

Orion B16-C



Multi-Band Multi-GNSS Carrier Phase Raw Measurement Receiver for Low Earth Orbit Application

Features

- Supports GPS, BDS, Galileo, GLONASS, QZSS
- Multi-Frequency
- 12.2mm x 16.0mm size
- NMEA-0183 and SkyTraq binary protocol
- Easy to integrate
- Operating temperature -40 ~ +85°C
- RoHS compliant

Applications

- GNSS Receiver Development
- Integration with Inertial Navigation System

The Orion B16-C is state-of-the-art global navigation satellite system receiver capable of carrier phase raw measurement output of GPS L1/L2C, BDS B1I/B2I, Galileo E1/E5b, GLONASS L1/L2 signals.

The Orion B16-C receiver is based on SkyTraq's high-performance Phoenix GNSS chipset, featuring fast signal acquisition search engine and high-sensitivity track engine. Search engine performs 16 million time-frequency hypothesis testing per second, offering industry-leading signal acquisition performance.

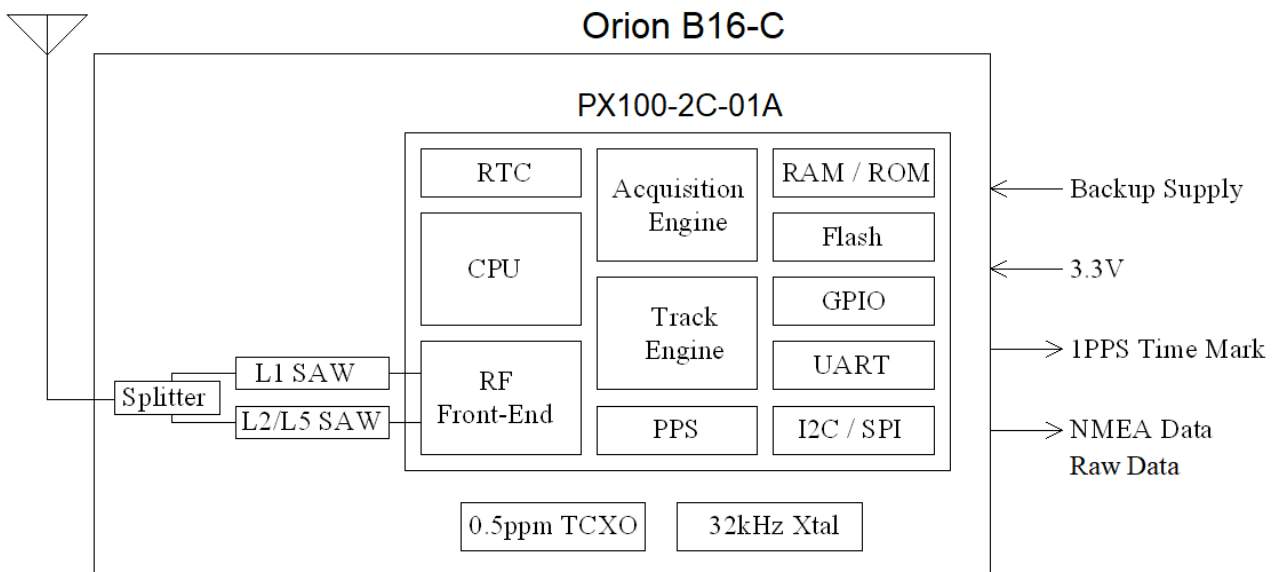
The Orion B16-C module contains SAW filters for increased jamming immunity. It works with active antenna.

TECHNICAL SPECIFICATIONS

Receiver Type	230 channel Phoenix GNSS engine GPS/QZSS L1/L2C, BeiDou B1I/B2I, Galileo E1/E5b, GLONASS L1OF/L2OF		
Accuracy	Position	1.5m CEP	autonomous mode
	Velocity	0.05m/sec* ¹	
	Time	12ns	
Time to First Fix	1 second hot-start under open sky (average) 28 second warm-start under open sky (average) 36 second cold-start under open sky (average)		
Reacquisition	1s		
Update Rate	Raw 1 / 2 / 4 / 5 / 8 / 10 / 20 Hz		
Operational Limits	Velocity up to 10Km/sec		
Serial Interface	3.3V LVTTTL level		
Protocol	NMEA-0183 V4.1 GGA, GLL, GSA, GSV, RMC, VTG 115200 baud, 8, N, 1 SkyTraq raw data binary 115200 baud, 8, N, 1		
Datum	Default WGS-84 and user definable		
Input Voltage	3.3V DC +/-10%		
Current Consumption	100mA @ 3.3V for Orion B16-C, 65mA @ 3.3V for Orion B16-C1		
Dimension	16.0mm L x 12.2mm W x 2.9mm H		
Weight:	1.7g		
Operating Temperature	-40°C ~ +85°C		
Storage Temperature	-55 °C ~ +100°C		
Humidity	5% ~ 95% non-condensing		

