

Product name	Description	Version
RTK-DUAL-A	Dual-frequency, Multi-constellation RTK Box	0.1
RTK-DUAL-B	Dual-frequency, Multi-constellation RTK Box with MEMS sensor	
RTK-DUAL-C	Dual-frequency, Multi-constellation RTK Box for drone applications	



## 1 Introduction

RTK-DUAL series is a dual-frequency multi-constellation RTK Box that designed for applications requiring accurate dual-antenna GNSS-based heading and RTK centimeter level positioning accuracy. The dual-antenna GNSS-based heading is not subject to magnetic interference. Unlike a standard dual-frequency multi-constellation RTK Box that can only estimate heading based on the movement, RTK-DUAL provides an accurate heading even while the vehicle is stationary. It is capable of concurrently tracking all global civil navigation systems, including GPS, GLONASS, GALILEO, BEIDOU and QZSS. It acquires both L1 and L5 signals at a time while providing heading between dual antennas and RTK position. RTK-DUAL adopts 12nm process and integrates efficient power management architecture to become one of the leading groups with the lightest weight and lowest power consumption on the market. Paired with our dual-frequency low power helical antennas, it can extend the usage time of battery powered drones, robotic lawn mowers, automated logistics vehicles, etc.

## 2 Features

- Unique Dual-engine RTK technology
- Dual-antenna design for high precision positioning and heading
- Support GPS, GLONASS, GALILEO, BEIDOU and QZSS
- Capable of SBAS (WAAS, EGNOS, MSAS, GAGAN)
- Support 270-channel GNSS
- Up to 5Hz update rate
- For unmanned systems and dynamic applications
- Built-in 3-axis gyroscope and accelerometer to continuously output heading during poor GNSS signals (only available on RTK-DUAL-B)
- Small form factor 50 x 42 x 21 mm

### 3 Application

- UAV, drone art, delivery drone
- Robotic lawn mowers, autonomous mobile robot (AMR)
- Marine application
- Precision agriculture
- Automatic sun tracking system

