ZTE中兴

ZXSDR RSU60E
Dual Mode Enhanced Radio System Unit
User Manual

V1.00

Revision History

Revision No.	Revision Date	Revision Reason
R1.0	2011–07–21	R1.0

Chapter 1
Declaration of RoHS Compliance

To minimize the environmental impact and take more responsibility to the earth we live, this document shall serve as formal declaration that ZXSDR RSU60E manufactured by ZTE CORPORATION are in compliance with the Directive 2002/95/EC of the European Parliament - RoHS (Restriction of Hazardous Substances) with respect to the following substances:

● Lead (Pb)
● Mercury (Hg)
● Cadmium (Cd)
● Hexavalent Chromium (Cr (VI))
● PolyBrominated Biphenyls (PBB's)
● PolyBrominated Diphenyl Ethers (PBDE's)

The ZXSDR RSU60E manufactured by ZTE CORPORATION meet the requirements of EU 2002/95/EC; however, some assemblies are customized to client specifications. Addition of specialized, customer-specified materials or processes which do not meet the requirements of EU 2002/95/EC may negate RoHS compliance of the assembly. To guarantee compliance of the assembly, the need for compliant product must be communicated to ZTE CORPORATION in written form. This declaration is issued based on our current level of knowledge. Since conditions of use are outside our control, ZTE CORPORATION makes no warranties, express or implied, and assumes no liability in connection with the use of this information.

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Chapter 2
FCC & IC STATEMENT

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. And this device must accept any interference received, including interference that may cause undesired operation.

Note:

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

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ZTE Proprietary and Confidential

Chapter 3
FCC Radiation Exposure Statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 4m between the radiator & your body.

3-1

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Chapter 4
RSU60

Table of Contents

4.1 Saftey Description

Safety Specifications Guide

These safety instructions must be considered as supplementary for local safety regulations. The priority must be given to local safety regulations if there is any conflict between the two.

The maintenance personnel must have the knowledge of safety operations and maintenance with required qualification and technical background.

⚠ **Warning!**

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

The equipment is intended for installation in RESTRICTED ACCESS LOCATIONS.

All the operation and maintenance personnel must follow the safety precautions and instructions provided by ZTE Corporation to avoid any accident.

📝 **Note:**

ZTE Corporation does not bear any liabilities incurred because of violation of the universal safety operation requirements, or violation of safety standards for designing, manufacturing and using the equipment.

FCC Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment .This equipment should be installed and operated with minimum distance 3m between the radiator& your body.

Safety Symbols

Table 4-1 lists safety symbols. They are to prompt the user of the safety precautions to be observed during ZXSDR RSU60E operation and maintenance.

Table 4-1 Safety Symbols Description

Safety Symbols	Meaning
	No smoking: Smoking is forbidden
	No flammables: No flammables can be stored.
	No touching: Do not touch.
	Universal alerting symbol: General safety attentions.
	Electric shock: Risk of electric shock.
	Electrostatic: The device may be sensitive to static electricity.
	Microwave: Beware of strong electromagnetic field.
	Laser: Beware of strong laser beam.
	Scald: Beware of scald.

Amongst these safety symbols, the universal alarm symbols are classified into three levels: danger, warning, and caution. The formats and meanings of the three levels are described as below:

 Danger!

Indicates a potentially hazardous situation which, if not avoided, will result in death or serious injury of people, or equipment damages and breakdown.

⚠️ Warning!

Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠️ Caution!

Indicates a potentially hazardous situation which, if not avoided, could result in serious injuries, equipment damages or interruption of part services.

Safety Instructions

This section describes the safety instructions related to electrical safety, antistatic, heavy objects and modules.

Electrical Safety Instructions

The following are the electrical safety instructions about tools, high voltage, power cables, holes and lightning:

- **Tools**

  Use special tools rather than common tools for high-voltage and AC operations.

