ROHS , TS16949 , ISO9001

ST903P

Multi-system Multi Frequency Band High Precision RTK Navigation and Positioning Module

Manual

www.xbteek.com

Revision History

Ver No.	Version	Date
V.1	New	July, 2022

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Catalogue

1. Product Descriptions

1.1 Product Overview

ST903P, the multi-system multi-frequency RTK high-precision navigation and positioning module designed and produced by Shenzhen Simple Technology Electronics Co., LTD, is a professional high-precision positioning module for centimeter-level high-precision positioning application. The module based on the design of high-precision navigation and positioning chip and the company's completely independent intellectual property rights of high-precision calculation, supports BDS, GPS/QZSS, Galileo, GLONASS multi-system, multi-frequency, internal integration of RTK algorithm, can provide stable centimeter-level high-precision positioning services. ST903P, with compact size, using LGA pad, supports standard take and place and reflow welding, has the anti-interference, small size, low power consumption, high precision degree characteristics. It is a professional CM level high precision navigation and positioning module of high cost-effective.

1.2 Main features

- Can receive multi-systems multi-frequency signals at the same time
- Support the signals of Beidou-3 satellite
- Multi-frequency RTK algorithm, centimeter-level positioning accuracy
- Smart Suppress^{TM} anti-interference technology
- 22*17mm of mainstream package dimension for easy integration
- Support antenna status detection function
- Support AGNSS, fast positioning

1.3 Application Areas

Widely used in transportation, agriculture, forestry, communications, power, surveying and mapping, disaster prevention and relief and other industries of monitoring, high-precision location services and high-precision vehicle navigation, intelligent logistics, intelligent robots, drones, automatic driving and other fields.

1.4 Performance Indicators

Power Supply	
Voltage	3.0V ~ 3.6V
RF Input Frequency band	BDS B1I, B2I, B1C GPS/QZSS L1C/A, L2C GLONASS L1, L2 Galileo E1
Standing-wave ratio	1.5 or less
Input impedance	50 Ω
Antenna gain	5 ~40dB
Physical characteristics	
Size	22 x 17 x 2.4 (mm)
Input/output data interface	
UART	LVTTL level; Default baud rate 115200bps
GNSS performance	
First positioning time [1]	Cold start: ≤35s Hot start: ≤1s Recapture: ≤1s

Positioning accuracy [2]	Single point positioning 2.0m RTK 0.02m+1ppm
Fixed solution convergence time	≤10s
Speed measurement accuracy [3]	0.05 m/s
Sensitivity [4]	Tracking: -160dBm
	Capture: -146 DBM
1PPS accuracy	50ns
Data update rate	1 /2 /5 /10Hz
Navigation data Format	NMEA0183 V4.10; RTCM3.X

[1] Test conditions: the number of available satellites is greater than 6, and the signal strength of all satellites is not less than -130dBm.

[2] Test conditions: CEP,50%, the number of satellites is greater than 8, 24 hours static positioning, the signal strength of all satellites is not less than -130dBm

