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| Product name | Description | Version |
|---|---|---|
| LS23030 | GPS mouse/ MTK3339,2m,USB,9600BPS (PPS over USB) | 1.4 |
| LS23032 | GPS mouse/ MTK3339,2m,PS2,9600BPS | |
| LS23033 | GPS mouse/ MTK3339,3m,RJ11,9600BPS | |
| LS23035 | GPS mouse/ MTK3339,5m,PS2 with lock,9600BPS | |
| LS23036 | GPS mouse/ MTK3339,3m,RJ11,9600BPS | |

Note: LS23036 is most popular. We recommend customers to use for their new design.

# Datasheet of GPS mouse, LS2303x series

## 1 Introduction

LS2303x series products are complete GPS receivers (also known as GPS mouse) based on the proven technology found in LOCOSYS 66 channel GPS SMD type receivers MC-1513 that use MediaTek chip solution. The GPS mouse will acquire up to 66 satellites at a time while providing fast Time-To-First-Fix, one-second navigation update and low power consumption. It can provide you with superior sensitivity and performance even in urban canyon and dense foliage environment. Its far-reaching capability meets the sensitivity requirements of car navigation as well as other location-based applications.

These products support hybrid ephemeris prediction to achieve faster cold start. One is self-generated ephemeris prediction 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 GPS module is powered on and satellites are available. The other is server-generated ephemeris prediction 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 cold start time less than 15 seconds.

## 2 Features

- MediaTek high sensitivity solution
- Support 66-channel GPS
- Low power consumption
- Fast TTFF at low signal level
- Built-in 12 multi-tone active interference canceller



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- Free hybrid ephemeris prediction to achieve faster cold start
- Built-in data logger
- Support AGPS
- Up to 10 Hz update rate
- Capable of SBAS (WAAS, EGNOS, MSAS)
- Support Japan QZSS
- 1 PPS over USB for timing application
- Linux/Android support
- Compatible with GPSD PPS support
- Indoor and outdoor multi-path detection and compensation
- Build-in micro battery to reserve system data for rapid satellite acquisition
- LED indicator for GPS fix or not fix
- Magnet for mounting on the car
- Skid resistant pad on the bottom
- Waterproof

## 3 Application

- Personal positioning and navigation
- Automotive navigation
- Marine navigation
- High-Quality NTP time server

## 4 GPS specification

| | | |
|---|---|---|
| GPS Chip | MediaTek MT3339 | |
| 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) | 32s (typical) without AGPS |
| | | <15s (typical) with AGPS (hybrid ephemeris prediction) |
| Position Accuracy | Autonomous | 3m (2D RMS) |
| | SBAS | 2.5m (depends on accuracy of correction data) |
| PPS Signal Accuracy | Chip level +/- 25ns , 1ms for PPS over USB [(2)] | |
| Datum | WGS-84 (default) | |
| Max. Altitude | < 50,000 m | |
| Max. Velocity | < 515 m/s | |
| Protocol Support | NMEA 0183 ver. 3.01 | 9600 bps[(1)], 8 data bits, no parity, 1 stop bits (default)<br>1Hz: GGA, GLL, GSA, GSV, RMC, VTG |

Note 1: Both baud rate and output message rate are configurable to be factory default.

2: The LS23030 makes PPS events visible for a compatible USB host system; they appear DCD state changes to the PL2303 driver. Its time precision will be limited by the USB pooling interval, usually 1 millisecond.



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# 5 Software interface

## 5.1 NMEA output message

*Table 5-1 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 |

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

Table 5-2 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,,*64

*Table5- 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 5-3 |
| 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 | | | |
| Checksum | *64 | | |
| <CR> <LF> | | | End of message termination |

*Table 5-3* Position Fix Indicators

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



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

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

Table 5-4 contains the values for the following example:

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

*Table 5-4* 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, R=Coarse Position, S=Simulator |
| Checksum | *52 | | |
| <CR> <LF> | | | End of message termination |

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

Table 5-5 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 5-5* GSA Data Format

| **Name** | **Example** | **Units** | **Description** |
|---|---|---|---|
| Message ID | $GPGSA | | GSA protocol header |
| Mode 1 | A | | See Table 5-6 |
| Mode 2 | 3 | | See Table 5-7 |
| 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 | | |



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

*Table 5-6 Mode 1*

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

*Table 5-7 Mode 2*

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

## ● GSV---GNSS Satellites in View

Table 5-8 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 5-8* GSV Data Format

| **Name** | **Example** | **Units** | **Description** |
|---|---|---|---|
| Message ID | $GPGSV | | GSV protocol header |
| Total number of messages[1] | 3 | | Range 1 to 3 |
| Message number[1] | 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 32) |
| 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 |

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

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

Table 5-9 contains the values for the following example:

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



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*Table 5-9* 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 | Not shown |
| Variation sense | | | E=east or W=west (Not shown) |
| Mode | A | | A=autonomous, D=DGPS, E=DR, N=Data not valid, R=Coarse Position, S=Simulator |
| Checksum | *53 | | |
| <CR> <LF> | | | End of message termination |

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

Table 5-10 contains the values for the following example:

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

*Table 5-10* 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, R=Coarse Position, S=Simulator |
| Checksum | *38 | | |
| <CR> <LF> | | | End of message termination |



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## 5.2 Proprietary NMEA input message

