E32-400T20S Product Specifications

433/470 MHz TTL LoRa Wireless Module

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Chapter 1 Product Overview

1.1 Product Introduction

E32-400T20S is a wireless serial port module developed by Ebyte for the wireless meter reading industry. It has a LoRa spread spectrum solution, an air wake-up function (low power consumption) a factory default 470MHz meter reading frequency band, and a long packet mode (197 bytes per packet), which can meet the application needs of the meter reading industry.

E32-400T20S supports LoRa ™ spread spectrum technology. LoRa ™ direct sequence spread spectrum technology has the advantages of longer communication distance, strong anti-interference ability, and strong confidentiality. It is a milestone in the field of low-speed communication and is favored by industry insiders. The default air rate of this series is 2.4kbps , the transmission power is 20dBm, and the industrial-grade crystal oscillator is used to ensure its stability and consistency. The accuracy is less than 10ppm commonly used in the industry. It has been in stable mass production and has been widely used in the fields of three-meter industry, Internet of Things transformation, smart furniture, etc.

E32-400T20S strictly complies with domestic and foreign design specifications such as FCC, CE, CCC, meets various RF-related certifications, and meets export requirements.

1.2 Features

- Supports advanced LoRa modulation mode , with the advantage of long-distance anti-interference ;
- Under ideal conditions, the communication distance can reach 5 km , which is better than traditional GFSK .
- Supports fixed-point transmission, broadcast transmission, and channel monitoring;
- Supports air wake-up (ultra-low power consumption) , suitable for battery applications;
- Support long packet mode, each packet is 197 bytes ;
- Maximum transmit power 20dBm (100mW) , software-adjustable in multiple levels;
- Supports global license-free ISM 433/470MHz frequency band;
- Supports data transmission rates of 0.3k to 19.2kbps;
- Supports 2.3 ~ 5.5 V power supply, and the best performance can be guaranteed when the power supply is greater than 3.3V ;
- Adopt active temperature compensated crystal oscillator, industrial standard design, support long-term use at -40 ~ + 85 ℃ ;
- Dual antennas are optional (IPEX / stamp hole), users can use them according to their needs.

1.3 Application Scenario

- Home security alarm and remote keyless entry;
- Smart home and industrial sensors, etc.
- Wireless alarm security system;
- Building automation solutions;

- Wireless industrial remote control;
- Smart smart agriculture and oilfield solutions;
- Healthcare products;
- Advanced Metering Infrastructure (AMI);
- Automotive industry applications.

Chapter 2 Specifications

2.1 Limit parameters

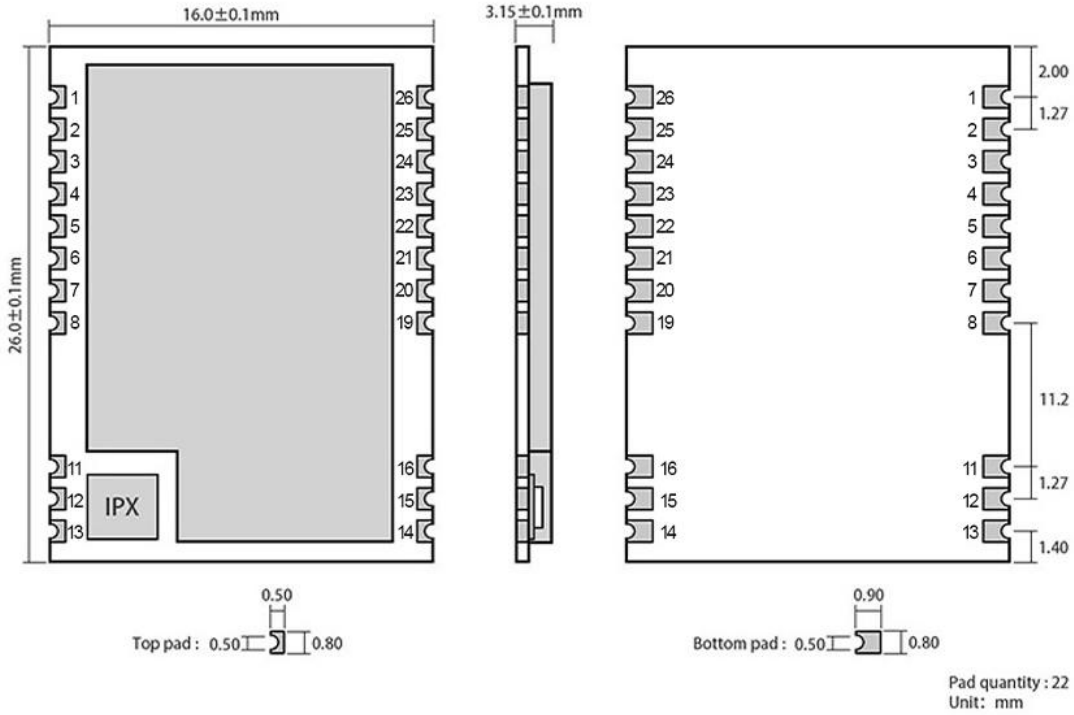
Main parameters	Performance		Remark
	Minimum	Maximum	
Supply voltage (V)	0	5. 5	the voltage exceeds 5.5 V , the module may be damaged.
Blocking power (dBm)	-	- 10	The probability of burning is lower when used at close range
Operating temperature (℃)	-40	+ 85	Industrial Grade

