Datasheet of BKR3-1612

Triple-band high precision GNSS/RTK module

Version 0.1

2025/7/23

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1. Introduction

The BKR3-1612 GNSS module, developed by LOCOSYS Technology Inc., is engineered for applications requiring high-precision positioning and exceptional reliability. Built upon an advanced GNSS SoC architecture and incorporating the latest BDS-3 (BeiDou Navigation Satellite System) framework, the module supports multi-band and multi-constellation reception capabilities. It can concurrently track all major global satellite navigation systems, including GPS, GLONASS, Galileo, BEIDOU, QZSS, IRNSS, and SBAS, while offering full support for L1, L2, and L5 triple-band signal reception with centimeter-level RTK positioning accuracy.

At the core of the module is the Beken chip, featuring a 32-bit DSP processor built on 22nm process technology and capable of operating at up to 350MHz. The chip supports up to 200 tracking channels and integrates a dedicated high-performance search engine. It delivers excellent sensitivity across cold start, hot start, and reacquisition modes (from -148dBm to -165dBm), ensuring stable and reliable positioning performance even in challenging signal environments such as dense urban areas or under canopy. The Beken also supports AGPS, RTCM3.X, and offers a maximum update rate of 20Hz, enhancing system responsiveness in dynamic applications.

Compared to traditional single-band or dual-band RTK, triple-band RTK offers the following advantages:

- Faster convergence time: Accelerates positioning initialization, improving efficiency for real-time applications.
- Enhanced multipath and interference rejection: Delivers greater positioning accuracy and robustness, particularly in complex environments like urban canyons or forests.
- Improved redundancy and reliability: Increases solver resilience and precision under varying operational conditions.

The module integrates a robust LDO power management system with built-in support for active antenna power supply, featuring short-circuit and open-circuit protection mechanisms. It also provides a 1PPS (pulse-per-second) output with sub-20ns accuracy, suitable for high-precision timing and synchronization tasks. Power efficiency is another highlight—continuous triple-band tracking (L1/L2/L5) consumes only around 20mA, and the module supports sleep modes for energy-saving operations, making it ideal for battery-powered wearable devices, vehicle systems, and AIoT edge devices.

The BKR3-1612 supports multiple communication interfaces and protocols, including UART, I²C, NMEA 0183, and RTCM3.X, and can be externally integrated with IMU sensors for enhanced sensor-fusion navigation. Its compact footprint and highly integrated architecture make it well-suited for edge computing platforms, automotive systems, and embedded solutions, fulfilling the stringent positioning requirements in V2X (Vehicle-to-Everything), UAVs, precision agriculture, autonomous robotics, and smart city infrastructure.

2. Features

- Based on high-performance, low-power Beken GNSS chipset
- Supports up to 200 signal tracking channels with an independent high-speed search engine
- Ultra-high tracking sensitivity: down to -165 dBm
- Concurrent reception of L1, L2, and L5 triple-band signals across multiple GNSS constellations
- Compatible with GPS, GLONASS, GALILEO, BEIDOU, and QZSS
- RTK-capable; supports RTCM 3.3 protocol
- Integrated LNA (Low Noise Amplifier) and SAW filter for improved RF performance
- Fully supports BDS-3 (BeiDou Navigation Satellite System - Generation 3)
- GNSS update rate up to 10 Hz
- Provides ±10 ns high-accuracy 1PPS (pulse-per-second) time pulse output
- Extremely fast TTFF (Time to First Fix), even under low signal conditions
- Multipath detection and suppression for improved accuracy in urban or obstructed environments
- Supports both active and passive antennas
- Low power consumption: maximum 70 mA @ 3.3V
- Compliant with NMEA-0183 protocol, with optional support for custom protocols
- Operating voltage range: 2.8V to 3.6V
- SMD (Surface Mount Device) design with stamp hole pads for easy integration
- Compact form factor: 16.9 × 12.7 × 2.37 mm (±0.5 mm tolerance)
- Operating temperature range: -40°C to +85°C
- RoHS compliant and fully lead-free

3. Applications

- UAV/UAS Aerial Mapping and Surveying:
  Enables precise flight control and image alignment, enhancing flight path planning and data overlay accuracy.

- Autonomous Driving and ADAS Systems:
  Provides lane-level positioning input to support safe driving and adaptive navigation functions.

- Smart Agriculture and Agricultural Machinery Automation:
  Supports precision seeding, field zoning, and autonomous operation of farming equipment.

- Surveying and Construction Engineering:
  Ideal for applications requiring high-precision positioning such as geodetic surveys, pipeline alignment, and slope monitoring.

- High-Precision Timing and Base Station Synchronization:
  Delivers sub-microsecond synchronization through 1PPS (pulse-per-second) signal output.

4. Functional Description

4.1 Key Features

Table 1: Key Features

Frequency	GPS/QZSS: L1 C/A,L5,L2C GLONASS: L1OF GALILEO: E1,E5 BEIDOU: B1I,B1C,B2A,B2I,B3I SBAS：WAAS, EGNOS, MSAS, GAGAN	
Channels	Support 200 Tracing channels with fast search engine	
Update rate	GNSS : 1Hz default, up to 20Hz RTK : 1Hz default, up to 10Hz	
Sensitivity(1)(2)	Hot start	-165dBm (with external LNA)
	Cold start	-148dBm (with external LNA)
	RE-acquisition	-159dBm (with external LNA)
	Tracking	-165dBm (with external LNA)
Acquisition Time(1)(2)	Hot start (Open Sky)	< 5s (typical)
	Cold Start (Open Sky)	< 28s (typical)
		1.5s(AGPS)
	RTK initialization time	≦ 10s
	RTK Re-acquisition time	≦ 2s
Datum	WGS-84(default)	
Position Accuracy(1)(2)	Autonomous: 1.0m (CEP)	
	RTK: 1cm+1ppm (CEP50）	
Velocity Accuracy	0.1m/sec	
Dynamics	≦ 4g	
Max. Altitude	< 18,000 m	
Max. Velocity	< 515 m/s	
Protocol Support	NMEA 0183 ver. 4.1	115200 bps ,8 data bits, no parity, 1 stop bits (default) 1Hz: GGA, GLL, GSA, GSV, RMC, VTG, ZDA,
	RAW data output(3)	Support RTCM 3.3 MSM4 or MSM7 and Ephemeris Message type output, 1019, 1020, 1042, 1044, 1046, 1074, 1077, 1084, 1087, 1094, 1097, 1114, 1147, 1124, 1127

Note (1): Performance was demonstrated using a high-quality external LNA and measured at room temperature.
The total gain of the external LNA, including cable losses, should range from 15 dB to 50 dB. For optimal noise performance, a gain between 15 dB and 25 dB is recommended.

Note (2): All satellites were simulated at a signal level of -130 dBm.
GPS was tested in combination with QZSS and SBAS, and all measurements were taken at room temperature.

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Note (3): RTCM messages are disabled by default.
To enable RTCM output, a specific command must be executed through the interface.

4.2 Block Diagram

The BKR3-1612 is a high-performance multi-band GNSS receiver module, capable of tracking GPS, GLONASS, GALILEO, BEIDOU, QZSS, and SBAS signals across L1, L2, and L5 bands. Designed in a compact surface-mount package, it offers robust signal acquisition and tracking capabilities.

