

# GPS Module

# Datasheet

Name: Ultra High Sensitivity and Low Power GPS Receiver Module

Model No.: SKG12BL

Revision: V3.04

## Revision History:

| Revision | Description                      | Approved | Date     |
|----------|----------------------------------|----------|----------|
| V1.01    | Initial release to V1.01         | Woody    | 20120708 |
| V2.01    | Update office's address          | George   | 20131119 |
| V3.03    | Update firmware                  | Woody    | 20150313 |
| V3.04    | Update certification information | George   | 20170831 |
|          |                                  |          |          |

## General Description

The SKG12BL is a complete GPS engine module that features super sensitivity, ultra low power and small form factor. The GPS signal is applied to the antenna input of module, and a complete serial data message with position, velocity and time information is presented at the serial interface with NMEA protocol or custom protocol.

It is based on the high performance features of the MediaTek MT3337 single-chip architecture, Its -165dBm tracking sensitivity extends positioning coverage into place like urban canyons and dense foliage environment where the GPS was not possible before. The small form factor and low power consumption make the module easy to integrate into portable device like PNDs, mobile phones, cameras and vehicle navigation systems.

## Applications

- LBS (Location Based Service)
- PND (Portable Navigation Device)
- Vehicle navigation system
- Mobile phone



Figure 1: SKG12BL Top View

## Features

- Ultra high sensitivity: -165dBm
- Extremely fast TTFF at low signal level
- Built-in 12 multi-tone active interference canceller
- Ultra low power consumption
- ±10ns high accuracy time pulse (1PPS)
- NMEA Output: GGA,GSA,GSV,RMC,VTG,GLL
- Support QZSS
- Advanced Features: Aiding EPO;EASY
- Small form factor: 16.0 x 12.2 x 2.4mm
- FCC compliance
- CE certificated
- RoHS certificated (Lead-free)

## Pin Assignment

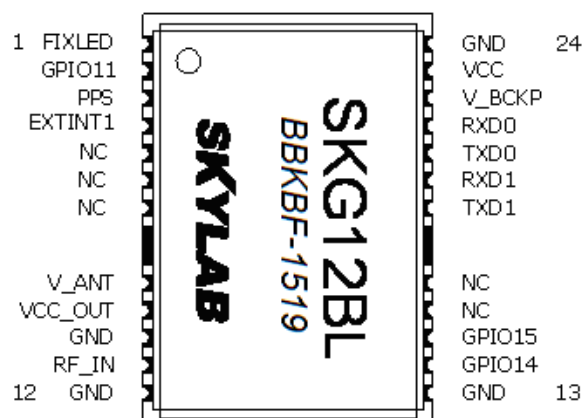


Figure 2: SKG12BL Pin Package

## Pin Description

| Pin No. | Pin name | I/O | Description                            | Remark                          |
|---------|----------|-----|--|---------------------------------|
| 1       | FIXLED   | O   | Reserved                               | Leave open if not used          |
| 2       | GPIO11   | I/O | General Purpose I/O                    | Leave open if not used          |
| 3       | PPS      | O   | Time Pulse Signal                      | Leave open if not used          |
| 4       | EXTINT1  | I   | External Interrupt                     | Leave open if not used          |
| 5       | NC       |     |  |                                 |
| 6       | NC       |     |  |                                 |
| 7       | NC       |     |  |                                 |
| 8       | V_ANT    | I   | Active Antenna External Voltage Supply | Leave open if not used          |
| 9       | VCC_OUT  | O   | VCC power output                       | Leave open if not used          |
| 10      | GND      | G   | Ground                                 |                                 |
| 11      | RF_IN    | I   | GPS Signal Input                       | 50Ω@1.57542GHz, DC block inside |
| 12      | GND      | G   | Ground                                 |                                 |
| 13      | GND      | G   | Ground                                 |                                 |
| 14      | GPIO14   | I   | UART0 Baud rate configuration pin      | Leave open if not used          |
| 15      | GPIO15   | I   | UART0 Baud rate configuration pin      | Leave open if not used          |
| 16      | NC       |     |  |                                 |
| 17      | NC       |     |  |                                 |
| 18      | TXD1     | O   | UART Serial Data Output 1              | Leave open if not used          |
| 19      | RXD1     | I   | UART Serial Data Input 1               | Leave open if not used          |
| 20      | TXD0     | O   | UART Serial Data Output 0              | Leave open if not used          |
| 21      | RXD0     | I   | UART Serial Data Input 0               | Leave open if not used          |
| 22      | V_BCKP   | I   | RTC and backup SRAM power              | Operating range: 2.0V to 4.2V   |
| 23      | VCC      | P   | Module Power Supply                    | Operating range: 3.0V to 4.2V   |
| 24      | GND      | G   | Ground                                 | Leave open if not used          |

