S8723X Series USB CW Power Sensor

User Manual

Saluki Technology Inc.

The document applies to the continuous wave USB power sensors of the following models:

- S87230 continuous wave USB power sensor (9kHz - 6GHz).
- S87231 continuous wave USB power sensor (10MHz - 18GHz).
- S87232 continuous wave USB power sensor (50MHz - 26.5GHz).
- S87233 continuous wave USB power sensor (50MHz - 40GHz).

Preface

Thanks for choosing S8723X series USB CW power sensor produced by Saluki Technology Inc. Please read this manual carefully for your convenience.

We devote ourselves to meeting your demands, providing you high-quality measuring instrument and the best after-sales service. We persist with "superior quality and considerate service", and are committed to offering satisfactory products and service for our clients.

Manual No.

S8723X-03-01

Version

Rev01 2019.07

Saluki Technology

Manual Authorization

The information contained in this User Manual is subject to change without notice. The power to interpret the contents of and terms used in this guide rests with Saluki.

Product Quality Certificate

The product meets the indicator requirements of the manual at the time of delivery. Calibration and measurement are completed by the measuring organization with qualifications specified by the state, and relevant data are provided for reference.

Quality/Environment Management

Research, development, manufacturing and testing of the product comply with the requirements of the quality and environmental management system.

Precautions

For the purpose of this manual, the following safety symbols apply, and please be familiar with them and their meanings before operating this instrument!

Contacts

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Chapter 1 Overview

This chapter introduces the main performance characteristics, main purposes and application fields of S87230 series USB continuous wave power sensor, and also explains how to properly operate the instrument and power safety precautions.

1.1 Product Overview

The S87230 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 Saluki Technology, 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 S87230 series USB continuous wave power sensors include four product types, namely S87230, S87231, S87232 and S87233, with the frequency range of 9kHz - 6GHz, 10MHz - 18GHz, 50MHz - 26.5GHz, and 50MHz - 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.

1.2 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.**

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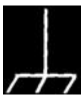
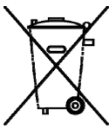
Please properly keep the basic safety instructions and product document and deliver them to the end user.

1.2.1 Safety sign

1.2.1.1 Product-related signs

The safety warning signs on the products are as follows (Table 1.1):

Table 1.1 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.	| O	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 "1.2.8 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 "1.2.8 Disposal/Environmental Protection" of this section.
	Warn! Radiation. For details, refer to Item 7 in "1.2.4 Operation Precautions" of this section.		

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

1.2.2 Operational status and position

Before operating the instrument, please note:

(1) Unless otherwise stated, the operating environment of S 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 ±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.

1.2.3 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.

1.2.4 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 "1.2.7 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 "1.2.8 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.

1.2.5 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.

1.2.6 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.

(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.

1.2.7 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.

1.2.8 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.

Chapter 2 Getting Started

This chapter introduces the pre-use and routine maintenance before use of the S87230 series USB CW power sensor to facilitate the user to have a preliminary understanding of the instrument. The content contained in this chapter is consistent with that in relevant chapters of Quick Start Guide.

2.1 Pre-use Precautions

This section describes the precautions before initial use of the S8723X series USB CW power sensor.

Warn

Damage prevention

To avoid the electric shock, fire and personal injury:

- Do not open the chassis without authorization;
- Do not attempt to dismantle or modify any part not described in this manual. Improper removal may cause the deterioration of electromagnetic shielding effectiveness, damage of internal parts, etc. and affect the reliability of product. If the product is under warranty, we will no longer provide the unpaid repairs.
- Please carefully read relevant content of "1.2 Safe Use Guideline" of the User's Manual and the following precautions for safe operation. In addition, attention shall be paid to relevant specific operating environment requirements specified in the reference data page.

Note

During instrument operation, please pay attention to the following aspects:

Improper application site or measurement setting will damage the instrument or the connecting device. Before powering on the instrument, please pay attention to the followings:

- Keep the instrument dry;
- Place the instrument horizontally and reasonably;
- Ensure that the surrounding temperature is in accordance with the requirements on the reference data page.
- Ensure that the power level of the port input signal conforms to the mark range;
- Ensure that the signal output port is properly connected and isn't overloaded.

Note

ESD protection

Pay attention to the ESD protection measures in the workplace to avoid the damage to instrument. For details, please refer to relevant content of "1.2 Safe Use Guideline" of the User's Manual.

Prompt

Effect of electromagnetic interference (EMI)

The electromagnetic interference can affect the measurement results, therefore, it is necessary to:

- Select appropriate shielded cables, for example, use RF shielded twisted pair/network connection cable;
- Close the opened and temporarily unused cable connection port or connect the matched load to the connection port in time;
- Refer to the electromagnetic compatibility (EMC) grade in the User Manual.

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2.1.1 Unpacking

Setp1: Check if there is any damage in the outer packaging and the anti-vibration packaging of the instrument. If no damage is found, keep the packaging in case of future need and continue the inspection as per the following steps;

Step 2: Unpack the instrument and check for any damage to the main unit and attached items.

Step 3: Verify the items in the packaging box carefully by cross-checking with packing list;

Step 4: If the outer package is broken, the instrument or accessories are damaged or there is any error of the delivery, it is strictly forbidden to switch on the instrument! Please contact us: sales@salukitec.com.

2.1.2 Environment requirements

The operating place of the S87230 series USB CW power sensor shall meet the following environment requirements.

(1) **Operating environment**

The operating environment should satisfy the following requirements:

Table 2.1 Operating Environment Requirements of the S87230 Series

Temperature	10°C - 40°C
Temperature range during error adjustment	23°C ± 5°C (allowed temperature deviation during error adjustment <1°C)
Humidity	Hygrometer measurement range: 20% - 80% (uncondensed) when the temperature <+29°C
Altitude	0 - 4,600m
Vibration	Maximum: 0.21G, 5Hz - 500Hz

Note

The above environmental requirements are only defined for the operating environment of the instrument and are not within the scope of specifications.