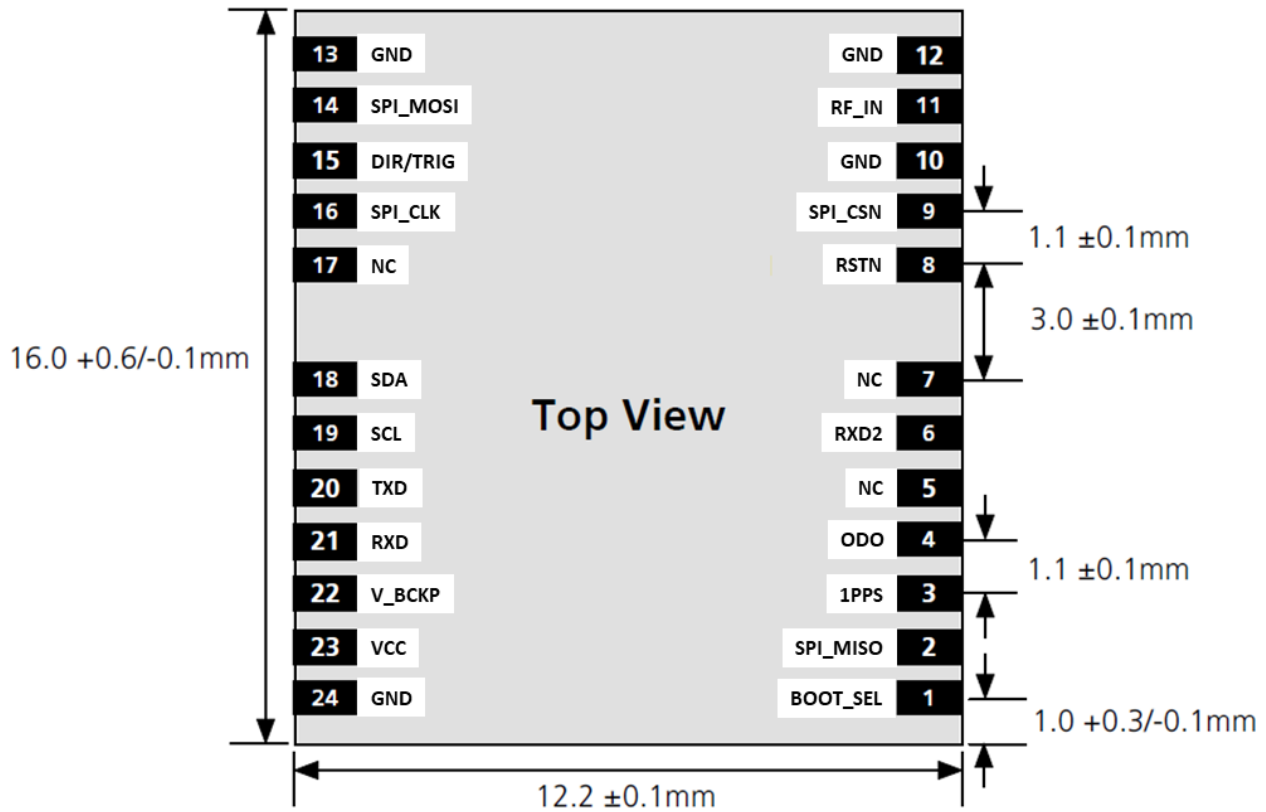
*¹ 50% @ 30 m/s for dynamic operation

FUNCTIONAL DESCRIPTION



Active antenna is required to use with Orion B16-C. The received signal goes through a signal splitter, to individual L1 and L2/L5 SAW filters to remove out-band interference, then to the PX100 GNSS receiver chip for signal processing.

MECHANICAL CHARACTERISTICS



PINOUT DESCRIPTION

Pin No.	Name	Description
1	BOOT_SEL	No connection for normal use. Pull-low for loading firmware into empty or corrupted Flash memory from ROM mode for the master processor.
2	SPI_MISO	Not used, leave unconnected
3	1PPS	One-pulse-per-second (1PPS) time mark output, 3.3V LV-TTL. The rising edge synchronized to UTC second when getting 3D position fix. The pulse duration is about 100msec at rate of 1 Hz.
4	ODO	Not used, leave unconnected
5	NC	No connection, empty pin
6	RXD2	Not used, leave unconnected
7	NC	No connection, empty pin
8	RSTN	External active-low reset input to the baseband. Only needed when power supply rise time is very slow or software controlled reset is desired.
9	SPI_CSN	Not used, leave unconnected
10	GND	Ground
11	RF_IN	RF input with 3.3V active antenna bias voltage
12	GND	Ground
13	GND	Ground

