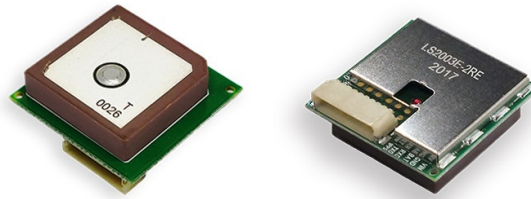


| Product name | Description                         | Version |
|--------------|-------------------------------------|---------|
| LS2003E-2RE  | Standalone GPS smart antenna module | 1.2     |



22 x 22 x 8.4 mm

## 1 Introduction

LS2003E-2RE is a complete standalone GPS smart antenna module, including embedded patch antenna and GPS receiver circuits. The module is powered by MediaTek the latest GPS ROM chip and can acquire a lot of satellites at a time while providing fast time-to-first-fix and low power consumption. Besides, it can provide you with superior sensitivity and performance even in urban canyon and dense foliage environment.

This module supports self-generate orbit prediction, EASY™, to achieve faster cold start and warm start. The EASY™ is no need of both network assistance and host CPU's intervention. The prediction is valid for up to 3 days and updates automatically from time to time when GPS module is powered on and satellites are available.

It is easy to install without both RF connector and coaxial cable that are needed in a separated GPS active antenna. In other words, reduce the cost and size. Also, speed up the time to market by eliminating R&D efforts on RF matching and stability between separated GPS antenna and module. Furthermore, it can be directly powered by a lithium battery without any external voltage regulars. Therefore, LS2003E-2RE of miniature size and brilliant performance is the best choice to be integrated into your slim devices.

## 2 Features

- MediaTek high sensitivity solution
- Support 66-channel GPS
- Ultra low power consumption
- Fast TTFF at low signal level
- Built-in 12 multi-tone active interference canceller
- Built-in DC/DC converter to save power
- Allow direct connection with the lithium battery
- Up to 10 Hz update rate
- ±11ns high accuracy time pulse (1PPS)
- Supports self-generate orbit prediction to achieve faster cold start
- Support 1PPS synchronize with NMEA output
- Support Japan QZSS
- Indoor and outdoor multi-path detection and compensation
- RoHS compliant

### 3 Application

- Personal positioning and navigation
- Automotive navigation
- Marine navigation