## Interfaces Configuration

### Power Supply

Regulated power for the SKG12BL is required. The input voltage Vcc should be 3.0V to 4.2V range, current is no less than 100mA. Suitable decoupling must be provided by external decoupling circuitry. It can reduce the Noise from power supply and increase power stability.

Main power supply Vcc current varies according to the processor load and satellite acquisition. Maximum Vcc peak current is about 30 mA during acquisition.

**Backup Battery Power**

In case of a power failure on pin Vcc, real-time clock and backup RAM are supplied through pin V\_BCKP. This enables the SKG12BL GPS Receiver to recover from power failure with either a hot start or a warm start (depending on the duration of Vcc outage). If no Backup Battery is connected, the receiver performs a cold start upon powered up.

Backup Battery Power V\_BCKP draws typically 7 uA current in backup state.

**Reset**

The SKG12BL modules include a RESET pin. Driving RESET low activates a hardware reset of the system. RESET is only an input and will not reset external circuitry. At power down the reset is forced when the Vcc drops below 2.7V.

**NOTE**

If not used, leave RESET not connected (floating).

**Antenna**

The SKG12BL GPS receiver is designed for supporting the active antenna or passive antenna connected with pin RF\_IN. The gain of active antenna should be no more than 25dB (18~20dB Typical). The maximum noise figure should be no more than 1.5dB and output impedance is at 50 Ohm.

**NOTE**

With passive antenna keep the cable loss at minimum(<1dB).

**UART Ports**

UART0 is use for NMEA output and command input, UART1 is use for RTCM input. The UART0 Baud rate can be configured as seen in table below . Default settings in bold.

| <b>Baud rate</b> | <b>Pin14</b>  | <b>Pin15</b>  |
|------------------|---------------|---------------|
| <b>9600bps</b>   | <b>NC</b>     | <b>NC</b>     |
| 4800bps          | 10K pull-down | NC            |
| 115200bps        | NC            | 10K pull-down |
| 38400bps         | 10K pull-down | 10K pull-down |

**RF\_IN**

The transmission line must to be control impedance from RF\_IN pin to the antenna or antenna connector of your choice. (Impedance 50Ω)

**PPS**

A pulse per second (1 PPS) is an electrical signal that very precisely indicates the start of a second. Depending on the source, properly operating PPS signals have an accuracy ranging 10ns. The PPS

signals are used for precise timekeeping and time measurement.

## Advanced Software Features

### AIC\_Multi-tone active interference canceller

Because different application (Wi-Fi , GSM/GPRS,3G/4G,Bluetooth )are integrated into navigation system , the harmonic of RF signal will influence the GPS reception , The multi- tone active-interference canceller can reject external RF interference which come from other active components on the main board , to improve the capacity of GPS reception without any needed HW change in the design .SKG12BL can cancel up to 12 independent channel interference continuous wave.

### EASY™

The EASY™ is embedded assist system for quick positioning, the GPS engine will calculate and predict automatically the single emperies ( Max. up to 3 days )when power on ,and save the predict information into the memory , GPS engine will use these information for positioning if no enough information from satellites , so the function will be helpful for positioning and TTFF improvement under indoor or urban condition ,the Backup power (VBACKUP) is necessary .

### Aiding EPO

The Aiding EPO supply the predicated Extended Prediction Orbit data to speed TTFF ,users can download the EPO data to GPS engine from the FTP server by internet or wireless network ,the GPS engine will use the EPO data to assist position calculation when the navigation information of satellites are not enough or weak signal zone .