14	SPI_MOSI	Not used, leave unconnected
15	DIR/TRIG	Not used, leave unconnected
16	SPI_CLK	Not used, leave unconnected
17	NC	No connection, empty pin
18	SDA	Not used, leave unconnected
19	SCL	Not used, leave unconnected
20	TXD	UART serial data output, 3.3V LVTTTL. One full-duplex asynchronous serial UART port is implemented. This UART output is normally used for sending position, time and velocity information from the receiver in NMEA-0183 format. When idle, this pin output HIGH.
21	RXD	UART serial data input, 3.3V LVTTTL. One full-duplex asynchronous serial UART port is implemented. This UART input is normally for sending commands or information to the receiver in SkyTraq binary protocol. In the idle condition, this pin should be driven HIGH. If the driving circuitry is powered independently of Orion B16-C, ensure that this pin is not driven to HIGH when Orion B16-C is put to sleep, or a 10K-ohm series resistor can be added to minimize leakage current.
22	V_BCKP	Backup supply voltage for internal RTC and backup SRAM, 1.3V ~ 3.6V. VBAT must be applied whenever VCC is applied. This pin should be powered continuously to minimize the startup time. If VCC and V_BCKP are both removed, the receiver will be in factory default mode upon power up, all user configuration set is lost. For applications the does not care cold starting every time, this pin can be connect to VCC.
23	VCC	Power supply, 3.3V DC
24	GND	Digital ground

ELECTRICAL SPECIFICATIONS

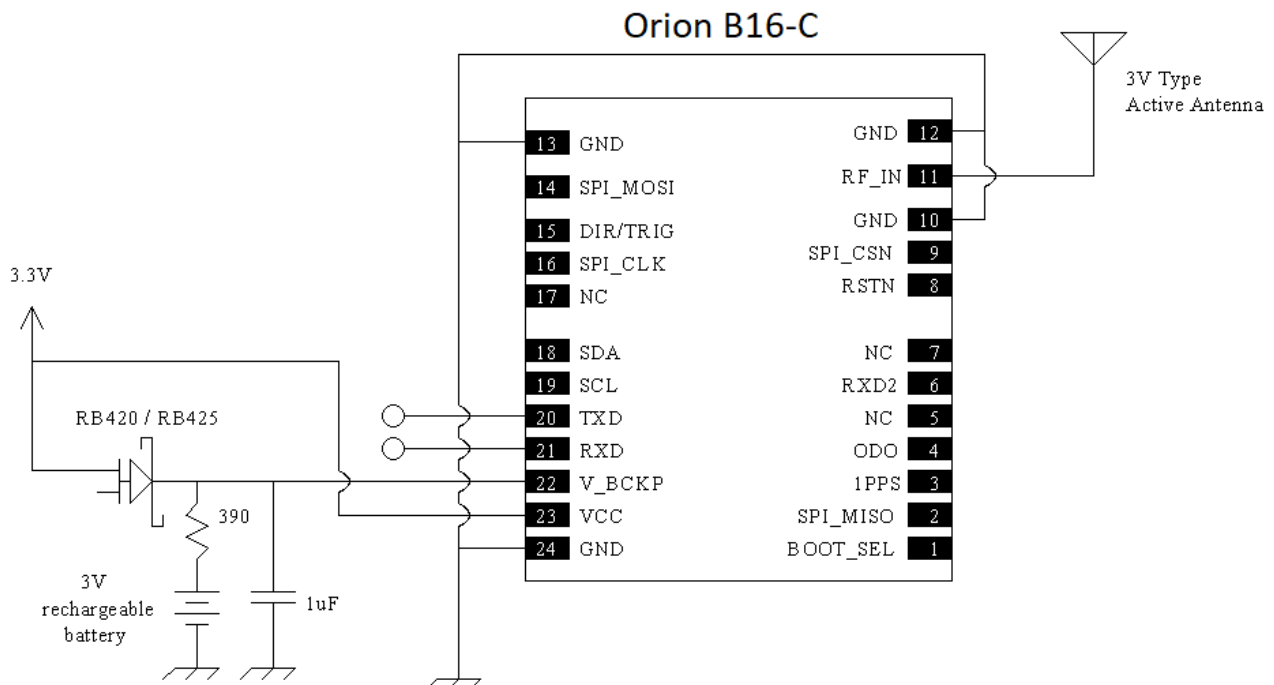
ABSOLUTE MAXIMUM RATINGS

Parameter	Minimum	Maximum	Condition
Supply Voltage (VCC)	-0.5	3.6	Volt
Backup Battery Voltage (V_BCKP)	-0.5	3.6	Volt
Input Pin Voltage	-0.5	VCC+0.5	Volt
Input Power at RF_IN		+5	dBm
Storage Temperature	-55	+100	degC