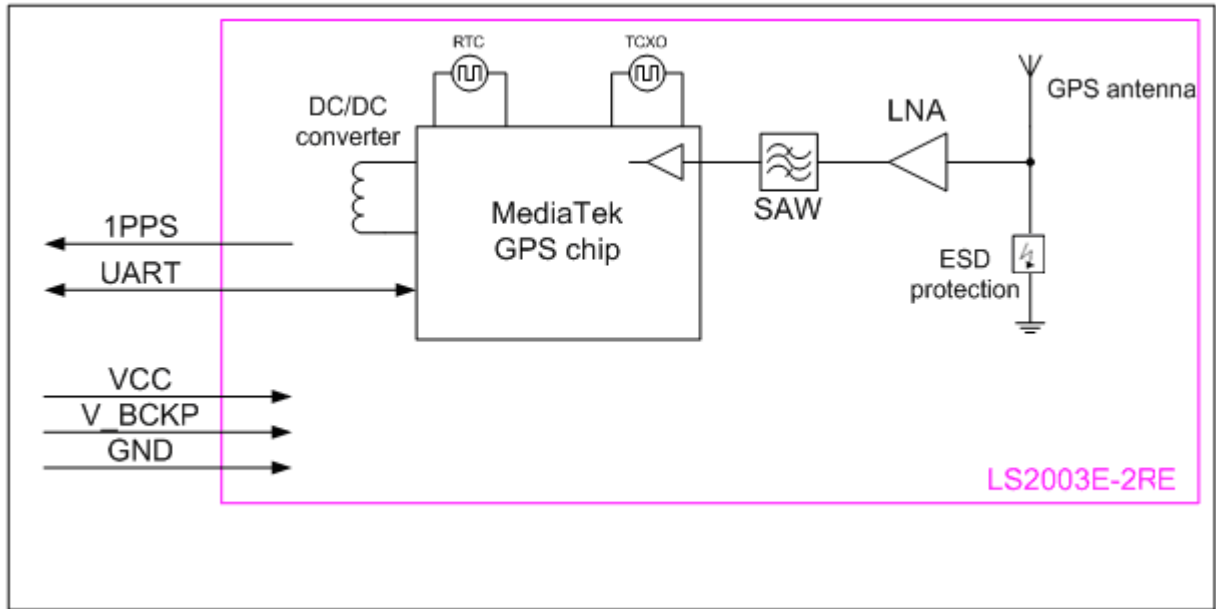


Fig 3-1 System block diagram of LS2003E-2RE

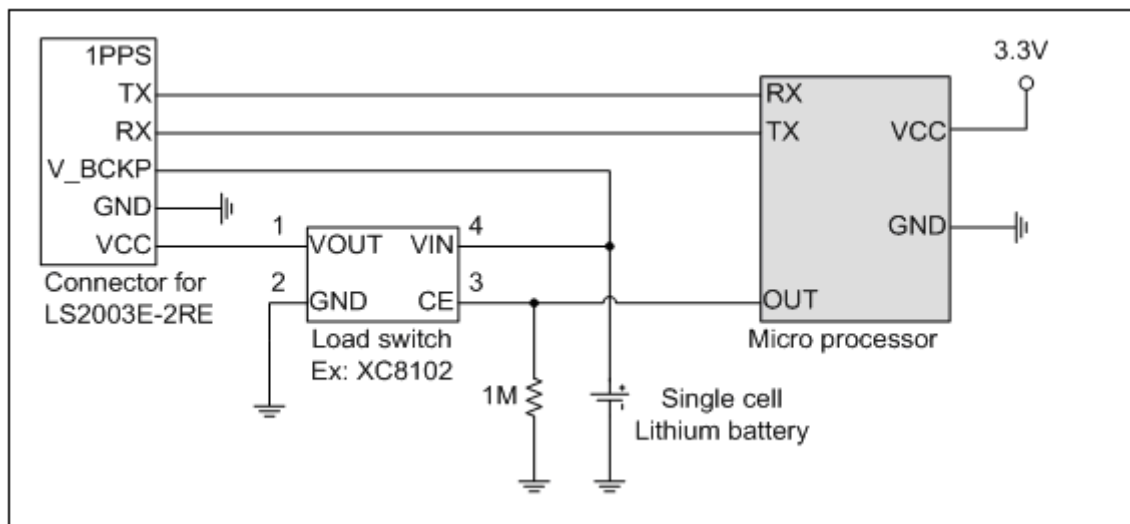


Fig 3-2 Typical application circuit that directly uses lithium battery to save power.

## 4 GPS receiver and antenna

### 4.1 GPS receiver

|                   |   |  |
|-------------------|---|--|
| Chip              | MediaTek MT3337E                                  |  |
| Frequency         | L1 1575.42MHz, C/A code                           |  |
| Channels          | Support 66 channels (22 Tracking, 66 Acquisition) |  |
| Update rate       | 1Hz default, up to 10Hz                           |  |
| Acquisition Time  | Hot start (Open Sky)                              | < 1s (typical)   |
|                   | Cold Start (Open Sky)                             | 33s (typical)  |
|                   |   | < 15s (typical) with self-generate orbit prediction  |
| Position Accuracy | Autonomous  | 1.2m CEP   |
| Datum             | WGS-84 (default)                                  |  |
| Max. Altitude     | < 50,000 m  |  |
| Max. Velocity     | < 515 m/s   |  |
| Protocol          | NMEA 0183 ver 3.01                                | 9600 bps <sup>(1)</sup> , 8 data bits, no parity, 1 stop bits<br>1Hz: GGA, GLL, GSA, GSV, RMC, & VTG |

Note 1: Both baud rate and output message rate are changeable by software command

### 4.2 GPS antenna

|                 |                                      |
|-----------------|--------------------------------------|
| Antenna type    | Patch antenna (4mm thickness)        |
| Polarization    | RHCP                                 |
| Frequency Range | 1575.42MHz ± 1.023MHz <sup>(1)</sup> |
| Gain            | 2 dBic Typ. @zenith <sup>(1)</sup>   |
| Axial ratio     | Max 4.0dB @zenith <sup>(1)</sup>     |

Note 1: This value is measured with the evaluation board and must be fine tuned when installed into your device. Please contact LOCOSYS for your antenna tuning.

## 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         | GPS DOP and active satellites            |
| GSV         | GPS satellites in view                   |
| RMC         | Recommended minimum specific GPS data    |
| VTG         | Course over ground and ground speed      |

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

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

\$GPGGA,053740.000,2503.6319,N,12136.0099,E,1.08,1.1,63.8,M,15.2,M,,0000\*64

Table 5.1-2 GGA Data Format

| Name                   | Example    | Units  | Description                       |
|------------------------|------------|--------|-----------------------------------|
| Message ID             | \$GPGGA    |        | GGA protocol header               |
| UTC Time               | 053740.000 |        | hhmmss.sss                        |
| Latitude               | 2503.6319  |        | ddmm.mmmm                         |
| N/S indicator          | N          |        | N=north or S=south                |
| Longitude              | 12136.0099 |        | dddmm.mmmm                        |
| E/W Indicator          | E          |        | E=east or W=west                  |
| Position Fix Indicator | 1          |        | See Table 5.1-3                   |
| Satellites Used        | 08         |        | Range 0 to 12                     |
| HDOP                   | 1.1        |        | Horizontal Dilution of Precision  |
| MSL Altitude           | 63.8       | meters |                                   |
| Units                  | M          | meters |                                   |
| Geoid Separation       | 15.2       | meters |                                   |
| Units                  | M          | meters |                                   |
| Age of Diff. Corr.     |            | second | Null fields when DGPS is not used |
| Diff. Ref. Station ID  | 0000       |        |                                   |
| Checksum               | *64        |        |                                   |
| <CR> <LF>              |            |        | End of message termination        |

Table 5.1-3 Position Fix Indicators

| Value | Description                  |
|-------|------------------------------|
| 0     | Fix not available or invalid |

|     |                                       |
|-----|---------------------------------------|
| 1   | GPS SPS Mode, fix valid               |
| 2   | Differential GPS, SPS Mode, fix valid |
| 3-5 | Not supported                         |
| 6   | Dead Reckoning Mode, fix valid        |

## ● GLL--- Geographic Position – Latitude/Longitude

Table 5.1-4 contains the values for the following example:

\$GPGLL,2503.6319,N,12136.0099,E,053740.000,A,A\*52

Table 5.1-4 GLL Data Format

| Name          | Example    | Units | Description                                  |
|---------------|------------|-------|--|
| Message ID    | \$GPGLL    |       | GLL protocol header                          |
| Latitude      | 2503.6319  |       | ddmm.mmmm                                    |
| N/S indicator | N          |       | N=north or S=south                           |
| Longitude     | 12136.0099 |       | dddmm.mmmm                                   |
| E/W indicator | E          |       | E=east or W=west                             |
| UTC Time      | 053740.000 |       | hhmmss.sss                                   |
| Status        | A          |       | A=data valid or V=data not valid             |
| Mode          | A          |       | A=autonomous, D=DGPS, E=DR, N=Data not valid |
| Checksum      | *52        |       |  |
| <CR> <LF>     |            |       | End of message termination                   |

## ● GSA---GPS DOP and Active Satellites

Table 5.1-5 contains the values for the following example:

\$GPGSA,A,3,24,07,17,11,28,08,20,04,,,,,2.0,1.1,1.7\*35

Table 5.1-5 GSA Data Format

| Name                 | Example | Units | Description                      |
|----------------------|---------|-------|----------------------------------|
| Message ID           | \$GPGSA |       | GSA protocol header              |
| Mode 1               | A       |       | See Table 5.1-6                  |
| Mode 2               | 3       |       | See Table 5.1-7                  |
| ID of satellite used | 24      |       | Sv on Channel 1                  |
| ID of satellite used | 07      |       | Sv on Channel 2                  |
| ....                 |         |       | ....                             |
| ID of satellite used |         |       | Sv on Channel 12                 |
| PDOP                 | 2.0     |       | Position Dilution of Precision   |
| HDOP                 | 1.1     |       | Horizontal Dilution of Precision |
| VDOP                 | 1.7     |       | Vertical Dilution of Precision   |
| Checksum             | *35     |       |                                  |

|           |  |                            |
|-----------|--|----------------------------|
| <CR> <LF> |  | End of message termination |
|-----------|--|----------------------------|

Table 5.1-6 Mode 1

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

Table 5.1-7 Mode 2

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

## ● GSV---GPS Satellites in View

Table 5.1-8 contains the values for the following example:

```
$GPGSV,3,1,12,28,81,285,42,24,67,302,46,31,54,354,,20,51,077,46*73
$GPGSV,3,2,12,17,41,328,45,07,32,315,45,04,31,250,40,11,25,046,41*75
$GPGSV,3,3,12,08,22,214,38,27,08,190,16,19,05,092,33,23,04,127,*7B
```

Table 5.1-8 GSV Data Format

| Name                                  | Example | Units   | Description  |
|---------------------------------------|---------|---------|--|
| Message ID                            | \$GPGSV |         | GSV protocol header                                |
| Total number of messages <sup>1</sup> | 3       |         | Range 1 to 3                                       |
| Message number <sup>1</sup>           | 1       |         | Range 1 to 3                                       |
| Satellites in view                    | 12      |         |  |
| Satellite ID                          | 28      |         | Channel 1 (Range 01 to 196)                        |
| Elevation                             | 81      | degrees | Channel 1 (Range 00 to 90)                         |
| Azimuth                               | 285     | 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                          | 20      |         | Channel 4 (Range 01 to 196)                        |
| Elevation                             | 51      | degrees | Channel 4 (Range 00 to 90)                         |
| Azimuth                               | 077     | degrees | Channel 4 (Range 000 to 359)                       |
| SNR (C/No)                            | 46      | dB-Hz   | Channel 4 (Range 00 to 99, null when not tracking) |
| Checksum                              | *73     |         |  |
| <CR> <LF>                             |         |         | End of message termination                         |

Note 1: Depending on the number of satellites tracked multiple messages of GSV data may be required.

## ● RMC---Recommended Minimum Specific GPS Data

Table 5.1-9 contains the values for the following example:

```
$GPRMC,053740.000,A,2503.6319,N,12136.0099,E,2.69,79.65,100106,,A*53
```

Table 5.1-9 RMC Data Format

| Name               | Example    | Units   | Description                                  |
|--------------------|------------|---------|--|
| Message ID         | \$GPRMC    |         | RMC protocol header                          |
| UTC Time           | 053740.000 |         | hhmmss.sss                                   |
| Status             | A          |         | A=data valid or V=data not valid             |
| Latitude           | 2503.6319  |         | ddmm.mmmm                                    |
| N/S Indicator      | N          |         | N=north or S=south                           |
| Longitude          | 12136.0099 |         | dddmm.mmmm                                   |
| E/W Indicator      | E          |         | E=east or W=west                             |
| Speed over ground  | 2.69       | knots   | True   |
| Course over ground | 79.65      | degrees |  |
| Date               | 100106     |         | ddmmyy                                       |
| Magnetic variation |            | degrees |  |
| Variation sense    |            |         | E=east or W=west (Not shown)                 |
| Mode               | A          |         | A=autonomous, D=DGPS, E=DR, N=Data not valid |
| Checksum           | *53        |         |  |
| <CR> <LF>          |            |         | End of message termination                   |