[3] Test conditions: CEP,50%@30m/s

[4] Test conditions: LNA test with good performance for external use

1.5 Block diagram of module

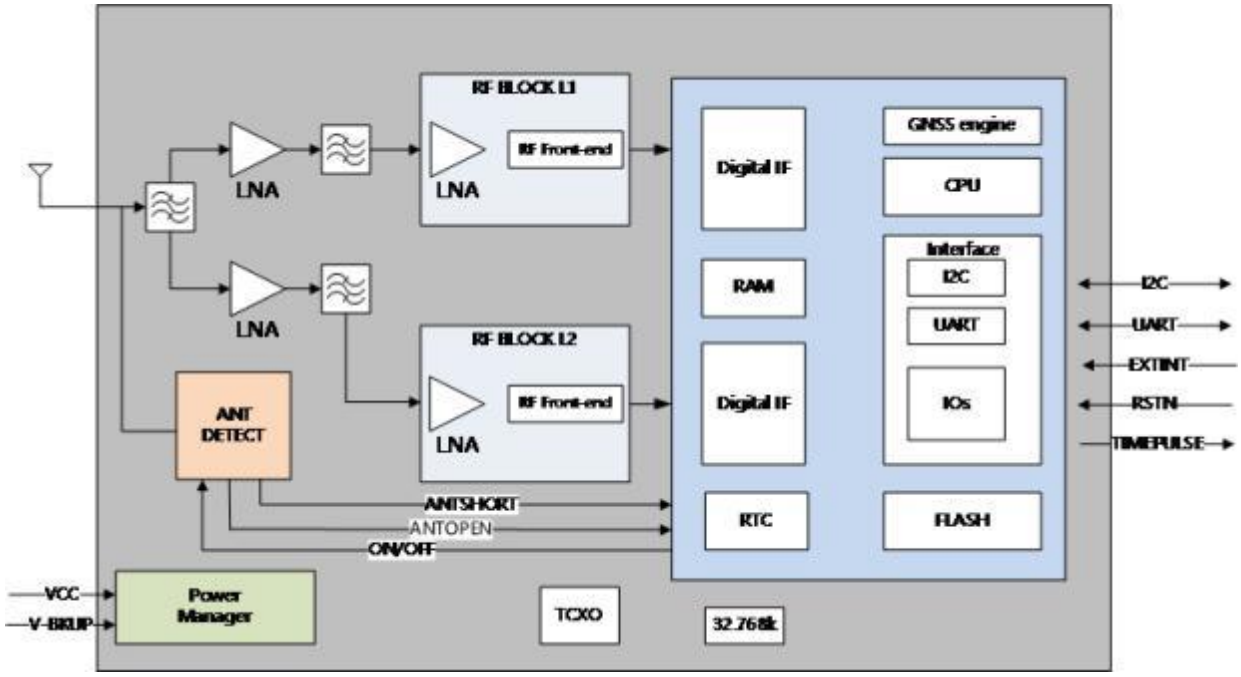

Figure 1-2 Block diagram of the module

2. Pins Description

2.1 Pins schematic

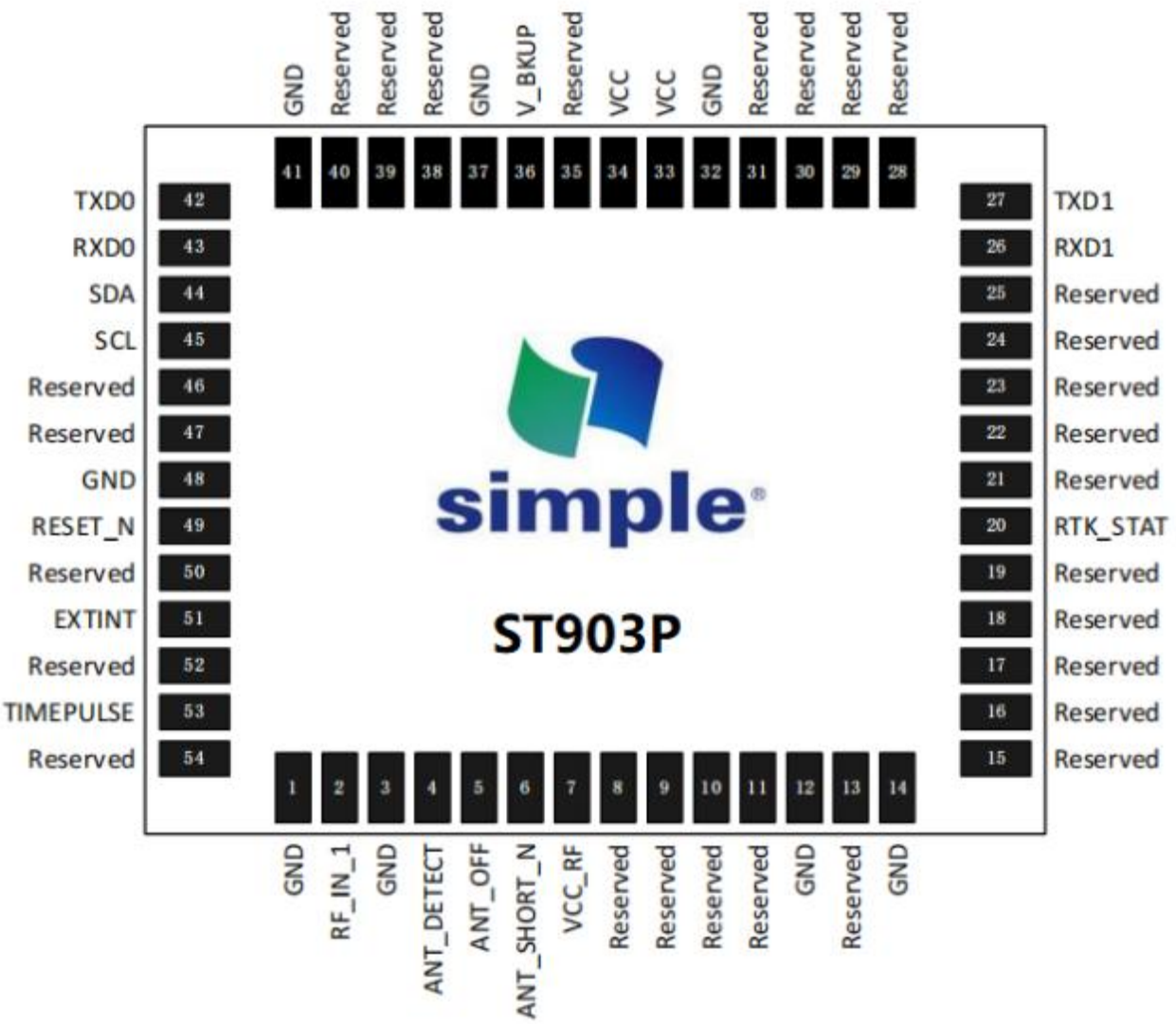

Figure 2-1 Pins diagram

2.2 Pins Description

Pin	Name	I/O	Level	Pins Description
1	GND	PWR	- -	Digital and power supply ground
2	RF_IN_1	I	- -	RF signal input
3	GND	PWR	- -	Digital and power supply ground
4	ANT_DETECT	O	LVTTL	Antenna open, detection output (open in high, normal in low)
5	ANT_OFF	O	LVTTL	Built-in antenna feed, switch control (off in high, enable in low)
6	ANT_SHORT_N	O	LVTTL	Antenna short, detection output (normal in high, short in low)
7	VCC_RF	O	3.3 V + / - 10%	feed output of the built-in module
8	Reserved	- -	- -	Keep the pin and do not connect to any networks
9	Reserved	- -	- -	Keep the pin and do not connect to any networks
10	Reserved	- -	- -	Keep the pin and do not connect to any network
11	Reserved	- -	- -	Keep the pin and do not connect to any networks
12	GND	PWR	- -	Digital and power supply ground
13	Reserved	- -	- -	Keep the pin and do not connect to any networks
14	GND	PWR	- -	Digital and power supply ground
15	Reserved	- -	- -	Keep the pin and do not connect to any networks
16	Reserved	- -	- -	Keep the pin and do not connect to any networks
17	Reserved	- -	- -	Keep the pin and do not connect to any networks
18	Reserved	- -	- -	Keep the pin and do not connect to any networks
19	Reserved	- -	- -	Keep the pin and do not connect to any networks
20	RTK_STAT	O	LVTTL	RTK status information
21	Reserved	- -	- -	Keep the pin and do not connect to any networks

22	Reserved	- -	- -	Keep the pin and do not connect to any networks
23	Reserved	- -	- -	Keep the pin and do not connect to any networks
24	Reserved	- -	- -	Keep the pin and do not connect to any networks
25	Reserved	- -	- -	Keep the pin and do not connect to any networks
26	RXD1	I	LVTTL	Input
27	TXD1	O	LVTTL	Output
28	Reserved	- -	- -	Keep the pin and do not connect to any networks
29	Reserved	- -	- -	Keep the pin and do not connect to any networks
30	Reserved	- -	- -	Keep the pin and do not connect to any networks
31	Reserved	- -	- -	Keep the pin and do not connect to any networks
32	GND	PWR	- -	Digital and power ground
33	VCC	PWR	3.3 V + / - 10%	Module power input
34	VCC	PWR	3.3 V + / - 10%	Module power input
35	Reserved	- -	- -	Keep the pin and do not connect to any networks
36	V_BKUP	PWR	2.0 V to 3.6 V	Module backup power input
37	GND	PWR	- -	Digital and power supply ground
38	Reserved	- -	- -	Keep the pin and do not connect to any networks
39	Reserved	- -	- -	Keep the pin and do not connect to any networks
40	Reserved	- -	- -	Keep the pin and do not connect to any networks
41	GND	PWR	- -	Digital and power ground
42	TXD0	O	LVTTL	UART0 Sending data, FW update
43	RXD0	I	LVTTL	UART0 Data Reception, FW update
44	SDA	I/O	LVTTL	I2C data
45	SCL	I/O	LVTTL	I2C clock
46	Reserved	- -	- -	Keep the pin and do not connect to any networks

