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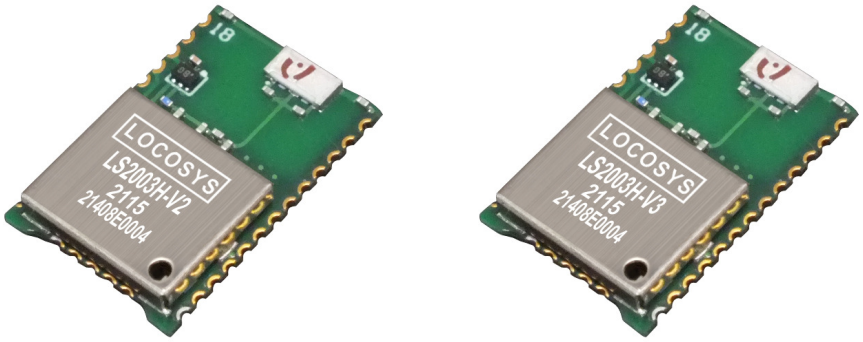
| Product name | Description | Version |
|---|---|---|
| LS2003H-Vx | Dual-frequency multi-constellation GNSS smart antenna | 0.2 |




# 1 Introduction

LS2003H-Vx series products are high-performance dual-band GNSS smart antenna modules, including an embedded antenna and GNSS receiver circuits, designed for a broad spectrum of OEM system applications. The GNSS smart antenna will acquire both L1 and L5 signals at a time while providing the better standalone position accuracy. It can provide you with fast Time-To-First-Fix, superior sensitivity and low power consumption.

The modules support hybrid ephemeris prediction to achieve faster cold start. One is self-generated ephemeris prediction (called EASY) 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.

Because of the built-in chip antenna, it is easy to install without both RF connector and coaxial cable that are needed in a separated GNSS active antenna. In other words, reduce the cost and size. Also, speed up the time to market by eliminating R&D efforts on RF matching and stability between separated GNSS antenna and module. If the external antenna is required, users can add some external components to achieve the function of automatically switching between the built-in GNSS chip antenna and the external antenna. Furthermore, it can be directly powered by a lithium battery without any external voltage regulars. Therefore, LS2003H-Vx of tiny size and brilliant performance is the best choice to be integrated into your slim devices.

# 2 Features

- Tiny size: 14 x 9.6 x 2 mm
- Concurrent reception of L1 and L5 band signals
- Support GPS, GLONASS, BEIDOU, GALILEO, QZSS and IRNSS (NavIC)
- Capable of SBAS (WAAS, EGNOS, MSAS, GAGAN) and QZSS SLAS
- Support 135-channel GNSS
- Fast TTFF at low signal level

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- Free hybrid ephemeris prediction to achieve faster cold start
- Smart jammer detection and suppression
- ±15ns high accuracy time pulse (PPS)
- SMD type with stamp holes; RoHS compliant

## 3 Application

- Personal positioning and navigation
- Automotive navigation
- Fleet management
- Hand-Held and wearable Device
- Tracker