With its simple UART serial interface and support for the standard NMEA-0183 protocol, the BKR3-1612 is easy to integrate and operate in a wide range of applications.

The BKR3-1612 module autonomously performs all essential GNSS functions, including system initialization, signal acquisition, signal tracking, data demodulation, and navigation solution computation, eliminating the need for external processing.

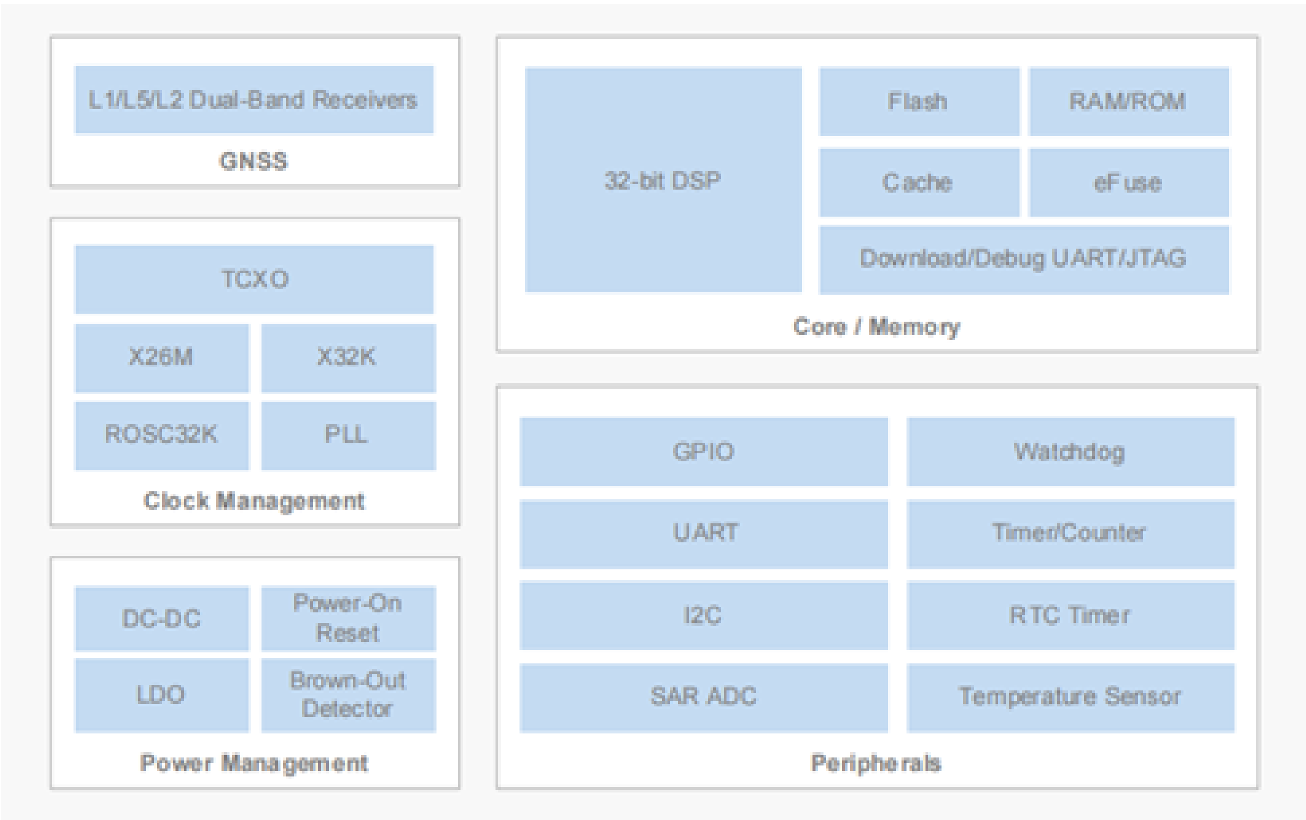

Figure 1: Block Diagram

4.3 Reference Circuit

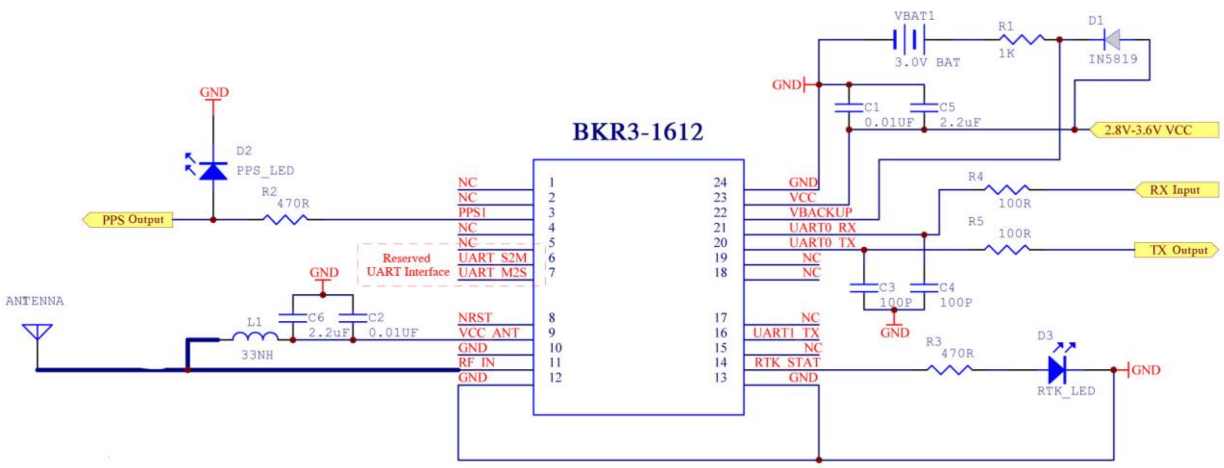

Figure 2: Reference Circuit

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5. Pin Assignment and Definition

The module is equipped with a 24-pin SMT (Surface-Mount Technology) pad, designed to interface seamlessly with your application platform.

Details of the available sub-interfaces provided through this pad are described in the following sections.