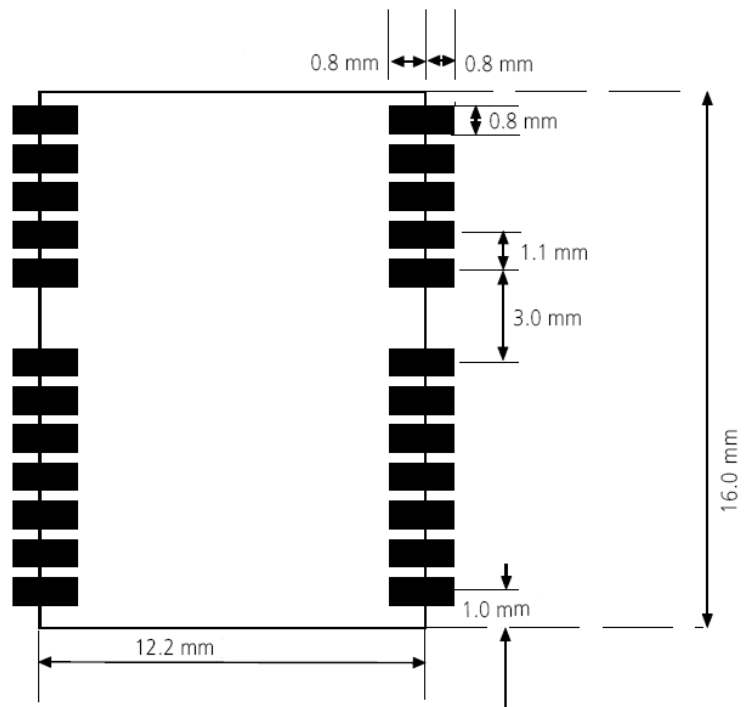
OPERATING CONDITIONS

Parameter	Min	Typ	Max	Unit
Supply Voltage (VCC)	3	3.3	3.6	Volt
Acquisition Current (exclude active antenna current) for Orion B16-C / C1		100 / 65		mA
Tracking Current (exclude active antenna current) for Orion B16-C / C1		85 / 65		mA
Backup Voltage (V_BCKP)	1.3		3.6	Volt
Backup Current (VCC voltage applied)		54		uA
Backup Current (VCC voltage off)		13		uA
Output Low Voltage			0.4	Volt
Output HIGH Voltage	2.4			Volt
Input LOW Voltage			0.8	Volt
Input HIGH Voltage	2			Volt
Input LOW Current	-10		10	uA
Input HIGH Current	-10		10	uA
RF Input Impedance (RF_IN)		50		Ohm

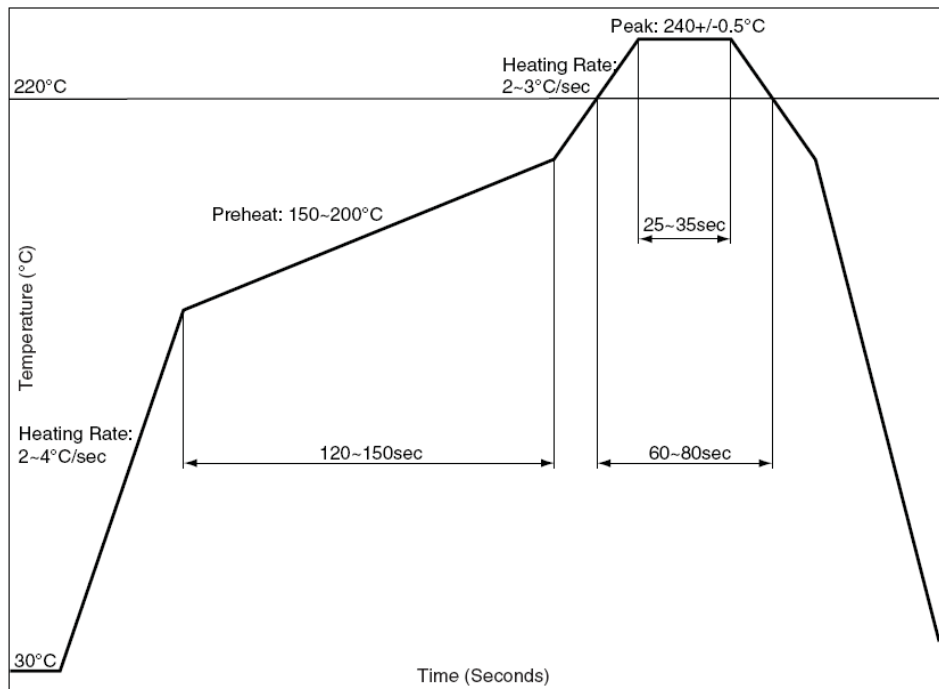
APPLICATION CIRCUIT



PRECOMMENDED LAYOUT PAD



RECOMMENDED REFLOW PROFILE



The reflow profile shown above should not be exceeded, since excessive temperatures or transport times during reflow can damage the module. Cooling temperature fall rate: max 3°C / sec

