1 Overview

1.1 General Description

HED-10L is a new generation BDS/GPS/GLONASS/GALILEO/QZSS multi-frequency and multi-system high-precision positioning and dual-antenna heading module developed by DATAGNSS. It is equipped with two high-performance CYNOSURE IV GNSS SoC.

It supports multi-frequency and multi-system RTK positioning as well as dual antenna heading, allowing users to configure flexibly. In addition, the module has a built-in advanced anti-interference unit, which can provide accurate positioning even in complex electromagnetic environments.

This product has the characteristics of high performance, low cost, high integration, and easy application. It is very suitable for large-scale applications in antenna parameters, drones, lawnmowers, precision agriculture, intelligent driving tests, and other fields with GNSS positioning and orientation requirements.

Figure 1 HED-10L module photo

1.2 Features

- 16mm x 21mm x2.4mm
- Supports BDS、GPS、GLONASS、Galileo、QZSS、SBAS
- Supports multi-frequency and multi-system or single-system RTK positioning, as well as dual-antenna heading solution.
- Dual GNSS positioning chip are highly integrated, supporting output of latitude, longitude, altitude, heading data.
- Support active antenna detection and short circuit protection.
- supports UART, I2C, SPI, CAN, etc.

1.3 System diagram

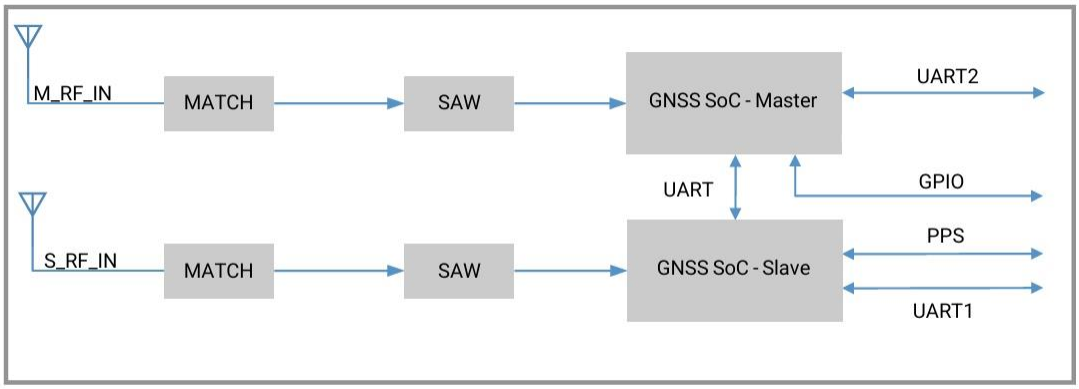

Figure 2 System diagram

1.4 Specifications

Table 2 Specifications

Parameter	Specification	
GNSS channels	256	
Satellite	BDS/GPS/GLONASS/Galileo/QZSS	
GNSS reception	GPS/QZSS: L1C/A, L5	
	BDS: B1I, B2a	
	GLONASS:G1	
	Galileo:E1, E5a	
Updating rate	Default 5Hz	
Position accuracy [1]	Single	1m (RMS)

	RTK(RMS)	H：1cm+1ppm
		V：2cm+1ppm
Heading accuracy	Accuracy	0.1°/1m baseline
	Initialization time	10s
Velocity & Time accuracy	GNSS	0.05m/s CEP
	1PPS	20ns
Time to First Fix (TTFF)	Hot start	1s
	Cold start	28s（typical）
Sensitivity [2]	Cold start	-148dBm
	Hot start	-154dBm
	Reacquisition	-154dBm
	Tracking	-161dBm
Antenna detection	Built-in antenna short circuit protection, open circuit detection.	
Serial interface	UART	2
	I2C[3]	1
	SPI[3]	1
	CAN[3]	1
Protocol	NMEA 0183 Protocol V4.00/V4.10（Default）/V4.11 Cynosure GNSS Receiver Protocol	
Operating condition	Main voltage	3.0V ~ 3.6V
	Digital I/O voltage	3.0V ~ 3.6V
	Backup voltage	1.8V ~ 3.6V
Power consumption	Tracking	48mA@3.3V
	Capture	55mA@3.3V
	Standby mode	30uA@3.3V
Operating temperature	-40°C ~ +85°C	
Storage temperature	-40°C ~ +85°C	
Humidity	95%	
Packaging size	16mm x 21mm x2.4mm LGA Package	

