SGP501

User Manual

Abstract
This document introduces the SGP501 high-precision RTK GNSS/MEMS module.

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1. Product Introduction

The SGP501 is a full-constellation, full-frequency GNSS RTK/PPP/MEMS IMU integrated navigation module with dual-antenna heading capability. Its six-degree-of-freedom IMU features high dynamic range and wide measurement capability. The tightly coupled RTK/PPP/INS navigation algorithm runs efficiently on-chip, supporting navigation data rates of up to 100 Hz. Designed for challenging environments such as urban canyons and extended tunnels, the SGP501 ensures 100% navigation availability and delivers centimeter-level, high-precision 3D attitude integrated navigation.

1.1 Functional Overview

The SGP501 module integrates advanced MEMS inertial sensors with carrier-phase differential (RTK) satellite navigation technology, fully leveraging satellite carrier phase measurements together with the relative angular and linear motion measurements provided by inertial sensors (three-axis gyroscope and three-axis accelerometer). By employing multi-dimensional extended Kalman filtering and other specialized algorithms, the module achieves high-precision 3D navigation and attitude determination within a compact device. It also supports dual-antenna heading and offers optional PPP (Precise Point Positioning) technology.

Key Features:

- Supports all constellations and full-frequency GNSS, including GPS, BDS, Galileo, GLONASS, and QZSS
- Centimeter-level positioning in open-sky environments
- Global coverage: PPP-AR with decimeter-level accuracy; nationwide coverage: PPP-RTK
- Continuous, uninterrupted navigation output in challenging environments such as underground parking lots, tunnels, urban canyons, and viaducts
- 3D attitude output (heading, pitch, roll), 3D position and velocity output, and continuous distance accumulation

- Dual-antenna heading capability
- Flexible installation with free-angle mounting on all three axes
- No mandatory requirement for wheel speed/odometer aiding
- High-rate navigation data output (configurable at 1/10/20/50/100 Hz)
- Optional output of raw GNSS and IMU data (custom versions)

The SGP501 module can be applied in various fields such as intelligent driving for automobiles, rail transit, smart agricultural machinery, and industrial UAVs. It adopts a 30×40 mm package with stamp-hole soldering

1.2 Pin Definition

The SGP501 module uses a 60-pin package. The pin numbers are shown in Figure 1.1, and their specific definitions are detailed in Table 1.1.

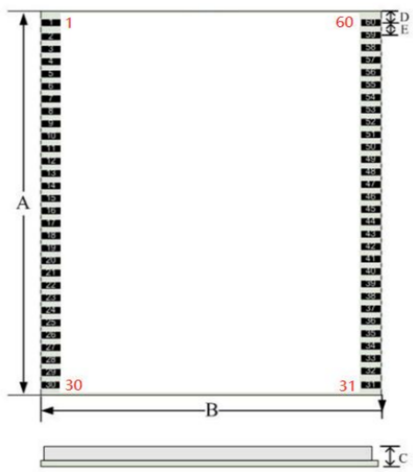

Figure 1.2 Pin Definition (Top View)

Note: Pin numbering and orientation are shown from the top view of the module

Table 1.1 Pin Assignment

Pin	Name	I/O	Description
1	GND	—	Ground
2	ANT1_IN	I	GNSS main antenna (positioning antenna)
3	GND	—	Ground
4	GND	—	Ground

5	ANT1_PWR	I	GNSS main antenna power supply
6	GND	—	Ground
7	RESERVED	—	Reserved
8	RUN LED	O	MCU running indicator
9	GND	—	Ground
10	RESERVED	—	Reserved
11	RESERVED	—	Reserved
12	RESERVED	—	Reserved
13	RESERVED	—	Reserved
14	GND	—	Ground
15	NOT CONNECT	—	No connection
16	NOT CONNECT	—	No connection
17	V_BACKUP	—	RTC backup battery
18	GND	—	Ground
19	PVT_STAT	O	PVT fix indicator, active high
20	RESERVED	—	Reserved
21	PPS2	O	Pulse per second 2
22	FRESET_N	I	Factory reset, active low
23	ERR_STAT	O	GNSS error indicator, active high
24	RTK_STAT	O	RTK fix indicator, active high
25	GND	—	Ground
26	SPI_MISO	I	Reserved SPI data input
27	SPI_MOSI	O	Reserved SPI data output
28	SPI_CLK	O	Reserved SPI clock
29	SPI_SS0	O	Reserved SPI chip select 0
30	SPI_SS1	O	Reserved SPI chip select 1
31	VCC_3.3V	Power	Power supply (+3.3 V)
32	VCC_3.3V	Power	Power supply (+3.3 V)
33	GND	—	Ground
34	GND	—	Ground

