E91-DTU (xxxSL37) Series Product Specifications

AT Command IP67 433MHz LoRa Wireless DTU



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Note ：

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Chapter 1: Product Overview

1.1 Brief Introduction

The E91-DTU (400SL37) series is a new generation of waterproof LoRa wireless data transmission radios. Developed based on SEMTECH's high-performance RF chips, these devices feature a maximum transmission power of 37 dBm and support multiple transmission modes. It operates in the 410.125 MHz to 493.125 MHz frequency band, supports interoperability with our E22 series modules, and features a 5-pin M12 waterproof aviation connector. The unit is housed in a plastic waterproof enclosure with a silicone O-ring seal and is internally potted for waterproofing, achieving an IP67 rating; it supports a wide input voltage range of 10 to 28 V (DC). LoRa spread-spectrum technology enables longer communication ranges and offers superior resistance to interference.

The E91-DTU (400SL37) series incorporates the latest generation of LoRa spread-spectrum technology, offering faster speeds, lower power consumption, and a more compact design. It supports features such as over-the-air wake-up, wireless configuration, carrier sense, automatic relaying, and communication key management, as well as configurable packet lengths, and offers custom development services.

1.2 Features and Functions

- Features the latest generation of LoRa spread-spectrum modulation technology, offering longer communication range and stronger interference resistance;
- Supports the 433 MHz/470 MHz bands (customizable);
- Features a flame-retardant plastic waterproof housing, internally potted for waterproofing, and sealed with a silicone gasket, providing IP67-rated water resistance;
- A simple and efficient power supply design that supports both power adapters and direct wiring, with a power supply range of 10–28 V (DC);
- The maximum transmit power is 37 dBm, and the technical specifications meet industry standards;
- Supports data transfer rates from 0.3 Kbps to 62.5 Kbps;
- Supports Modbus protocol transmission;
- Operating temperature range: -40°C to +85°C; suitable for a wide range of harsh operating environments; a true industrial-grade product;
- Multiple protection features, including reverse polarity protection, over-voltage protection, and antenna surge protection, significantly enhance the radio's reliability;
- Communication ports and power connectors feature isolation and high protection;
- Supports firmware updates via the serial port for easier maintenance;
- Supports both HEX and AT instruction sets, allowing users to choose flexibly;
- Supports relay networking; multi-level relaying is suitable for ultra-long-distance communication; multiple networks can operate simultaneously within the same area;
- Users can set their own communication keys, which cannot be read, greatly enhancing the confidentiality of user data;

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- Supports LBT functionality, which monitors channel noise before transmission, significantly improving the module's communication success rate in harsh environments;
- Supports RSSI (Received Signal Strength Indication) for assessing signal quality;
- Supports wireless parameter configuration, allowing command packets to be sent wirelessly to remotely configure or read wireless module parameters;
- Supports point-to-point transmission, broadcast transmission, and channel monitoring;
- Multi-level adjustable air transmission rate;
- Parameters are retained during a power loss; after power is restored, the module will operate according to the configured parameters;
- Built-in watchdog timer that automatically resets and resumes operation in the event of an unexpected situation;

1.3 Application Scenarios

- Smart Irrigation and Environmental Monitoring in Agriculture;
- Monitoring of photovoltaic power plants and management of distributed photovoltaic systems, etc;
- Home Security Alarms and Remote Keyless Entry;
- Smart home devices and industrial sensors, etc;
- Wireless Alarm Security System;
- Building Automation Solutions;
- Wireless Industrial-Grade Remote Control;
- Healthcare products;
- Advanced Metering Infrastructure (AMI).

Chapter 2: Specifications

2.1 E91-DTU (400SL37) Series Product Comparison Chart

frequency band	Product Model	Carrier frequency①MHz	Transmit power②dBm	Test distance③km	Waterproof rating	Size mm	Antenna Type④
433MHz	E91-DTU(400SL37)	410.125～493.125	37	25	IP67	120*75*48	SMA,External thread, internal bore

Note:

(1)Carrier frequency①: The frequency range can be customized by the user;

(2)Transmit power②: 37dBm=5000mW, The error range is ±1 dBm. For details on power levels, please refer to Sections 5 and 6 of this document;

(3)Test distance③: Clear, open area; airspeed 2.4 kbps; antenna mast height 2 meters (for reference only; actual testing is recommended);

(4)Antenna Type④: Equivalent impedance of approximately 50 Ω;

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2.2 Basic Specifications

2.2.1 Basic Specifications

Conditions：Tc=25℃，VCC=12.0V，433.125MHz

Parameters	Description
Modulation method	New generation LoRa modulation technology
Interface Method	M12, 5-pin waterproof connector
Communication Interface	RS485
Beam width	240 Btye，Maximum capacity per batch; if exceeded, the system automatically splits the batch. This setting can be adjusted via the host computer or command; see Chapter 5 of this document for detailed commands
Cache size	1000Btye
Work Environment	
Operating temperature	-40℃～+85℃，Industrial standards
Waterproof rating	IP67-rated
Storage temperature	-40℃～+125℃
RF Parameters	
Transmit power	37dBm=5000mW，For more details, see Sections 5 and 6 of this article.
Operating frequency band	410.125MHz～493.125MHz，Supports custom frequency bands
Receive sensitivity	-132dBm，Data rate: 2.4 kbps @ SF11
Air speed	0.3～62.5Kbps，The air flow rate is adjustable in multiple stages; for details, see Sections 5 and 6 of this document
Blocking power	10dBm
Electrical Specifications	
Supply voltage	10～28V(DC)，We recommend using a 12V/2A or 24V/1A power supply
Emission current	1100～1300mA，Instantaneous power consumption @ 37 dBm, powered by 12 V DC / 2 A
Receiving current	≈60mA，Operates on a 12V DC/2A power supply

2.2.2 Detailed current specifications

Conditions：Tc=25℃，433.125MHz

Model	Emission current mA			Receiving current mA		
	8V	12V	28V	8V	12V	28V

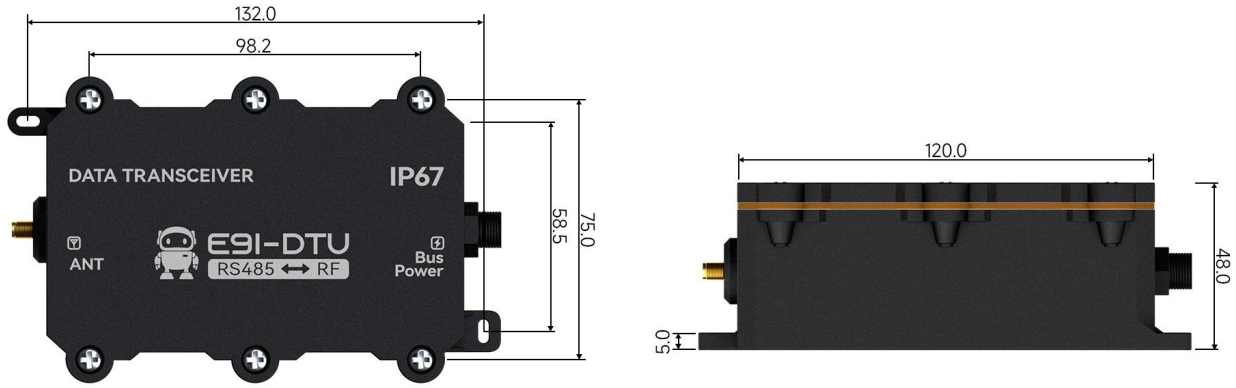
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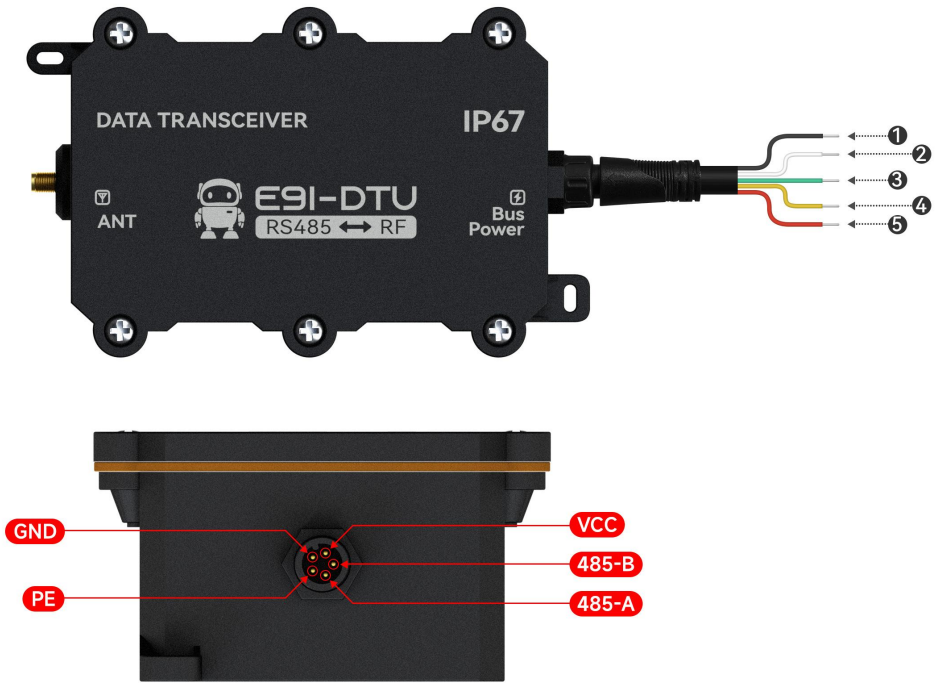
E91-DTU(400SL37)	1800～2100	1100～1300	500～600	≈85	≈60	≈26