- **High Voltage**

  ⚠️ **Danger!**

  High voltage is hazardous. Direct or indirect contact with high voltage or main supply using a wet object could result in death.

  → Strictly follow local safety rules to install AC power devices.

  → Installation staff must be qualified for performing high-voltage and AC operations.

  → Do not wear any watch, hand chain, bracelet, ring or any other conductive objects during such operations.

  → Prevent moisture from accumulating on the equipment during operations in a damp environment.

- **Power Cable**

  ⚠️ **Warning!**

  Never install or uninstall power cables while they are live. Otherwise, the power cable, when contacting a conductor, may result in sparks or electric arc causing a fire or even damage to eyes.

  → Make sure of shutting off power supply before installing or disconnecting a power cable.

  → Before connecting the power cable, make sure that the connecting cable and its label are appropriate for the actual installation requirements.

- **Drilling Holes**

4-5

Warning!

It is not allowed to drill chassis holes without permission.

→ Unqualified drilling could damage wiring and cables inside the chassis. Additionally, metal pieces inside the chassis created by the drilling could result in a short circuit. Use insulation protection gloves and first move cables inside a chassis away when drilling is necessary on a chassis.

→ Protect eyes during drilling as dust or flying debris may damage eyes.

→ Clean any debris in time after drilling.

● **Lightning**

Danger!

Do not perform high-voltage, AC, iron tower or mast operations in a thunderstorm.

Thunderstorms would give rise to a strong electromagnetic field in the atmosphere. Therefore, the equipment must be grounded and protected in time against lightning strikes.

Antistatic Safety Instructions

Caution!

Static electricity produced by human body can damage static-sensitive components on circuit board, such as large-scale integrated circuits.

● Friction caused by human body activities is the root cause of electrostatic charge accumulation. Static voltage carried by a human body in a dry environment can be up to 30 kV, and can remain there for a long time. An operator with static electricity may discharge electricity through a component when he/she touches the conductor and causing damage.

● Wear an antistatic wrist strap (the other end of wrist strap must be well grounded) before touching the equipment or holding a plug-in board, circuit board, Integrated Circuit (IC) chip or other devices, to prevent human static electricity from damaging sensitive components.

● The antistatic wrist strap used must be subject to regular check. Do not replace the cable of an antistatic wrist strap with any other cables.

- Do not contact static-sensitive modules with any object that easily generates static electricity. For example, friction of package bag, transfer box and transfer belt made from insulation plastic may cause static electricity on components. Discharge of static electricity may damage components when they contact a human body or the ground.
- Modules should only contact materials such as an antistatic bag. Keep modules in antistatic bags during storage and transportation.
- Discharge static electricity of the test device before use, that is, ground the test device first.
- Do not place the module near a strong DC magnetic field, such as the cathode-ray tube of a monitor. Keep the module at least 10 cm away.

Hoisting Heavy Objects

⚠ **Warning!**

When hoisting heavy objects, ensure that nobody is standing or walking under the hoisted object.

- Ensure the hoister can meet hoisting requirements when disassembling heavy equipment, or moving and replacing equipment.
- The installation personnel must be duly trained and qualified for hoisting operations.
- Hoisting tools must be inspected and complete before service.
- Make sure that hoisting tools are fixed firmly on a sufficiently secured object or wall before the hoisting operation.
- Give brief oral instructions during hoisting operations to prevent any mishap.

Unplugging/Plugging a Module

- Never plug a module with excessive force, to ensure that the pins on the backplane do not get deformed.
- Plug the module right into the slot and make sure module circuit faces do not contact each other lest any short circuit may occur.
- Keep hands off the module circuit, components, connectors and cable trough when holding a module.

Rack Mount Safety Instructions

Rack Mount Instructions - The following or similar rack-mount instructions are included with the installation instructions:

- Elevated Operating Ambient - If installed in a closed or multi-unit rack assembly, the operating ambient temperature of the rack environment may be greater than room ambient. Therefore, consideration should be given to installing the equipment in an environment compatible with the maximum ambient temperature (Tma) specified by the manufacturer.