## Performance Specification

| Parameter            | Specification   |   |
|----------------------|---|---|
| Receiver Type        | L1 frequency band, C/A code, 22 Tracking / 66 Acquisition-Channel |   |
| Sensitivity          | Tracking  | -165dBm Typical                         |
|                      | Acquisition   | -148dBm Typical                         |
| Accuracy             | Position  | 3.0m CEP50 without SA(Typical Open Sky) |
|                      | Velocity  | 0.1m/s without SA                       |
|                      | Timing (PPS)  | 10ns RMS                                |
| Acquisition Time     | Cold Start  | 23s(Typical Open Sky)                   |
|                      | Warm Start  | 23s                                     |
|                      | Hot Start   | 1s                                      |
|                      | Re-Acquisition  | <1s                                     |
| Assisted GPS support | EPO   |   |
| Power Consumption    | Tracking  | 23mA @3.3V Typical                      |
|                      | Acquisition   | 26mA @3.3V                              |

|                             |              |              |
|-----------------------------|--------------|--------------|
| Navigation Data Update Rate | Max 10Hz     | Default 1Hz  |
| Operational Limits          | Altitude     | Max 18,000m  |
|                             | Velocity     | Max 515m/s   |
|                             | Acceleration | Less than 4g |

## Electrical Characteristics

### Absolute Maximum Rating

| Parameter                              | Symbol | Min  | Max  | Units |
|--|--------|------|------|-------|
| <b>Power Supply</b>                    |        |      |      |       |
| Power Supply Volt.                     | VCC    | -0.3 | 4.3  | V     |
| <b>Input Pins</b>                      |        |      |      |       |
| Input voltage on any input connection  | VIO    | -0.3 | 3.6  | V     |
| Backup Battery                         | V_BCKP | -0.3 | 4.3  | V     |
| RF input power                         | RF_IN  |      | -40  | dBm   |
| Human Body Model ESD capability        | RF_IN  |      | 2000 | V     |
| Machine Model ESD capability           | RF_IN  |      | 100  | V     |
| <b>Environment</b>                     |        |      |      |       |
| Storage Temperature                    | Tstg   | -40  | 125  | °C    |
| Peak Reflow Soldering Temperature <10s | Tpeak  |      | 260  | °C    |
| Humidity                               |        |      | 95   | %     |

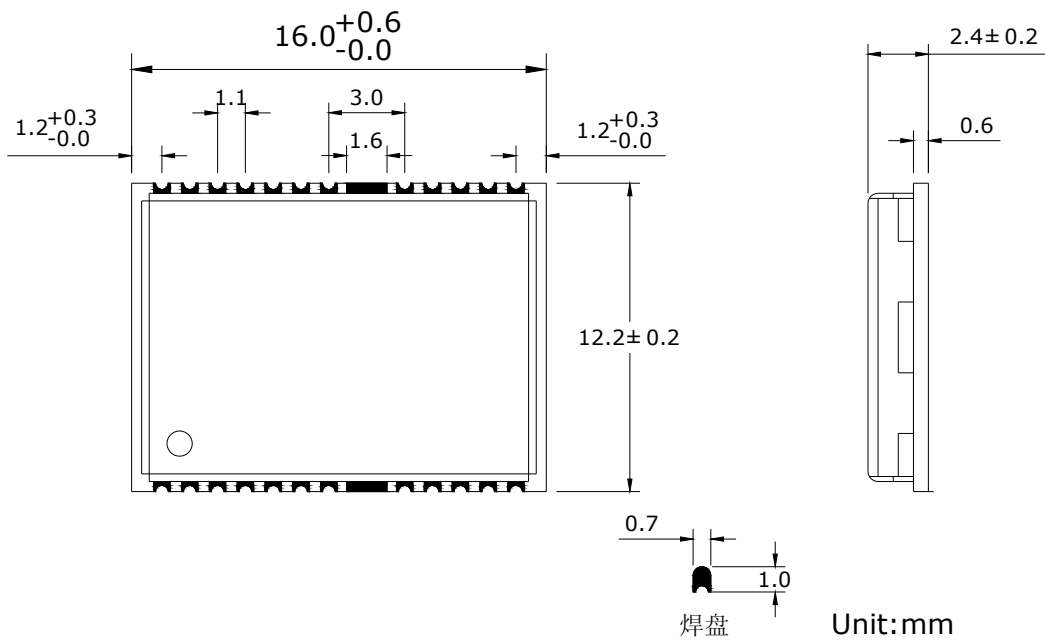
Note: Absolute maximum ratings are stress ratings only, and functional operation at the maxims is not guaranteed. Stress beyond the limits specified in this table may affect device reliability or cause permanent damage to the device. For functional operating conditions, refer to the operating conditions tables as follow.