Chapter 3: Mechanical Dimensions and Pin Definitions

3.1 E91-DTU (400SL37) Mechanical Dimensions



3.2 Overview of Components and Features



NO	Name	Features	Note
1	ANT	RF interface	SMA-K, male thread with female bore,

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NO	Name	Features	Note
			approximately 6 mm long, with an equivalent impedance of approximately 50 Ω
2	M12 Waterproof 5-Pin Female Connector	Communication power cable	1.Black wire: Power ground wire
			2.White wire: RS485 Signal B
			3.Green wire: PE, connected to ground
			4.Yellow wire: RS485 Signal A
			5.Red wire: VCC power supply (10–28 V DC)
3	M12 Waterproof 5-Pin Male Connector	Connect to the radio,power supply + RS485	VCC: Power supply positive (DC 10–28 V)
			RS485-B：RS-485 Signal B
			RS485-A：RS-485 Signal A
			PE：Grounding: Connecting with the Earth
			GND：Power negative

★ Note: If communication issues occur when connecting the radio to multiple devices but not when using a single device, try connecting a 120Ω resistor in parallel between the 485_A and 485_B terminals.

★ The E91-DTU (400SL37) can be powered by a 10–28 V DC power supply and features a 5-pin M12 aviation connector for wiring.

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Chapter 4: Detailed Explanation of Features

- The E91-DTU (400SL37) uses software-based mode switching; please refer to Chapter 6 for the AT+MODE command;

4.1 Operating Mode

The module has three operating modes, which can be configured via commands or from a host computer. Details are shown in the table below:

Model（0-3）	Mode Switch Command	Overview of the Model	Note
0 Transmission Mode	AT+MODE=0	Serial port enabled, Wi-Fi enabled, transparent transmission	Can be configured remotely; see Section 5.1.3.2 for details
1 WOR Mode	AT+MODE=1	Supports only those defined as WOR senders	Supports air wake-up for WOR receivers
2 Configuration Mode	AT+MODE=2	Users can access the registers via the serial port to control the module's operating status	-

4.1.1 Transmission mode enabled, mode 0 (AT+MODE=0)

4.1.1.1 Quick Start Guide for Transparent Transmission

What you send is what you get; simply use the Serial Port Assistant for communication (the default factory settings are identical for both devices, and the transmission mode is set to transparent). An example is shown below:

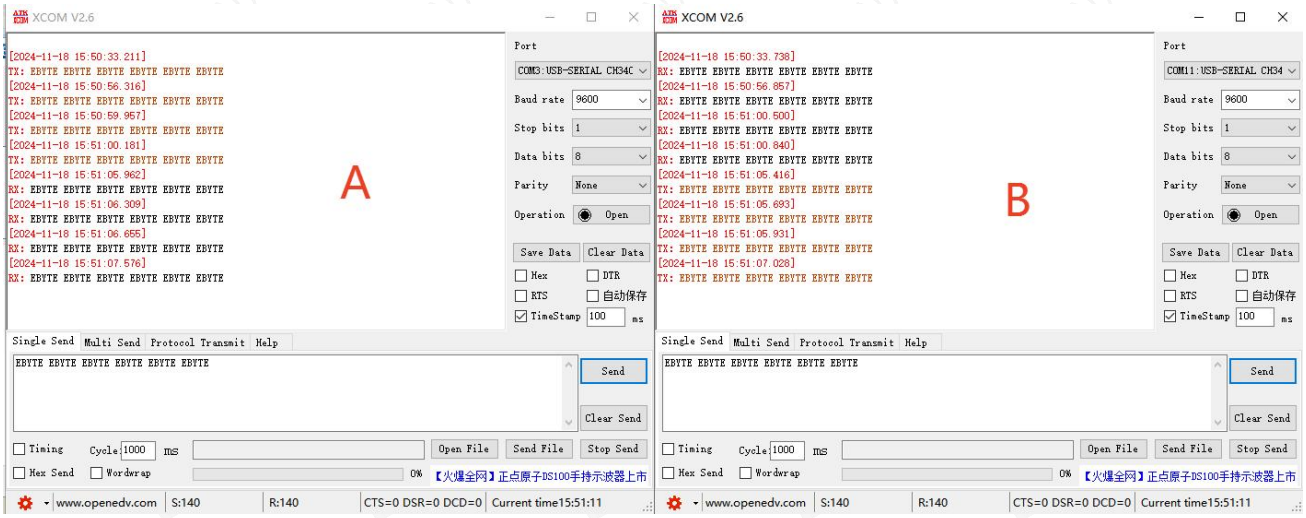


Figure 1 Diagram of bidirectional transmission and reception

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4.1.1.2 Quick Start Guide for Point-to-Point Transmission (Specifying Destination Address and Channel)

Data is transmitted and received using a fixed format: destination address + destination channel + data, which effectively prevents certain types of interference.

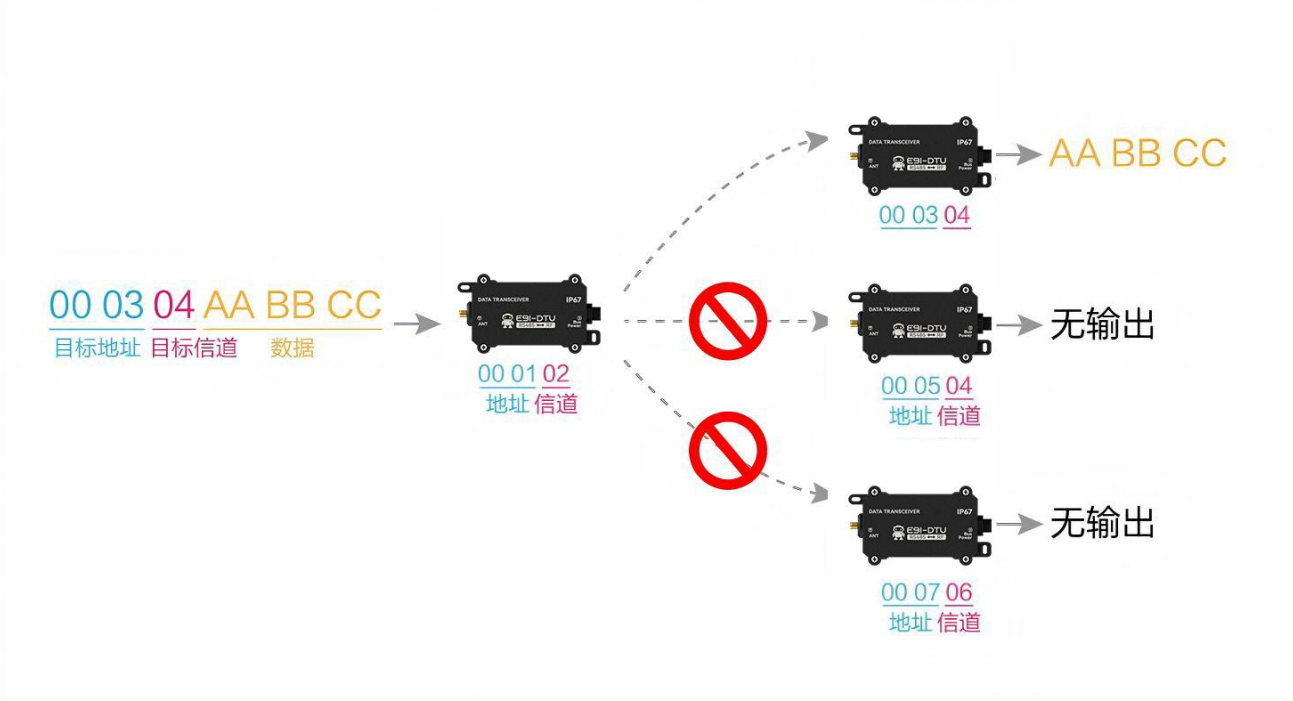


Figure 2 Schematic Diagram of Point-to-Point Transmission

Instructions:

Step 1、Modify the module parameters via the host computer: In configuration mode (AT+MODE=2), change the module address and channel, switch the transmission mode from transparent to fixed-point, and finally save the parameters to complete the modification.