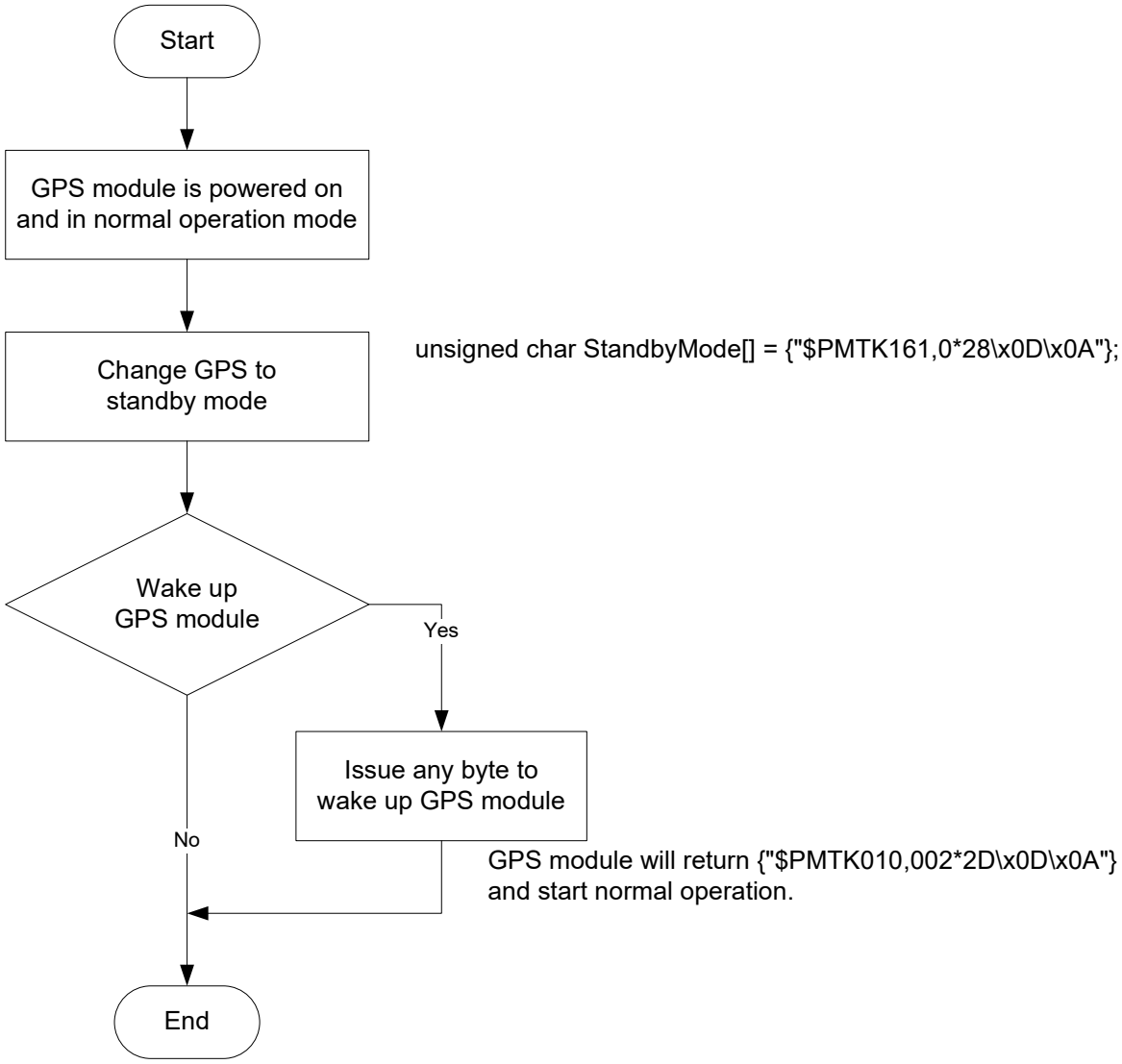
Please refer to MTK proprietary message.

## 5.3 Examples to configure the power mode of GPS module

The GPS module supports different power modes that user can configure by issuing software commands.

### 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.




### 5.3.2 Periodic mode

When GPS module is commanded to periodic mode, it will be in operation and standby periodically. Its status of power consumption is as below chart.