- Reduced Air Flow - Installation of the equipment in a rack should be such that the amount of air flow required for safe operation of the equipment is not compromised.
- Mechanical Loading - Mounting of the equipment in the rack should be such that a hazardous condition is not achieved due to uneven mechanical loading.
- Circuit Overloading - Consideration should be given to the connection of the equipment to the supply circuit and the effect that overloading of the circuits might have on overcurrent protection and supply wiring. Appropriate consideration of equipment nameplate ratings should be used when addressing this concern.
- Reliable Earthing - Reliable earthing of rack-mounted equipment should be maintained. Particular attention should be given to supply connections other than direct connections to the branch circuit (e.g. use of power strips).

Other Safety Instructions

NOTE **Note:**

Do not perform maintenance or debugging independently, unless a qualified person is present.

- Perform an airtight test before RRU delivery, and prohibit disassembling the RRU on site.
- Replacing any parts or making any changes to the equipment might result in an unexpected danger. Therefore, be sure not to replace any parts or perform any changes to the equipment unless authorized otherwise.
- Due to that RRU is in high temperature during running, the RRU should be installed in some regions out of operators' reach or strictly restricted.
- Contact ZTE office if you have any question, to ensure your safety.

4.2 Product Descripition

4.2.1 Overview

ZTE Software Defined Radio (SDR) uses an architecture of separating the baseband part from the Radio Frequency (RF) part. This architecture features high integration, low consumption, flexible configuration and convenient installation & maintenance. The new generation ZTE GSM&UMTS Base Station (BS) products based on the SDR is the first SDR-based GSM&UMTS BS in the industry. It is able to help the operators have qualitative leap. The form of this product can be distributed BBU + RRU or BBU + RSU. The product form of ZTE SDR can be distributed BBU + RRU or BBU + RSU, macro BS or micro BS.

ZXSDR RSU60E is the RSU part of ZTE GSM&UMTS distributed SDR Common BTS Platform Solution. It provides functions including RF modulation/demodulation, forward power amplification, reverse low noise amplification, RF performance measurement and carrier power control etc.

With a smaller size and lighter weight, the ZXSDR RSU60E has significant advantages for saving space, relocations, installation flexibility, and power savings. It designed for both indoor and outdoor applications.

4.2.2 Position in a Network

In GSM&UMTS mobile communication network, the relationship between ZXSDR RSU60E and other network entities is shown in Figure 4-1.

Figure 4-1 ZXSDR RSU60E Position in a Network
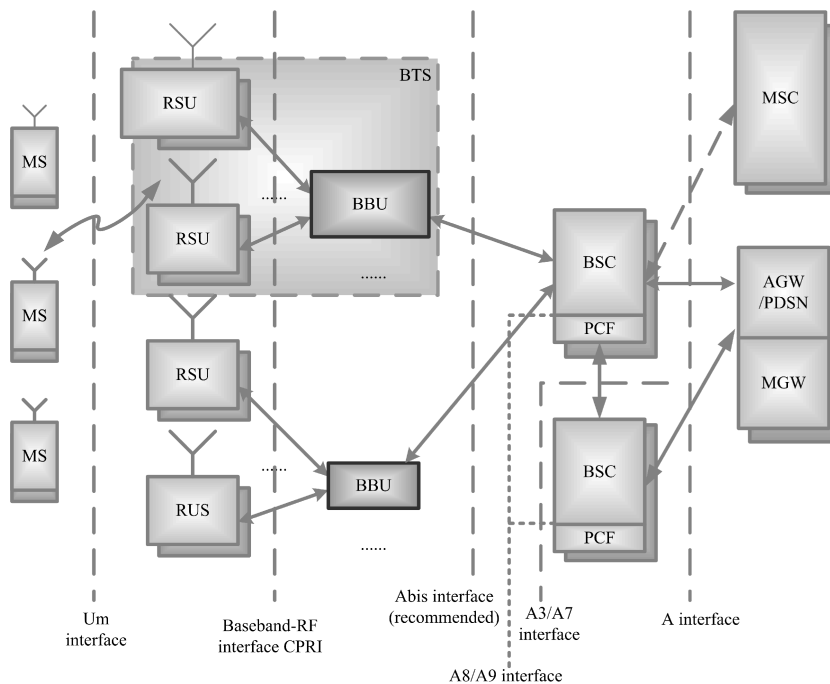
The ZXSDR RSU60E is an independent RF subsystem. Together with BBU , it forms the complete BTS.The BTS implements radio transmission with the MS through the Um air interface. In addition, the BTS implements control of radio channels and communication with the BSC

