the structure and syntax of instrument message, refer to the ["5.1.3 SCPI command"](#) for details. According to the different transmission directions, the instrument messages can be divided into command and instrument response. Unless otherwise stated, all remote control interfaces use the same method for instrument messages.

a) Command:

The command (programming message) is a message sent from the host computer to the instrument to remotely control the instrument's functions and to inquiry the status information. Commands are divided into the following two categories:

- According to the impact on the instrument:
 - Setup command: Change the instrument setup status, such as reset or set frequency.
 - Inquiry command: Inquiry and return data, such as identify instrument or inquiry parameter values. The inquiry command suffixes the question mark to end.
- According to the definition in the standard:
 - Generic command: Functions and syntax defined by IEEE 488.2, applicable to all types of instruments (if implemented) for management of standard status registers, reset, and self-test, etc.
 - Instrument control command: Instrument characteristic commands, which are used to implement the instrument functions, such as set the frequency. The syntax also follows the SCPI specification.

b) Instrument response:

The instrument response (response message and service request) is the inquiry result information sent by the instrument to the computer. This information includes the measurement results, instrument status, etc.

5.1.3 SCPI command

5.1.3.1 Introduction to SCPI command

SCPI (Standard Commands for Programmable Instruments) is a set of commands based on Standard IEEE488.2 suitable for all instruments, and mainly aims to enable the same function to have the same remote control command, so as to achieve the versatility of remote control commands.

The SCPI command consists of a command header and one or more parameters. The command header and parameters are separated by spaces. The command header contains one or more key fields. The command directly suffixed by question mark is the inquiry command. The commands are divided into general commands and instrument-specific commands, and their grammatical structures are different. The SCPI command has the following features:

- 1) The remote control commands are intended for the testing functions, not for describing instrument operation;
- 2) The remote control commands reduce the duplication of similar test function implementation procedures and ensure programming compatibility;
- 3) The remote control messages are defined in a layer that is irrelevant to the hardware of the communication physical layer;
- 4) The remote control commands have nothing to do with the remote control methods and languages, and SCPI test programs are easy to be transplanted;
- 5) The remote control commands have scalability and can adapt to different scales of measurement control;
- 6) SCPI's scalability makes it a "live" 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 the remote control command collection, classification and description of 87230 series USB continuous wave power sensor, please refer to:

- 1) Remote Control Appendix A "SCPI Command Quick Inquiry Sheet";
- 2) "3 Remote Control Command" of the Remote Control Manual;

5.1.3.2 SCPI command description

1) General terms

The following terms apply to this section. To better understand the content of the chapter, you need to understand the exact definition of these terms.

a) Controller

The controller is any computer that is used to communicate with SCPI devices. The controller may be a personal computer, a small computer, or a card inserted into a cage. Some artificial intelligence devices can also be used as controllers.

b) Device

The device is any device that supports SCPI. Most devices are electronic measurement or incentive devices and communicate via the GPIB interface.

c) Remote control message

The remote control message is a combination of one or more correctly formatted SCPI commands. The remote control message tells the device how to measure and output the signal.

d) Response message

The response message is a data set using the specified SCPI format. The response message is always from device to controller or monitoring device. The response message tells the controller about the internal state or measured value of the device.

e) Command

The command is the command that meets the SCPI standard. The combination of control device commands forms a message. In general, the command includes keywords, parameters, and punctuation.

f) Event command

Event-type remote control commands cannot be inquired. An event command generally has no corresponding front panel key settings. Its function is to trigger an event at a specific moment.

g) Inquiry

An inquiry is a special type of command. When inquiring the control device, return a response message that fits the syntax requirements of the controller. The inquiry statement always ends with a question mark.

2) Command type

There are two types of SCPI command: general commands and instrument-specific commands. Generic commands are defined by IEEE 488.2 and are used to manage macros, status register, synchronization, and data storage. As the general commands are headed by an asterisk, they are easily identified. For example *IDN?, *OPC, *RST are general commands. A general command does not belong to any instrument-specific command. The instrument interprets the general commands in the same way,

5.1 Remote control basics

regardless of the current path setting of the commands.

The instrument-specific commands are easily identified as they contain a colon (:). The colon is used at the beginning of the command expression and in the middle of the keyword, for example: FREQUency[:CW?]. According to the internal function module of the instrument, the instrument-specific commands are divided into the corresponding subsystem command sub-collections. For example, the power subsystem (:POWer) contains the power-related commands, and the status subsystem (:STATus) contains the commands for the status control registers.

3) Instrument-specific command syntax

Table 5.2 Special Characters in Command Syntax

Symbol	Meaning	Example
	The " " between the keyword and parameter represents a variety of options.	[:SENSe]:BANDwidth BWIDth HIGH LOWer BANDwidth and BWIDth are options, HIGH and LOWer are options.
[]	The square brackets indicate that the included keyword or parameter is optional when constituting a command. The command can be implemented even when these implied keywords or parameters are ignored.	[:SENSe]:BANDwidth? SENSe is optional.
< >	The part inside the angle brackets indicates that it is not used as per the literal meaning in the command, and represents the part must be included.	[:SENSe]:FREQUency[:CW FIXed] <val>[unit] In this command, <val> must be replaced by the actual frequency. [unit] is an omissible unit. For example: FREQ 3.5GHZ FREQ 3.5e+009
{ }	The part inside the braces indicates that the parameters are optional.	MEMory:TABLE:FREQUency <val>{,<val>} For example: MEM:TABL:FREQ 5e7