### Operating Conditions

| Parameter                    | Symbol          | Condition | Min  | Typ | Max | Units |
|------------------------------|-----------------|-----------|------|-----|-----|-------|
| Power supply voltage         | Vcc             |           | 3    | 3.3 | 4.2 | V     |
| Backup Battery               | V_BCKP          |           | 2    | 3.3 | 4.2 | V     |
| Power supply voltage ripple  | Vcc_PP          | Vcc=3.3V  |      |     | 30  | mV    |
| Supply current, Acquisition  | Icc             | Vcc=3.3V  |      | 26  |     | mA    |
| Supply current, Tracking     | Icc             | Vcc=3.3V  |      | 23  |     | mA    |
| Supply current, backup state | Ibckp           | Vcc=3.3V  |      | 7   |     | uA    |
| VCC_OUT Antenna bias supply  | VCC_OUT         |           |      | Vcc |     | V     |
| Input high voltage           | V <sub>IH</sub> |           | 2    |     | 3.6 | V     |
| Input low voltage            | V <sub>IL</sub> |           | -0.3 |     | 0.8 | V     |

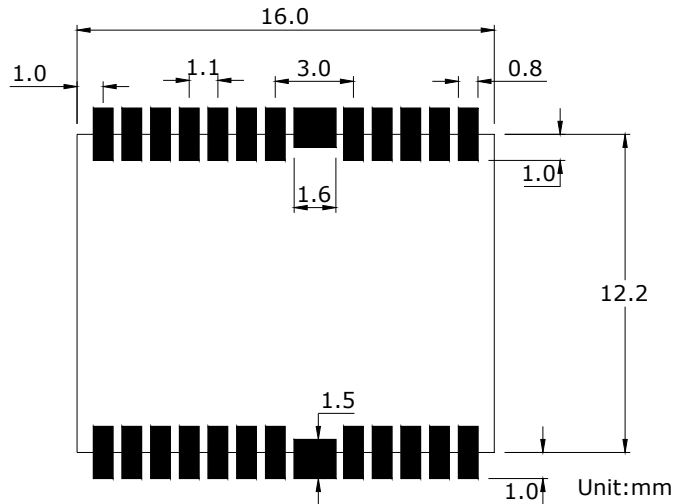
|                       |           |  |      |  |     |    |
|-----------------------|-----------|--|------|--|-----|----|
| Output high voltage   | $V_{OH}$  |  | 2.4  |  | 3.1 | V  |
| Output low voltage    | $V_{OL}$  |  | -0.3 |  | 0.4 | V  |
| Operating temperature | $T_{opr}$ |  | -40  |  | 85  | °C |