* *[1] Open sky condition.*
* *[2] Demonstrated with a good external LNA.*
* *[3] Supported upon request with special firmware.*

2 PIN DESCRIPTION

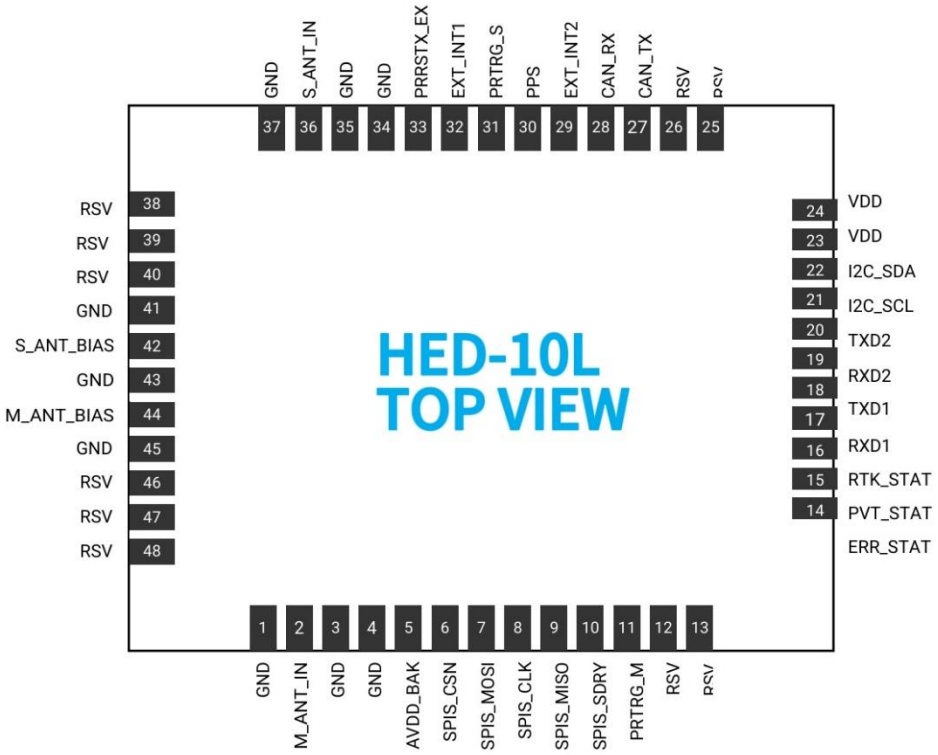

Figure 3 Pin assignment

Table 3 Detailed pin descriptions

Function	Symbol	No.	I/O	Description
Power	VDD	23, 24	Power	Main power supply voltage input.
	GND	1, 3, 4, 34, 35, 37, 41, 43, 45	GND	Ground
	AVDD_BAK	5	Power	Module backup power supply. When the main power is disconnected, the backup power supply provides power to RTC and related registers. Voltage requirement: 2.0V~3.6V.
	M_ANT_BIAS	44	Power	Main antenna power supply
	S_ANT_BIAS	42	Power	Main antenna power supply
Antenna	M_ANT_IN	2	I	Main antenna signal input，impedance 50Ω
	S_ANT_IN	36	I	Secondary antenna signal input，impedance 50Ω
UART	TXD1	18	O	Serial port 1，LVTTL Voltage
	RXD1	17	I	
	TXD2	20	O	Serial port 2，LVTTL Voltage
	RXD2	19	I	
SPI Interface	SPIS_CSN	6	O	SPI Data interface
	SPIS_MOSI	7	O	
	SPIS_CLK	8	I/O	
	SPIS_MISO	9	I	
	SPIS_SDRY	10	O	
I2C	I2C_SCL	21	I/O	I2C Data interface
	I2C_SDA	22	I/O	
CAN	CAN_TX	27	O	CAN Data interface
	CAN_RX	28	I	
Other	PRRSTX_EX	33	I	Module reset input,low level effective.
	PRTRG_M	11	I	Module main chip working mode control input, used for firmware upgrade.
	PRTRG_S	31	I	Module secondary chip working mode control input, used for firmware upgrade.
	PPS	30	I	Pulse signal output in seconds.
	EXT_INT1	32	I	External interrupt input 1, default as general GPIO.
	EXT_INT2	29	I	External interrupt input 2, default as general GPIO.
	ERR_STAT	14	O	Abnormal indication, high level effective.
	PVT_STAT	15	O	PVT positioning indication, high level effective.
	RTK_STAT	16	O	RTK positioning indication, high level effective.
	RSV	12, 13, 25, 26, 38, 39, 40, 46, 47, 48	--	Reserved pins, keep floating.