35	TXD1	O	UART1 transmit
36	RXD1	I	UART1 receive
37	TXD2	O	UART2 transmit
38	RXD2	I	UART2 receive
39	TXD3	O	UART3 transmit
40	RXD3	I	UART3 receive
41	I2C_SDA	I/O	Reserved I^2C data
42	I2C_SCL	I/O	Reserved I^2C clock
43	GND	—	Ground
44	PPS1	O	Pulse per second 1
45	RESERVED	—	Reserved
46	RST_N	I	Reset (does not clear user config), active low
47	GND	—	Ground
48	RSV	—	Reserved
49	RSV	—	Reserved
50	RSV	—	Reserved
51	RSV	—	Reserved
52	GND	—	Ground
53	CAN_TXD	—	CAN transmit
54	CAN_RXD	—	CAN receive
55	GND	—	Ground
56	ANT2_PWR	I	GNSS secondary antenna power supply
57	GND	—	Ground
58	GND	—	Ground
59	ANT2_IN	I	GNSS secondary antenna (heading antenna)
60	GND	—	Ground

1.3 System Performance

Table 1.2 performance specifications

Positioning Accuracy (1σ)	Open Sky*	RTK	0.01m + 1ppm
		PPP-AR	0.3m
		Standalone	1.5m
	Urban Environment	5.0m	
	GNSS Outages	60s	10m
		>60s	1% of travel distance 0.3% of travel distance (by odometer aiding)
Attitude Accuracy (1σ)	Dual-Antenna Heading	0.1^{0} (2m baseline)	
	Heading hold	0.1^{0}/min	
	Heading	0.3^{0} (±300deg/s); 0.8^{0} (±1000deg/s)	
	Roll	0.5^{0} (±300deg/s) ;1.2^{0} (±1000deg/s)	
	Pitch	0.5^{0} (±300deg/s); 1.2^{0} (±1000deg/s)	
Velocity Accuracy (1σ)	0.05m/s		
Timing Accuracy (1σ)	20ns		
Solution Rate	Configurable 1/10/20/50/100Hz		
GNSS Frequency	BDS B1I/B2I/B3I; GPS L1C/A/L2P/L2C/L5 Galileo E1/E5a/E5b; GLONASS L1/L2 QZSS L1/L2/L5; SBAS		
Size	30mm x 40mm		

*: specifications are defined under the condition that the satellite signal strength exceeds 42 dB-Hz.

1.4 Electrical and Physical Characteristics

Table 1.3 Electrical and Physical Characteristics

Supply Voltage	3.0V – 3.6V
Power Consumption	1.45W (typical)
Reflow Soldering Temp.	260℃
Dimensions	30 mm × 40 mm × 5.5 mm
Operating Temperature	-40℃ - +85℃
Vibration Resistance	6g (20 – 2000Hz)
Shock Resistance	500g (20ms)

1.5 Software Data Interface

Table 1.4 data interface

Category	Description
I/O Interfaces	UART ×3, SPI ×1 (reserved), I²C ×1 (reserved), CAN ×1
UART Ports	COM1: GNSS configuration, baud rate 115200 COM2: Main port – navigation positioning & firmware upgrade, baud rate 460800 COM3: PPP positioning, baud rate 230400
Input Protocols	RTCM 3.2 MSM4/MSM7 adaptive
Output Protocols	NMEA 0183, custom text, binary protocol*