2.2 Working Parameters

Main parameters		Performance			Remark
		Minimum	Typical Value	Maximum	
Operating voltage (V)		2.3	5.0	5.5	≥ 5 V guaranteed output power
Communication level (V)			3. 3		Using 5V TTL may burn out
Operating temperature (℃)		-40	-	+ 85	Industrial-grade design
Working frequency band (MHz)		410	-	525	Support ISM band
Power consumption	Emission current (mA)		106		Instantaneous power consumption
	Receive current (mA)		15		
	Sleep current (μA)		4		Software shutdown
Maximum transmit power (dBm)		19.0	19.5	20.0	
Receiving sensitivity (dBm)		-144	-146	-147	The air rate is 2.4kbps
Air rate (bps)		0.3k	2.4k	19.2 k	User -configured

Main parameters	Describe	Remark
Reference distance	5000m	Clear and open environment, antenna gain 5dBi, antenna height 2.5 meters, air rate 2.4kbps
Subcontracting	197 Byte	The maximum capacity of a single package, if exceeded, it will be automatically divided into packages.
Cache capacity	512 Byte	
Modulation	LoRa™	
Communication interface	UART Serial Port	TTL level
Packaging	SMD	
Interface	Stamp Holes	1.27mm
Dimensions	16*26mm	
Antenna interface	IPEX/Stamp Hole	Characteristic impedance is about 50 ohms

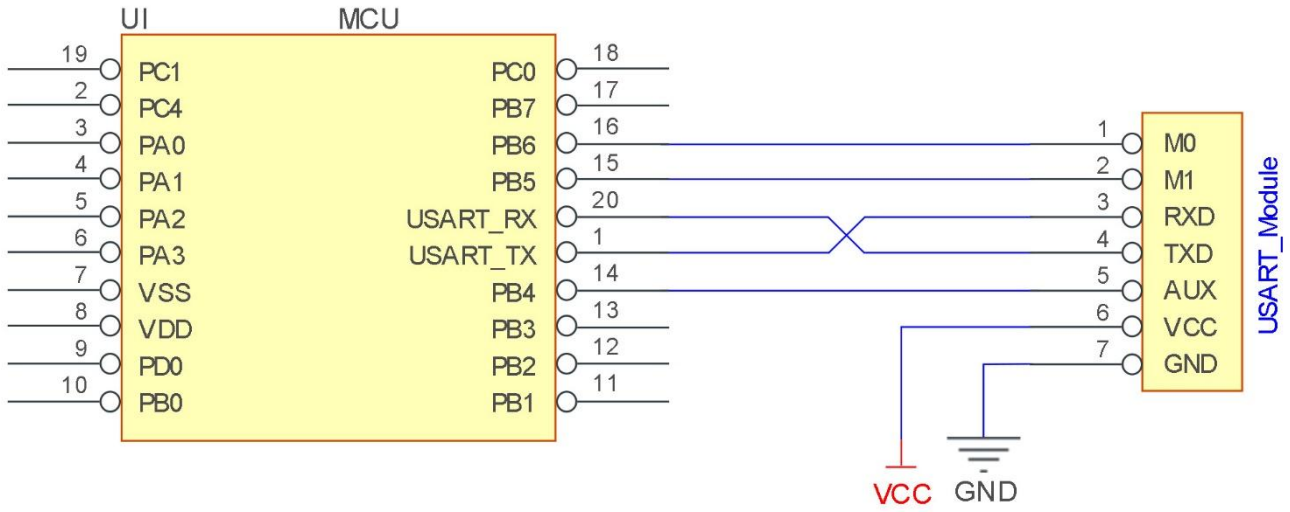
Chapter 3 Mechanical Dimensions and Pin Definition



Pin number	Pin Name	Pin Direction	Pin Purpose

1	NC	-	Empty feet
2	GND	-	Module ground wire
3	NC	-	Empty feet
4	NC	-	Empty feet
5	NC	-	Empty feet
6	NC	-	Empty feet
7	NC	-	Empty feet
8	GND	-	Module ground wire
11	GND	-	Module ground wire
12	ANT	-	Antenna
13	GND	-	Module ground wire
14	GND	-	Module ground wire
15	GND	-	Module ground wire
16	GND	-	Module ground wire
19	GND	-	Module ground wire
20	M0	Input (very weak pull-up)	Cooperate with M1 to determine the 4 working modes of the module (cannot be left floating, can be grounded if not used)
21	M1	Input (very weak pull-up)	Cooperate with M0 to determine the 4 working modes of the module (cannot be left floating, can be grounded if not used)
22	RxD	Enter	TTL serial port input, connected to external TXD output pin;
23	TXD	Output	TTL serial port output, connected to external RXD input pin;
24	AUX	Output	Used to indicate the working status of the module; The user wakes up the external MCU, and the power-on self-test initialization period outputs a low level; (can be left floating)
25	VCC	-	Module power positive reference, voltage range: 2.6～5.5V DC
26	GND	-	Module ground wire