(2) ESD protection

The static electricity is destructive to electronic components and equipment. Generally, we will use two anti-static measures, including combination of conductive table mat and wrist combination as well as combination of conductive floor mat and ankle strap. If these two combinations are used together, a good anti-static protection can be provided. If the combination is used separately, only the former can provide protection. For the safety of users , anti-static components must provide an isolation resistance of at least 1MΩ to the ground.

Please correctly use the following anti-static measures to reduce electrostatic damage:

- Ensure that all instruments are properly grounded to avoid generating static electricity;

- Before connecting the coaxial cable to the instrument, contact its inner and outer conductors with the ground temporarily;
- The staff shall wear anti-static wrist straps or adopt other anti-static measures before contacting joints and core wires or carrying out any assembly operation.

Warn

Operating voltage range

The above anti-static measures can't be taken in a place where the voltage exceeds 500V.

2.1.3 Power on/off

(1) Host system requirements

The S87230 series USB CW power sensor shall be applied with the standard USB mini-AB socket, and shall be subject to power display or direct remote control on the computer or other test instrument with USB host interface.

Before using the USB CW power sensor, please ensure that the host satisfies the following requirements:

- The computer or any hardware device with a USB host interface;
- Support Windows98SE/ME/XP/2000/2003/Win7/WIN10 or higher version;
- The host is installed with the version above VISA 3.0 and the virtual power test panel provided along with the machine;
- It is also available for programming through the remote programming software including Microsoft® Visual Basics, C++ and LabVIEW.

(2) USB cable selection

The S87230 series USB CW power sensor is equipped with special USB cable, which can be screwed and fixed on the body, as shown in Fig. 2.1. The user can also use his own USB cables, but shall ensure that cables satisfy the international safety standards.

Warn

Prevent personal injury and damage to the instrument.

Poor contact or wrong wiring may lead to instrument damage or even personal injury. Therefore, the users are recommended to use the USB cable provided by us. If other non-standard cables shall be used, please contact our technical personnel.

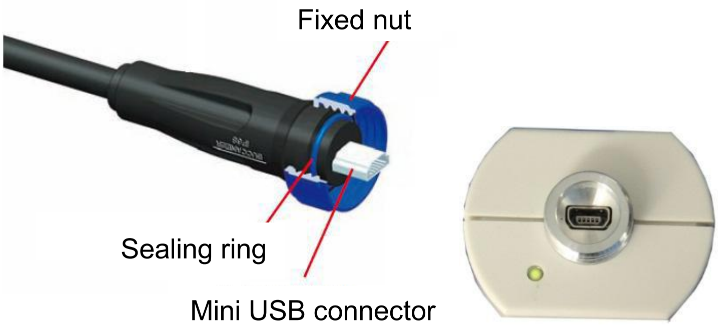


Fig.2.1 Fixable USB cable

(3) Power on the instrument

The S87230 series USB CW power sensor is applied with the computer standard USB interface. Table 2.2 lists the power supply requirements of the S87230 series USB CW power sensor during normal operation.

Table 2.2

Power Supply Parameter	Applicable Scope
Output voltage	+5 V ±5% DC
Rated current	0.5A

The normal power consumption of the S87230 series USB CW power sensor is 1.8 W. When the computer USB interface is inserted with multiple USB devices and it can't guarantee that each interface can provide 0.5 A output current, the computer will prompt that some sensors can't be found. In this case, please use the USB HUB with external power supply.

Connect the sensor with the USB port of the host with the USB cable conforming to the requirements, and observe whether the green indicator lamp of the sensor is lit up.

Step 1: Connect the small port of the USB cable with the S87230 series USB CW power sensor and tighten it, and then connect its large port with the computer or measurement instrument USB host interface, and the power sensor green indicator lamp will light up later;

Step 2: The "Equipment Manager" of the host can find the new "USB Test and Measurement Devices".

Fig2.2 Connecting the USB CW power senor to the computer

(4) Power off

Remove the USB cable to turn off the USB CW power sensor. In this case, the green LED indicator lamp will go out.

2.1.4 Connect Use of Connectors

During test of the USB CW power sensor, it shall be connected to the USB cable and then connected to the source to be tested. The 1.85 mm, 2.4 mm and 3.5 mm male connectors shall be used, and even different types of switching adapters shall be used. Even though connectors are designed and manufactured according to the highest standards, their service life is limited. Wear is unavoidable in normal use and can make the connector performance degrade or even unable to meet the measurement requirement, therefore, correct maintenance and measurement connections not only provide accurate and repeatable measurement results but also prolong the useful life, reduce the measurement cost.

Note the following aspects during actual use:

(1) Check of connectors

It is necessary to wear an anti-static wrist strap when checking the connectors. It is recommended to use a magnifier to check:

1) the electroplated surface for wear and deep scratches;
2) the thread for deformation;
3) the thread and joint surface for metallic particles;
4) the inner conductor for bending and breakage;
5) the screw for improper rotation.

Note

Check the connectors so as not to damage the instrument ports

Any damaged connector may damage the good connector connected to it even for the first time of measurement. To protect the ports of the USB CW power sensor, the connector to be used shall be checked before connection.

(2) Connection

The connectors should be checked and cleaned before measurement and connection to ensure that they are clean and undamaged. It is necessary to wear an anti-static wrist strap during connection. The correct connection methods and procedures are as follows:

Step 1. As shown in Fig.2.3, align the axes of the two interconnected connectors to ensure that the pin of the male connector slides concentrically into the hole of the female connector.