47	Reserved	- -	- -	Keep the pin and do not connect to any networks
48	GND	PWR	- -	Digital and power supply ground
49	RESET_N	I	LVTTL	Module reset, signal input (effective in low)
50	Reserved	- -	- -	Keep the pin and do not connect to any networks
51	EXTINT	I	LVTTL	External interrupt input pin (effective in low)
52	Reserved	- -	- -	Keep the pin and do not connect to any networks
53	TIMEPULSE	O	LVTTL	Second pulse output

3. Hardware Interface Descriptions

3.1 Antenna

ST903P module provides an antenna signal input interface (RF_IN_1), and the antenna interface is recommended to be connected to the external GNSS active antenna. The internal design of the interface is 50 ohm characteristic impedance. To obtain better performance, it is recommended to reserve the external impedance matching circuit. The antenna interface has the feed output function, and the typical feed voltage is 3.3V.

3.2 Power Supply

The ST903P module provides two input power interfaces (VCC and V_BKUP) and one output power interface (VCC_RF). VCC is the main power supply of the module, which supplies power to the on-chip main IC through the on-chip power conversion chip. V_ BKUP is the backup power supply of the module, which can still supply power to the RTC circuit and backup RAM in the module when the main power is off, so as to realize the hot start function and shorten the positioning time. VCC_RF can supply power to external active antenna (typical supply voltage 3.3V) or external LNA. The interior of the module connects the RF_ IN via inductance.

3.3 UART

The ST903P module provides two sets of serial ports, namely UART0 (TXD0, RXD0), and UART1 (TXD1, RXD1). UART0 supports data transmission and firmware upgrade, and the input/output signal type is of LVTTL level. Default baud rate is 115200bps, the highest can be set to 230400bps, the serial baud rate can be configured by the user. When designing the product, make sure UART0 is connected to a PC or external processor for firmware upgrade. UART1 only supports RTCM data input, and the input signal type is LVTTL level, the default baud rate is 115200bps, the maximum can be set to 230400bps, and the serial port baud rate can be configured by the user.

3.4 TIMEPULSE

The ST903P module provides 1 second pulse signal output interface (TIMEPULSE). The TIMEPULSE signal can provide timing function for external systems. Pulse edge trigger mode and pulse width can be adjusted, and the default output is one pulse per second. This signal can be unconnected if not used.

3.5 RTK_STAT

The ST903P module provides 1 RTK status output interface (RTK_STAT). Different level representation means that RTK is in different states: accepting RTCM data into Fix solution, and it always outputs in low level; Accepting RTCM data into RTD floating-point solution, then pull down twice a second; Accepting RTCM data into the Float floating-point solution, then pull down once in every 2 seconds; having no RTCM data, the level is always high.

3.6 RESET_N

The ST903P module provides an external reset signal input interface (RESET_N), which is effective at low levels above 10ms. This signal interface can be suspended if not in use.

3.7 I2C

ST903P module provides a set of I2C interface (SDA, SCL), I2C interface can be used for serial data transmission, can work in Master/Slave mode, bus maximum speed 400Kbps. It is not available in the default configuration, but can be used in custom mode.

3.8 EXTINT

The ST903P module provides 1 external interrupt signal input interface (EXTINT). It is not available in the default configuration, but can be used in custom mode.

4 Default Firmware Configuration

4.1 Serial Port Settings (CFGPRT)

Serial Port Number	Parameter name	Default configuration	Default Configuration Instructions
UART0	Baud rate	115200	Default baud rate 115,200 bps
	Enter protocol instructions	7	RTCM Protocol
	Output protocol instructions	1	NMEA Protocol
UART1	Baud rate	115200	Default baud rate 115,200 bps
	Enter protocol instructions	4	RTCM Protocol
	Output protocol indication	0	Data output is not supported

4.2 Message Setting (CFGMSG)

Message type	Parameter name	Default configuration	Default Configuration Instructions
NMEA message	RMC	1	1Hz output
	VTG	1	1Hz output
	GGA	1	1Hz output
	GSA	1	1Hz output
	GSV	1	1Hz output
	GLL	1	1Hz output
	ZDA	0	Off
	GST	0	Off
	TXT	1	1Hz output

4.3 Satellite System Setup (CFGSYS)

Navigation Type	Default configuration	Default Configuration Instructions
NavSys	0xF	GPS + BDS+Galileo+GLO

4.4 Navigation System Setup (CFGNAV)

Parameter name	Default configuration	Default Configuration Instructions
NavRate	1000	1000ms Positioning frequency
minElev	10	Satellite cutoff Angle 10 degrees

5. Differential Data Protocol

ST903P module supports RTCM3.X protocol differential data input, RTK positioning solution. The RTK differential positioning can be achieved by sending the the external base station differential data through the the serial port to module.

The Supported RTCM3.X Messages as below:

RTCM3.X Message types	Description
1005/1006	Reference station coordinates
1074	GPS observations values, need to include L1C/A, L2C frequency point
1084	GLONASS observations values, need to include G1, G2 frequency point
1094	Galileo observations values, need to include E1 frequency point
1114	QZSS observations values, need to include L1C/A and L2C frequencies points.
1124	BDS observations values, need to include B1I, B1C, B2I frequency points

6. Electrical Characteristics

6.1 Absolute Maximum

Parameters	Symbols	Minimum value	Maximum	Units	Conditions
Supply voltage (VCC)	Vcc	-0.5	3.6	V	- -
VCC maximum ripple	Vrpp	0	50	mV	- -
Input pin voltage	Vin	-0.5	Vcc +0.2	V	- -
ESD	VESD(HBM)	--	2000	V	All pins
MSD (MSL) rating	Level 3				

