

Product name	Description	Version
MC-1612-V3b	Dual-frequency multi-constellation GNSS positioning module	1.1



## 1 Introduction

LOCOSYS MC-1612-V3b is a high-performance dual-band GNSS positioning module that is capable of tracking all global civil navigation systems. It adopts 12 nm process and integrates efficient power management architecture to perform low power and high sensitivity.

The module supports hybrid ephemeris prediction to achieve faster cold start. One is self-generated ephemeris prediction (called EPOC) that is no need of both network assistance and host CPU's intervention. This is valid for up to 3 days and updates automatically from time to time when GNSS module is powered on and satellites are available. The other is server-generated ephemeris prediction (called EPO) that gets from an internet server. This is valid for up to 14 days. Both ephemeris predictions are stored in the on-board flash memory and perform a cold start time less than 15 seconds.

The RF front end of the module is specifically designed to comply with sensitivity specification contained in AIS 140 standard. It is the best solution to those customers that design tracking applications in compliance with AIS 140.

## 2 Features

- Support GPS, GLONASS, GALILEO, BEIDOU, QZSS and NavIC
- Capable of SBAS (WAAS, EGNOS, MSAS, GAGAN) and QZSS SLAS
- Support 135-channel GNSS
- Ultra low power consumption
- Fast TTFF at low signal level
- Free hybrid ephemeris prediction to achieve faster cold start
- Up to 10 Hz update rate
- $\pm 10$ ns high accuracy time pulse (PPS)
- GNSS software package that can pass Android GMS certification
- IATF 16949 quality control
- Small form factor 16 x 12.2 x 2.4 mm
- SMD type with stamp holes; RoHS compliant

## 3 Application

- Personal positioning and navigation
- Automotive navigation
- Marine navigation

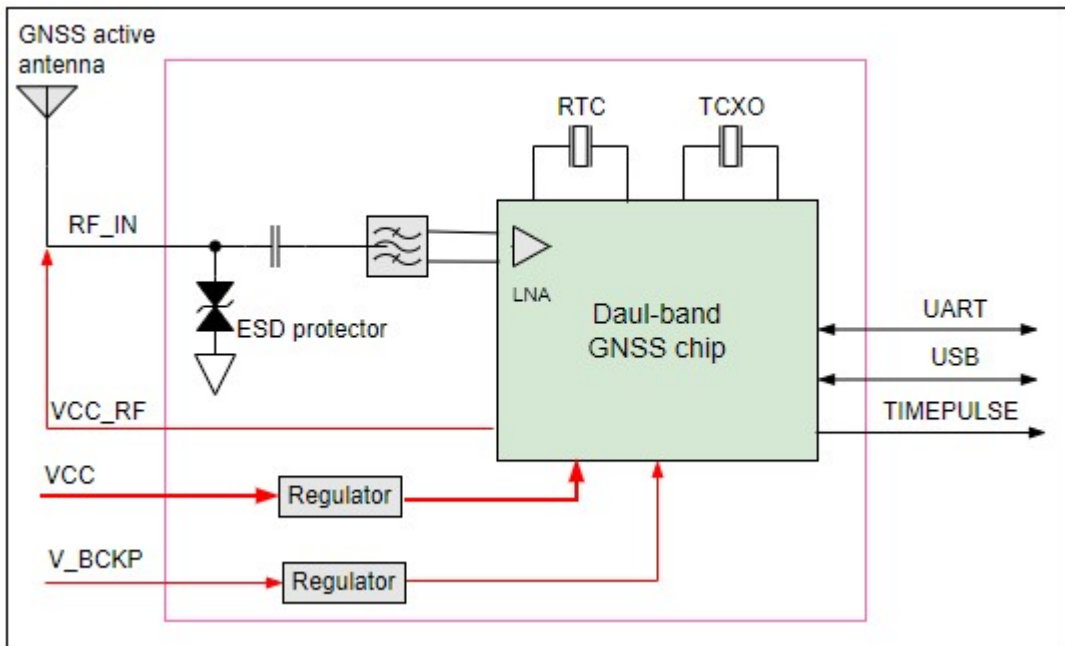


Fig 3-1 System block diagram.

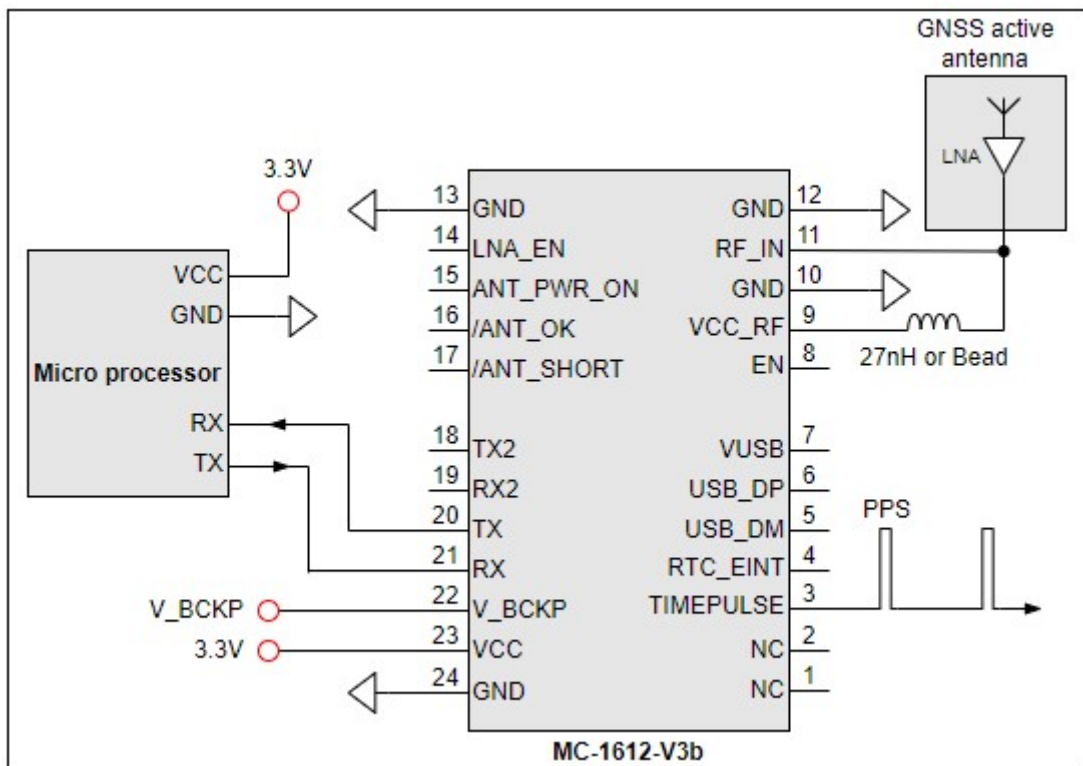


Fig 3-2 Typical application circuit that uses an active antenna.

