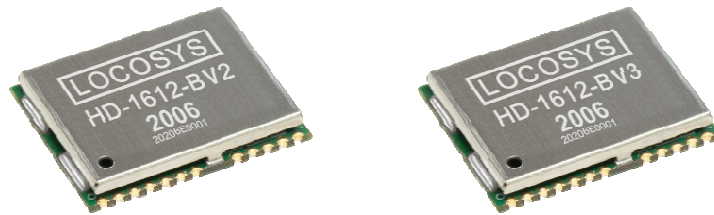


Product name	Description	Version
HD-1612-BV2	Dual-frequency multi-constellation GNSS positioning module (GPS, BEIDOU, GALILEO, QZSS, GLONASS)	1.2
HD-1612-BV3	Dual-frequency multi-constellation GNSS positioning module (GPS, BEIDOU, GALILEO, QZSS, IRNSS)	



1 Introduction

LOCOSYS HD-1612-BV2/HD-1612-BV3 are high-performance dual-band GNSS positioning modules that are capable of tracking all global civil navigation systems (GPS, GLONASS, BDS, GALILEO, QZSS and IRNSS). They integrate efficient power management architecture to perform low power and high sensitivity. Besides, concurrent reception of L1 and L5 band signals achieves sub-meter position accuracy. They are suitable for personal, automotive and marine navigations.

The RF front end of HD-1612-BV3 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

- Sub-meter position accuracy
- Concurrent reception of L1 and L5 band signals
- Support GPS, GLONASS, BEIDOU, GALILEO, QZSS and IRNSS
- Supports BDS-3 signal
- Capable of SBAS (WAAS, EGNOS, MSAS, GAGAN)
- 40 tracking channels
- Smart jammer detection and suppression
- Built-in LNA and SAW filter
- Built-in active antenna detection.
- IATF 16949 quality control
- Small form factor 16 x 12.2 x 2.4 mm
- SMD type; RoHS / REACH compliant

3 Application

- Personal positioning and navigation

- Automotive navigation
- Marine navigation

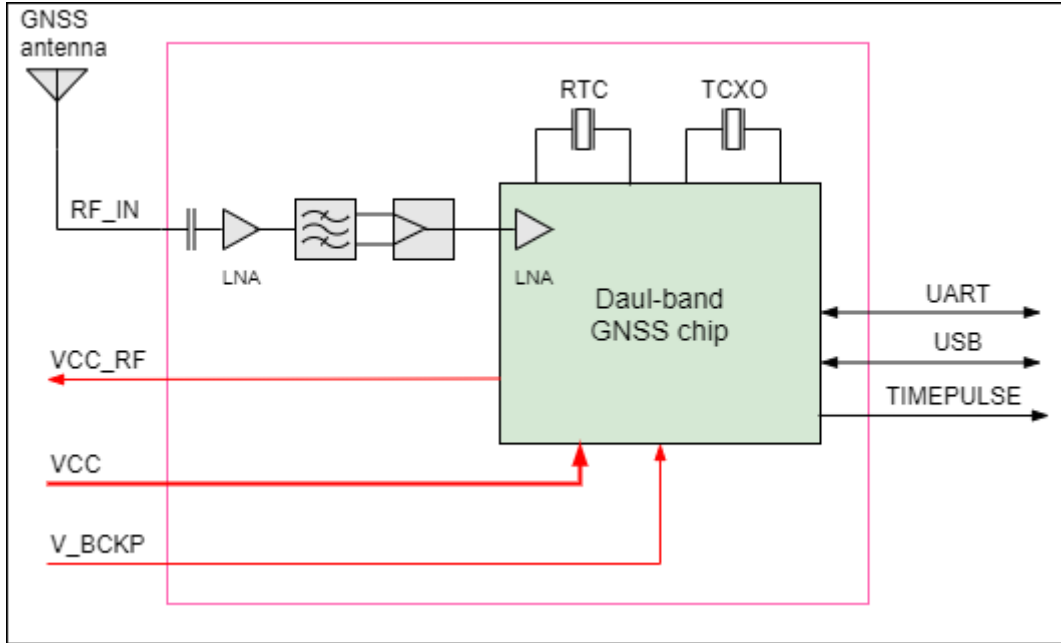


Fig 3-1 System block diagram.