Table 5.3 Command Syntax

Characters, keywords, and grammar	Example
Capitalized characters represent the minimum set of characters required to execute the command.	[:SENSe]:FREQUency[:CW FIXed]?, FREQ is the short format part of the command.
The lowercase character portion of the command is optional; this flexible format is called "flexible listening." For more information, refer to the "Command Parameters and Responses" section.	:FREQUency :FREQ,:FREQUency or FREQUENCY, Any one of them is correct.
When a colon is between two command mnemonics, it moves the current path in the command tree down one level. For more information, refer to the command path section of the "Command Tree".	:TRIGger:MODE? TRIGger is the top-level keyword of this command.
If the command contains multiple parameters, adjacent parameters are separated by commas. The parameter is not part of the command path, so it does not affect the path layer.	MEMory:TABLE:FREQUency <val>{,<val>}

5.1 Remote control basics

The semicolon separates two adjacent commands but does not affect the current command path.	:FREQ 2.5GHZ;;POW 10DBM
Whitespace characters, such as <space> or <tab>, are usually ignored as long as they do not appear between keywords or in keywords. However, you must separate the command and parameter with whitespace characters without affecting the current path.	:FREQuency or:POWer:LEVel6.2 is not allowed. The: LEVel and 6.2 must be separated by a space. Namely,:POWer:LEVel 6.2

A typical command is composed of the keyword prefixed with a colon. The keyword is followed by parameters. Here is an example of a grammar statement.

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

In the above example, the [:LEVel] of the command is followed by: POWer with no spaces in between. The followed [:LEVel]: MINimum|MAXimum is the parameter part. There is a space between the command and the parameter. The other parts of the syntax expression are described in Tables 5.2 and 5.3.

4) Command tree

Most remote control programming uses instrument-specific commands. When parsing such commands, SCPI uses a structure similar to a file system. This command structure is called the command tree.

The top command is the root command, referred to as the "root". When the command is parsed, it follows the tree structure to follow a specific path to reach the next level of commands. For example::POWer:ALC:SOURce?, where: 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 the instrument software—the command interpreter—is responsible for parsing each received SCPI command. The command interpreter uses a series of rules that distinguish the command tree paths and divides the commands into separate command elements. After parsing the current command, keep the current command path unchanged. The advantage of doing so is that as the same command keyword may appear in different paths, the subsequent commands can be parsed more quickly and efficiently. After start up or *RST (reset) the instrument, reset the current command path as the root.

5) Command parameters and responses

Table 5.4 Types of SCPI Command Parameters and Response

Parameter type	Response data type
Numerical	Real or integer
Extended numeric	Integer
Discrete	Discrete
Boolean	Digital Boolean
String	String
Piece	Block with certain length
	Block with uncertain length
Non-decimal numeric	Hexadecimal
	Octal
	Binary

SCPI defines different data formats in the use of remote control and response messages to follow the principles of "flexible listening" and "accurate speaking." For more information, refer to IEEE 488.2. "Flexible listening" means that the format of commands and parameters is flexible.

5.1 Remote control basics

For example, the set frequency offset status command of the USB continuous wave power sensor: `FREQUENCY:OFFSet:STATe ON|OFF|1|0`,

The following command format is that the set frequency offset function is opened:

```
:FREQUENCY:OFFSet:STATe ON,:FREQUENCY:OFFSet:STATe 1,
:FREQ:OFFS:STAT ON,:FREQ:OFFS:STAT 1
```

There are one or more corresponding response data types for different parameter types. When inquiring, a numeric type parameter will return a data type. The response data is exact and strict and is called "accurate speaking".

For example, inquiry of the power state (`:POWER:ALC:STATe?`). When it is on, regardless of the previously sent setting command: `POWER:ALC:STATe 1` or `POWER:ALC:STATe ON`, the returned response data is always 1 during inquiry.

a) Numerical parameters

Numeric parameters can be used in both instrument-specific and general commands. Numeric parameters accept all common decimal counting methods, including signs, decimal points, and scientific counting methods. If a device only receives a specified numeric type, such as an integer, it automatically rounds the received numeric parameter.

The following are examples of numeric types:

0	No decimal point
100	Optional decimal point
1.23	With sign bit
4.56e<space>3	Index marker e can be followed by spaces
-7.89E-01	Index marker e can be in uppercase or lowercase
+256	Positive sign is allowed before it
5	Decimal point can be advanced

b) Extended numeric parameters

Most measurements related to instrument-specific commands use extended numeric parameters to specify physical quantities. Extended numeric parameters receive all numeric parameters and other special values. All extended numeric parameters receive MAXimum and MINimum as parameter values. Whether other special values (such as UP and DOWN) are received or not are determined by the instrument's resolution capability, and all valid parameters are listed in the SCPI command table.

Note: Extended numeric parameters do not apply to general commands or STATus subsystem commands.

Examples of extended numerical parameters:

101	Numerical parameters
1.2GHz	GHz can be used as an index (E009)
200MHz	MHz can be used as an index (E006)
-100mV	-100 mV
10DEG	10°
MAXimum	The maximum effective setting
MINimum	The minimum effective setting
UP	Add one step
DOWN	Reduce one step

c) Discrete parameters

When there are a limited number of parameter values to be set, discrete parameters are used for identification. Discrete parameters use mnemonics to represent each valid setting. Like remote control command mnemonics, discrete parameter mnemonics have two formats (long format and short format) and can be mixed uppercase and lowercase.

In the following example, discrete parameters are used with commands.

```
:TRIGger[:SEQuence]:SOURce BUS|IMMEdiate|EXTernal
```

GPIB, LAN, RS-232 triggering

IMMEdiate immediate triggering

EXTernal external triggering

d) Boolean parameters

Boolean parameters represent a true or false binary condition, which can only have four possible values.

Example of Boolean parameters:

ON	Logic truth
OFF	Logic false
1	Logic truth
0	Logic false

e) String parameters

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

The following is an example of a string parameter.