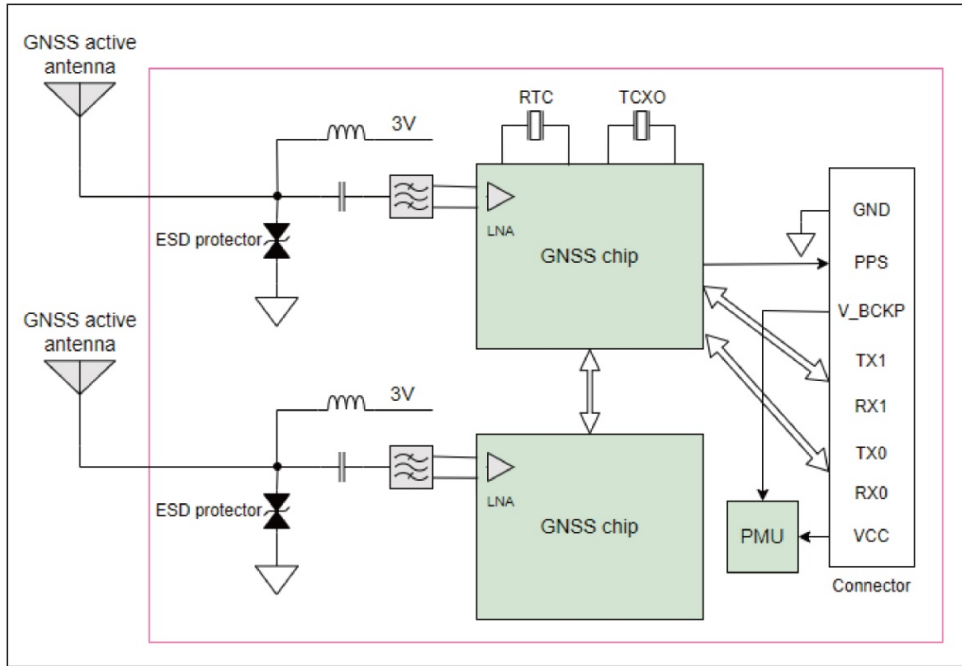


Fig 3-1 System block diagram for RTK-DUAL-A · RTK-DUAL-C

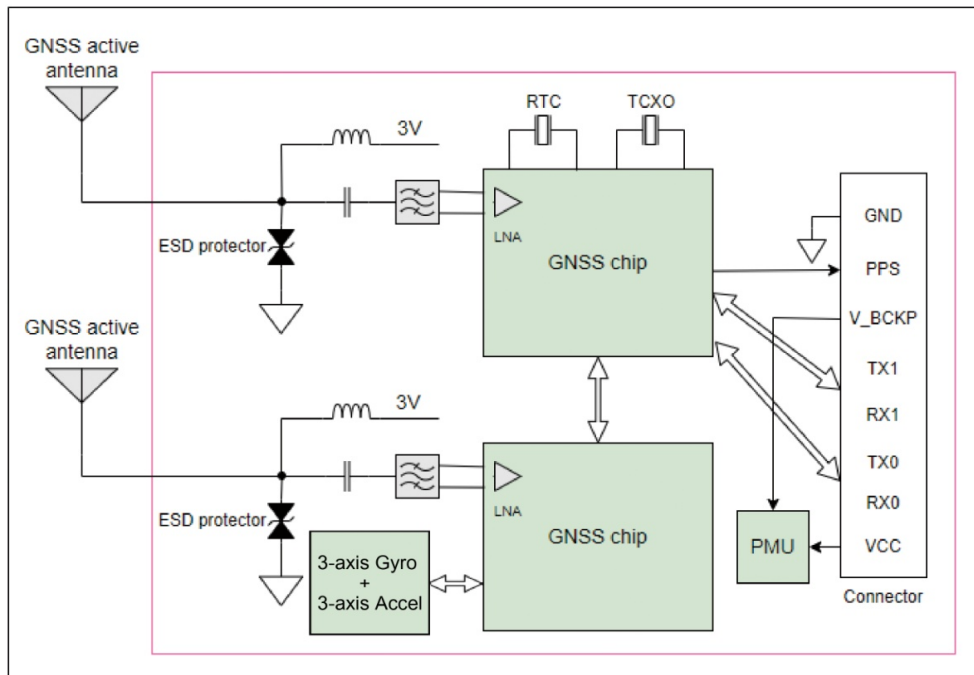


Fig 3-2 System block diagram for RTK-DUAL-B

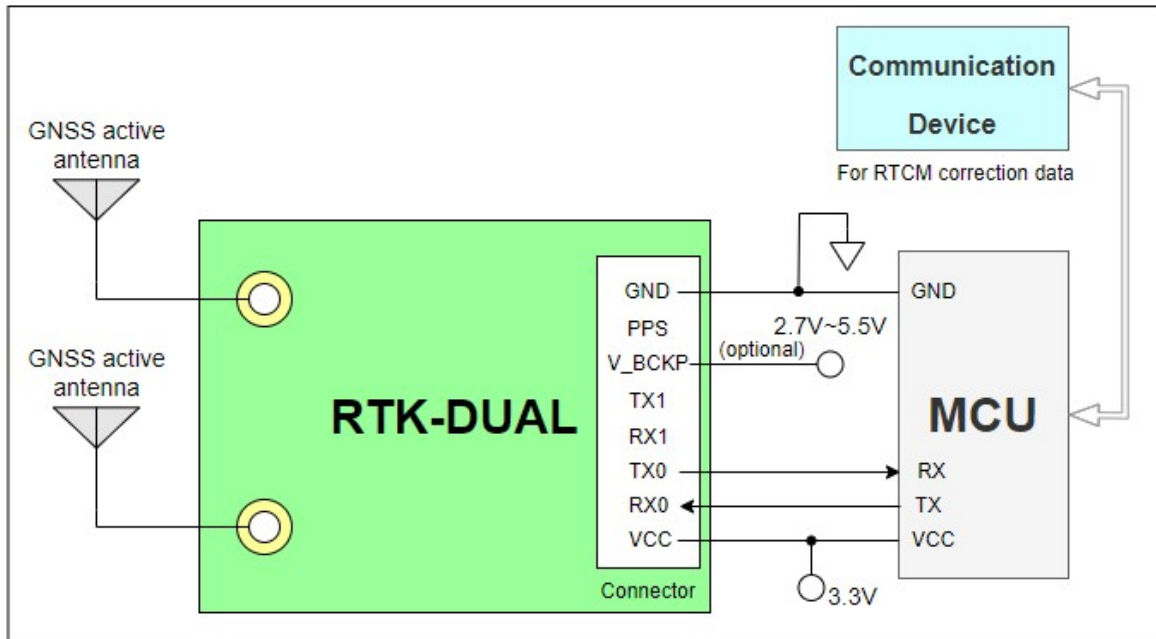


Fig 3-3 Typical application circuit A.