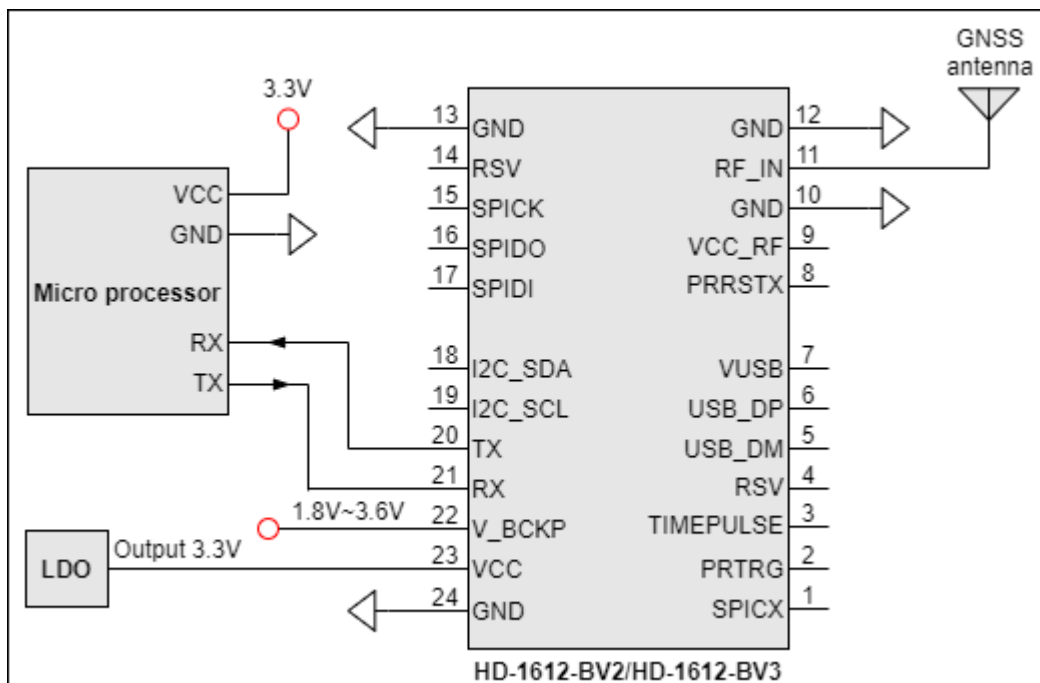


Fig 3-2 Typical application circuit that uses a passive antenna.

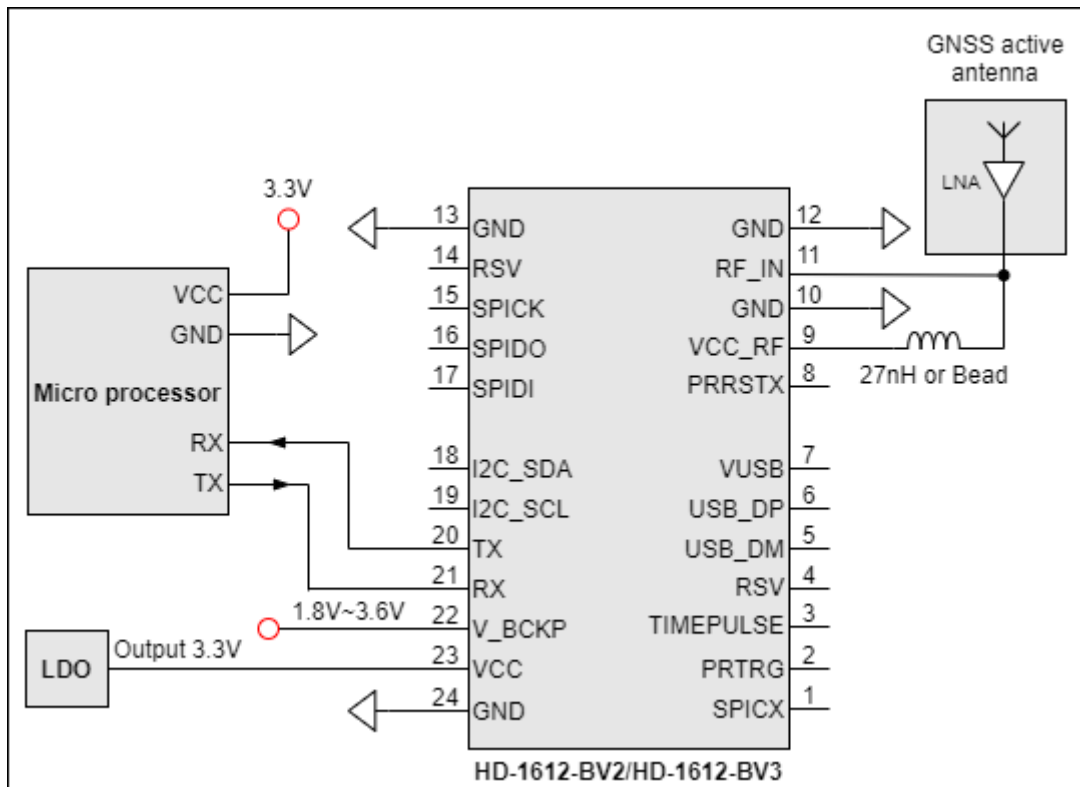


Fig 3-3 Typical application circuit that uses an active antenna.