5.1 Pin Assignment

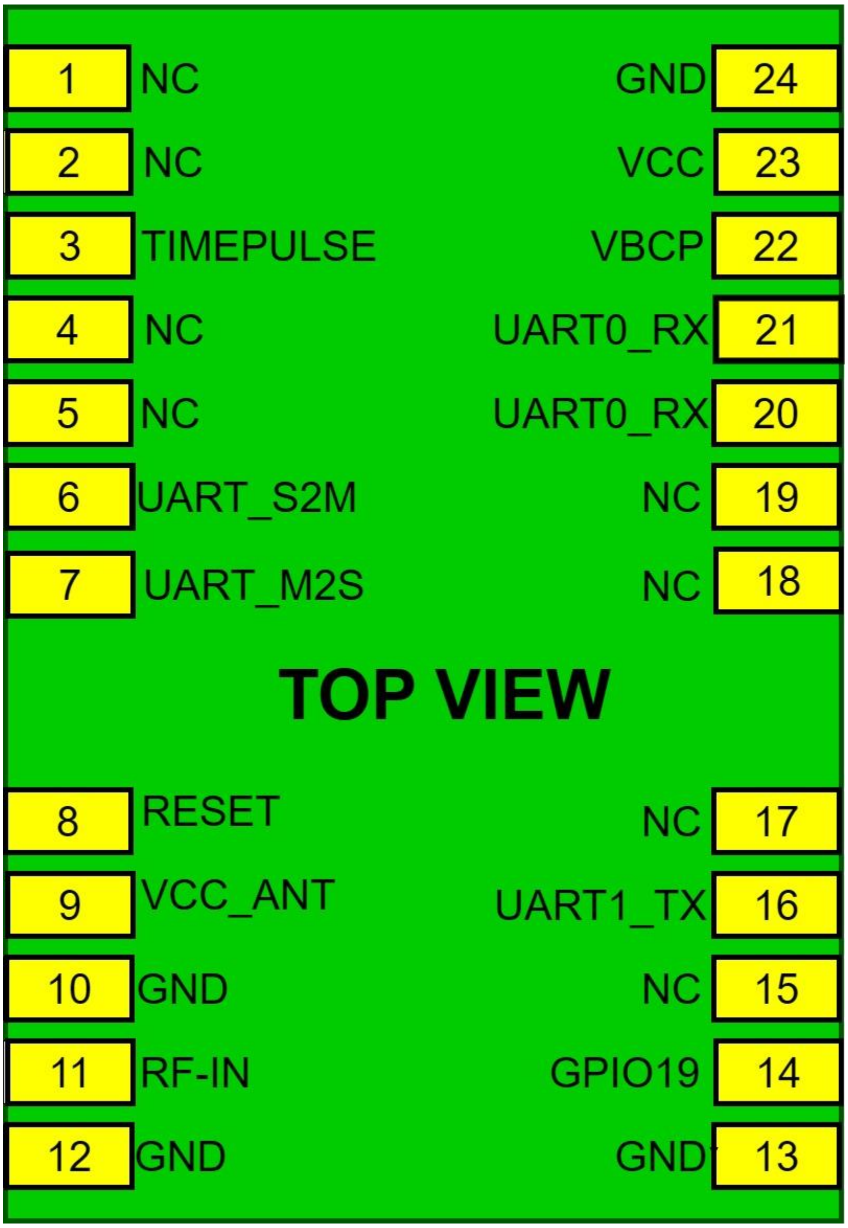

Figure 3: Pin Assignment

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5.2 Pin Definition

Table 2: Pin Definition

Pin No.	Name	I/O	Description
1	NC		No connect
2	NC		No connect
3	TIME PULSE	O	PPS output
4	NC		No connect
5	NC		No connect
6	UART_S2M		UART Serial Data Output
7	UART_M2S		UART Serial Data Input
8	RESET	1/O	RESET, leave it vacant when not in use
9	VCC_ANT		Active antenna power supply , 2.8~3.6V
10	GND		GND
11	RF_IN	I	RF input
12	GND		GND
13	GND		GND
14	GPIO19		Default RTK status 0-fixed Blinking-receiving and using corrections 1-no corrections
15	NC		No connect
16	UART1_TX	O	UART Serial Data Output
17	NC		No connect
18	NC		No connect
19	NC		No connect
20	UART_TX	O	Serial port TX port
21	UART_RX	I	Serial port RX port
22	VBCP		Backup battery
23	VCC		Working voltage：2.8-3.6V, Recommended use：3.3V
24	GND		GND

6. DC Electrical Specification

Table 3: Operating Conditions

Parameter	**Min**	**Typ**	**Max**	**Unit**
Supply Voltage (VCC)	2.8	3.3	3.6	Volt
Acquisition Current (exclude active antenna current)		65		mA
Tracking Current (exclude active antenna current)		70		mA
I/O port &UART port working voltage6				
Output Low Voltage	-		0.4	Volt
Output HIGH Voltage	2.4		-	Volt
Input LOW Voltage	0.3		0.7	Volt
Input HIGH Voltage	2.1		3.6	Volt
Input LOW Current	-10		10	uA
Input HIGH Current	-10		10	uA
RF Input Impedance (RFIN)		50		Ohm

Table 4: Absolute Maximum Ratings

Parameter	**Minimum**	**Maximum**	**Condition**
Supply Voltage (VCC)	-0.5	3.6	Volt
Input Pin Voltage	-0.5	VCC+0.5	Volt
Input Power at RF_IN		+20	dBm
Storage Temperature	-40	+125	°C

7. UART Interface

The module provides a universal asynchronous receiver-transmitter (UART) serial port.
It is designed as DCE (Data Communication Equipment), following the standard DCE-DTE (Data Terminal Equipment) connection convention.

Communication between the module and the host device (DTE) is established through the signal lines illustrated in the following diagram.

The UART supports data baud rates ranging from 9600 bps to 1,000,000 bps.

UART Interface:

- TXD: Transmits data to the RXD1 line of the DTE.
- RXD: Receives data from the TXD1 line of the DTE.

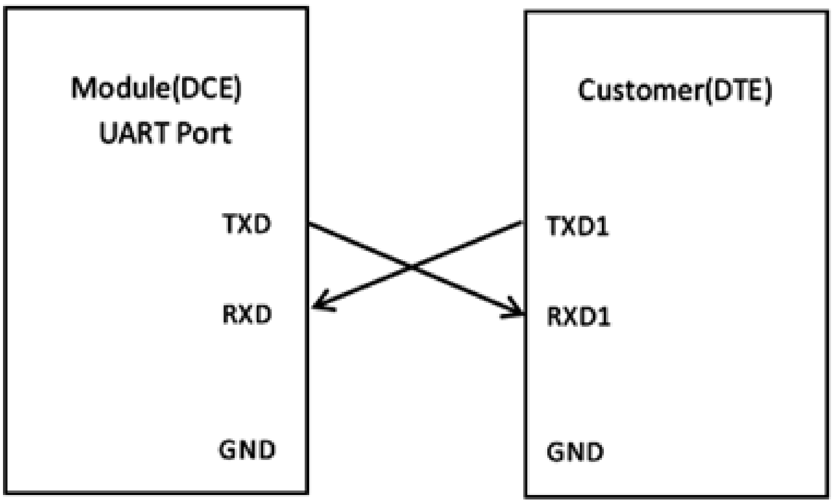

Figure 4: Serial Port connection

This UART port has the following features:

- UART port can be used for NMEA Protocol output and proprietary commands input.
- The default output NMEA type setting is GGA, GSA, GSV, VTG, RMC, GLL
- UART port supports the following data rates:
  9600, 14400, 19200, 38400, 57600, 115200, 230400, 460800, 1000000 bps.
  115200bps by default, 8 bits, no parity bit, 1 stop bit.
- Hardware flow control and synchronous operation are not supported.

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The UART port does not support the RS-232 level but only CMOS level. If the module's UART port is connected to the UART port of a computer, it is necessary to add a level shift circuit between the module and the computer. Please refer to the following figure.