4.2.3 Outer View

Figure 4-2 shows the outer view of ZXSDR RSU60E.

Figure 4-2 Outer View of ZXSDR RSU60E
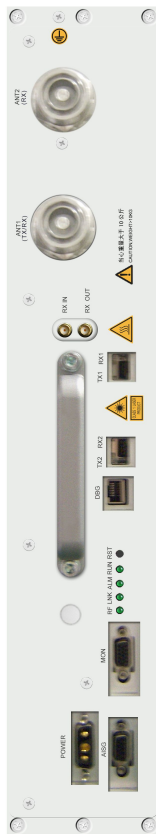
4.2.4 Production Functions

ZXSDR RSU60E provides primary functions is shown as Table 4-2.

Table 4-2 The Primary Functions of ZXSDR RSU60E

Function	Description
RF	Band: PCS1900
	RF modulation/demodulation
	RF transceiver duplexer
	Low noise amplification for received RF signal
	Amplification for transmitted RF signal

Function	Description
	RF transceiver
Interface	Baseband-RF interface: compliant with Common Public Radio Interface (CPRI) protocol
Equipment maintenance and test	Electronic label
	Remote upgrade of software version for FPGA/BOOT/DSP/CPU
	Remote reset of service boards
	Automatic calibration
	Reverse spectrum query: querying the reverse received signal spectrum of each carrier
	Power amplification control and protection: over-power, over-temperature, and standing wave alarm
Reliability	Reverse voltage protection
Scenario	Indoor and outdoor applications

4.2.5 Production Features

Here are the product features of ZXSDR RSU60E

- Easy transportation and installation will save labor and building costs
- Lower power consumption reduces installation of power expenditures and saves on electricity charges.
- Suitable for complicated base station environments

  Supports star and chain networks between baseband and RF to provide more convenient solutions for complicated base station environments.

4.3 Technical Descripition

4.3.1 System Architecture

A ZXSDR RSU60E consists of the transmit/receive signal board (ADTR), power amplifier (PA), duplexer (DFL), and power supply (RPDC).Figure 4-3 shows the schematic diagram of the ZXSDR RSU60E.

Figure 4-3 Schematic Diagram of the ZXSDR RSU60E
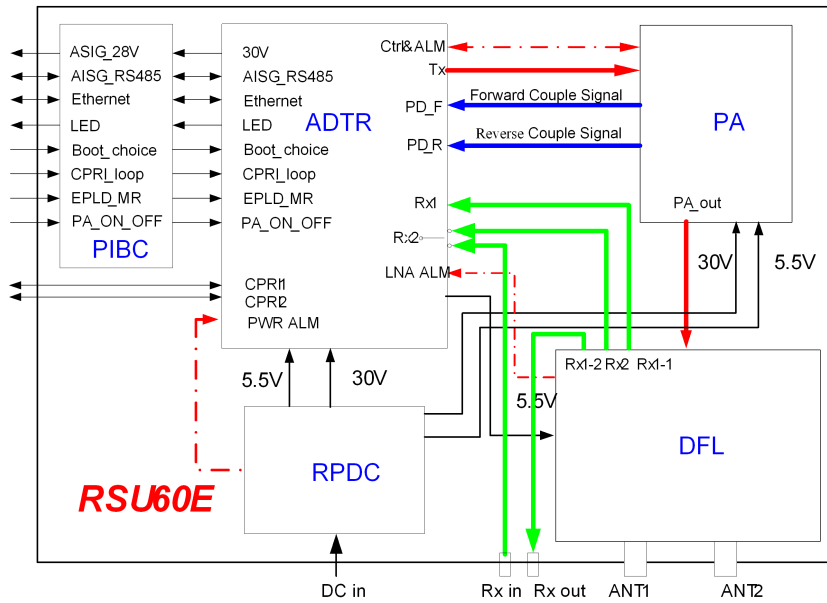
The functions of ZXSDR RSU60E's subsystem is shown as Table 4-3.