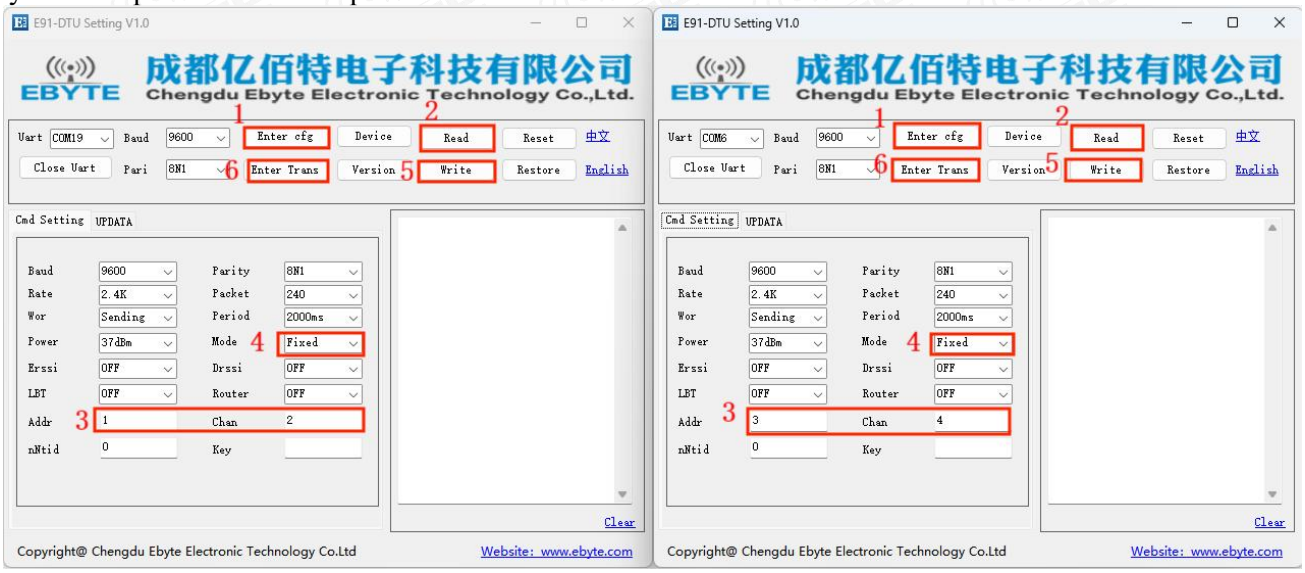


Figure 3 Host Computer Interface

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Step 2 、 Switch the module to normal mode (AT+MODE=0): Set Module A's parameters to 000304AABBCC and send them to Module B. Similarly, when Module B sends data, the format is 000102AABBCC. (In fixed-point mode, the data transmission format is: destination address + destination channel + data).

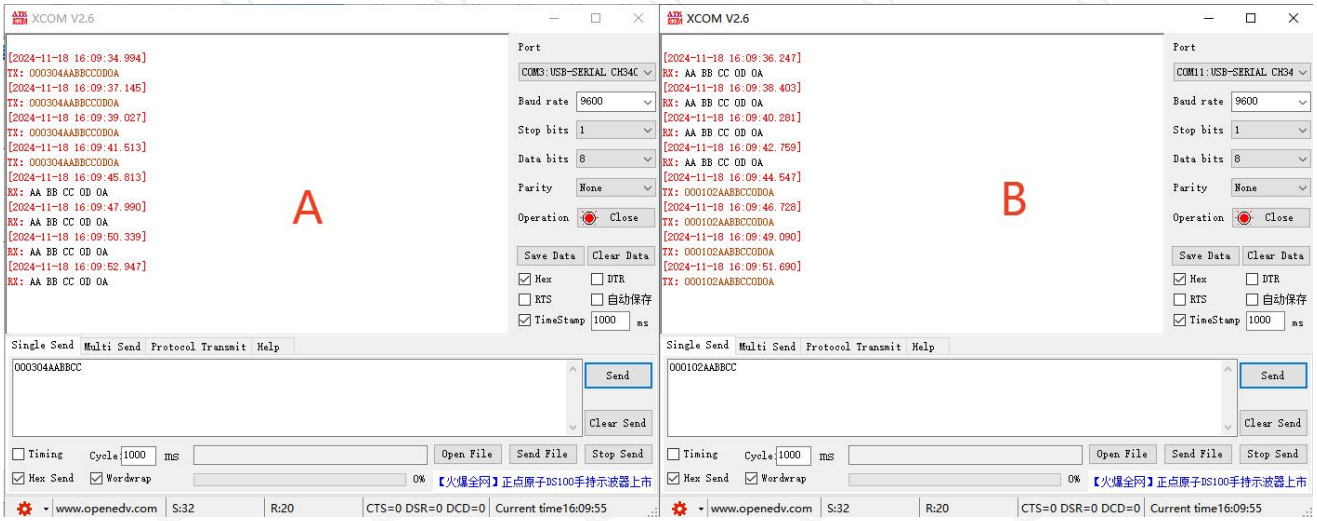


Figure 4 Data Transmission Diagram

4.1.1.3 Quick Start Guide for Broadcasting

- Set Module A's address to 0xFFFF and the channel to 0x04. When Module A transmits (in the same mode, transparent transmission, or fixed-point transmission), all receiving modules on channel 0x04 will receive the data, thereby achieving the purpose of broadcasting.
- Set Module A's address to 0xFFFF and the channel to 0x04. When Module A is configured as a receiver, it can receive all data on channel 0x04, thereby achieving the purpose of monitoring.

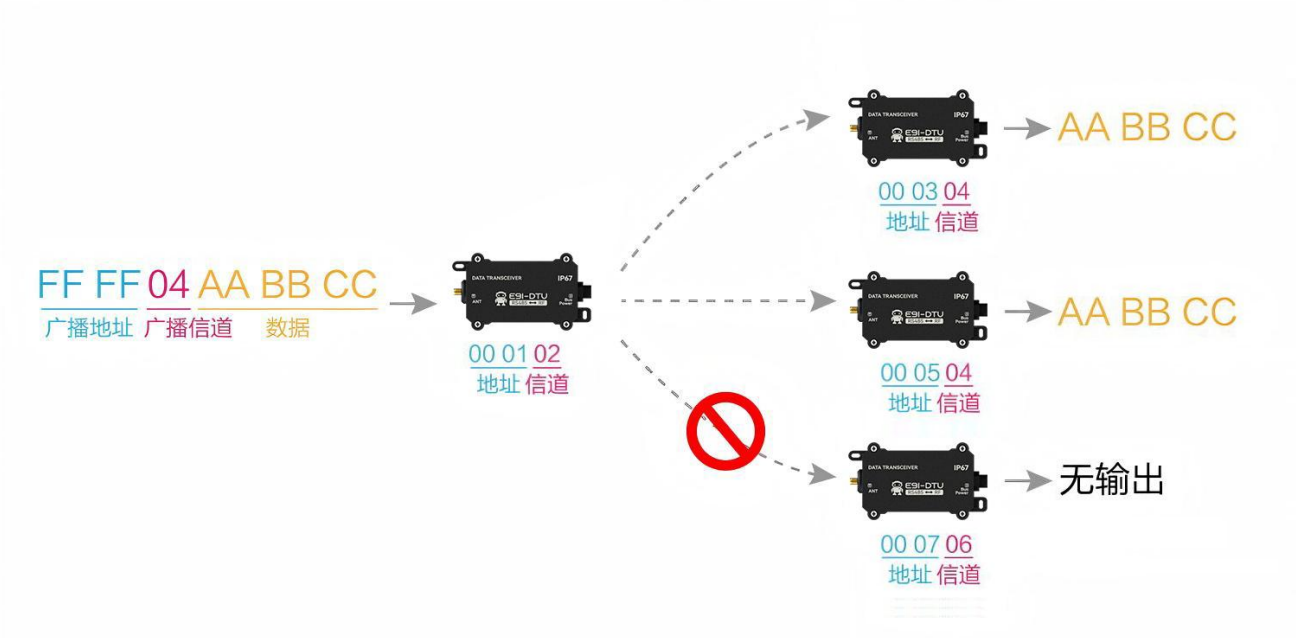


Figure 5 Schematic Diagram of Point-to-Point Broadcast Transmission

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Instructions:

Step 1、Modify the module parameters via the host computer: In configuration mode (AT+MODE=2), change the module address and channel, switch the transmission mode from transparent to fixed-point, and finally save the parameters to complete the modification.

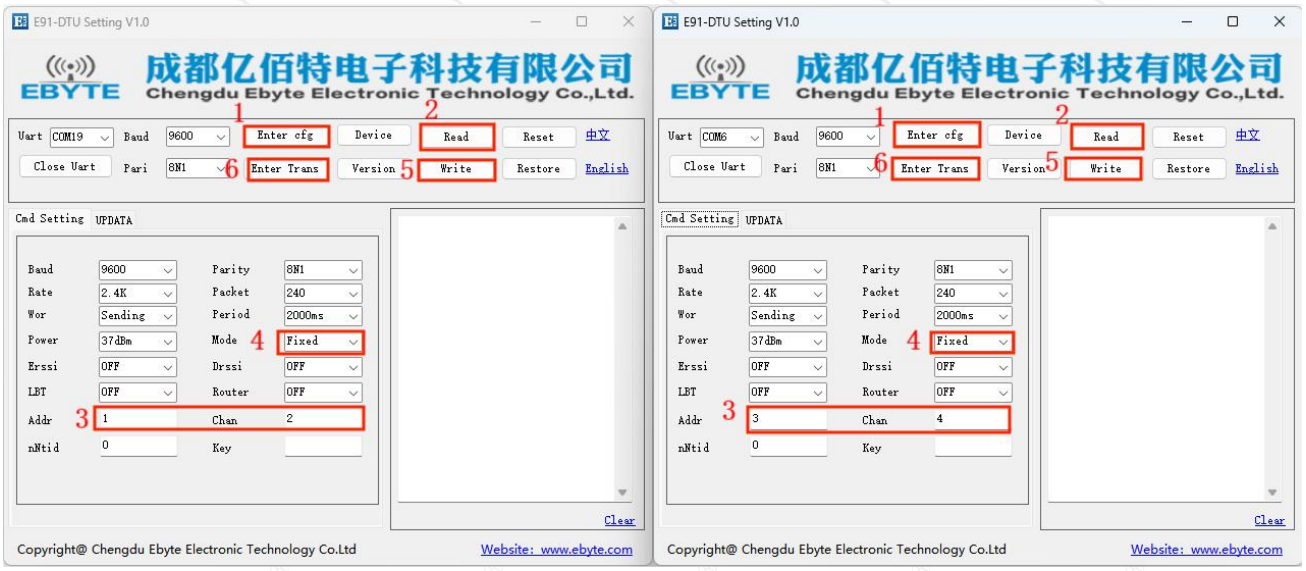


Figure 6 Host Computer Interface

Step 2、To switch the module to normal mode (AT+MODE=0): Set module A's parameters to FFFF04AABBCC and send them to module B. Similarly, when module B sends data, the format is FFFF02AABBCC. (In fixed-point broadcast mode, the data transmission format is: broadcast address + target channel + data.).