3 ELECTRICAL CHARACTERISTIC

3.1 Absolute Maximum Rating

Table 4 Absolute rating

Symbol	Parameter	Min.	Max.	Unit
VCC		-0.3	3.63	V
V_{in}	Input pin voltage	-0.3	3.63	V
VBAK	Backup power voltage	-0.3	3.63	V
M_ANT_IN/S_ANT_IN	GNSS Master/ secondary antenna signal output	-0.3	6	V
M_ANT_IN/S_ANT_IN input Power	Main/secondary antenna RF input power	--	+10	dBm
$T_{storage}$	Storage temperature	-55	95	°C
T_{open}	Operating temperature	-40	85	°C
T_{solder}	Solder reflow temperature	--	260	°C
ESD	Maximum tolerable ESD level	--	2000	V

3.2 IO Characteristics

3.2.1 PRRSTX and PRTRG

Table 5 PRRSTX and PRTRG

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
I_{IZ}	Input leakage current	--	--	--	+/-1	uA
V_{IH}	Input high voltage	--	AVDD_BAK×0.67	--	AVDD_BAK	V
V_{IL}	Input low voltage	--	0	--	AVDD_BAK×0.27	V
V_{OH}	Output high voltage	I_{OH} = 5.3mA, AVDD_BAK = 3.3V	2.64	--	--	V
		I_{OH} = 1.2mA, AVDD_BAK = 1.8V	1.53	--	--	V
V_{OL}	Output low voltage	I_{OL} = 3.9mA, AVDD_BAK = 3.3V	--	--	0.4	V
		I_{OL} = 1.9mA, AVDD_BAK = 1.8V	--	--	0.45	V
C_i	Input capacitance	--	--	--	11	pF
R_{PU}	Pull-up resistance	--	35	--	84	kΩ

3.2.2 Others

Table 6 Others

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
I_{IZ}	Input leakage current	--	--	--	+/-1	uA
V_{IH}	Input high voltage	--	VDD×0.67	--	VDD	V
V_{IL}	Input low voltage	--	0	--	VDD×0.27	V
V_{OH}	Output high voltage	I_{OH} = 5.3mA, VDD = 3.3V	2.64	--	--	V
V_{OL}	Output low voltage	I_{OL} = 3.9mA, VDD = 3.3V	--	--	0.4	V
C_i	Input capacitance	--	--	--	11	pF
R_{PU}	Pull-up resistance	--	35	--	84	kΩ

3.3 DC Characteristics

3.3.1 Operating Conditions

Table 7 Operating conditions

Symbol	Parameter	Min.	Typ.	Max.	Unit
VDD	Power supply voltage	3.0	3.3	3.6	V
AVDD_BAK	Backup battery voltage	1.8	3.3	3.6	V
ICC_{max}	Maximum operating current @ VDD	--	--	100	mA
T_{env}	Operating temperature	-40	--	85	°C

3.3.2 Power Consumption

Table 8 Power consumption

Parameter	Condition	Measure Pin	Typ.	Unit
GNSS	Tracking	VDD[1]	48	mA
	Capuring		55	
Standy mode	--	AVDD_BAK[2]	30	uA

* *[1] Condition: VDD = 3.3V @ Room Temperature*
* *[2] Condition: AVDD_BAK = 3.3V @ Room Temperature. All Pins Open.*

3.4 Antenna characteristics

Table 9 Antenna characteristics

Symbol	Parameter	Min.	Typ.	Max.	Unit
G_{ant}	Best input efficiency	25	35	45	dB

4 HARDWARE DESCRIPTION

4.1 Connecting Power

The HED-10L positioning module is equipped with two power supply pins: VDD (main power) and AVDD_BAK (backup power). To ensure the positioning performance of the module, it is recommended to control the ripple of the module's power supply. It is suggested to use an output current.