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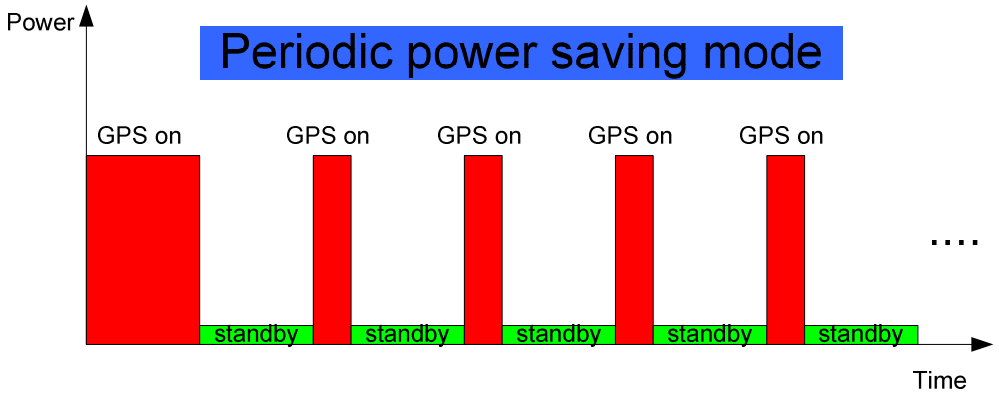
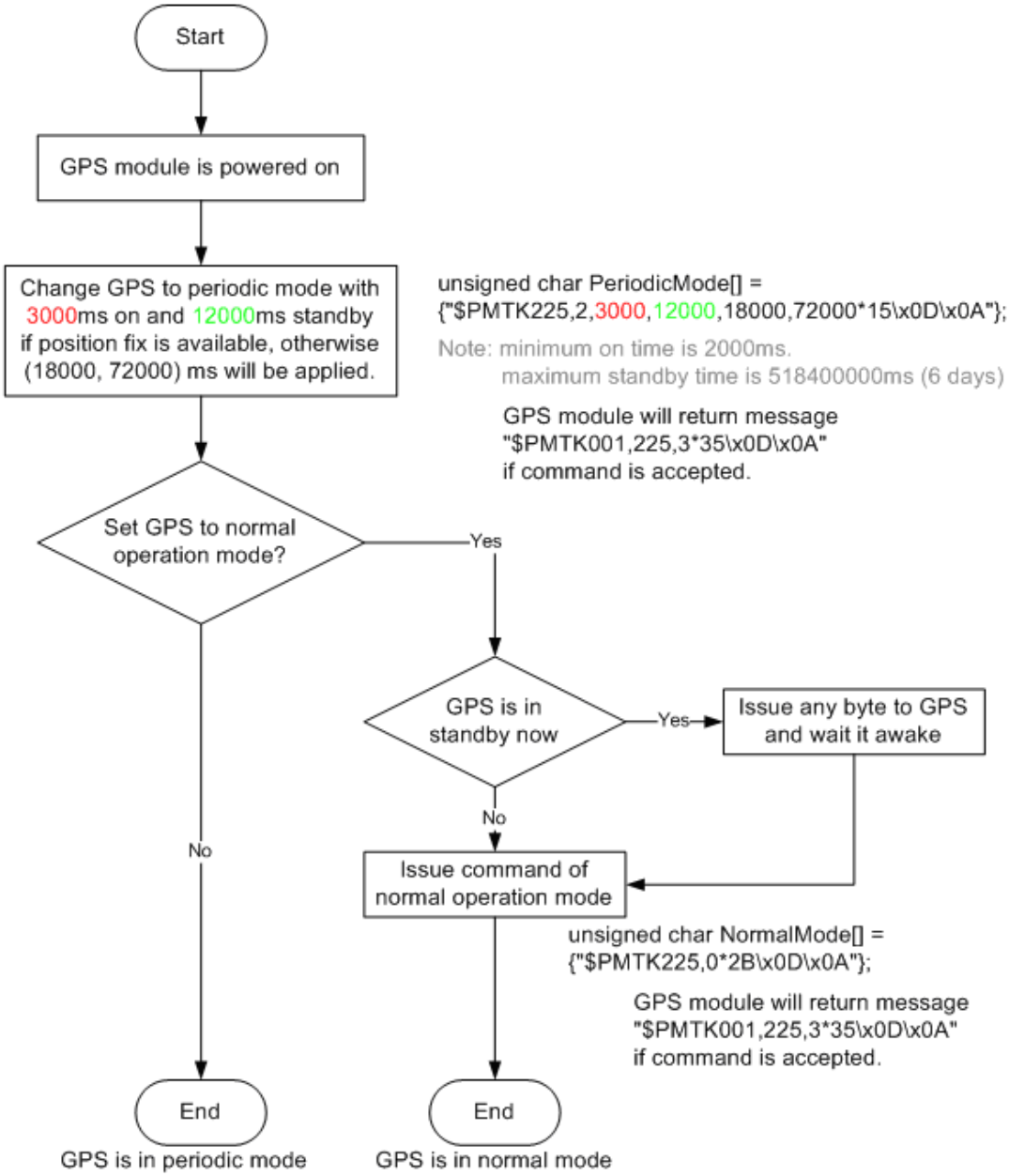



The following flow chart is an example to make GPS module go into periodic mode and then back to normal operation mode.



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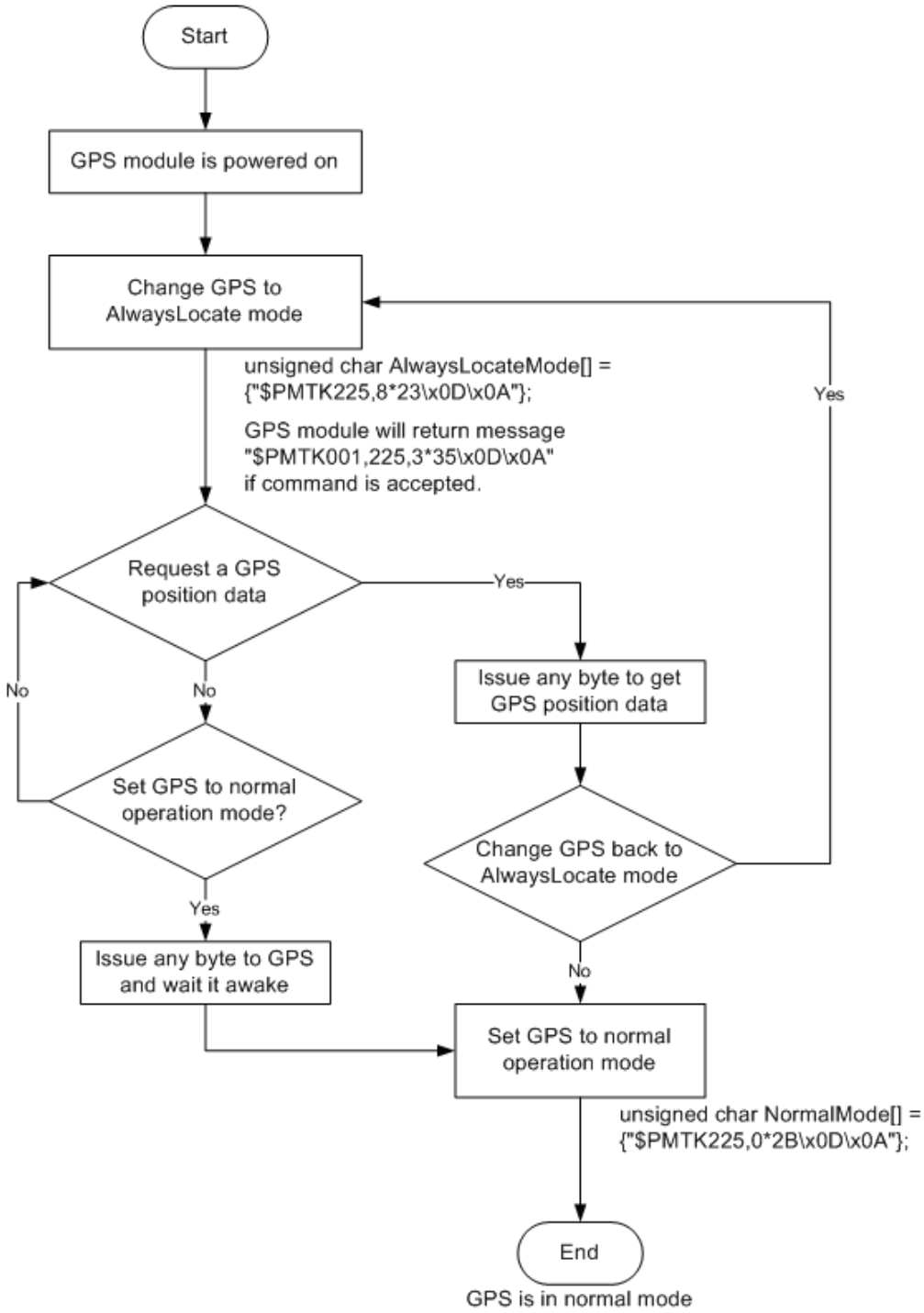
### 5.3.3 AlwaysLocate™ mode