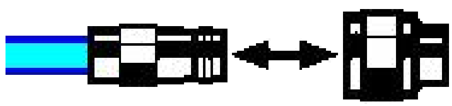


Fig. 2.3 Coaxial alignment of interconnected connectors

Step 2. As shown in Fig. 2.4, move both connectors straight together, so that they can be connected smoothly; rotate the threaded sleeve of connector (rather than the connector itself) until it is tightened; during connection, there can be no relative rotary motion both connectors;

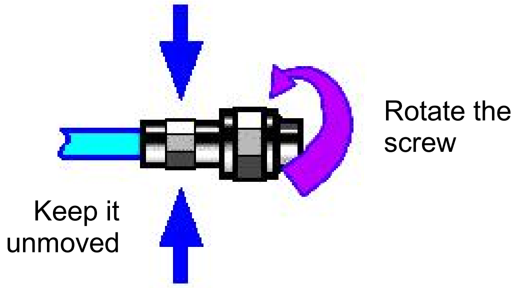


Fig. 2.4 Connection

Step 3. As shown in Fig. 2.5, use a torque wrench to tighten the connectors and finish the connection; the torque wrench shall not exceed the starting break point and an auxiliary wrench can be used to prevent the connector rotating.

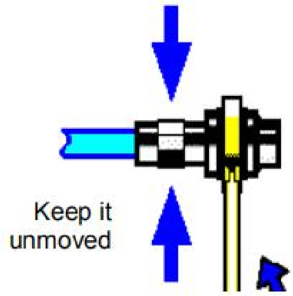


Fig. 2.5 Completion of final connection with a torque wrench

(3) Disconnection

Step 1. Support the connector to prevent any part from being shaken, distorted, or bent;

Step 2. Use an open-end wrench to prevent the main connector from rotating;

Step 3. Use another wrench to loosen the screw on the connector.

Step 4. Loosen the screw by hand until the connection is completely broken.

Step 5. Separate two connectors by pulling them apart in parallel.

(4) Use of the toque wrench

The torque wrench should be used as indicated in Fig. 2.6. Please pay attention to the following points when using the torque wrench:

- Confirm that the torque of the torque wrench is set correctly before use;
- Ensure that the angle between the torque wrench and the other wrench (used to support the connector or cable) is less than 90° before applying a force;
- Gently grasp the end of the torque wrench handle and apply a force in the direction perpendicular to the handle until the breakout torque of the wrench is reached.

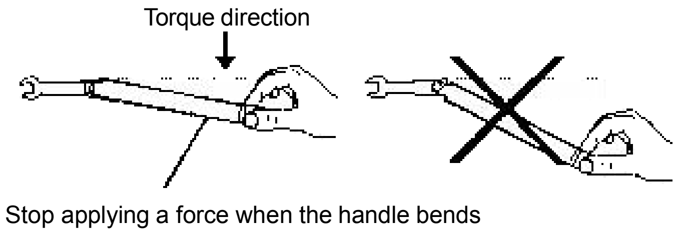


Fig. 2.6 Use of torque wrench

(5) Use and preservation of connectors

1) Protect the connectors with a protective sheath when not used;

2) Do not place the connectors, tools, etc. in a same box, which is the most common cause leading to connector damage;

3) Keep the connector and analyzer at the same temperature. If the connector is held by hand or cleaned with compressed air, the temperature will be significantly changed. The connector can be used for calibration only after its temperature is stabilized;

4) Do not touch the joint surface of the connector because it is difficult to remove skin oil and dust particles from the joint surface;

5) Do not place the contact surface of the connector downwards onto a hard surface; otherwise, the electroplated layer and joint surface of the connector may be damaged.

6) Wear an anti-static wrist strap and work on a grounded conductive workbench mat to protect the analyzer and connector against electrostatic discharge.

(6) Cleaning of connectors

It is necessary to wear an anti-static wrist strap when cleaning the connectors as per the following steps:

1) Use clean low-pressure air to remove the loose particles on the thread and joint surface of the connector and check the connectors thoroughly. If further cleaning is required, proceed as follows;

2) Wet (but not soak) a lint-free cotton swab with isopropyl alcohol;

3) Use a cotton swab to remove dirt and debris from the joint surface and thread of the connector. When cleaning the inner surface, be careful not to apply an external force to the central inner conductor or leave the cotton swab fibers on the central conductor of the connector;

4) Evaporate the alcohol and then blow the surface clean with compressed air;

5) Check the connectors to confirm that they are free of particles and residues;

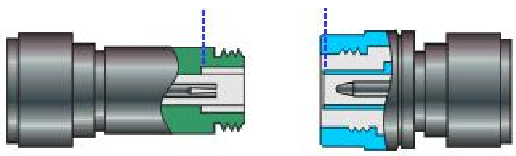
6) If the connector still has visible defects after cleaning, it indicates that the connector may be damaged. Never use a damaged connector, and confirm the causes of damage before measurement and connection.

(7) Use of adapter

When the measuring port of analyzer is different from the type of connector used, an adapter must be adopted for measurement connection. In addition, even if the measurement port of the analyzer is the same as the type of connector for the port of tested part, it is also a good idea to use an adapter. Under these two conditions, the measuring port can be protected, thus extending its service life and reducing the maintenance cost. Before connecting the adapter to the measuring port of analyzer, it should be carefully checked and cleaned. A high-quality adapter should be used to reduce the impact of mismatch on the measurement accuracy.

(8) Joint surface of connector

An important concept in microwave measurement is the reference surface for all measurement. In the case of calibration, the reference surface is defined as the surface on which the measuring port and the calibration standard are jointed. Proper connection and calibration depend on whether the connectors can be completely and straightly contact with each other at each point of the joint surface, so as to ensure minimum power standing-wave ratio, achieve the minimum power loss, and ensure the measurement accuracy.



2.2 Routine Maintenance

This section introduces the daily maintenance method of the S87230 series USB CW power sensor.

2.2.1 Cleaning method

Clean the instrument surface as per the following steps:

Step 1. Power it off, and disconnect the power cord;

Step 2. Gently wipe off the surface with a piece of dry or slightly moist soft cloth, and it is not allowed to wipe off its inside;

Step 3. Do not use chemical detergents, such as alcohol, acetone or diluted detergent.