**Mechanical Specification**



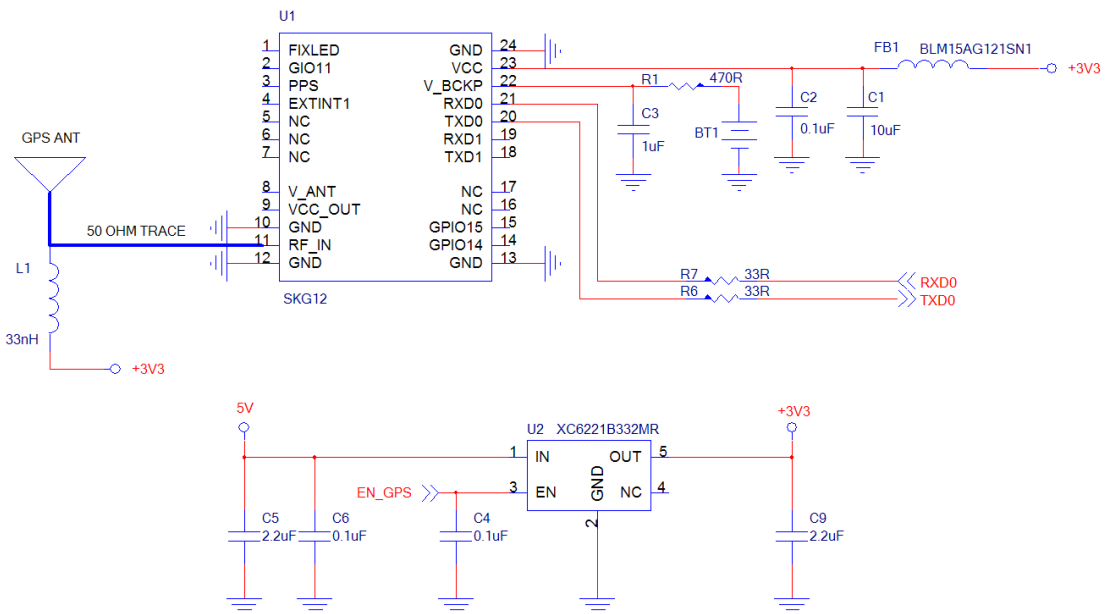
**Figure 3: SKG12BL Dimensions**

**Recommend Layout**



**Figure 4: SKG12BL Footprint**

**Reference design schematic**



**Figure 5: SKG12BL Typical Reference design schematic**

**Packaging Specification**

SKG12BL modules are shipped in reel and with 1200 units per reel. Each tray is 'dry' package.