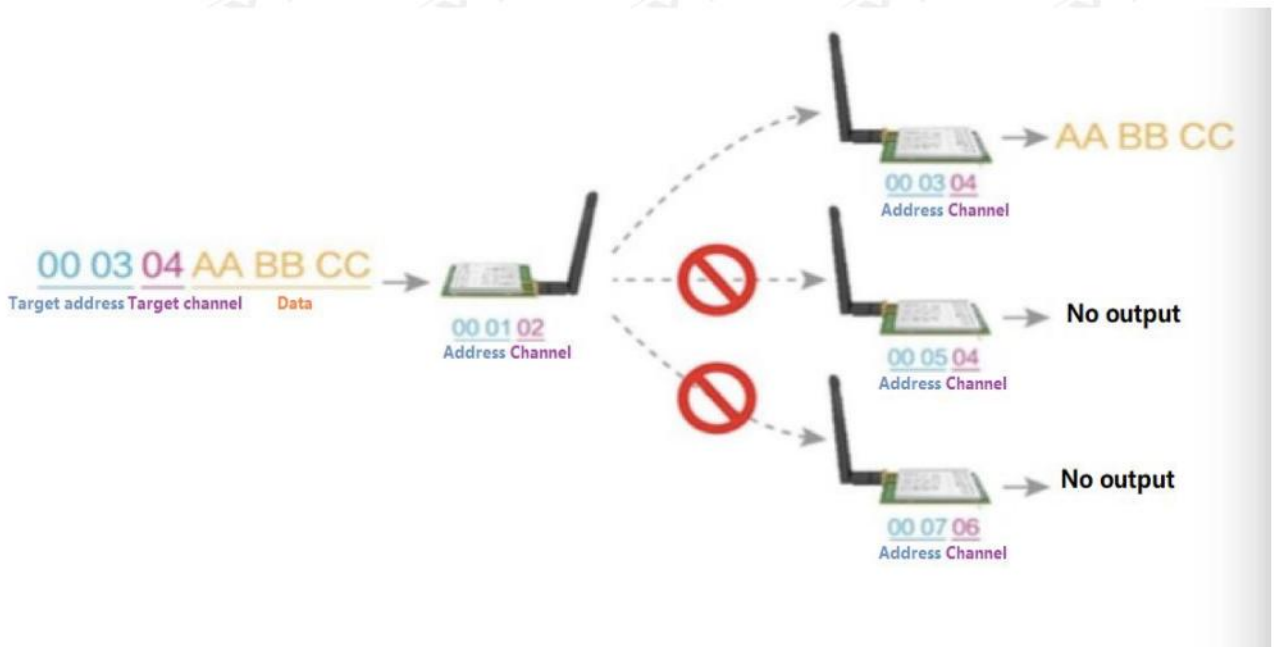
Chapter 4 Recommended Connection Diagram



Serial number	Brief connection instructions between the module and the MCU (the above figure takes the STM8L MCU as an example)
1	The wireless serial port module is TTL level, please connect it to the TTL level MCU.
2	Some 5V microcontrollers may require 4-10K pull-up resistors to be added to the TXD and AUX pins of the module.

Chapter 5 Functional Details

5.1 Fixed-point transmission (Hexadecimal)



5.2 Broadcast transmission (hexadecimal)

5.3 Broadcast Address

- For example: Set the module A address to 0xFFFF and the channel to 0x04.

- When module A is used as a transmitter (same mode, transparent transmission), all receiving modules under channel 0x04 can receive data, thus achieving the purpose of broadcasting.

5.4 Listening address

- For example: Set the module A address to 0xFFFF and the channel to 0x04.
- When module A is used as a receiver, it can receive all the data under channel 0x04 to achieve the purpose of monitoring.

5.5 Module Reset

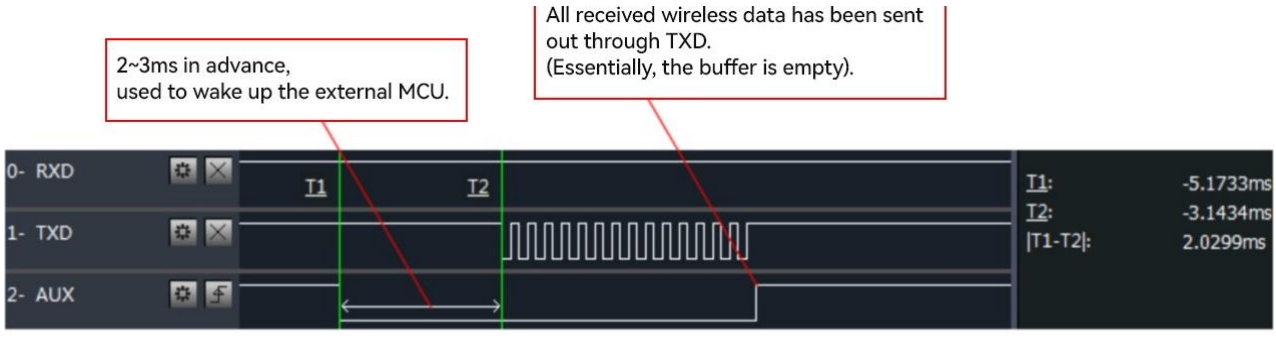
- After the module is powered on, AUX will immediately output a low level, perform a hardware self-test, and set the working mode according to the user parameters. During this process, AUX maintains a low level, and after completion, AUX outputs a high level and starts normal operation according to the working mode composed of M1 and M0. Therefore, the user needs to wait for the rising edge of AUX as the starting point for the normal operation of the module.

5.6 AUX Detailed Explanation

- AUX is used for wireless transceiver buffer indication and self-test indication.
- It indicates whether the module has data that has not been transmitted wirelessly, or whether the received wireless data has not been sent out through the serial port, or the module is in the process of initializing self-test.