6.2 Operating Conditions

Parameters	Symbols	Minimum value	Recommended value	Max. value	Units	Conditions
RTC supply voltage	Vrtc	2.0	3.0	3.6	V	- -
RTC supplies current	Irtc	30	37	- -	uA	- -
Supply voltage (VCC)	Vcc	3.0	3.3	3.6	V	- -
Supply current	Icc	94	105	- -	mA	- -
Peak current	Iccp	- -	- -	150	mA	Vcc= 3.3V
Input pin, low level	Vin_low	- -	- -	0.2 * Vcc	V	- -
Input pin, high level	Vin_high	0.7 * Vcc	- -	- -	V	- -
Output pin, low level	Vout_ low	- -	- -	0.4	V	Iout= -8 mA
Output pin, high level	Vout_ high	Vcc - 0.4	- -	- -	V	Iout= 8 mA
Antenna feed power	Vcc_RF	3.0	3.3	3.6	V	Iout≤100mA
RF link gain	Gant	5	- -	40	dB	- -
Receiver link noise factor	NFtot	- -	3	- -	dB	- -

6.3 Working Environment

Working temperature	-40℃~ +85℃
Storage temperature	-40℃ to +85℃

7. Mechanical Dimensions

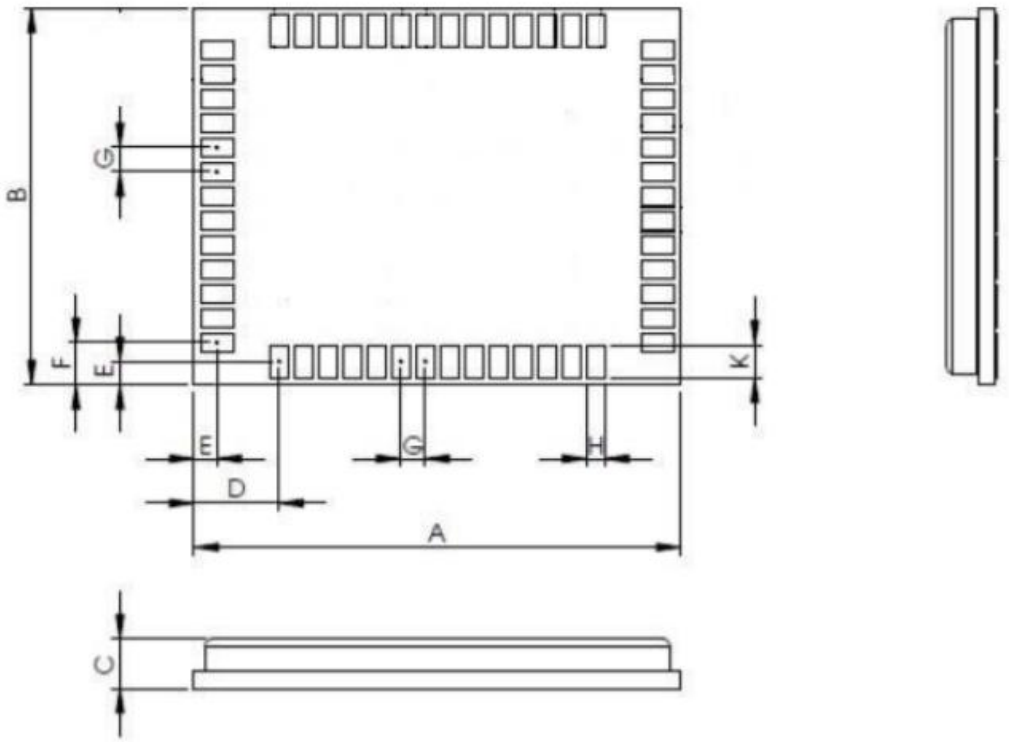

Figure 7-1 Module Dimensions

Parameters	Numerical value (mm)	Parameters	Numerical value (mm)
A	22.00 - 0.2 + / 0.4	F	1.90 + / - 0.1
B	17.00 + / - 0.2	G	1.10 + / - 0.1
C	2.40 + / - 0.2	H	0.80 + / - 0.1
D	3.85 + / - 0.1	K	1.50 + / - 0.1
E	1.05 + / - 0.1		
Weight	2g		

