| Product name | Description | Version |
|---|---|---|
| MC-1612a-52Q | Multi-constellation GNSS positioning module | 0.1 |

# 1  Introduction

LOCOSYS MC-1612a-52Q is high-performance GNSS positioning module that is capable of tracking all global civil navigation systems. It supports new GPS L1C and BEIDOU B1C signals. Besides, it integrates efficient power management architecture to perform low power and high sensitivity.

The module supports hybrid ephemeris prediction to achieve faster cold start. One is self-generated ephemeris prediction (called EASY) that is no need of both network assistance and host CPU's intervention. This is valid for up to 3 days and updates automatically from time to time when GNSS module is powered on and satellites are available. The other is server-generated ephemeris prediction (called EPO) that gets from an internet server. This is valid for up to 14 days. Both ephemeris predictions are stored in the on-board flash memory and perform a faster cold start time.

# 2  Features

- Support GPS, GLONASS, GALILEO, BEIDOU and QZSS
- Capable of SBAS (WAAS, EGNOS, MSAS, GAGAN) and QZSS SLAS
- Built in LNA and SAW filter
- Low power consumption
- Fast TTFF at low signal level
- Free hybrid ephemeris prediction to achieve faster cold start
- Up to 20 Hz update rate
- ±10ns high accuracy time pulse (PPS)
- Small form factor 16 x 12.2 x 2.4 mm
- SMD type with stamp holes; RoHS compliant

# 3  Application

- Personal positioning and navigation
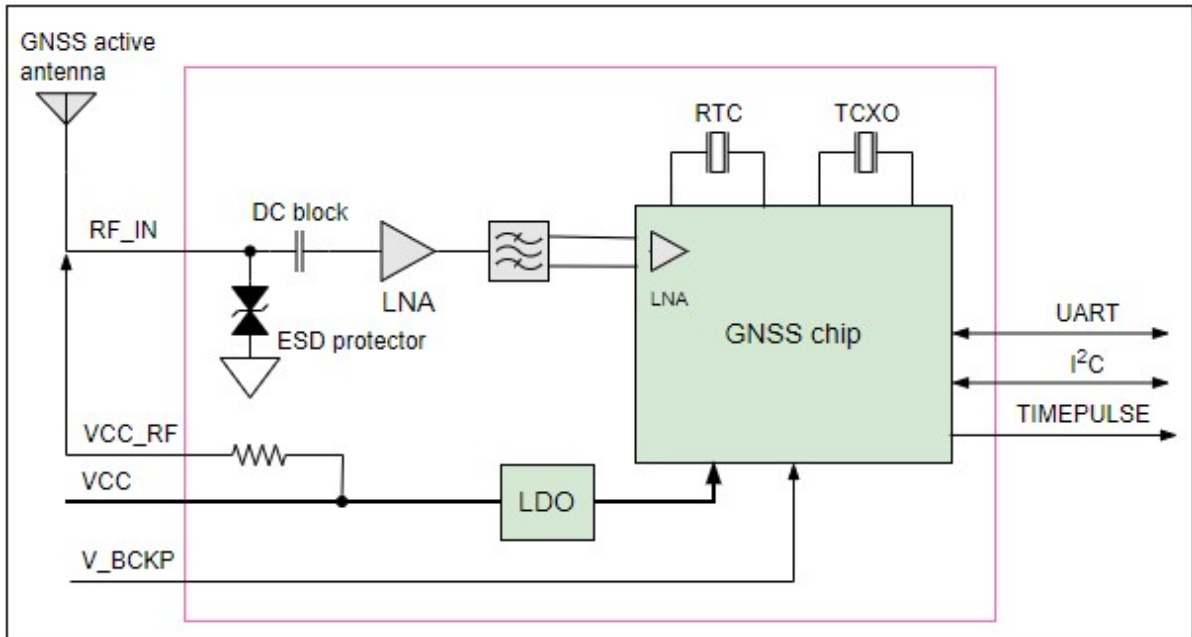- Automotive navigation
- Marine navigation

**LOCOSYS Technology Inc.**
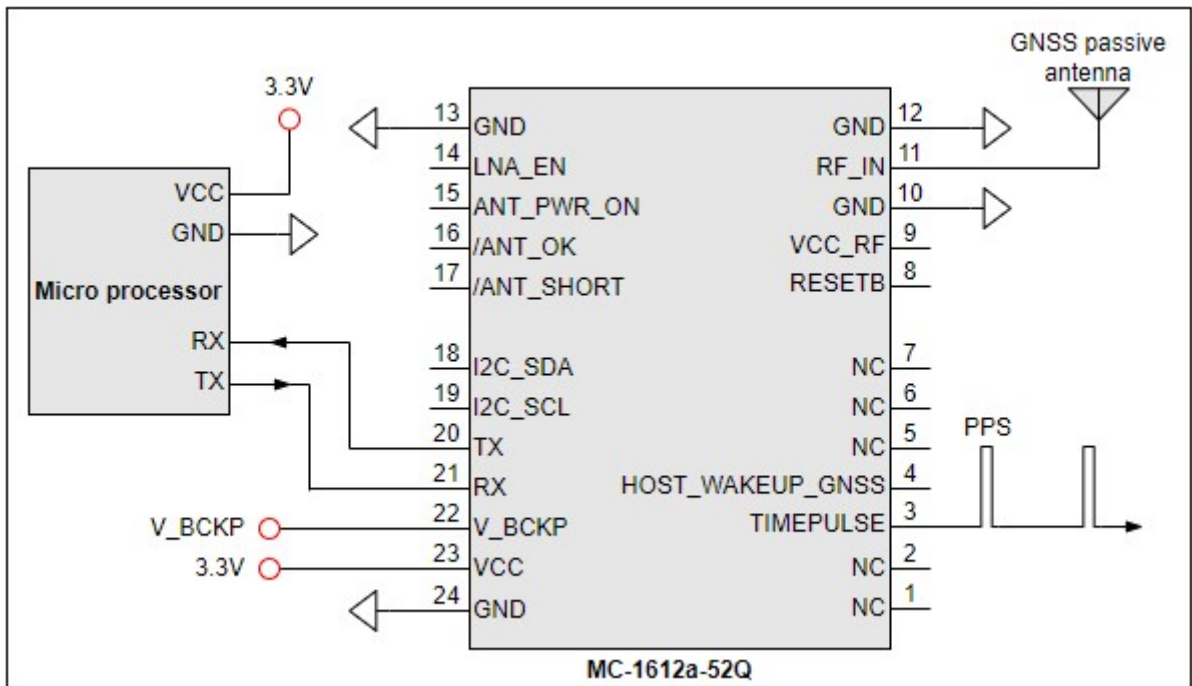20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

Fig. 3-1 System block diagram.