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

f) Real number response data

Most of the test data is real-numbered. Its format can be basic decimal counting method or scientific counting method. Most advanced remote control languages support both formats.

Real number response data example:

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

g) Integer response data

The integer response data is a decimal expression including the integer value of the sign bit. When the status register is inquired, it mostly returns integer response data.

Example of integer response data:

0	Sign bit optional
+100	Positive sign is allowed before it

5.1 Remote control basics

-100	Negative sign is allowed before it
256	No decimal point

h) Discrete response data

Discrete response data and discrete parameters are basically the same, the main difference is that the return format of discrete response data is only in short format with uppercase.

Example of discrete response data:

INTernal	The fixed amplitude method is internal
EXTernal	The fixed amplitude method is external
MMHead module	The fixed amplitude method is a millimeter wave source

i) Digital boolean response data

Boolean response data returns a binary value of 1 or 0.

j) String response data

String response data and string parameters are the same, the main difference is that the delimiters for string response data use double quotes instead of single quotes. String response data can also be embedded in double quotes, and there can be no characters between double quotes. Here are some examples of string response data:

“This is a string”

“one double quote inside brackets: (“”)”

6) The numerical value system in the command

The value of the command can be entered in binary, decimal, hexadecimal or octal format. When using binary, hexadecimal, or octal format, the value requires a suitable identifier in front of it. Decimal (default format) format does not require an identifier. When a value is entered without a preceding indicator, the device ensures that it is in decimal format. The following list shows the required indicators for each format:

- #B indicates that this number is a binary value;
- #H indicates that this number is a hexadecimal value;
- #Q indicates that this number is an octal number.

Here are the various representations of the decimal number 45 in the SCPI command:

#B101101

#H2D

#Q55

The following example uses a hexadecimal value of 000A to set the RF output power to 10dBm (or the value equal to the numerical value of the current selected unit, such as DBUV or DBUVEMF).

:POW #H000A

When using a non-decimal format, a unit of measurement, such as DBM or mV, is not used with numeric values.

7) Command line structure

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

- Enter;
- Enter and EOI;

- EOI and the last data byte.

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

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

The command line contains two commands. The first command belongs to the MMEM subsystem and the second command belongs to the HCOP subsystem. If the adjacent commands belong to the same subsystem, the command path is partially repeated and the command can be abbreviated. For example:

```
HCOP:ITEM ALL;HCOP:IMM
```

The command line contains two commands, both commands belong to the HCOP subsystem and are the same at the first level. Therefore, the second command can be started from the lower level of HCOP, and the colon at the beginning of the command can be omitted. It can be abbreviated as the following command line:

```
HCOP:ITEM ALL;IMM
```

5.1.4 Command sequence and synchronization

IEEE488.2 defines the difference between overlap commands and consecutive commands:

- Continuous commands refer to the command sequences that are executed continuously. Generally, each command executes fast;
- The overlap commands mean that the previous command is not executed and completed automatically before the next command is executed. Generally, the overlap command takes longer to process and allows the program to synchronously process other events during this time.

Even if you set multiple commands in a command line, they are not necessarily executed in the order in which they are received. In order to ensure that the commands are executed in a certain order, each command must be sent as a separate command line.

Example: The command line contains settings and inquiry commands

If multiple commands in a command line contain inquiry commands, the inquiry result is unpredictable. The following command returns a fixed value:

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

Returned value: 1000000000 (1GHz)

The following command returned value is not fixed: :FREQ:STAR 1GHz;STAR?;SPAN 1000000

The returned result may be the current starting frequency value of the instrument before the command is sent, as the host program will only execute the commands one by one after receiving the command message. If the host program is executed after receiving the command, the returned result may also be 1 GHz.

Prompt

The setting command and inquiry command are sent separately

General rules: In order to ensure the correct returned result of the inquiry command, the setting command and inquiry command should be sent in different remote control messages.

In order to prevent the overlapped execution of commands, multithreading or commands can be used: *OPC, *OPC?, or *WAI. These three commands are executed only after the hardware is set. During programming, the computer can force waiting for some time to synchronize certain events. The following

5.1 Remote control basics

gives separate descriptions:

➤ **Controller program uses multithreading**

Multithreading is used to achieve synchronization between the waiting for the command to be completed and the user interface and remote control. That is, a single thread waits for *OPC to complete without blocking the execution of the GUI or remote control thread.

➤ **The usage of the three commands in synchronous execution is shown in the following table:**

Table 5.5 Command Syntax

Method	Action	Programming method
*OPC	After the command is executed, set the operation completion bit in the ESR register.	Set ESE BIT0; Set SRE BIT5; Send the overlap command and *OPC; Wait for the service request signal (SRQ) The service request signal represents the completion of the execution of overlap command.
*OPC?	Stop executing the current command until it returns 1. The command returns only when the operation completion bit in the ESR register is set, indicating that the previous command processing is completed.	Terminate the processing of the current command before executing other commands. Send the command directly after the current command.
*WAI	Before executing *WAI, wait until all commands have been sent and continue processing uncompleted commands.	Terminate the processing of the current command before executing other commands. Send the command directly after the current command.

5.1.5 Status reporting system

The status reporting system stores all operating status information and error message of the current instrument. They are stored in the status register and error queue, respectively, and can be inquired through the remote control interface.