8. Hardware Integration Guide

8.1 Minimum Reference Design

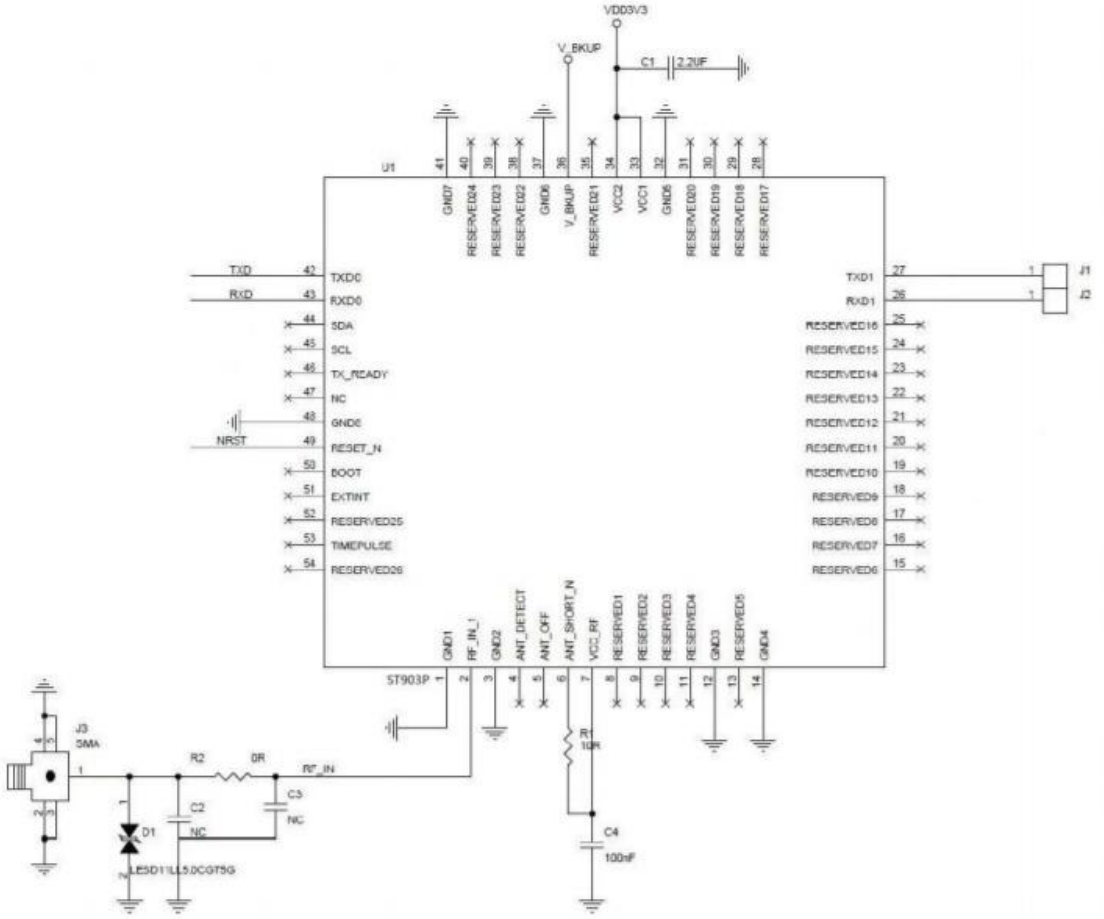

Figure 8-1 Minimum reference design

Figure 9-1 shows the reference design of the ST903P. Provides VDD3V3 and V_BKUP to power supplies externally, connect the RF input to an active antenna, and output NMEA0183 data through the serial port.

R1 is the detection resistance for the antenna detection of the module, and VCC_RF supplies power to the external active antenna through the external R1 to feed the RF_IN_1 pin. To ensure the normal operation of the external active antenna and the inspection function of the internal antenna, please ensure that $50mV \leq V_{R1}=I_{ANT}*R1 \leq 100mV$, where a I_{ANT} is the operating current of the external active antenna, and V_{R1} is the voltage drop at both ends of resistor R1. When the external active antenna is short-circuited, R1 acts as a temporary current limiting until the VCC_RF output is turned off. So a minimum package is recommended of 1Ω/1206, 5Ω/0603, 10Ω/0402.

8.2 Antenna considerations

8.2.1 Antenna Signals

The module is a high precision module of L1+L2 frequency band. For better performance, it is recommended to use active wires, and at the same time reserving 50 ohm impedance matching circuit outside the module.

Table 8-1 Reference Specifications of Active Antenna

Support frequency points	L1 band	1559~1606MHz
	L2 band	1197~1249MHz
Antenna standing wave ratio	< 1.5	
Gain	5~40 dB	
Phase center	<10mm height/orientation	
Noise factor	< 1.5 dB @ Hz	
Out-of-band suppression	≥30dB	
Shaft ratio	<3 dB	
Output impedance	50 Ω	

Active antennas need to support both L1+L2 bands for optimal performance. Use active antenna, need to feed the active antenna. The module supports RF_IN_1 pin to feed the external, can be directly connected with the active antenna, no need the series capacitor in the middle.

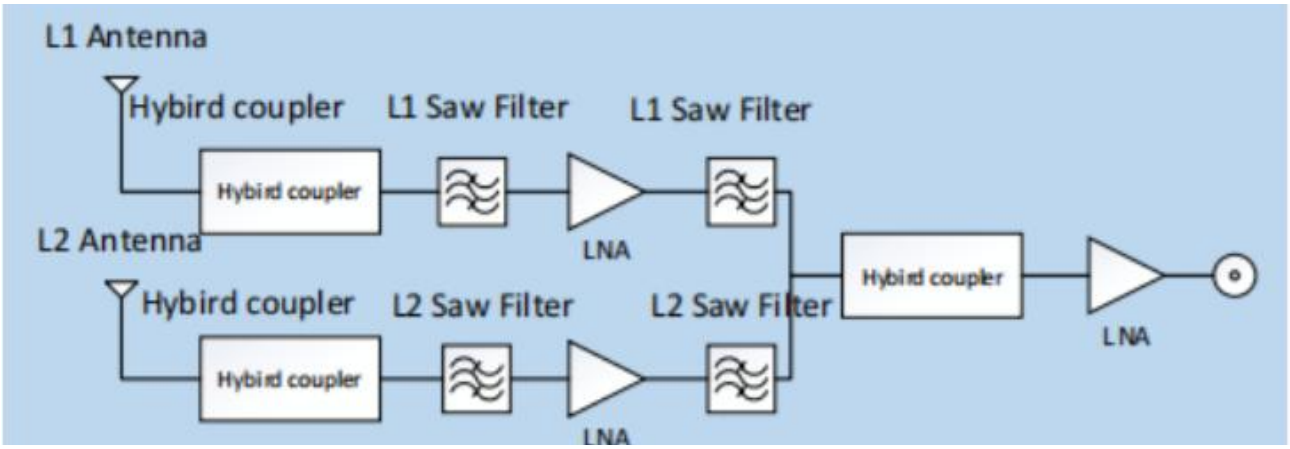

Figure 8-2 Dal-frequency active Ceramic Antenna

8.2.2 Active Antenna Detection and Short Circuit Protection

The module integrates with the antenna detection function, which can detect the open circuit, short circuit and normal working state of the active antenna. To implement this function, do not connect the capacitor in series between the RF_IN_1 pin of the module and the active antenna, and ensure that the R1 value meets the requirements of Figure 9-1.

The module supports the antenna short-circuit protection function. When the external active antenna shorts out, the module will automatically cut off the output of the feed power VCC_ RF, to achieve the purpose of protecting the module and antenna. After the short-circuit protection occurs, the module will regularly check whether the short-circuit state is disappeared. If the short circuit disappears, the module will delay to restore the output of VCC_RF.