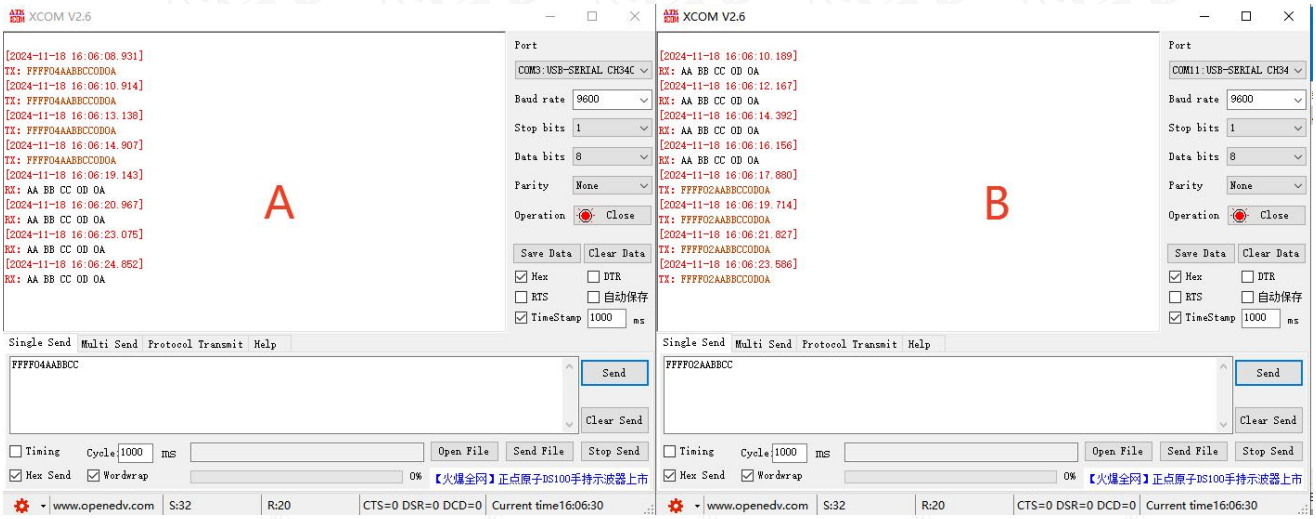


Figure 7 Data Transmission Diagram

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4.1.2 Using WOR mode, Mode 1 (AT+MODE=1)

Note: The E91-DTU (400SL37) does not support WOR reception; the demonstration here uses the E91-DTU (400SL30) as the WOR receiver.

4.1.2.1 Quick Start Guide for Transparent Transmission

Instructions:

Step 1、Modify the module parameters via the host computer: In configuration mode (AT+MODE=2), modify the module's WOR role and write the parameters to complete the modification.

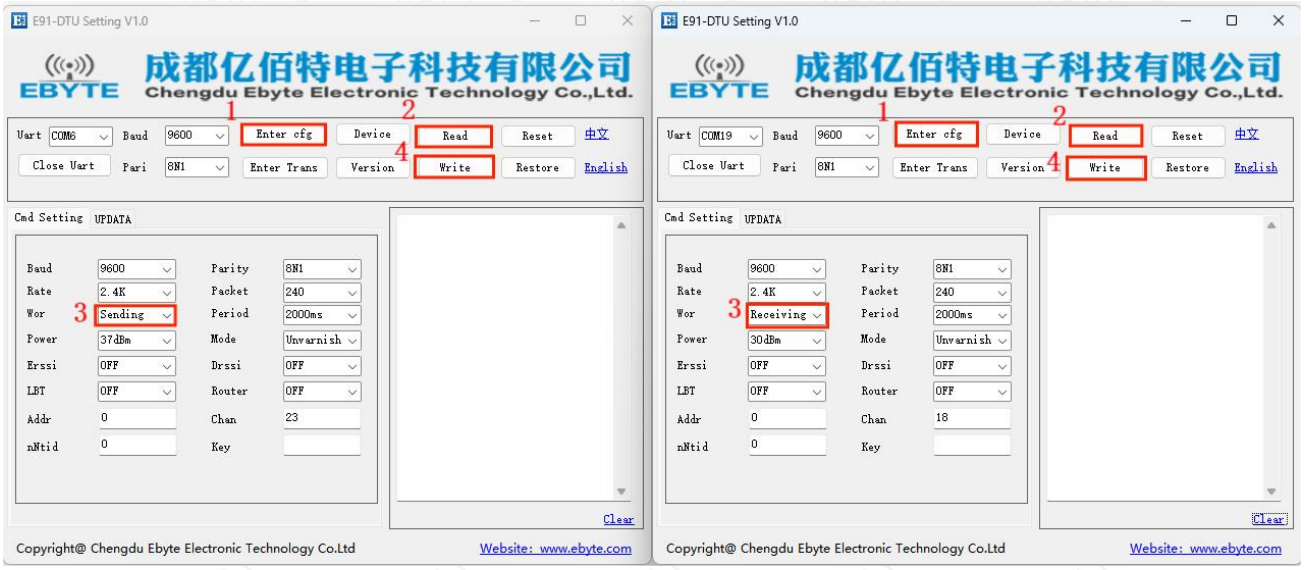


Figure 8 Host Computer Interface

Step 2、Switch the module's operating mode to WOR mode (using the Serial Port Assistant, send: AT+MODE=1): In WOR mode, the sending module transmits data to the receiving module, but the receiving module cannot send data back to the sending module.

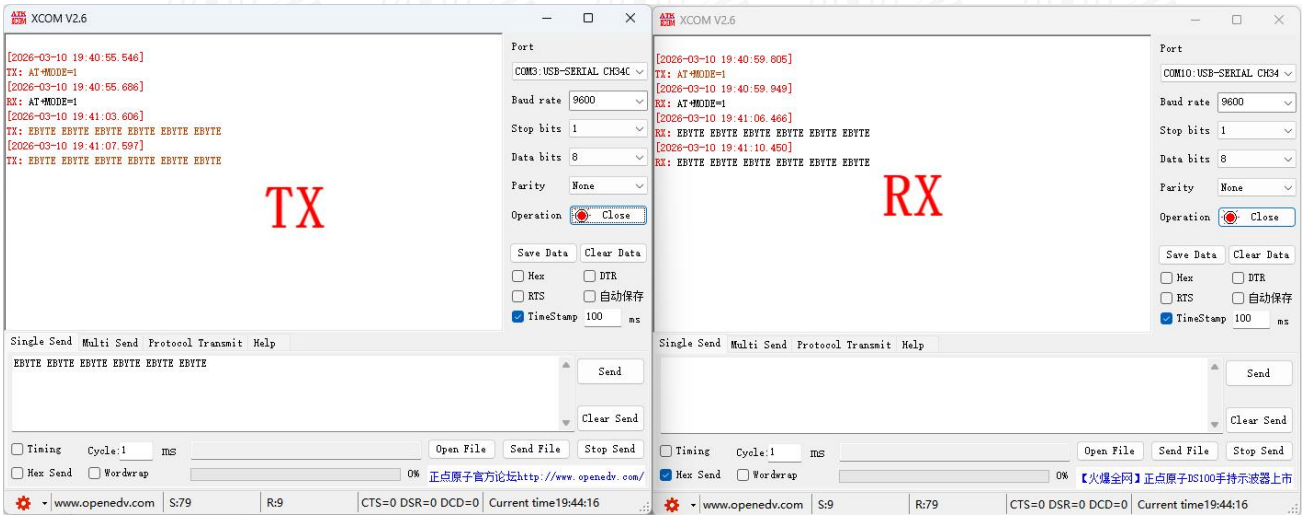


Figure 9 Data Transmission Diagram

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4.1.3 Configuration mode: Mode 2 (AT+MODE=2)

4.1.3.1 Quick Start Guide for the Configuration Tool

The figure below shows the configuration interface on the host computer. Users can switch to configuration mode using AT commands or the host computer's buttons to quickly configure and read parameters on the host computer.



Figure 10 Host Computer Interface

- In the host computer configuration, the module address, frequency channel, network ID, and key are all displayed in decimal format; for the valid ranges of these parameters, please refer to Section 6.3 for the specific parameters of different product models in the registers.
- When configuring relay mode using the host computer, users should take special care. Since all parameters are displayed in decimal format on the host computer, the module address and network ID must be entered after converting the number system; For example, if the network ID entered for Transmitter A is 02 and the network ID entered for Receiver B is 10, when setting the module address for Relay R, convert the hexadecimal value 0X020A to the decimal value 522 and enter 522 as the module address for Relay R; that is, the module address value to be entered for Relay R in this case is 522.