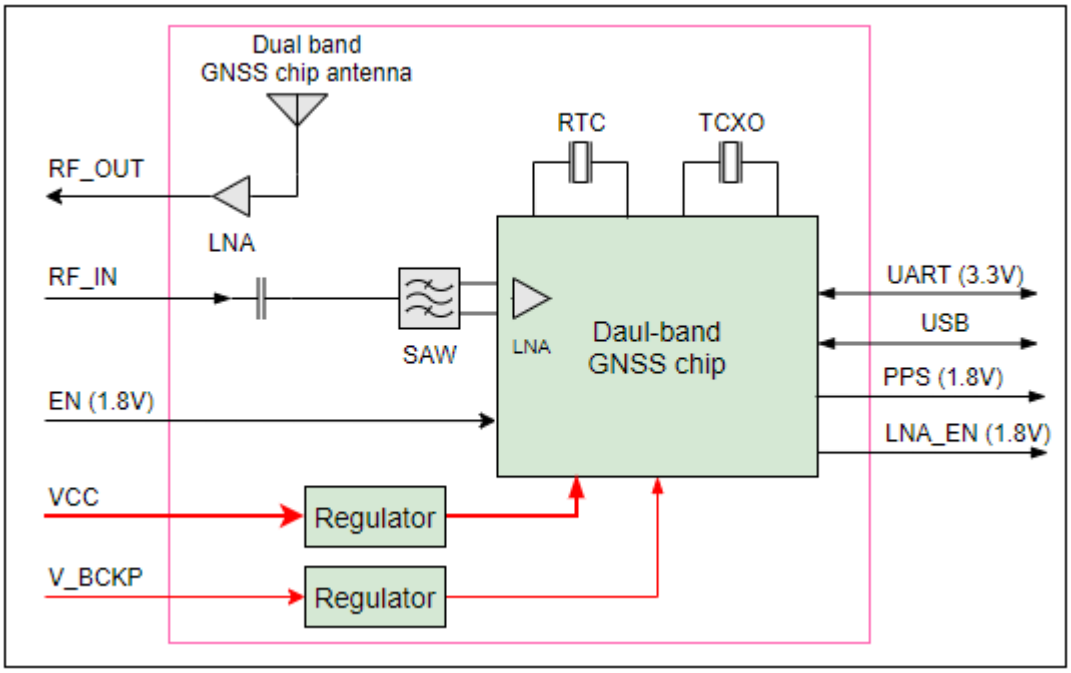


Fig 3-1 System block diagram of LS2003H-Vx

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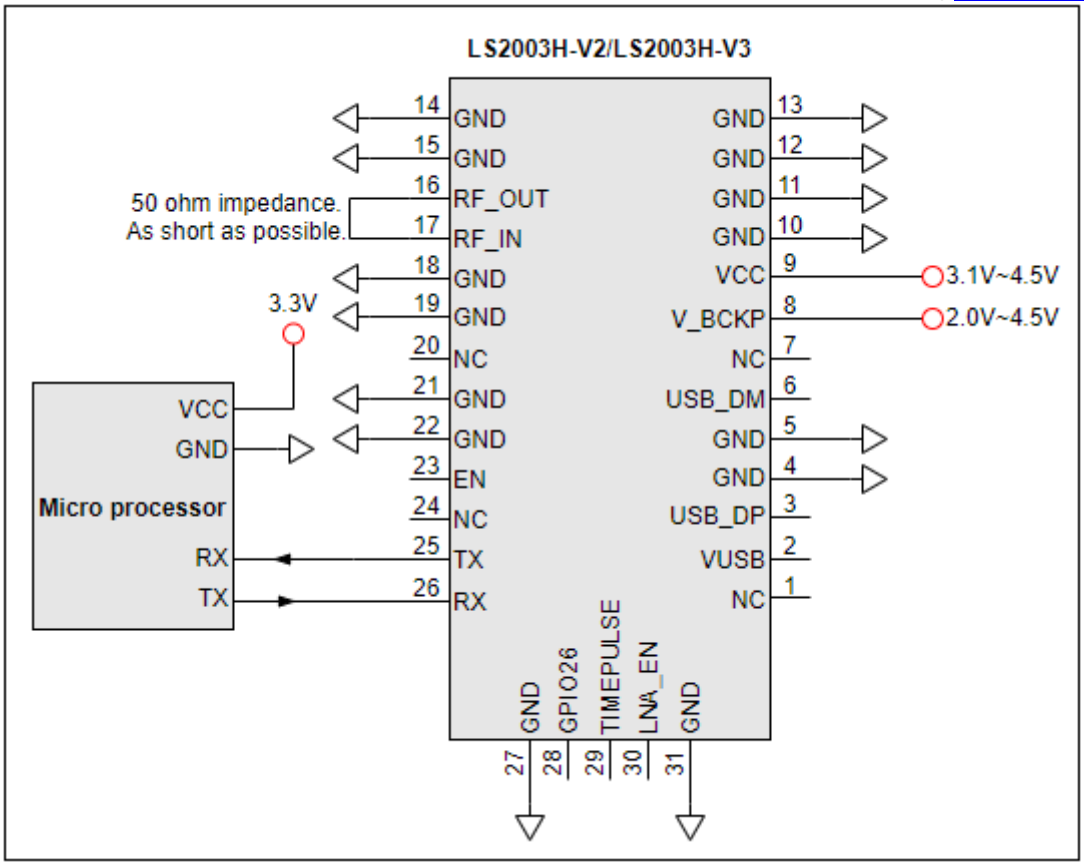


Fig 3-2 Typical application circuit

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# 4 GNSS receiver

| | | |
|---|---|---|
| Frequency | LS2003H-V2 | GPS/QZSS: L1 C/A, L5C<br>GLONASS: L1OF<br>BEIDOU: B1I, B2a<br>GALILEO: E1, E5a |
| | LS2003H-V3 | GPS/QZSS: L1 C/A<br>GLONASS: L1OF<br>BEIDOU: B1I<br>GALILEO: E1<br>IRNSS (NAVIC): L5 |
| Channels | Support 135 channels | |
| Update rate | 1Hz, up to 10Hz | |
| 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 | < 1.5m CEP |
| Datum | WGS-84 (default) | |
| Max. Altitude | < 18,000 m | |
| Max. Velocity | < 500 m/s | |
| Protocol Support | NMEA 0183 ver. 4.1 | 115200 bps (1), 8 data bits, no parity, 1 stop bits (default)<br>1Hz: GGA, GSA, GST, GSV, RMC, VTG, GST |

Note 1: Both baud rate and output message rate are configurable to be factory default.

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# 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 |
| GST | Estimated error in position solution |
| 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

*Table 5.1-2* 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 view |
| 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 |

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*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 |
| 6 | Estimated/Dead reckoning fix |

- **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<br>A = Autonomous GNSS fix<br>D = Differential GNSS fix<br>R = RTK fixed<br>F = RTK float<br>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 | | |
| <CR> <LF> | | | End of message termination |

*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 | IRNSS |

- **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.<br>GP=GPS/QZSS, GL=GLONSS, GA=GALILEO,<br>GB=BEIDOU, GI=IRNSS. |
| 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<br>GLONASS: L1 C/A=1<br>GALILEO: E1=7, E5a=1<br>BEIDOU: B1=1, B2a=4<br>IRNSS: L6=1 |
| Checksum | *54 | | |
| <CR> <LF> | | | End of message termination |

- **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

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*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<br>A = Autonomous GNSS fix<br>D = Differential GNSS fix<br>R = RTK fixed<br>F = RTK float<br>E = Estimated/Dead reckoning fix |
| Navigational status indicator | V | | S = Safe<br>C = Caution<br>U = Unsafe<br>V = Void |
| Checksum | *01 | | |
| <CR> <LF> | | | End of message termination |

## ● 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 | $GNVTG | | 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<br>A = Autonomous GNSS fix<br>D = Differential GNSS fix<br>R = RTK fixed<br>F = RTK float<br>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]

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$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.

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[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>

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[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR006*3C\r\n

Response:

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

### 5.2.7 ID: 007

[Description]

Full Cold Start.

In addition to Cold start, this command clears the system/user configurations at the start.

It resets the GNSS module to the factory default.

[Data Field]

$PAIR007*CS<CR><LF>

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR007*3D\r\n

Response:

$PAIR001,007,0*3C\r\n ==> Success

### 5.2.8 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:

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

Response:

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

[Note]

The change will take effect after reboot.

### 5.2.9 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

### 5.2.10 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

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### 5.2.11 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

### 5.2.12 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

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### 5.2.13 ID: 070

[Description]

Set the speed threshold for static navigation.

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_threshold>*CS<CR><LF>

Speed_threshold. 0~20 dm/s. The maximum is 20 dm/s. 1 dm/s = 0.1m/s

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR070,4*25\r\n

Response:

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

[Note]

For vehicle application, setting the threshold to 15 dm/s, i.e., 1.5 m/s can reduce the position drift when waiting for the traffic light.

$PAIR070,15*15\r\n

### 5.2.14 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

### 5.2.15 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. Reserved
4. Stationary mode: For stationary applications with zero dynamics.
5. Reserved
6. Reserved
7. Swimming mode: For swimming purpose so that it smooths the trajectory and improves the accuracy of distance calculation.

[Return]

PAIR_ACK for send result.

[Example]

Send:

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

Response:

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

### 5.2.16 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' Reserved

'4' Stationary mode: For stationary applications where a zero dynamic assumed.