8.2.3 Active antenna feed

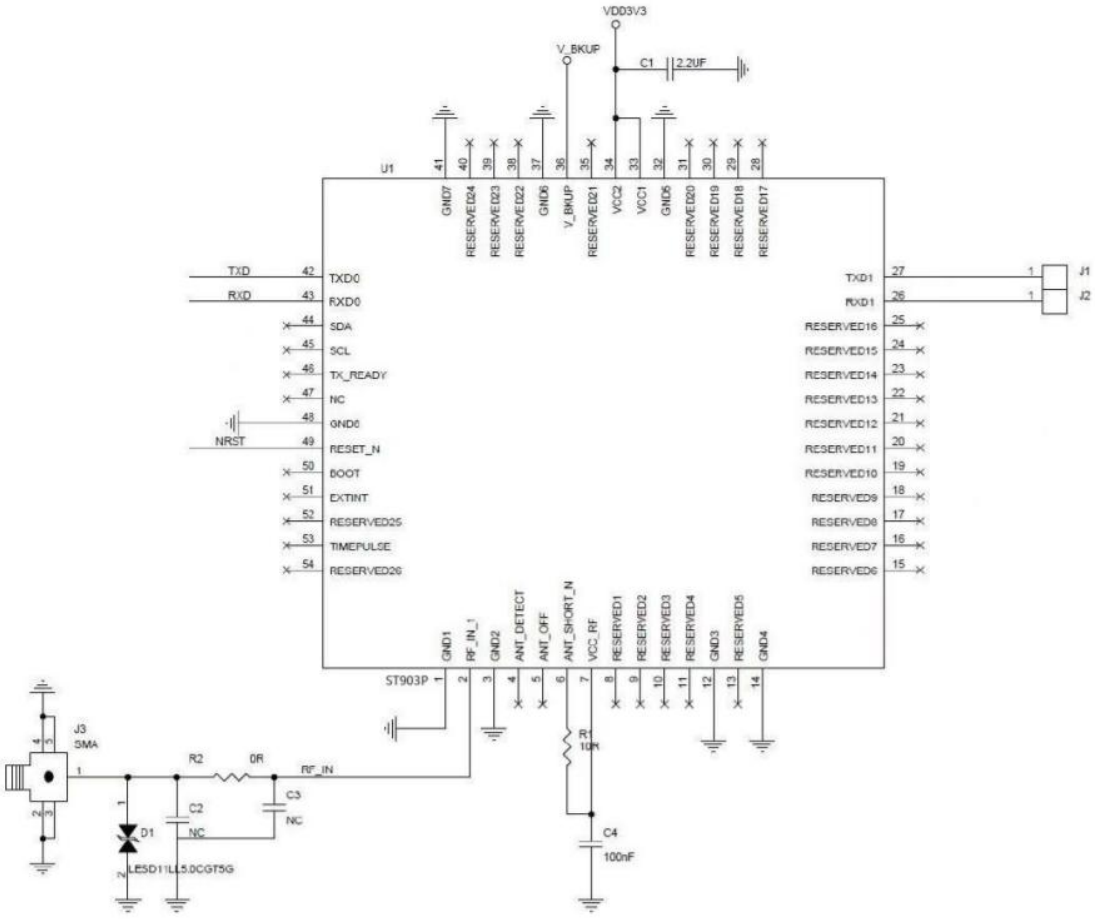

Figure 8-3 Internal Feed Reference Design

Module is connected to the active antenna to receive satellite signals, need to feed the active antenna. The module supports RF_IN_1 pin to feed the external, can be directly connected with the active antenna, noneed series capacitor in the middle.

Figure 9-2 Reference circuit design.

The module supports the external power feed function. When the external power feed function is used, The antenna state detection circuit, integrated inside, is unavailable.

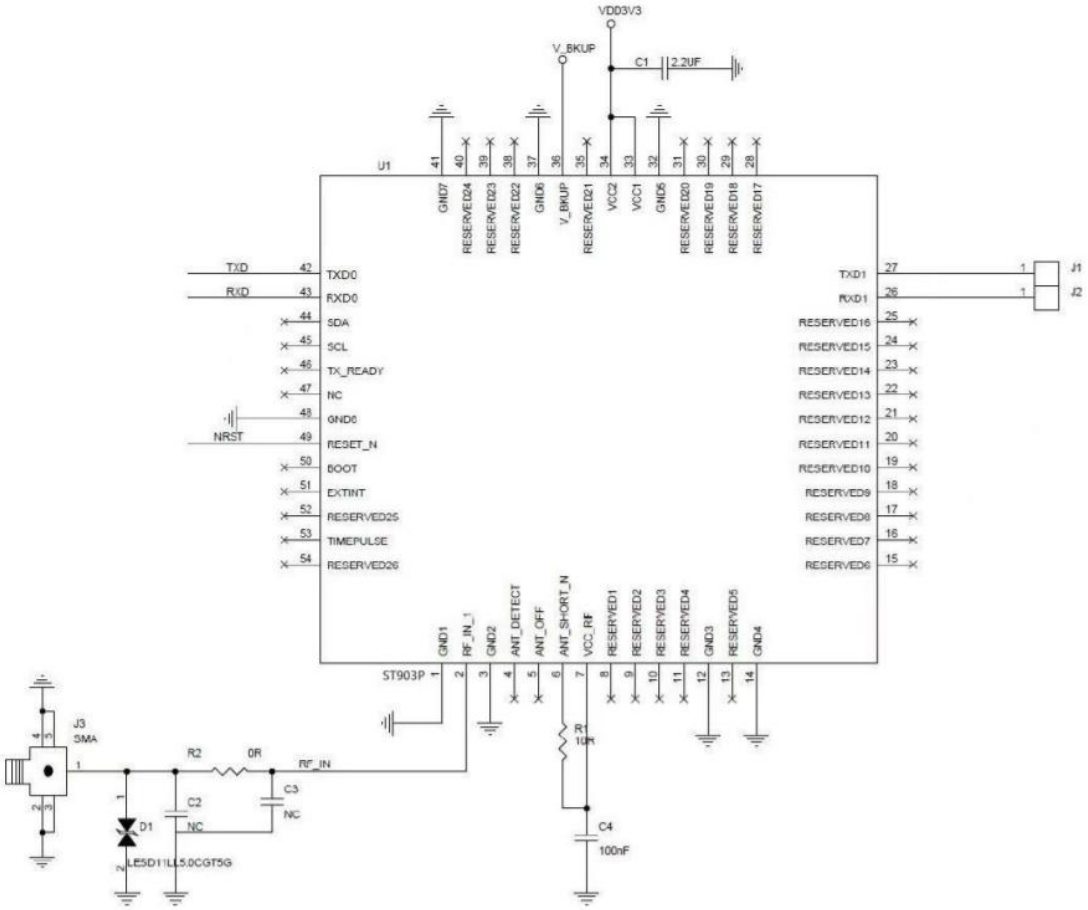

Figure 8-4 External Feed Reference Design

The 10Ω resistance between VCC_RF and ANT_SHORT_N is not required when using an external power feed. 100pF (C3) capacitor is connected in series between the module RF input and the DC feed to avoid RF and IO pins damage for high feed voltage.

The external feed is connected to the RF wiring through 27~100nh. As shown in Figure 9-4, the VDD5V is connected to the RF track by 27nh after passing through the 100nF (C2) decoupling capacitor.