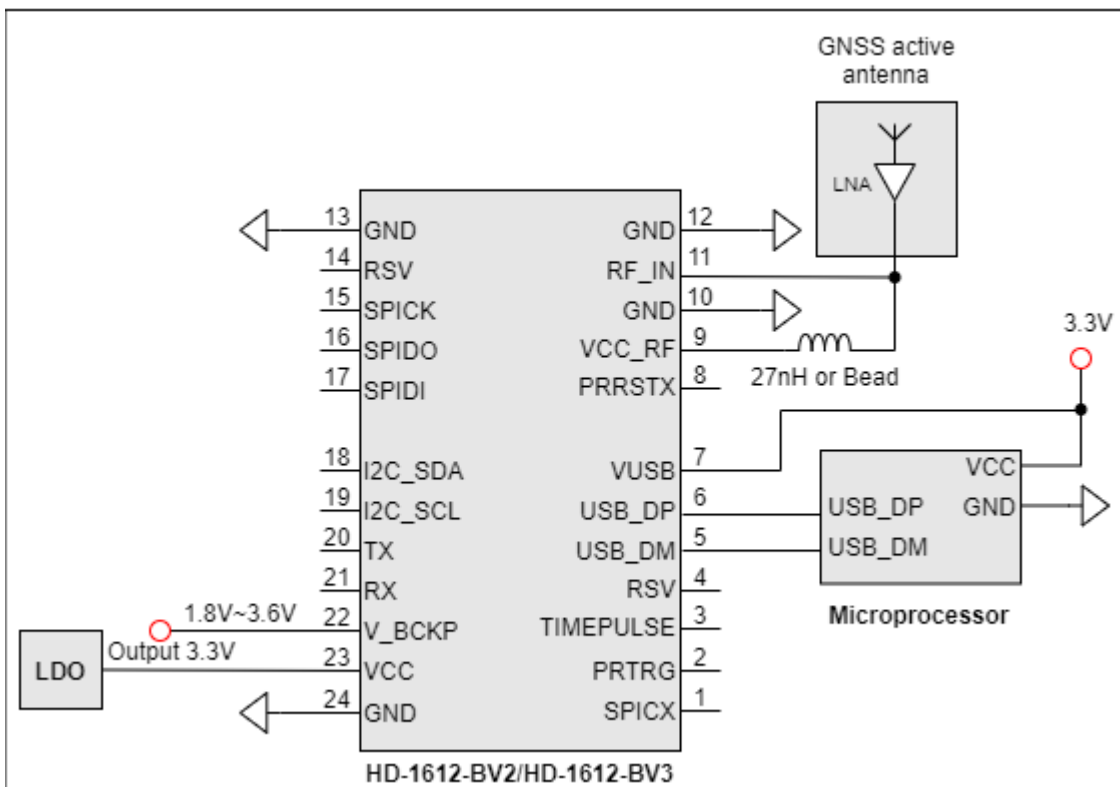


Fig 3-4 Typical application circuit that uses USB interface.

4 GNSS receiver

Frequency	HD-1612-BV2	GPS/QZSS: L1 C/A, L5C BEIDOU: B1I, B2a GALILEO: E1, E5a GLONASS: L1OF
	HD-1612-BV3	GPS/QZSS: L1 C/A, L5C BEIDOU: B1I, B2a GALILEO: E1, E5a IRNSS L5
Channels	40 channels	
Update rate	1Hz default, up to 10Hz	
Sensitivity	Tracking	-161dBm (with external LNA)
	Cold start	-148dBm (with external LNA)
Acquisition Time	Hot start (Open Sky)	1s (typical)
	Cold Start (Open Sky)	28s (typical)
Position Accuracy ⁽¹⁾	GNSS	< 1m CEP
Velocity & Time accuracy	GNSS	0.1m/s CEP
	1PPS	20ns
Max. Altitude	< 18,000 m	
Max. Velocity	< 515 m/s	
Protocol Support	NMEA 0183 ver. 4.1	115200bps ⁽²⁾ , 8 data bits, no parity, 1 stop bits (default) 1Hz: GGA, GLL, GSA, GSV, RMC and VTG 1Hz: \$GNTXT

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

- **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

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 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		
<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 5.1-8 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,1,1,03,31,47,342,44,1,42,62,45,26,30,49,40,6*79
 \$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 5.1-8 GSV Data Format