5.6.1 Serial port data output indication

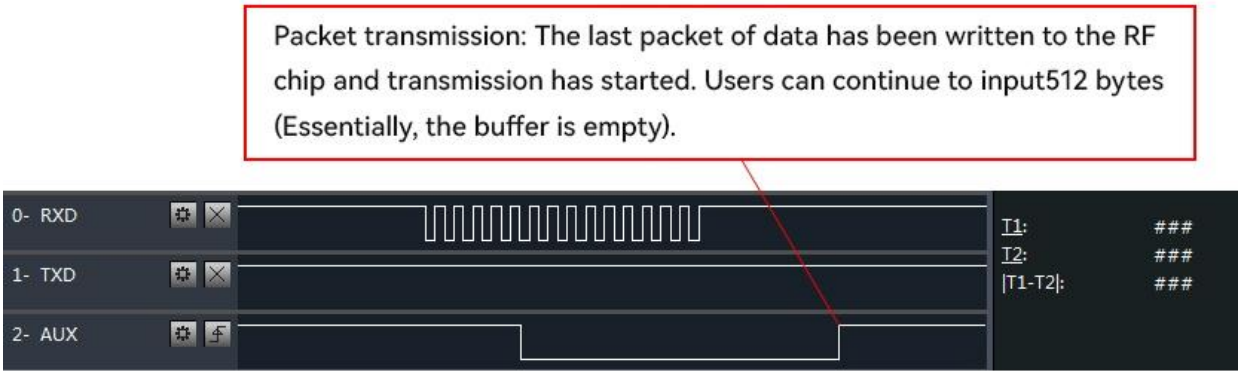
- MCU in sleep mode ;



AUX pin timing diagram when module serial port sends out data.

5.6.2 Wireless transmission indication

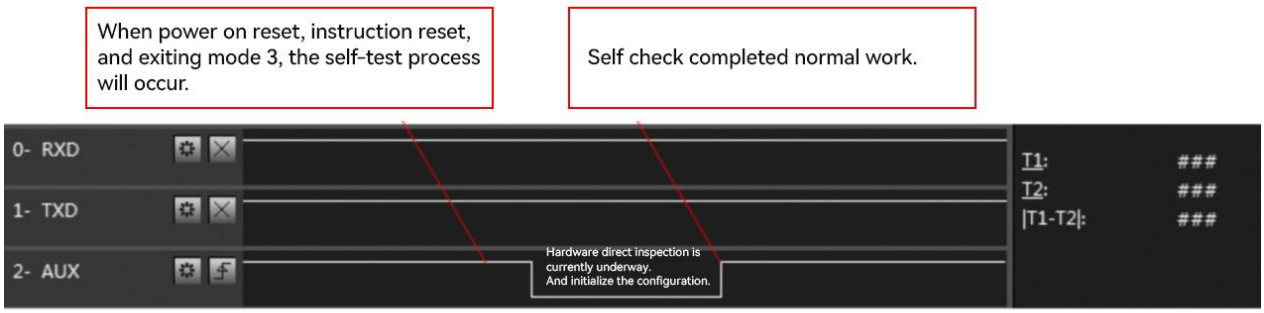
- Buffer empty: data in the internal 512-byte buffer are all written to the wireless chip (automatically divided into packets);
- When AUX=1, the user continuously sends data less than 512 bytes without overflow;
- When AUX=0, the buffer is not empty: the data in the internal 512-byte buffer has not been fully written to the wireless chip and the transmission has not yet started. At this time, the module may have timed out waiting for the end of user data, or is transmitting wireless packets;
- 【Note】: When AUX=1, it does not mean that all serial port data of the module has been transmitted wirelessly. It is also possible that the last packet of data is being transmitted.



AUX pin timing diagram when the module receives serial port data.

5.6.3 The module is being configured

- Only when resetting and exiting sleep mode;



During self check, AUX pin timing diagram.

5.6.4 AUX Notes

- For the above functions 1 and 2, the output low level is given priority, that is, if any low level output condition is met, AUX will output a low level; when all low level conditions are not met, AUX will output a high level.
- When AUX outputs a low level, it means the module is busy and the working mode detection will not be performed at this time; when the module AUX outputs a high level within 1ms, the mode switching will be completed.

- After the user switches to a new working mode, the module will not actually enter this mode until at least 2ms after the AUX rising edge. If AUX is always at a high level, the mode switch will take effect immediately.
- When the user enters other modes from mode 3 (sleep mode) or during the reset process, the module will reset the user parameters, during which AUX outputs a low level.
- Due to the characteristics of the LoRa modulation method, the information transmission delay is much longer than that of FSK. For example, at an airspeed of 1.2kbps, the transmission delay of 100 bytes is about 1.5 seconds. Customers are advised not to transmit large amounts of data at low airspeeds to avoid data loss due to data accumulation and cause communication abnormalities.

Chapter 6 Working Mode

The module has four working modes, which are controlled by pins M0 , M1 Settings; details are shown in the following table:

Mode (0-3)	M0	M1	Mode Introduction	Remark
0 Normal mode	0	0	Serial port open, wireless open, transparent transmission	The receiver must be in mode 0 or 1
1 Wake-up mode	1	0	Serial port is turned on, wireless is turned on; The only difference from mode 0: before the data packet is transmitted, a wake-up code is automatically added to wake up the receiver working in mode 2	The receiver can be mode 0 The receiver can be mode 1 The receiver can be mode 2
2 Power saving mode	0	1	The serial port reception is closed, the wireless is in air wake-up mode, and after receiving wireless data, the serial port is opened to send data.	The transmitter must be in mode 1 Cannot transmit in this mode
3 Sleep mode	1	1	The module enters sleep mode and can receive parameter setting commands.	See the detailed working parameters for details.

6.1 Mode Switching

- The user can combine M0 and M1 with high and low levels to determine the working mode of the module. The 2 GPIOs of the MCU can be used to control the mode switching; after changing M0 and M1: the module is idle, and after 1ms, it can start working in the new mode; if the module has serial port data that has not been transmitted through the wireless, it can enter the new working mode only after the transmission is completed; if the module receives wireless data and sends data out through the serial port, it needs to send it out before entering the new working mode; so the mode switching is only effective when the AUX output is 1, otherwise the switching will be delayed.