D1, an ESD protection device with Cj<0.5pF is required.

When layout the PCB, the L1 and D1 should be directly laid on the RF cable to avoid RF cable bifurcation, which affects the RF performance.

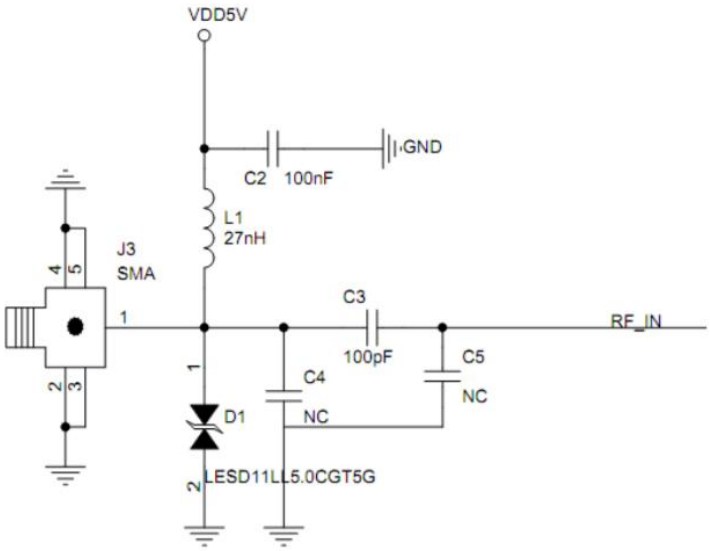

Figure 8-5 External Feed Reference Design

8.2.4 External Antenna Detection circuit

When the external power supply is used to feed the antenna, the antenna detection circuit inside the module is not available, and additional voltage detection circuit is needed to realize the antenna status detection. Connect ANT_SHORT and ANT_OPEN to the IO port of MCU, can realize the real-time monitoring of antenna status.

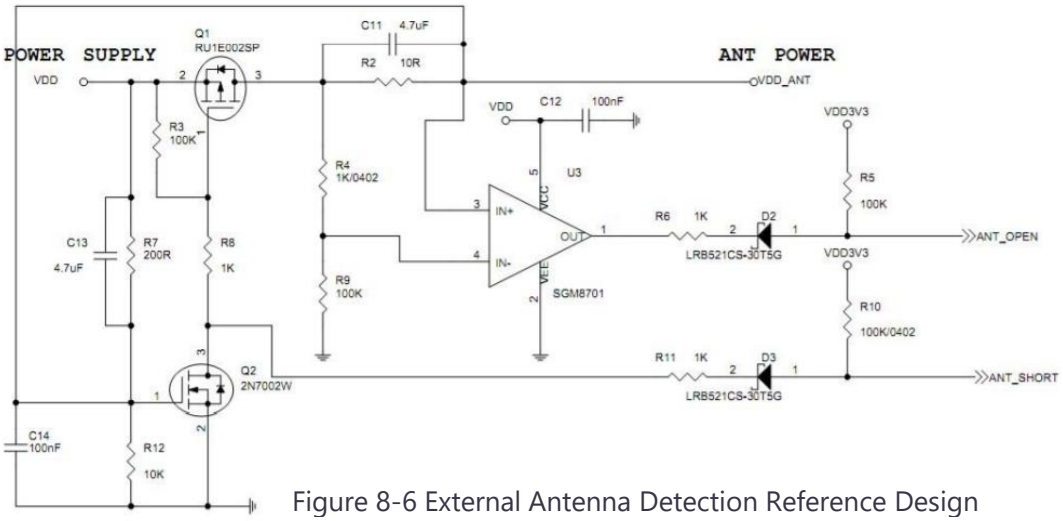

Figure 8-6 External Antenna Detection Reference Design

Table 8-2 Truth Table for External Active Antenna Status Detection

ANT_OPEN	ANT_SHORT	ANT_STATE
0	0	OK
X	1	SHORT
1	0	OPEN

8.3 Power Supply Considerations

To make the module work normally, it is necessary to supply power to the module VCC and V_BKUP. Precautions as belows:

1) Provide a reliable power supply for the VCC pin. The power supply should rise monotonably during the power-on process, and the power-on time should not exceed 10ms. And the oscillograph should not have the steps or backchannels during the power-on process. In addition, after the power supply is powered off, the level should be restored to zero.

2) It is recommended to use low-ripple LDO to power module VCC, and the difference between power ripple peaks (Max. and Min.) should not exceed 50mV. To ensure that the power ripple entering the module is within this range, a 2.2uF and 100nF capacitor needs to be placed near the pin of the module VCC.

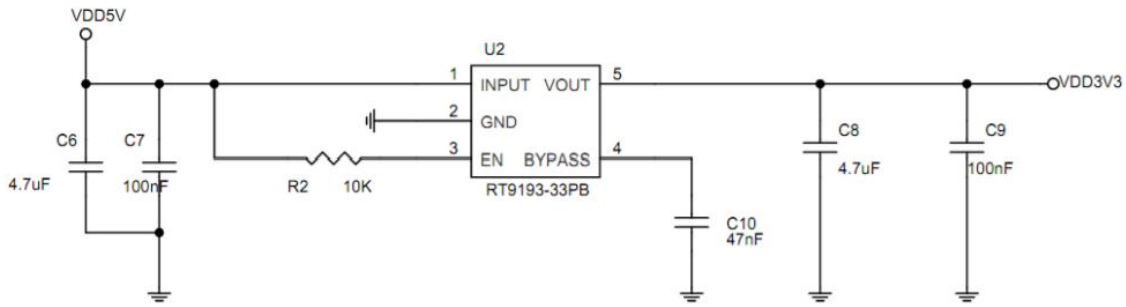

Figure 8-7 Power Supply Module

1) It is recommended to widen the power supply cable or use a split copper surface to transmit current, avoiding high-power, high-inductive devices, such as magnetic coils.

2) To implement the hot start function, it is recommended to supply power to module V_BKUP with the supply voltage ranging from 2.0V to 3.6V. If the design does not have a backup power supply, it is recommended that V_BKUP be connected to VCC.

8.4 Electromagnetic Interference Precautions

Any signal line larger than 3mm in length can act as an antenna, and high-frequency signals in the receiving environment will take them as noise and transmit to the GNSS receiving module, thereby affecting GNSS positioning performance.