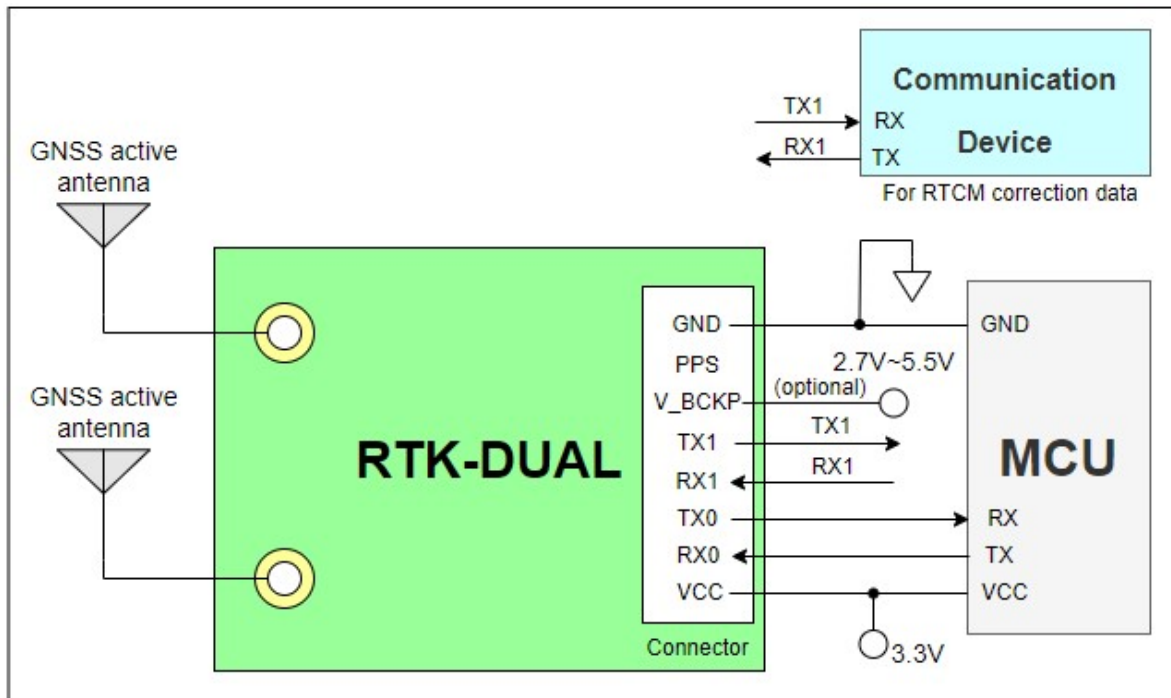


Fig 3-4 Typical application circuit B.

#### 4 GNSS receiver

Frequency	GPS/QZSS: L1 C/A, L5C GLONASS: L1OF GALILEO: E1, E5a BEIDOU: B1I, B2a	
Channels	270 channels	
Update rate	2Hz (default), 5Hz	
Sensitivity	Tracking	-165dBm (with external LNA)
	Cold start	-148dBm (with external LNA)
Acquisition Time	Cold start (open sky)	28s (typical)
	RTK Convergence	< 10s (typical; after 3D fix)
Position Accuracy <sup>(1)</sup>	Autonomous	1.5m CEP
	RTK	1cm + 1ppm (horizontal) CEP 1.5cm + 1ppm (vertical) CEP
Heading Accuracy <sup>(2)</sup>	2° RMS @ 0.1m antenna separation 0.32° RMS @ 0.5m antenna separation 0.16° RMS @ 1m antenna separation 0.08° RMS @ 2m antenna separation	
Aided heading	Degraded by ≤ 2° (RMS) up to 30 seconds during poor GNSS signals (only available on RTK-DUAL-B)	
Max. Altitude	< 18,000 m	
Max. Velocity	< 500 m/s	
Protocol Support	115200 bps <sup>(3)</sup> , 8 data bits, no parity, 1 stop bits (default)	
	NMEA 0183 ver. 4.1	1Hz: GSA、GSV 2Hz: HDT, PLSHD, GGA, RMC
	RTCM V3.3	Message type 1005, 1074, 1084, 1094, 1114, 1124