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'5' Reserved

'6' Reserved

'7' Swimming mode: For swimming purpose so that it smooths the trajectory and improves the accuracy of distance calculation.

[Example]

Send:

$PAIR081*33\r\n

Response:

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

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

### 5.2.17 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

### 5.2.18 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.

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'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

### 5.2.19 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

### 5.2.20 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]

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PAIR_ACK for send result.

[Example]

Send:

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

Response:

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

### 5.2.21 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.

### 5.2.22 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

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### 5.2.23 ID: 890

[Description]

This command is used to set geofencing configuration.

[Data Field]

$PAIR890,<FenceNum>,<ConfLvl>,<Lat1>,<Lon1>,<Rad1>,...,<RadN>*CS<CR><LF>

FenceNum(N): Number of geofences, the value is limited to 4.

When the value is set to 0, the geofencing function is disabled.

ConfLvl: The confidence level for state evaluation.

'0' No requirement

'1' 1-Sigma (68%)

'2' 2-Sigma (95%)

'3' 3-Sigma (99.7%)

'4' 4-Sigma (99.99%)

'5' 5-Sigma (99.9999%)

Lat: Latitude of the geofence circle center (deg)

Lon: Longitude of the geofence circle center (deg)

Rad: Radius of the geofence circle (m)

[Return]

PAIR_ACK for send result.

[Example]

Enable the geofencing function:

Send:

$PAIR890,1,1,25.0567,121.5743,30*20\r\n

Response:

$PAIR001,890,0*3A\r\n ==> Success

Disable the geofencing function:

Send:

$PAIR890,0*27\r\n

Response:

$PAIR001,890,0*3A\r\n ==> Success

### 5.2.24 ID: 891

[Description]

This command is used to get geofencing configuration.

[Data Field]

$PAIR891*CS<CR><LF>

[Return]

PAIR_ACK for send result.

$PAIR891,<FenceNum>,<ConfLvl>,<Lat1>,<Lon1>,<Rad1>,...,<RadN>*CS<CR><LF>

FenceNum(N): Number of geofences, the value is limited to 4.

ConfLvl: The confidence level for state evaluation.

'0' No requirement

'1' 1-Sigma (68%)

'2' 2-Sigma (95%)

'3' 3-Sigma (99.7%)

'4' 4-Sigma (99.99%)

'5' 5-Sigma (99.9999%)

Lat: Latitude of the geofence circle center (deg)

Lon: Longitude of the geofence circle center (deg)

Rad: Radius of the geofence circle (m)

[Example]

Send:

$PAIR891*3A\r\n

Response:

$PAIR001,891,0*3B\r\n ==> Success

$PAIR891,1,1,25.0567,121.5743,30*21\r\n

## 5.3 Geofence

This function enables the user to assign the desired areas for the geofencing application. It can be up to 4 desired areas at the same time.

Each area is composed of a circle. Enter the latitude and longitude as the center of the circle, and the maximum radius is 65535 meters.

- When the GNSS module is in one of the circular areas, GPIO26 outputs low level.
- When the GNSS module is outside all the circular areas or on the boundary, GPIO26 outputs high level.
- When the status is unknown or the geofencing function is not enabled, GPIO26 outputs high level.

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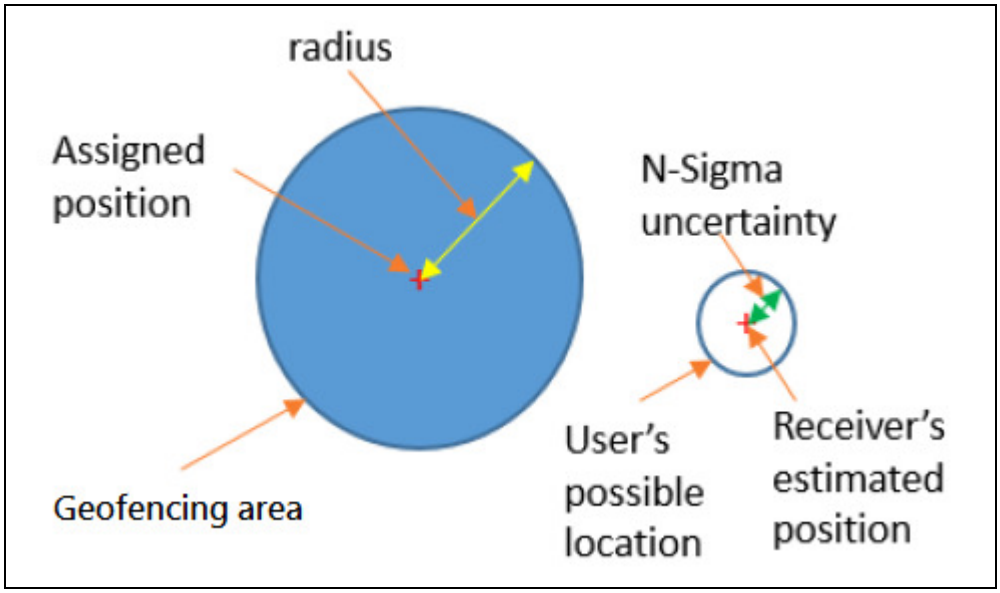

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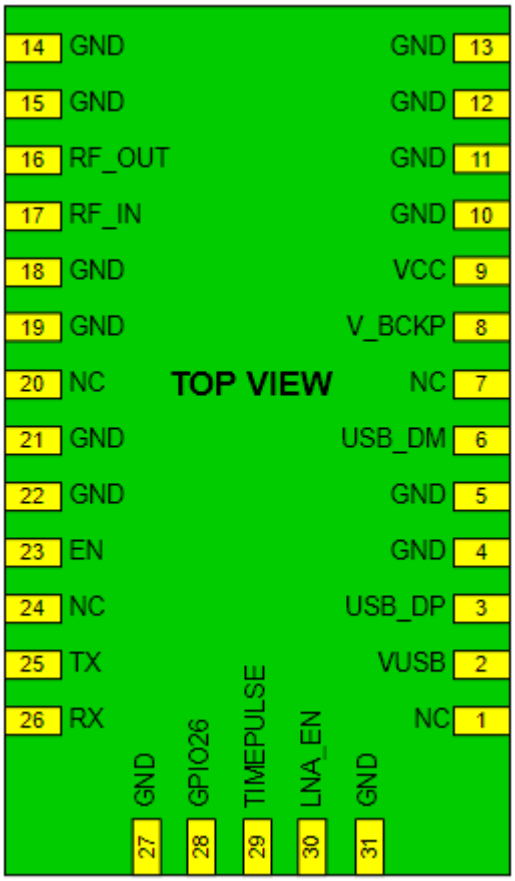
# 6 Pin assignment and descriptions