2.2.2 Maintenance of testing port

The S87230 series USB CW power sensor has a USB cable connector and a microwave power signal input port. If the connector is damaged or there is dust inside, the RF wave band test results will be affected; therefore, please observe the following methods for maintenance of such connector:

- Connectors shall be kept clean and away from dust;
- To prevent ESD, do not directly contact the connector surface;
- Do not use damaged connector;
- Clean connectors with a dryer, and do not grind the surface with a tool like abrasive paper.

Chapter 3 Operation Guide

This chapter introduces the selection of the S87230 series USB CW power sensor, and detailed operation methods and measurement procedures for different measurement functions.

3.1 Selection of Power Sensor

The S87230 series USB CW power sensor includes four models including S87230, S87231, S87232 and S87233, as shown in the following Table.

Table 3.1 S87230 Series USB CW Power Sensor

No.	Sensor Model	Power Range	Frequency range	Interface Type
1	S87230	-50 dBm to +20 dBm	9 kHz - 6 GHz	N (m)
2	S87231	-60 dBm to +20 dBm	10 MHz - 18 GHz	N (m)
3	S87232	-60 dBm to +20 dBm	50MHz - 26.5GHz	3.5 mm (m)
4	S87233	-60 dBm to +20 dBm	50MHz - 40GHz	2.4mm (m)

Fig. 3.1 S87230 series USB CW power sensor

The S87230 series USB CW power sensor can realize continuous wave power measurement. As the performance specifications are different by model, the user can select the suitable sensor according to the characteristics and measurement requirements of signals to be tested as well as the specifications of each sensor. The basic functions of the sensor are shown in Table 3.1. Refer to "6.3 Technical specifications" for the description of the specific indicators of each sensor.

3.2 Virtual Power Measurement Panel

The USB interface of the S87230 series USB CW power sensor conforms to the USBTMC (USB Test and Measurement) protocol, which is a kind of enumerated equipment (namely, it can be found through the viFindRsrc function of the VISA library). The vendor ID and equipment ID (decimal) are 1204 and 4100 respectively, and the serial number are as shown in each sensor.

The user can realize the remote control of the USB sensor through the VISA library; for the specific configuration, please refer to the *Programming Manual of the S87230 Series USB CW Power Sensor*, and the virtual power test panel can also be used for the power test. The user shall install the version above VISA 3.0 and run the virtual power test panel program provided in CD. The open virtual power test panel is as shown in Fig. 3.2.

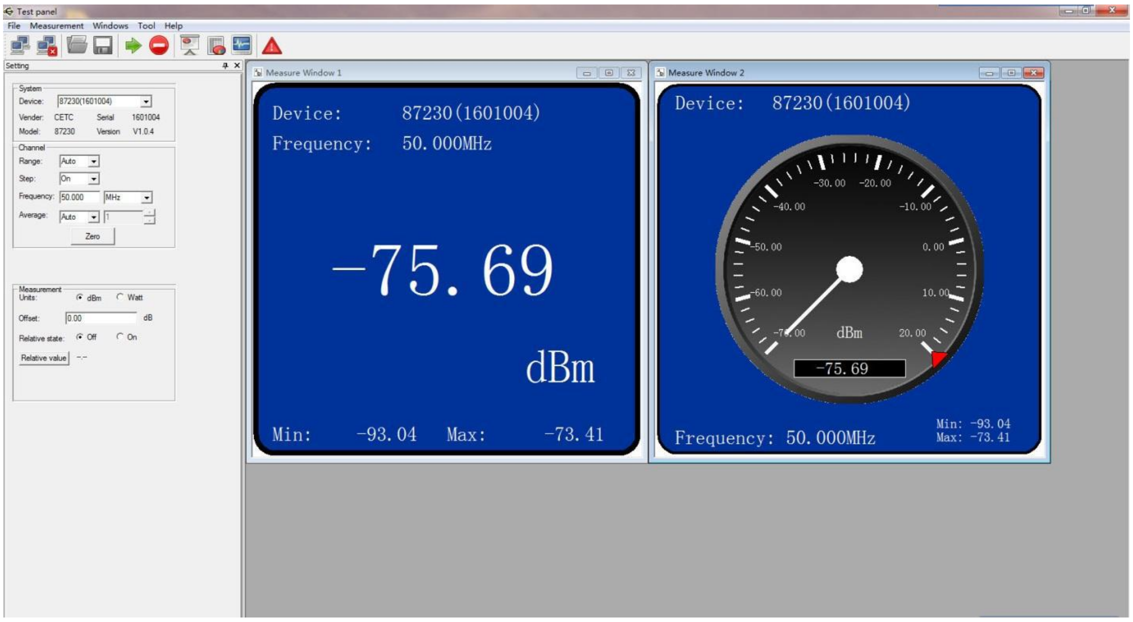


Fig. 3.2 Virtual power test panel

Connection and operation steps of the USB CW power sensor:

Step 1. Connect the USB power sensor with the computer; open the power test panel; select the USB device to be connected in the pop up "Instrument Connection" window in the system, and click "Connection" button. As shown in Fig. 3.3, the measurement process is normal;

Step 2. The user can check the type, serial number and firmware version number of the USB CW power sensor in the "System" label on the left side of the window;

Step 3. Click  or  button of the toolbar, and the system will display the measurement result in the open value window or disable measurement;

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

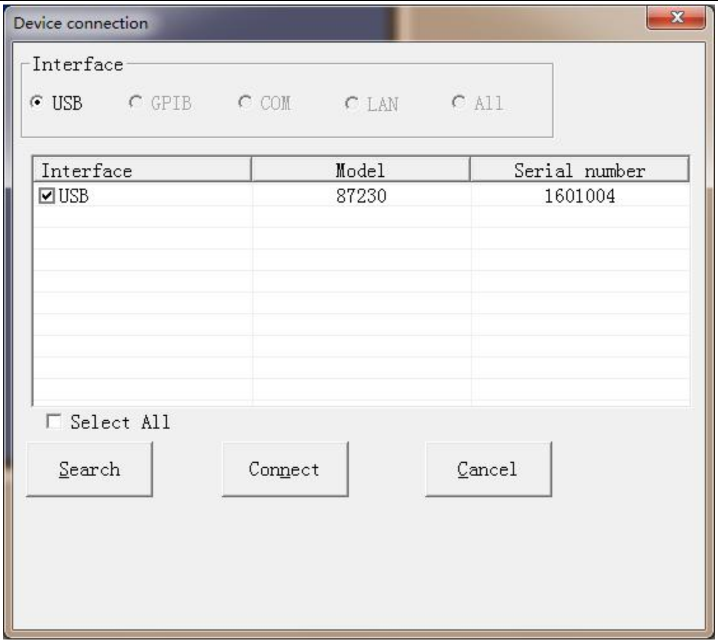
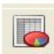