- For example, in mode 0 or mode 1, if the user continuously inputs a large amount of data and switches modes at the same time, the mode switching operation is invalid. The module will process all user data before detecting a new mode. Therefore, it is generally recommended to detect the output status of the AUX pin and wait for 2ms after the AUX output is high before switching.

- When the module is switched from other modes to sleep mode, if there is data that has not been processed, the module will enter sleep mode only after processing the data (including receiving and sending). This feature can be used for fast sleep, thereby saving power consumption; for example: the transmitting module works in mode 0, the user initiates the serial port data "12345", and then there is no need to wait for the AUX pin to be idle (high level), and it can be directly switched to sleep mode, and the user's main MCU will be put to sleep immediately. The module will automatically send all the user data wirelessly and automatically enter sleep within 1ms, thereby saving the MCU's working time and reducing power consumption.

- Similarly, any mode switching can take advantage of this feature. After the module processes the current mode event, it will automatically enter the new mode within 1ms. This saves the user the work of querying AUX and can achieve the purpose of fast switching; for example, switching from transmit mode to receive mode. The user MCU can also enter sleep mode in advance before the mode switching, and use the external interrupt function to obtain AUX changes to switch the mode.

- This operation mode is very flexible and efficient, designed entirely according to the operational convenience of the user's MCU, and can reduce the workload of the entire system as much as possible, improve system efficiency, and reduce power consumption.

6.2 Normal mode (mode 0)

Type	When M0 = 0, M1 = 0, the module works in mode 0
Sending	The module receives user data from the serial port. The length of the wireless data packet transmitted by the module is 58 bytes. When the amount of data input by the user reaches 58 bytes, the module will start wireless transmission. At this time, the user can continue to input the data to be transmitted. When the bytes that the user needs to transmit are less than 58 bytes, the module waits for 3 bytes. If there is no more user data input, it is considered that the data is terminated. At this time, the module sends all data packets wirelessly. When the module receives the first user data, AUX outputs a low level. When the module puts all the data into the RF chip and starts transmitting, AUX outputs a high level. At this point, it indicates that the last packet of wireless data has been transmitted, and the user can continue to input data up to 512 bytes; Data packets sent in mode 0 can only be received by receiving modules in mode 0 or mode 1.
Reciving	The module keeps the wireless receiving function on and can receive data packets from mode 0 and mode 1. After receiving the data packet, the module AUX outputs a low level, and after a delay of 5ms, it starts to send the wireless data through the serial port TXD pin. After all the wireless data is output through the serial port, the module AUX outputs a high level.

6.3 Wake-up mode (mode 1)

Type	When M0 = 1, M1 = 0, the module works in mode 1
Sending	The module starts transmitting data packets under the same conditions as the AUX function in mode 0. The only difference is that the module will automatically add a wake-up code before each data packet, and the length of the wake-up code depends on the wake-up time set in the user parameters; The purpose of the wake-up code is to wake up the receiving module working in mode 2; Therefore, the data transmitted by mode 1 can be received by modes 0, 1, and 2.
Reciving	Equivalent to mode 0.

6.4 Power saving mode (mode 2)

Type	When M0 = 0, M1 = 1, the module works in mode 2
Sending	The module is in sleep mode, the serial port is closed, and it cannot receive serial port data from the external MCU, so this mode does not have the wireless transmission function.
Reciving	In mode 2, the transmitter must work in mode 1; monitor the wake-up code regularly. Once a valid wake-up code is received, the module will continue to be in the receiving state and wait for the entire valid data packet to be received; Then AUX outputs a low level. After a delay of 5ms, the serial port is opened to send the received wireless data through TXD. After completion, AUX outputs a high level. The wireless module continues to enter the "sleep-listen" working state (polling). By setting different wake-up times, the module has different receiving response delays (up to 2s) and average power consumption (minimum 30uA); Users need to strike a balance between communication latency and average power consumption.

6.5 Sleep mode (mode 3)

Type	When M0 = 1, M1 = 1, the module works in mode 3
Sending	Unable to transmit wireless data.
Reciving	Unable to receive wireless data.
Configuration	The sleep mode can be used to set the module parameters. Use the serial port 9600 and 8N1 to set the module working parameters through a specific instruction format.
Notice	When entering other modes from sleep mode, the module will reconfigure parameters. During the configuration process, AUX remains at a low level. After completion, it outputs a high level, so it is recommended that users detect the rising edge of AUX.

Chapter 7 Instruction Format

In sleep mode (mode 3: M0=1, M1=1), the supported command list is as follows (when setting, only 9600, 8N1

format is supported):

Serial number	Instruction Format	Detailed description
1	C0+ Operating Parameters	Send C0+5 bytes of working parameters in hexadecimal format, a total of 6 bytes, must be sent continuously (save when power is off)
2	C1+C1+C1	Send three C1s in hexadecimal format, and the module returns the saved parameters. They must be sent continuously.
3	C2+ Operating Parameters	Send C2+5 bytes of working parameters in hexadecimal format , a total of 6 bytes, must be sent continuously (not saved when power is off)
4	C3+C3+C3	Send three C3 in hexadecimal format, and the module returns version information. It must be sent continuously.
5	C4+C4+C4	Send three C4s in hexadecimal format and the module will generate a reset. This must be sent continuously.

7.1 Factory default parameters

Model	Factory default parameter value: C0 00 00 1A 3C 40						
Module Model	Frequency	Address	Channel	Air speed	Baud rate	Serial port format	Transmit power
E32 - 400T20S	470MHz	0x0000	0x3C	2.4kbps	9600	8N1	20dBm

7.2 Reading working parameters

Instruction Format	Detailed description
C1+C1+C1	In sleep mode (M0=1, M1=1), send a command (HEX format) to the module serial port: C1 C1 C1, the module will return the current configuration parameters, for example: C0 00 00 1A 17 44.