5.1.5.1 Status register organization structure

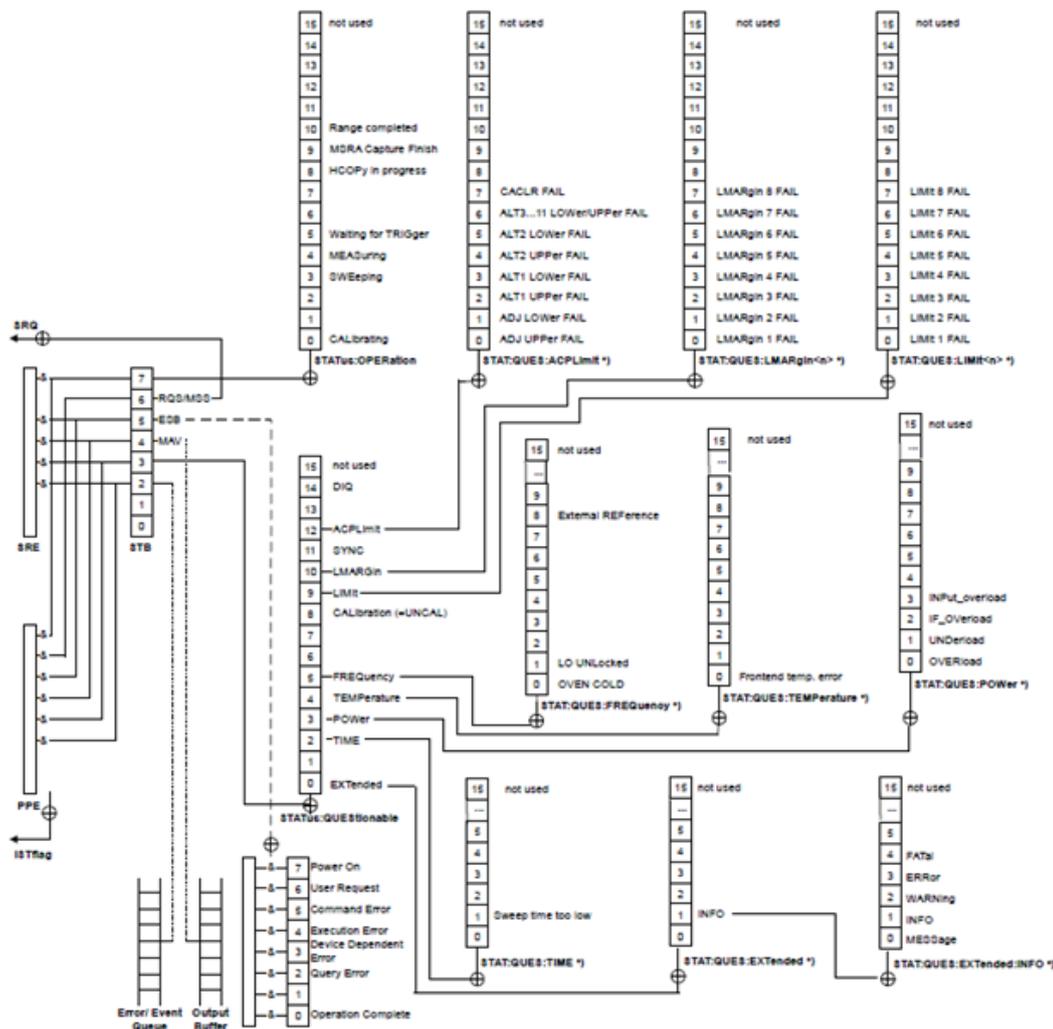


Figure 5.1 Hierarchy of Status Registers

The register classification is described as follows:

1) STB, SRE

The status byte (STB) register and its associated mask register—the service request enable register (SRE)—constitute the top level registers of the status reporting system. STB saves the general working status of the instrument by collecting the low-level register information.

2) ESR and SCPI status registers

The STB receives the following register information:

- The value of the event status register (ESR) and the event status enable (ESE) mask register;
- SCPI status registers include: STATUS:OPERation and STATUS:QUESTIONable registers (SCPI definition), they contain the specific operating information of the instrument. All SCPI status registers have the same internal structure (please refer to the "2.1.5.2 SCPI Status register structure" of the Remote Control Manual)

3) IST,PPE

Similar to SRQ, an individual of the IST sign ("Individual STATUS") is a combination of all states of the instrument. The associated parallel poll enable register (PPE) determines which data bits of the STB act on the IST sign.

5.2 Instrument remote control interface and configuration

4) Output buffer zone

It stores the messages that the instrument returns to the controller. It does not belong to the status reporting system but determines the value of the STB's MAV bit.

For the detailed description of the above registers, please refer to the "[2.1.5 Status reporting system](#)" of the Remote Control Manual.

Please refer to the level structure diagram of the status register in Figure 5.1.

Prompt

SRE, ESE

The service request enable register SRE can be used as an enable part of the STB. Similarly, ESE can be used as an enable part of ESR.

5.1.5.2 Application of status reporting system

The status reporting system is used to monitor the status of one or more instruments in the test system. In order to correctly implement the functions of the status reporting system, the controller in the test system must receive and evaluate the information of all instruments. The standard methods used include:

- 1) Instrument initiated service request (SRQ);
- 2) All the instruments in the serial inquiry bus system are initiated by the controller in the system, and aims to find the initiator and reason of the service request.
- 3) Parallel inquiry of all instruments;
- 4) Inquire specific instrument status by the remote control commands.

Please refer to the "[2.1.5 Status reporting system](#)" of the Remote Control Manual for specific usage.

5.1.6 Programming precautions

1) Please initialize the instrument status before changing settings

When setting up the instrument in a remote control manner, you first need to initialize the instrument status (for example, send "*RST") and then implement the desired status settings.

2) Command sequence

In general, you need to send the setting commands and inquiry commands separately. Otherwise, the returned value of the inquiry command will change according to the current instrument operation sequence.

3) Failure response

Service requests can only be initiated by the instrument itself. The controller program in the test system should instruct the instrument to initiate a service request when an error occurs, and then enter the corresponding interrupt service program for processing.