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

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/
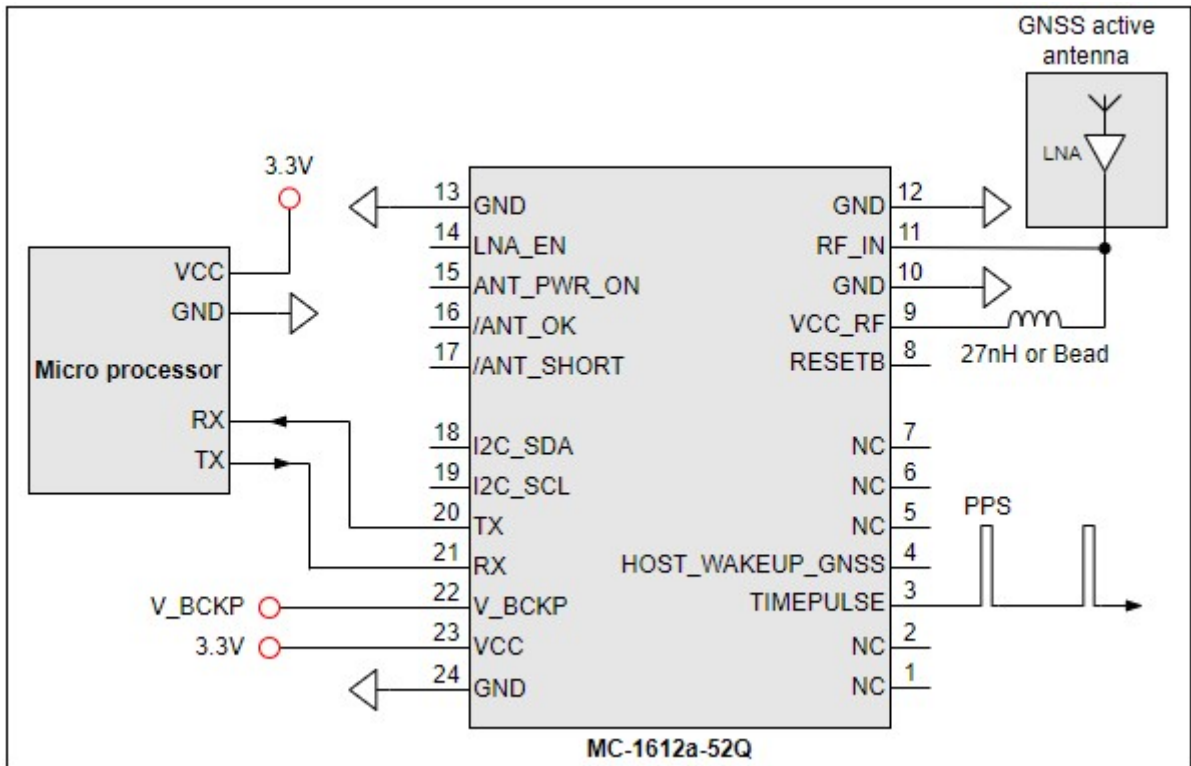
Fig. 3-3 Typical application circuit that uses an active antenna.

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐 www.locosystech.com/

| Reference BOM | | | |
|---|---|---|---|
| Part | Spec/value | Vendor | Remark |
| C1 | 18pF±5%, MLCC | YAGEO | |
| D1 | CS0801S | CitrusCom | ESD protection. Input capacitance ≤ 0.5pF |
| | LESD11LL5.0CT5G | Leshan Radio Company | |
| L1 | BEAD, 300R, size 0603 PBY16080T-301Y-N | YAGEO | Must use size 0603 or larger. |
| L2 | 22nH±5%, CLH series | YAGEO | |
| R1 | 10R±5%, size 0603 | YAGEO | Must use size 0603 or larger. |
| R2 | 1K±5% | YAGEO | |
| R3 | 100K±5% | YAGEO | |
| R4, R6 | 10K±5% | YAGEO | |
| R5, R7 | 12K±5% | YAGEO | |
| U1 | MCP6L01T-E/LT | Microchip | |
| U2 | XC6221A332 | TOREX | |

Fig 3-4 The reference circuit of an external active antenna that can get its status.

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☏ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

Table 3.1 The status of the external active antenna in Fig 3-4.

| /ANT_SHORT | /ANT_OK | Description |
|---|---|---|
| LOW | Don't care. | Antenna is short. ANT_PWR_ON outputs low. The module outputs the following message. $GNTXT,01,01,02,ANT_SHORT,D2,*73 |
| HIGH | LOW | Antenna is properly connected. ANT_PWR_ON outputs high. The module outputs the following message. $GNTXT,01,01,02,ANT_OK,D2,*25 |
| HIGH | HIGH | Antenna is not connected. ANT_PWR_ON outputs high. The module outputs the following message. $GNTXT,01,01,02,ANT_OPEN,D2,*35 |

## 4 GNSS receiver

| Frequency | GPS/QZSS: L1 C/A, L1C | |
|---|---|---|
| | GLONASS: L1OF | |
| | GALILEO: E1 | |
| | BEIDOU: B1I, B1C | |
| Channels | Support 47 channels | |
| Update rate | 1Hz default, up to 20Hz | |
| Sensitivity | Tracking | -165dBm |
| | Cold start | -149dBm |
| Acquisition Time | Hot start (Open Sky) | 1s (typical) |
| | Cold Start (Open Sky) | 28s (typical) without AGPS |
| | | < 15s (typical) with AGPS (ephemeris prediction) |
| Position Accuracy | Autonomous: 2m (CEP) [1] | |
| Max. Altitude | < 18,000 m [2] | |
| Max. Velocity | < 500 m/s | |
| Protocol Support | NMEA 0183 ver. 4.1 | 115200 bps [3], 8 data bits, no parity, 1 stop bits (default) 1Hz: GGA, GLL, GSA, GSV, RMC, VTG, GST, TXT |

<Note>

1. Open sky, demonstrated with a good antenna.

2. The maximum altitude of the balloon mode is 80,000 m.

3. Both baud rate and output message rate are configurable to be factory default.

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

## 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 |
| GST | Estimated error in position solution |

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

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

$GNGGA,061300.000,2503.71255,N,12138.74493,E,2,38,0.44,121.12,M,15.32,M,,*7E

*Table5.1- 2 GGA Data Format*

| Name | Example | Units | Description |
|---|---|---|---|
| Message ID | $GNGGA | | GGA protocol header |
| UTC Time | 061300.000 | | hhmmss.sss |
| Latitude | 2503.71255 | | ddmm.mmmmm |
| N/S indicator | N | | N=north or S=south |
| Longitude | 12138.74493 | | dddmm.mmmmm |
| E/W Indicator | E | | E=east or W=west |
| Position Fix Indicator | 2 | | See Table 5.1-3 |
| Satellites Used | 38 | | Number of satellites in use |
| HDOP | 0.44 | | Horizontal Dilution of Precision (meters) |
| MSL Altitude | 121.12 | 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 | *7E | | Checksum |
| <CR> <LF> | | | End of message termination |

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

*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,2503.71255,N,12138.74493,E,061300.000,A,D*42

*Table 5.1-4* GLL Data Format

| Name | Example | Units | Description |
|---|---|---|---|
| Message ID | $GNGLL | | GLL protocol header |
| Latitude | 2503.71255 | | ddmm.mmmmm |
| N/S indicator | N | | N=north or S=south |
| Longitude | 12138.7493 | | dddmm.mmmmm |
| E/W indicator | E | | E=east or W=west |
| UTC Time | 061300.000 | | hhmmss.sss |
| Status | A | | A=data valid or V=data not valid |
| Mode | D | | N = No position fix<br>A = Autonomous GNSS fix<br>D = Differential GNSS fix<br>R = RTK fixed<br>F = RTK float<br>E = Estimated/Dead reckoning fix |
| Checksum | *42 | | |
| <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,3,19,195,17,06,20,11,09,02,194,12,05,04,0.81,0.44,0.68,1*04