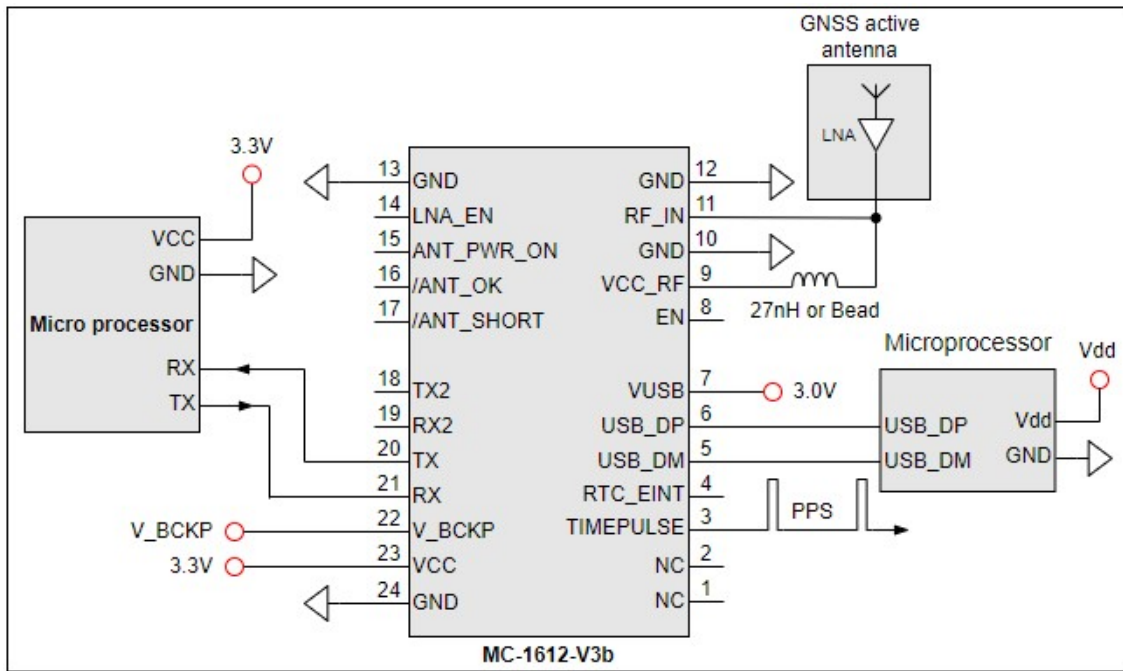


Fig 3-3 Typical application circuit that uses USB interface.

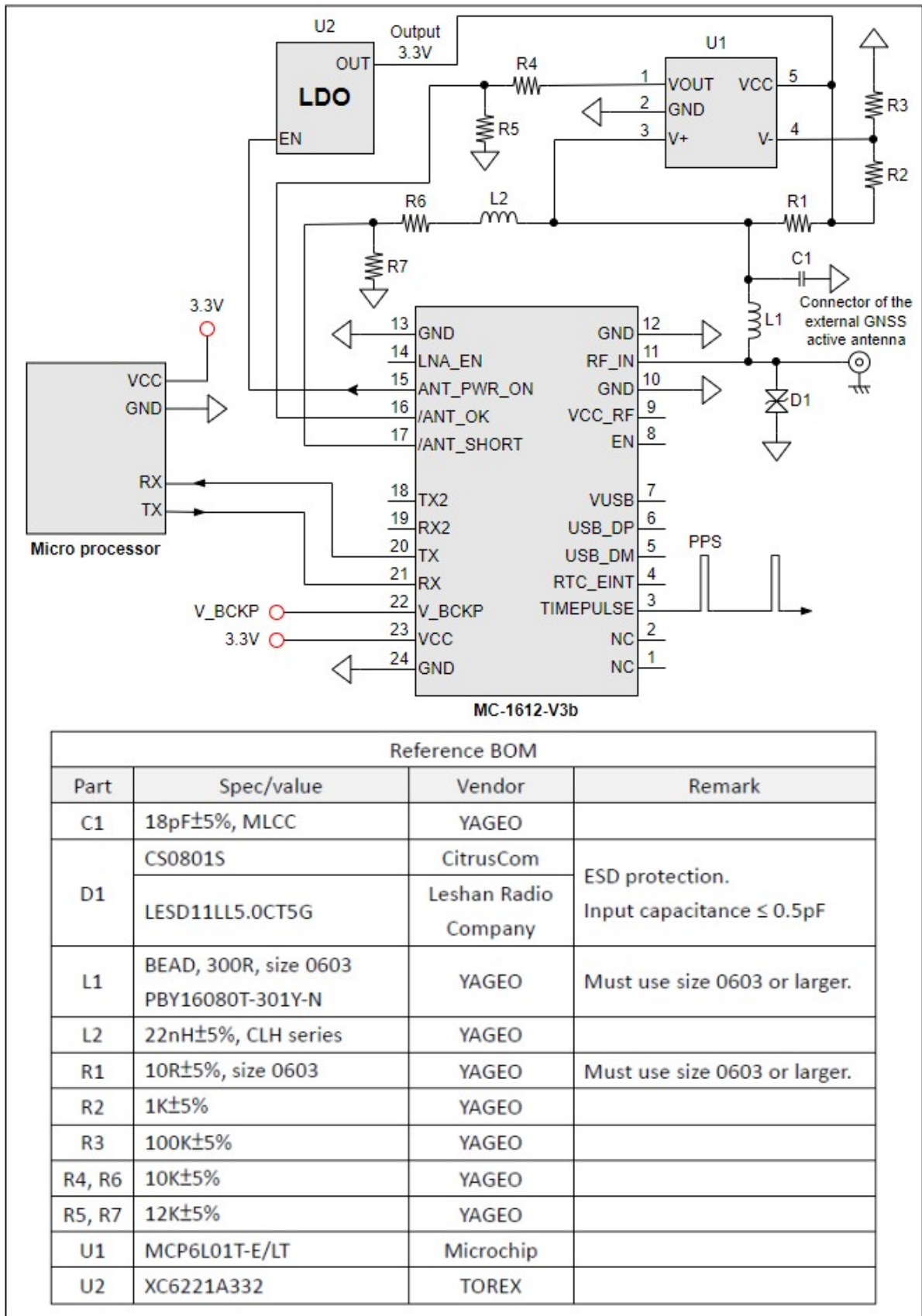


Fig 3-4 The reference circuit of an external active antenna that can get its status.

Table 3.1 The status of the external active antenna in Fig 3-4.

/ANT_SHORT	/ANT_OK	Description
LOW	Don't care.	Antenna is short. ANT_PWR_ON outputs low. The module outputs the following message. \$GNTXT,01,01,02,ANT_SHORT,D2,*73
HIGH	LOW	Antenna is properly connected. ANT_PWR_ON outputs high. The module outputs the following message. \$GNTXT,01,01,02,ANT_OK,D2,*25
HIGH	HIGH	Antenna is not connected. ANT_PWR_ON outputs high. The module outputs the following message. \$GNTXT,01,01,02,ANT_OPEN,D2,*35

#### 4 GNSS receiver

Frequency	GPS/QZSS: L1 C/A GLONASS: L1OF GALILEO: E1 BEIDOU: B1I NavIC: L5	
Channels	Support 135 channels	
Update rate	1Hz default, up to 10Hz	
Sensitivity	Tracking	-165dBm (with external LNA)
	Cold start	-148dBm (with external LNA)
Acquisition Time	Hot start (Open Sky)	1s (typical)
	Cold Start (Open Sky)	28s (typical) without AGPS
		< 15s (typical) with AGPS (ephemeris prediction)
Position Accuracy	Autonomous: 2.5m (CEP) <sup>(1)</sup>	
Max. Altitude	< 18,000 m	
Max. Velocity	< 500 m/s	
Protocol Support	NMEA 0183 ver. 4.1	115200 bps <sup>(2)</sup> , 8 data bits, no parity, 1 stop bits (default) 1Hz: GGA, GLL, GSA, GSV, RMC, VTG, GST, TXT

Note 1. Open sky, dual band, demonstrated with a good external LNA.

Note 2. Both baud rate and output message rate are configurable to be factory default.