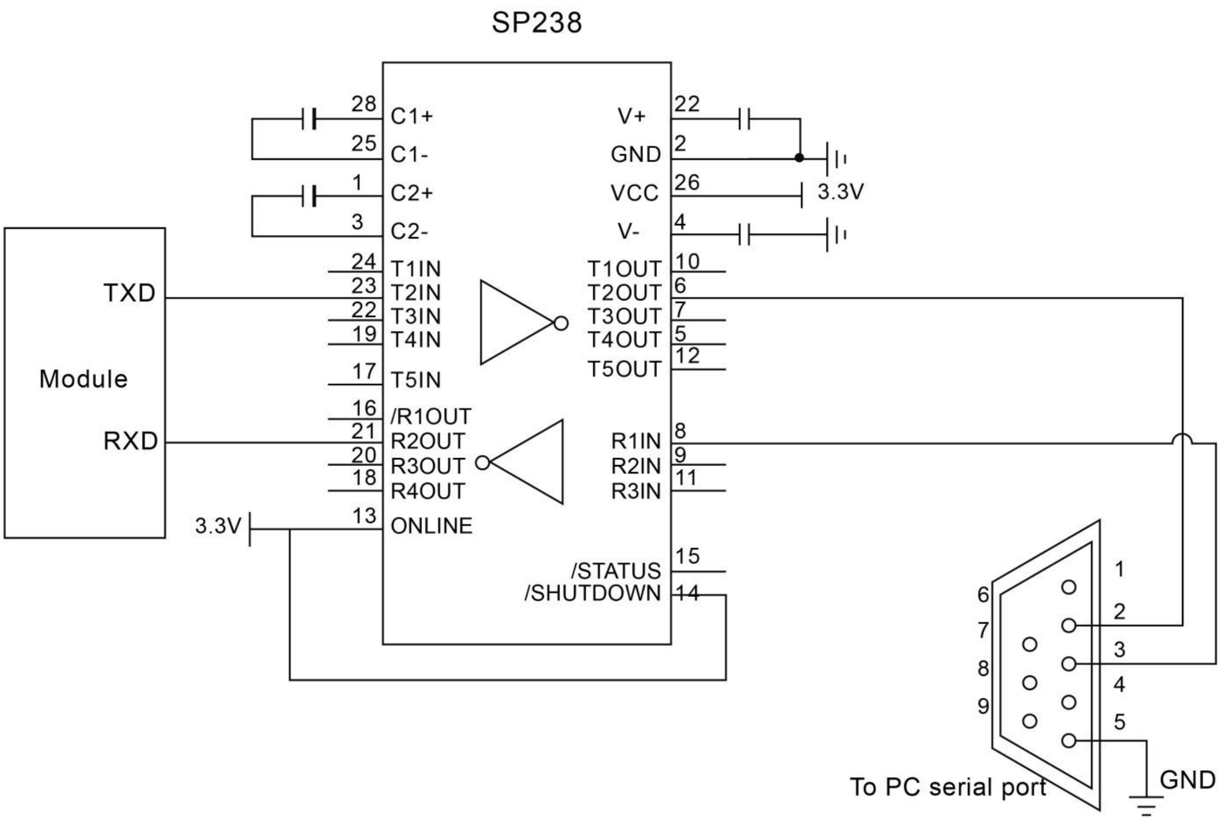

Figure 5: RS-232 Level Shift Circuit

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8. Antenna Consideration

The BKR3-1612 is designed for use with both active antennas and passive antennas that have higher gain. Passive ceramic patch antennas are low-cost and offer good sensitivity. Larger ceramic patch antennas with a 50-ohm output and higher gain can be connected directly to the module's RF input. Typically, the ceramic patch antenna and the BKR3-1612 module are mounted on opposite sides of the PCB to minimize the risk of picking up digital noise. To enhance signal reception, it is recommended to use a larger ground plane beneath the patch antenna; the larger the ground plane, the higher the overall antenna gain.

The center frequency of the ceramic patch antenna varies depending on the size of the ground plane. For optimal operation across L1, L2, and L5 bands, the antenna's frequency bandwidth should cover approximately 1174 MHz to 1179 MHz and 1573 MHz to 1606 MHz, respectively, when mounted on the PCB. It is common practice to request the ceramic patch antenna vendor to select or tune an antenna that best matches the customer’s PCB design.

An active antenna is essentially a passive antenna with a built-in low-noise amplifier (LNA) and a coaxial cable connecting the antenna to the module. It offers the flexibility of being positioned remotely from the module but requires antenna power. Although active antennas typically cost more than passive patch antennas, they generally perform better in low-signal environments. Active antennas with a gain between 10 and 20 dB and a noise figure below 1.5 dB are suitable for use with the BKR3-1612.

Antenna Type	Passive	Active
GPS&QZSS Frequency (MHz)	1575.42 +/-2 (L1) 1227.6 +/- 2(L2C) 1176.45 +/-12 (L5)	1575.42 +/-2 (L1) 1227.6 +/- 2(L2C) 1176.45 +/-12 (L5)
BDS Frequency (MHz)	1561.098 +/- 2 (B1I) 1575.42 +/- 2 (B1C) 1176.45 +/- 2 (B2A) 1207.14 +/- 2 (B2I) 1268.52 +/- 2(B3I)	1561.098 +/- 2 (B1I) 1575.42 +/- 2 (B1C) 1176.45 +/- 2 (B2A) 1207.14 +/- 2 (B2I) 1268.52 +/- 2(B3I)
GLONASS Frequency (MHz)	1602MHz +/- 4 (L1) 1227.6 +/- 2(L2C)	1602MHz +/- 4 (L1) 1227.6 +/- 2(L2C)
GALILEO Frequency (MHz)	1575.42 +/-2 (E1) 1176.45 +/-12 (E5)	1575.42 +/-2 (E1) 1176.45 +/-12 (E5)
VSWR	< 2 (typical)	< 2 (typical)
Polarization	RHCP	RHCP
Antenna Gain	>0dBi	> -2dBi
LNA Gain		20dB(typical)

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Noise Figure		<1.5dB
Total Gain		> 18 dBi

9. Power Supply Requirement

The BKR3-1612 requires a stable power supply with ripple on the VCC pin kept below 50 mV peak-to-peak. Power supply noise can negatively impact the receiver's sensitivity. It is recommended to place bypass capacitors of 10 µF and 0.1 µF close to the module's VCC pin. The capacitor values can be adjusted based on the amount and type of noise present on the power line.

10. Backup Supply

The backup supply voltage pin (VBCP) is designed to keep the SRAM memory and the RTC powered when the module is turned off. This allows the module to achieve a faster time-to-first-fix when powered on again. The backup current consumption is less than 12 µA. During normal operation, the internal processor accesses the SRAM, resulting in a higher current drain in active mode.

11. 1pps Output

When using four or more satellites for 3D positioning, the rising edge of the 1 pulse-per-second (1PPS) signal on the 1PPS pin is aligned with the UTC second, with an accuracy of approximately 20 nanoseconds. If the module is not positioned, the 1PPS pin outputs a constant low signal.