$GNGSA,A,3,14,,,,,,,,,,,,0.81,0.44,0.68,1*03

$GNGSA,A,3,66,81,88,65,79,82,,,,,,,0.81,0.44,0.68,2*0B

$GNGSA,A,3,03,15,34,27,30,,,,,,,,0.81,0.44,0.68,3*02

$GNGSA,A,3,33,40,07,10,38,28,08,41,13,14,43,42,0.81,0.44,0.68,4*0B

$GNGSA,A,3,11,39,,,,,,,,,,,,0.81,0.44,0.68,4*09

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

*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 | 19 | | SV on Channel 1 |
| ID of satellite used | 195 | | SV on Channel 2 |
| …. | | | …. |
| ID of satellite used | | | SV on Channel 12 |
| PDOP | 0.81 | | Position Dilution of Precision |
| HDOP | 0.44 | | Horizontal Dilution of Precision |
| VDOP | 0.68 | | Vertical Dilution of Precision |
| GNSS system ID | 1 | | See Table 5.1-8 |
| Checksum | *04 | | |
| <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,4,1,15,196,73,108,46,19,72,077,47,195,71,061,47,199,59,164,22,1*5B

$GPGSV,4,2,15,17,54,115,47,06,49,003,48,20,44,248,47,11,36,306,46,1*6E

$GPGSV,4,3,15,09,35,079,45,02,31,307,45,194,28,175,43,12,25,302,43,1*52

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

$GPGSV,4,4,15,05,14,230,38,04,14,051,38,14,11,173,43,1*53

$GLGSV,2,1,07,66,71,107,44,81,39,356,48,88,36,067,47,67,33,187,,1*7B

$GLGSV,2,2,07,65,25,033,46,79,17,262,47,82,08,315,43,1*46

$GAGSV,2,1,05,03,49,122,45,15,47,342,45,34,37,056,43,27,33,273,43,7*7B

$GAGSV,2,2,05,30,30,208,41,7*49

$GBGSV,4,1,14,33,72,072,50,40,63,187,48,07,63,217,45,10,63,251,45,1*74

$GBGSV,4,2,14,38,58,328,48,28,56,353,49,08,52,306,44,41,47,200,48,1*75

$GBGSV,4,3,14,13,47,291,45,14,45,047,45,43,44,092,47,42,20,040,42,1*71

$GBGSV,4,4,14,11,20,105,41,39,11,172,42,1*78

*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 | 4 | | Range 1 to 9 |
| Message number | 1 | | Range 1 to 9 |
| Satellites in view | 15 | | |
| Satellite ID | 196 | | Channel 1 |
| Elevation | 73 | degrees | Channel 1 (Range 00 to 90) |
| Azimuth | 108 | degrees | Channel 1 (Range 000 to 359) |
| SNR (C/No) | 46 | dB-Hz | Channel 1 (Range 00 to 99, null when not tracking) |
| …. | | | …. |
| Satellite ID | 199 | | Channel 4 |
| Elevation | 59 | degrees | Channel 4 (Range 00 to 90) |
| Azimuth | 164 | degrees | Channel 4 (Range 000 to 359) |
| SNR (C/No) | 22 | dB-Hz | Channel 4 (Range 00 to 99, null when not tracking) |
| Signal ID | 1 | | GPS/QZSS: L1 C/A=1 GLONASS: L1 C/A=1 GALILEO: E1=7 BEIDOU: B1=1, B1C=3 |
| Checksum | *5B | | |
| <CR> <LF> | | | End of message termination |

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

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

$GNRMC,061300.000,A,2503.71255,N,12138.74493,E,0.01,30.70,150622,,,D,V*38

*Table 5.1-10* RMC Data Format

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

| Name | Example | Units | Description |
|---|---|---|---|
| Message ID | $GNRMC | | RMC protocol header |
| UTC Time | 061300.000 | | hhmmss.sss |
| Status | A | | A=data valid or V=data not valid |
| Latitude | 2503.71255 | | ddmm.mmmm |
| N/S Indicator | N | | N=north or S=south |
| Longitude | 12138.74493 | | dddmm.mmmmm |
| E/W Indicator | E | | E=east or W=west |
| Speed over ground | 0.001 | knots | True |
| Course over ground | 30.70 | degrees | |
| Date | 150622 | | ddmmyy |
| Magnetic variation | | degrees | |
| Variation sense | | | E=east or W=west |
| Mode | D | | N = No position fix<br>A = Autonomous GNSS fix<br>D = Differential GNSS fix<br>R = RTK fixed<br>F = RTK float<br>E = Estimated/Dead reckoning fix |
| Navigational status indicator | V | | S = Safe<br>C = Caution<br>U = Unsafe<br>V = Void |
| Checksum | *38 | | |
| <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,30.70,T,,M,0.01,N,0.01,K,D*12

*Table 5.1-11* VTG Data Format

| Name | Example | Units | Description |
|---|---|---|---|
| Message ID | $GPVTG | | VTG protocol header |
| Course over ground | 30.70 | degrees | Measured heading |
| Reference | T | | True |
| Course over ground | | degrees | Measured heading |
| Reference | M | | Magnetic |
| Speed over ground | 0.001 | knots | Measured speed |

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

| Units | N | | Knots |
|---|---|---|---|
| Speed over ground | 0.001 | km/hr | Measured speed |
| Units | K | | Kilometer per hour |
| Mode | D | | N = No position fix<br>A = Autonomous GNSS fix<br>D = Differential GNSS fix<br>R = RTK fixed<br>F = RTK float<br>E = Estimated/Dead reckoning fix |
| Checksum | *12 | | |
| <CR> <LF> | | | End of message termination |

● **GST---Estimated error in position solution**

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

$GNGST,061300.000,2.6,1.9,1.6,169.8,1.9,1.6,6.8*71

*Table 5.1-12* GST Data Format

| Name | Example | Units | Description |
|---|---|---|---|
| Message ID | $GNGST | | GST protocol header |
| UTC Time | 061300.000 | | hhmmss.sss |
| RangeRMS | 2.6 | meters | RMS value of the standard deviation of the ranges |
| stdMajor | 1.9 | meters | Standard deviation of semi-major axis of error ellipse |
| stdMinor | 1.6 | Meters | Standard deviation of semi-minor axis of error ellipse |
| Orient | 169.8 | degrees | Orientation of semi-major axis of error ellipse |
| stdLat | 1.9 | meters | Standard deviation of latitude error |
| stdLong | 1.6 | meters | Standard deviation of longitude error |
| stdAlt | 6.8 | meters | Standard deviation of altitude error |
| Checksum | *71 | | |
| <CR> <LF> | | | End of message termination |

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

## 5.2   Proprietary commands

The commonly used commands are in the following.

### 5.2.1 ID: 001

[Description]

PAIR_ACK. Acknowledge of the input command.

[Return]

$PAIR001,Command_ID,Result*CS<CR><LF>

Command_ID: The command / packet type the acknowledge responds.

Result: The result of the command.

  0: The command was successfully sent.

  1: The command is processing. You must wait for the result.

  2: Sending the command failed.

  3: This command ID is not supported.

  4: Command parameter error. Out of range / some parameters were lost / checksum error.

  5: Service is busy. You can try again soon.

[Example]

Send:

$PAIR002*38\r\n

Response:

$PAIR001,002,0*39\r\n ==> Success

### 5.2.2 ID: 002

[Description]

Power on the GNSS system. Include DSP/RF/Clock and other GNSS sections.

[Data Field]

$PAIR002*CS<CR><LF>

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR002*38\r\n

Response:

$PAIR001,002,1*38\r\n ==> The power on process is running. Please wait a moment.

$PAIR001,002,0*39\r\n ==> Power on was successful.