7.3 Version number reading

Instruction Format	Detailed description
C3+C3+C3	In sleep mode (M0=1, M1=1), send a command to the module serial port (HEX format): C3 C3 C3, the module will return the current configuration parameters, for example: C3 32 xx yy; the second byte represents the frequency, if it is 32 , it is 433 MHz applicable frequency; if it is 38 , it is 470MH z applicable frequency; if it is 45 , it is 868 MHz applicable frequency; if it is 44 , it is 915 MHz applicable frequency; if it is 46 , it is 170 MHz applicable frequency; xx is the version number, and yy refers to other features of the module.

7.4 Reset Instructions

Instruction Format	Detailed description
C4+C4+C4	In sleep mode (M0=1, M1=1), send a command (HEX format) to the module serial port: C4 C4 C4, the module will generate a reset; during the reset process, the module performs a self-check, and AUX outputs a low level. After the reset is completed, AUX outputs a high level, and the module starts to work normally. At this time, you can switch modes or initiate the next instruction.

7.5 Parameter setting instructions

	Name	Describe				Remark
0	HEAD	Fixed 0xC0 or 0xC2, indicating that this frame data is a control command				Must be 0xC0 or C2: C0: The set parameters will be saved when the power is off; C2: The set parameters will not be saved when the power is off.
1	ADDH	Module address high byte (default 00H)				00H-FFH
2	ADDL	Module address low byte (default 00H)				00H-FFH
3	SPED	7	6	Serial port check digit		The serial port modes of the two communicating parties can be different.
		0	0	8N1 (default)		
		0	1	801		
		1	0	8E1		
		1	1	8N1 (equivalent to 00)		
		5	4	3	TTL serial port rate (bps)	The baud rates of the two communicating parties can be different; The serial port baud rate has nothing to do with the wireless transmission parameters and does not affect the wireless transceiver characteristics.
		0	0	0	The serial port baud rate is 1200	
		0	0	1	The serial port baud rate is 2400	
		0	1	0	The serial port baud rate is 4800	
		0	1	1	The serial port baud rate is 9600 (default)	
		1	0	0	The serial port baud rate is 19200	
		1	0	1	The serial port baud rate is 38400	
		1	1	0	The serial port baud rate is 57600	
		1	1	1	The serial port baud rate is 115200	
		2	1	0	General wireless air rate (bps)	The lower the air rate, the longer the distance, the stronger the anti-interference performance and the longer the transmission time; The wireless transmission rate over the air must be the same between the two communicating parties.
		0	0	0	The air speed is 0.3k	
		0	0	1	The air speed is 1.2k	
		0	1	0	The air rate is 2.4k (default)	
		0	1	1	The air rate is 4.8k	
		1	0	0	Air speed is 9.6k	
		1	0	1	The air speed is 19.2k	
		1	1	0	Air speed is 19.2k (same as 101)	
		1	1	1	Air speed is 19.2k (same as 101)	
4	CHAN	7～0 bits, corresponding to (410 MHz+CHAN * 1 MHz) , default 3CH (470MHz)				00H-73H, corresponding to 410 ~ 525MHz
5	OPTION	7	Fixed-point transmission enable bit (similar to MODBUS)			When it is 1, the first 3 bytes of each user data frame are used as high and low addresses and channels. When transmitting, the module changes its own address and channel, and restores the original settings after completion.
		0	Transparent transmission mode			
		1	Fixed-point transmission mode			
		6	IO driver mode (default 1)			This bit is used to enable the internal pull-up resistor of the module; The open-drain mode has stronger level adaptability and may require an external pull-up resistor in some cases.
		1	TXD, AUX push-pull output, RXD pull-up input			
		0	TXD, AUX open circuit output, RXD open circuit input			
		5	4	3	Wireless wake-up time	When both the transceiver and transmitter modules work in mode 0, the
		0	0	0	250ms (default)	

		0	0	1	500ms	delay time is invalid and can be any value. The transmitter works in mode 1 and will continue to transmit the call code for the corresponding time; The receiver works in mode 2. This time refers to the receiver's monitoring interval (wireless wake-up). It can only receive data from the transmitter working in mode 1. The longer the wake-up time, the lower the power consumption.
		0	1	0	750ms	
		0	1	1	1000ms	
		1	0	0	1250ms	
		1	0	1	1500ms	
		1	1	0	1750ms	
		1	1	1	2000ms	
		2	FEC Switch			After turning off FEC, the actual data transmission rate increases, but the anti-interference ability decreases, and the distance is slightly closer. Please choose according to the actual application; Both communicating parties must be on or off.
		0	Disable FEC error correction (default)			
		1	Enable FEC error correction			
		1	0	Transmit power (approximate)		The external power supply must provide a current output capability of more than 250mA and ensure that the power ripple is less than 100mV ; It is not recommended to use a lower power transmission because its power utilization efficiency is not high.
		0	0	20dBm (default)		
		0	1	17dBm		
		1	0	14 dBm		
		1	1	10dBm		

Example (the meaning of the byte "SPED" in sequence number 3):								
The binary bits of the byte	7	6	5	4	3	2	1	0
Specific value (user configuration)	0	0	0	1	1	0	1	0
Representative significance	Serial port check bit 8N1		The serial port baud rate is 9600			The air rate is 2.4k		
Corresponding hexadecimal	1				A			