Fig. 3.3 Equipment Connection Window

Step 5. The settings including unit selection, offset and relative measurement can be carried out in the "Measurement" label window;

Step 6. Click  and  buttons of the toolbar to create the value display window and analog display window;

Step 7. Click  button of the toolbar to research and connect the new USB power sensor.

3.3 Zeroing and Calibration Before Measurement

In order to improve the measurement accuracy of the S87230 series USB CW power sensor, it is necessary to zero it before small signal power measurement.

The S87230 series USB CW power sensor has been calibrated before delivery with the calibration source traceable to the national standard, and thus calibration is not recommended to the users.

3.3.1 Zero calibration

Zeroing refers to measurement and storage of noise of the whole measurement channel. In the process of measurement, the zeroed value shall be deducted from the actually measured value, namely deducting the channel noise, and this reading is the real channel input signal level.

If the sensor is connected to other equipment, firstly disable the signal output of the equipment, and then zero it.

The specific steps are as follows:

Step 1. Connect the sensor to the output port of the source to be tested, and disable the output of the source;

Step 2. Carry out external zero with the SCPI or [Zero] button on the power test panel. The green LED lamp will flash during zero.

It is recommended to zero the S87230 series USB CW power sensor in following conditions:

- When the temperature change is larger than 5℃;

- After 24 h;
- Before measuring the low power continuous wave signal. For example, when measuring the small signal with a maximum power 10 dB higher than the minimum detectable power of the applied power sensor.

Note

For the S87230 seriesUSB CW power sensor with a frequency band covering 9 kHz - 6 GHz, as DC couple is used as detection component, some signal sources may lead to DC or low frequency leakage when the RF output is "OFF", thus resulting in too high level of the measured signal and zero failure.

3.3.2 Internal zero

The internal zero means that a switch is equipped in front of the measurement channel. The user can measure and save the noise of the channel without disconnecting the sensor from the DUT. During internal zero, the RF signal is always applied to the power sensor, which can reduce the wear of the sensor connector and shorten the test time, and thus is especially suitable for the occasions when it is inconvenient to disable the power signal output.

Generally speaking, the conventional zero usually has a better zero effect, and the internal zero and the conventional zero functions shall be selected according to the actual measurement demands. During programming, the user can recall CALibration[1]:ZERO:TYPE command to select the internal zero or conventional zero function. For specific operation, please refer to the *Programming Manual of the S87230 Series USB CW Power Sensor*.

Note

During measurement of low level signal, automatic zero shall be carried out before measurement, so as to ensure the measurement accuracy.

Set the step detection to "Off" status when the measurement of low power signal with amplitude lower than -40 dBm is carried out to obtain more accurate measurement results, but the measurement speed is lower.

3.3.3 Calibraiton

The calibration means that the power sensor is connected to the known standard calibration source output port for power tracing under the current measurement conditions (current temperature, current power reference, etc.). As the S87230 series USB CW power sensor has been calibrated before delivery, the calibration is not recommended to the users. However, the advanced users can automatically calibrate the sensor in the following conditions:

- When the user uses a customized 0 dBm power standard for measurement and comparison;
- When it is beyond 1-year calibration period, and the user thinks that it has measurement errors and it is unavailable for returning and calibration.

3.4 Continuous Wave Power Measurement

The S87230 series USB CW power sensor can realize the average power measurement of the continuous wave signal. The dynamic range of power measurement is -60 dBm to +20 dBm, and the frequency range is 9 kHz - 40 GHz.

The user can carry out power measurement of the continuous wave through our power test panel or SCPI. For details, please refer to the *Programming Manual of the S87230 Series USB CW Power Sensor* in the accompanied CD. It is classified into three steps generally:

Step 1. Zero the USB CW power sensor;

Step 2. Set the frequency of the signal to be tested;

Step 3. Carry out power measurement of the continuous wave with the sensor.

When multi-channel measurement shall be carried out, the user can directly insert several USB CW power sensors into the computer or build a multi-channel power test system with USB HUB, as shown in Fig. 3.4.

Fig. 3.4 Multi-channel power test with USB HUB

The specific operation steps are as follows:

Step 1. Open the virtual power test panel, and the system will automatically find the connected USB CW power sensors, and then select all connected power sensors, and click "Connection" button. As shown in Fig. 3.5, the system will automatically display the USB CW power sensor found first and display the measurement results;

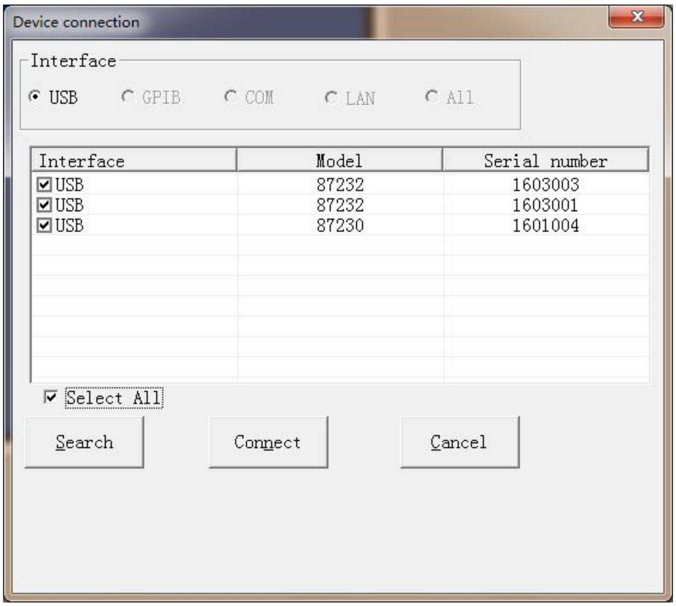
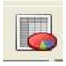