4) Error queue

Each time the controller program processes a service request, it should inquire the instrument's error queue instead of the status register to obtain a more accurate error cause. Especially during the testing phase of the controller program, it should inquire the instrument's error queue frequently to obtain the wrong command sent by the controller to the instrument.

5.2 Instrument remote control interface and configuration

The USB remote control system adopts the USBTMC protocol to control the instrument.

5.3 Basic programming method for VISA interface

5.2.1 Establishment of connection

The USB cable is used to connect 87230 series USB continuous wave power sensor to an external controller (computer).

5.2.2 Interface configuration

The instrument's VID and PID are 0x04b4 and 0x1004 respectively, and the serial number is marked on the sensor. The three interface information are fixed and cannot be configured by the user.

5.3 Basic programming method for VISA interface

The following is an example of how to use the VISA library to implement the basic method of remote control programming of the instrument. Take the C++ language as an example.

5.3.1 Installation of the VISA Library

To achieve remote control you first need to install the VISA library. Among which the VISA library encapsulates the underlying VXI, GPIB, LAN, and USB interface underlying transfer functions to facilitate direct call by the user. The programming interface supported by the USB continuous wave power sensor is USB. These interfaces realize remote control of USB continuous wave power sensor when being used in conjunction with VISA library and programming languages.

5.3.2 Initialization of the controller

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

//The following example shows how to open and establish a communication connection between the VISA library and the instrument (instrument descriptor specification).

```
//Initialize the controller: Open the default explorer and return the instrument handle analyzer
```

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

```
void InitController()
```

```
{
```

```
    ViStatus iStatus;
```

```
    ViChar rgcInstr[256] = "USB0::0x04b4::0x1004::1801001::INSTR";//The resource descriptor
```

```
    iStatus = viOpenDefaultRM(&defaultRM);
```

```
    if (VI_SUCCESS == iStatus)
```

```
    {
```

```
        iStatus = viOpen(defaultRM, rgcInstr, VI_NULL, VI_NULL, &analyzer);
```

```
    }
```

```
}
```

5.3.3 Initialization of the instrument

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

The following example shows the initialization of the instrument default status and clears the status register.

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

```
void InitDevice()
```

```
{
```

```
    ViStatus iStatus;
```

```
    long retCnt;
```

```
    iStatus = viWrite(analyzer, "*CLS", 4, &retCnt);//reset the status register
```

5.3 Basic programming method for VISA interface

```
iStatus = viWrite(analyzer, "*RST", 4, &retCnt);//Reset the instrument
```

```
}
```

5.3.4 Sending of the setting command

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

The following example shows how to set the center frequency of 87230 series USB continuous wave power sensor.

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

void SimpleSettings()

```
{
```

```
ViStatus iStatus;
```

```
long retCnt;
```

```
//Set the frequency to 128MHz
```

```
iStatus=viWrite(iDevHandle, "FREQ 1.28e8\n", strlen("FREQ 1.28e8\n"), &uiRetCnt);
```

```
}
```

5.3.5 Reading of the instrument status

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

The following example shows how to read the instrument's setup status.

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

void ReadSettings()

```
{
```

```
ViStatus iStatus;
```

```
long uiRetCnt;
```

```
char rgcBuf[256];
```

```
//Inquire the frequency
```

```
iStatus = viWrite(iDevHandle, "FREQ?\n", strlen("FREQ?\n"), &uiRetCnt);
```

```
Sleep(10UL);
```

```
iStatus = viRead(iDevHandle, rgcBuf, sizeof(rgcBuf), &uiRetCnt);
```

```
//Print the debugging information
```

```
Printf("frequency %s", rgcBuf);
```

```
}
```

5.3.6 Synchronization of commands

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

The following describes the command synchronization method by taking the scanning process as an example.

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

void SweepSync()

```
{
```

```
ViStatus iStatus;
```

5.3 Basic programming method for VISA interface

```

long retCnt;
ViEventType etype;
ViEvent eevent;
int stat;
char OpcOk[2];

/*****/
/* The command INITiate[:IMMediate] initiates a single scan (INIT:CONT OFF when continuous
scan is off)*/
/* The next command in the command buffer can be executed when a single scan is completed.
*/
/*****/
iStatus = viWrite(analyzer, ":INIT:CONT OFF", 13, &retCnt);
//Method 1 to wait for the end of the scan: Use *WAI
iStatus = viWrite(analyzer, ":INIT", 18, &retCnt);
iStatus = viWrite(analyzer, "*WAI", 18, &retCnt);

//Method 2 to wait for the end of the scan: Use *OPC?
iStatus = viWrite(analyzer, ":INIT", 20, &retCnt);
iStatus = viWrite(analyzer, "*OPC?", 18, &retCnt);
iStatus = viRead(analyzer, OpcOk, 2, &retCnt);//waits *OPC to return "1"

//Method 3 to wait for the end of the scan: Use *OPC
//In order to use the GPIB service request, set "Disable Auto Serial Poll" to "yes"
iStatus = viWrite(analyzer, "*SRE 32", 7, &retCnt);
iStatus = viWrite(analyzer, "*ESE 1", 6, &retCnt);//Enable service request ESR
//Set the event enable bit, the operation is completed
iStatus = viEnableEvent(analyzer, VI_EVENT_SERVICE_REQ, VI_QUEUE, VI_NULL);
//Enable SRQ event
iStatus = viWrite(analyzer, ":INIT ", 18, &retCnt);
iStatus = viWrite(analyzer, "*OPC", 18, &retCnt);

//Start scan synchronously with OPC
iStatus = viWaitOnEvent(analyzer, VI_EVENT_SERVICE_REQ, 10000, &etype, &eevent)
//Wait for service request
iStatus = viReadSTB(analyzer, &stat);
iStatus = viClose(eevent);//Close event handler
//Forbid SRQ event
iStatus = viDisableEvent(analyzer, VI_EVENT_SERVICE_REQ, VI_QUEUE);