Close all power except AVDD_BAK, the module will enter standby mode, at this time only a small current is needed to maintain the RTC clock and backup RAM. After power recovery, the system can recover from backup RAM for fast hot start. In case of continuous power supply to the backup power source, ephemeris data can still be retained and hot start or warm start can be achieved when the system is powered on again; if there is no connection to the backup power source and the module does not receive auxiliary data, then the system will perform a cold start when powered on again.

NOTE: If there is no available backup power supply, AVDD_BAK pin must be connected to VDD or left floating.

4.2 Antenna Design

In order to achieve directional functionality, the HED-10L module has two antenna interfaces (supporting passive antennas and active antennas). When using an active antenna, it is recommended that the antenna gain does not exceed 40dB. The antenna interface comes with a power output for supplying power to the active antenna.

Both of the module's antenna interfaces support active antenna detection and overcurrent protection functions, which can detect the normal connection, open circuit, and short circuit status of the active antenna and provide prompt information through NMEA data.

Table 10 Antenna status NMEA output

Antenna status	GNSS module output message
Short circuit	$GNTXT,01,01,01, ANT_SHORT*06
Normal operating	$GNTXT,01,01,01, ANT_OK*50
Open circuit	$GNTXT,01,01,01, ANT_OPEN*40

4.3 Reset and Mode Control

The HED-10L module contains two chips, a master and a slave. The working mode is controlled by the PRRSTX, PRTRG_M, and PRTRG_S pins. PRRSTX is the shared reset pin for both chips, while PRTRG_M and PRTRG_S are control signals for the working mode of the master chip and slave chip

respectively. During chip reset, PRTRG_M and PRTRG_S can be used to control whether the chip enters Boot mode or User mode.

Users can download module firmware in two ways: user mode and Boot mode.

- User mode download: Upgrade directly through the serial port, no need for any operation, after the download is complete, the system will automatically reset.
- Boot mode download: PRTRG and PRRSTX need to cooperate with each other. The timing requirements for PRTRG and PRRSTX are shown in the following figure. After entering boot mode, serial port upgrade is adopted. After the serial port upgrade is completed, the system cannot automatically reset. It is necessary to use PRRSTX again to make the system enter user working mode.

When connecting PRRSTX and PRTRG to the control system IO, it is recommended to use IO pins with open-drain output function, and prohibit adding pull-up or pull-down resistors to such pins.

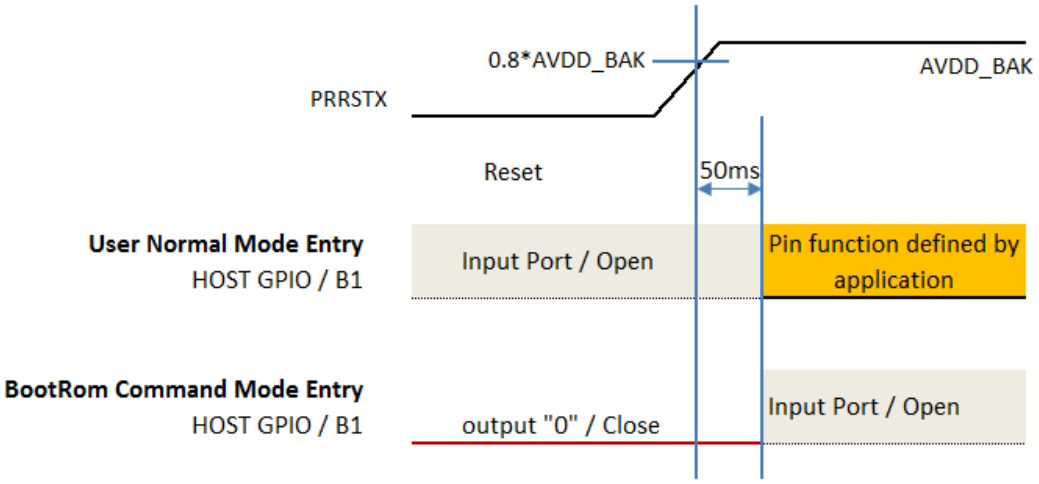

Figure 4 Work mode switch

Table 11 Shortest reset duration

Parameter	Symbol	Pin	Condition	Min.	Typ.	Max.	Unit
Reset input duration	t_{RSTL}	PRRSTX	Normal power supply, and the oscillator is stable.	100	--	--	mS