## 5 Software interface

### 5.1 NMEA output message

Table 5.1-1 NMEA output message

NMEA record	Description
GGA	Global positioning system fixed data
GLL	Geographic position - latitude/longitude
GSA	GNSS DOP and active satellites
GSV	GNSS satellites in view
RMC	Recommended minimum specific GNSS data
VTG	Course over ground and ground speed
GST	Estimated error in position solution

- **GGA--- Global Positioning System Fixed Data**

Table 5.1-2 contains the values for the following example:

\$GNGGA,091250.000,2503.71250,N,12138.74514,E,1,32,0.55,119.0,M,17.2,M,,\*7E

Table5.1- 2 GGA Data Format

Name	Example	Units	Description
Message ID	\$GNGGA		GGA protocol header
UTC Time	091250.000		hhmmss.sss
Latitude	2503.71250		ddmm.mmmmm
N/S indicator	N		N=north or S=south
Longitude	12138.74514		dddmm.mmmmm
E/W Indicator	E		E=east or W=west
Position Fix Indicator	1		See Table 5.1-3
Satellites Used	32		Number of satellites in use
HDOP	0.55		Horizontal Dilution of Precision (meters)
MSL Altitude	119.0	meters	Antenna Altitude above/below mean-sea-level (geoid) (in meters)
Units	M	meters	Units of antenna altitude, meters
Geoidal Separation	17.2	meters	
Units	M	meters	Units of geoidal separation, meters
Age of diff. GNSS data		second	Null fields when DGPS is not used
Diff. Ref. Station ID			Differential reference station ID, 0000-1023
Checksum	*7E		Checksum
<CR> <LF>			End of message termination

Table 5.1-3 Position Fix Indicators

Value	Description
0	No position fix
1	Autonomous GNSS fix
2	Differential GNSS fix
4	RTK fixed
5	RTK float

## ● GLL--- Geographic Position – Latitude/Longitude

Table 5.1-4 contains the values for the following example:

\$GNGLL,2503.71193,N,12138.74582,E,094450.000,A,A\*47

Table 5.1-4 GLL Data Format

Name	Example	Units	Description
Message ID	\$GNGLL		GLL protocol header
Latitude	2503.71193		ddmm.mmmmm
N/S indicator	N		N=north or S=south
Longitude	12138.74582		dddmm.mmmmm
E/W indicator	E		E=east or W=west
UTC Time	094450.000		hhmmss.sss
Status	A		A=data valid or V=data not valid
Mode	A		N = No position fix A = Autonomous GNSS fix D = Differential GNSS fix R = RTK fixed F = RTK float E = Estimated/Dead reckoning fix
Checksum	*47		
<CR> <LF>			End of message termination

## ● GSA---GNSS DOP and Active Satellites

Table 5.1-5 contains the values for the following example:

\$GNGSA,A,3,11,195,194,199,08,07,01,27,16,09,23,,1.19,0.64,1.00,1\*3F

\$GNGSA,A,3,87,81,76,,,,,,,,,1.19,0.64,1.00,2\*0F

\$GNGSA,A,3,,,,,,,,,,,,,1.19,0.64,1.00,3\*09

\$GNGSA,A,3,34,24,12,07,11,10,08,38,25,09,13,16,1.19,0.64,1.00,4\*02

Table 5.1-5 GSA Data Format

Name	Example	Units	Description
------	---------	-------	-------------



Message ID	\$GNGSA		GSA protocol header
Mode 1	A		See Table 5.1-6
Mode 2	3		See Table 5.1-7
ID of satellite used	11		SV on Channel 1
ID of satellite used	195		SV on Channel 2
....			....
ID of satellite used			SV on Channel 12
PDOP	1.19		Position Dilution of Precision
HDOP	0.64		Horizontal Dilution of Precision
VDOP	1.00		Vertical Dilution of Precision
GNSS system ID	4		See Table 5.1-8
Checksum	*3F		

Table 5.1-6 Mode 1

Value	Description
M	Manually set to operate in 2D or 3D mode
A	Automatically switching between 2D or 3D mode

Table 5.1-7 Mode 2

Value	Description
1	No position fix
2	2D fix
3	3D fix

Table 5.1-8 GNSS system ID

Value	Description
1	GPS
2	GLONASS
3	GALILEO
4	BEIDOU
6	NavIC

## ● GSV---GNSS Satellites in View

Table 5.1-9 contains the values for the following example:

```
$GPGSV,3,1,09,8,71,268,47,27,63,18,49,11,44,191,46,4,41,237,46,1*54
$GPGSV,3,2,09,16,38,42,42,9,32,279,39,26,22,70,38,31,15,131,36,1*56
$GPGSV,3,3,09,7,15,320,40,1*6B
$GPGSV,1,1,04,8,71,268,50,27,63,18,49,9,32,279,43,26,22,70,42,8*6C
$GLGSV,2,1,05,82,63,47,47,83,56,182,36,80,47,9,42,79,33,85,45,1*71
$GLGSV,2,2,05,81,15,27,37,1*71
```

\$GAGSV,1,1,04,08,48,300,43,03,47,025,45,13,36,309,42,05,06,061,34,7\*79  
 \$GAGSV,1,1,04,08,48,300,43,03,47,025,47,13,36,309,43,05,06,061,33,1\*7B  
 \$GBGSV,5,1,17,12,80,182,47,24,64,5,51,7,58,355,44,3,57,205,45,1\*7C  
 \$GBGSV,5,2,17,1,54,141,44,34,52,211,49,9,48,230,45,10,47,316,42,1\*79  
 \$GBGSV,5,3,17,26,44,100,47,16,39,207,43,4,38,117,41,2,37,240,41,1\*77  
 \$GBGSV,5,4,17,39,37,210,43,6,36,198,41,38,27,173,41,25,18,317,42,1\*4E  
 \$GBGSV,5,5,17,35,16,39,40,1\*7F  
 \$GBGSV,1,1,02,24,64,5,50,26,44,100,43,4\*77

Table 5.1-9 GSV Data Format

Name	Example	Units	Description
Message ID	\$GPGSV		GSV protocol header GP=GPS/QZSS, GL=GLONSS, GA=GALILEO, GB=BEIDOU, GI=NavIC.
Total number of messages	3		Range 1 to 9
Message number	1		Range 1 to 9
Satellites in view	09		
Satellite ID	8		Channel 1
Elevation	71	degrees	Channel 1 (Range 00 to 90)
Azimuth	268	degrees	Channel 1 (Range 000 to 359)
SNR (C/No)	47	dB-Hz	Channel 1 (Range 00 to 99, null when not tracking)
....			....
Satellite ID	4		Channel 4 (Range 01 to 196)
Elevation	41	degrees	Channel 4 (Range 00 to 90)
Azimuth	237	degrees	Channel 4 (Range 000 to 359)
SNR (C/No)	46	dB-Hz	Channel 4 (Range 00 to 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=4 NavIC: L5=1

● **RMC---Recommended Minimum Specific GNSS Data**

Table 5.1-10 contains the values for the following example:

\$GNRMC,070143.000,A,2503.71317,N,12138.74533,E,0.002,70.50,130220,,A,V\*01

Table 5.1-10 RMC Data Format

Name	Example	Units	Description
Message ID	\$GNRMC		RMC protocol header

UTC Time	070143.000		hhmmss.sss
Status	A		A=data valid or V=data not valid
Latitude	2503.7117		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12138.74533		dddmm.mmmmm
E/W Indicator	E		E=east or W=west
Speed over ground	0.002	knots	True
Course over ground	70.50	degrees	
Date	130220		ddmmyy
Magnetic variation		degrees	
Variation sense			E=east or W=west
Mode	A		N = No position fix A = Autonomous GNSS fix D = Differential GNSS fix R = RTK fixed F = RTK float E = Estimated/Dead reckoning fix
Navigational status indicator	V		S = Safe C = Caution U = Unsafe V = Void
Checksum	*01		

● **VTG---Course Over Ground and Ground Speed**

Table 5.1-11 contains the values for the following example:

\$GNVTG,0.00,T,,M,0.003,N,0.006,K,A\*26

Table 5.1-11 VTG Data Format

Name	Example	Units	Description
Message ID	\$GPVTG		VTG protocol header
Course over ground	0.00	degrees	Measured heading
Reference	T		True
Course over ground		degrees	Measured heading
Reference	M		Magnetic
Speed over ground	0.003	knots	Measured speed
Units	N		Knots
Speed over ground	0.006	km/hr	Measured speed
Units	K		Kilometer per hour

Mode	A		N = No position fix A = Autonomous GNSS fix D = Differential GNSS fix R = RTK fixed F = RTK float E = Estimated/Dead reckoning fix
Checksum	*26		
<CR> <LF>			End of message termination

● **GST---Estimated error in position solution**

Table 5.1-12 contains the values for the following example:

\$GNGST,075707.000,2.9,1.8,1.5,113.3,1.6,1.8,5.9\*7F

Table 5.1-12 GST Data Format

Name	Example	Units	Description
Message ID	\$GNGST		GST protocol header
UTC Time	075707.000		hhmmss.sss
RangeRMS	2.9	meters	RMS value of the standard deviation of the ranges
stdMajor	1.8	meters	Standard deviation of semi-major axis of error ellipse
stdMinor	1.5	meters	Standard deviation of semi-minor axis of error ellipse
Orient	113.3	degrees	Orientation of semi-major axis of error ellipse
stdLat	1.6	meters	Standard deviation of latitude error
stdLong	1.8	meters	Standard deviation of longitude error
stdAlt	5.9	meters	Standard deviation of altitude error
Checksum	*7F		
<CR> <LF>			End of message termination

## 5.2 Proprietary commands

The commonly used commands are in the following.