Name	Example	Units	Description
Message ID	\$GPGSV		GSV protocol header GP=GPS/QZSS, GL=GLONSS, GA=GALILEO, 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 GLONASS: L1 C/A=1 GALILEO: E1=6, E5a=2 BEIDOU: B1=1, B2a=4 IRNSS: L6=1
Checksum	*54		
<CR> <LF>			End of message termination

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

Table 5.1-9 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 5.1-9 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		
<CR> <LF>			End of message termination

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

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

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

Table 5.1-10 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

5.2 Proprietary NMEA output message

Table 5.2-1 Proprietary NMEA output message

Output message	Description
\$GNTXT,01,01,01,ANT_OK*50	Active antenna is well connected.
\$GNTXT,01,01,01,ANT_OPEN*40	Active antenna is open, i.e. not connected.
\$GNTXT,01,01,01,ANT_SHORT*06	Active antenna is short.

5.3 Proprietary command sets

The following table shows the most common use proprietary command sets.

Table 5.3-1 The table below summarizes the set of proprietary command sets for the HD-1612-BV2 / HD-1612-BV3

Command descriptions	Software command
Perform a Cold start	F1 D9 06 40 01 00 01 48 22
Perform a Warm start	F1 D9 06 40 01 00 02 49 23
Perform a Hot start	F1 D9 06 40 01 00 03 4A 24
Perform a Factory reset	F1 D9 06 09 08 00 02 00 00 00 FF FF FF FF 15 01
UART configures as 115200bps	F1 D9 06 00 08 00 00 00 00 00 00 C2 01 00 D1 E0
UART configures as 57600bps	F1 D9 06 00 08 00 00 00 00 00 00 E1 00 00 EF 3B
UART configures as 38400bps	F1 D9 06 00 08 00 00 00 00 00 00 96 00 00 A4 5A
UART configures as 19200bps	F1 D9 06 00 08 00 00 00 00 00 00 4B 00 00 59 79
UART configures as 9600bps	F1 D9 06 00 08 00 00 00 00 00 80 25 00 00 B3 07
Enable ZDA message	F1 D9 06 01 03 00 F0 07 01 02 1E
Disable ZDA message	F1 D9 06 01 03 00 F0 07 00 01 1D
Navigate with GPS +QZSS(L1+L5) only	F1 D9 06 0C 04 00 21 02 00 04 3D 2A
Navigate with GPS+GLONASS+GALILEO +QZSS (L1+L5) system	F1 D9 06 0C 04 00 33 02 10 04 5F 92
Navigate with GPS+GLONASS+GALILEO	F1 D9 06 0C 04 00 37 82 10 04 E3 22

+ BEIDOU+QZSS (L1+L5) system	
Switch to Vehicle mode	F1 D9 06 0F 02 00 96 00 AD A3
Switch to Pedestrian mode	F1 D9 06 0F 02 00 00 00 17 77
Query firmware version	F1 D9 0A 05 00 00 0F 37

6 Pin assignment and descriptions

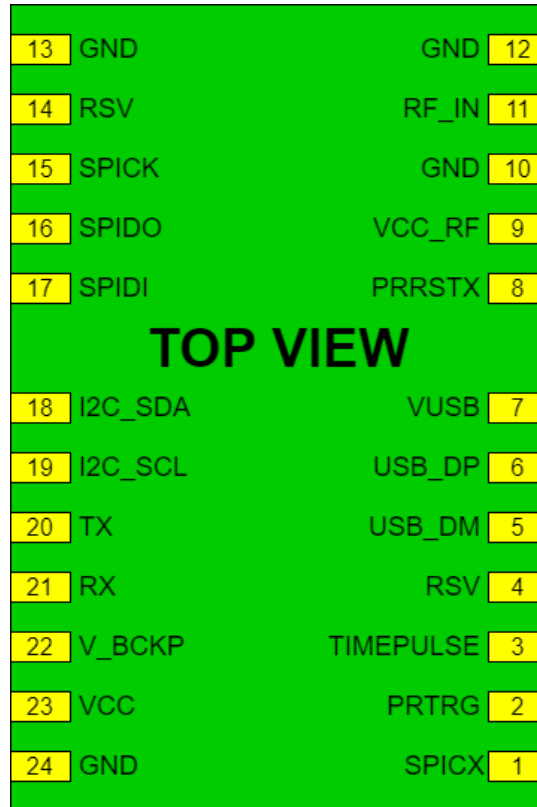


Table 6-1 Pin descriptions

Pin #	Name	Type	Description	Note
1	SPICX	O	SPI chip select. Leave unconnected if not used.	
2	PRTRG	I	Mode selection, or the trigger input in deep sleep mode to wake up the system. Leave unconnected if not used.	
3	TIMEPULSE	O	Time pulse (PPS, default 100ms pulse/sec)	
4	RSV		Reserved pin. Leave unconnected.	
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 3.0-3.6V to enable USB interface. Leave unconnected if not used.	
8	PRRSTX	I	External reset, low active. Leave unconnected if not used.	