Fig. 3.5 Equipment when several USB CW power sensors are connected

Step 2. Click  or  button of the toolbar, and open the measurement result of other power sensor in form of value display or analog display, as shown in Fig. 3.6;

Step 3. Click one measurement window, and the system will indicate the currently selected measurement window with yellow border, and then select the "Equipment" drop-down menu under the "System" label to assign the window to other equipment;

Step 4. Click one measurement window, and the system will indicate the currently selected measurement window with yellow border, and then the channel can be zeroed and the measurement frequency and offset can be set;

Step 5. When several USB CW power sensors are connected, the open measurement window can be automatically arranged with the window/tile or cascade command.

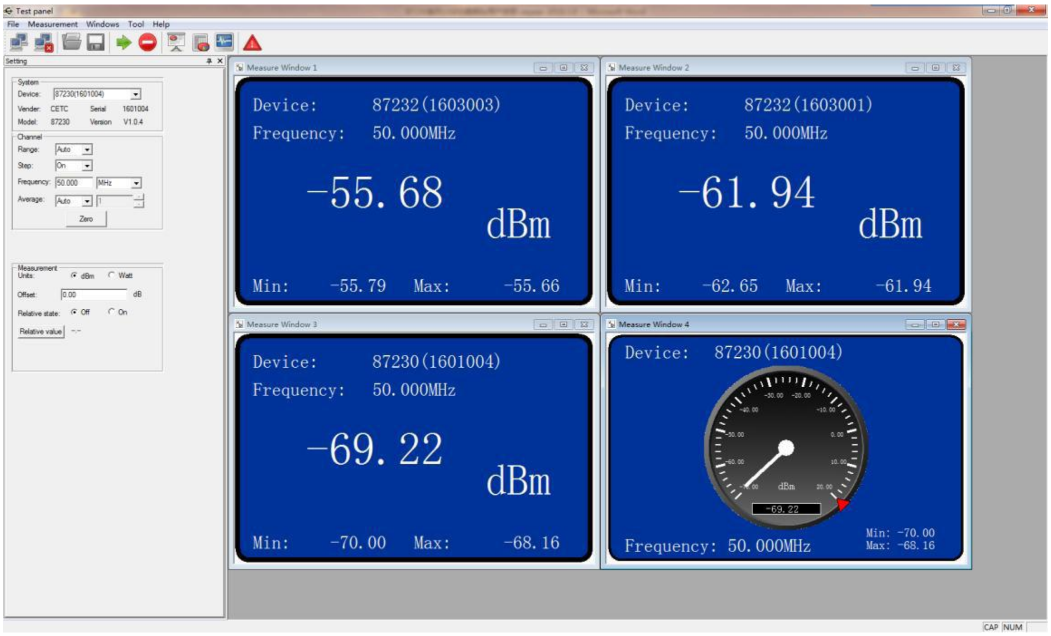


Fig. 3.6 Measurement window connected with multiple USB CW power sensors

The S 87230 series USB CW power sensor can be connected with a computer for microwave power measurement with a virtual panel or user programming or be connected with some electronic measurement instruments of our company for microwave power measurement with its power options.

Tel: 886.909 602 109 Email: sales@salukitec.com
www.salukitec.com

Chapter 4 Remote Control

This chapter introduces the remote control basis, remote control interface and configuration methods of S87230 series USB continuous wave power sensor, and briefly introduces the concept and classification of the I/O instrument driver library.

4.1 Remote Control Basics

4.1.1 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 4.1 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 "4.1.1.1 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 "4.1.1.2 GPIB interface".
USB (Universal Serial Bus)	USB::<vendor ID>::<product_ID>::<serial_numb er>[::INSTR]	Instrument rear panel port. For details, refer to “4.1.1.3 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.

4.1.1.1 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. 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.

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.

4.1.1.2 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.

4.1.1.3 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.

4.1.2 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 transmitted to the instrument through the data line.

2) Instrument message

For the structure and syntax of instrument message, refer to the "4.1.3 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.

4.1.3 SCPI command

4.1.3.1 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.

4.1.3.2 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, 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 4.2 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]:FREQency[: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 4.3 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>}

A typical command is composed of the keyword prefixed with a colon. The keyword is followed byparameters. 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 4.2 and 4.3.

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 4.4 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.

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
-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 structures

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

4.1.4 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.

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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 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 4.5 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
*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.

4.1.5 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.