<Note>

- 24hr, static, open sky, demonstrated with good active dual-frequency antennas.
- 2hr, static, open sky, demonstrated with good active dual-frequency antennas.
- Both baud rate and output message rate are configurable to be factory default. For drone applications (RTK-DUAL-C), the default baud rate is 230400 bps and the output messages are binary as below. UBX-NAV-PVT (5Hz), UBX-NAV-DOP (5Hz), UBX-NAV-TIMEGPS (1Hz), UBX-NAV-RELPOSNEED (5Hz)

## 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
HDT	Heading, True

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

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

\$GNGGA,061730.000,2503.7135400,N,12138.7466600,E,1,46,0.49,131.36,M,15.32,M,,\*71

Table 5.1-2 GGA Data Format

Name	Example	Units	Description
Message ID	\$GNGGA		GGA protocol header
UTC Time	061730.000		hhmmss.sss
Latitude	2503.7135400		ddmm.mmmmmmm
N/S indicator	N		N=north or S=south
Longitude	12138.7466600		dddmm.mmmmmmm
E/W Indicator	E		E=east or W=west
Position Fix Indicator	1		See Table 5.1-3
Satellites Used	46		Number of satellites in use
HDOP	0.49		Horizontal Dilution of Precision (meters)
MSL Altitude	131.36	meters	Antenna Altitude above/below mean-sea-level (geoid) (in meters)
Units	M	meters	Units of antenna altitude, meters
Geoidal Separation	15.32	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	*71		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,2503.7135400,N,12138.7466600,E,061730.000,A,A\*48

Table 5.1-4 GLL Data Format

Name	Example	Units	Description
Message ID	\$GNGLL		GLL protocol header
Latitude	2503.7135400		ddmm.mmmmmmm
N/S indicator	N		N=north or S=south
Longitude	12138.7466600		dddmm.mmmmmmm
E/W indicator	E		E=east or W=west
UTC Time	061730.000		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	*48		
<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	1		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 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=7, E5a=1 BEIDOU: B1=1, B2a=4 IRNSS: L6=1
Checksum	*54		
<CR> <LF>			End of message termination



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

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

\$GNRMC,061730.000,A,2503.7135400,N,12138.7466600,E,0.01,0.00,230522,,A,V\*00

Table 5.1-10 RMC Data Format

Name	Example	Units	Description
Message ID	\$GNRMC		RMC protocol header
UTC Time	061730.000		hhmmss.sss
Status	A		A = Autonomous V = invalid D = Differential
Latitude	2503.7135400		ddmm.mmmmmmm
N/S Indicator	N		N=north or S=south
Longitude	12138.7466600		dddmm.mmmmmmm
E/W Indicator	E		E=east or W=west
Speed over ground	0.01	knots	True
Course over ground	0.00	degrees	
Date	230522		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	*00		
<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
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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/h	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

● **HDT---Heading, True**

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

\$GPHDT,40.056,T\*02

Table 5.1-12 HDT Data Format

Name	Example	Units	Description
Message ID	\$GPHDT		HDT protocol header
Heading	40.056	degrees	Dual-antenna GNSS-based heading
Reference	T		True
Checksum	*02		
<CR> <LF>			End of message termination

## 5.2 Proprietary output message

Table 5.2-1 Proprietary output message

NMEA like record	Description
\$PLSHD	Dual-antenna GNSS-based heading

### ● PLSHD --- Dual-antenna GNSS-based heading

Table 5.2-2 contains the values for the following example:

\$PLSHD,1,27,35,1.547,40.056,-16.737\*76

Table 5.2-2 PLSHD Data Format

Name	Example	Units	Description
Message ID	\$PLSHD		PLSHD protocol header
Valid flag	1		0: invalid data 1: valid data from dual-antenna GNSS 9: valid data from MEMS
Satellite number of ANT1	27		
Satellite number of ANT2	35		
Length	1.547	meter	Length between two antennas.
Heading	40.056	degree	Heading from ANT1 to ANT2. Range 0 to 360.
Elevation	-16.737		Elevation from ANT1 to ANT2. Range -90 to 90.
Checksum	*76		
<CR> <LF>			End of message termination