### 5.2.3 ID: 003

[Description]

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

Power off GNSS system. Include DSP/RF/Clock and other GNSS sections. The location service is not available after this command is executed. The module can still receive configuration commands.

[Data Field]

$PAIR003*CS<CR><LF>

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR003*39\r\n

Response:

$PAIR001,003,1*39\r\n ==> The power off process is running. Please wait a moment.

$PAIR001,003,0*38\r\n ==> Power off was successful.

### 5.2.4 ID: 004

[Description]

Hot Start. Use the available data in the NVRAM.

[Data Field]

$PAIR004*CS<CR><LF>

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR004*3E\r\n

Response:

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

### 5.2.5 ID: 005

[Description]

Warm Start. Not using Ephemeris data at the start.

[Data Field]

$PAIR005*CS<CR><LF>

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR005*3F\r\n

Response:

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

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

### 5.2.6 ID: 006

[Description]

　　Cold Start. Not using the Position, Almanac and Ephemeris data at the start.

[Data Field]

　　$PAIR006*CS<CR><LF>

[Return]

　　PAIR_ACK for send result.

[Example]

　　Send:

　　　　$PAIR006*3C\r\n

　　Response:

　　　　$PAIR001,006,0*3D\r\n ==> Success

### 5.2.7 ID: 007

[Description]

　　Full Cold Start.

　　In addition to Cold start, this command clears the system/user configurations at the start.

　　It resets the GNSS module to the factory default.

[Data Field]

　　$PAIR007*CS<CR><LF>

[Return]

　　PAIR_ACK for send result.

[Example]

　　Send:

　　　　$PAIR007*3D\r\n

　　Response:

　　　　$PAIR001,007,0*3C\r\n ==> Success

### 5.2.8 ID: 864

[Description]

　　Set baud rate configuration.

[Data Field]

　　$PAIR864,<Port_Type>,<Port_Index>,<Baudrate>*CS<CR><LF>

　　Port_Type: HW Port Type.

　　　　0: UART

　　Port_Index: HW Port Index

LOCOSYS **Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐 www.locosystech.com/

0: UART0

Baudrate: the baud rate needs config.

Support 115200, 230400, 460800, 921600, 3000000

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR864,0,0,115200*1B\r\n

Response:

$PAIR001,864,0*31\r\n ==> Success

[Note]

The change will take effect after reboot.

### 5.2.9 ID: 050

[Description]

Set Position Fix Interval.

If set less than 1000 ms, ASCII NMEA will automatically increase the update interval in order to decrease IO throughput. (Any fix interval changes between 1Hz and multi Hz causes GNSS to power on/off)

[Data Field]

$PAIR050,<Fix_Interval>*CS<CR><LF>

Fix_Interval: Position fix interval in milliseconds (ms). [Range: 100 ~ 1000]

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR050,1000*12\r\n

Response:

$PAIR001,050,0*3E\r\n ==> Success

[Note]

20Hz is available only for drone mode and cannot be set by the command. Please contact us.

### 5.2.10 ID: 051

[Description]

Get Position Fix Interval.

[Data Field]

$PAIR051*CS<CR><LF>

[Return]

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

1. PAIR_ACK for send result.

2. $PAIR050,<Fix_Interval>*CS<CR><LF>

Fix_Interval: Position fix interval in milliseconds (ms). [Range: 100 ~ 1000]

[Example]

Send:

$PAIR051*3E\r\n

Response:

$PAIR001,051,0*3F\r\n ==> Success

$PAIR051,1000*13\r\n

### 5.2.11 ID: 062

[Description]

Set the NMEA sentence output interval of corresponding NMEA type.

[Data Field]

$PAIR062,<Type>,<Output_Rate>*CS<CR><LF>

Type: NMEA Type

-1 Reset all sentence to default value.

0 NMEA_SEN_GGA,      // GGA interval - GPS Fix Data

1 NMEA_SEN_GLL,      // GLL interval - Geographic Position - Latitude longitude

2 NMEA_SEN_GSA,      // GSA interval - GNSS DOPS and Active Satellites

3 NMEA_SEN_GSV,      // GSV interval - GNSS Satellites in View

4 NMEA_SEN_RMC,      // RMC interval - Recommended Minimum Specific GNSS Sentence

5 NMEA_SEN_VTG,      // VTG interval - Course Over Ground and Ground Speed

6 NMEA_SEN_ZDA,      // ZDA interval - Time & Date

7 NMEA_SEN_GRS,      // GRS interval - GNSS Range Residuals

8 NMEA_SEN_GST,      // GST Interval - GNSS Pseudorange Error Statistics

Output_Rate: Output interval setting (Valid range: 0~20)

0 - Disabled or not supported sentence

1 - Output once every one position fix

2 - Output once every two position fixes

3 - Output once every three position fixes

4 - Output once every four position fixes

5 - Output once every five position fixes

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR062,0,3*3D\r\n

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☏ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

Response:

$PAIR001,062,0*3F\r\n ==> Success

### 5.2.12 ID: 063

[Description]

Get the NMEA sentence output interval of corresponding NMEA type.

[Data Field]

$PAIR063,<Type>*CS<CR><LF>

Type: NMEA Type

-1 return all sentence configuration.

0 NMEA_SEN_GGA,　　　// GGA interval - GPS Fix Data

1 NMEA_SEN_GLL,　　　// GLL interval - Geographic Position - Latitude longitude

2 NMEA_SEN_GSA,　　　// GSA interval - GNSS DOPS and Active Satellites

3 NMEA_SEN_GSV,　　　// GSV interval - GNSS Satellites in View

4 NMEA_SEN_RMC,　　　// RMC interval - Recommended Minimum Specific GNSS Sentence

5 NMEA_SEN_VTG,　　　// VTG interval - Course Over Ground and Ground Speed

6 NMEA_SEN_ZDA,　　　// ZDA interval - Time & Date

7 NMEA_SEN_GRS,　　　// GRS interval - GNSS Range Residuals

8 NMEA_SEN_GST,　　　// GST Interval - GNSS Pseudorange Error Statistics

[Return]

1. PAIR_ACK for send result.

2. $PAIR063,<Type>,<Output_Rate>*CS<CR><LF>

Type: NMEA Type

0 NMEA_SEN_GGA,　　　// GGA interval - GPS Fix Data

1 NMEA_SEN_GLL,　　　// GLL interval - Geographic Position - Latitude longitude

2 NMEA_SEN_GSA,　　　// GSA interval - GNSS DOPS and Active Satellites

3 NMEA_SEN_GSV,　　　// GSV interval - GNSS Satellites in View

4 NMEA_SEN_RMC,　　　// RMC interval - Recommended Minimum Specific GNSS Sentence

5 NMEA_SEN_VTG,　　　// VTG interval - Course Over Ground and Ground Speed

6 NMEA_SEN_ZDA,　　　// ZDA interval - Time & Date

7 NMEA_SEN_GRS,　　　// GRS interval - GNSS Range Residuals

8 NMEA_SEN_GST,　　　// GST Interval - GNSS Pseudorange Error Statistics

Output_Rate: Output interval setting (Valid range: 0~20, default value: 1)

0 - Disabled or not supported sentence

1 - Output once every one position fix

2 - Output once every two position fixes

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌏www.locosystech.com/

3 - Output once every three position fixes

4 - Output once every four position fixes

5 - Output once every five position fixes

[Example]

    Send:

        $PAIR063,0*23\r\n

    Response:

        $PAIR001,063,0*3E\r\n ==> Success

        $PAIR063,0,3*3C\r\n

## 5.2.13 ID: 070

[Description]

    Set the static navigation speed threshold.