```

5.4 I/O Library

```
//Main program continues...
```

```
}
```

5.4 I/O Library

5.4.1 Overview of I/O Library

The I/O library is a software program library pre-written for the instrument, and is called an instrument driver. It is an intermediate layer of the software between the computer and instrument hardware device, consists of the function library, utility program, tool kit, and is a collection of a series of software code modules. This collection corresponds to a planned operation, such as configuring the instrument, reading from the instrument, writing into the instrument, and triggering the instrument. It resides in the computer and serves as the bridge and link between the computer and instrument. By providing a high-level modular library that facilitates programming, the user no longer needs to learn complex low-level programming protocols specific to an instrument. Using the instrument driver is the key to rapidly develop test and measurement applications.

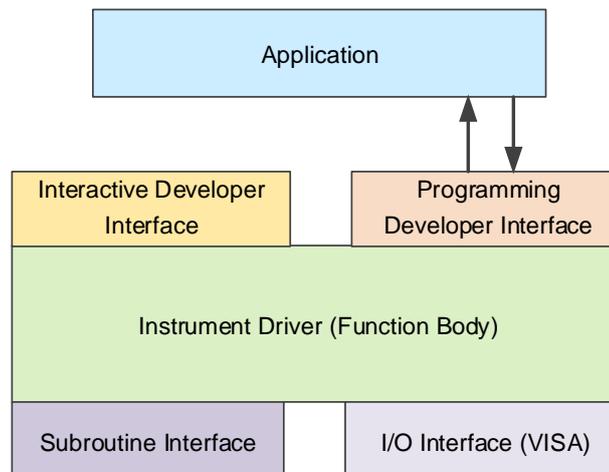


Figure 5.2 Structure Model of Instrument Driver

From a functional point of view, a general-purpose instrument driver is generally composed of a function body, an interactive developer interface, a programming developer interface, a subroutine interface, and an I/O interface, as shown in Figure 5.2.

The specific description is as follows:

- 1) Function body. It is the main function part of the instrument driver and can be understood as the framework program of the instrument driver.
- 2) Interactive developer interface. For user convenience, the application development environments that support the development of instrument drivers often provide graphical interactive development interfaces. For example, in Labwindows/CVI, the function panel is an interactive development interface. In the function panel, each parameter of the instrument driver function is represented by a graphical control;
- 3) Programming developer interface. It is a software interface for the application to call the instrument driver function, such as the dynamic link library file.dl of the instrument driver under Windows system;
- 4) I/O interface. It completes the actual communication between the instrument driver and the instrument. Bus-specific I/O software, such as GPIB, RS-232, can be used; common standard I/O software across multiple buses can also be used: VISA I/O;
- 5) Subroutine interface. It is the software interface for the instrument driver to access other support libraries, such as the database, FFT functions, etc. When the instrument driver needs to call other software modules, operating systems, remote control code libraries, and analysis function libraries to complete its task, the subroutine interface will be used.

5.4.2 Installation and configuration of I/O library

With the application of the test field has experienced different stages of development from the traditional instrument to the virtual instrument, and in order to solve the instrument interchangeability and reusability of the test program in the automatic test system, the instrument driver has experienced different development processes. Currently, the most popular driver is the IVI (Interchangeable Virtual Instruments) instrument driver. It is based on the IVI specification, defines a new instrument programming interface, and inserts the class driver and VPP architecture into VISA, so that the test application is completely independent of the instrument hardware. It also adds unique instrument simulation, range detection, status buffer and other functions, improving the efficiency of system operation and truly realizing instrument interchange.

IVI driver is divided into two types: IVI-C and IVI-COM. IVI-COM is based on Microsoft Component Object Model (COM) technology and adopts the form of COM API; IVI-C is based on ANSI C and adopts the form of C API. Both drive types are designed according to the instrument categories defined in the IVI specification, and their application development environments are the same, including Visual Studio, Visual Basic, Agilent VEE, LabVIEW, CVI/LabWindows, etc.

In order to meet the needs of different users in different development environments, it is currently necessary to provide two driving types. The IVI driver of the USB continuous wave power sensor is developed by Nimbus Driver Studio and generates the IVI-COM and IVI-C driver and program installation packages directly. For detailed installation and configuration, please refer to the accompanied document data of your selected control card and I/O library.

The IVI driver after installation is divided into IVI intrinsic function group and instrument type function group (basic function group and extended function group). For specific function classification, function and attribute description, please refer to the driver's built-in help documentation.

Prompt

Configure ports and installation of IO libraries

Before using a computer to control a USB continuous wave power sensor, please verify that you have properly installed and configured the necessary ports and I/O libraries.

6 Fault diagnosis and repair

This chapter will tell you how to find the problem and accept the after-sales service, and explain the error message of the USB continuous wave power sensor.

If 87230 series USB continuous wave power sensor purchased by you encounters some problems during operation, or you need to purchase the related parts or accessories of the USB continuous wave power sensor, we will provide complete after-sales services.

Under normal circumstances, the cause of the problem is from the hardware, software, or improper use by the user. Once problems arise, please contact us in time. If 87230 series USB continuous wave power sensor purchased by you is within the warranty period, we will repair your 87230 series USB continuous wave power sensor free of charge as promised on the warranty; if 87230 series USB continuous wave power sensor purchased by you is beyond the warranty period, the specific repair cost will be charged according to the contract.