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4.1.3.2 Quick Start Guide for Remote Configuration

Instructions:

Step 1、Remotely read and modify module parameters via the host computer: Modules A and B must have matching parameters to enable remote configuration. An example is shown in the figure on the right: Module A is switched to configuration mode, and Module B is switched to normal mode.

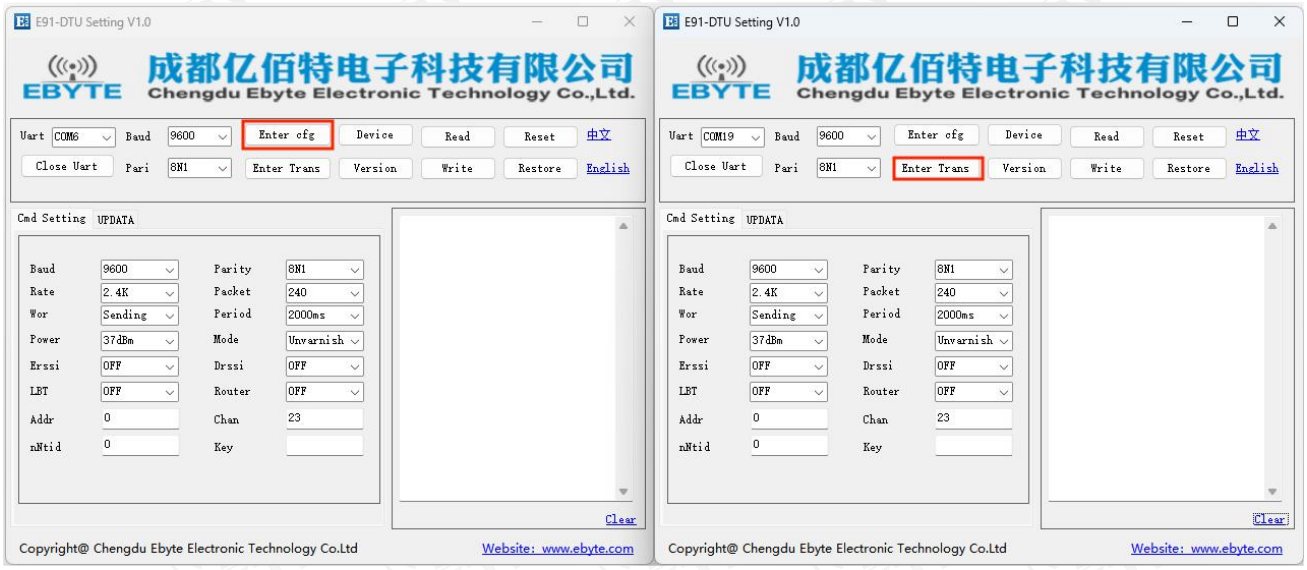


Figure 11 Host Computer Interface

Step 2、Modify parameters remotely and save the changes.

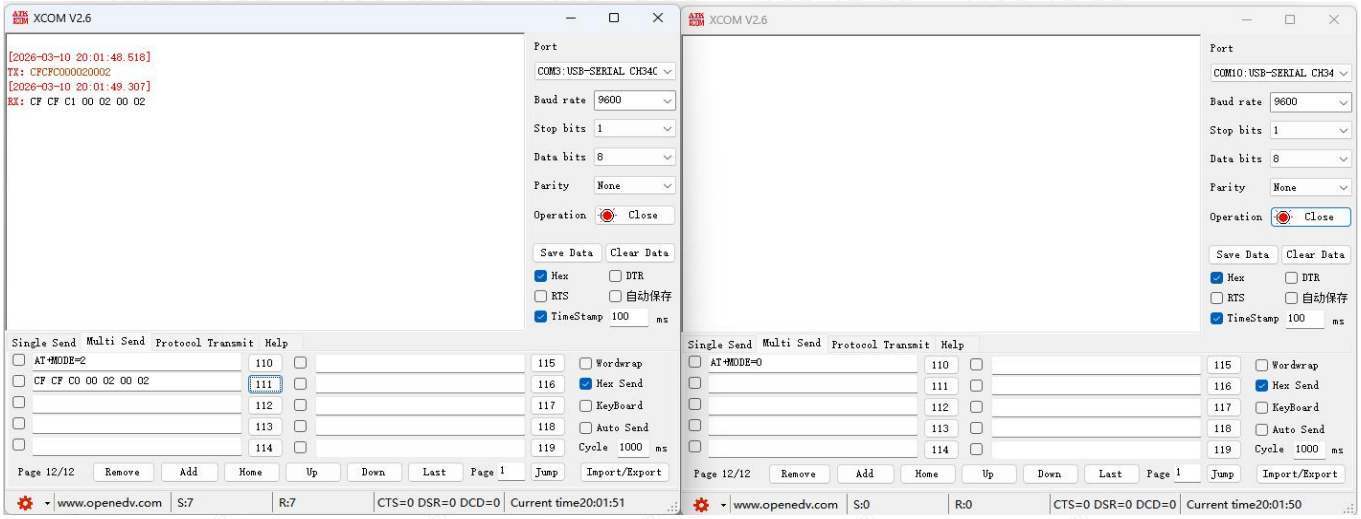


Figure 12 Host Computer Interface

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Step 3、Switch Module B to configuration mode to view the modified parameters.



Figure 13 Host Computer Interface

4.2 Relay Networking Rules

Relay networking uses relay nodes to forward data between source and destination nodes, thereby expanding network coverage and improving communication reliability.

NO	Relay Mode Description
1	After configuring the relay mode in the settings, switch to normal mode, and the relay will begin operating, enabling bidirectional data forwarding between the two NETIDs.
2	In relay mode, ADDH and ADDL are no longer used as module addresses; instead, they correspond to NETID forwarding pairs. If a packet is received on one of these networks, it is forwarded to the other network.
3	In relay mode, the relay module cannot send or receive data and cannot operate in low-power mode.
4	The repeater's own network ID is invalid.
5	It is not recommended to use two or more repeaters with identical or swapped ADDH and ADDL addresses, as this may cause a loop between the repeaters.

As shown in the example below：

Level 1 Relay

- “Node 1” has a NETID of 08. “Node 2” has a NETID of 33.
- “The ADDH and ADDL values for “Relay 1” are 08 and 33, respectively.
- Therefore, the signal sent by Node 1 (08) can be forwarded to Node 2 (33)
- Since Node 1 and Node 2 have the same address, the data sent by Node 1 can be received by Node 2.

Second-level relay

- The ADDH and ADDL values for “Relay 2” are 33 and 05, respectively.
- Therefore, Relay 2 can forward data from Relay 1 to the network with NETID: 05.
- As a result, Node 3 and Node 4 can receive data from Node 1. Node 4 outputs data normally, but Node 3 does not output data because its address is different from Node 1's.

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Two-way relay

- As shown in the figure: Data sent by Node 1 is received by Nodes 2 and 4, and data sent by Nodes 2 and 4 is also received by Node 1.

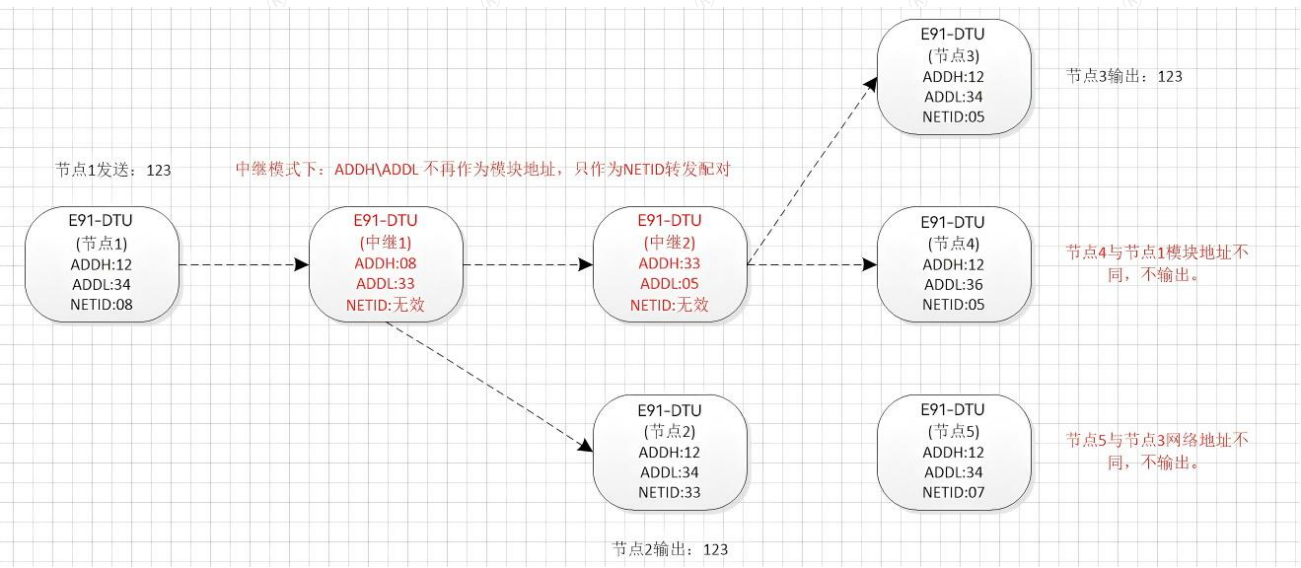


Figure 14 Relay Network Diagram

4.3 Serial Port Firmware Update

① If a customer needs to update the firmware, they must obtain the appropriate update package from their sales representative and then use the PC software provided by YibaiTe to perform the firmware update. Generally, users do not need to update the firmware; please do not use the “AT+IAP” command.