### 5.2.1 ID: 001

[Description]

PAIR\_ACK. Acknowledge of the input command.

[Return]

\$PAIR001,Command\_ID,Result\*CS<CR><LF>

Command\_ID: The command / packet type the acknowledge responds.

Result: The result of the command.

0: The command was successfully sent.

1: The command is processing. You must wait for the result.

2: Sending the command failed.

3: This command ID is not supported.

4: Command parameter error. Out of range / some parameters were lost / checksum error.

5: Service is busy. You can try again soon.

[Example]

Send:

\$PAIR002\*38\r\n

Response:

\$PAIR001,002,0\*39\r\n ==> Success

### 5.2.2 ID: 002

[Description]

Power on the GNSS system. Include DSP/RF/Clock and other GNSS sections.

[Data Field]

\$PAIR002\*CS<CR><LF>

[Return]

PAIR\_ACK for send result.

[Example]

Send:

\$PAIR002\*38\r\n

Response:

\$PAIR001,002,1\*38\r\n ==> The power on process is running. Please wait a moment.

\$PAIR001,002,0\*39\r\n ==> Power on was successful.

### 5.2.3 ID: 003

[Description]

Power off GNSS system. Include DSP/RF/Clock and other GNSS sections. The location service is not available after this command is executed. The module can still receive configuration commands.

[Data Field]

```
$PAIR003*CS<CR><LF>
```

[Return]

PAIR\_ACK for send result.

[Example]

Send:

```
$PAIR003*39\r\n
```

Response:

```
$PAIR001,003,1*39\r\n ==> The power off process is running. Please wait a moment.
```

```
$PAIR001,003,0*38\r\n ==> Power off was successful.
```

#### 5.2.4 ID: 004

[Description]

Hot Start. Use the available data in the NVRAM.

[Data Field]

```
$PAIR004*CS<CR><LF>
```

[Return]

PAIR\_ACK for send result.

[Example]

Send:

```
$PAIR004*3E\r\n
```

Response:

```
$PAIR001,004,0*3F\r\n ==> Success
```

#### 5.2.5 ID: 005

[Description]

Warm Start. Not using Ephemeris data at the start.

[Data Field]

```
$PAIR005*CS<CR><LF>
```

[Return]

PAIR\_ACK for send result.

[Example]

Send:

```
$PAIR005*3F\r\n
```

Response:

\$PAIR001,005,0\*3E\r\n ==> Success

### 5.2.6 ID: 006

[Description]

Cold Start. Not using the Position, Almanac and Ephemeris data at the start.

[Data Field]

\$PAIR006\*CS<CR><LF>

[Return]

PAIR\_ACK for send result.

[Example]

Send:

\$PAIR006\*3C\r\n

Response:

\$PAIR001,006,0\*3D\r\n ==> Success

### 5.2.7 ID: 864

[Description]

Set baud rate configuration.

[Data Field]

\$PAIR864,<Port\_Type>,<Port\_Index>,<Baudrate>\*CS<CR><LF>

Port\_Type: HW Port Type.

0: UART

Port\_Index: HW Port Index

0: UART0

Baudrate: the baud rate needs config.

Support 115200, 230400, 460800, 921600, 3000000

[Return]

PAIR\_ACK for send result.

[Example]

Send:

\$PAIR864,0,0,115200\*1B\r\n

Response:

\$PAIR001,864,0\*31\r\n ==> Success

[Note]

The change will take effect after reboot.

### 5.2.8 ID: 050

[Description]

Set Position Fix Interval.

If set less than 1000 ms, ASCII NMEA will automatically increase the update interval in order to decrease IO throughput.

[Data Field]

\$PAIR050,<Fix\_Interval>\*CS<CR><LF>

Fix\_Interval: Position fix interval in milliseconds (ms). [Range: 100 ~ 1000]

[Return]

PAIR\_ACK for send result.

[Example]

Send:

\$PAIR050,1000\*12\r\n

Response:

\$PAIR001,050,0\*3E\r\n ==> Success

### 5.2.9 ID: 051

[Description]

Get Position Fix Interval.

[Data Field]

\$PAIR051\*CS<CR><LF>

[Return]

1. PAIR\_ACK for send result.
2. \$PAIR050,<Fix\_Interval>\*CS<CR><LF>

Fix\_Interval: Position fix interval in milliseconds (ms). [Range: 100 ~ 1000]

[Example]

Send:

\$PAIR051\*3E\r\n

Response:

\$PAIR001,051,0\*3F\r\n ==> Success

\$PAIR051,1000\*13\r\n

### 5.2.10 ID: 062

[Description]

Set the NMEA sentence output interval of corresponding NMEA type.

[Data Field]

\$PAIR062,<Type>,<Output\_Rate>\*CS<CR><LF>

Type: NMEA Type

-1 Reset all sentence to default value.

0 NMEA\_SEN\_GGA, // GGA interval - GPS Fix Data



1 NMEA\_SEN\_GLL, // GLL interval - Geographic Position - Latitude longitude  
 2 NMEA\_SEN\_GSA, // GSA interval - GNSS DOPS and Active Satellites  
 3 NMEA\_SEN\_GSV, // GSV interval - GNSS Satellites in View  
 4 NMEA\_SEN\_RMC, // RMC interval - Recommended Minimum Specific GNSS Sentence  
 5 NMEA\_SEN\_VTG, // VTG interval - Course Over Ground and Ground Speed  
 6 NMEA\_SEN\_ZDA, // ZDA interval - Time & Date  
 7 NMEA\_SEN\_GRS, // GRS interval - GNSS Range Residuals  
 8 NMEA\_SEN\_GST, // GST Interval - GNSS Pseudorange Error Statistics

Output\_Rate: Output interval setting (Valid range: 0~20)

- 0 - Disabled or not supported sentence
- 1 - Output once every one position fix
- 2 - Output once every two position fixes
- 3 - Output once every three position fixes
- 4 - Output once every four position fixes
- 5 - Output once every five position fixes

[Return]

PAIR\_ACK for send result.

[Example]

Send:

\$PAIR062,0,3\*3D\r\n

Response:

\$PAIR001,062,0\*3F\r\n ==> Success

### 5.2.11 ID: 063

[Description]

Get the NMEA sentence output interval of corresponding NMEA type.

[Data Field]

\$PAIR063,<Type>\*CS<CR><<LF>

Type: NMEA Type

-1 return all sentence configuration.