Chapter 8 Hardware Design

- It is recommended to use a DC regulated power supply to power the module. The power supply ripple coefficient should be as small as possible and the module should be reliably grounded.
- Please pay attention to the correct connection of the positive and negative poles of the power supply. Reverse connection may cause permanent damage to the module.
- Please check the power supply to ensure that it is within the recommended power supply voltage. If it exceeds the maximum value, the module will be permanently damaged.
- Please check the stability of the power supply. The voltage should not fluctuate greatly or frequently.
- When designing the power supply circuit for the module, it is often recommended to retain more than 30% margin, which is conducive to long-term stable operation of the whole machine;
- The module should be kept as far away as possible from power supplies, transformers, high-frequency wiring

and other parts with large electromagnetic interference;

- High-frequency digital routing, high-frequency analog routing, and power routing must avoid the bottom of the module. If it is necessary to pass under the module, assuming that the module is soldered on the Top Layer, ground copper should be laid on the Top Layer of the module contact part (all copper should be laid and well grounded), and it must be close to the digital part of the module and routed on the Bottom Layer ;
- Assuming the module is soldered or placed on the Top Layer, it is also wrong to randomly route the wires on the Bottom Layer or other layers, which will affect the module's spurious signal and receiving sensitivity to varying degrees ;
- If there are devices with large electromagnetic interference around the module, it will also greatly affect the performance of the module. It is recommended to keep away from the module according to the intensity of the interference. If possible, appropriate isolation and shielding can be performed.
- If there are traces with large electromagnetic interference around the module (high-frequency digital, high-frequency analog, power traces), it will also greatly affect the performance of the module. It is recommended to keep them away from the module according to the intensity of the interference. If possible, appropriate isolation and shielding can be performed.
- If the communication line uses 5V level, a 1k-5.1k resistor must be connected in series (not recommended, there is still a risk of damage) ;
- Try to stay away from some TTL protocols whose physical layer is also 2.4GHz, such as USB3.0;
- The antenna installation structure has a great impact on the module performance. Make sure the antenna is exposed and preferably vertically upward;
- When the module is installed inside the case, you can use a high-quality antenna extension cable to extend the antenna to the outside of the case;
- The antenna must not be installed inside a metal shell, as this will greatly reduce the transmission distance.

Chapter 9 FAQ

9.1 The transmission distance is not ideal

- When there is a straight-line communication obstacle, the communication distance will be attenuated accordingly ;
- Temperature, humidity, and co-channel interference can increase the communication packet loss rate ;
- The ground absorbs and reflects radio waves, so the test results are poor when close to the ground ;
- Seawater has a strong ability to absorb radio waves, so the test results at the seaside are poor ;
- If there are metal objects near the antenna, or the antenna is placed in a metal shell, the signal attenuation will be very serious ;
- The power register is set incorrectly, or the air rate is set too high (the higher the air rate, the closer the distance) ;
- The power supply voltage at room temperature is lower than the recommended value. The lower the voltage, the lower the power output .
- The antenna used does not match the module well or the antenna itself has quality issues.

9.2 Modules are vulnerable to damage

- Please check the power supply to ensure that it is within the recommended power supply voltage. If it exceeds the maximum value, the module will be permanently damaged .
- Please check the stability of the power supply. The voltage should not fluctuate greatly or frequently .
- Please ensure anti-static operation during installation and use, as high-frequency components are sensitive to static electricity ;
- Please ensure that the humidity is not too high during installation and use, as some components are humidity sensitive devices ;
- If there is no special requirement, it is not recommended to use it at too high or too low temperature.

9.3 Bit Error Rate Too High

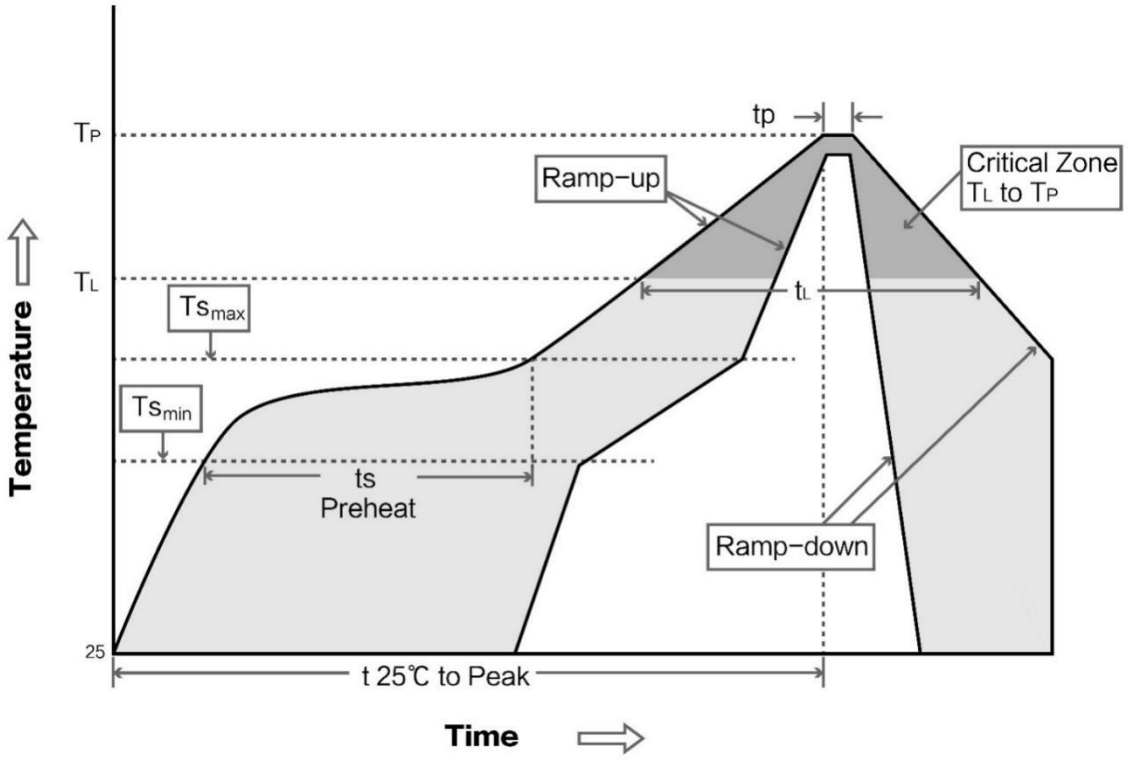
- There is interference from the same frequency signal nearby. Stay away from the interference source or change the frequency or channel to avoid interference.
- Unsatisfactory power supply may also cause garbled characters, so the reliability of the power supply must be ensured;
- Extension cables or feeder cables that are of poor quality or are too long can also cause a high bit error rate.