| Pin # | Name | Type | Description | Note |
|---|---|---|---|---|
| 1 | NC | | Not connected | |
| 2 | VUSB | I | USB voltage supply. Connect this pin to 2.92 ~ 3.22V to enable USB interface. Leave unconnected if not used. | 1 |
| 3 | USB_DP | I/O | USB D+ line. Leave unconnected if not used. | |
| 4 | GND | P | Ground | |
| 5 | GND | P | Ground | |
| 6 | USB_DM | I/O | USB D- line. Leave unconnected if not used. | |
| 7 | NC | | Not connected | |
| 8 | V_BCKP | I | 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). | 2 |
| 9 | VCC | I | DC supply input. Must be clean and stable. | |
| 10 | GND | P | Ground | |
| 11 | GND | P | Ground | |

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| | | | | |
|---|---|---|---|---|
| 12 | GND | P | Ground | |
| 13 | GND | P | Ground | |
| 14 | GND | P | Ground | |
| 15 | GND | P | Ground | |
| 16 | RF_OUT | O | Embedded chip antenna output (50 ohm). | |
| 17 | RF_IN | I | GNSS RF signal input (50 ohm).<br>The overall gain of the external active antenna must be between 8dB ~ 20dB. | |
| 18 | GND | P | Ground | |
| 19 | GND | P | Ground | |
| 20 | NC | | Not connected | |
| 21 | GND | P | Ground | |
| 22 | GND | P | Ground | |
| 23 | EN | I | Enable the module, high active. Internal 1M 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. | |
| 24 | NC | | Not connected | |
| 25 | TX | O | Serial output | |
| 26 | RX | I | Serial input | |
| 27 | GND | P | Ground | |
| 28 | GPIO26 | O | Geofence output pin. | |
| 29 | TIMEPULSE | O | Time pulse (PPS, default 100ms pulse/sec when GNSS fix is available) | |
| 30 | LNA_EN | O | Output pin to control the external LNA. High active. | |
| 31 | GND | P | Ground | |

<Note>

1. USB selective suspend function is not supported.
2. In order to get the advantage of hybrid ephemeris prediction, this pin must be always powered during the period of effective ephemeris prediction.

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# 7 DC & Temperature characteristics

## 7.1 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 |
| Input current | Icc | LS2003H-V2 | | 60 (1) | 140 (2) | mA |
| | | LS2003H-V3 | | 38 (1) | 120 (2) | |
| High Level Input Voltage | $V_{IH}$ | For TX, RX | 2.2 | | 3.6 | V |
| Low Level Input Voltage | $V_{IL}$ | | -0.3 | | 0.8 | V |
| High Level Output Voltage | $V_{OH}$ | | 2.18 | | 3.3 | V |
| Low Level Output Voltage | $V_{OL}$ | | | | 0.4 | V |
| High Level Input Voltage | $V_{IH}$ | For TIMEPULSE, EN, LNA_EN, GPIO26 | 1.21 | | 1.98 | |
| Low Level Input Voltage | $V_{IL}$ | | -0.3 | | 0.6 | |
| High Level Output Voltage | $V_{OH}$ | | 1.29 | | 1.98 | |
| Low Level Output Voltage | $V_{OL}$ | | | | 0.45 | |

<Note>

1. 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. If GNSS is powered off by $PAIR003 command, it consumes about 10mA.
2. Measured with 1MHz sampling rate.

## 7.2 Temperature characteristics

| Parameter | Symbol | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| Operating Temperature | Topr | -40 | - | 85 | ℃ |
| Storage Temperature | Tstg | -40 | 25 | 85 | ℃ |