AlwaysLocate™ is an intelligent controller of periodic mode. Depending on the environment and motion conditions, GPS module can adaptively adjust working/standby time to achieve balance of positioning accuracy and power consumption. In this mode, the host CPU does not need to control GPS module until the host CPU needs the GPS position data. The following flow chart is an example to make GPS module go into AlwaysLocate™ mode and then back to normal operation mode.

Note: AlwaysLocate™ is a trade mark of MTK.



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## 5.4 Data logger

The GPS module has internal flash memory for logging GPS data. The configurations include time interval, distance, speed, logging mode, and … etc. For more information, please contact us.

## 5.5 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 | $PMTK314,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF> |
| Only RMC at 1Hz | $PMTK314,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF> |
| Only VTG at 1Hz | $PMTK314,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF> |
| Only GGA at 1Hz | $PMTK314,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF> |
| Only GSA at 1Hz | $PMTK314,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF> |
| Only GSV at 1Hz | $PMTK314,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF> |
| Only ZDA at 1Hz | $PMTK314,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0*29<CR><LF> |
| RMC, GGA, GSA at 1Hz and GSV at 0.2Hz | $PMTK314,0,1,0,1,1,5,0,0,0,0,0,0,0,0,0,0,0,0*2C<CR><LF> |



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| |
|---|
| 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)(1) | $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> |
| Every 2000ms (0.5Hz)(2) | $PMTK220,2000*1C<CR><LF> |
| If the command is correct and executed, GPS module will output message $PMTK001,220,3*30<CR><LF> | |

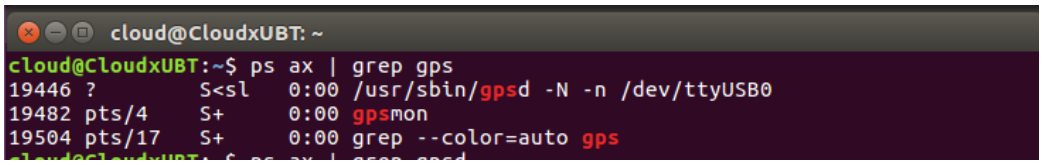
Note 1: The minimum interval of position fix is 100ms, i.e. the maximum update rate is 10Hz.

Note 2: The current consumption is the same with the update rate of 1Hz.

## 6 How to make sure LS23030's PPS over USB is working in Linux Ubuntu?

GPSD is daemon which uses to handle the NMEA and PPS information on Linux system. The GPSD client application called "gpsmon" could be used to check if PPS is working in Linux Ubuntu version 16.04.4. "gpsmon" is a monitor that watches packets coming from a GPS and displays them along with diagnostic information. Here provides some steps for installation of GPSD and verifying PPS performance on Linux system. User can check if a GPSD program has been installation on the Ubuntu. Using following command to determine if GPSD is running in system.

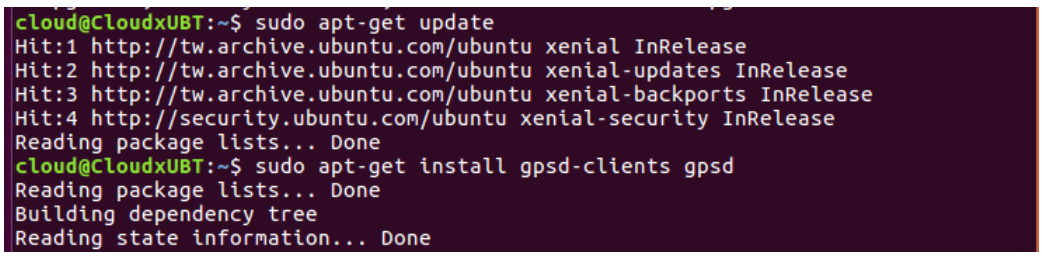
**$ps ax | grep gps**




User should install the GPSD package by following commands if it does not installation in Ubuntu.

**$sudo apt-get update**

**$sudo apt-get install gpsd-clients gpsd**



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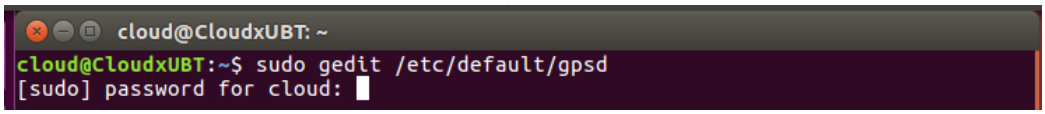
Before starting GPSD, LS23030 should connect to USB port. It normally enumerates a USB device such as "/dev/ttyUSB0" in this case. By using following command to determine device name if module is connecting to host by USB.