4.1.5.1 Status register organization structure

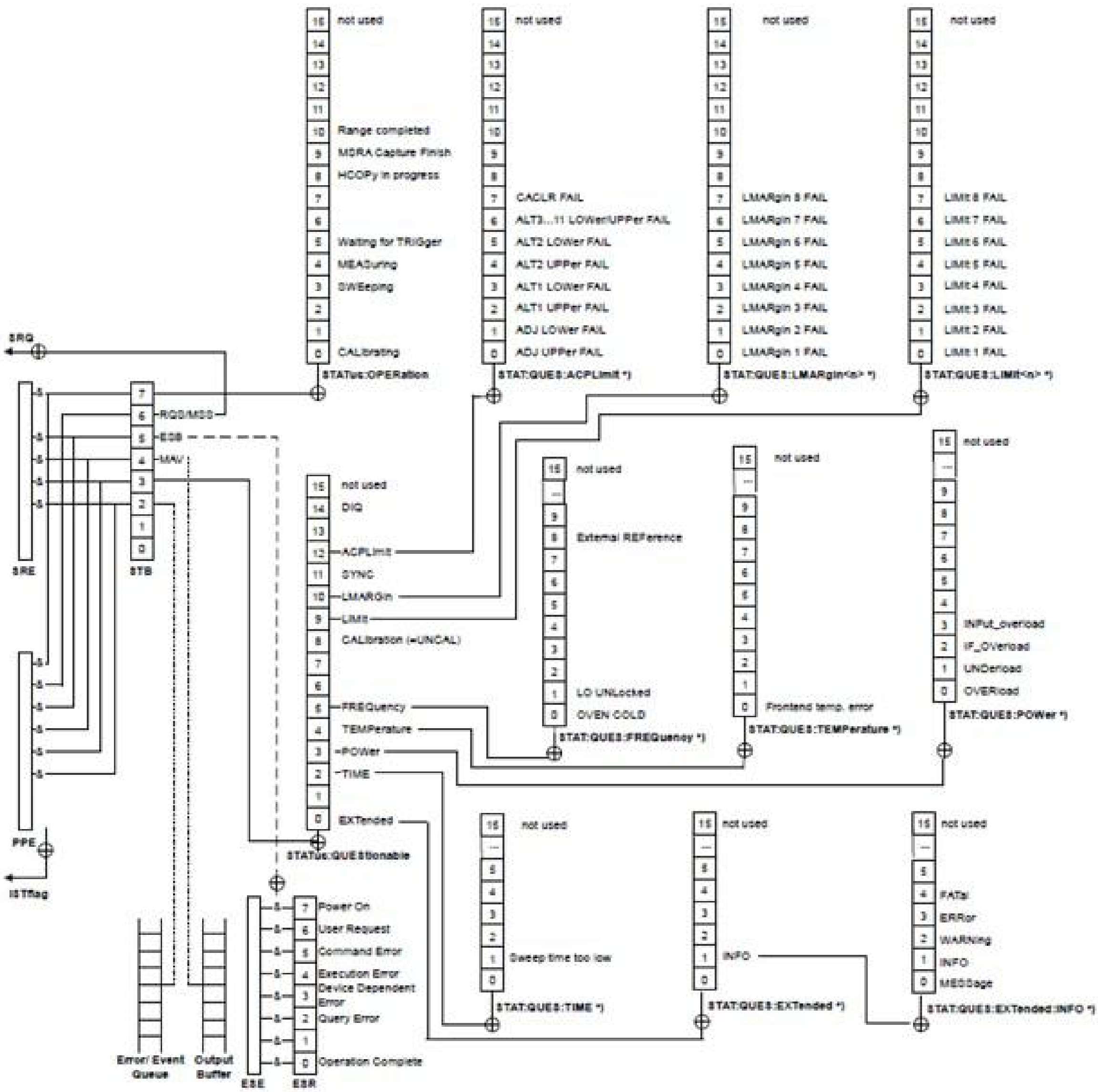

Fig 5.1 Hierarchy of status registers

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.

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.

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.

Please refer to the level structure diagram of the status register in Fig.4.1.

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.

4.1.5.2 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.

4.1.6 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.

4.2 Instrument Remote Control Interface and Configuration

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

4.2.1 Establishment of connection

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

4.2.2 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.

4.3 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.

4.3.1 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.

4.3.2 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);
    }
}
```

4.3.3 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
    iStatus = viWrite(analyzer, "*RST", 4, &retCnt);//Reset the instrument
}
```

4.3.4 Sending of the setting command

/**/

The following example shows how to set the center frequency of S87230 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);
}
```

4.3.5 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);

}

4.3.6 Synchronization of commands

/***/

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

/***/

void SweepSync()