## ● VTG---Course Over Ground and Ground Speed

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

\$GPVTG,79.65,T,,M,2.69,N,5.0,K,A\*38

Table 5.1-10 VTG Data Format

| Name               | Example | Units   | Description                                  |
|--------------------|---------|---------|--|
| Message ID         | \$GPVTG |         | VTG protocol header                          |
| Course over ground | 79.65   | degrees | Measured heading                             |
| Reference          | T       |         | True   |
| Course over ground |         | degrees | Measured heading                             |
| Reference          | M       |         | Magnetic                                     |
| Speed over ground  | 2.69    | knots   | Measured speed                               |
| Units              | N       |         | Knots  |
| Speed over ground  | 5.0     | km/hr   | Measured speed                               |
| Units              | K       |         | Kilometer per hour                           |
| Mode               | A       |         | A=autonomous, D=DGPS, E=DR, N=Data not valid |
| Checksum           | *38     |         |  |
| <CR> <LF>          |         |         | End of message termination                   |

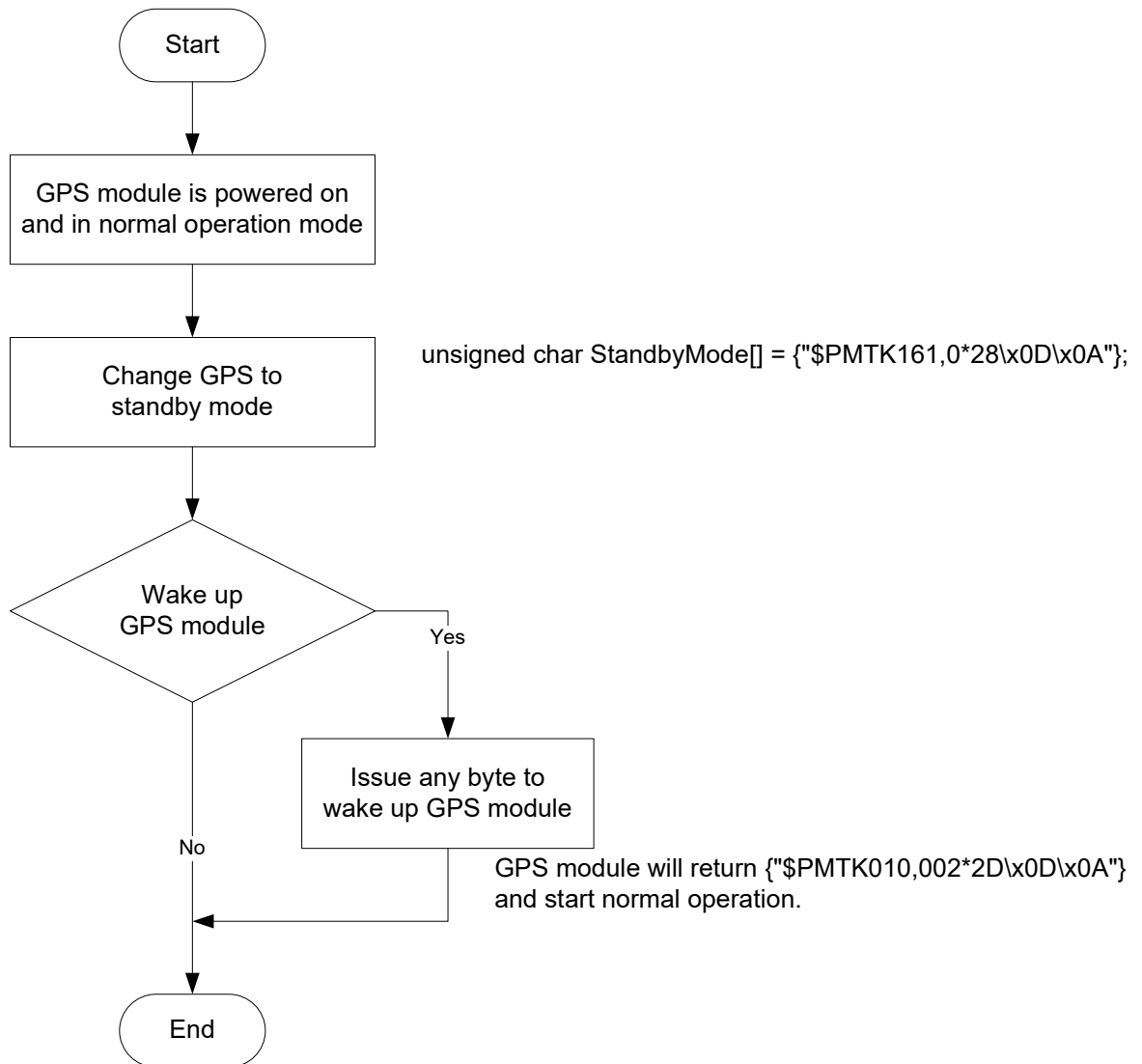
5.2 Proprietary NMEA input message

Please refer to MTK proprietary message.

5.3 Examples to configure the power mode of GPS module

5.3.1 Standby mode

User can issue software command to make GPS module go into standby mode that consumes less than 200uA current. GPS module will be awaked when receiving any byte. The following flow chart is an example to make GPS module go into standby mode and then wake up.



5.4 Examples to configure the update rate of GPS module

The GPS module supports up to 10Hz update rate that user can configure by issuing software commands. Note that the configurations by software commands are stored in the battery-backed SRAM that is powered through VBACKUP pin. Once it drains out, the default/factory settings will be applied.