Table 4-3 The functions of subsystem

Part	Description
ADTR	ADTR, the unit that integrates the processor, clock, CPRI interface, DPD digital predistortion, RF transmitting and receiving functions, is the core unit of the ZXSDR RSU60E.
PA	● Amplifies downlink RF signal input via the ADTR and then sends the signal to the DFL ● Provides digital pre-distortion feedback signals for the ADTR ● Provides a PA output enable/disable interface
DFL	● Performs filtering and low noise amplification of the reverse GSM&UMTS signal from the antenna ● Filters the forward RF signal to be sent ● Reports LNA alarms to the ADTR ● In the case of main/diversity combined cabinets, the main receive LNA output end of the DFL has the power splitter function and reserves an external port (Rx out)
RPDC	Converts -48V DC input power supply to DC power supply required by the PA, ADTR, or DFL

4.3.2 Signal Processing Flow

The internal signal processing flow of ZXSDR RSU60E is as below:

● Forwardlink processing

The business data from BBU enters the ADTR, and then for intermediate frequency processing. After the power amplification sent to the antenna for transmission.

● Reverselink processing

The reverse GSM&UMTS signals from the antenna are converted to baseband digital signal by ADTR, then send to BBU.

4.3.3 Technical Specifications

4.3.3.1 Physical Indices

4.3.3.1.1 Dimension

The dimensions of ZXSDR RSU60E in mm are : 482.6(H) × 88 (W) × 360.0 (D).

4.3.3.1.2 Weight

Weight of a ZXSDR RSU60E : < 15 kg (33.1 pounds).

4.3.3.2 Power

● Power Supply

-48 V DC Voltage range: -40 V~ -57 V.

● Power Consumption

The total power consumption of the equipment is 360 W.

4.3.3.3 Capacity Indices

ZXSDR RSU60E Capacity Indices is shown as Table 4-4

Table 4-4 ZXSDR RSU60E Capacity Indices

Item	Carriers supported
1	GSM 6C(max Single RAT)
2	UMTS 3C(max Single RAT)
3	2GMS+2UMTS;4GSM+1UMTS

4.3.3.4 Temperature and Humidity

Temperature: -5 ℃ ~ +45 ℃. The change frequency must be less than 0.5 ℃/min.

Relative humidity: 5% ~95%

4.3.3.5 Reliability Indices

● Mean Time Between Failures (MTBF) : > 100,000 hours
● MTTR (Mean Time To Repair): < 0.5 hour

● Availability: > 99.999%

4.3.3.6 RF Indices

RF indices of the ZXSDR RSU60E comply with *3GPPTS51.021,Recommended Minimum Performance Standards* and *3GPPTS25.141,Recommended Minimum Performance Standards*.

Table 4-5 illustrates the Technical Specifications of RSU60E.