0 NMEA\_SEN\_GGA, // GGA interval - GPS Fix Data  
 1 NMEA\_SEN\_GLL, // GLL interval - Geographic Position - Latitude longitude  
 2 NMEA\_SEN\_GSA, // GSA interval - GNSS DOPS and Active Satellites  
 3 NMEA\_SEN\_GSV, // GSV interval - GNSS Satellites in View  
 4 NMEA\_SEN\_RMC, // RMC interval - Recommended Minimum Specific GNSS

Sentence

5 NMEA\_SEN\_VTG, // VTG interval - Course Over Ground and Ground Speed  
 6 NMEA\_SEN\_ZDA, // ZDA interval - Time & Date

7 NMEA\_SEN\_GRS, // GRS interval - GNSS Range Residuals  
 8 NMEA\_SEN\_GST, // GST Interval - GNSS Pseudorange Error Statistics

**[Return]**

1. PAIR\_ACK for send result.  
 2. \$PAIR063,<Type>,<Output\_Rate>\*CS<CR><LF>

Type: NMEA Type

0 NMEA\_SEN\_GGA, // GGA interval - GPS Fix Data  
 1 NMEA\_SEN\_GLL, // GLL interval - Geographic Position - Latitude longitude  
 2 NMEA\_SEN\_GSA, // GSA interval - GNSS DOPS and Active Satellites  
 3 NMEA\_SEN\_GSV, // GSV interval - GNSS Satellites in View  
 4 NMEA\_SEN\_RMC, // RMC interval - Recommended Minimum Specific GNSS

**Sentence**

5 NMEA\_SEN\_VTG, // VTG interval - Course Over Ground and Ground Speed  
 6 NMEA\_SEN\_ZDA, // ZDA interval - Time & Date  
 7 NMEA\_SEN\_GRS, // GRS interval - GNSS Range Residuals  
 8 NMEA\_SEN\_GST, // GST Interval - GNSS Pseudorange Error Statistics

Output\_Rate: Output interval setting (Valid range: 0~20, default value: 1)

- 0 - Disabled or not supported sentence
- 1 - Output once every one position fix
- 2 - Output once every two position fixes
- 3 - Output once every three position fixes
- 4 - Output once every four position fixes
- 5 - Output once every five position fixes

**[Example]**

Send:

\$PAIR063,0\*23\r\n

Response:

\$PAIR001,063,0\*3E\r\n ==> Success

\$PAIR063,0,3\*3C\r\n

**5.2.12 ID: 070****[Description]**

Set the static navigation speed threshold.

If the actual speed is less than the threshold, the output position remains the same and the output speed will be zero.

If the threshold value is set to 0, this function is disabled.

**[Data Field]**

\$PAIR070,<Speed\_thresholld>\*CS<CR><LF>

Speed\_threshold. 0~20 dm/s. Default value is 0 dm/s.

The minimum is 1 dm/s, the maximum is 20 dm/s.

1 dm/s = 0.1m/s

[Return]

1. PAIR\_ACK for send result.

[Example]

Send:

```
$PAIR070,4*25\r\n
```

Response:

```
$PAIR001,070,0*3C\r\n ==> Success
```

### 5.2.13 ID: 071

[Description]

Query the static navigation speed threshold.

[Data Field]

```
$PAIR071*CS<CR><LF>
```

[Return]

1. PAIR\_ACK for send result.

2. \$PAIR071,<Speed\_threshold>\*CS<CR><LF>

Speed\_threshold: 0~2 m/s.

The maximum is 2.0 m/s.

[Example]

Send:

```
$PAIR071*3C\r\n
```

Response:

```
$PAIR001,071,0*3D\r\n ==> Success
```

```
$PAIR071,0.4*3A\r\n
```

### 5.2.14 ID: 080

[Description]

Set navigation mode.

[Data Field]

```
$PAIR080,<CmdType>*CS<CR><LF>
```

CmdType:

0. Normal mode: For general purpose

1. Fitness mode: For running and walking purpose so that the low-speed (< 5 m/s) movement will have more of an effect on the position calculation.

2. Reserved

3. Balloon mode: For high-altitude balloon purpose that the vertical movement will have more effect on the position calculation.
4. Stationary mode: For stationary applications with zero dynamics.
5. Drone mode: Used for drone applications with equivalent dynamics range and vertical acceleration on different flight phase. (Ex. hovering, cruising, etc.)
6. Reserved
7. Swimming mode: For swimming purpose so that it smooths the trajectory and improves the accuracy of distance calculation.
8. Reserved
9. Bike mode: For sharing bike application.

[Return]

PAIR\_ACK for send result.

[Example]

Send:

```
$PAIR080,1*2F\r\n ==> Enter fitness mode.
```

Response:

```
$PAIR001,080,0*33\r\n ==> Success
```

### 5.2.15 ID: 081

[Description]

Get navigation mode.

[Data Field]

```
$PAIR081*CS<CR><LF>
```

[Return]

1. PAIR\_ACK for send result.
2. \$PAIR081,<CmdType>\*CS<CR><LF>

CmdType:

0. [Default Value] Normal mode: For general purpose
1. Fitness mode: For running and walking activities so that the low-speed (< 5 m/s) movement will have more of an effect on the position calculation.
2. Reserved
3. Balloon mode: For high-altitude balloon purpose that the vertical movement will have more effect on the position calculation.
4. Stationary mode: For stationary applications where a zero dynamic assumed.
5. Drone mode: Used for drone applications with equivalent dynamics range and vertical acceleration on different flight phase. (Ex. hovering, cruising, etc.) (Note: The precision of NMEA automatically changes to 7 decimal places for latitude/longitude, and 3 decimal places for altitude.)

6. Reserved
7. Swimming mode: For swimming purpose so that it smooths the trajectory and improves the accuracy of distance calculation.
8. Reserved
9. Bike mode: For sharing bike application.

[Example]

Send:

```
$PAIR081*33\r\n
```

Response:

```
$PAIR001,081,0*32\r\n ==> Success
```

```
$PAIR081,1*2E\r\n ==> Current is fitness mode.
```

### 5.2.16 ID: 400

[Description]

Set DGPS correction data source mode.

[Data Field]

```
$PAIR400,<Mode> *CS<CR><LF>
```

Mode: DGPS data source mode.

'0': No DGPS source

'1': RTCM

'2': SBAS (Include WAAS/EGNOS/GAGAN/MSAS)

'3': QZSS SLAS

[Return]

PAIR\_ACK for send result.

[Example]

Send:

```
$PAIR400,2*20\r\n ==> Set SBAS Mode
```

Response:

```
$PAIR001,400,0*3F\r\n ==> Success
```

### 5.2.17 ID: 401

[Description]

Query the DGPS data source mode.

[Data Field]

```
$PAIR401*CS<CR><LF>
```

[Return]

1. PAIR\_ACK for send result.
2. \$PAIR401,<Mode>\*CS<CR><LF>

Mode: DGPS data source mode.

'0': No DGPS source  
'1': RTCM  
'2': SBAS (Include WAAS/EGNOS/GAGAN/MSAS)  
'3': QZSS SLAS

[Example]

Send:

```
$PAIR401*3F\r\n
```

Response:

```
$PAIR001,401,0*3E\r\n ==> Success  
$PAIR401,2*21\r\n ==> SBAS Mode
```

### 5.2.18 ID: 410

[Description]

Enable searching a SBAS satellite or not.

When navigation mode is Fitness or Swimming mode, SBAS is not supported.

[Data Field]

```
$PAIR410,<Enabled>*CS<CR><LF>
```

Enabled: Enable or disable

'0' = Disable

'1' = Enable

[Return]

PAIR\_ACK for send result.

[Example]

Send:

```
$PAIR410,1*22\r\n ==> Enable SBAS
```

Response:

```
$PAIR001,410,0*3E\r\n ==> Success
```

### 5.2.19 ID: 420

[Description]

Enable the QZSS SLAS (Sub-meter Level Augmentation Service) operation.

When navigation mode is Fitness or Swimming mode, QZSS SLAS is not supported.

[Data Field]

```
$PAIR420,<Enabled>*CS<CR><LF>
```

Enabled: Enable or disable

'0' = Disable

'1' = Enable

[Return]

PAIR\_ACK for send result.

[Example]

Send:

\$PAIR420,1\*21\r\n ==> Enable QZSS SLAS

Response:

\$PAIR001,420,0\*3D\r\n ==> Success

### 5.2.20 ID: 513

[Description]

Save the current configuration from RTC RAM to flash.

[Data Field]

\$PAIR513\*CS<CR><LF>

[Return]

PAIR\_ACK for send result.