```
{
    ViStatus iStatus;
    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);
    //Main program continues...
}
```

4.4 I/O Library

4.4.1 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.

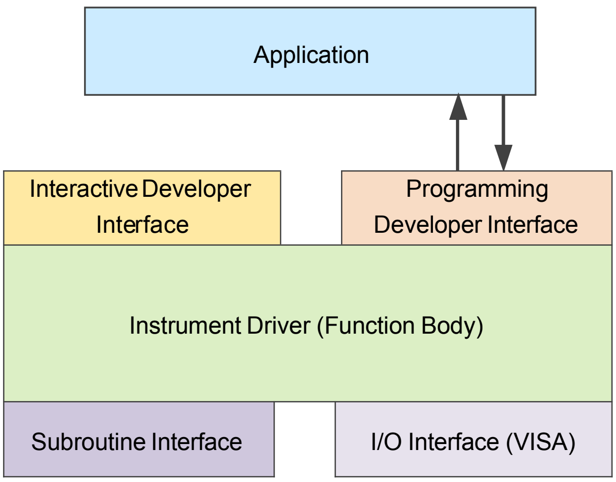

Fig.4.2 Structure model of instrument driver

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 Fig.4.2.

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.

4.4.2 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 I/O 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.

Chapter 5 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 S 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 S 87230 series USB continuous wave power sensor purchased by you is within the warranty period, we will repair your S 87230 series USB continuous wave power sensor free of charge as promised on the warranty; if S 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.

5.1 Operating Principle

The S 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 Fig.5.1.

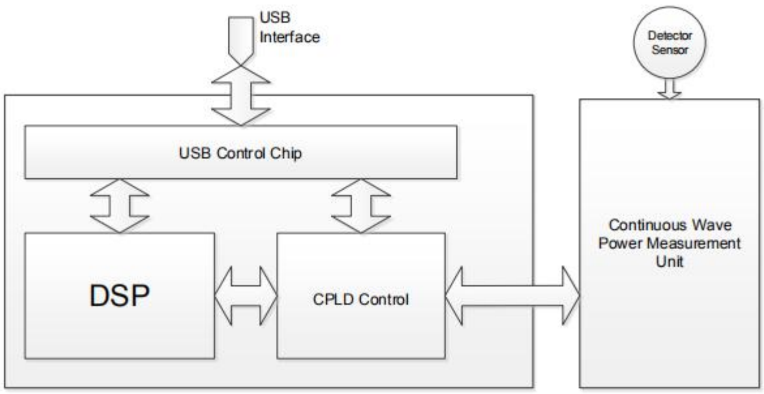

Fig.5.1 Block diagram of USB continuous wave power sensor

5.2 Fault Diagnosis and Guides

Prompt

Fault diagnosis and guidance

This section is to guide you how to make a simple diagnosis and processing when S87230 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 save it, and analyze the possible causes and refer to the methods provided in this chapter totroubleshoot the problem beforehand. You can also contact our customer service center and provide thecollected 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.salukitec.com tofind the nearest technical support contact information.

This chapter mainly helps the user to diagnose the fault of S87230 series USB continuous wave powersensor and determine whether it is necessary to seek after-sales service, including the interpretation ofthe internal error message of this machine.

Generally, the causes of the problem are hardware, software, or improper use of by the user. The S87230series 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.

5.2.1 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.

5.2.2 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.

5.2.3 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.

5.3 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.

5.4 Repair Method

5.4.1 Contact us

When the S87230 series USB CW power sensor incurs a problem, observe and save error information, analyze the possible causes and eliminate and solve the problems according to the methods provided in the section “5.2 Fault diagnosis and troubleshooting”. If the fault is not solved, please contact our service center according to the following contact information and provide the collected error information, and we will help you solve the problem as soon as possible.

Contact information:

Service Tel:	886.909 602 109
Website:	www.salukitec.com
Email:	sales@salukitec.com
Address:	No. 367 Fuxing N Road, Taipei 105, Taiwan (R.O.C.)

5.4.2 Packing and mailing

When your S87230 series USB CW power sensor incurs a problem that is difficult to solve, please contact us by phone or fax. If it is decided that the S87230 USB CW power sensor needs to be returned for repair, please package it using the original packaging material and box, and follow these steps:

1) Please include a detailed explanation of the problem that you’ve encountered when using the USB power sensor along with the apparatus in the packaging box.

2) Pack the USB CW power sensor with the original packaging material to reduce possible damage.

3) Put the linings at four corners of the outer packaging box, and put the instrument in the outer packaging box;

4) Seal the packaging box with tapes, and reinforce it with nylon tape;

5) Mark “Fragile! No Touch! Handle with Care!” words;

6) Please arrange the consignment as required for the precise instrument.

7) Keep copies of all the shipping documents.

Note

Precautions for packaging 87230 series USB continuous wave power sensor

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

Chapter 6 Technical Specifications

This chapter describes the technical specifications and main test methods of S87230 series USB continuous wave power sensor.

6.1 Declaration

Unless otherwise specified, the test conditions of all specifications are: Temperature range: 23 °C ± 5 °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 Ω 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).

6.2 Product Features

6.2.1 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.

6.2.2 Main Functions

The S87230 series USB continuous wave power sensor has the following main functions:

1) Continuous wave signal absolute power accurate measurement function;
2) Single sensor volume, light weight, and easy to carry;
3) Zero calibration function;

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4) The user do not need to calibrate it;

5) Support the USB remote control function, and provide interchangeable virtual instrument (IVI) driver;

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

6.3 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:

S87230: 9kHz - 6GHz

S87231: 10MHz - 18GHz

S87232: 50MHz - 26.5GHz

S87233: 50MHz - 40GHz

2) Power measurement range:

S87230: -50dBm to +20dBm

S87231: -60dBm to +20dBm

S87232: -60dBm to +20dBm

S87233: -60dBm to +20dBm

3) Zero calibration accuracy:

S87230: ≤ 10nW

S87231: ≤ 1nW

S87232: ≤ 1nW

S87233: ≤ 1nW

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

S87230:

100kHz - 6GHz: 1.15

S87231:

10MHz - 50MHz: 1.21

50MHz - 2GHz: 1.15

2GHz - 12.4GHz: 1.20

12.4GHz - 18GHz: 1.27

S87232:

50MHz - 2GHz: 1.15

2GHz - 12.4GHz: 1.20

12.4GHz - 18GHz: 1.27

18GHz - 26.5GHz: 1.30

S87233:

50MHz - 2GHz: 1.15

2GHz - 12.4GHz: 1.20

12.4GHz - 18GHz: 1.27

18GHz - 26.5GHz: 1.30

5) Calibration factor Uncertainty (0dBm):

S87230:

9kHz - 6GHz: ±0.16dB

S87231:

10MHz - 18GHz: ±0.25dB

S87232:

50MHz - 18GHz: ±0.25dB

18GHz - 26.5GHz: ±0.35dB

S87233:

50MHz - 18GHz: ±0.25dB

18GHz - 40GHz: ±0.35dB

6) Power linearity (23±5°C):

S87230:

+10dBm to +20dBm:	±0.18 dB
-40dBm to +10dBm:	±0.14 dB
-50dBm to -40dBm:	±0.79 dB

S 87231/S87232/S87233:

+10dBm to +20dBm:	±0.18 dB
-40dBm to +10dBm:	±0.14 dB
-50dBm to -40dBm:	±0.39 dB
-60dBm to -50dBm:	±0.79dB

7) Connector form and input impedance:

S87230: N(m), 50Ω

S87231: N(m), 50Ω

S87232: 3.5mm(m), 50Ω

S87233: 2.4mm(m), 50Ω

8) Weight:

S87230: 235g

S87231: 235g

S87232: 225g

S87233: 216g

9) Overall dimensions (width × height × depth):

S87230: 46.2 mm × 35.6 mm × 142.6 mm

S87231: 46.2 mm × 35.6 mm × 142.6 mm

S87232: 46.2 mm × 35.6 mm × 135.4 mm

S87233: 46.2 mm × 35.6 mm × 125.9 mm

10) Power consumption:

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+5V DC，1.8W

11) Environmental adaptability:

Operating temperature: 0°C to 50°C

Storage temperature: -40°C to +70°C

- End of Document -