② Once upgrade mode is entered, the baud rate will automatically switch to 115200 and remain there until the mode is automatically exited. Logs will be output during this period.

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4.3.1 Quick Start Guide for Host Computer Upgrade

Step 1、Use the host computer to put the module into configuration mode (Note: The baud rate is 9600 in configuration mode); open the configuration software and select the Firmware Upgrade tab.

Step 2、Click “Read Parameters” to view the module information in the left pane of the host computer.

Step 3、Open the file (select the firmware .bin file) > Click Start Download.

Step 4、Click to start the download. The firmware update will begin, and a message will appear once it is complete.

Step 5、After the firmware update is complete, reopen the serial port to verify that the parameters are being read.



Figure 15 Host Computer Interface

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Chapter 5: Register Read/Write Control

5.1 HEX Command Format

In configuration mode (Mode 2: AT+MODE=2), the list of supported commands is as follows (when configuring, the serial port only supports 9600 baud, 8N1 format)：

NO	Command Format	Detailed descriptions
1	Set the register	Instruction: C0 + start address + length + parameters Response: C1 + start address + length + parameters Example 1: Configure the channel to 0x09 Instruction Start Address Length Parameters Send： C0 05 01 09 Back： C1 05 01 09 Example 2: Configure the module address (0x1234), network address (0x00), serial port (9600 8N1), and baud rate (1.2K) simultaneously Send：C0 00 04 12 34 00 61 Back：C1 00 04 12 34 00 61
2	Read register	Instruction: C1 + start address + length Response: C1 + start address + length + parameters Example 1: Reading the channel Instruction Start Address Length Parameters Send： C1 05 01 Back： C1 05 01 09 Example 2: Simultaneously reading module address, network address, serial port, and airspeed Send：C1 00 04 Back：C1 00 04 12 34 00 61
3	Set up a temporary register	Instruction: C2 + start address + length + parameters Response: C1 + start address + length + parameters Example 1: Configure the channel to 0x09 Instruction Start Address Length Parameters Send： C2 05 01 09 Back： C1 05 01 09 Example 2: Configure the module address (0x1234), network address (0x00), serial port (9600 8N1), and baud rate (1.2K) simultaneously Send：C2 00 04 12 34 00 61 Back：C1 00 04 12 34 00 61
4	Wireless Configuration	Instruction: CF CF + standard instruction Response: CF CF + Standard Response Example 1: The wireless configuration channel is 0x09 Wireless Header Instruction Start Address Length Parameters

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NO	Command Format	Detailed descriptions
		Send： CF CF C0 05 01 09 Back： CF CF C1 05 01 09 Example 2: Simultaneously configure the wireless module address (0x1234), network address (0x00), serial port (9600 8N1), and baud rate (1.2K) Send：CF CF C0 00 04 12 34 00 61 Back：CF CF C1 00 04 12 34 00 61
5	Invalid format	Format Error Response FF FF FF

5.2 Register Function Overview

Address	Name	Bit							
		bit 7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
00h	ADDH	Mailing Address[15:8]							
01h	ADDL	Mailing Address[7:0]							
02h	NETID	Web address[7:0]							
03h	REG0	Serial baud rate[2:0]			Serial Port Check Character Type[1:0]		Wireless transmission rate[2:0]		
04h	REG1	Serial packet length[1:0]		Environment RSSI	Reserve	Reserve	Soft Cut Mode	Wireless transmit power [1:0]	
05h	REG2	Channel Control[7:0]							
06h	REG3	Data RSSI	Transmission method	Relay Enable	Listen first, then speak	Air Wake-Up	Air Wake Cycle [2:0]		
07h	CRYPT_H	Wireless data encryption key[15:8]							
08h	CRYPT_L	Wireless data encryption key[7:0]							
09h	WD_H	The window time during which the recipient can respond (send) after receiving data following an air-based wake-up[15:8]							
0Ah	WD_L	The window time during which the recipient can respond (send) after receiving data following an air-wakeup [7:0]							

Note: For the design of register software structures, please refer to the sample code for the E22-xxxTBL-SC series (available in the "Related Downloads" section of this page); see e22_demo.h for details.

5.3 Detailed Description of Registers

NO	Read/ write	Name	Description	Note
00H	**Read/ write**	ADDH	ADDH（Default 0）	1. High byte and low byte of the module

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<table>
<tr><td>01H</td><td>Read/ write</td><td>ADDL</td><td colspan="5">ADDL（Default 0）</td><td>address；
2. When the module address is set to FFFF, it functions as a broadcast and listen address; that is, the module will not perform address filtering in this case.</td></tr>
<tr><td>02H</td><td>Read/ write</td><td>NETID</td><td colspan="5">NETID（Default 0）</td><td>1. Network address, used to distinguish networks；
2. When communicating with each other, they should be set to the same value。</td></tr>
<tr><td rowspan="15">03H</td><td rowspan="15">Read/ write</td><td rowspan="15">REG0</td><td>7</td><td>6</td><td>5</td><td>UART Baud Rate（bps）</td><td rowspan="9">1. The two modules communicating with each other may have different baud rates and different parity settings；
2. When sending a series of large data packets, users need to be aware of potential data congestion—and even packet loss—caused by the constant baud rate；
3. It is generally recommended that both communicating parties use the same baud rate.</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>serial port baud rate is 1200</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>serial port baud rate is 2400</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>serial port baud rate is 4800</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>serial port baud rate is 9600 (default)</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>serial port baud rate is 19200</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>serial port baud rate is 38400</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>serial port baud rate is 57600</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>serial port baud rate is 115200</td></tr>
<tr><td>4</td><td>3</td><td colspan="2">Serial port parity bit</td><td rowspan="5">The serial port modes of the two communicating parties may differ；</td></tr>
<tr><td>0</td><td>0</td><td colspan="2">8N1（default）</td></tr>
<tr><td>0</td><td>1</td><td colspan="2">8O1</td></tr>
<tr><td>1</td><td>0</td><td colspan="2">8E1</td></tr>
<tr><td>1</td><td>1</td><td colspan="2">8N1（Equivalent to 00）</td></tr>
<tr><td>2</td><td>1</td><td>0</td><td>Wireless data rate（bps）</td><td rowspan="9">Note: Both communicating parties must use the same air interface data rate; the higher the air interface data rate, the lower the latency and the shorter the transmission distance.</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>Air speed 0.3k</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>Air speed 1.2k</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>Air speed 2.4k（default）</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>Air speed 4.8k</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>Air speed 9.6k</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>Air speed 19.2k</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>Air speed 38.4k</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>Air speed 62.5k</td></tr>
<tr><td rowspan="5">04H</td><td rowspan="5">Read/ write</td><td rowspan="6">REG1</td><td>7</td><td>6</td><td colspan="2">Subcontracting Settings</td><td rowspan="5">Note：
1. When the user sends data that is shorter than the packet length, the receiving end's serial port output appears as uninterrupted, continuous output；
2. If the user sends data that exceeds the packet length, the receiving serial port will output the data in separate packets.</td></tr>
<tr><td>0</td><td>0</td><td colspan="2">240 bytes（default）</td></tr>
<tr><td>0</td><td>1</td><td colspan="2">128 bytes</td></tr>
<tr><td>1</td><td>0</td><td colspan="2">64 bytes</td></tr>
<tr><td>1</td><td>1</td><td colspan="2">32 bytes</td></tr>
<tr><td></td><td></td><td>5</td><td colspan="3">RSSI Ambient Noise Enable</td><td>1. Once enabled, the commands C0,</td></tr>
</table>

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			0	Disabled (default)	C1, C2, and C3 can be sent in transmission mode or WOR send mode to read registers; 2. Register 0x00: Current ambient noise RSSI; 3. Register 0x01: RSSI at the time of the last data reception (current ambient noise: dBm = -(256 - RSSI)); 4. Instruction format: C0 C1 C2 C3 + start address + read length; ●Return: C1 + address + read length + valid read value; ■ For example: Send C0 C1 C2 C3 00 01 ■ Return: C1 00 01 RSSI (Addresses must start with 00)
			1	Enable	
		4	3	Reserve	
		2	Enable logging of abnormal operating conditions		Print logs in different formats depending on the specific abnormal operating condition. For details, see Section 5.7, “Detailed Explanation of Log Printing for Abnormal Operating Conditions.”
		0	Disabled (default)		
		1	Enable		
		1	0	Transmit power	1. Power and current have a nonlinear relationship; power supply efficiency is highest at maximum power; 2. The current does not decrease proportionally as the power decreases.
		0	0	37dBm（default）	
		0	1	37dBm	
		1	0	37dBm	
		1	1	37dBm	
05H	**Read/ write**	REG2	Channel Control（CH） 0–83 represent a total of 84 channels (applicable to the 400 MHz band)		1. Actual frequency in the 400 MHz band= 410.125 + CH * 1M
06H	**Read/ write**	REG3	7	Enable RSSI bytes (packet RSSI)	1. Once enabled, when the module receives wireless data and outputs it via the TXD serial port, an RSSI strength byte will follow. 2. The current packet RSSI is: dBm = -(256 - RSSI)
			0	Disabled (default)	
			1	Enable	
			6	Transmission method	During point-to-point transmission, the module identifies the first three bytes of the serial data as: high-order address + low-order address + channel, and uses this as the wireless transmission destination.
			0	Transparent transport (default)	
			1	Point-to-point transmission	
			5	Relay function	1. Once the relay function is enabled, if the destination address is not the module itself, the module will initiate a single forwarding operation; 2. To prevent data from being sent back, it is recommended to use this in conjunction with the fixed-point
			0	Disable relay functionality (default)	
			1	Enable relay function	