Due to the transmitting capacity per second of the current baud rate, GPS module has to be changed to higher baud rate for high update rate of position fix. The user can use the following software commands to change baud rate.

| Baud rate       | Software command            |
|-----------------|-----------------------------|
| Factory default | \$PMTK251,0*28<CR><LF>      |
| 4800            | \$PMTK251,4800*14<CR><LF>   |
| 9600            | \$PMTK251,9600*17<CR><LF>   |
| 19200           | \$PMTK251,19200*22<CR><LF>  |
| 38400           | \$PMTK251,38400*27<CR><LF>  |
| 57600           | \$PMTK251,57600*2C<CR><LF>  |
| 115200          | \$PMTK251,115200*1F<CR><LF> |

Note: <CR> means Carriage Return, i.e. 0x0D in hexadecimal. <LF> means Line Feed, i.e. 0x0A in hexadecimal.

If the user does not want to change baud rate, you can reduce the output NMEA sentences by the following software commands.

| NMEA sentence   | Software command                                 |
|---|--|
| Factory default   | \$PMTK314,-1*04<CR><LF>                          |
| Only GLL at 1Hz   | \$PMTK314,1,0,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF> |
| Only RMC at 1Hz   | \$PMTK314,0,1,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF> |
| Only VTG at 1Hz   | \$PMTK314,0,0,1,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF> |
| Only GGA at 1Hz   | \$PMTK314,0,0,0,1,0,0,0,0,0,0,0,0,0,0*29<CR><LF> |
| Only GSA at 1Hz   | \$PMTK314,0,0,0,0,1,0,0,0,0,0,0,0,0,0*29<CR><LF> |
| Only GSV at 1Hz   | \$PMTK314,0,0,0,0,0,1,0,0,0,0,0,0,0,0*29<CR><LF> |
| Only ZDA at 1Hz   | \$PMTK314,0,0,0,0,0,0,0,0,0,0,0,0,0,1*29<CR><LF> |
| RMC, GGA, GSA at 1Hz and GSV at 0.2Hz   | \$PMTK314,0,1,0,1,1,5,0,0,0,0,0,0,0,0*2C<CR><LF> |
| If the command is correct and executed, GPS module will output message \$PMTK001,314,3*36<CR><LF> |  |

After the GPS module is changed to higher baud rate or reduced NMEA sentence, the user can configure it to high update rate of position fix by the following commands.

| Interval of position fix          | Software command         |
|-----------------------------------|--------------------------|
| Every 100ms (10Hz) <sup>(1)</sup> | \$PMTK220,100*2F<CR><LF> |
| Every 200ms (5Hz)                 | \$PMTK220,200*2C<CR><LF> |

|   |                           |
|---|---------------------------|
| Every 500ms (2Hz)   | \$PMTK220,500*2B<CR><LF>  |
| Every 1000ms (1Hz)  | \$PMTK220,1000*1F<CR><LF> |
| If the command is correct and executed, GPS module will output message \$PMTK001,220,3*30<CR><LF> |                           |

Note 1: The minimum interval of position fix is 100ms, i.e. the maximum update rate is 10Hz.

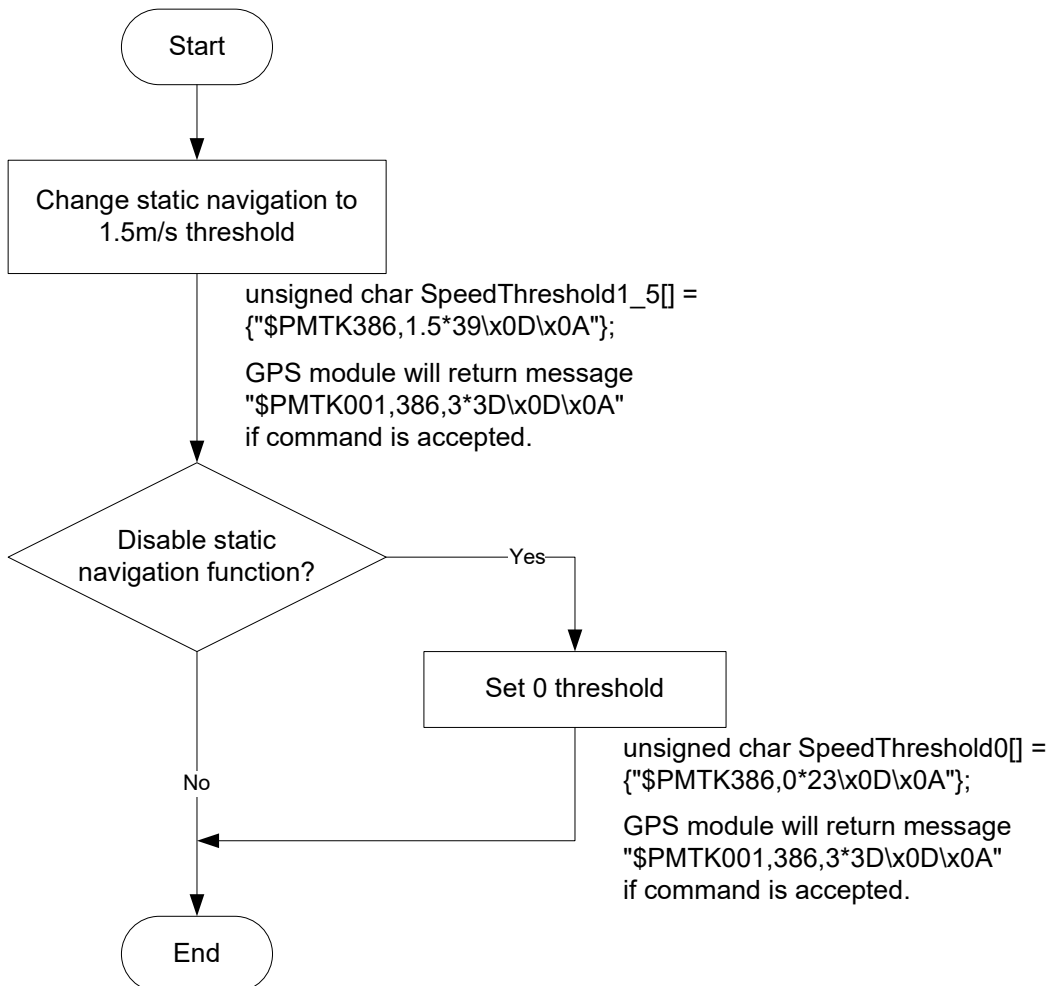
### 5.5 Configure the static navigation parameter