[Example]

Send:

\$PAIR513\*3D\r\n

Response:

\$PAIR001,513,0\*3C\r\n

[Note]

The changes of the configuration are kept in the RTC RAM that is powered from V\_BCKP pin. If the power from V\_BCKP pin is not kept, the changes will be lost after system reboot. The user can use this command to save the changes into the non-volatile flash memory.

### 5.2.21 ID: 514

[Description]

Clear the current configuration and restore the factory default settings. This function does not support run time restore when GNSS is power on. Please send \$PAIR003 command to power off GNSS before using this command.

[Data Field]

\$PAIR514\*CS<CR><LF>

[Return]

PAIR\_ACK for send result.

[Example]

Send:

\$PAIR514\*3A\r\n

Response:

\$PAIR001,514,0\*3B\r\n

### 5.2.22 ID: 066

#### [Description]

Configure the receiver to start searching for satellites. The setting is available when the NVRAM data is valid.

The device restarts when it receives this command.

Support constellation: GPS, NavIC, GPS+GALILEO+NavIC,

GPS+GLONASS+GALILEO+BEIDOU, GPS+GLONASS+GALILEO+BEIDOU+NavIC.

QZSS is always switchable.

#### [Data Field]

\$PAIR066,<GPS\_Enabled>,<GLONASS\_Enabled>,<Galileo\_Enabled>,<BeiDou\_Enabled>,<QZSS\_Enabled>,<NavIC\_Enabled>\*CS<CR><LF>

GPS\_Enabled:

"0", disable (DO NOT search GPS satellites).

"1", search GPS satellites.

GLONASS\_Enabled:

"0", disable (DO NOT search GLONASS satellites).

"1", search GLONASS satellites.

Galileo\_Enabled:

"0", disable (DO NOT search Galileo satellites).

"1", search Galileo satellites.

BeiDou\_Enabled:

"0", disable (DO NOT search BeiDou satellites).

"1", search BeiDou satellites.

QZSS\_Enabled:

"0", disable (DO NOT search QZSS satellites).

"1", search QZSS satellites.

NavIC\_Enabled:

"0", disable (DO NOT search NavIC satellites).

"1", search NavIC satellites.

#### [Return]

PAIR\_ACK for send result.

#### [Example]

Send:

\$PAIR066,1,0,0,0,0\*3B\r\n ==> Search GPS satellites only.

Response:

\$PAIR001,066,0\*3B\r\n ==> Success

Send:



\$PAIR066,1,0,1,0,1,1\*3A\r\n ==> Search GPS, GALILEO, NavIC and QZSS satellites.

Response:

\$PAIR001,066,0\*3B\r\n ==> Success

[Note]

Supported constellation combinations will vary depending on the firmware version.

### 5.2.23 ID: 154

[Description]

Enable to output Return Link Message from navigation data.

[Data Field]

\$PAIR154,<Enable>\*CS<CR><LF>

Enable:

0: disable

1: enable

[Return]

PAIR\_ACK for send result.

[Example]

Send:

\$PAIR154,1\*27\r\n

Response:

\$PAIR001,154,0\*3B\r\n ==> Success

### 5.2.24 ID: 155

[Description]

Query output Return Link Message status.

[Data Field]

\$PAIR155\*CS<CR><LF>

Enable:

0: disable

1: enable

[Return]

1. PAIR\_ACK for send result.

2. \$PAIR155,<Enable>\*CS<CR><LF>

Enable:

0: Disable

1: Enable

[Example]

Send:

\$PAIR155\*3B\r\n

Response:

\$PAIR001,155,0\*3A\r\n ==> Success

\$PAIR155,1\*26\r\n

6 Pin assignment and descriptions



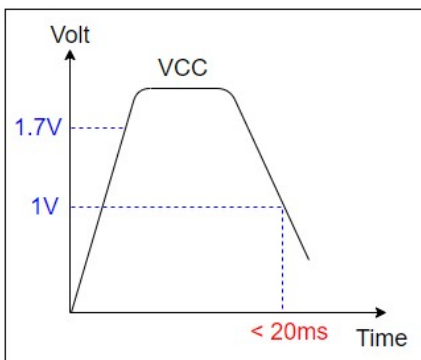
Table 6-1 Pin descriptions

Pin #	Name	Type	Description	Note
1	NC		Not connect	
2	NC		Not connect	
3	TIMEPULSE	O	Time pulse (PPS, default 100 ms pulse/sec when GNSS fix is available. Output high level is 1.8V)	
4	RTC_EINT	I	RTC external interrupt	
5	USB_DM	I/O	USB D- line. Leave unconnected if not used.	
6	USB_DP	I/O	USB D+ line. Leave unconnected if not used.	
7	VUSB	I	USB voltage supply. Connect this pin to 2.92 ~ 3.22V to enable USB interface. Leave unconnected if not used.	1
8	EN	I	Enable the module, high active. Internal 10K ohm pull-up resistor to 1.8V. Setting this pin to low will disable “hot start” function, i.e. boot from “cold start”. Leave unconnected if not used.	
9	VCC_RF	O	Output voltage for active antenna	
10	GND	P	Ground	
11	RF_IN	I	GNSS RF signal input. The overall gain of the active antenna must be between 16dB ~ 35dB.	
12	GND	P	Ground	

13	GND	P	Ground	
14	LNA_EN	O	Output pin to control the external LNA, high active. Internal pull down.	
15	ANT_PWR_ON	O	Output pin to control the power of the active antenna. High active.	2
16	/ANT_OK	I	Input pin of the active antenna's connection status. Leave unconnected if not used.	2
17	/ANT_SHORT	I	Input pin of the active antenna's short status. Leave unconnected if not used.	2
18	TX2	O	Serial output 2. Leave unconnected if not used.	
19	RX2	I	Serial input 2. Leave unconnected if not used.	
20	TX	O	Serial output	
21	RX	I	Serial input	
22	V_BCKP	P	Backup battery input. It is recommended to connect a backup supply voltage to V_BCKP in order to enable warm and hot start features. Moreover, V_BCKP is a must of the system running. If no backup power is available, connect V_BCKP to the main power supply (VCC).	3
23	VCC	P	DC supply input. Must be clean and stable.	4
24	GND	P	Ground	

<Note>

1. USB selective suspend function is not supported.
2. Refer to Fig 3-4 and Table 3.1 for the application of controlling an external active antenna and getting its status.
3. In order to get the advantage of hybrid ephemeris prediction, this pin must be always powered during the period of effective ephemeris prediction.
4. If an abnormal input voltage as shown in the figure below is input, even if the correct voltage is input again later, the module may not work until V\_BCKP pin is re-powered.



## 7 DC & Temperature characteristics

### 7.1 Absolute maximum ratings

Parameter	Symbol	Ratings	Units
DC Supply Input Voltage	VCC_ABS	5.5	V
Input Backup Battery Voltage	V_BCKP_ABS	5.5	V
Operating Temperature Range	T_OPR_ABS	-40 ~ 85	°C
Storage Temperature Range	T_STG_ABS	-40 ~ 85	°C

### 7.2 DC Electrical characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
DC Supply Input Voltage	VCC		3.1	3.3	4.5	V
Input Backup Battery Voltage	V_BCKP		2.0		4.5	V
VCC_RF Output Voltage	VCC_RF			VCC		V
Supply Current	I <sub>SS</sub>	VCC = 3.3V, w/o active antenna, Peak Acquisition Tracking		31 35 <sup>(2)</sup>	110 <sup>(1)</sup>	mA mA mA
	I <sub>SHDN</sub>	VCC=3.3V, EN=0V		22		uA
Backup Battery Current	I <sub>BAT</sub>	VIN = 0V		64		uA
VCC_RF Output Current	I <sub>OUT</sub>	VIN = 3.3V			30	mA
High Level Input Voltage	V <sub>IH</sub>	For TX, RX	2.2		3.6	V
Low Level Input Voltage	V <sub>IL</sub>		-0.3		0.8	V
High Level Output Voltage	V <sub>OH</sub>		2.18		3.3	V
Low Level Output Voltage	V <sub>OL</sub>				0.4	V
High Level Input Voltage	V <sub>IH</sub>	For TIMEPULSE, RTC_EINT, EN, LNA_EN, ANT_PWR_ON, /ANT_OK, /ANT_SHORT, TX2, RX2	1.21		1.98	V
Low Level Input Voltage	V <sub>IL</sub>		-0.3		0.6	V
High Level Output Voltage	V <sub>OH</sub>		1.29		1.98	V
Low Level Output Voltage	V <sub>OL</sub>				0.45	V