9	VCC_RF	O	Output voltage for active antenna. The current is limited below 25mA.	
10	GND	P	Ground	
11	RF_IN	I	GNSS RF signal input.	
12	GND	P	Ground	
13	GND	P	Ground	
14	RSV		Reserved pin. Leave unconnected.	
15	SPICK	O	SPI clock. Leave unconnected if not used.	
16	SPIDO	O	SPI data. Leave unconnected if not used.	
17	SPIDI	I	SPI data. Leave unconnected if not used.	
18	I2C_SDA	I/O	I2C data. Leave unconnected if not used.	
19	I2C_SCL	O	I2C clock. Leave unconnected if not used.	
20	TX	O	Serial output	
21	RX	I	Serial input	
22	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 for the system running. If no backup power is available, connect V_BCKP to the main power supply (VCC).	
23	VCC	I	DC supply input. Must be clean and stable.	
24	GND	P	Ground	

7 DC & Temperature characteristics

7.1 Absolute maximum ratings

Parameter	Symbol	Ratings	Units
DC Supply Voltage	VCCabs	3.63	V
Input Backup Battery Voltage	V_BCKPabs	3.63	V
Operating Temperature Range	Topr_abs	-40 ~ 85	°C
Storage Temperature Range	Tstg_abs	-40 ~ 85	°C

7.2 DC Electrical characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
DC Supply Input Voltage	VCC		1.8	3.3	3.6	V
USB supply Voltage	VUSB		3.0	3.3	3.6	V
Backup Battery Input Voltage	V_BCKP		1.8	3.3	3.6	V
VCC_RF Output Voltage	VCC_RF			VCC-0.15		V
Supply Current	Iss	VCC = 3.3V, w/o active antenna, Peak Acquisition Tracking			200 ⁽¹⁾	mA
				43		mA
				41 ⁽²⁾		mA
Backup Battery Current	Ibat	VCC = 0V		12		uA
VCC_RF Output Current	I _{out}	VIN = 3.3V			25	mA
High Level Input Voltage	V _{IH}		0.7*VCC		VCC	V
Low Level Input Voltage	V _{IL}		0		0.3*VCC	V
High Level Output Voltage	V _{OH}	VCC = 3.3V	2.64		VCC	V
		VCC = 1.8V	1.53		VCC	
Low Level Output Voltage	V _{OL}	VCC = 3.3V			0.4	V
		VCC = 1.8V			0.45	

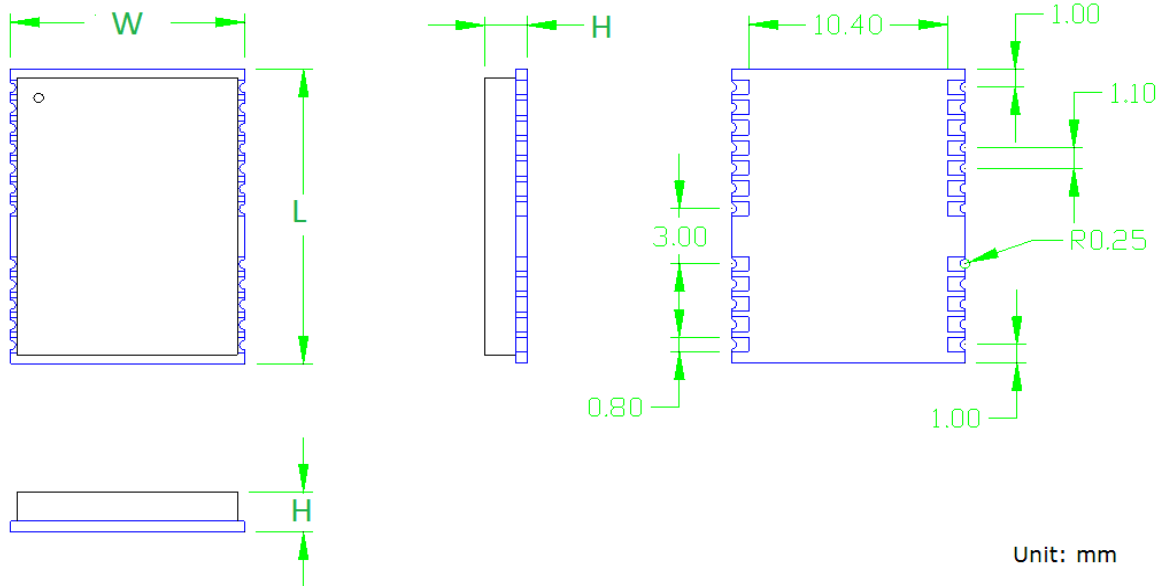
Note1: Measured with 1MHz sampling rate.