Figure 5 Shortest reset duration

5 DEFAULT MESSAGE

Table 12 Default message

Interface	Settings
UART1	Data format: 1 start bit, 8 data bits, 1 stop bit, no parity bit. Default baud rate：230400bps After normal power-on, the module will activate the following NMEA messages by default: GGA, RMC, PALYSBLS , and it can be configured to support other NMEA and Allystar binary protocols.
Timepulse	1 pulse per second, synchronized at rising edge, pulse length 100 ms.

* *Special firmware support*

When the external system shuts down the main power of the module, the high level of the serial port may prevent the module from entering sleep mode. Therefore, it is recommended to synchronously disconnect the serial port connection or set the serial port to input state or high impedance state when shutting down the main power of the module.

6 MECHANICAL SPECIFICATION

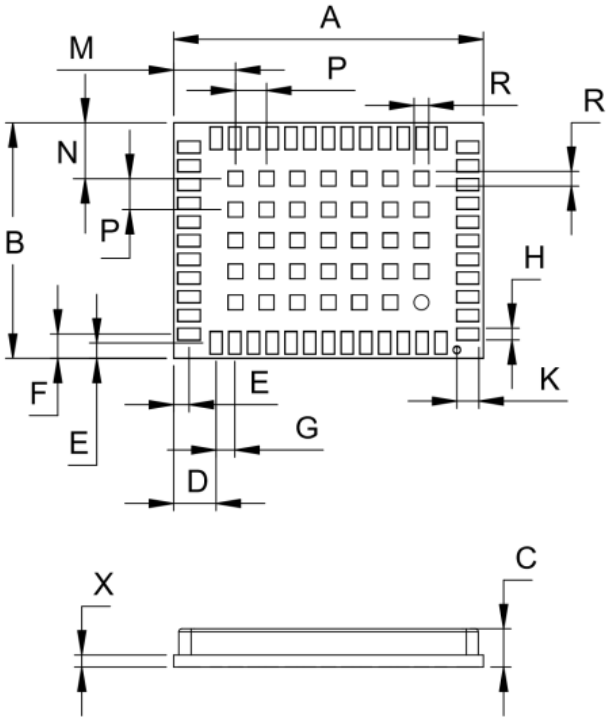

Figure 7 HED-10L Dimensions

Table 13 Dimensions

Symbol	Min. (mm)	Typ.(mm)	Max. (mm)
A	20.80	21.00	21.50
B	15.80	16.00	16.50
C	2.20	2.40	2.60
D	2.78	2.88	2.98
E	0.95	1.05	1.15
F	1.55	1.65	1.75
G	1.17	1.27	1.37
H	0.70	0.80	0.90
K	1.40	1.50	1.60
M	4.10	4.20	4.30
N	3.70	3.80	3.90
P	2.00	2.10	2.20
R	0.90	1.00	1.10
X	0.72	0.82	0.92

7 REFERENCE DESIGN

7.1 Schematic reference design

7.1.1 Key points of schematic design

1. Module main power VDD is recommended to be powered by 3.3V. When AVDD_BAK is not connected to a backup power supply, keep it floating.

2. PRRSTX_EX, PRTRG_M, and PRTRG_S pins are used for controlling module firmware upgrades. It is recommended to expose test points or connect them to the GPIO of the main control MCU. These three pins disable external pull-up or pull-down resistors and are recommended to be connected to GPIOs of the main control MCU that can be set as open-drain outputs, or connected between the main control GPIOs through MOS tubes or transistors (when using USER TO BOOT scheme, PRTRG_M/PRTRG_S may not need to be controlled).。

3. TXD1/RXD1 and TXD2/RXD2 are by default the NMEA output serial ports of the master and slave chips respectively. It is recommended to connect them to the main control MCU for easy access to the satellite reception, positioning, and antenna connection status of both channels.