    If the actual speed is less than the threshold, the output position remains the same and the output speed will be zero.

    If the threshold value is set to 0, this function is disabled.

[Data Field]

    $PAIR070,<Speed_t28holld>*CS<CR><LF>

    Speed_threshold.    0~20 dm/s. Default value is 0 dm/s.

    The minimum is 1 dm/s, the maximum is 20 dm/s.

    1 dm/s = 0.1m/s

[Return]

    1. PAIR_ACK for send result.

[Example]

    Send:

        $PAIR070,4*25\r\n

    Response:

        $PAIR001,070,0*3C\r\n ==> Success

## 5.2.14 ID: 071

[Description]

    Query the static navigation speed threshold.

[Data Field]

    $PAIR071*CS<CR><LF>

[Return]

    1. PAIR_ACK for send result.

    2. $PAIR071,<Speed_threshold>*CS<CR><LF>

    Speed_threshold: 0~2 m/s.

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

The maximum is 2.0 m/s.

[Example]

Send:

$PAIR071*3C\r\n

Response:

$PAIR001,071,0*3D\r\n ==> Success

$PAIR071,0.4*3A\r\n

### 5.2.15 ID: 080

[Description]

Set navigation mode.

[Data Field]

$PAIR080,<CmdType>*CS<CR><LF>

CmdType:

0. Normal mode: For general purpose

1. Fitness mode: For running and walking purpose so that the low-speed (< 5 m/s) movement will have more of an effect on the position calculation.

2. Reserved

3. Balloon mode: For high-altitude balloon purpose that the vertical movement will have more effect on the position calculation.

4. Stationary mode: For stationary applications with zero dynamics.

5. Drone mode: used for drone applications with equivalent dynamics range and vertical application on different flight phase. (Ex. Hovering, cruising, etc.)

6. Reserved

7. Swimming mode: For swimming purpose so that it smooths the trajectory and improves the accuracy of distance calculation.

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR080,1*2F\r\n ==> Enter fitness mode.

Response:

$PAIR001,080,0*33\r\n ==> Success

### 5.2.16 ID: 081

[Description]

Get navigation mode.

[Data Field]

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

$PAIR081*CS<CR><LF>

[Return]

1. PAIR_ACK for send result.

2. $PAIR081,<CmdType>*CS<CR><LF>

CmdType:

0.  [Default Value] Normal mode: For general purpose

1.  Fitness mode: For running and walking activities so that the low-speed (< 5 m/s) movement will have more of an effect on the position calculation.

2.  Reserved

3.  Balloon mode: For high-altitude balloon purpose that the vertical movement will have more effect on the position calculation.

4.  Stationary mode: For stationary applications where a zero dynamic assumed.

5.  Drone mode: Used for drone applications with equivalent dynamics range and vertical acceleration on different flight phase. (Ex. hovering, cruising, etc.) (Note: The precision of NMEA automatically changes to 7 decimal places for latitude/longitude, and 3 decimal places for altitude.)

6.  Reserved

7.  Swimming mode: For swimming purpose so that it smooths the trajectory and improves the accuracy of distance calculation.

[Example]

Send:

$PAIR081*33\r\n

Response:

$PAIR001,081,0*32\r\n ==> Success

$PAIR081,1*2E\r\n ==> Current is fitness mode.

### 5.2.17 ID: 400

[Description]

Set DGPS correction data source mode.

[Data Field]

$PAIR400,<Mode> *CS<CR><LF>

Mode: DGPS data source mode.

'0': No DGPS source

'1': RTCM

'2': SBAS (Include WAAS/EGNOS/GAGAN/MSAS)

'3': QZSS SLAS

[Return]

PAIR_ACK for send result.

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

[Example]

Send:

$PAIR400,2*20\r\n ==> Set SBAS Mode

Response:

$PAIR001,400,0*3F\r\n ==> Success

### 5.2.18 ID: 401

[Description]

Query the DGPS data source mode.

[Data Field]

$PAIR401*CS<CR><LF>

[Return]

1. PAIR_ACK for send result.

2. $PAIR401,<Mode>*CS<CR><LF>

Mode: DGPS data source mode.

'0': No DGPS source

'1': RTCM

'2': SBAS (Include WAAS/EGNOS/GAGAN/MSAS)

'3': QZSS SLAS

[Example]

Send:

$PAIR401*3F\r\n

Response:

$PAIR001,401,0*3E\r\n ==> Success

$PAIR401,2*21\r\n ==> SBAS Mode

### 5.2.19 ID: 410

[Description]

Enable searching a SBAS satellite or not.

When navigation mode is Fitness or Swimming mode, SBAS is not supported.

[Data Field]

$PAIR410,<Enabled>*CS<CR><LF>

Enabled: Enable or disable

'0' = Disable

'1' = Enable

[Return]

PAIR_ACK for send result.

[Example]

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☏ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

Send:

$PAIR410,1*22\r\n ==> Enable SBAS

Response:

$PAIR001,410,0*3E\r\n ==> Success

### 5.2.20 ID: 420

[Description]

Enable the QZSS SLAS (Sub-meter Level Augmentation Service) operation.

When navigation mode is Fitness or Swimming mode, QZSS SLAS is not supported.

[Data Field]

$PAIR420,<Enabled>*CS<CR><LF>

Enabled: Enable or disable

'0' = Disable

'1' = Enable

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR420,1*21\r\n ==> Enable QZSS SLAS

Response:

$PAIR001,420,0*3D\r\n ==> Success

### 5.2.21 ID: 513

[Description]

Save the current configuration from RTC RAM to flash.

[Data Field]

$PAIR513*CS<CR><LF>

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR513*3D\r\n

Response:

$PAIR001,513,0*3C\r\n

[Note]

The changes of the configuration are kept in the RTC RAM that is powered from V_BCKP pin. If the power from V_BCKP pin is not kept, the changes will be lost after system reboot. The user can use this command to save the changes into the non-volatile flash memory. When the

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☏ 886-2-8698-3698
🖷 886-2-8698-3699
🌐 www.locosystech.com/

update rate is greater than 1Hz, this command can only be set when the GNSS system is powered off.

### 5.2.22    ID: 514

[Description]

Clear the current configuration and restore the factory default settings. This function does not support run time restore when GNSS is power on. Please send $PAIR003 command to power off GNSS before using this command.

[Data Field]

$PAIR514*CS<CR><LF>

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR514*3A\r\n

Response:

$PAIR001,514,0*3B\r\n

### 5.2.23    ID: 066

[Description]

Configure the receiver to start searching for satellites. The setting is available when the NVRAM data is valid.

The device restarts when it receives this command.

Support constellation: GPS, GPS+GLONASS, GPS+GALILEO, GPS+BEIDOU, GPS+GLONASS+GALILEO+BEIDOU.

QZSS is always switchable.

[Data Field]

$PAIR066,<GPS_Enabled>,<GLONASS_Enabled>,<Galileo_Enabled>,<BeiDou_Enabled>,<QZSS_Enabled>,<NavIC_Enabled>*CS<CR><LF>

GPS_Enabled:

"0", disable (DO NOT search GPS satellites).

"1", search GPS satellites.

GLONASS_Enabled:

"0", disable (DO NOT search GLONASS satellites).

"1", search GLONASS satellites.

Galileo_Enabled:

"0", disable (DO NOT search Galileo satellites).

"1", search Galileo satellites.