Note2: GNSS, L1 + L5 bands. Measured for 12 hours when position fix (1Hz) is available and input voltage is 3.3V.

7.3 Temperature characteristics

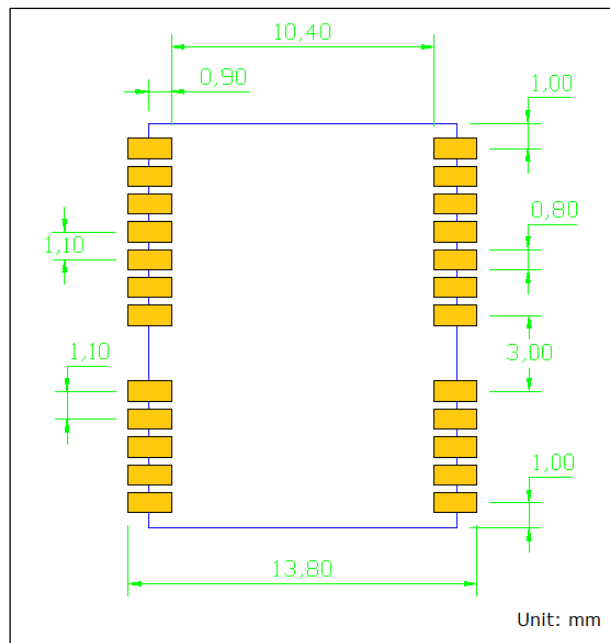
Parameter	Symbol	Min.	Typ.	Max.	Units
Operating Temperature	Topr	-40	-	85	°C
Storage Temperature	Tstg	-40	25	85	°C