## 5.3 Proprietary input command

Table 5.3-1 Proprietary input message

NMEA like record	Description
\$PAIR004	Perform GNSS hot start
\$PAIR005	Perform GNSS warm start
\$PAIR006	Perform GNSS cold start
\$PAIR007	Perform GNSS full cold start
\$PLSC,VER	Query firmware version
\$PLSC,FIXRATE	Set/query update rate
\$PLSC,UART2,{PLSC,ANTDIST}	Set/query the distance between two antennas
\$PLSC,UART2,{PLSC,ANTDISTDEV}	Set/query the deviation of the distance between two antennas

- **\$PAIR004 --- Perform GNSS hot start**

Table 5.3-2 contains the values for the following example:

\$PAIR004\*3E

Table 5.3-2 PAIR004 Data Format

Name	Example	Units	Description
Message ID	\$PAIR004		\$PAIR004 protocol header
Checksum	*3E		
<CR> <LF>			End of message termination

Response:

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

- **\$PAIR005 --- Perform GNSS warm start**

Table 5.3-3 contains the values for the following example:

\$PAIR005\*3F

Table 5.3-3 PAIR005 Data Format

Name	Example	Units	Description
Message ID	\$PAIR005		\$PAIR005 protocol header
Checksum	*3F		
<CR> <LF>			End of message termination

Response:

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

- **\$PAIR006 --- Perform GNSS cold start**

Table 5.3-4 contains the values for the following example:

\$PAIR006\*3C

Table 5.3-4 PAIR006 Data Format

Name	Example	Units	Description
Message ID	\$PAIR006		\$PAIR006 protocol header
Checksum	*3C		
<CR> <LF>			End of message termination

Response:

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

- **\$PAIR007 --- Perform GNSS full cold start**

Table 5.3-5 contains the values for the following example:

\$PAIR007\*3D

Table 5.3-5 PAIR007 Data Format

Name	Example	Units	Description
Message ID	\$PAIR007		\$PAIR007 protocol header
Checksum	*3D		
<CR> <LF>			End of message termination

Response:

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

- **\$PLSC,VER --- Query firmware version**

Table 5.3-6 contains the values for the following example:

\$PLSC,VER\*61

Table 5.3-6 PLSC,VER Data Format

Name	Example	Units	Description
Message ID	\$PLSC,VER		\$PLSC,VER protocol header
Checksum	*61		
<CR> <LF>			End of message termination

Response:

\$PLSR,VER,RTK35X,V1.0L0516AY,Lib20220411,857,1\*2A\r\n

- **\$PLSC,FIXRATE --- Set/query update rate**

Table 5.3-7 contains the values for the following example:

\$PLSC,FIXRATE,?\*66

Table 5.3-7 PLSC,FIXRATE Data Format

Name	Example	Units	Description
Message ID	\$PLSC,FIXRATE		\$PLSC,FIXRATE protocol header
Rate	?		Valid input: 1, 2, 5, 10 or ?. ? means to query the update rate.
Checksum	*66		
<CR> <LF>			End of message termination

Response:

\$PLSR,FIXRATE,5,2,10\*4E \r\n ==> Current update rate is 5, default is 2, acceptable maximum is 10.

- **\$PLSC,UART2,{PLSC,ANTDIST --- Set/query the distance between two antennas**

Table 5.3-8 contains the values for the following example:

\$PLSC,UART2,{PLSC,ANTDIST,1550}\*76

Table 5.3-8 PLSC,ANTDIST Data Format

Name	Example	Units	Description
Message ID	\$PLSC,UART2,{PLSC,ANTDIST		\$PLSC,ANTDIST protocol header

Distance	1550	mm	Set the distance between two antennas. Maximum 65536. Default 0 (disable the function). ? means to query the distance.
Checksum	*76		
<CR> <LF>			End of message termination

Response:

```
$PLSR,UART2,<$PLSC,ANTDIST,1550>*47\r\n
$PLSR,ANTDIST,1550*4D\r\n
```

- **\$PLSC,UART2,{PLSC,ANTDISTDEV --- Set/query the deviation of the distance between two antennas**

Table 5.3-9 contains the values for the following example:

```
$PLSC,UART2,{PLSC,ANTDISTDEV,30}*23
```