1.6 Module Package Dimensions

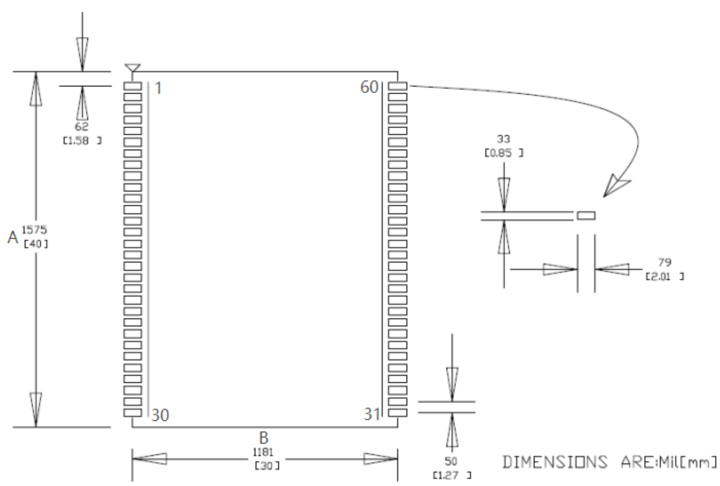

Figure 1.3 Module Package Dimensions (All dimensions in mm)

Table 1.5 Module Physical Dimensions

(All dimensions in mm, Tolerance: ±0.1 mm unless otherwise noted)

Dimension	Minimum (mm)	Nominal(mm)	Maximum (mm)
A	39.8	40.0	40.2
B	29.8	30.0	30.2
C	5.4	5.5	5.6
D	/	1.58	/
E	/	1.27	/

1.7 Hardware PCB Reference Design

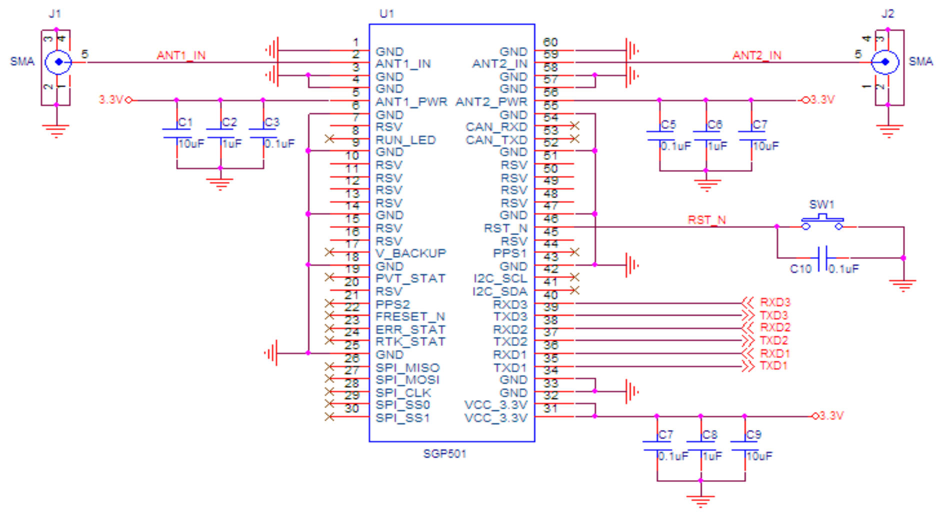

Figure 1.4 the recommended PCB design for the InsCore module

2. Installation and Handling Notes

- Ensure VCC reliably drops below 0.7 V and remains stable after power-off.
- Connect all GND pins to ground.
- Connect the RF_IN signal to the antenna with 50 Ω impedance matching; keep traces as short and smooth as possible.
- Power ripple peak should not exceed 50 mV.
- Avoid routing PCB traces directly underneath the module.
- The module is sensitive to temperature changes; keep it away from hot airflow and high-power heating components.
- The module is sensitive to RF interference; avoid placing it near interference sources such as communication antennas, RF traces, crystal oscillators, large inductors, and high-frequency digital signal lines.
- For optimal navigation performance, install the module with a radial (pitch) angle less than 20° (radial pointing direction is not required).
- For railway, subway, and airborne platforms, fixed axial installation is required; the module' s forward axis must align with the defined forward direction of the platform.
- When removing a soldered module, it is recommended to melt the solder on both sides of the pins using a soldering iron and then lift it with tweezers to avoid damage.
- Place decoupling capacitors as close as possible to the module' s power supply pins, and ensure power traces are at least 0.5 mm wide. RF traces from the module RF port to the antenna connector should be 0.2–0.3 mm wide with 50 Ω impedance.