12. Layout Guidelines

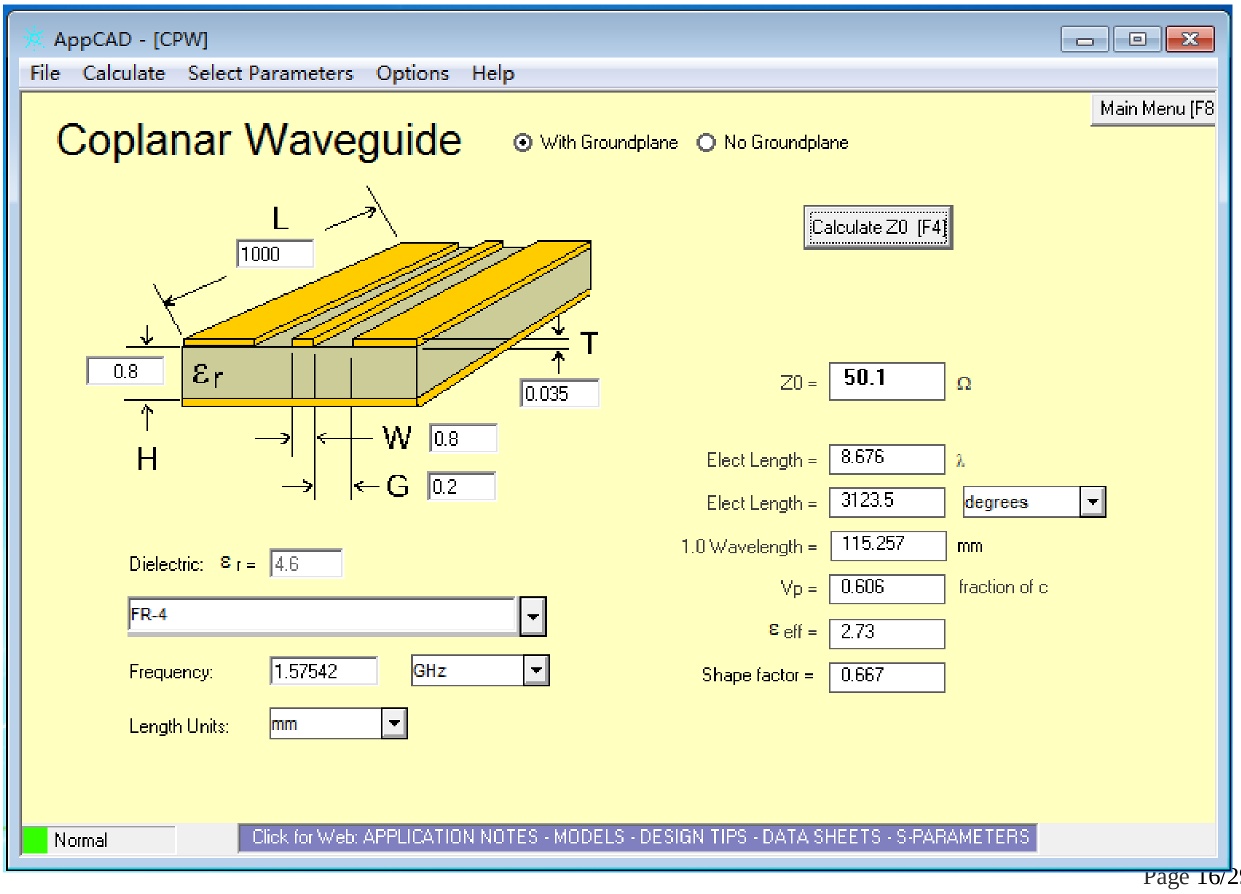
Separate the RF and digital circuits into distinct regions on the PCB. It is essential to maintain a 50-ohm impedance throughout the entire RF signal path. Keep the RF signal path as short as possible.

Avoid routing the RF signal line near noisy sources such as digital signals, oscillators, switching power supplies, or other RF transmitting circuits. Do not route the RF signal line underneath or above any components (including the BKR3-1612) or other signal traces. To minimize signal loss, avoid routing the RF signal path on inner layers of a multi-layer PCB.

Avoid sharp bends in the RF signal path. If bends are necessary, use two 45-degree bends or a circular bend instead of a single 90-degree bend.

Minimize the use of via holes in the RF signal path whenever possible, as each via adds inductive impedance. However, via holes are acceptable for connecting RF grounds between different PCB layers. Each ground pin of the module should have a short trace that connects directly to the ground plane below through a via.

Bypass capacitors should be low-ESR ceramic types and placed directly adjacent to the pins they serve.



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13. ESD handling precautions

The BKR3-1612 module is an Electrostatic Sensitive Device (ESD). Proper handling precautions must be observed to avoid severe damage to the GPS receiver. Since GPS receivers are sensitive to electrostatic discharge, special care is required during handling. Patch antennas require particular attention due to their susceptibility to electrostatic charges. In addition to standard ESD safety procedures, the following guidelines should be followed when handling the receiver:

- Unless there is galvanic coupling between the local ground (e.g., the workbench) and the PCB ground, the first point of contact when handling the PCB should always be between the local ground and the PCB ground.

- Before mounting the patch antenna, ensure the device ground is connected. When handling the RF pin, avoid contact with charged capacitors and be cautious when touching materials prone to static buildup (e.g., patch antennas with ~10 pF capacitance, coaxial cables with ~50–80 pF/m, soldering irons, etc.).

- To prevent electrostatic discharge through the RF input, avoid touching any exposed antenna areas. If there is a risk of contact with exposed antenna areas in a non-ESD protected workspace, implement appropriate ESD protection measures in the design.

- When soldering RF connectors and patch antennas to the receiver’s RF pin, use an ESD-safe soldering iron and tip.

Table 5: ESD Endurance Table (Temperature: 25°C, Humidity: 45%)

Pin	Contact Discharge	Air Discharge
RF_IN	±5KV	±10KV
VCC	±5KV	±10KV
UART	±3KV	±6KV
Others	±2KV	±4KV

14. Mechanical Dimensions

This chapter describes the mechanical dimensions of the module.