Table 5.3-9 PLSC,ANTDISTDEV Data Format

Name	Example	Units	Description
Message ID	\$PLSC,UART2,{PLSC,ANTDISTDEV		\$PLSC,ANTDISTDEV protocol header
Deviation	30	mm	Set the deviation of the distance between two antennas in order to filter out the wrong dual-antenna GNSS heading in harsh environment. Maximum 255. Default 0 (disable the function). ? means to query the deviation.
Checksum	*09		
<CR> <LF>			End of message termination

Response:

```
$PLSR,UART2,<$PLSC,ANTDISTDEV,30>*12
$PLSR,ANTDISTDEV,30*18\r\n
```

6 Pin assignment and descriptions

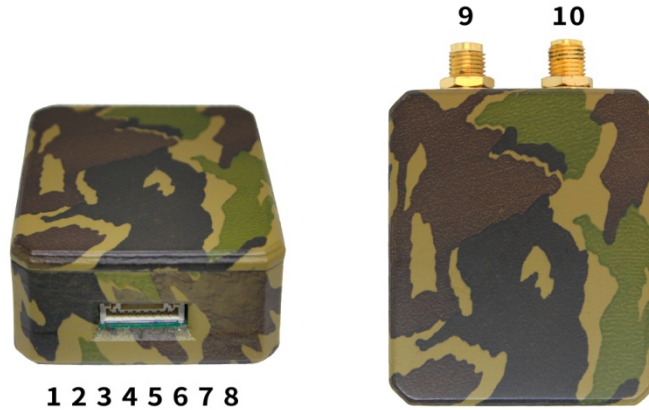
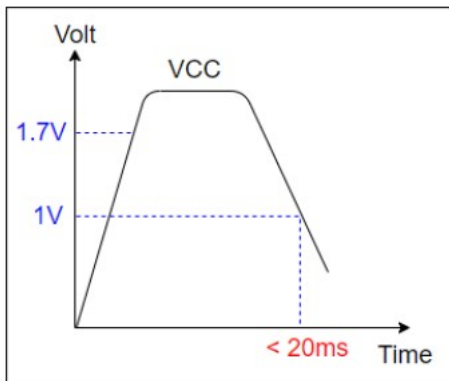


Table 6-1 Pin descriptions

Pin #	Name	Type	Description	Note
1	VCC	I	DC supply input.	1
2	RX0	I	Input of serial interface 0.	2
3	TX0	O	Output of serial interface 0.	2
4	RX1	I	Input of serial interface 1.	3
5	TX1	O	Output of serial interface 1.	3
6	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. If these features are not needed, leave this pin unconnected.	
7	PPS	O	Time pulse (PPS, default 100ms pulse/sec when GNSS fix is available.)	
8	GND	P	Ground.	
9	ANT1	I	Active antenna input 1. The output position of the module is based on this antenna.	4
10	ANT2	I	Active antenna input 2. Dual-antenna GNSS-based heading is the direction from ANT1 to ANT2.	4

<Note>

1. The input voltage from 0 to its working voltage must be a stable rising slope. Avoid powering the module at the same time during mechanical contact of the connector. The mechanical contact bounce may result in the following voltage waveform. This may make the module not work. When this happens, VCC and V\_BCKP must be re-powered to enable the module.



2. Main interface for NMEA and RTCM3 messages.
3. RTCM3 messages from the base station can be input from serial interface 0 or serial interface 1 without any setting.
4. The total gain of the active antenna, including antenna gain, insertion loss of SAW, LNA gain, cable loss ... etc., must be between 15dB and 27dB.



## 7 DC & Temperature characteristics

### 7.1 Absolute maximum ratings

Parameter	Symbol	Ratings	Units
DC Supply Input Voltage	VCCabs	5.5	V
Input Backup Battery Voltage	V_BCKPabs	5.5	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		3.1	3.3	5.5	V
Backup Battery Input Voltage	V_BCKP		2.7	3.3	5.5	V
Output Voltage of ANT1 and ANT2	V_ANT		2.9	3	3.3	V
DC Supply Current <sup>1,2</sup>	I <sub>ss</sub>	VCC = 3.3V VCC = 5.0V		54 36		mA
Backup Battery Supply Current	I <sub>bat</sub>	VCC=0V	-40°C	53		μA
			25°C	67		
			85°C	330		
V_ANT Output Current <sup>3</sup>	I <sub>out</sub>	VCC = 3.3V			90	mA
High Level Input Voltage	V <sub>IH</sub>		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