LOCOSYS **Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

BeiDou_Enabled:

"0", disable (DO NOT search BeiDou satellites).

"1", search BeiDou satellites.

QZSS_Enabled:

"0", disable (DO NOT search QZSS satellites).

"1", search QZSS satellites.

NavIC_Enabled:

"0", disable (DO NOT search NavIC satellites).

"1", search NavIC satellites.

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR066,1,0,0,0,0,0*3B\r\n ==> Search GPS satellites only.

Response:

$PAIR001,066,0*3B\r\n ==> Success

Send:

$PAIR066,1,0,1,0,1,0*3B\r\n ==> Search GPS, GALILEO and QZSS satellites.

Response:

$PAIR001,066,0*3B\r\n ==> Success

## 5.2.24    ID: 154

[Description]

Enable to output Return Link Message from navigation data.

[Data Field]

$PAIR154,<Enable>*CS<CR><LF>

Enable:

0: disable

1: enable

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR154,1*27\r\n

Response:

$PAIR001,154,0*3B\r\n ==> Success

## 5.2.25    ID: 155

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

[Description]

Query output Return Link Message status.

[Data Field]

$PAIR155*CS<CR><LF>

Enable:

0: disable

1: enable

[Return]

1. PAIR_ACK for send result.

2. $PAIR155,<Enable>*CS<CR><LF>

Enable:

0: Disable

1: Enable

[Example]

Send:

$PAIR155*3B\r\n

Response:

$PAIR001,155,0*3A\r\n ==> Success

$PAIR155,1*26\r\n


## 5.2.26    ID: 158

[Description]

Enable B1C.

[Data Field]

$PAIR158,<Enable>*CS<CR><LF>

Enable:

0: disable

1: enable

[Return]

PAIR_ACK for send result.

[Example]

Send:

$PAIR158,1*2B\r\n

Response:

$PAIR001,158,0*37\r\n ==> Success


## 5.2.27    ID: 159

[Description]

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐 www.locosystech.com/

Query output B1C enable status.

[Data Field]

$PAIR159*CS<CR><LF>

Enable:

0: disable

1: enable

[Return]

1. PAIR_ACK for send result.

2. $PAIR155,<Enable>*CS<CR><LF>

Enable:

0: Disable

1: Enable

[Example]

Send:

$PAIR159*37\r\n

Response:

$PAIR001,159,0*36\r\n ==> Success

$PAIR159,1*2A\r\n

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

# 6 Pin assignment and descriptions
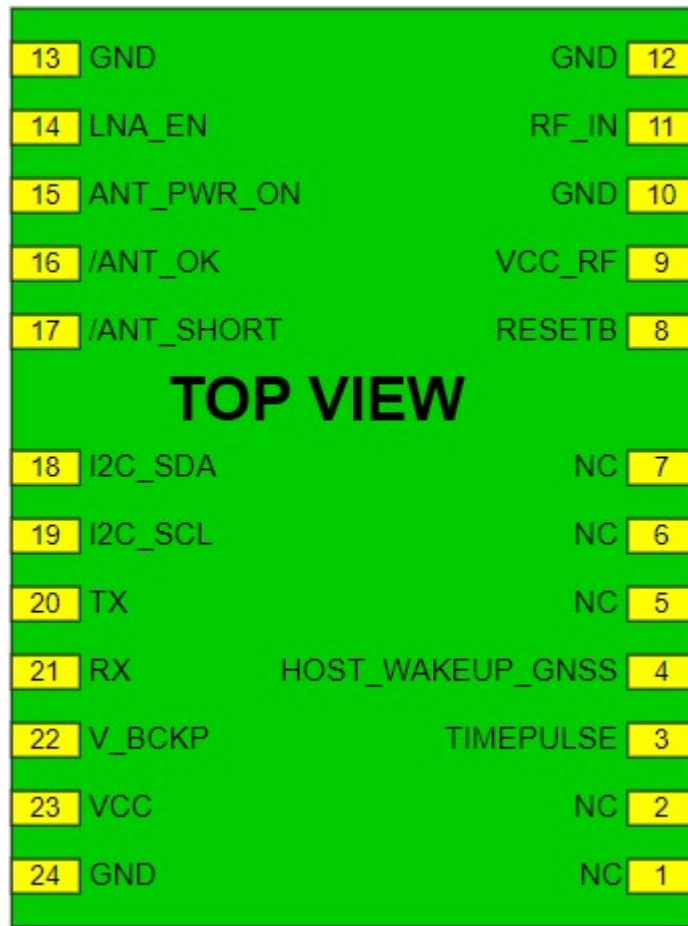


Table 6-1 Pin descriptions

| Pin # | Name | Type | Description | Note |
|---|---|---|---|---|
| 1 | NC | | Not connect | |
| 2 | NC | | Not connect | |
| 3 | TIMEPULSE | O | Time pulse (PPS, default 100 ms pulse/sec when GNSS fix is available) | |
| 4 | HOST_WAKEUP_GNSS | I | Host wakes up GNSS module. Leave unconnected if not used. | |
| 5 | NC | | Not connect | |
| 6 | NC | | Not connect | |
| 7 | NC | | Not connect | |
| 8 | RESETB | I | Internal 10K ohm pull-up resistor. Mode control pin between RTC and normal mode. Leave unconnected if not used. | |
| 9 | VCC_RF | O | Output voltage for active antenna. | |
| 10 | GND | P | Ground | |

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☏ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

# 7 DC & Temperature characteristics

## 7.1 Absolute maximum ratings

| Parameter | Symbol | Ratings | Units |
|---|---|---|---|
| DC Supply Input Voltage | $VCC_{ABS}$ | 3.63 | V |
| Input Backup Battery Voltage | $V\_BCKP_{ABS}$ | 3.63 | V |
| Operating Temperature Range | $T_{OPR\_ABS}$ | -40 ~ 85 | ℃ |
| Storage Temperature Range | $T_{STG\_ABS}$ | -40 ~ 85 | ℃ |

## 7.2 DC Electrical characteristics

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| DC Supply Input Voltage | VCC | | 3 | 3.3 | 3.6 | V |
| Input Backup Battery Voltage | V_BCKP | | 1.62 | | 3.63 | V |
| VCC_RF Output Voltage | VCC_RF | | | VCC | | V |
| Supply Current | $I_{SS}$ | VCC = 3.3V, w/o active antenna, Peak Acquisition Tracking | | 29 33 [2] | 140 [1] | mA mA mA |
| | $I_{RTC}$ | VCC=3.3V, RESETB=0V | | 192 | | µA |
| Backup Battery Current | $I_{BAT}$ | VCC = 0V | | 32 | | µA |
| VCC_RF Output Current [3] | $I_{OUT}$ | | | | 30 | mA |
| High Level Input Voltage | $V_{IH}$ | | 2 | | | V |
| Low Level Input Voltage | $V_{IL}$ | | | | 0.8 | V |
| High Level Output Voltage | $V_{OH}$ | | 2.4 | | | V |
| Low Level Output Voltage | $V_{OL}$ | | | | 0.4 | V |

<Note>

1. This happens when downloading AGPS data to the module.
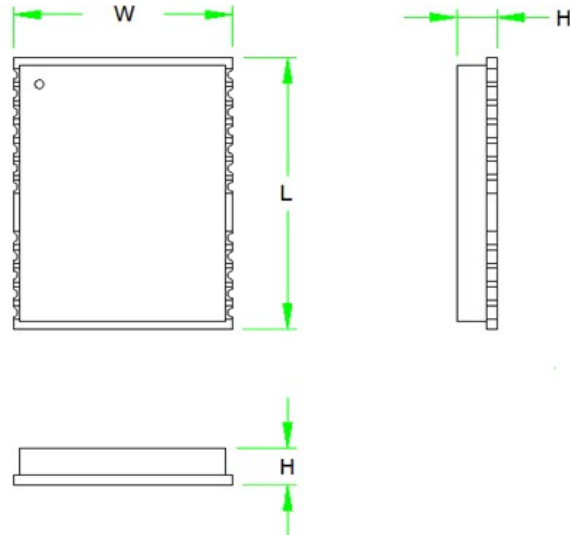
2. Measured when position fix (1Hz) is available, input voltage is 3.3V and the function of self-generated ephemeris prediction is inactive.