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 Product handling

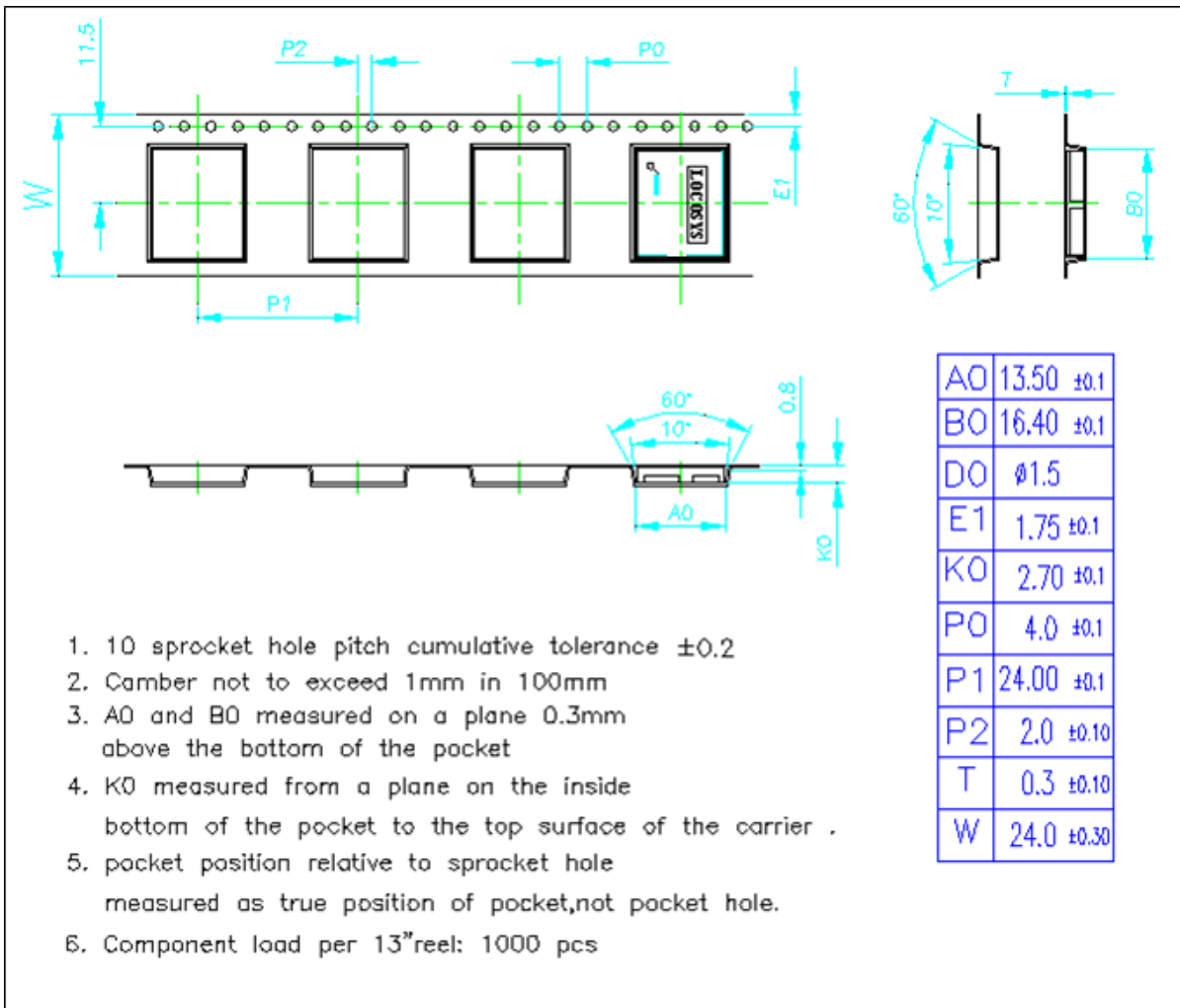
9.1 ESD precaution

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.