The output position of GPS module will keep the same and output speed will be zero if the actual speed is below the threshold of the static navigation parameter. This is useful for different applications. For example, the car stopped at a red light will get stationary GPS position if the threshold is 1.5m/s. It is better to disable this function by setting threshold to 0 for pedestrian navigation. This function is default disabled.

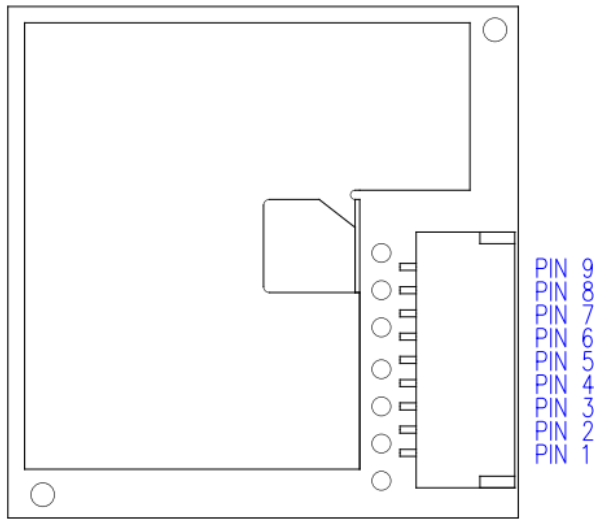
The format of the software command is as below.

\$PMTK386,speed threshold\*checksum<CR><LF>

The unit of speed threshold is meter per second. The range of speed threshold is from 0.1m/s to 2.0m/s. Value 0 is to disable the function.



## 6 Pin assignment and descriptions



| Pin # | Name   | Type | Description   |
|-------|--------|------|---|
| 1     | NC     |      | Not connect.  |
| 2     | 1PPS   | O    | Pulse per second (default 100 ms pulse/sec when 3D fix is available)                    |
| 3     | TX     | O    | Serial data output  |
| 4     | RX     | I    | Serial data input   |
| 5     | NC     |      | Not connect.  |
| 6     | NC     |      | Not connect.  |
| 7     | V_BCKP | P    | Backup battery supply voltage.<br><b>This pin must be powered to enable the module.</b> |
| 8     | GND    | P    | Ground  |
| 9     | VCC    | P    | DC supply voltage   |

7 DC & Temperature characteristics

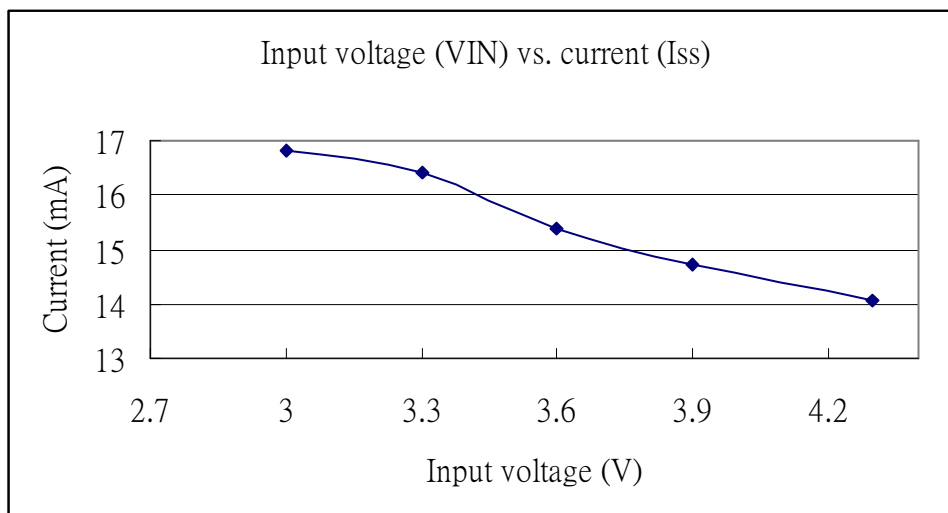
7.1 Absolute maximum ratings

| Parameter                    | Symbol | Ratings  | Units |
|------------------------------|--------|----------|-------|
| Input Voltage                | VCC    | 4.3      | V     |
| Input Backup Battery Voltage | V_BCKP | 4.3      | V     |
| Operating Temperature Range  | Topr   | -40 ~ 85 | °C    |
| Storage Temperature Range    | Tstg   | -40 ~ 85 | °C    |