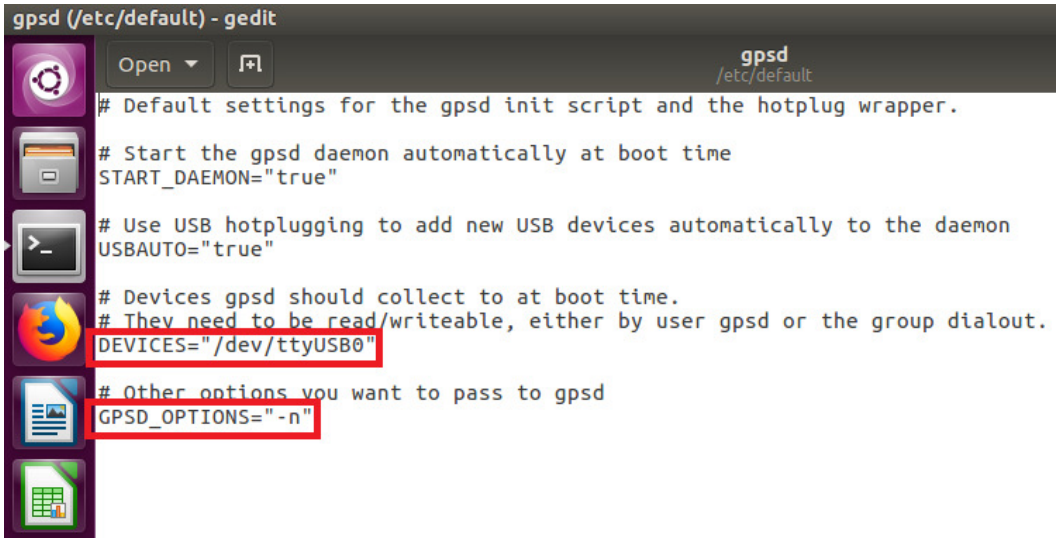
**$ls /dev/ttyU***

Now customer gets the device name as "/dev/ttyUSB0" and checks the GPSD file. By using following command to configure host file at "/etc/default/gpsd".

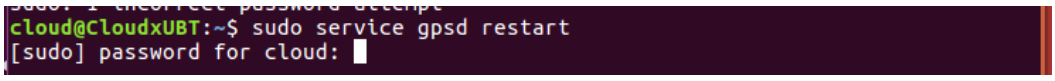
**$sudo gedit /etc/default/gpsd**




Please set the device name (DEVICE="/dev/ttyUSB0") and set GPSD options with the nowait (-n) parameter (GPSD_OPTIONS="-n") as following example then restart the GPSD service.

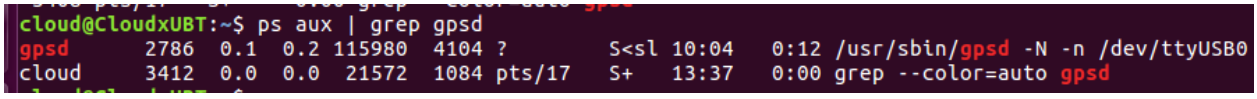



**$sudo service gpsd restart**




By using following command to check GPSD is working as expected. (“-n” and “/dev/ttyUSB0” parameters)

**$ps aux | grep gpsd**




Execute the GPSD client program.



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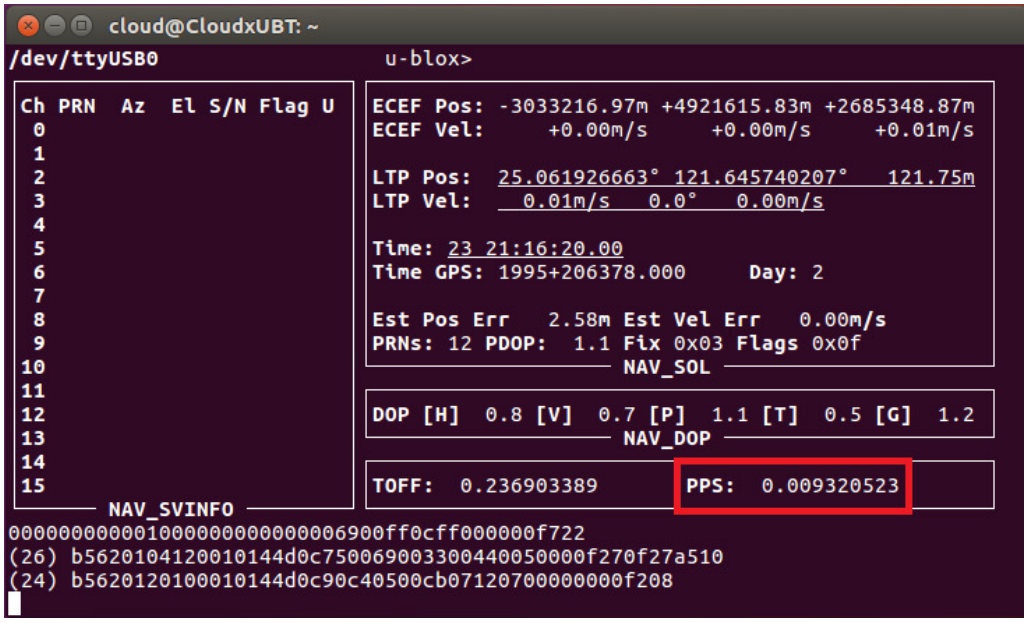
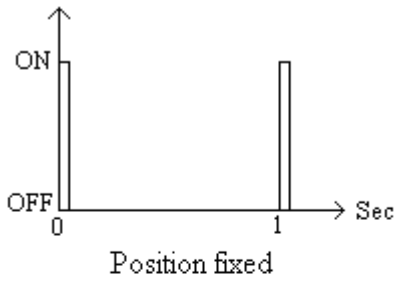
**$gpsmon**



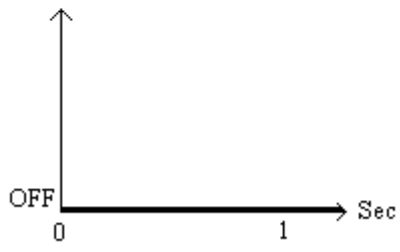

As shown above, PPS is detected with delay of 0.009320523 seconds to the local clock while delay of GPS is 0.236903389 seconds (shown by TOFF)

## 7 LED indicator

The red LED is an indicator of GPS positioning status. In continuous power mode, it flashes once per second when position is fixed. Otherwise it is off. The timing in detail is as below.