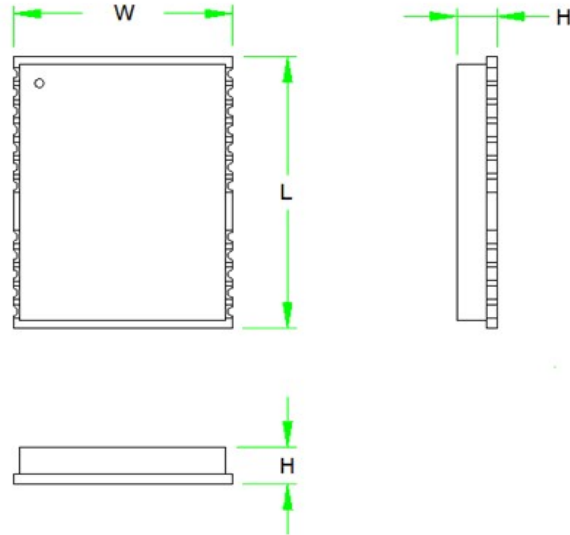
Note 1. This happens when downloading AGPS data to the module.

Note 2. Measured when position fix (1Hz) is available, input voltage is 3.3V and the function of self-generated ephemeris prediction is inactive. If USB interface is enabled, it will increase about 8mA.

### 7.3 Temperature characteristics

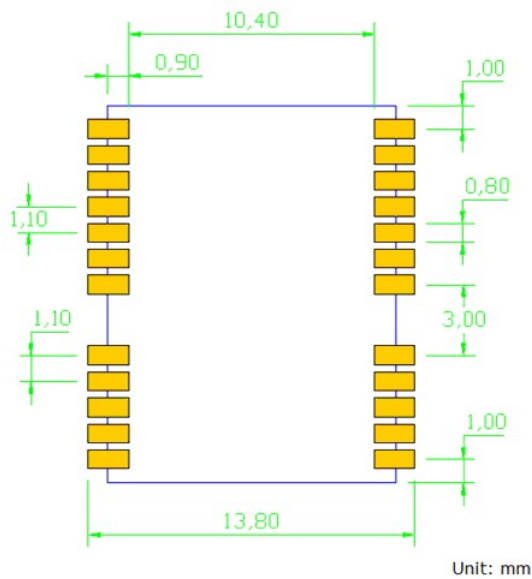
Parameter	Symbol	Min.	Typ.	Max.	Units
Operating Temperature	T <sub>OPR</sub>	-40	-	85	°C
Storage Temperature	T <sub>STG</sub>	-40	25	85	°C

8 Mechanical specification  
 8.1 Outline dimensions



Symbol	Min. (mm)	Typ. (mm)	Max. (mm)
W	12.1	12.2	12.3
L	15.7	16.0	16.4
H	2.2	2.4	2.6

8.2 Recommended land pattern dimensions



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

9 Reel Packing information

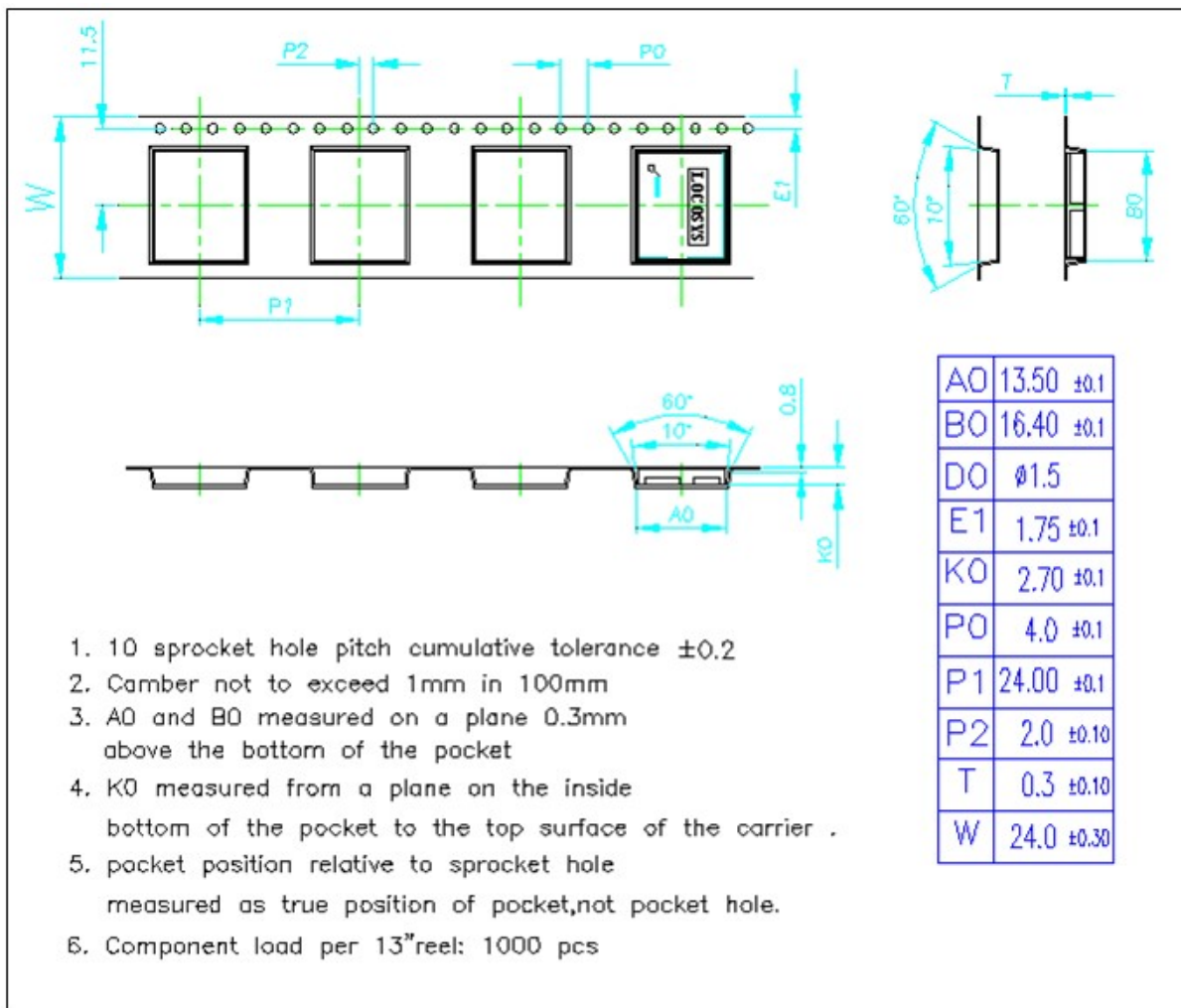
9.1 ESD precaution

GNSS modules are electrostatic sensitive devices. Handling the modules without proper ESD protection may result in severe damage to them. ESD protection must be implemented throughout the processing, handling and even when the modules are being returned for repair.