<Note>

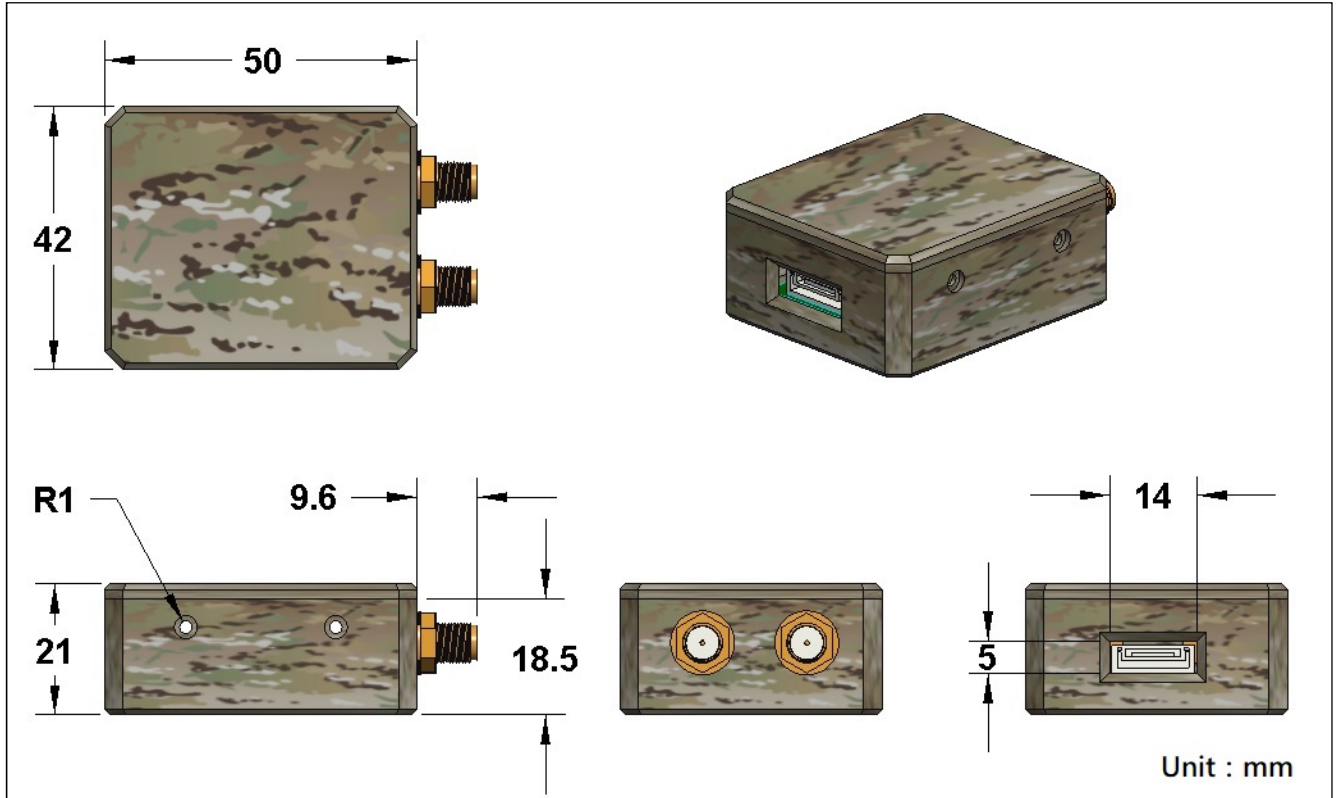
1. Measured when dual-antenna GNSS-based heading and RTK position are available without the power consumption of two external antennas.
2. The inrush current that occurs at the first power-on or “full cold start” command can be as high as 350mA for 20μs.
3. A built-in LDO supplies power to both ANT1 and ANT2. The short circuit protection current is about 25mA.

### 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



9 Product ordering information

9.1 Ordering information

Product name	Description	Remark
RTK-DUAL-A	Multi-system, Multi-frequency RTK Box	115200 bps
RTK-DUAL-B	Multi-system, Multi-frequency RTK Box with MEMS sensor	2Hz NMEA output
RTK-DUAL-C	Multi-system, Multi-frequency RTK Box for drone applications	230400 bps 5Hz binary output

## Document change list

### Revision 0.1

- Draft release on November 21, 2022.