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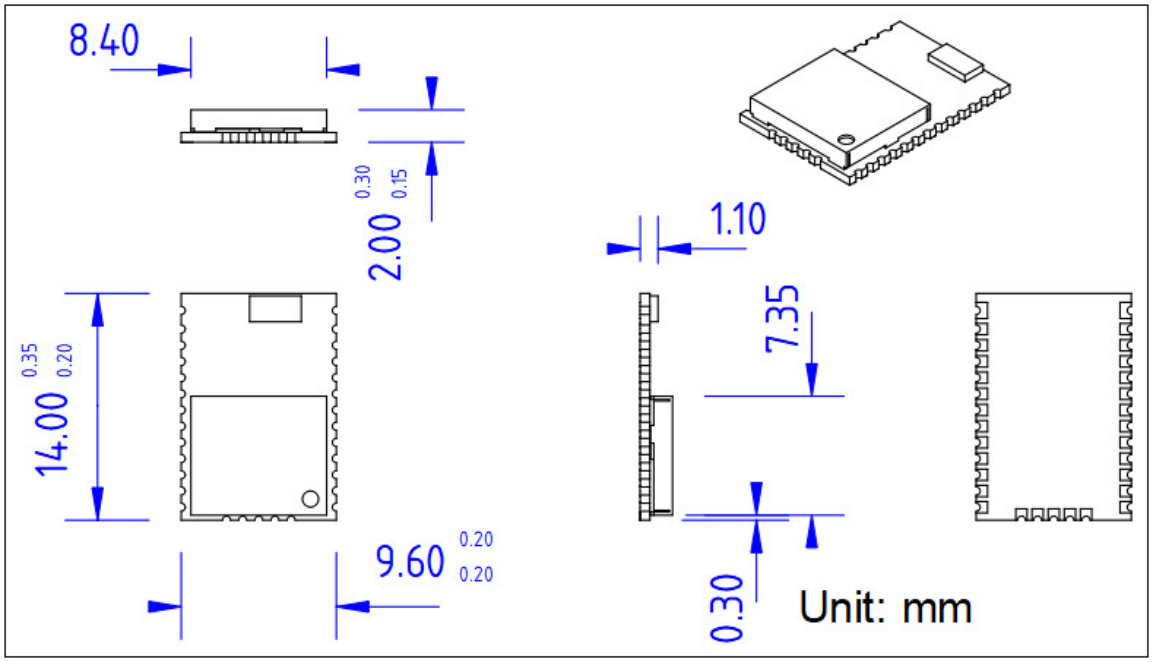
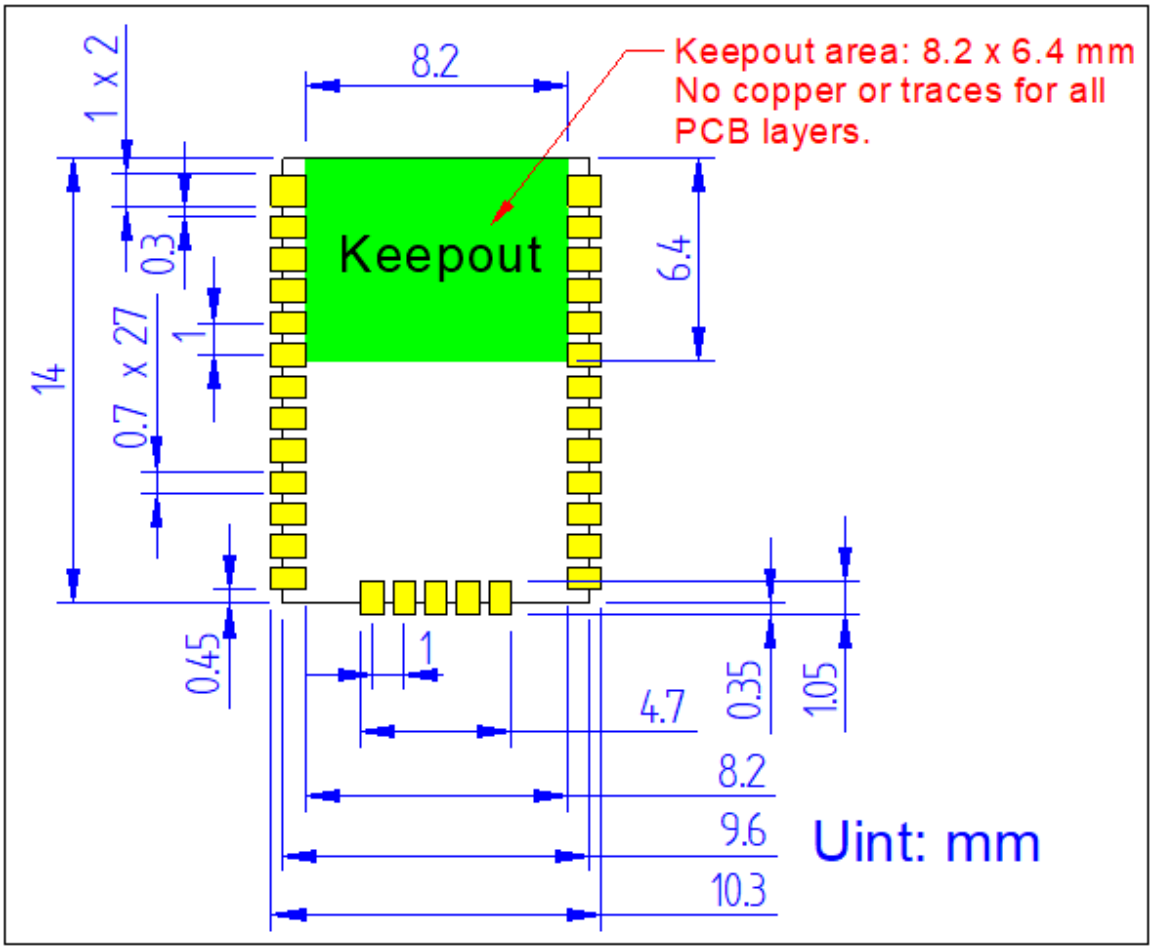
# 8 Mechanical specification

## 8.1 Outline dimensions




## 8.2 Recommended land pattern dimensions



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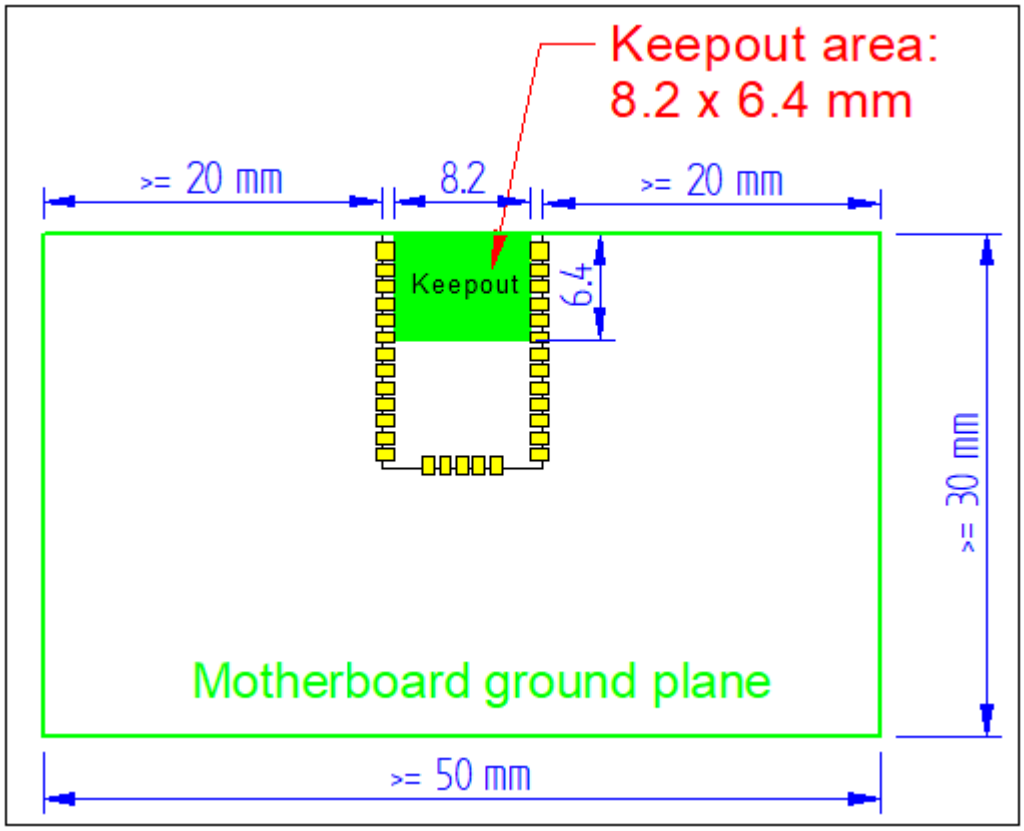
## 8.3 PCB layout suggestion