ANTENNA CONSIDERATIONS

The Orion B16-C is designed to be used with GPS/GLONASS L1/L2, Beidou B1/B2, Galileo E1/E5 multi-frequency active antenna. Antenna with gain up to 40dB and noise figure less than 2dB can be used. It is important to select a high-performance antenna to achieve optimal carrier phase application performance.

POWER SUPPLY REQUIREMENT

Orion B16-C requires a stable power supply, avoid ripple on VCC pin (<50mVpp). Power supply noise can affect the receiver's sensitivity. Bypass capacitors should be placed close to the module VCC pin, with values adjusted depending on the amount and type of noise present on the supply line.

BACKUP SUPPLY

The purpose of backup supply voltage pin (V_BCKP) is to keep the SRAM memory and the RTC powered when the module is powered down. This enables the module to have a faster time-to-first-fix when the module is powered on again. The backup current drain is less than 55 μ A. In normal powered on state, the internal processor access the SRAM and current drain is higher in active mode

1PPS OUTPUT

A 1 pulse per second signal (100msec HIGH duration) is generated on 1PPS pin when the receiver has 3D position fix using 4 or more satellites. The rising edge of the pulse is aligned with UTC second, with accuracy of about 10nsec. It outputs constant LOW when no position fix is available.

LAYOUT GUIDELINES

Separate RF and digital circuits into different PCB regions.

It is necessary to maintain 50-ohm impedance throughout the entire RF signal path. Try keeping the RF signal path as short as possible.

Do not route the RF signal line near noisy sources such as digital signals, oscillators, switching power supplies, or other RF transmitting circuit. Do not route the RF signal under or over any other components (including Orion B16-C), or other signal traces. Do not route the RF signal path on an inner layer of a multi-layer PCB to minimize signal loss.

Avoid sharp bends for RF signal path. Make two 45-deg bends or a circular bend instead of a single 90-degree bend if needed.

Avoid vias with RF signal path whenever possible. Every via adds inductive impedance. Vias are acceptable for connecting the RF grounds between different layers. Each of the module's ground pins should have short trace tying immediately to the ground plane below through a via.

The bypass capacitors should be low ESR ceramic types and located directly adjacent to the pin they are for.

HANDLING GUIDELINE

The Orion B16-C modules are rated MSL4, must be used for SMT reflow mounting within 72 hours after taken out from the vacuumed ESD-protective moisture barrier bag in factory condition < 30degC / 60% RH. If this floor life time is exceeded, or if the received ESD-protective moisture barrier bag is not in vacuumed state, then the device need to be pre-baked before SMT reflow process. Baking is to be done at 85degC for 8 to 12 hours. Once baked, floor life counting begins from 0, and has 72 hours of floor life at factory condition < 30degC / 60% RH.

Orion B16-C module is ESD sensitive device and should be handled with care.

NMEA Output Description

The output protocol supports NMEA-0183 standard. The implemented messages include GGA, GLL, GSA, GSV, VTG, RMC, and ZDA messages. The NMEA message output has the following sentence structure:

\$aacc,c-c*hh<CR><LF>

The detail of the sentence structure is explained in Table 1.

Table 1: The NMEA sentence structure

character	HEX	Description
"\$"	24	Start of sentence.
Aacc		Address field. "aa" is the talker identifier. "ccc" identifies the sentence type.
","	2C	Field delimiter.
C-c		Data sentence block.
"*"	2A	Checksum delimiter.
Hh		Checksum field.
<CR><LF>	0D0A	Ending of sentence. (carriage return, line feed)

Table 2: Overview of SkyTraq receiver's NMEA messages

\$GPGGA	Time, position, and fix related data of the GPS receiver.
\$GNGLL	Position, time and fix status.
\$GNGSA	Used to represent the ID's of satellites which are used for position fix. When GPS satellites are used for position fix, \$GNGSA sentence is output with system ID 1. When GLONASS satellites are used for position fix, \$GNGSA sentence is output with system ID 2. When Galileo satellites are used for position fix, \$GNGSA sentence is output with system ID 3. When BDS satellites are used for position fix, \$GNGSA sentence is output with system ID 4.
\$GPGSV \$GLGSV \$GAGSV \$GBGSV	Satellite information about elevation, azimuth and CNR, \$GPGSV is used for GPS satellites, while \$GLGSV is used for GLONASS satellites, while \$GAGSV is used for GALILEO satellites, while \$GBGSV is used for BEIDOU satellites.
\$GNRMC	Time, date, position, course and speed data.
\$GNVTG	Course and speed relative to the ground.
\$GNZDA	UTC, day, month and year and time zone.