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					mode; that is, the destination address and the source address should be different.
			4	LBT Enabled	1. Once enabled, the system will monitor the channel before transmitting wireless data, which can help mitigate interference to some extent, but may result in data latency; 2. The maximum LBT dwell time is 2 seconds; once 2 seconds are reached, transmission is forced.
			0	Disabled (default)	
			1	Enable	
			3	WOR Mode Transmit/Receive Control	**Supports only WOR senders; setting it as a WOR receiver is invalid.**
			0	WOR Receiver Operating in WOR monitoring mode, with a monitoring cycle as described below (WOR cycle), can significantly reduce power consumption.	
			1	WOR Sender (default) Enable the module's transceiver, and include a wake-up code of a certain duration when transmitting data.	
			2 1 0	WOR cycle	**Applies only to Mode 1;** 1. Period T = (1 + WOR) × 500 ms, with a maximum of 4000 ms and a minimum of 500 ms; 2. The longer the WOR polling interval, the lower the average power consumption, but the greater the data latency; 3. The sender and recipient must match (very important)）
			0 0 0	500ms	
			0 0 1	1000ms	
			0 1 0	1500ms	
			0 1 1	2000ms（default）	
			1 0 0	2500ms	
			1 0 1	3000ms	
			1 1 0	3500ms	
			1 1 1	4000ms	
07 H	**write**	CRYPT_H	Key high byte (default 0)		1. Write only; read returns 0; 2. Used for encryption to prevent wireless data from being intercepted by similar modules; 3. The module will use these two bytes as calculation factors to perform transform-based encryption on the wireless signals in the air.
08 H	**write**	CRYPT_L	Key low byte (default 0)		
80	**Read**	PI	Product information (7 bytes)		Product information (7 bytes)

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H ～ 86 H		D		Note: For greater convenience, please refer to the AT+DEVTYPE=? query command in Section 6.1.

5.4 Default Values of Register Parameters

Model	**Default factory settings for the 400 MHz module：C0 00 09 00 00 00 62 00 17 03 00 00**						
Module Model	Frequency	Address	Channel	Air speed	Baud rate	Serial Port Format	Transmit power
E91-DTU(400SL37)	433.125MHz	0x0000	0x17	2.4kbps	9600	8N1	37dbm

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Chapter 6: AT Commands

- To configure parameters or query information using AT commands, you must be in configuration mode (the serial port in configuration mode is fixed at 9600 baud, 8 bits, 1 stop bit);
- Automatically detects the carriage return/line feed character at the end of the user's AT command; it can recognize commands with or without the carriage return/line feed (\r\n);
- If an error occurs during the recognition or execution of a T command, the response will be "=ERR" ;
- If the input parameters exceed the specified range, they will be restricted. Please ensure that the parameters do not exceed the range to avoid unexpected issues.

6.1 General Instructions

6.1.1 AT+RESET Soft Reset

Command Format	AT+RESET
Execution example	Send：AT+RESET Response：=OK
Feature Description	The actual reset process will not begin until a response is received (=OK). Please wait approximately 30 ms before proceeding to the next step

6.1.2 AT+DEFAULT Restore Factory Settings

Command Format	AT+DEFAULT
Execution example	Send：AT+DEFAULT Response：=OK
Feature Description	After the response (=OK), in addition to restoring the parameters, a restart process will be executed. Please wait approximately 30 ms before proceeding to the next step

6.1.3 AT+DEVTYPE Look up Product Model

Command Format	AT+DEVTYPE=?
Execution example	Send：AT+DEVTYPE=? Response：DEVTYPE=E91-DTU(400SL37)
Feature Description	Product Line：E91 Operating band：400 Maximum power：37

6.1.4 AT+FWCODE Check Software Version

Command Format	AT+FWCODE=?
Execution example	Send：AT+FWCODE=? Response：FWCODE=7435-2-10
Feature Description	Major Version：7435 Branch ID：2 Version number：10 (Increase starting from 10)

6.1.5 AT+MODE Software Switching Operating Modes

Command	AT+MODE=<mode>

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Format	
Configuration Example	Send：AT+MODE=0 Response：=OK
Query Example	Send：AT+MODE=? Response：AT+MODE=2
Parameter Description	**<mode>** ： Operating Mode Number 0 Transmission mode 1 Wake-on-Radio Mode (WOR) 2 Configuration Mode
Feature Description	● Can be used in any operating mode ● The actual mode switch will not begin until a response is received (=OK). Please wait approximately 15 ms before proceeding to the next step

6.1.6 AT+ADDR Mailing Address (Match Filter)

Command Format	AT+ADDR=<address>
Configuration Example	Send：AT+ADDR=0 Response：=OK
Query Example	Send：AT+ADDR=? Response：AT+ADDR=0
Parameter Description	**<address>** ： Mailing Address 0 - 65535
Feature Description	● Default address 0 ● The address is not a radio frequency characteristic; it is merely an identifier carried within the data packet that helps the receiving software determine whether to apply matching filters ● Broadcast address 65535. When acting as a receiver, it can receive data sent from any address on the same channel (without filtering). When acting as a sender, the data packets it sends carry the broadcast address, so the recipient will not filter them (broadcast data)

6.1.7 AT+NETID Communication Network Code (Match Filtering)

Command Format	AT+NETID=<net>
Configuration Example	Send：AT+NETID=0 Response：=OK
Query Example	Send：AT+NETID=? Response：AT+NETID=0
Parameter Description	**<net>** ： Communication Network Code 0 - 255
Feature Description	● Default Network 0 ● The network code is not an RF characteristic; it is merely an identifier carried within a data packet that helps the receiving software determine whether to relay, forward, or filter the packet ● The priority of network code filtering is lower than that of broadcast addresses. Even if the network codes differ, broadcast data can still be received

6.1.8 AT+CHANNEL Communication channel (carrier frequency)

Command	AT+CHANNEL=<ch>

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Format	
Configuration Example	Send：AT+CHANNEL=0 Response：=OK
Query Example	Send：AT+CHANNEL=? Response：AT+CHANNEL=0
Parameter Description	**<ch>** ： Communication channel 0 - 83
Feature Description	● The channel ranges vary by frequency band; please be sure to distinguish between them ● The actual carrier frequency corresponding to a channel in the 400 MHz band = 410.125 MHz + ch * 1 MHz

6.1.9 AT+KEY Communication Encryption (Data Encryption)

Command Format	AT+KEY=<key>
Configuration Example	Send：AT+KEY=0 Response：=OK
Parameter Description	**<key>** ： Encryption and decryption keys 0 - 65535
Feature Description	● Default 0 ● Cannot query (unable to read password) ● Modules with mismatched passwords cannot communicate (they cannot decode the correct data packets, fail the checksum verification, and are discarded)

6.1.10 AT+UART Serial Port Baud Rate and Parity

Command Format	AT+UART=<baud>,<parity>
Configuration Example	Send：AT+UART=3,0 Response：=OK
Query Example	Send：AT+UART=? Response：AT+UART=3,0
Parameter Description	**<baud>** ： Serial baud rate 0 1200bps 1 2400bps 2 4800bps 3 9600bps (Default) 4 19200bps 5 38400bps 6 57600bps 7 115200bps **<parity>** ： Serial Port Check Character Type 0 No checksum (default) 1 Odd Parity Odd 2 Even parity Even
Feature Description	● In configuration mode (AT+MODE=2, Mode 2), force a fixed baud rate of 9600 with 8N1 ● This change takes effect after switching work modes

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6.1.11 AT+PACKET Serial port packet length

Command Format	AT+PACKET=<len>
Configuration Example	Send：AT+PACKET=0 Response：=OK
Query Example	Send：AT+PACKET=? Response：AT+PACKET=0
Parameter Description	**<len>** ： Serial Data Packet Length 0 240 bytes (default) 1 128 bytes 2 64 bytes 3 32 bytes
Feature Description	● If the data received via the serial port during reception is shorter than the specified length, it is treated as a timeout and the frame is discarded, then repackaged for wireless transmission ● During serial reception, when the data received from the user reaches the specified length, it will be immediately packaged and transmitted wirelessly ● Any user-supplied data exceeding the specified length will continue to accumulate in the serial buffer. Once wireless transmission is complete, the data will be split into segments according to the specified length and sent in a single packet on a cyclical basis

6.1.12 AT+RATE Wireless transmission rate

Command Format	AT+RATE=<rate>
Configuration Example	Send：AT+RATE=2 Response：=OK
Query Example	Send：AT+RATE=? Response：AT+RATE=2
Parameter Description	**<rate>** ： Air speed 0 0.3Kbps 1 1.2Kbps 2 2.4Kbps (default) 3 4.8Kbps 4 9.6Kbps 5 19.2Kbps 6 38.4Kbps 7 62.5Kbps
Feature Description	● The airspeed ranges vary by frequency band; please be sure to distinguish between them ● The higher the data rate, the lower the communication latency (shorter transmission time), but the lower the reception sensitivity (shorter communication range）