LS2003H-Vx smart antenna modules are intended to be placed on the top edge of the motherboard. The performance of the built-in GNSS chip antenna relies on the ground plane on the motherboard. The optimum size is 80 x 40 mm, but a smaller ground plane can also be used. The minimum size requirement of the motherboard ground plane is shown as below picture. The optimal placement is at the center of the top edge, but offset placement is allowed by keeping at least a 20 mm distance to the nearest ground plane edge. A ground plane width of 50 mm is the suggested minimum. Extending the width can increase the performance of the built-in GNSS chip antenna. Conversely, increasing the height of the ground plane beyond 30 mm has little effect on the antenna performance.




Note that the built-in GNSS chip antenna requires a small ground plane clearance and a void area (8.2x6.4 mm) for copper plane and trace for all layers under the antenna. Placement of other components is not allowed under the keep-out area on the opposite side.

Connect GND soldering pads of LS2003H-Vx to the motherboard ground plane with as short traces as possible. Use one via hole for each GND pad of LS2003H-Vx.

The oscillator of LS2003H-Vx is sensitive to sudden changes in ambient temperature that can adversely impact GNSS performance. Place LS2003H-Vx away from heat or air-cooling sources, such as high-power devices, cooling fans and air vents.

## 8.4 Installation position

LS2003H-Vx can receive satellite signal from top edge, top side and bottom side, so that it

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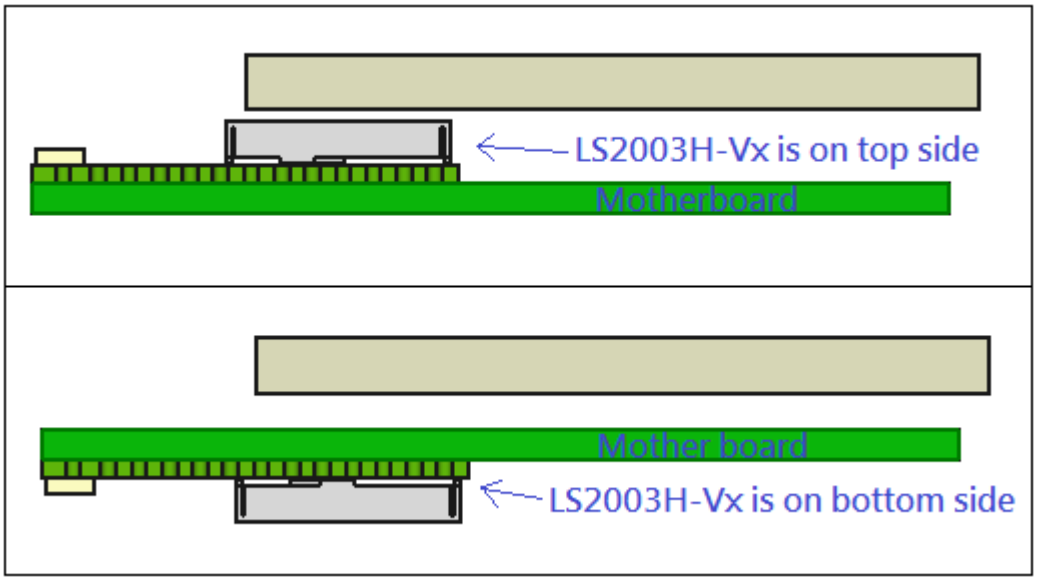
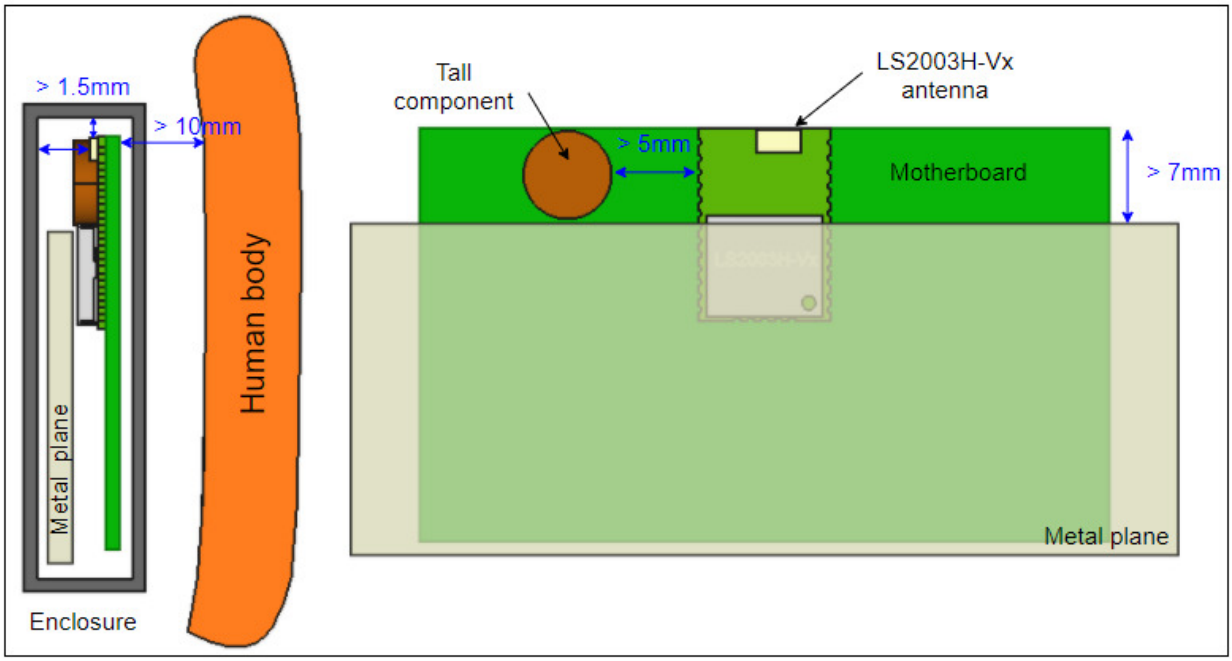
can be placed on either top or bottom side of the motherboard.