The formats of the supported NMEA messages are described as follows:

GGA – Global Positioning System Fix Data

Time, position and fix related data for a GPS receiver.

Structure:

\$GPGGA,hhmmss.sss,ddmm.mmmmm,a,dddmm.mmmmm,a,x,xx,x.x,x.x,M,x.x,M,x.x,xxxx*hh<CR><LF>
 1 2 3 4 5 6 7 8 9 10 11 12 13

Example:

\$GNGGA,052315.000,2447.09094,N,12100.52369,E,2,12,0.6,97.9,M,19.6,M,,0000*75<CR><LF>

Field	Name	Example	Description
1	UTC Time	025315.000	UTC of position in hhmmss.sss format, (000000.000 ~ 235959.999)
2	Latitude	2447.09094	Latitude in ddmm.mmmm mformat Leading zeros transmitted
3	N/S Indicator	N	Latitude hemisphere indicator, 'N' = North, 'S' = South
4	Longitude	12100.52369	Longitude in dddmm.mmmmm format Leading zeros transmitted
5	E/W Indicator	E	Longitude hemisphere indicator, 'E' = East, 'W' = West
6	Quality Indicator	2	GPS quality indicator 0: position fix unavailable 1: valid position fix, SPS mode 2: valid position fix, differential GPS mode 3: GPS PPS Mode, fix valid 4: Real Time Kinematic. System used in RTK mode with fixed integers 5: Float RTK. Satellite system used in RTK mode., floating integers 6: Estimated (dead reckoning) Mode 7: Manual Input Mode 8: Simulator Mode
7	Satellites Used	12	Number of satellites in use, (00 ~ 12)
8	HDOP	0.6	Horizontal dilution of precision, (0.0 ~ 99.9)
9	Altitude	97.9	mean sea level (geoid), (-9999.9 ~ 17999.9)
10	Geoidal Separation	19.6	Geoidal separation in meters
11	Age pf Differential GPS data		Age of Differential GPS data NULL when DGPS not used
12	DGPS Station ID	0000	Differential reference station ID, 0000 ~ 1023
13	Checksum	75	

GLL – Latitude/Longitude

Latitude and longitude of current position, time, and status.

Structure:

\$GNGLL,ddmm.mmmmm,a,dddmm.mmmmm,a,hhmmss.sss,A,a*hh<CR><LF>
1 2 3 4 5 6 7 8

Example:

\$GNGLL,2447.09094,N,12100.52369,E,052315.000,A,D*4A<CR><LF>

Field	Name	Example	Description
1	Latitude	2447.09094	Latitude in ddmm.mmmmm format Leading zeros transmitted
2	N/S Indicator	N	Latitude hemisphere indicator 'N' = North 'S' = South
3	Longitude	12100.52369	Longitude in dddmm.mmmmm format Leading zeros transmitted
4	E/W Indicator	E	Longitude hemisphere indicator 'E' = East 'W' = West
5	UTC Time	052315.000	UTC time in hhmmss.sss format (000000.000 ~ 235959.999)
6	Status	A	Status, 'A' = Data valid, 'V' = Data not valid
7	Mode Indicator	D	Mode indicator 'A' = Autonomous mode 'D' = Differential mode 'E' = Estimated (dead reckoning) mode 'M' = Manual input mode 'S' = Simulator mode 'N' = Data not valid
8	Checksum	4A	

GSA – GNSS DOP and Active Satellites

GNSS receiver operating mode, satellites used in the navigation solution reported by the GGA or GNS sentence and DOP values.

Structure:

```
$GNGSA,A,x,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,x.x,x.x,x.x,x*hh<CR><LF>
  1 2 3 3 3 3 3 3 3 3 3 3 3 4 5 6 7 8
```

Example:

```
$GNGSA,A,3,10,12,14,20,21,24,25,31,32,193,,,1.1,0.6,0.9,1*01<CR><LF>
$GNGSA,A,3,69,70,73,79,80,,,,,,,,,1.1,0.6,0.9,2*3C<CR><LF>
$GNGSA,A,3,01,02,03,06,09,10,14,16,21,22,26,,1.1,0.6,0.9,4<CR><LF>
```