Table 4-5 The Technical Specifications of RSU60E

Band PCS1900	A:TX:1930 MHz~1970 MHz RX:1850 MHz~1890 MHz B:TX:1950 MHz~1990 MHz RX:1870 MHz~1910 MHz channel raster is 200 kHz
Output power at the Top of Cabinet(TOC)	80 W
Total transmit power	The total transmit power is within +2 dB and -2 dB of the Manufacturer's rated power.
Modulation mode	GMSK\8PSK\QPSK\16QAM\64QAM

4.3.3.7 Interface Indices

The interface indices of ZXSDR RSU60E is shown as Table 4-6.

Table 4-6 Description of ZXSDR RSU60E's interfaces

Type	Description	Index
CPRI	Fiber/Cable	2CPRI interfaces: 1 CPRI for BBU or upper-level RSU 1 CPRI for lower-level RSU
UE	Um interface	1 Tx/Rx 1 diversity receivers

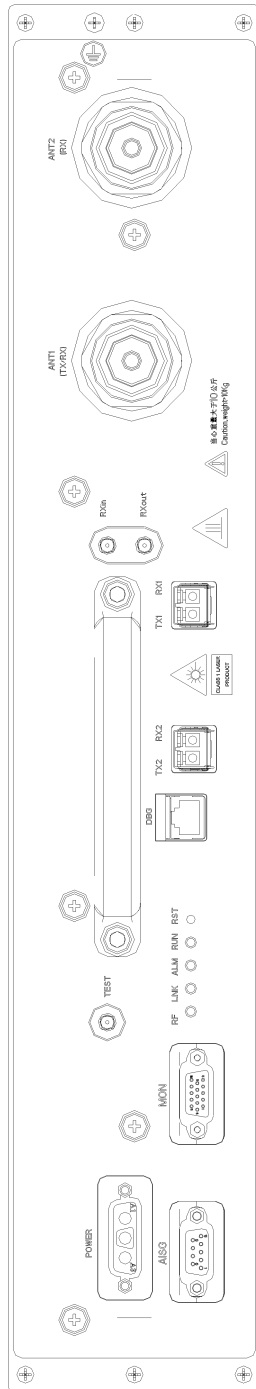# 4.4 Hardware Decsripition

4.4.1 Function

RSU provides the following functions:

● Communication with the baseband subrack
● Conversion between air interface RF signals and digital signals
● RF signal amplification, transmission, and reception
● Clock synchronization.

4.4.2 Panel

Figure 4-4 illustrates the ZXSDR RSU60E panel.

Figure 4-4 ZXSDR RSU60E Panel

4.4.3 Button

There is only one button (RST) on the ZXSDR RSU60E panel.Table 4-7 describes the button.

Table 4-7 ZXSDR RSU60E Panel Button Description

Button	Description
RST	Reset button

4.4.4 Indicators

Table 4-8 describes ZXSDR RSU60E panel indicators.

Table 4-8 ZXSDR RSU60E Panel Indicator Description

Indicator	Color	Meaning	Description
RUN	Green	Running status indicator	Always on: The RSU is resetting or starting up. Blinking at 1 Hz: The RSU is functioning properly. Blinking at 5 Hz: The RSU is downloading version files. Off: The RSU fails the self-check.
ALM	Red	Alarm indicator	Off: There is on alarm or the RSU is resetting, starting up, or downloading version files. Blinking at 5 Hz: There is a critical alarm. Blinking at 1 Hz: There is a minor alarm.
LNK	Green	Optical link status indicator	Always on: The optical connection is normal. Off: The optical fiber fails. Blinking at 5 Hz: This link is used as the clock reference source and the phase lock loop (PLL) is in the fast capture state. Blinking at 0.25 Hz: This link is used as the clock reference source and the phase lock loop (PLL) is in the tracing state.
RF	Orange	RF working status indicator	Off: The RF has no output. On: The RF has output.

4.4.5 Panel Interfaces

Table 4-9 describes ZXSDR RSU60E panel interfaces.