## 7.3 Temperature characteristics

| Parameter | Symbol | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| Operating Temperature | $T_{OPR}$ | -40 | - | 85 | °C |
| Storage Temperature | $T_{STG}$ | -40 | 25 | 85 | °C |

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐 www.locosystech.com/

# 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
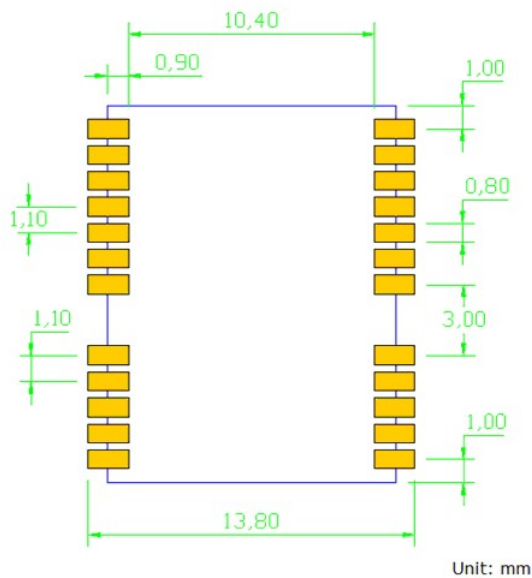


Note: The recommended land pattern dimensions are shown for reference only, as actual pad layouts may vary depending on application.