The EMI problem must be considered in the receiver design. The signal power received by the GNSS antenna is very low, so the GNSS module is susceptible to interference from any type of nearby RF source, which is mainly divided into out-of-band interference and in-band interference:

1) Out-of-band interference: Usually, the maximum power transmitted by any type of wireless communication system (such as LTE, GSM, WCDMA, WIFI, BT, etc.) is far greater than the GNSS signal strength, which enters the GNSS receiving module through the GNSS receiving antenna or unshielded cable, affecting the GNSS positioning performance. Out-of-band interference can be effectively improved by adding SAW filter to the RF front end. In addition, when designing GNSS receiving products, it is necessary to consider that GNSS receiving antennas and GNSS modules are far away from the wireless communication system and its antenna with strong transmitting power.、

In addition, strong interference signals may produce intermodulation signals that fall within the GNSS frequency band and interfere with the performance of GNSS modules.

1) In-band interference: Signals whose signal frequency is very close to the GNSS frequency. Such interference signals are usually caused by harmonics of signals of the display, bus, clock, etc. In-band interference has the following optimization measures:

➢ Maintain a good grounding concept in the design

➢ Pay attention to RF line and signal line shielding

➢ Layout optimization, GNSS module, antenna stay away from the noise source

➢ Add filter in the interference source: such as add low-pass filter in the digital signal output port, add the bandpass filter in LTE, GSM, WCDMA, WIFI, BT and other RF signal output port.

8.5 Other Notes

To make the module work normally, the relevant precautions as below:

1) Ground all GND pins of the module.

2) Connect the RF_IN_1 signal to the antenna, and maintain 50 ohm impedance matching.

3) Ensure that the main device and serial port 0 are connected with consistent baud rate.

To obtain good performance, special attention should also be paid in the following items:

1) Pay attention to impedance matching of the antenna line, as short and smooth as possible, avoid layer change and go acute Angle.

2) To ensure a good signal-to-noise ratio, ensure that the antenna is well separated from the electromagnetic radiation source, especially the 1197~1249MHz and 1559~1606MHz frequency band of electromagnetic radiation.

3) When layout the PCB, try to avoid laying directly below ST903P modules.

4) This module is a temperature-sensitive device, the drastic change of temperature will lead to its performance reduction, try to keep away from high temperature airflow and high power heating devices in use.

5) If the module needs to be reset externally, ensure that the driving current is >5mA.

6) To avoid the module damaged be caused by static electricity, it is recommended to add an ESD protection device between the module and the input port of the external antenna. Before using the module, ensure that the antenna is connected reliably. Do not plug or remove the antenna with electric heating. Recommended ESD protection devices:

Device Model	Manufacturer	Junction Capacitance Parameters (pf)	VBR parameter (V)
LESD11LL5. 0 CGT5G	Leshan Radio	Typ: 0.25	Min: 6
ESD9R3. 3ST5G	Onsemi	Typ: 0.5	Min: 4.6
ESD5V3U1U-02LS	Infineon	Typ: 0.4	Min: 6

This module is a precision device, using LGA pad. To ensure that the patch is well welded, it is recommended to use reflow welding to avoid problems such as virtual welding and short circuit. Do not use a heat gun to weld the module. Too high temperature of the heat gun may cause the module performance damaged.

9. Production Requirements

The recommended furnace temperature curve for module welding as below:

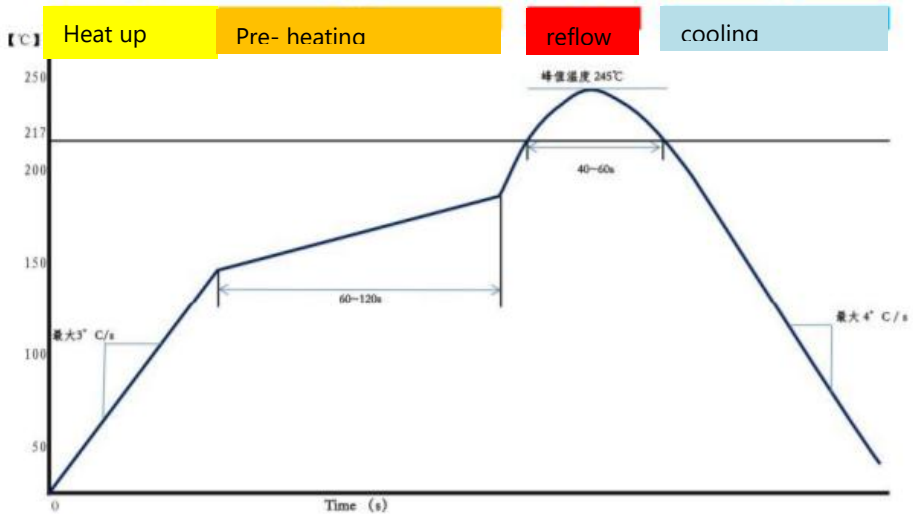

Figure 9-1 Recommended furnace temperature curve

The ST903P module kit is a lead-free product, and the default subsequent machining is lead -free welding. Our company has verified the lead-free welding of modules in actual production. The above recommended temperature settings, take lead-free welding as an example.

Note:

1) Module patch production process, it is recommended to use reflow only once, That is, one side of the patch module can be finally heated.
2) It is not recommended that the module be reflow twice, that is, the patch production process, first patch the surface of the module and the go through the furnace, but then paste the other side and go through the furnace; When the other side is pass through the furnace, the module may cause virtual welding or even fall because of its own weight. If secondary reflow welding is required, the above risks must be assessed, and it is recommended to use some fixtures.
3) The setting of welding temperature depends on many factors of the factory, such as the nature of the motherboard, solder paste type, solder paste thickness, etc. Please also refer to the relevant IPC standards and solder paste indicators.

10. Package and Transportation

10.1 Packing

The ST903P module is packaged with anti-static and moisture-proof tape, and the tape is of 250pcs/ roll.

10.2 ESD Protection

The ST903P module is an electrostatic sensitive device. Therefore, pay attention to ESD protection during transportation and production.

Do not touch or weld with non-anti-static soldering iron in case of the module damaged.

Figure 10-1 Antistatic

11. Ordering Information

Part No.	MPQ	MOQ	Description
ST903P	250	250	Multisystem Multi Frequency Band High Precision RTK Navigation and Positioning Module

Shenzhen Simple Technology Electronics Co., LTD.

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