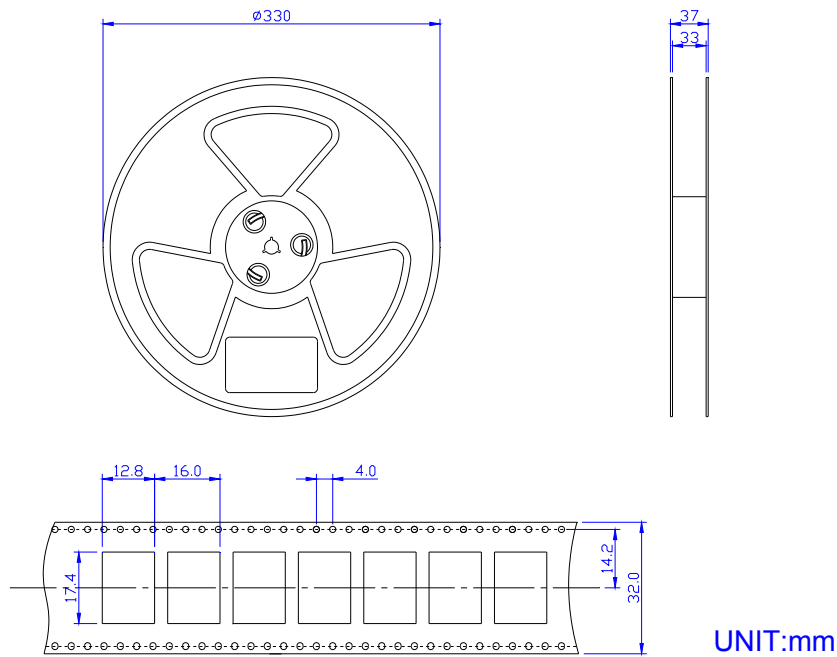


Figure 6: SKG12BL Packaging

### Manufacturing Process Recommendations

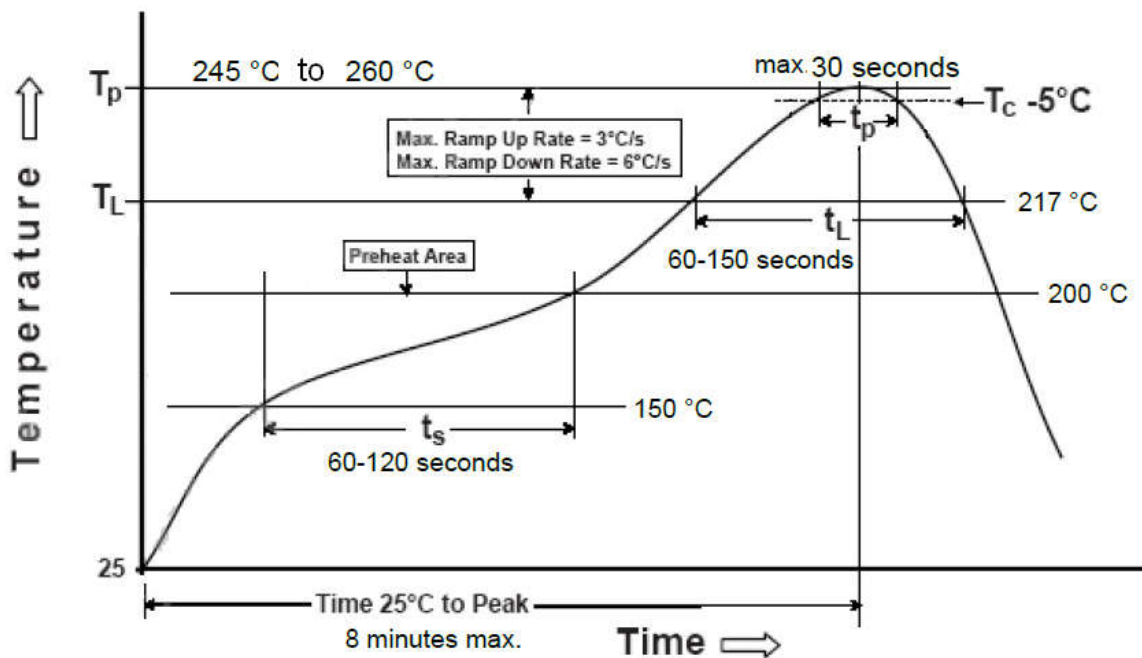


Figure 7: SKG12BL Typical Leadfree Soldering Profile

**Note:** The final soldering temperature chosen at the factory depends on additional external factors like

choice of soldering paste, size, thickness and properties of the baseboard, etc. Exceeding the maximum soldering temperature in the recommended soldering profile may permanently damage the module.

## Software Protocol

### NMEA 0183 Protocol

The NMEA protocol is an ASCII-based protocol, Records start with a \$ and with carriage return/line feed. GPS specific messages all start with \$GPxxx where xxx is a three-letter identifier of the message data that follows. NMEA messages have a checksum, which allows detection of corrupted data transfers.

The Skylab SKG12BL supports the following NMEA-0183 messages: GGA, GLL, GSA, GSV, RMC VTG. The module default NMEA-0183 output is set up GGA, GLL, GSA, GSV, RMC VTG , and default baud rate is set up 9600bps.

Table 1: NMEA-0183 Output Messages

| NMEA Record | Description                            | Default |
|-------------|--|---------|
| GGA         | Global positioning system fixed data   | Y       |
| GLL         | Geographic position—latitude/longitude | Y       |
| GSA         | GNSS DOP and active satellites         | Y       |
| GSV         | GNSS satellites in view                | Y       |
| RMC         | Recommended minimum specific GNSS data | Y       |
| VTG         | Course over ground and ground speed    | Y       |

### GGA-Global Positioning System Fixed Data

This sentence contains the position, time and quality of the navigation fix.

See RMC for Fix Status, Fix Mode, Fix Date, Speed, and True Course.

See GSA for Fix Type, PDOP, and VDOP.

\$GPGGA,021514.000,2232.1799,N,11401.1823,E,1,6,1.25,84.0,M,-2.2,M,,\*74

Table 2: GGA Data Format

| Name                   | Example    | Units  | Description                            |
|------------------------|------------|--------|--|
| Message ID             | \$GPGGA    |        | GGA protocol header                    |
| UTC Position           | 021514.000 |        | hhmmss.sss                             |
| Latitude               | 2232.1799  |        | ddmm.mmmm                              |
| N/S indicator          | N          |        | N=north or S=south                     |
| Longitude              | 11401.1823 |        | dddmm.mmmm                             |
| E/W Indicator          | E          |        | E=east or W=west                       |
| Position Fix Indicator | 1          |        | See Table 2-1                          |
| Satellites Used        | 6          |        | Range 0 to 12                          |
| HDOP                   | 1.25       |        | Horizontal Dilution of Precision       |
| MSL Altitude           | 84.0       | meters | Altitude (referenced to the Ellipsoid) |

|                     |           |        |                                 |
|---------------------|-----------|--------|---------------------------------|
| AltUnit             | M         | meters | Altitude Unit                   |
| GeoSep              | -2.2      | meters | Geoidal Separation              |
| GeoSepUnit          | M         | meters | Geoidal Separation Unit         |
| Age of Diff.Corr.   | <Null>    | second | Null fields when it is not Used |
| Diff.Ref.Station ID | <Null>    |        | Null fields when it is not Used |
| Checksum            | *74       |        |                                 |
| EOL                 | <CR> <LF> |        | End of message termination      |