Field	Name	Example	Description
1	Mode	A	Mode 'M' = Manual, forced to operate in 2D or 3D mode 'A' = Automatic, allowed to automatically switch 2D/3D
2	Mode	3	Fix type 1 = Fix not available 2 = 2D 3 = 3D
3	Satellite used 1~12	10, 12, 14, 20, 21, 24, 25, 31, 32, 193	01 ~ 32 are for GPS; 33 ~ 64 are for WAAS (PRN minus 87); 193 ~ 197 are for QZSS; 65 ~ 88 are for GLONASS (GL PRN) ; 01 ~ 36 are for GALILEO (GA PRN); 01 ~ 37 are for BDS (BD PRN). GPS, GLONASS, GALILEO and BDS satellites are differentiated by the GNSS system ID in table 3. Maximally 12 satellites are included in each GSA sentence.
4	PDOP	1.1	Position dilution of precision (0.0 to 99.9)
5	HDOP	0.6	Horizontal dilution of precision (0.0 to 99.9)
6	VDOP	0.9	Vertical dilution of precision (0.0 to 99.9)
7	GNSS System ID	1	GNSS system ID* 1 = GPS 2 = GLONASS 3 = GALILEO 4 = BDS 5 = IRNSS
8	Checksum	01	

*GNSS System ID identifies the GNSS system ID according to Table 3.

Table 3: GNSS Identification Table for GSA, GSV

System	System ID (Talker)	Signal ID	Signal Name
GPS	1 (GP)	0	All signals
		1	L1 C/A
		2	L1 P(Y)
		3	L1C
		4	L2 P(Y)
		5	L2C-M
		6	L2C-L
		7	L5-I
		8	L5-Q
GLONASS	2 (GL)	0	All signals
		1	G1 C/A
		2	G1P
		3	G2 C/A
		4	GLONASS (M) G2P
GALILEO	3 (GA)	0	All signals
		1	E5a
		2	E5b
		3	E5 a+b
		4	E6-A
		5	E6-BC
		6	L1-A
		7	L1-BC
BDS	4 (BD)	0	All signals
		1	B1
		5	B2A
		B	B2
		8	B3
		3	B1C
IRNSS	6 (GI)	0	All signals
		1	L5

GSV – GNSS Satellites in View

Number of satellites (SV) in view, satellite ID numbers, elevation, azimuth, and SNR value. Four satellites maximum per transmission.

Structure:

```
$GPGSV,x,x,xx,xx,xx,xxx,xx,...,xx,xx,xxx,xx,x *hh<CR><LF>
  1 2 3 4 5 6 7 4 5 6 7 8 9
```

Example:

```
$GPGSV,4,1,15,10,79,250,50,194,73,072,,193,69,127,45,25,64,114,46,1*67<CR><LF>
$GPGSV,4,2,15,20,54,175,45,32,44,334,46,41,39,242,43,12,36,055,46,1*68<CR><LF>
$GPGSV,4,3,15,31,32,256,45,14,25,310,39,24,15,049,38,21,07,191,35,1*61<CR><LF>
$GPGSV,4,4,15,15,04,106,18,29,03,144,,26,01,206,,1*56<CR><LF>
$GLGSV,2,1,06,80,77,332,44,69,55,098,49,70,46,347,43,73,29,221,45,1*79<CR><LF>
$GLGSV,2,2,06,79,25,026,42,71,01,325,,1*76<CR><LF>
$GBGSV,3,1,12,21,77,107,50,26,73,278,49,06,59,009,45,03,58,203,43,1*7D<CR><LF>
$GBGSV,3,2,12,16,58,002,47,07,55,180,,01,53,142,43,09,47,329,43,1*73<CR><LF>
$GBGSV,3,3,12,02,40,241,39,10,31,200,40,22,25,134,41,14,19,321,41,1*77<CR><LF>
```

Field	Name	Example	Description
1	Number of message	4	Total number of GSV messages to be transmitted (1-5)
2	Sequence number	1	Sequence number of current GSV message
3	Satellites in view	15	Total number of satellites in view (00 ~ 20)
4	Satellite ID	10	01 ~ 32 are for GPS; 33 ~ 64 are for WAAS (PRN minus 87); 193 ~ 197 are for QZSS; 65 ~ 88 are for GLONASS (GL PRN) ; 01 ~ 36 are for GALILEO (GA PRN); 01 ~ 37 are for BDS (BD PRN). GPS, GLONASS, GALILEO and BDS satellites are differentiated by the GNSS system ID in table 3. Maximally 4 satellites are included in each GSV sentence.
5	Elevation	79	Satellite elevation in degrees, (00 ~ 90)
6	Azimuth	250	Satellite azimuth angle in degrees, (000 ~ 359)
7	SNR	50	C/No in dB (00 ~ 99) Null when not tracking
8	GNSS System ID	1	Signal ID*
9	Checksum	67	

*GNSS Signal ID identifies the GNSS signal name according to Table 3.

RMC – Recommended Minimum Specific GNSS Data

Time, date, position, course and speed data provided by a GNSS navigation receiver.