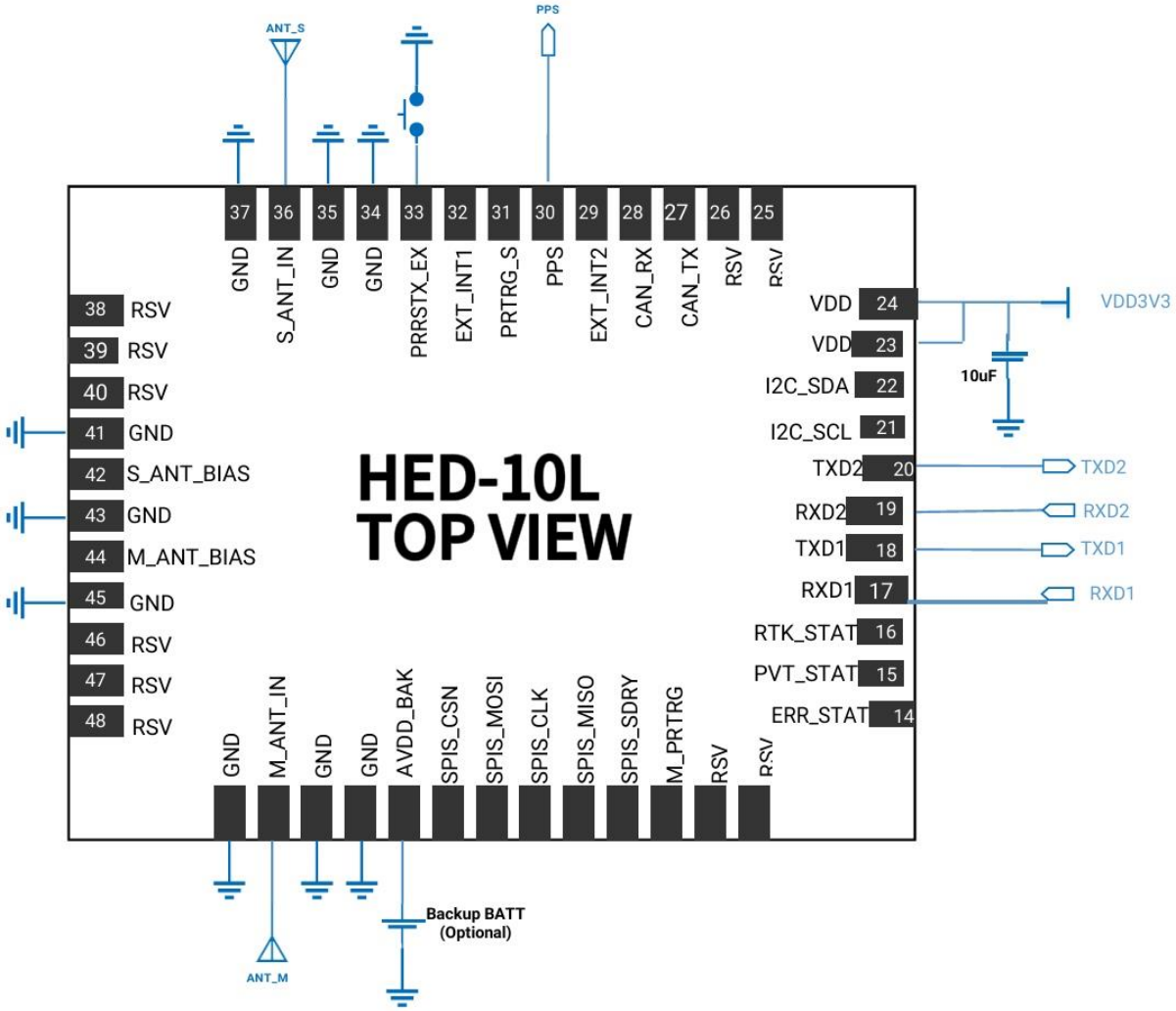

Figure 8 HED-10L Reference design

7.2 PCB Footprint Reference

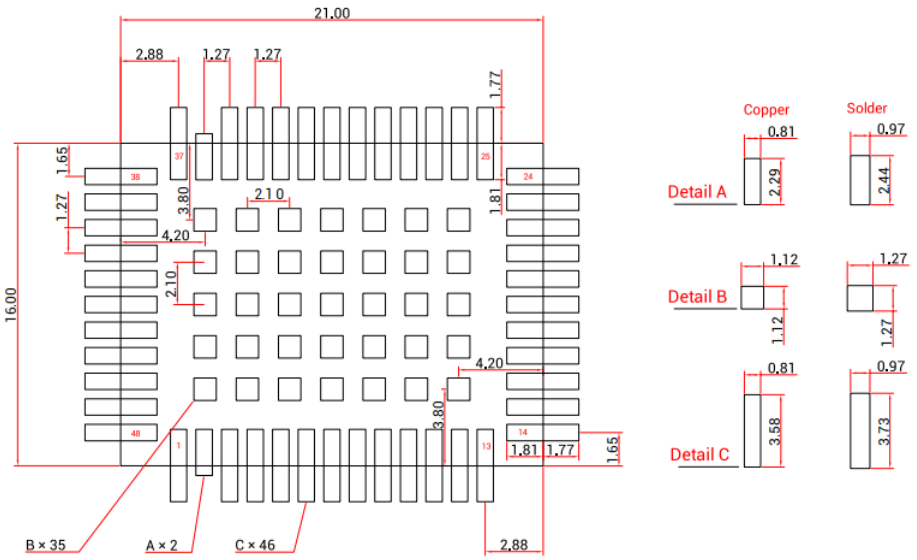

Figure 9 HED-10L Footprint Reference

For the convenience of testing, the solder pads for the functional pins are designed to be longer and extend beyond the module outline. For example:

(1) The solder pad described in Detail C extends 1.77mm beyond the module outline.

(2) The solder pad described in Detail A extends 0.47mm beyond the module outline. Because these solder pads are RF pins, it is desired to have their surface traces as short as possible to minimize external interference on RF signals, so they are designed to be appropriately shorter.

7.3 LAYOUT NOTES

To fully utilize the advantages and performance of this module, please pay attention to the following:

1) Place decoupling capacitors near the module's power supply pins and ensure that the width of power traces is above 0.5mm.

2) It is recommended to have a RF trace width greater than 0.2mm from the module's RF port to the antenna interface, and place it as close as possible. The RF trace should follow a coplanar waveguide impedance model, with a distance of approximately 1 times between the trace and ground copper plane to maintain an impedance of 50Ω.

3) It is recommended to reference the second layer ground for routing from the module's RF port to the antenna interface, while ensuring that the second layer ground plane remains intact.