Table 4-9 Interfaces on the Front Panel of the ZXSDR RSU60E

Interface	End A	End B	Description
ANT1(TX/RX)	RSU	Tx/Rx antenna	Connects to the Tx/Rx antenna for the Tx/Rx major channel.
ANT2(RX)	RSU	Rx antenna	Connects to the antennal for the Rx minor antenna
Rx out	RSU	RSU with expanded frequency points	Frequency-point expansion output interface for outputting the Rx signals of the major channel.
Rx in	RSU with expanded frequency points	RSU	Frequency-point expansion input interface for inputting the Rx signals of the minor channel.
TX1/RX1	RSU	BBU or the upper-layer cascaded RSU	Connects to the CPRI optical interface of BBU or the upper-layer cascaded RSU
TX2/RX2	RSU	Lower-layer cascaded RSU	Connects to the CPRI optical interface of the lower-layer cascaded RSU
DBG	RSU	PC or testing equipment (with a the testing board)	Commissioning Ethernet interface and testing interface
MON	RSU	External equipment	Provides four dry-contact input interfaces and RS-485 environment monitoring interface
AISG	RSU	Antenna	Connects to the AISG interface
POWER	RSU	RF power of the power distribution module	Power input interface

4.5 Hardware Installation
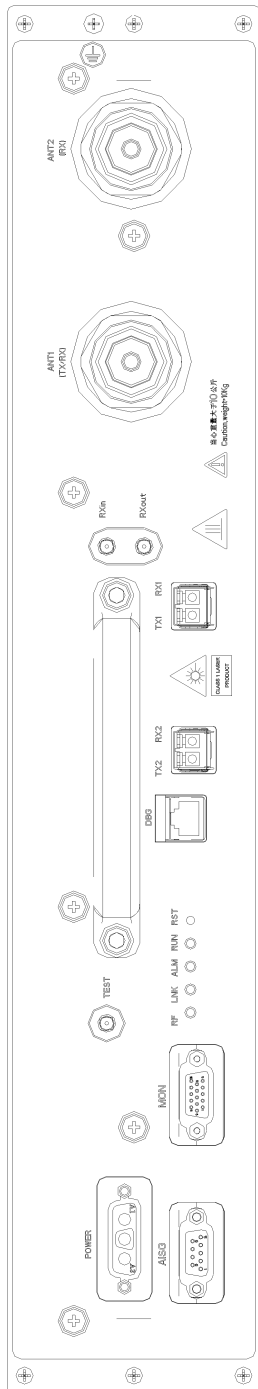
4.5.1 Installing the RSU Module

Prerequisites

● Before installing the RF module, wear the ESD wrist strap to avoid damaging the RF module.
● The RF cabinet has already been installed.

Context

Figure 4-5 shows the front panel of a ZXSDR RSU60E.

Figure 4-5 ZXSDR RSU60E Panel

Steps

1. Determine the target slot, hold the handle of the module with one hand, support the lower back of the module with the other hand, and try to make parallel the module and the guiding plane.

2. Push the module slightly into the slot to more than half the depth of the slot.

3. Change the place where exercise force and then push further the module with even force.

4. Push the module until the inner side of the front panel closely touch the vertical shaft.

5. Secure the module using five M5 x 20 screws.

6. Secure the ground lug.

– End of Steps –

4.5.2 Connecting RSU Monitoring Cable

Prerequisites

- ZXSDR RSU60E RF cabinet has already been installed.
- The RSU module has already been installed.

Context

The RSU monitoring cable of the RF cabinet is routed to the right side of the RF cabinet in delivery. After the RSU module is installed, insert the terminal of the RSU monitoring cable to the MON (monitoring) interface of the RSU module.

NOTE **Note:**

If multiple RSU modules need to be monitored, only one RSU module needs to be connected to the RSU monitoring cable.

Steps

1. Connect one end of the RSU monitoring cable to the MON (monitoring) interface of the RSU module and fasten the screw.

2. Bundle the RSU monitoring cable.

– End of Steps –

4.5.3 Installing Optical Fibers Between BBU and RSU

Prerequisites

- The ESD wrist strap must be worn.
- The baseband power cabinet and the RF cabinet have been independently installed.