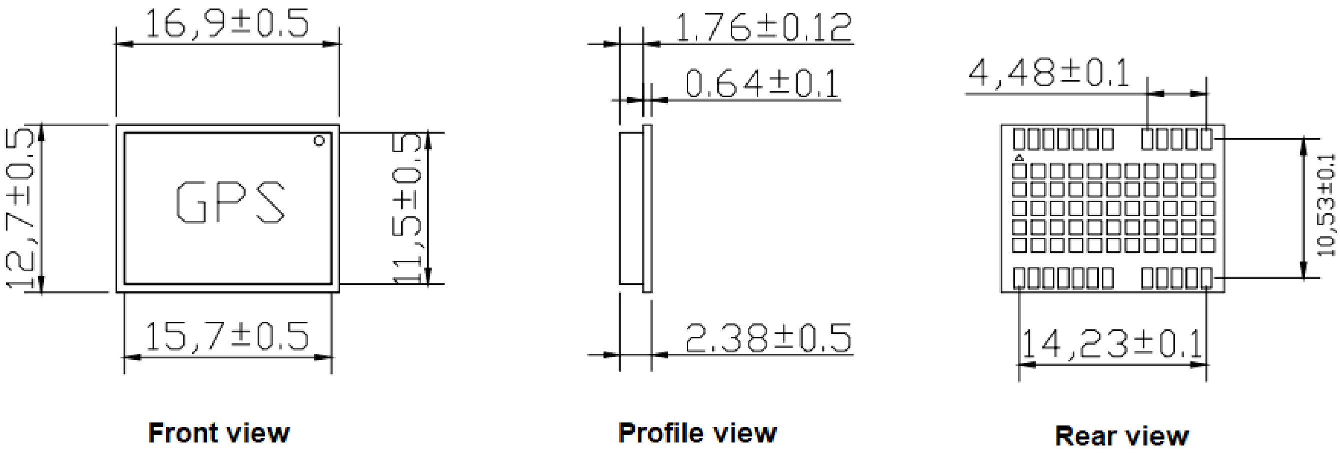

Figure 7: Top view Dimensions

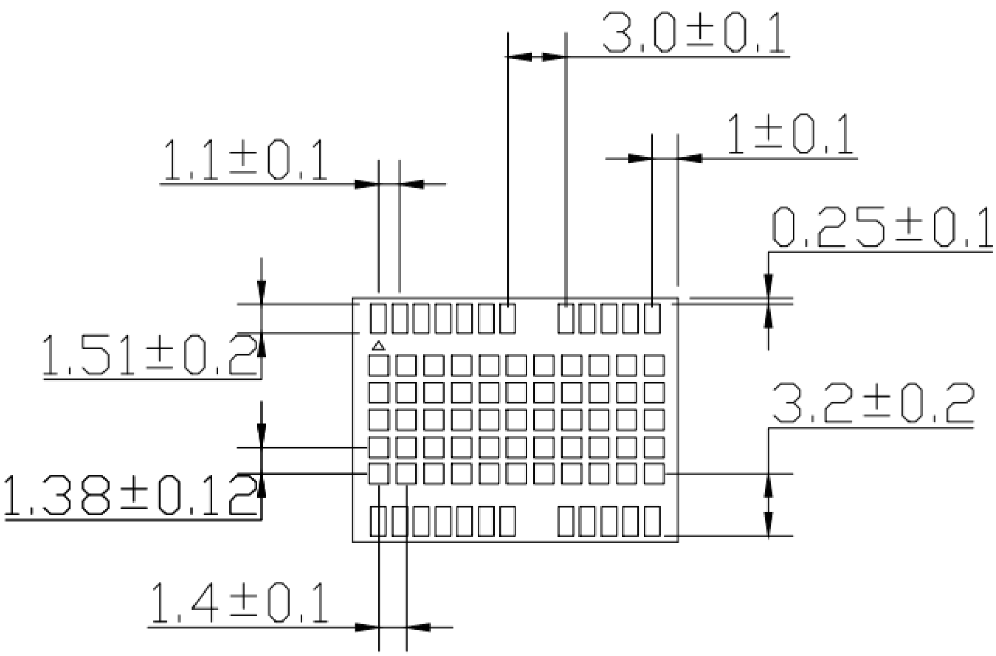

Figure 8: Footprint of Recommendation

Note: The recommended land pattern dimensions are shown for reference only, as actual pad layouts may vary depending on application.

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15. Manufacturing, Packaging and Ordering Information

15.1 Assembly and Soldering

The BKR3-1612 module is designed for SMT assembly and soldering using a Pb-free reflow process on the top side of the PCB. It is recommended that the solder paste stencil have a minimum thickness of 100 µm to ensure adequate solder volume. Increasing the pad openings on the paste mask can help achieve proper soldering and good solder wetting on the pads. The suggested peak reflow temperature is 240ºC for Sn96.5Ag3.0Cu0.5 solder alloy, with an absolute maximum temperature of 260ºC. To prevent damage from repeated heating, it is advised to mount the module only after completing the reflow soldering of the opposite side of the PCB. The recommended reflow soldering thermal profile is shown below:

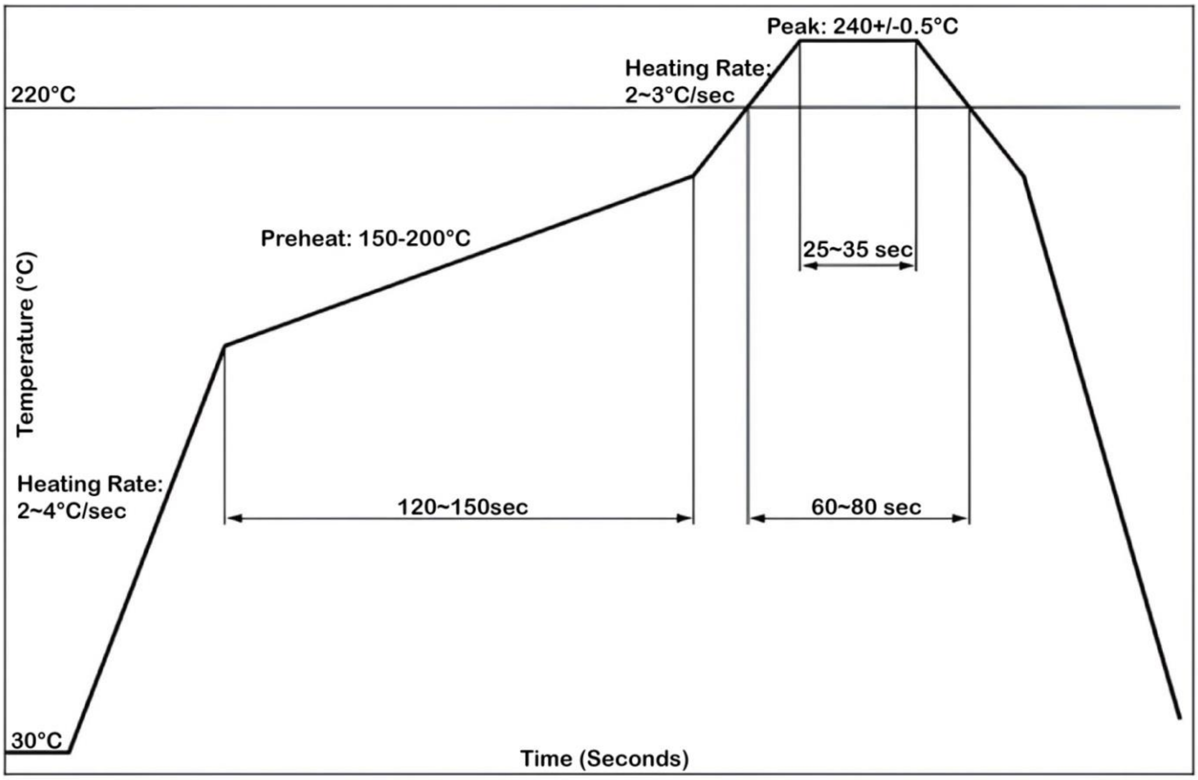

Figure 9: Recommended Reflow Soldering Thermal Profile

15.2 Moisture Sensitivity

The BKR3-1612 module is moisture sensitive at Level 3. To prevent permanent damage during reflow soldering, baking is required in the following cases:

- The humidity indicator card shows one or more spots that are no longer blue.
- The moisture seal has been opened and the module has been exposed to excessive humidity.

In such cases, the BKR3-1612 must be baked for 192 hours in a controlled environment at 40°C (+5°C/-0°C) with less than 5% relative humidity, or alternatively, for 24 hours at a high temperature of 125°C ± 5°C.

Since the plastic packaging tape is not heat-resistant, the module should be removed from the tape before baking to avoid damage to the tape due to high temperature. You may also refer to the SMT factory's actual production process for further guidance.