4) Do not place the module near sources of interference such as communication antennas, crystal oscillators, large inductors, or high-frequency digital signal lines. It is also ideal for filling up all areas on the bottom side of the module with a ground plane.

8 SOFTWARE INTERFACE

8.1 NMEA Message Format

Table 14 NMEA output message

NMEA	Description
GGA	Global positioning system fixed data
RMC	Recommended minimal data for GNSS
PALYSBLS	Heading statement
TXT	Intermediate process data (debug information)

8.1.1 GGA - Global Positioning System Fix Data

Table 15 GGA Data Formate

Name	Example	Unit	Description
Message ID	$GNGGA		GGA protocol header
UTC Time	074144.000		hhmmss.sss
Latitude	3957.79941		ddmm.mmmmm
N/S indicator	N		N = north or S = south
Longitude	11619.02981		dddmm.mmmmm
E/W Indicator	E		E = east or W = west
Position Fix Indicator	1		See Table 16
Satellites Used	19		Number of satellites in use, 00-24
HDOP	0.83		Horizontal Dilution of Precision (meters)
MSL Altitude	105.5	meters	Antenna Altitude above/below mean-sea level (geoid) (in meters)
Units	M	meters	Units of antenna altitude, meters
Geoidal Separation	-8.4	meters	The accuracy error of the geoid, the difference between the WGS-84 ellipsoid and mean sea level (geoid), "-" indicates that mean sea level is lower than the ellipsoid surface.
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	*65		Checksum
<CR> <LF>			End of message termination

Table 16 Position Fix Indicators

Value	Description
0	Fix not available
1	GNSS fix
2	Differential GNSS fix

Output example of Table 15 shows as below:

$GNGGA,074144.000,3957.79941,N,11619.02981,E,1,19,0.83,105.5,M,-8.4,M,,*65

8.1.2 RMC - Recommended Minimum Specific GNSS Data

Table 17 RMC Data Format

Name	Example	Unit	Description
Message ID	$GNRMC		RMC protocol header
UTC Time	075939.000		hhmmss.sss
Status	A		A = data valid or V = data not valid
Latitude	2225.56166		ddmm.mmmmm
N/S Indicator	N		N = north or S = south
Longitude	11412.68199		dddmm.mmmmm
E/W Indicator	E		E = east or W = west
Speed over ground	0.000	knots	Speed over ground
Course over ground	64.79	degrees	Degrees to true north
Date	020589		ddmmyy
Magnetic variation	0.0	degrees	
Variation sense	E		E = east or W = west
Mode	A		A = Autonomous, D = DGPS, N = Data not valid,
Checksum	*4B		
<CR> <LF>			End of message termination

Output example of Table 17 shows as below:

$GNRMC,075939.000,A,2225.56166,N,11412.68199,E,0.000,64.79,020589,0.0,E,A*1D

$GNRMC,074458.000,A,3957.79932,N,11619.03010,E,0.005,0.00,280419,,,A*4B

8.1.3 PALYSBLS – Yaw，Pitch and Baseline state

Table 3 $PALYSBLS -- Yaw, Pitch and Base-line state

No.	Field	Format
1	$	Start character (Code 24h)
2	PALYSBLS	Address field
3	hhmmss.s-s	Time of position (heading) fix
4	x.x	Latitude-projection of base-line, m
5		Longitude-projection of base-line, m
6		Height-projection of base-line, m
7		Base-line length (Rover-to-Base distance), m
8		Base-line yaw (angle between base-line vector and North direction), degrees
9		Base-line pitch (angle between base-line vector and horizon), degrees
10	a	Mode Indicator: A = Autonomous mode D = Differential mode F = Float RTK R = Real Time Kinematic E = Estimated (dead reckoning) mode N = Data not valid
11	*hh	Checksum indicator ("*", code 2Ah) and checksum
12	<CR><LF>	End of message indicator (codes 0Dh and 0Ah)

9 PACKAGING AND HANDLING

9.1 Packaging

9.1.1 Packaging Notes

HED-10L GNSS module is a Moisture Sensitive Device (MSD) and Electrostatic Sensitive Device (ESD). During the packing and shipping, it is strictly required to take appropriate MSD handling instructions and precautions. The table below shows the general packing hierarchy for the standard shipment.

Table 19 Packing hierarchy

Module	Reel	Sealed bag	Packaging box	Shipping carton
				

NOTE: This packaging information is not applicable to orders with non-standard quantities. The packaging information for orders with non-standard quantities is not described here, please refer to the packaging structure diagram and rely on actual shipping and receiving.

9.1.2 Module packaging

This module adopts the scroll (composed of a scroll belt and a scroll disc) method, and is packaged with anti-static sealed bags to meet customers' needs for efficient production, batch installation, and disassembly.

9.2 Storage

In order to prevent moisture intake and protect against electrostatic discharge, HED-10L is packaged together with a humidity indicator card and desiccant to absorb humidity.

9.3 Handing

9.3.1 ESD Handling Precaution

GNSS positioning module contains highly sensitive electronic circuits and belongs to electrostatic sensitive devices (ESD). Please pay attention to the following operating procedures. Failure to follow these preventive measures may cause serious damage to the module!

- Before attaching the antenna patch, please ground it.
- When introducing the RF pin, please do not touch any charged capacitors and other components (such as antenna chip ~10 pF; coaxial cable ~50 - 80 pF/m; soldering iron).
- To prevent electrostatic discharge, do not expose the antenna area to the outside; if it is exposed due to design reasons, please take appropriate ESD protection measures.
- When welding RF connectors and antenna patches, please make sure to use ESD safe soldering iron.

9.3.2 ESD Protection Measures

This series of GNSS positioning modules is sensitive to static electricity. Whenever handling the module, particular care must be exercised to reduce the risk of electrostatic charges. In addition to standard ESD safety practices, the following measures should be taken into account.

- Adds ESD Diodes to the RF input part to prevent electrostatics discharge.
- Do not touch any exposed antenna area.
- Adds ESD Diodes to the UART interface.

9.3.3 Moisture Sensitivity Level

The Moisture Sensitivity Level (MSL) of the GNSS modules is MSL3.