Table 2-1: Position Fix Indicators

| Value | Description                           |
|-------|---------------------------------------|
| 0     | Fix not available or invalid          |
| 1     | GPS SPS Mode, fix valid               |
| 2     | Differential GPS, SPS Mode, fix valid |
| 3     | GPS PPS Mode, fix valid               |

### GLL-Geographic Position – Latitude/Longitude

This sentence contains the fix latitude and longitude.

\$GPGLL,2232.1799,N,11401.1824,E,021513.000,A,A\*50

Table 3: GLL Data Format

| Name          | Example    | Units | Description                            |
|---------------|------------|-------|--|
| Message ID    | \$GPGLL    |       | GLL protocol header                    |
| Latitude      | 2232.1799  |       | ddmm.mmmm                              |
| N/S Indicator | N          |       | N=north or S=south                     |
| Longitude     | 11401.1824 |       | dddmm.mmmm                             |
| E/W Indicator | E          |       | E=east or W=west                       |
| UTC Position  | 021513.000 |       | hhmmss.sss                             |
| Fix Status    | A          |       | A=data valid or V=data not valid       |
| Fix Mode      | A          |       | A=autonomous, N = No fix, D=DGPS, E=DR |
| Checksum      | *50        |       |  |
| EOL           | <CR> <LF>  |       | End of message termination             |

### GSA-GNSS DOP and Active Satellites

This sentence contains the mode of operation, type of fix, PRNs of the satellites used in the solution as well as PDOP, HDOP and VDOP.

\$GPGSA,A,3,26,05,18,15,27,29,,,,,,,,,1.52,1.25,0.87\*0F

Table 4: GSA Data Format

| Name    | Example | Units | Description         |
|---------|---------|-------|---------------------|
| Message | \$GPGSA |       | GSA protocol header |
| Mode 1  | A       |       | See Table 4-2       |
| Mode 2  | 3       |       | See Table 4-1       |

|                      |           |  |  |
|----------------------|-----------|--|--|
| ID of satellite used | 26        |  | Sv on Channel 1                                    |
| ID of satellite used | 05        |  | Sv on Channel 2                                    |
| ...                  | ...       |  | ...  |
| ID of satellite used | <Null>    |  | Sv on Channel 12 (Null fields when it is not Used) |
| PDOP                 | 1.52      |  | Position Dilution of Precision                     |
| HDOP                 | 1.25      |  | Horizontal Dilution of Precision                   |
| VDOP                 | 0.87      |  | Vertical Dilution of Precision                     |
| Checksum             | *0F       |  |  |
| EOL                  | <CR> <LF> |  | End of message termination                         |

Table 4-1: Mode 1

| Value | Description       |
|-------|-------------------|
| 1     | Fix not available |
| 2     | 2D Fix            |
| 3     | 3D Fix            |

Table 4-2: Mode 2

| Value | Description                                     |
|-------|---|
| M     | Manual-forced to operate in 2D or 3D mode       |
| A     | Automatic-allowed to automatically switch 2D/3D |

### GSV-GNSS Satellites in View

This sentence contains the PRNs, azimuth, elevation, and signal strength of all satellites in view.

\$GPGSV,3,1,12,15,79,333,42,42,50,127,,29,45,263,44,02,36,124,30\*7E

\$GPGSV,3,2,12,26,36,226,34,05,35,046,22,27,33,161,29,21,16,319,\*7D

\$GPGSV,3,3,12,10,15,066,31,18,14,285,45,24,12,319,15,08,09,047,18\*7E

Table 5: GSV Data Format

| Name               | Example | Units   | Description                                       |
|--------------------|---------|---------|---|
| Message ID         | \$GPGSV |         | GSV protocol header                               |
| Number of Message  | 3       |         | Total number of GSV sentences (Range 1 to 3)      |
| Message Number     | 1       |         | Sentence number of the total (Range 1 to 3)       |
| Satellites in View | 12      |         | Number of satellites in view                      |
| Satellite ID       | 15      |         | Channel 1(Range 01 to 32)                         |
| Elevation          | 79      | degrees | Channel 1(Range 00 to 90)                         |
| Azinmuth           | 333     | degrees | Channel 1(Range 000 to 359)                       |
| SNR(C/NO)          | 42      | dB-Hz   | Channel 1(Range 00 to 99, null when not tracking) |
| ...                |         |         | ...   |
| Satellite ID       | 02      |         | Channel 4(Range 01 to 32)                         |
| Elevation          | 36      | degrees | Channel 4(Range 00 to 90)                         |