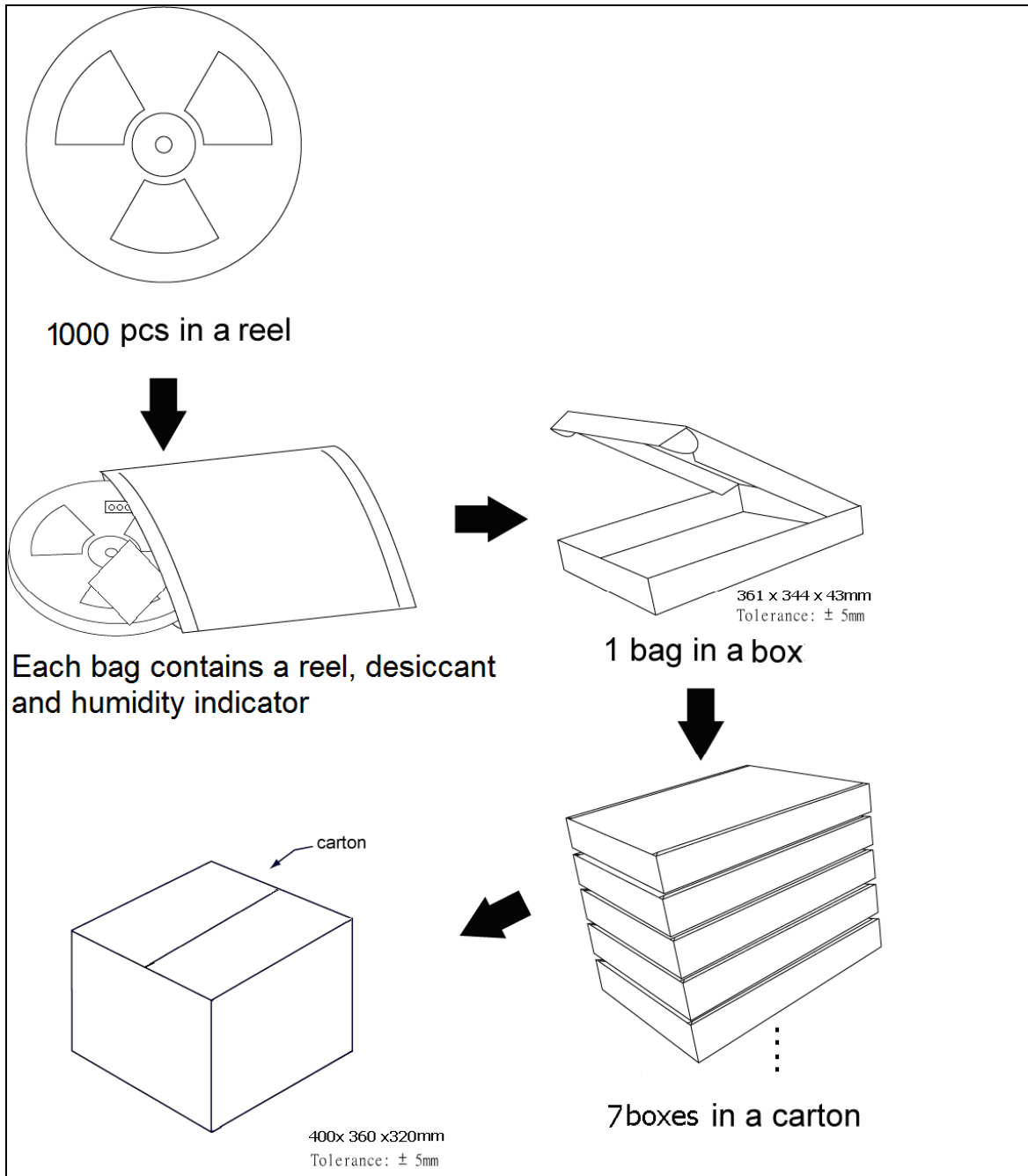
9.2 Packaging

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 Tape and reel packaging



9.2.2 Box packaging



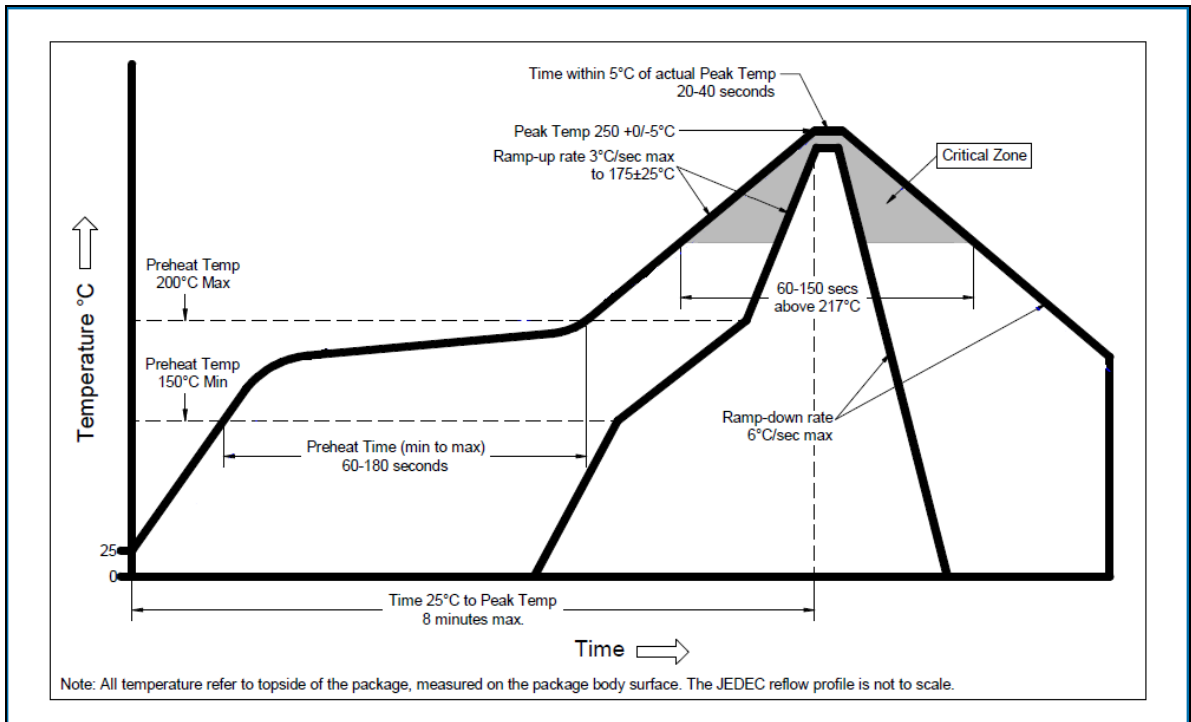
9.3 Moisture sensitivity level

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 $\cong 30^{\circ}\text{C}$ and 60% RH or stored at $\cong 20\%$ 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
HD-1612-BV2	Dual-frequency multi-constellation GNSS positioning module	GPS, BEIDOU, GALILEO, QZSS, GLONASS
HD-1612-BV3	Dual-frequency multi-constellation GNSS positioning module	GPS, BEIDOU, GALILEO, QZSS, IRNSS

Document change list

Revision 0.1

- Draft release on February 15, 2020.

Revision 0.2 (March 3, 2020)

- Added signal ID's description of GSV message in Table 5.1-8.

Revision 0.3 (April 6, 2020)

- Removed SBAS in section 4.

Revision 1.0 (May 11, 2020)

- Added Fig. 3-4
- Changed the tracking sensitivity to -161 dBm.
- Added the description “default 100ms pulse/sec” for PPS.
- Changed VCC_RF output voltage to VCC-0.15
- Added the typical acquisition current.
- Changed the typical tracking current to 42 mA.

Revision 1.1 (May 29, 2020)

- Added the compliant description of AIS-140 in section 1.
- Changed cold start time from 32s to 28s.
- Changed acquisition current from 44 mA to 43 mA.
- Changed the typical tracking current from 42 mA to 41 mA.

Revision 1.2 (September 22, 2020)

- Added the proprietary command sets in section 5.3.