Position fixed




Position not fixed



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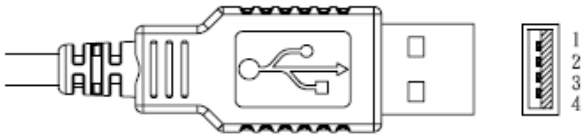
# 8 Pin assignment and descriptions

- **LS23030**

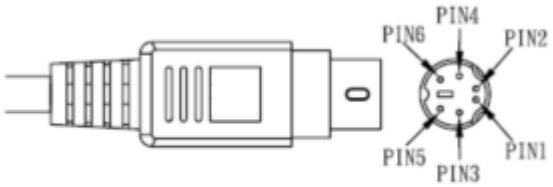
| Pin # | Name | Type | Description |
|---|---|---|---|
| 1 | VBUS | P | USB power input |
| 2 | D- | | D- line |
| 3 | D+ | | D+ line |
| 4 | GND | P | Ground |




USB A-TYPE Plug

- **LS23032**

| Pin # | Name | Type | Description |
|---|---|---|---|
| 1 | GND | P | Ground |
| 2 | VDD | P | Power input |
| 3 | NC | | Not connect |
| 4 | RX | I | Data input (RS232 level) |
| 5 | TX | O | Data output (RS232 level) |
| 6 | NC | | Not connect |




PS2 MALE

- **LS23033**

| Pin # | Name | Type | Description |
|---|---|---|---|
| 1 | VDD | P | Power input |
| 2 | RX | I | Data input (RS232 level) |
| 3 | TX | O | Data output (RS232 level) |
| 4 | GND | P | Ground |
| 5 | NC | | Not connect |
| 6 | NC | | Not connect |



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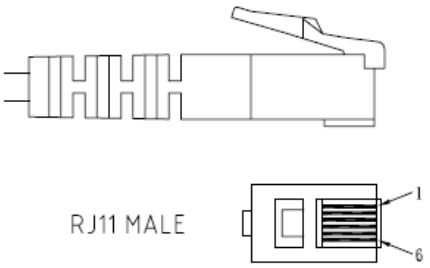
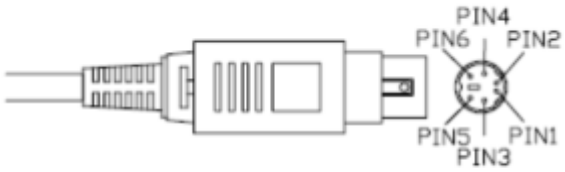



- **LS23035**

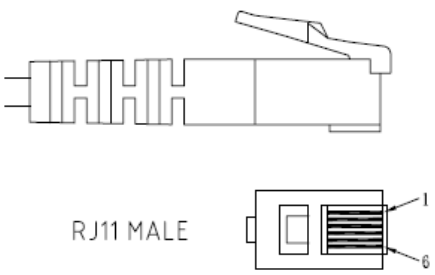
| Pin # | Name | Type | Description |
|---|---|---|---|
| 1 | VDD | P | Power input |
| 2 | GND | P | Ground |
| 3 | NC | | Not connect |
| 4 | TX | O | Data output (RS232 level) |
| 5 | RX | I | Data input (RS232 level) |
| 6 | NC | | Not connect |




PS2 MALE
with lock

- **LS23036**

| Pin # | Name | Type | Description |
|---|---|---|---|
| 1 | NC | | Not connect |
| 2 | GND | P | Ground |
| 3 | RX | I | Data input (RS232 level) |
| 4 | TX | O | Data output (RS232 level) |
| 5 | VDD | P | Power input |
| 6 | NC | | Not connect |



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# 9 DC & Temperature characteristics

## 9.1 Power consumption (continuous mode)

| Parameter | Symbol | Product | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Input voltage | VCC | LS23030 | 4.75 | 5 | 5.25 | V |
| | | LS23032 | 4 | 5 | 6 | |
| | | LS23033 | 4 | 5 | 6 | |
| | | LS23035 | 4 | 5 | 6 | |
| | | LS23036 | 4 | 5 | 6 | |
| Input current | Icc | LS23030 | | 22 (1) | | mA |
| | | LS23032 | | 19 (1) | | |
| | | LS23033 | | 19 (1) | | |
| | | LS23035 | | 19 (1) | | |
| | | LS23036 | | 19 (1) | | |

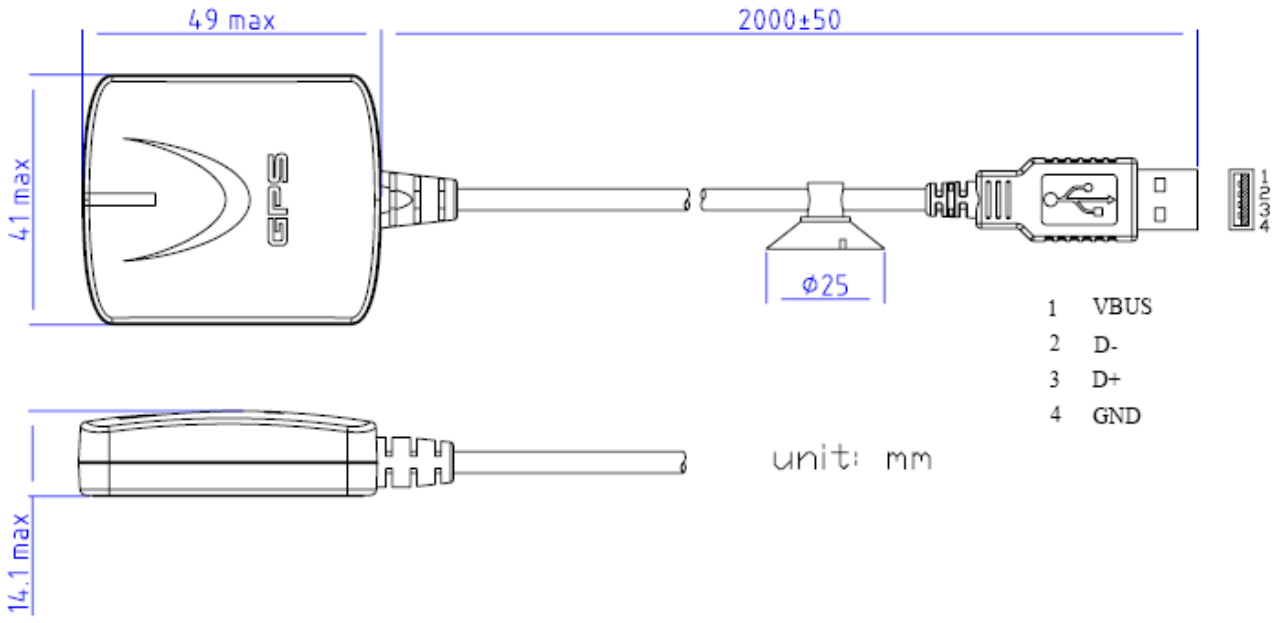
1. Measured when position fix (1Hz) is available and the function of self-generated ephemeris prediction is inactive.