Refer to below picture for the surrounding materials.
Place any tall nearby components at least 5mm away from LS2003H-Vx.
Any adjacent metal plane should have at least 7mm distance to the top edge of LS2003H-Vx.
An enclosure or plastic cover should have at least 1.5mm distance to the built-in antenna.
Keep at least 10mm between the motherboard and the human body.



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# 9 Product handling

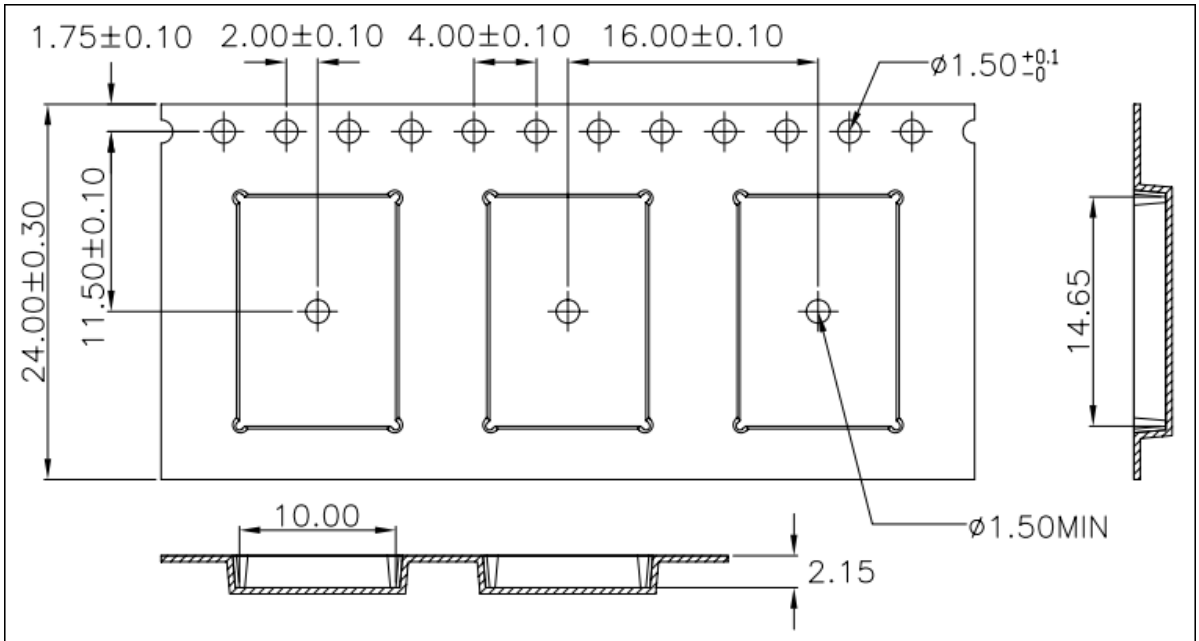
## 9.1 ESD precaution

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 Reel Packaging




1. 10 sprocket hole pitch cumulative tolerance ±0.20.
2. Carrier camber is within 1 mm in 250 mm.
3. Material : Black Conductive Polystyrene Alloy.
4. All dimensions meet EIA-481-D requirements.
5. Thickness : 0.30±0.05mm.
6. Packing length per 19" reel : 74.5 Meters.
7. Component load per 13" reel : 1500 pcs.

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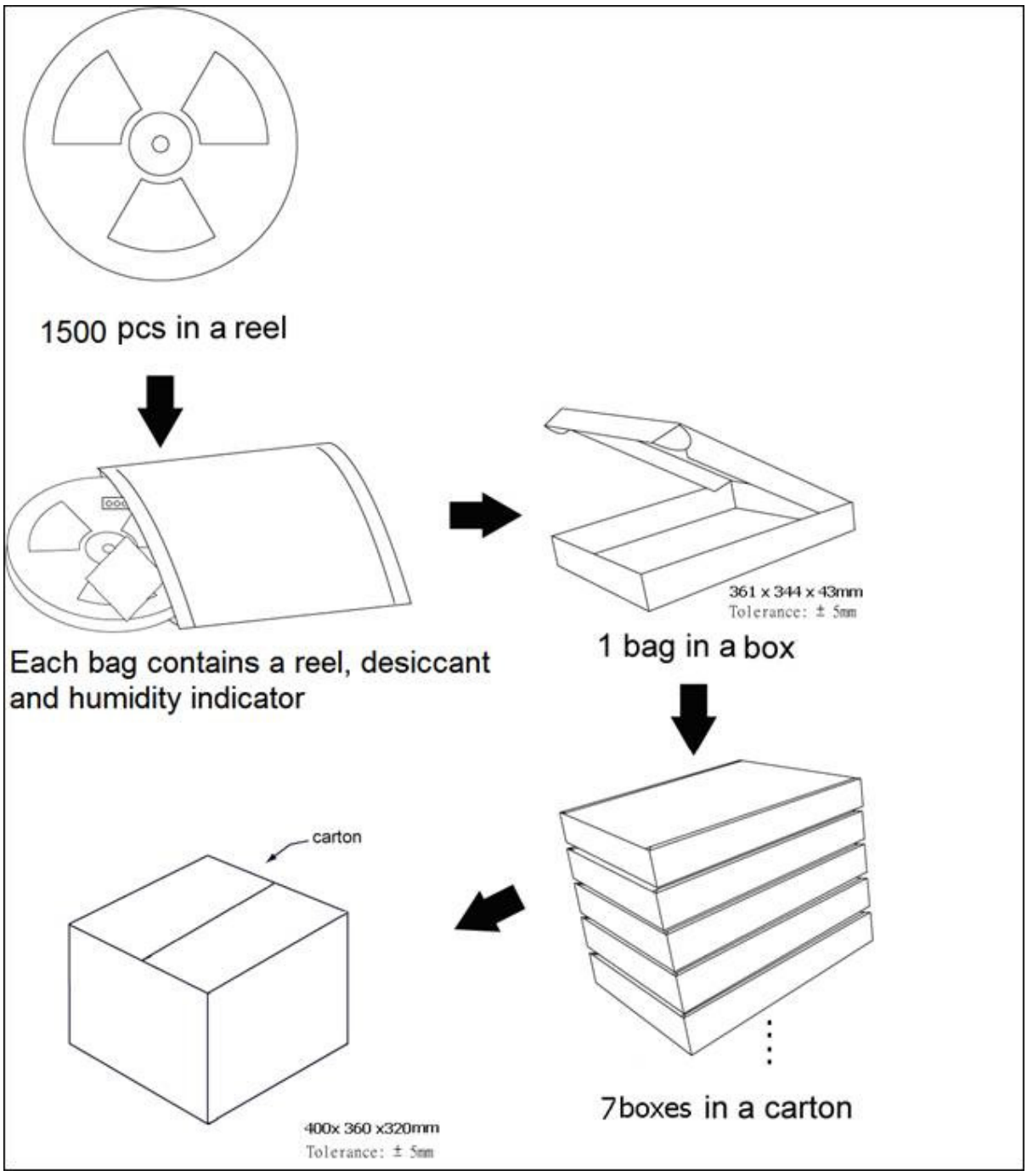
### 9.2.2 Box Packaging