15.3 Tape and Reel Packaging

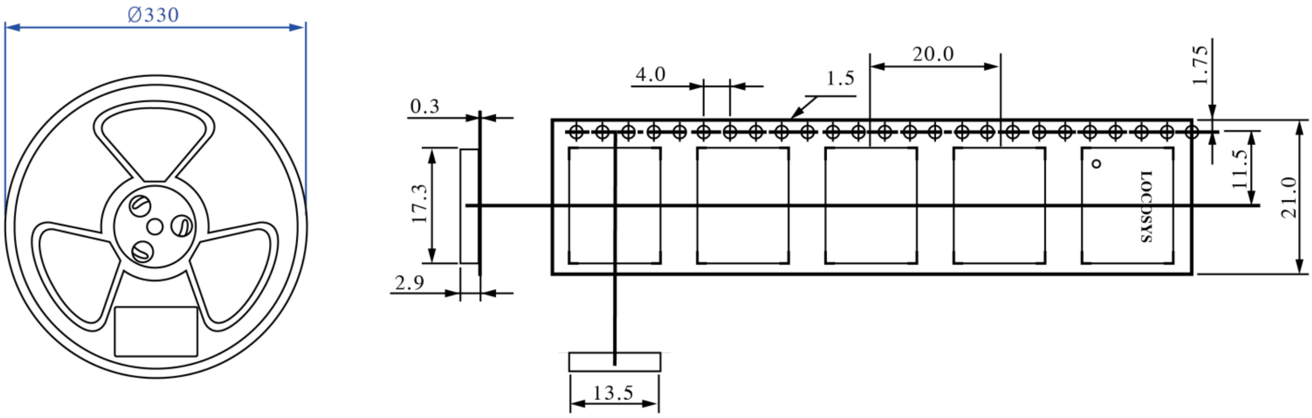

Figure 10: Tape and Reel Specifications

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Figure 11: Packaging physical Figure

Table 6: Reel Packaging

Model Name	MOQ for MP	Minimum Package: 1000pcs
BKR3-1612	1,000 pcs	Size: 365mm × 348mm × 50mm N.W: 0.90 kg G.W: 1.48 kg

16. Software Interface

16.1 GNSS – Differential GNSS

The RTK navigation mode operates using the data format provided by RTCM version 3.3. The BKR3-1612 supports DGNSS functionality in accordance with the RTCM 10403.3 protocol. The decoded RTCM 3.3 messages are listed in the following table:

Table 7: RTCM3.3 message

Message Type	Message Name
RTCM 1074	MSM4, GPS pseudo-distance, Carrier phase, Carrier-noise ratio
RTCM 1077	MSM7, High precision GPS pseudo-distance, Carrier phase, Doppler, Carrier-noise ratio
RTCM 1084	MSM4, GLONASS pseudo-distance, carrier phase, carrier-noise ratio
RTCM 1087	MSM7, High precision GLONASS pseudo-distance, Carrier phase, Doppler, Carrier-noise ratio
RTCM 1094	MSM4, Galileo pseudo-distance, Carrier phase, Carrier-noise ratio
RTCM 1097	MSM7, High precision Galileo pseudo-distance, Carrier phase, Doppler, Carrier-noise ratio
RTCM 1104	MSM4, SBAS pseudo-distance, Carrier phase, Carrier-noise ratio
RTCM 1107	MSM7, High precision SBAS pseudo-distance, Carrier phase, Doppler, Carrier-noise ratio
RTCM 1114	MSM4, QZSS pseudo-distance, Carrier phase, Carrier-noise ratio
RTCM 1117	MSM7 High precision QZSS pseudo-distance, Carrier phase, Doppler, Carrier-noise ratio
RTCM 1124	MSM4, BeiDou pseudo-distance, Carrier phase, Carrier-noise ratio
RTCM 1127	MSM7, High precision BeiDou pseudo-distance, Carrier phase, Doppler, Carrier-noise ratio

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16.2 NMEA output message

Table 8: NMEA output message

NMEA record	Description
GGA	Global Positioning System Fix Data
GSA	GNSS DOP and Active Satellites
GSV	GNSS Satellites in View
VTG	Course Over Ground and Ground Speed
RMC	Recommended Minimum Specific GNSS Data
GLL	Geographic position – Latitude / Longitude

- ### GGA – Global Positioning System Fix Data

Contains the values for the following example:

$GNGGA,093721.00,2503.7122282,N,12138.7454554,E,2,49,0.4,138.226,M,0.000,M,,*4F

Name	Example	Description
Message ID	$GNGGA	GGA protocol header
UTC Time	093721.00	UTC of position in hhmmss.sss format, (000000.00 ~ 235959.99)
Latitude	2503.7122282	Latitude in ddmm.mmmmmmm format Leading zeros transmitted
N/S Indicator	N	Latitude hemisphere indicator, ‘N’ = North, ‘S’ = South
Longitude	12138.7454554	Longitude in dddmm.mmmmmmm format Leading zeros transmitted
E/W Indicator	E	Longitude hemisphere indicator, ‘E’ = East, ‘W’ = West
Quality Indicator	2	Quality Indicator 0: position fix unavailable 1: valid position fix, SPS mode 2: valid position fix, differential GPS mode 4: RTK fixed 5: RTK float
Satellites Used	49	Number of satellites in use, (00 ~ 56)
HDOP	0.4	Horizontal dilution of precision, (0.0 ~ 99.9)
Altitude	138.226	mean sea level (geoid),
Units	M	Units of antenna altitude, meters

Geoidal Separation	0.000	Geoidal separation in meters
Units	M	Units of geoidal separation, meters
Age of Differential GPS data		Age of Differential GPS data NULL when DGPS not used
DGPS Station ID		Differential reference station ID, 0000 ~ 1023
Checksum	4F	

● GSA – GNSS DOP and Active Satellites

Contains the values for the following example:

$GNGSA,A,3,21, 12,15,18,20,24,10,32,25,13,,,1.2,0.7,1.0,1*18
$GNGSA,A,3,01,02,03,04,06,07,08,09,10,11,12,13,0.7,0.4,0.6,4*35
$GNGSA,A,3,74,73,75,69,84,83,85,68,,,,,0.7,0.4,0.6,2*39
$GNGSA,A,3,10,11,12,24,25,31,33,,,,,,0.7,0.4,0.6,3*37
$GNGSA,A,3,09,10,,,,,,,,,,,0.8,0.4,0.6,5*37

Name	Example	Description
Message ID	$GNGSA	GSA protocol header
Mode	A	Mode 'M' = Manual, forced to operate in 2D or 3D mode 'A' = Automatic, allowed to automatically switch 2D/3D
Mode	3	Fix type 1 = Fix not available 2 = 2D 3 = 3D
Satellite used 1~12	21, 12, 15, 18, 20, 24, 10, 32, 25, 13	01 ~ 32 are for GPS 33 ~ 64 are for SBAS (PRN minus 87) 193 ~ 199 are for QZSS 65 ~ 88 are for GLONASS (GL PRN) 01 ~ 36 are for GALILEO (GA PRN) 01~ 37 are for BDS (BD PRN) 01 ~ 07 are for NavIC
PDOP	1.2	Position dilution of precision (0.0 to 99.9)
HDOP	0.7	Horizontal dilution of precision (0.0 to 99.9)
VDOP	1.0	Vertical dilution of precision (0.0 to 99.9)
GNSS System ID	1	See below Table 8
Checksum	18	