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- Fault diagnosis and troubleshooting.....47
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- Repair method.....49

6.1 Operating principle

The 87230 series USB continuous wave power sensors adopts the control and data processing of the low-power high-performance DSP machine, and utilizes the independent interface chip to realize the USB communication function. It can be used with a computer or other test instruments, and can be very conveniently to be fitted with a wide microwave millimeter wave average power test system. The principle is shown in Figure 6.1.

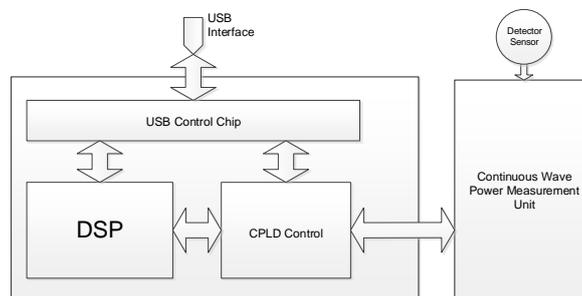


Figure 6.1 Block Diagram of USB Continuous Wave Power Sensor

6.2 Fault diagnosis and troubleshooting

Prompt

Fault diagnosis and guidance

This section is to guide you how to make a simple diagnosis and processing when 87230 series USB continuous wave power sensor fails, if necessary, please feedback the problem to the manufacturer as accurate as possible, so that we can solve it for you as soon as possible.

If an error message tip appears in the status indication area of the user interface of the USB continuous wave power sensor, please refer to the menu “[Tool]->[Error]” for specific description of the error message.

Under normal circumstances, the causes of instrument problems are improper use by the user, incorrect settings, or hardware or software failures. Once a problem occurs, first observe the error message and

6.3 Error message

save it, and analyze the possible causes and refer to the methods provided in this chapter to troubleshoot the problem beforehand. You can also contact our customer service center and provide the collected error message, and we will help you solve the problem as quickly as possible. For details, please refer to the contact information provided in this manual, or check online at www.ceyear.com to find the nearest technical support contact information.

This chapter mainly helps the user to diagnose the fault of 87230 series USB continuous wave power sensor and determine whether it is necessary to seek after-sales service, including the interpretation of the internal error message of this machine.

Generally, the causes of the problem are hardware, software, or improper use of by the user. The 87230 series USB continuous wave power sensor may have the following types of failures:

- USB device is missing;
- LED green indicator light is not on;
- Unexpected phenomena, such as performing erroneous operations, obvious errors in measurement results, etc.

6.2.1 USB device is missing

If you USB device is missing in the Computer Device Manager after power on, check as per the following steps:

Step 1 Please make sure that the USB cable is connected properly and check whether the USB power supply is normal.

Step 2 Please check whether there are multiple USB devices connected. If necessary, use USB HUB with external power supply.

Step 3 Please check whether the host is properly fitted with the device VISA library and driver.

6.2.2 LED green indicator light is not on

If the LED green indicator light of the sensor does not light up after power on, check as per the following steps:

Step 1 Check whether the USB cable is connected properly;

Step 2 Check whether the host is powered on and whether the USB host interface is normal.

6.2.3 Unexpected phenomena

There are many causes for unexpected phenomena during use. You can refer to the following test steps to determine the cause of the instrument's problem. Usually, these test methods can solve the problem or determine the cause of the problem clearly.

- Check whether the USB cable is mechanically connected and whether the electrical characteristics are compatible.
- When something goes wrong after you make some settings, check the operation and make sure all settings are correct. If the test is completed, please check whether the measurement result is consistent with the signal to be tested and whether the measurement result meets the performance specifications of the sensor.
- When the instrument has unexpected results, if you are not sure whether the settings you made are correct, set them again based on the signal to be tested and test requirements after replugging.

6.3 Error message

During actual use, if the operation is improper or the configuration is incorrect, the system will automatically provide an error message. The user can roughly judge the type of problem based on the error, and take corresponding measures to eliminate the problem or decide repair.

Click  on the User Power Test Panel to view the most recent error message.

6.4 Repair method

Refer to the *Remote Control Manual for 87230 Series USB Continuous Wave Power Sensor* for detailed description of error messages.

6.4 Repair method

6.4.1 Contact us

If there is a problem with 87230 series USB continuous wave power sensor, first observe the error message and save it, analyze the possible causes and refer to the methods provided in “6.2 Fault diagnosis and troubleshooting” to troubleshoot the problem beforehand. If it is not resolved, please contact our service consulting center according to the following contact information and provide the collected error message, and we will assist you in solving the problem as quickly as possible.

Contact information:

Tel: **+86-0532-86896691**
Website: www.ceyear.com
Email: sales@ceyear.com
Postal code: **266555**
Address: **No. 98 Xiangjiang Road, Qingdao City, China**

6.4.2 Packaging and mailing

When your 87230 series USB continuous wave power sensor presents a problem which is difficult to be solved, you can contact us by phone or fax. If it is confirmed that the USB continuous wave power sensor needs to be repaired after contacting us, please pack the USB continuous wave power sensor in the original packing material and packing box according to the following steps:

- 1) Write a detailed description of the faults of the USB continuous wave power sensor and place it in the packing box together with the instrument;
- 2) Pack the USB continuous wave power sensor with the original packaging material to reduce possible damage;
- 3) Properly place the cushions at the corners of the outer packing carton and put the instruments in the outer packing carton;
- 4) Seal the packing box mouth with tape and reinforce the packing box with nylon belt;
- 5) Mark "Fragile! Don't Touch! Handle With Care!" on the box body;
- 6) Please ship it as per precision instrument;
- 7) Keep a copy of all shipping documents.

Note**Precautions for packaging 87230 series USB continuous wave power sensor**

Packaging 87230 series USB continuous wave power sensor with other materials may damage the instrument.