7.2 DC Electrical characteristics

| Parameter                    | Symbol           | Conditions     | Min. | Typ.              | Max. | Units |
|------------------------------|------------------|----------------|------|-------------------|------|-------|
| Input Voltage                | VCC              |                | 3.0  |                   | 4.3  | V     |
| Input Backup Battery Voltage | V_BCKP           |                | 2.0  |                   | 4.3  | V     |
| Supply Current               | I <sub>VCC</sub> | Full operation |      | 17 <sup>(1)</sup> | 53   | mA    |
| Backup Battery Current       | I <sub>BAT</sub> | VCC = 0        |      | 6                 |      | uA    |
| High Level Input Voltage     | V <sub>IH</sub>  |                | 2.0  |                   | 3.6  | V     |
| Low Level Input Voltage      | V <sub>IL</sub>  |                | -0.3 |                   | 0.8  | V     |
| High Level Input Current     | I <sub>IH</sub>  |                | -1   |                   | 1    | uA    |
| Low Level Input Current      | I <sub>IL</sub>  |                | -1   |                   | 1    | uA    |
| High Level Output Voltage    | V <sub>OH</sub>  |                | 2.4  |                   | 3.3  | V     |
| Low Level Output Voltage     | V <sub>OL</sub>  |                |      |                   | 0.4  | V     |
| High Level Output Current    | I <sub>OH</sub>  |                |      | 2                 |      | mA    |
| Low Level Output Current     | I <sub>OL</sub>  |                |      | 2                 |      | mA    |

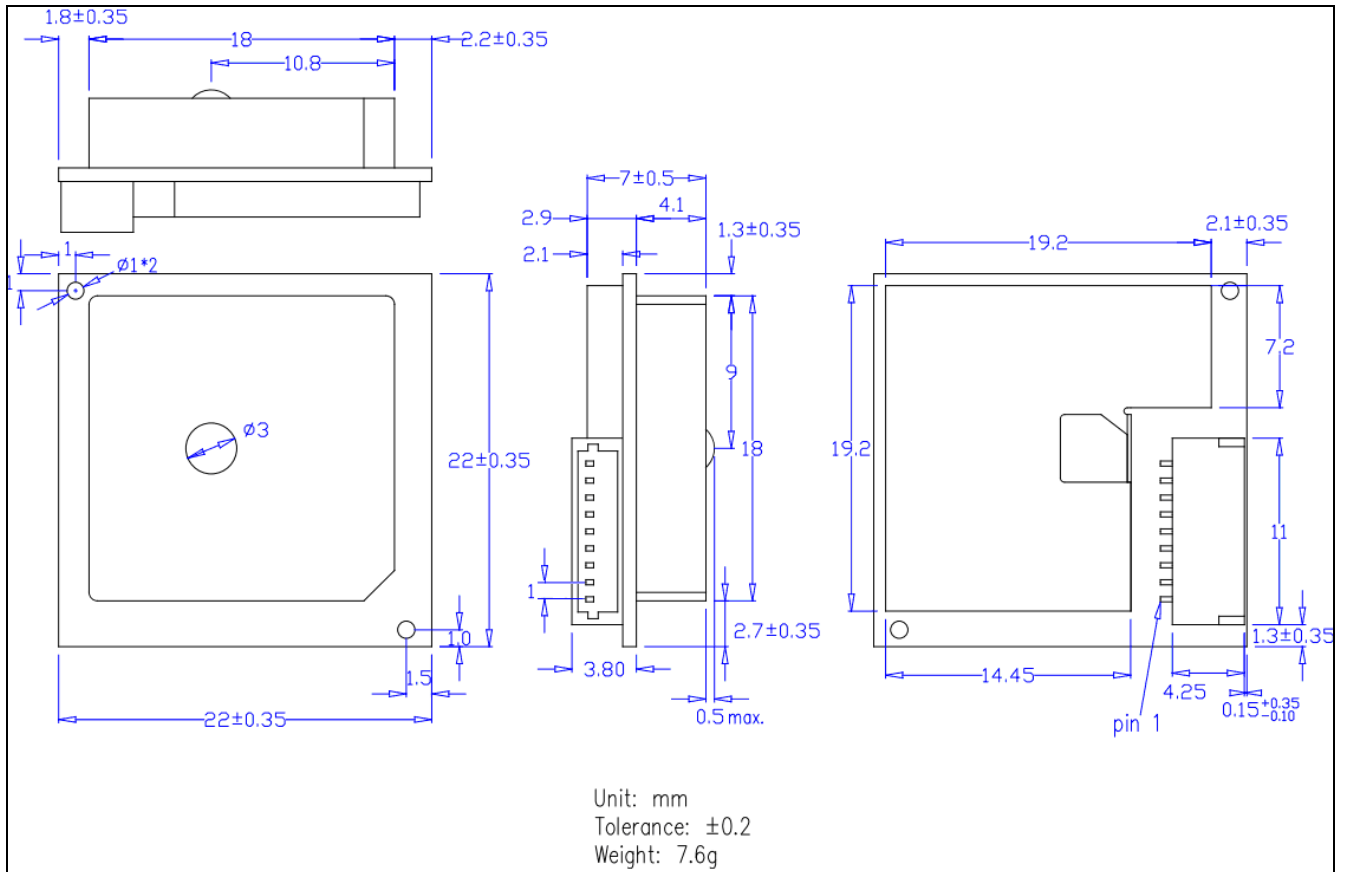
Note 1: Measured when position fix (1Hz) is available and input voltage is 3.3V. For different input voltage (VCC), the current consumption is as below chart. This is because LS2003E-2RE has a built-in DC/DC converter.