## 9.2 Temperature characteristics

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

# 10 Mechanical specification

- **LS23030 (USB interface)**



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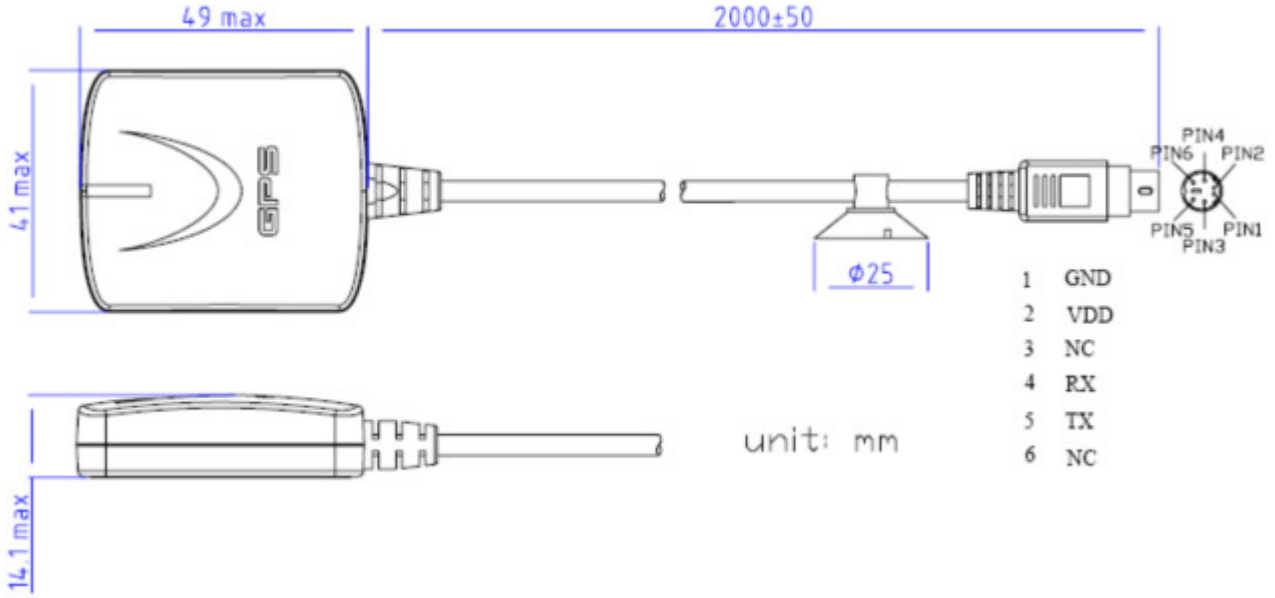
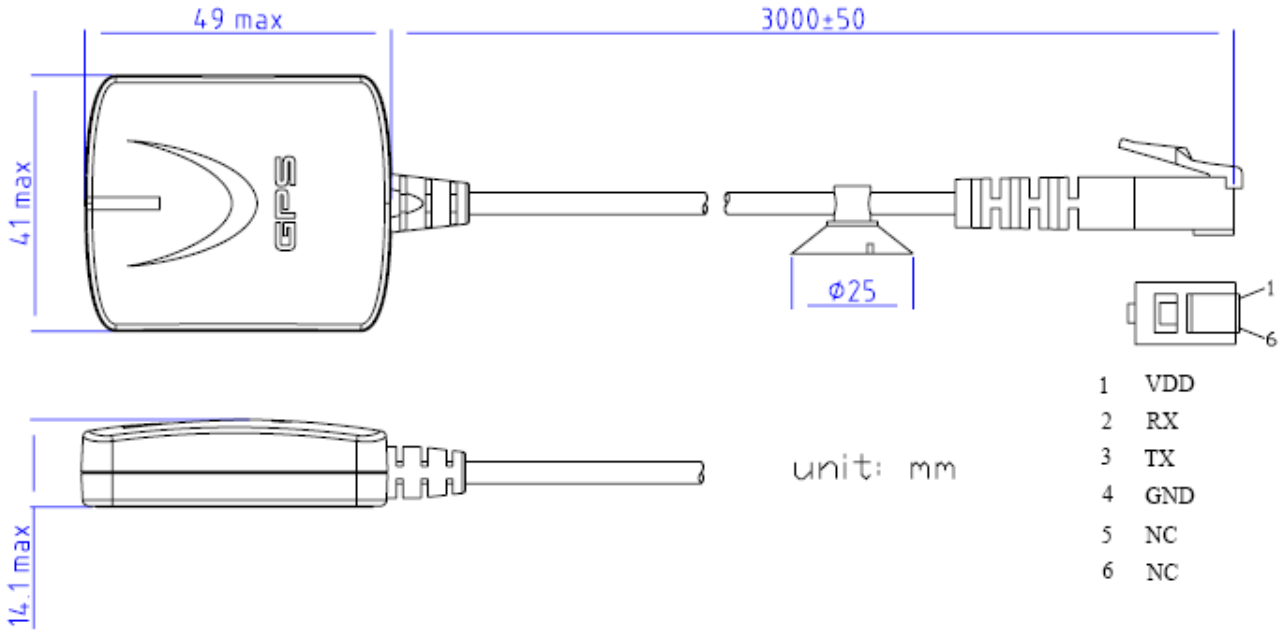
- **LS23032 (RS232 interface)**