Context

When the baseband power cabinet and the RF cabinet are installed side by side or they are far away from each other, you need to connect BBU and RSU using optical fibers.

Pay attention to the following points when installing optical fibers:

- Do not damage the optical fiber cladding during operations.
- Protect optical fiber connectors and avoid contaminating them.
- Do not forcibly bundle optical fibers.
- Curve optical fibers at the turning.

Steps

1. Affix a temporary label.

   Affix temporary labels to both ends of the new optical fiber to set up a mapping. If more than one optical fiber needs to be installed, use different labels to differentiate optical fibers.

2. Route optical fibers.

   a. Optical fibers go out from the side waterproof module of the baseband module and go through the routing apertures on the base.

   b. Then, optical fibers go through the routing apertures on the base of the RF cabinet, traverse the waterproof modules, and connect to the six optical interfaces for RF modules.

3. Insert optical fiber connectors.

   Insert optical fiber connectors according to the mapping on temporary labels.

   ⚠️ **Caution!**

   Insert optical fiber connectors tightly.

4. Bundle optical fibers.

   Bundle and secure optical fibers along the routing troughs, which complies with relevant regulations.

5. Affix an engineering label to an optical fiber.
   Remove the temporary label for the optical fiber and affix an engineering label.

!![Caution] **Caution!**

Protect an optical fiber with the winding tube when routing the optical fiber inside the cabinet. Protect an optical fiber with the corrugated pipe when routing the optical fiber outside the cabinet.

– End of Steps –

4.5.4 Installing the Interconnected Cable Between BBU and RSU

Prerequisites

- The ZXSDR RSU60E cabinet has already been installed.
- The BBU module and RSU module have already been installed.

Context

ZXSDR RSU60EIn the system, optical fibers or SFP cables can be used to connect BBU and RSU. During the stacked installation of the ZXSDR RSU60E, a 2 m SFP high-speed cable is recommended for interconnecting BBU and RSU. Figure 4-6 shows an SFP cable.

Figure 4-6 High-Speed Cable

Steps

1. Affix temporary labels to both ends of the SFR cable, with markings 0-5 to set up one-to-one mapping with interfaces TX0RX0 to TX5RX5 of BBU and six TX/RX interfaces of RSU.

2. Insert one end of the SFP cable to a TX/RX interface of RSU.

3. Route the SFP cable along the routing trough and cabinet sides to the FS module of BBU. The SFP cables connecting to the RSUs in slots 1 to 3 on the RF cabinet go through the left routing apertures and those SFP cables go through the right apertures if connecting to slots 4 to 6 on the RF cabinet.

4. Insert SFP cables into the interfaces TX0RX0 to TX5RX5 of the BBU FS board according to the markings 0-5.

5. Bundle SFP cables.

6. Remove temporary labels and affix engineering labels.

– End of Steps –

4.5.5 Installing the RF Jumper

Prerequisites

The ZXSDR RSU60E RF cabinet and other modules have already been installed.

Context

The RF jumpers for the three ZXSDR RSU60E go through the waterproof module on the right.

Remove the front baffle of the base before installing the RF jumpers and reseat the front baffle after all jumpers are completely installed.

Steps

1. Connect the RF jumpers to ANT1 and ANT2 interfaces of RSU from left to right.

2. Wear the waterproof rubber plug after every two RF jumpers are installed.

3. Insert the horizontal and longitudinal slide blocks and use the hexagon ring wrench to fasten them.

⚠️ **Caution!**

Clamp the waterproof rubber plug tightly and make sure that the unused cabling aperture wears the plug.

4. Repeat the preceding steps to install other RSU-related jumpers.

– End of Steps –

Result

The RF jumpers go out from the base. The cables between cabinets must be protected with protective tubes, without any exposed part of the cables and the openings at two ends of these cables must be sealed.

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Figures

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Tables