Structure:

\$GNRMC,hhmmss.sss,A,dddmm.mmmmm,a,dddmm.mmmmm,a,x.x,x.x,ddmmyy,,,a,a*hh<CR><LF>
 1 2 3 4 5 6 7 8 9 101112

Example:

\$GNRMC,052315.000,A,2447.09094,N,12100.52369,E,000.0,169.9,261219,,,D,V*0F<CR><LF>

Field	Name	Example	Description
1	UTC time	052315.000	UTC time in hhmmss.sss format (000000.00 ~ 235959.999)
2	Status	A	Status 'V' = Navigation receiver warning 'A' = Data Valid
3	Latitude	2447.09094	Latitude in dddmm.mmmmm format Leading zeros transmitted
4	N/S indicator	N	Latitude hemisphere indicator 'N' = North 'S' = South
5	Longitude	12100.52369	Longitude in dddmm.mmmmm format Leading zeros transmitted
6	E/W Indicator	E	Longitude hemisphere indicator 'E' = East 'W' = West
7	Speed over ground	000.0	Speed over ground in knots (000.0 ~ 999.9)
8	Course over ground	169.9	Course over ground in degrees (000.0 ~ 359.9)
9	UTC Date	261219	UTC date of position fix, ddmmyy format
10	Mode indicator	D	Mode indicator 'A' = Autonomous mode 'D' = Differential mode 'E' = Estimated (dead reckoning) mode 'F' = Float RTK. Satellite system used in RTK mode, floating integers 'M' = Manual Input Mode 'N' = Data not valid 'P' = Precise 'R' = Real Time Kinematic. System used in RTK mode with fixed integers 'S' = Simulator Mode
11	Navigation status		Navigation status indicator according to IEC61108 requirement on 'Navigational (or Failure) warnings and status indicators'. 'S' = Safe 'C' = Caution 'U' = Unsafe 'V' = Navigation status not valid, equipment is not providing navigation status indicator.
12	checksum	0F	

VTG – Course Over Ground and Ground Speed

The actual course and speed relative to the ground.

Structure:

GNVTG,x.x,T,,M,x.x,N,x.x,K,a*hh<CR><LF>
 1 2 3 4 5

Example:

\$GNVTG,169.9,T,,M,000.0,N,000.0,K,D*11<CR><LF>

Field	Name	Example	Description
1	Course	169.9	True course over ground in degrees (000.0 ~ 359.9)
2	Speed	000.0	Speed over ground in knots (000.0 ~ 999.9)
3	Speed	000.0	Speed over ground in kilometers per hour (000.0 ~ 1800.0)
4	Mode	D	Mode indicator 'A' = Autonomous mode 'D' = Differential mode 'E' = Estimated (dead reckoning) mode 'M' = Manual input mode 'N' = Data not valid 'P' = Precise 'S' = Simulator mode
5	Checksum	11	

ZDA – TIME AND DATE

UTC, day, month, year and local time zone

Structure:

\$GNZDA,hhmmss.sss,xx,xx,xxxx,xx,xx*hh<CR><LF>
 1 2 3 4 5 6 7

Example:

\$GNZDA,052315.000,26,12,2019,00,00*45<CR><LF>

Field	Name	Example	Units	Description
1	UTC time	052315.000		UTC time in hhmmss.sss format (000000.00 ~ 235959.999)
2	UTC Day	26		UTC time: day (01 ~ 31)
3	UTC Month	12		UTC time: month (01 ~ 12)
4	UTC Year	209		UTC time: year (4 digit format)
5	Local zone hour	00		Local zone hours (00 ~ +/- 13)
6	Local zone minutes	00		Local zone minutes (00 ~59)
7	Checksum	45		Checksum

Raw Measurement Binary Interface Description

Please see application note AN0039

ORDERING INFORMATION

Model Name	Description
Orion B16-C	Multi-Band Multi-GNSS Carrier Phase Raw Measurement Receiver Module GPS/QZSS L1/L2C, GLONASS L1/L2, Galileo E1/E5b, Beidou B1I/B2I
Orion B16-C1	Single-Frequency Multi-GNSS Carrier Phase Raw Measurement Receiver Module GPS/QZSS L1, GLONASS L1, Galileo E1, Beidou B1I
Orion B16-C5	Multi-Band Multi-GNSS Carrier Phase Raw Measurement Receiver Module GPS/QZSS L1/L5, Galileo E1/E5a, Beidou B1I/B2a

Revision History

Revision	Date	Description
1.0	November 6, 2020	Initial release
1.1	November 19, 2020	Updated Ordering Information Updated Functional Description & Application Circuit figures
1.2	May 12, 2021	Updated Current Consumption
1.3	March 8, 2023	Updated Ordering Information

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