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

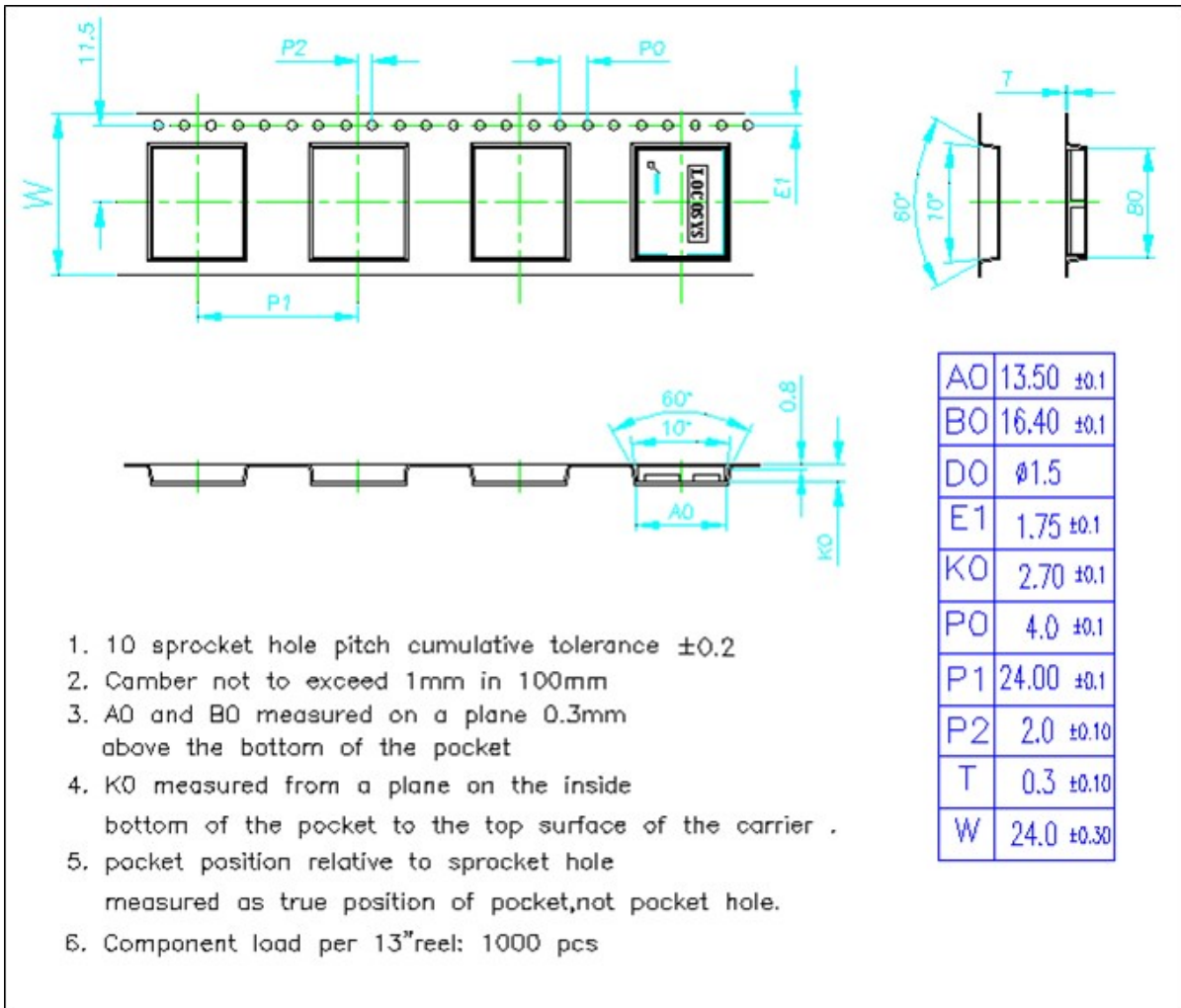# 9 Reel Packing information

## 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.
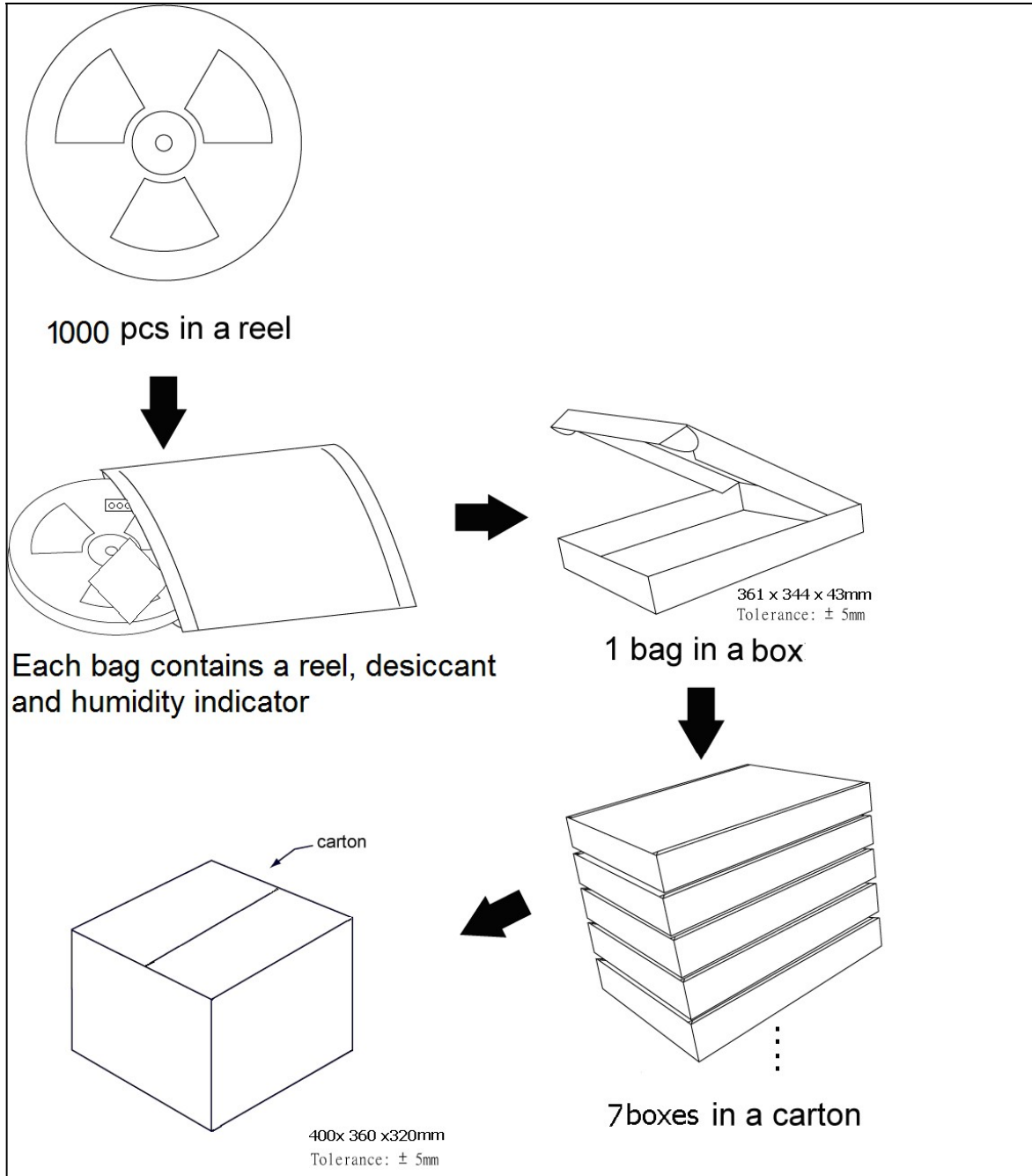
## 9.2 Packaging

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 Packaging



| | |
|---|---|
| AO | 13.50 ±0.1 |
| BO | 16.40 ±0.1 |
| DO | Ø1.5 |
| E1 | 1.75 ±0.1 |
| KO | 2.70 ±0.1 |
| PO | 4.0 ±0.1 |
| P1 | 24.00 ±0.1 |
| P2 | 2.0 ±0.10 |
| T | 0.3 ±0.10 |
| W | 24.0 ±0.30 |

1. 10 sprocket hole pitch cumulative tolerance ±0.2
2. Camber not to exceed 1mm in 100mm
3. AO and BO measured on a plane 0.3mm above the bottom of the pocket
4. KO measured from a plane on the inside bottom of the pocket to the top surface of the carrier .
5. pocket position relative to sprocket hole measured as true position of pocket,not pocket hole.
6. Component load per 13"reel: 1000 pcs

LOCOSYS **Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐 www.locosystech.com/

## 9.2.2 Box packaging



1000 pcs in a reel

Each bag contains a reel, desiccant and humidity indicator

361 x 344 x 43mm
Tolerance: ± 5mm

1 bag in a box

carton

400x 360 x320mm
Tolerance: ± 5mm

7 boxes in a carton

**LOCOSYS**

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐 www.locosystech.com/

## 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 ≤ 30℃ and 60% RH or stored at ≤ 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℃ + 5℃ / -0℃ and < 5% RH
b. 24 hours at 125℃ + 5℃ / -0℃

## 9.4 Reflow soldering
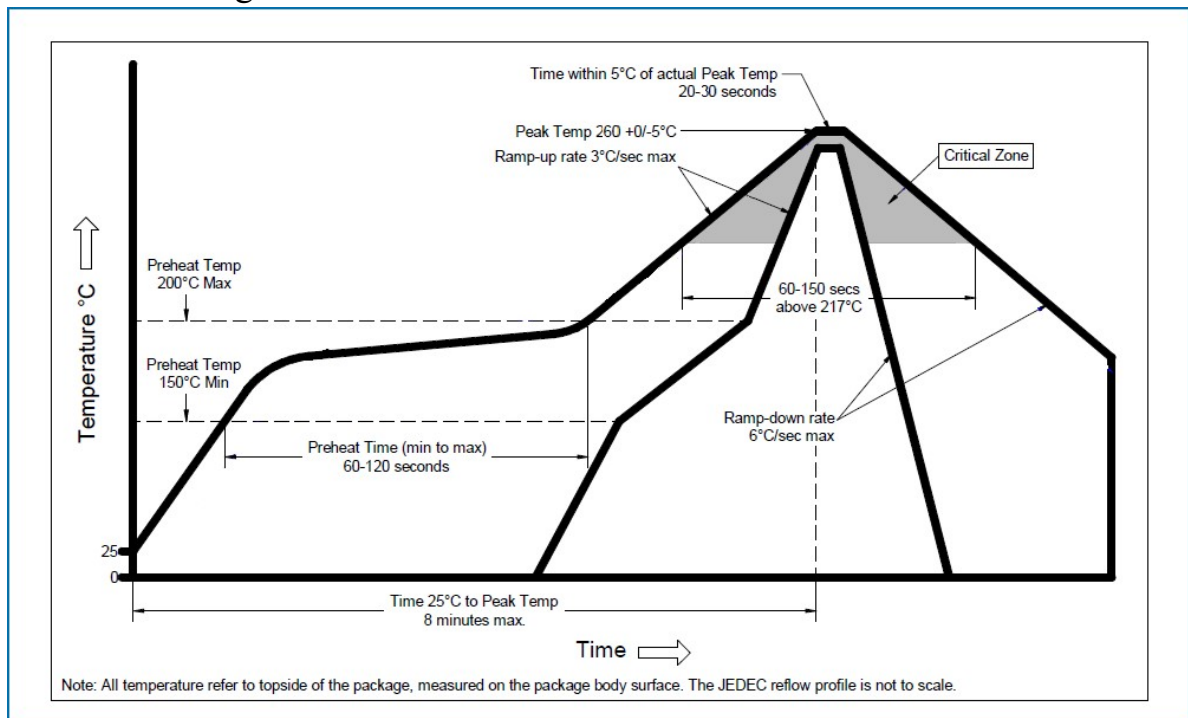


Note the module mounted to the top side (first reflow side) may fall off during reflow soldering of the bottom side.

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐www.locosystech.com/

# 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 |
|---|---|---|
| MC-1612a-52Q | Multi-constellation GNSS positioning module | GPS/QZSS: L1 C/A, L1C<br>GLONASS: L1OF<br>GALILEO: E1<br>BEIDOU: B1I, B1C |

**LOCOSYS Technology Inc.**
20F.-13, No.79, Sec. 1, Xintai 5th Rd.,
Xizhi District, New Taipei City 221, Taiwan
☎ 886-2-8698-3698
🖷 886-2-8698-3699
🌐 www.locosystech.com/

# Document change list

## Revision 0.1

- Draft release on February 22, 2023.