6.4 Repair method

Prompt

Packaging and transport of the instrument

When transporting or handling the instrument, please strictly observe the precautions described in "[2.2.7 Transport](#)".

7 Technical specifications

This chapter describes the technical specifications and main test methods of 87230 series USB continuous wave power sensor.

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7.1 Declaration

Unless otherwise specified, the test conditions of all specifications are: Temperature range: $23\text{ °C} \pm 5\text{ °C}$, half an hour after boot. The instrument supplemental information helps the user to better understand the performance of the instrument and is not within the scope of the technical specifications. The important entries are as follows:

Technical specifications (spec): Indicates the guaranteed performance when the calibrated instruments are placed at least for two hours under the operating temperature range of 0 °C to 50 °C , and then are subject to 30 minutes of warm-up unless otherwise stated. It includes the measurement uncertainty. Unless otherwise stated, the data in this article are all technical specifications.

Typical value (typ): Indicates the typical performance that can be achieved by 80% of the instruments. This data is not guaranteed data, and does not include the uncertainties in the measurement process. It is only valid at room temperature (approximately 25 °C).

Rating value (nom): Indicates the expected average performance, design performance characteristics, or the performance that cannot be tested by a limited test method, such as a $50\ \Omega$ connector. The product performance marked as a rating is not included in the product warranty and is measured at room temperature (approximately 25 °C).

Measured value (meas): Indicates the performance characteristics measured during the design phase, such as the amplitude drift over time, so as to compare with the expected performance. This data is not guaranteed data and is measured at room temperature (approximately 25 °C).

7.2 Product features

7.2.1 Features

- Single sensor volume: Small volume, comparable to conventional power sensors, light weight, and easy to carry.
- USB remote control interface: The sensor provides standard USB remote control interface, which can be used for inquiry or setting of zero calibration, measurement, frequency response offset, average, and offset.
- Zero calibration function: Perform zero calibration when the connection with external signals is disconnected.
- Diode power sensor: Can provide high sensitivity. The frequency calibration factors that are traceable to national standards are stored in the EEPROM in the sensor and is downloaded to the instrument when the application is loaded. The temperature sensor in the sensor can track the temperature change.

7.2.2 Main functions

The 87230 series USB continuous wave power sensor has the following main functions:

- 1) Single sensor volume, light weight, and easy to carry;
- 2) Continuous wave signal absolute power accurate measurement function;
- 3) Zero calibration function;
- 4) The user do not need to calibrate it;
- 5) Support the USB remote control function, and provide interchangeable virtual instrument (IVI)

7.3 Technical specifications

driver;

6) Compatible with other computers or measuring instruments with USB host interface, and can quickly set up a microwave power test system.

7.3 Technical specifications

When the instrument is stored at ambient temperature for 2 hours, the boot warm-up time should be no less than 30 minutes to meet all technical specifications.

1) Frequency range

87230: 9kHz~6GHz

87231: 10MHz~18GHz

87232: 50MHz~26.5GHz

87233: 50MHz~40GHz

2) Power measurement range

87230: -50dBm~+20dBm

87231: -60dBm~+20dBm

87232: -60dBm~+20dBm

87233: -60dBm~+20dBm

3) Zero calibration accuracy

87230: $\leq 10\text{nW}$

87231: $\leq 1\text{nW}$

87232: $\leq 1\text{nW}$

87233: $\leq 1\text{nW}$

4) Standing-wave ratio (SWR) of input port

87230:

100kHz~6GHz: 1.15

87231:

10MHz~50MHz: 1.21

50MHz~2GHz: 1.15

2GHz~12.4GHz: 1.20

12.4GHz~18GHz: 1.27

87232:

50MHz~2GHz: 1.15

2GHz~12.4GHz: 1.20

12.4GHz~18GHz: 1.27

18GHz~26.5GHz: 1.30

87233:

50MHz~2GHz: 1.15

2GHz~12.4GHz: 1.20

12.4GHz~18GHz: 1.27

18GHz~26.5GHz: 1.30

26.5GHz~40GHz: 1.50

5) Calibration factor Uncertainty (0dBm)

87230:

9kHz~6GHz: ± 0.16 dB

87231:

10MHz~18GHz: ± 0.25 dB

87232:

50MHz~18GHz: ± 0.25 dB

18GHz~26.5GHz: ± 0.35 dB

87233:

50MHz~18GHz: ± 0.25 dB

18GHz~40GHz: ± 0.35 dB

6) Power linearity ($23\pm 5^\circ\text{C}$)

87230:

+10dBm~+20dBm: ± 0.18 dB

-40dBm~+10dBm: ± 0.14 dB

-50dBm~-40dBm: ± 0.79 dB

87231/87232/87233:

+10dBm~+20dBm: ± 0.18 dB

-40dBm~+10dBm: ± 0.14 dB

-50dBm~-40dBm: ± 0.39 dB

-60dBm~-50dBm: ± 0.79 dB

7) Connector form and input impedance

87230: N (m), 50Ω

87231: N (m), 50Ω

87232: 3.5mm (m), 50Ω

87233: 2.4mm (m), 50Ω

8) Weight

87230: 235g

87231: 235g

87232: 225g

87233: 216g

9) Overall dimensions (width x height x depth)

87230: 46.2 mm x 35.6 mm x 142.6 mm

87231: 46.2 mm x 35.6 mm x 142.6 mm

87232: 46.2 mm x 35.6 mm x 135.4 mm

87233: 46.2 mm x 35.6 mm x 125.9 mm

10) Power consumption

7 Technical specifications

7.3 Technical specifications

+5V DC, 1.8W

11) Environmental adaptability

Operating temperature: 0°C~50°C

Storage temperature: -40°C~+70°C