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Table 9: GNSS system ID

Value	Description
1	GPS
2	GLONASS
3	GALILEO
4	BEIDOU
5	IRNSS

- GSV – GNSS Satellites in View

Contains the values for the following example:

```
$GPGSV,4,1,16,02,37,033,34,03,48,113,32,06,20,234,19,07,24,198,33,1*62
$GPGSV,4,2,16,14,63,328,28,17,38,315,28,18,00,000,00,19,19,291,26,1*61
$GPGSV,4,3,16,21,22,040,34,22,40,325,24,30,36,234,35,194,71,113,38,1*55
$GPGSV,4,4,16,195,71,045,37,196,31,148,30,199,60,168,33,57,00,000,31,1*57
$GPGSV,4,1,14,02,37,033,00,03,48,113,37,06,20,234,29,07,24,198,00,8*68
$GPGSV,4,2,14,14,63,328,40,17,38,315,00,19,19,291,00,21,22,040,00,8*64
$GPGSV,4,3,14,22,40,325,00,30,36,234,36,194,71,113,39,195,71,045,38,8*6B
$GPGSV,4,4,14,196,31,148,34,199,60,168,39,,,,,,,,8*6C
$BDGSV,6,1,24,01,51,136,38,02,37,239,32,03,57,204,39,04,39,118,35,1*7C
$BDGSV,6,2,24,05,00,000,32,06,26,210,37,07,62,344,40,08,37,182,34,1*72
$BDGSV,6,3,24,09,31,224,37,10,51,323,40,11,17,264,34,12,53,316,41,1*7B
$BDGSV,6,4,24,13,27,191,36,16,23,203,37,19,07,057,35,21,13,158,34,1*78
$BDGSV,6,5,24,22,22,106,39,24,62,258,45,25,22,314,37,26,38,176,42,1*7D
$BDGSV,6,6,24,34,34,282,40,35,00,000,39,38,48,176,41,39,17,198,38,1*76
$BDGSV,3,1,12,19,07,057,23,21,13,158,29,22,22,106,30,24,62,258,38,3*7E
$BDGSV,3,2,12,25,22,314,29,26,38,176,33,34,34,282,31,35,00,000,30,3*7F
$BDGSV,3,3,12,38,48,176,34,39,17,198,28,40,56,008,35,44,55,360,36,3*7B
$BDGSV,3,1,10,01,53,133,00,02,41,244,00,03,60,206,00,04,39,117,00,5*79
$BDGSV,3,2,10,06,53,201,24,07,00,000,00,08,57,004,26,09,37,204,22,5*72
$BDGSV,3,3,10,13,52,346,25,16,56,199,25,,,,,,,,5*71
$BDGSV,3,1,4,20,27,302,40,23,40,085,42,25,08,043,34,27,21,189,35,2*74
$GLGSV,2,1,08,74,71,294,38,73,52,175,42,75,19,330,29,69,09,111,35,1*74
$GLGSV,2,2,08,84,48,346,25,83,06,040,22,85,31,270,40,68,07,064,23,1*7B
$GAGSV,2,1,07,10,67,264,37,11,41,239,29,12,73,350,25,24,63,331,34,7*76
$GAGSV,2,2,07,25,11,320,25,31,60,126,31,33,23,037,26,,,,,7*47
$GAGSV,2,1,07,10,67,264,38,11,41,239,29,12,73,350,34,24,63,331,37,1*7C
$GAGSV,2,2,07,25,11,320,28,31,60,126,37,33,23,037,32,,,,,1*4F
$IRGSV,1,1,04,05,00,000,45,07,00,000,45,09,15,272,35,10,55,164,43,1*67
```

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Name	Example	Description
Message ID	$GPGSV	GSV protocol header GP=GPS/QZSS, GL=GLONSS,GA=GALILEO, GB=BEIDOU GI=IRNSS
Number of message	4	Total number of GSV messages to be transmitted
Sequence number	1	Sequence number of current GSV message
Satellites in view	16	Total number of satellites in view
Satellite ID	02	01 ~ 32 are for GPS 33 ~ 64 are for SBAS (PRN minus 87) 193~ 199 are for QZSS 65 ~ 88 are for GLONASS (GL PRN) 01 ~ 36are for GALILEO (GA PRN) 01 ~ 37 are for BDS (BD PRN) 01 ~ 07 are for NavIC.
Elevation	37	Satellite elevation in degrees, (00 ~ 90)
Azimuth	033	Satellite azimuth angle in degrees, (000 ~ 359)
SNR	34	C/No in dB (00 ~ 99) Null when not tracking
Signal ID	1	GPS/QZSS: L1 C/A=1, L5Q=8 GLONASS: L1 C/A=1 GALILEO: E1=7, E5a=1 BEIDOU: B1=1, B2a=3, B2b=5, B1C=2 IRNSS: L5=1
Checksum	62	

- ## VTG – Course Over Ground and Ground Speed

Contains the values for the following example:

$GNVTG,0.00,T,,M,0.00,N,0.00,K,D*26

Name	Example	Description
Message ID	$GNVTG	VTG protocol header
Course over ground	0.00	Course over ground, degrees True
Reference	T	True
Course over ground		Course over ground, degrees Magnetic
Reference	M	Magnetic
Speed	0.00	Speed over ground in knots

Reference	N	Knots
Speed	0.00	Speed over ground in kilometers per hour
Reference	K	Kilometer per hour
Mode	D	Mode indicator 'N' = Data not valid 'A' = Autonomous mode 'D' = Differential mode
Checksum	26	

- RMC – Recommended Minimum Specific GNSS Data

Contains the values for the following example:

$GNRMC,092732.00,A,2503.7133708,N,12138.7448218,E,0.00,0.00,240624,,,A,V*31

Name	**Example**	**Description**
Message ID	$GNRMC	RMC protocol header
UTC time	092732.00	UTC time in hhmmss.sss format (000000.00 ~ 235959.999)
Status	A	Status 'V' = Navigation receiver warning 'A' = Data Valid
Latitude	2503.7133708	Latitude in ddmm.mmmmmmm format Leading zeros transmitted
N/S indicator	N	Latitude hemisphere indicator 'N' =North 'S' = South
Longitude	12138.7448218	Longitude in dddmm.mmmmmmm format Leading zeros transmitted
E/W Indicator	E	Longitude hemisphere indicator 'E' = East 'W' = West
Speed over ground	0.00	Speed over ground in knots
Course over ground	0.00	Course over ground in degrees
UTC Date	240624	UTC date of position fix, ddmmyy format
Magnetic variation		degrees
Variation sense		

Mode indicator	A	Mode indicator 'N' = Data not valid 'A' = Autonomous mode 'D' = Differential mode
Navigational status indicator	V	S = Safe C = Caution U = Unsafe V = Void
Checksum	31	

GLL – Geographic position – Latitude / Longitude

Contains the values for the following example:

$GNGLL,2503.7123037,N,12138.7455144,E,094421.00,A,D*74

Name	**Example**	**Description**
Message ID	$GNGLL	$GNGLL protocol header
Latitude	25037123037	Latitude in ddmm.mmmmmmm format Leading zeros transmitted
N/S Indicator	N	Latitude hemisphere indicator 'N' = North 'S' = South
Longitude	12138.7455144	Longitude in dddmm.mmmmmmm format Leading zeros transmitted
E/W Indicator	E	Longitude hemisphere indicator 'E' = East 'W' = West
UTC Time	094421.00	UTC time in hhmmss.sss format (000000.00 ~ 235959.99)
Status	A	Status, 'A' = Data valid, 'V' = Data not valid
Mode Indicator	D	Mode indicator 'N' = Data not valid 'A' = Autonomous mode 'D' = Differential mode
Checksum	74	

17. Document change list

Revision 0.1

- Draft release on July 23, 2025.