|           |           |         |   |
|-----------|-----------|---------|---|
| Azimuth   | 124       | degrees | Channel 4(Range 000 to 359)                       |
| SNR(C/NO) | 30        | dB-Hz   | Channel 4(Range 00 to 99, null when not tracking) |
| Checksum  | *7E       |         |   |
| EOL       | <CR> <LF> |         | End of message termination                        |

Depending on the number of satellites tracked multiple messages of GSV data may be required.

### RMC-Recommended Minimum Specific GNSS Data

This sentence contains the recommended minimum fix information.

See GGA for Fix Quality, Sats Used, HDOP, Altitude, Geoidal Separation, and DGPS data.

See GSA for Fix Type, PDOP and VDOP.

\$GPRMC,023345.000,A,2232.1767,N,11401.1953,E,0.18,151.55,100410,,,A\*6B

Table 6: RMC Data Format

| Name                         | Example    | Units   | Description  |
|------------------------------|------------|---------|--|
| Message ID                   | \$GPRMC    |         | RMC protocol header                                |
| UTS Position                 | 023345.000 |         | hhmmss.sss   |
| Status                       | A          |         | A=data valid or V=data not valid                   |
| Latitude                     | 2232.1767  |         | ddmm.mmmm  |
| N/S Indicator                | N          |         | N=north or S=south                                 |
| Longitude                    | 11401.1953 |         | dddmm.mmmm   |
| E/W Indicator                | E          |         | E=east or W=west                                   |
| Speed Over Ground            | 0.18       | Knots   |  |
| Course Over Ground           | 151.55     | Degrees | True Course  |
| Date(UTC)                    | 100410     |         | ddmmyy   |
| Magnetic variation           | <Null>     | Degrees | Null fields when it is not Used                    |
| Magnetic Variation Direction | <Null>     |         | E=east or W=west (Null fields when it is not Used) |
| Fix Mode                     | A          |         | A=autonomous, N = No fix, D=DGPS, E=DR             |
| Checksum                     | *6B        |         |  |
| EOL                          | <CR> <LF>  |         | End of message termination                         |

### VTG-Course Over Ground and Ground Speed

This sentence contains the course and speed of the navigation solution.

\$GPVTG,148.81,T,,M,0.13,N,0.24,K,A\*3D

Table 7: VTG Data Format

| Name       | Example | Units   | Description         |
|------------|---------|---------|---------------------|
| Message ID | \$GPVTG |         | VTG protocol header |
| Tcourse    | 148.81  | Degrees | True Course         |
| Reference  | T       |         | T = True            |

|                   |           |         |   |
|-------------------|-----------|---------|---|
| Mcourse           | <Null>    | Degrees | Magnetic Course (Null fields when it is not Used) |
| Reference         | M         |         | M = Magnetic (Null fields when it is not Used)    |
| Speed over ground | 0.13      | Knots   | Nautical Miles per Hour                           |
| Units             | N         |         | Knots   |
| Speed over ground | 0.24      | Km/hr   | in Kilometers per Hour                            |
| Units             | K         |         | Kilometer per hour                                |
| Mode              | A         |         | A=Autonomous, N=No fix, D=DGPS, E=DR              |
| Checksum          | *3D       |         |   |
| EOL               | <CR> <LF> |         | End of message termination                        |

**CMD List**

| <b>CMD TYPE</b>   | <b>CMD Example:</b>            |
|-------------------|--------------------------------|
| Hot Restart       | \$PMTK101*32<CR><LF>           |
| Warm Restart      | \$PMTK102*31<CR><LF>           |
| Cold Restart      | \$PMTK103*30<CR><LF>           |
| Full Cold Restart | \$PMTK104*37<CR><LF>           |
| Set baud rate     | \$PMTK251,baudrate*CRC<CR><LF> |

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