6.1.13 AT+TRANS Wireless transmission mode (transparent/fixed-point)

Command Format	AT+TRANS=<mode>
Configuration Example	Send：AT+TRANS=0 Response：=OK
Query Example	Send：AT+TRANS=? Response：AT+TRANS=0

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Parameter Description	**<mode>** ： Transmission method 0 Transparent transmission (default) 1 Point-to-point transmission
Feature Description	● Point-to-point transmission applies special processing to the first three bytes of user-input data. The first and second bytes are identified as the destination address, and the third byte is identified as the destination channel (for automatic channel switching) ● After completing the point-to-point data transmission, the system automatically switches back to the original channel

6.1.14 AT+LBT Listen-then-proceed (yield)

Command Format	**AT+LBT=<on_off>**
Configuration Example	Send：AT+LBT=0 Response：=OK
Query Example	Send：AT+LBT=? Response：AT+LBT=0
Parameter Description	**<on_off>** ： Switch 0 Close (default) 1 Open
Feature Description	● When the LBT (Listen Before Talk) feature is enabled, the system checks whether the ambient signal strength is below the set threshold before each wireless transmission. If the condition is met within the timeout period, the wireless transmission is initiated. If the condition is not met by the maximum timeout period, the wireless transmission is forced to start.

6.1.15 AT+ROUTER Relay Forwarding

Command Format	**AT+ROUTER=<on_off>**
Configuration Example	Send：AT+ROUTER=0 Response：=OK
Query Example	Send：AT+ROUTER=? Response：AT+ROUTER=0
Parameter Description	**<on_off>** ： Switch 0 Close (default) 1 Open
Feature Description	● Once enabled, please refer to the section on repeater networking modes in Chapter 5 ● Relaying essentially involves forwarding the received wireless data once more, which doubles the transmission time (latency) ● The relay operates in half-duplex mode; please ensure you allow sufficient time for the relay to complete the forwarding process. If a user sends data to the relay while it is in the process of forwarding, packet loss may occur

6.1.16 AT+WOR Wake-up Calls (Send/Receive)

Command Format	**AT+WOR=<role>**
Configuration Example	Send：AT+WOR=0 Response：=OK
Query	Send：AT+WOR=?

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Example	Response：AT+WOR=1
Parameter Description	**<role>** ： Role 0 Recipient (setting is invalid) 1 Sender (default)
Feature Description	● The receiver is in a low-power mode, while the transmitter remains in normal power consumption mode ● The receiver enters sleep mode according to the configured radio wake-up cycle to reduce power consumption, and cannot receive wireless signals while in sleep mode. When the sleep timer expires, the RF unit briefly wakes up and enters a receive state. If a wake-up signal is detected during this window, the receiver enters a normal continuous receive state and waits for subsequent wireless data. If no signal is detected, it enters the next sleep-wake-up cycle ● The sender inserts a wake-up code before the user data according to the configured air wake-up interval, meaning it wakes up the receiver first and then transmits the data; therefore, this results in a longer transmission time (latency) Supports WOR senders only

6.1.17 AT+WTIME Air Wake Cycle

Command Format	**AT+WTIME=<timeout>**
Configuration Example	Send：AT+WTIME=3 Response：=OK
Query Example	Send：AT+WTIME=? Response：AT+WTIME=3
Parameter Description	**<timeout>** ： Sleep time 0 500ms 1 1000ms 2 1500ms 3 2000ms (default) 4 2500ms 5 3000ms 6 3500ms 7 4000ms
Feature Description	● The longer the sleep time of the air-wake-up receiver, the lower the average power consumption, but the greater the communication latency

6.1.18 AT+DELAY Air-to-ground wake-up response time

Command Format	**AT+DELAY=<timeout>**
Configuration Example	Send：AT+DELAY=0 Response：=OK
Query Example	Send：AT+DELAY=? Response：AT+DELAY=0
Parameter Description	**<timeout>** ： Response window time (milliseconds) 0 - 65535
Feature Description	● Default value is 0, meaning that after the wake-on-air receiver receives wireless data and outputs it via the serial port, it immediately enters sleep mode ● After setting the time (e.g., 1000 milliseconds), once the air-wake-up receiver has received the wireless data and output it via the serial port, it will remain in the normal wake-up state for the set duration. During this window, the user can send response data

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	to the module and have it transmitted

6.1.19 AT+ERSSI Ambient signal strength

Command Format	**AT+ERSSI=<on_off>**
Configuration Example	Send：AT+ERSSI=0 Response：=OK
Query Example	Send：AT+ERSSI=? Response：AT+ERSSI=0
Parameter Description	**<on_off>** ： Switch 0 Close (Default) 1 Open
Feature Description	● Once enabled, please refer to the “RSSI Ambient Noise Enable” section in the register description and use a hexadecimal command to read the data

6.1.20 AT+DRSSI Received packet signal strength

Command Format	**AT+DRSSI=<on_off>**
Configuration Example	Send：AT+DRSSI=0 Response：=OK
Query Example	Send：AT+DRSSI=? Response：AT+DRSSI=0
Parameter Description	**<on_off>** ： Switch 0 Close (Default) 1 Open
Feature Description	● When enabled, signal strength data (1 byte, hexadecimal representation, signed number) will be appended to the end of received packets ● Conversion example: Suppose the received signal strength data is 0xC4 (-60 dBm). Converting the hexadecimal value 0xC4 to decimal yields 196. The conversion formula is: RSSI = -(256 - 196) = -60 ● If the distance between the transmitter and receiver is too short or the transmitter power is too high, the received signal strength may be 0 (the upper limit); please convert this directly to 0 dBm

6.1.21 AT+POWER Power Settings

Command Format	AT+POWER=**<Power>**
Configuration Example	Send：AT+POWER=0 Response：AT+POWER=0
Query Example	Send：AT+POWER=? Response：AT+POWER=0
Parameter Description	**<Power>** ： Power

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	0 37dBm （Default） 1 37dBm 2 37dBm 3 37dBm
Feature Description	-

Chapter 7: Frequently Asked Questions

7.1 The transmission distance is not ideal

- When there are obstacles in the line-of-sight path, the communication range will decrease accordingly;
- Temperature, humidity, and co-channel interference can increase the packet loss rate;
- The ground absorbs and reflects radio waves, so test results are poor when conducted near the ground;
- Seawater strongly absorbs radio waves, so test results are poor near the coast;
- The presence of metal objects near the antenna, or placement inside a metal enclosure, can cause severe signal attenuation;
- Incorrect power register settings or excessively high data rates (higher data rates result in shorter communication distances);
- Low battery voltage at room temperature below the recommended value; lower voltage results in lower transmit power;
- Poor antenna-to-module matching or issues with the antenna’s quality.

7.2 The module is prone to damage

- Please check the power supply to ensure it falls within the recommended voltage range; exceeding the maximum voltage may cause permanent damage to the module;
- Please check the stability of the power supply; the voltage must not fluctuate significantly or frequently;
- Please ensure that anti-static procedures are followed during installation and use, as high-frequency components are sensitive to static electricity;
- Please ensure that humidity levels are not too high during installation and use, as some components are humidity-sensitive;
- Unless there are special requirements, it is not recommended to use the module at extremely high or low temperatures.

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7.3 The bit error rate is too high

- There is interference from nearby signals on the same frequency; move away from the source of interference or change the frequency or channel to avoid interference;
- A poor power supply may also cause garbled data; ensure the reliability of the power supply;
- Poor-quality or excessively long extension cables or feedlines can also result in a high bit error rate.

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Chapter 8: Antenna Guide

8.1 Recommended Antennas

Antennas play a crucial role in communication. Poor-quality antennas can often have a significant negative impact on communication systems. Therefore, we recommend a selection of antennas that are compatible with our wireless modules and offer excellent performance at a reasonable price.

Model	Type	Frequency(Hz)	Interface	Gain(dBi)	Height(mm)	feedline(cm)	Features
TX433-JZG-6	Rubber rod antenna	433M	SMA-J	2.5	62	-	Ultra-short, straight-type, omnidirectional antenna
TX433-JW-5	Rubber rod antenna	433M	SMA-J	2.0	50	-	Flexible antenna rod, omnidirectional antenna
TX433-JWG-7	Rubber rod antenna	433M	SMA-J	2.5	75	-	Flexible antenna rod, omnidirectional antenna
TX433-JK-11	Rubber rod antenna	433M	SMA-J	2.5	110	-	Flexible rubber rod, omnidirectional antenna
TX433-XPL-100	Suction-cup antenna	433M	SMA-J	3.5	185	100	Compact suction cup antenna, great value
TX433-XP-200	Suction-cup antenna	433M	SMA-J	4.0	190	200	Neutral suction cup antenna, low loss
TX433-XPH-300	Suction-cup antenna	433M	SMA-J	6.0	965	300	Large suction cup antenna, high gain
TX490-JZ-5	Rubber rod antenna	470/490M	SMA-J	2.0	50	-	Ultra-short straight-type, omnidirectional antenna
TX490-XPL-100	Suction-cup antenna	470/490M	SMA-J	3.5	120	100	Compact suction cup antenna, great value

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Revision History

Version	Revision Date	Revision Notes	Maintainer
1.0	2026-3-20	Initial version	Hao

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