Chapter 10 Welding Operation Instructions

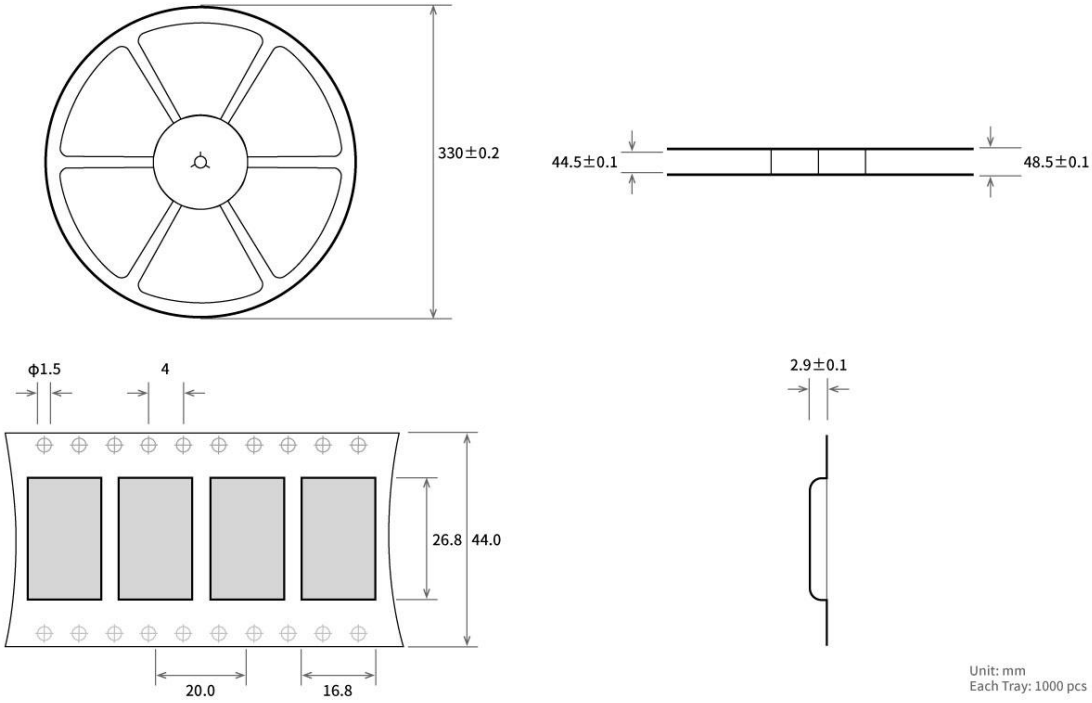
1 0.1 Reflow temperature

Profile Feature	Curve characteristics	Sn-Pb Assembly	Pb-Free Assembly
Solder Paste	Solder Paste	Sn63/Pb37	Sn96.5/Ag3/Cu0.5
Preheat Temperature min (Tsmin)	Minimum preheating temperature	100 ℃	150 ℃
Preheat temperature max (Tsmax)	Maximum preheating temperature	150 ℃	200 ℃
Preheat Time (Tsmin to Tsmax)(ts)	Warm-up time	60-120 sec	60-120 sec
Average ramp-up rate(Tsmax to Tp)	Average ascent rate	3 ℃ /second max	3 ℃ /second max
Liquid Temperature (TL)	Liquidus temperature	183 ℃	217 ℃
Time(tL)Maintained Above(TL)	Time above liquidus	60-90 sec	30-90 sec
Peak temperature (Tp)	Peak temperature	220-235 ℃	230-250 ℃
Aveage ramp-down rate（Tp to Tsmax）	Average descent rate	6 ℃ /second max	6 ℃ /second max
Time 25 ℃ to peak temperature	Time from 25 ℃ to peak temperature	6 minutes max	8 minutes max

1 0.2 Reflow Oven Curve



Chapter 11 Bulk Packaging Methods



Revision History

Version	Revision Date	Revision Notes	Maintainer
1.0	2017-11-10	Initial release	huaa
1.1	2018-01-11	New Models	huaa
1.2	2018-01-15	New Models	huaa
1.3	2018-01-22	New Models	huaa
1.4	2018-05-24	Added antenna selection	h ua
1.5	2018-10-11	Manual Split	h ua
1.6	2019-03-15	Content Modifications	R ay
1.8	2019-10-24	Content Modifications	Ren
1.9	2020-04-13	Content Modifications	Ren
2.0	2023-2-10	Content Modifications	Yan

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