9.2 Packaging

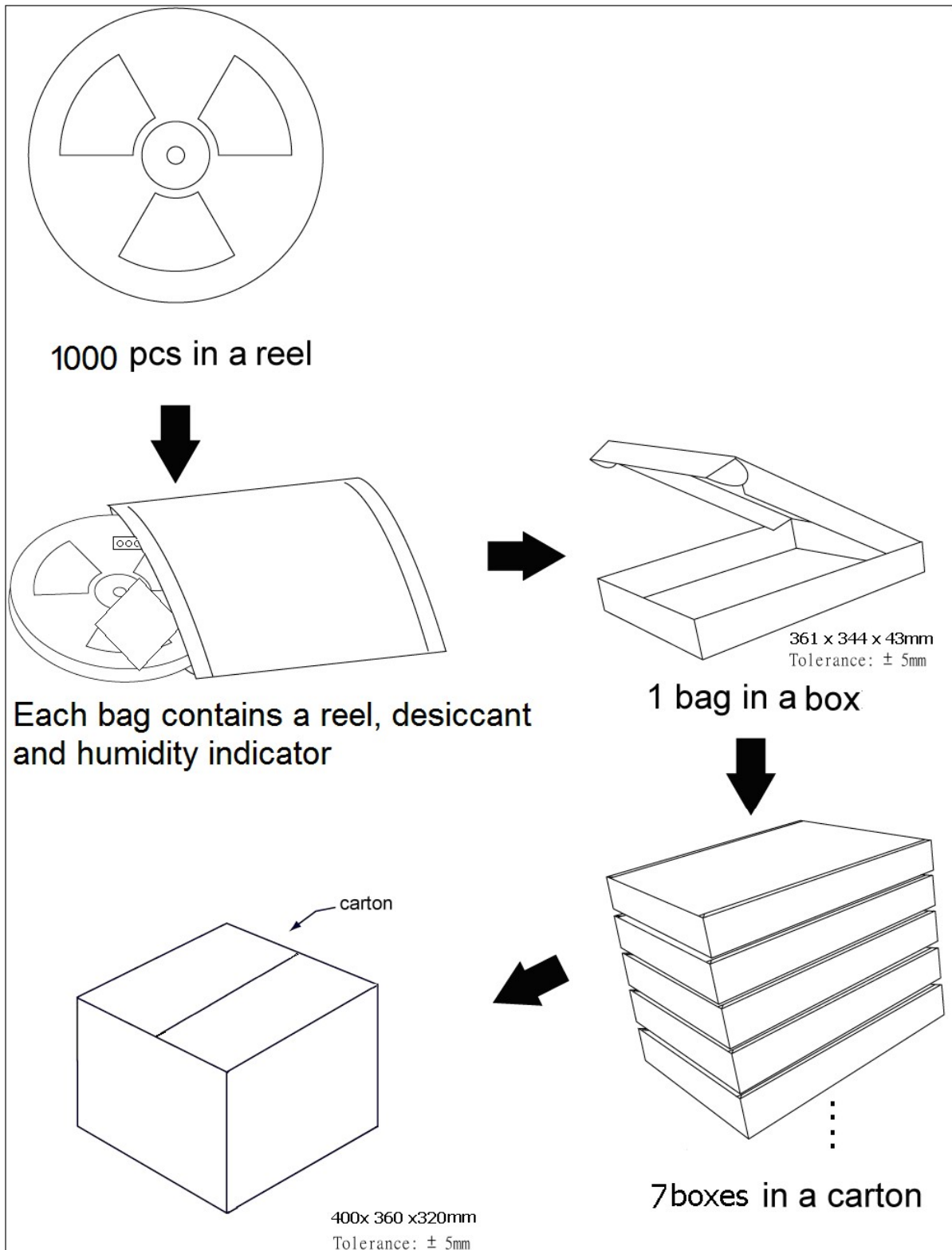
The modules are sealed in a moisture barrier ESD bag with the appropriate units of desiccant and a humidity indicator card. It should not be opened until the modules are ready to be soldered onto the application.

9.2.1 Packaging





9.2.2 Box packaging



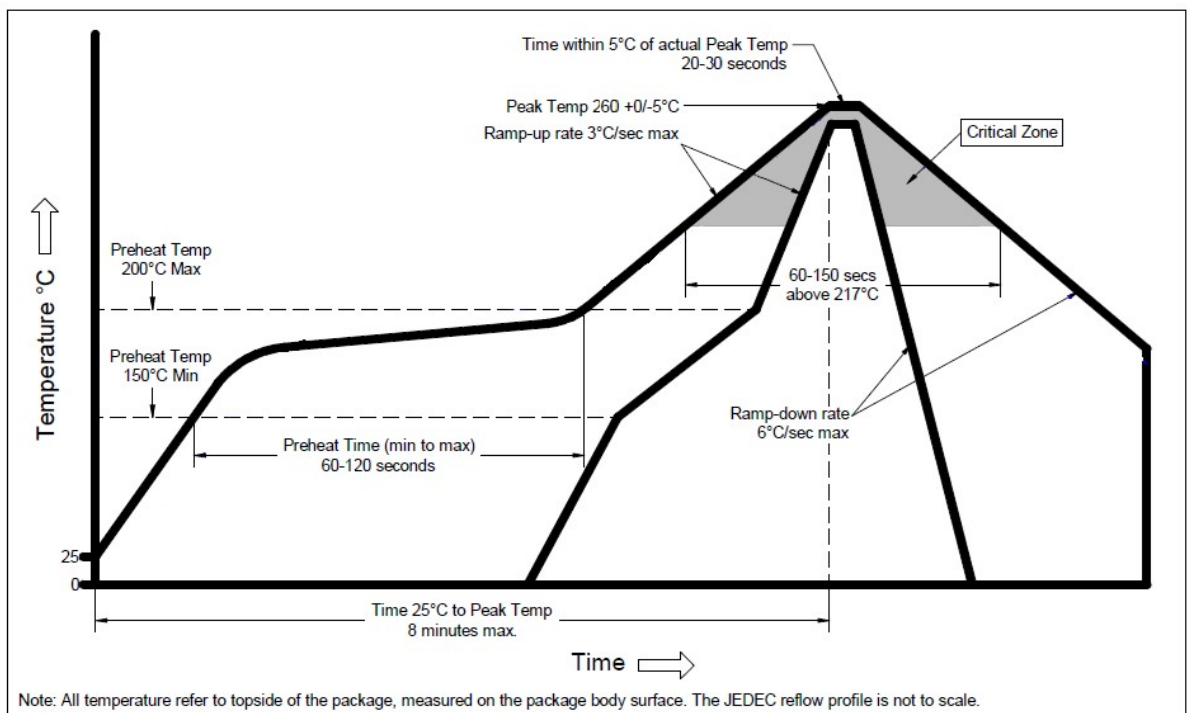
### 9.3 Moisture sensitivity level

The moisture sensitivity level of the module is 3. After the sealed bag is opened, modules should be mounted within 168 hours at factory conditions of  $\leq 30^{\circ}\text{C}$  and 60% RH or stored at  $\leq 20\%$  RH.

The modules require baking before mounting if above conditions are not met. If baking is required, the modules without the tape and reel may be baked for:

- a. 192 hours at  $40^{\circ}\text{C} + 5^{\circ}\text{C} / -0^{\circ}\text{C}$  and  $< 5\%$  RH
- b. 24 hours at  $125^{\circ}\text{C} + 5^{\circ}\text{C} / -0^{\circ}\text{C}$

### 9.4 Reflow soldering



Note the module mounted to the top side (first reflow side) may fall off during reflow soldering of the bottom side.

## 10 Product marking and ordering information

### 10.1 Product marking

The marking of the module is engraved on the metal shielding that has product information, such as LOCOSYS logo, product name and manufacturing date.

### 10.2 Ordering information

Product name	Description	Remark
MC-1612-V3b	Dual-frequency multi-constellation GNSS positioning module	GPS/QZSS: L1 C/A GLONASS: L1OF GALILEO: E1 BEIDOU: B1I NavIC: L5

## Document change list

### Revision 1.0 (November 23, 2022)

- Official release.

### Revision 1.1 (July 3, 2024)

- Changed EASY to EPOC in section 1.
- Added ESD protector to Fig 3-1
- Removed the proprietary command ID 007 in section 5.2
- Added balloon and bike modes to the ID 080 and 081 in section 5.2
- Added the proprietary command ID 070, 066, 154 and 155 in section 5.2
- Revised the pull-up resister of pin 8 from 1M to 10K in section 6.
- Changed the overall gain of the active antenna from 8~25dB to 16~35dB in section 6.