## 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 ≦ 30°C and 60% RH or stored at ≦ 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:

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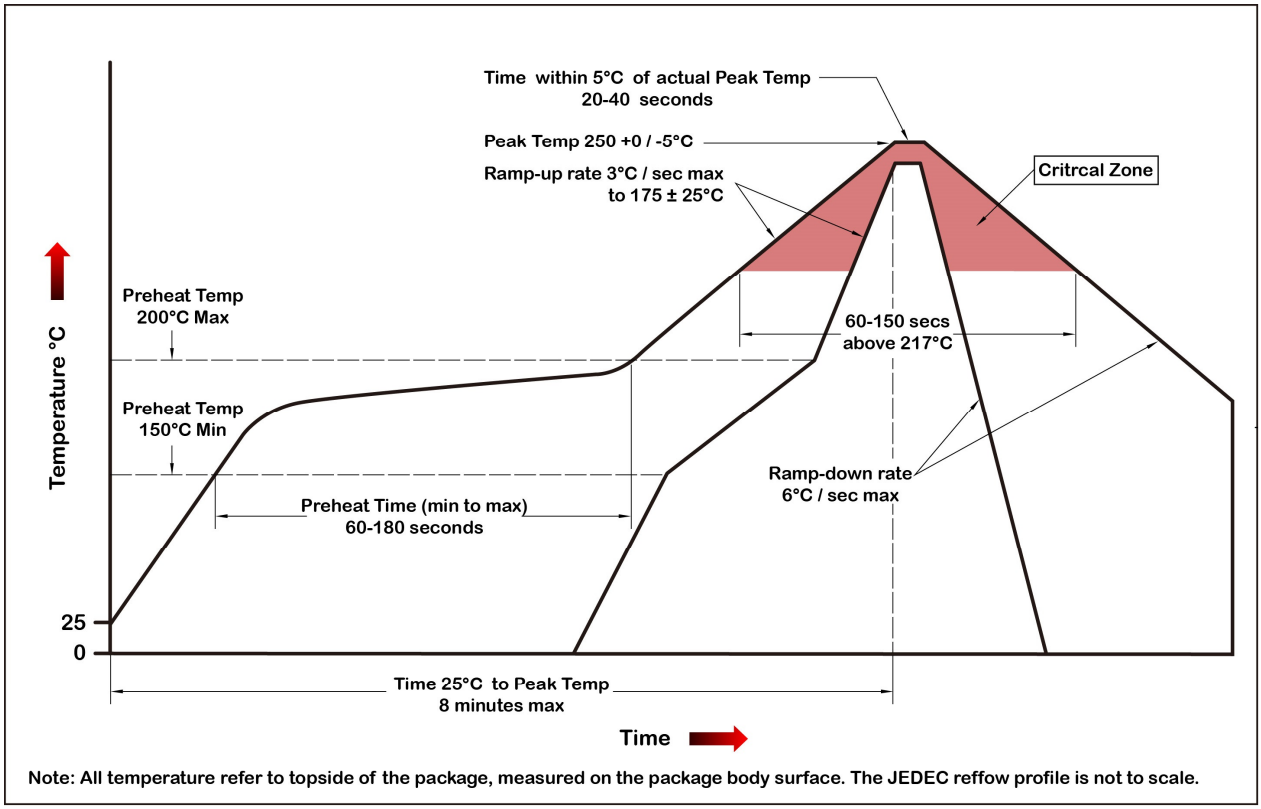
a. 192 hours at 40°C + 5°C / -0°C and < 5% RH
b. 24 hours at 125°C + 5°C / -0°C

## 9.4 Reflow soldering




Note: All temperature refer to topside of the package, measured on the package body surface. The JEDEC reffow profile is not to scale.

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

# 10 Ordering information

| Product name | Description | Remark |
|---|---|---|
| LS2003H-V2 | Dual-frequency multi-constellation GNSS smart antenna | GPS/QZSS: L1 C/A, L5C<br>GLONASS: L1OF<br>BEIDOU: B1I, B2a<br>GALILEO: E1, E5a |
| LS2003H-V3 | Dual-frequency multi-constellation GNSS smart antenna | GPS/QZSS: L1 C/A<br>GLONASS: L1OF<br>BEIDOU: B1I<br>GALILEO: E1<br>IRNSS: L5 |

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# Document change list

## Revision 0.1

- Draft release on March 25, 2021.

## Revision 0.2 (April 27, 2021)

- Up to 10Hz position fix rate.
- Changed the max. velocity from 515 m/s to 500 m/s in section 4
- Added proprietary commands (ID: 050, 051, 062, 063, 890, 891) in section 5.2
- Added section 5.3
- Changed the description of GPIO26 pin in section 6.
- Changed the typical input current of LS2003H-V2 from 66 mA to 60 mA
- Changed the typical input current of LS2003H-V3 from 45 mA to 38 mA
- Changed the reflow soldering picture in section 9.4