7.3 Temperature characteristics

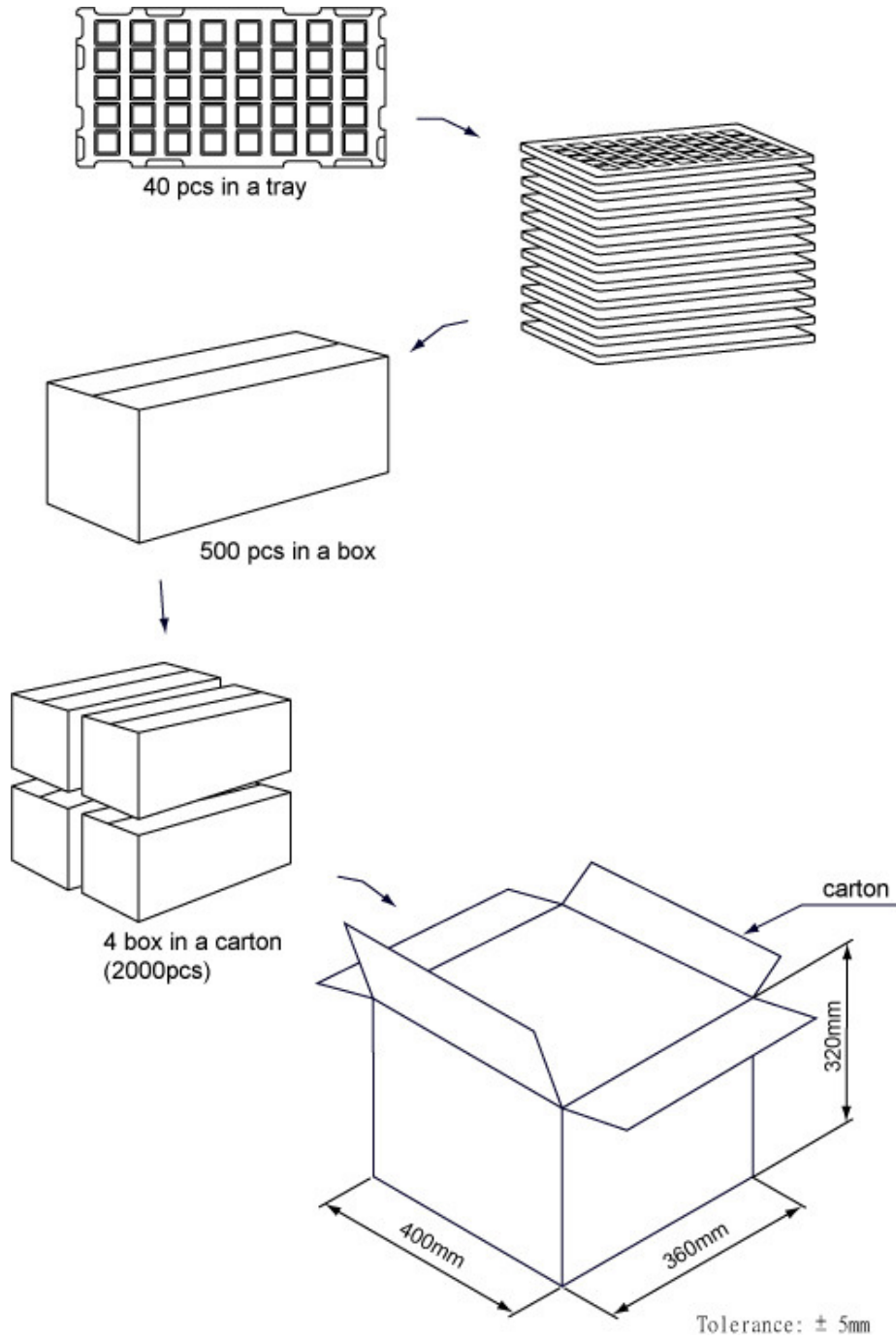
| Parameter             | Symbol | Min. | Typ. | Max. | Units |
|-----------------------|--------|------|------|------|-------|
| Operating Temperature | Topr   | -40  | -    | 85   | °C    |
| Storage Temperature   | Tstg   | -40  | 25   | 85   | °C    |

8 Mechanical specification



The connector's part number is 1W1001WOR0-09NA from the company, TOKUTSU. It belongs to WAFER horizontal SMT single row connector, pitch 1.0mm

9 Packing information



## Document change list

### Revision 1.0

- First release on Mar. 12, 2015

### Revision 1.0 to revision 1.1 (Jun 30, 2015)

- Revised product name from LS2003E-2R to LS2003E-2RE
- Revised chip from MT3337 to MT3337E
- Added support 1PPS synchronize with NMEA output feature
- Added support self-generate orbit prediction to achieve faster cold star feature
- Remove Capable of SBAS (WAAS, EGNOS, MSAS, GAGAN) feature
- Remove Section 5.3.2 Periodic mode and 5.3.3 AlwaysLocate™ mode feature

### Revision 1.1 to revision 1.2 (May 8, 2020)

- Changed the connector.
- Changed the pictures on page 1 and in section 6.
- Changed the dimension in section 8.