- **LS23033 (RS232 interface)**



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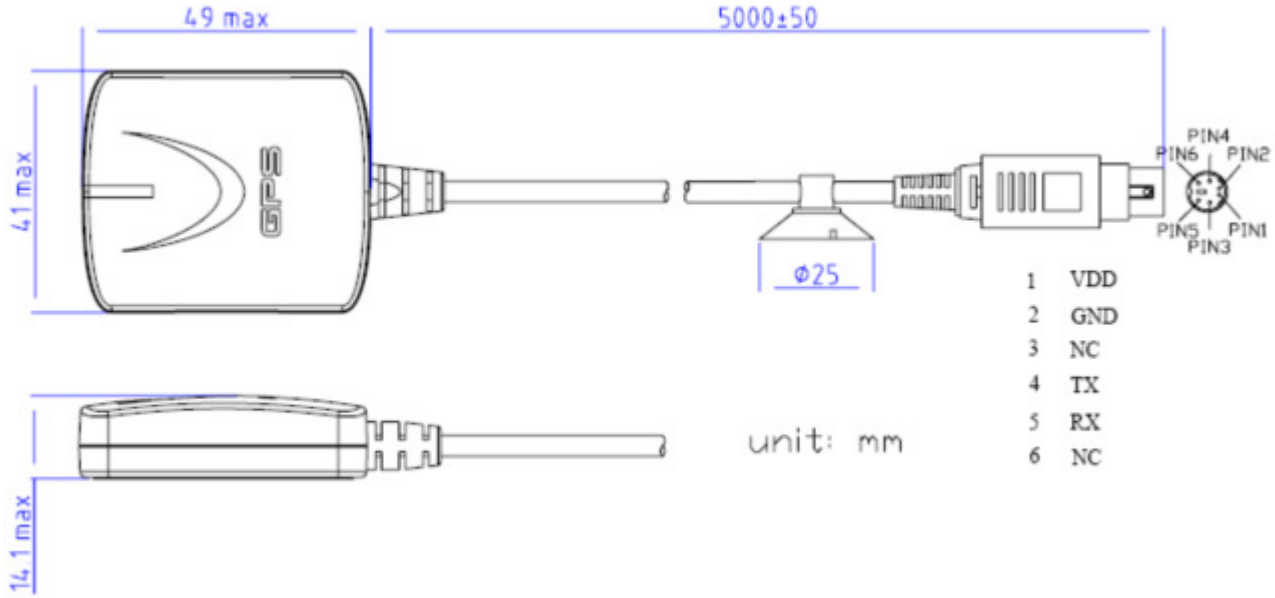
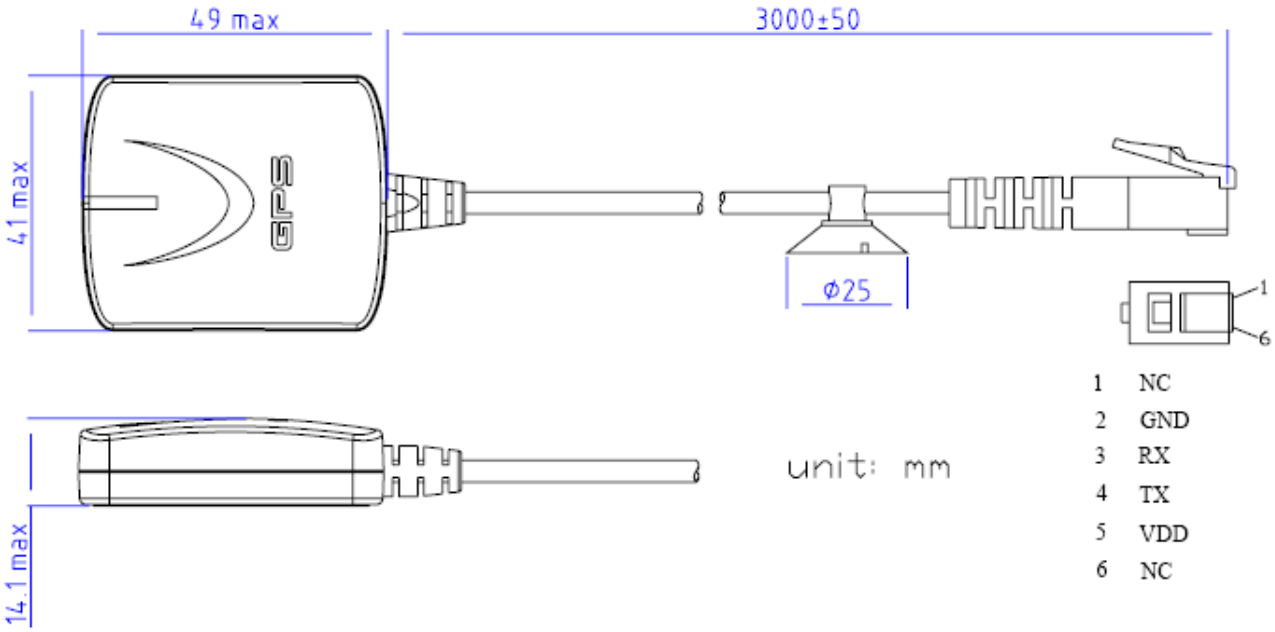
- **LS23035 (RS232 interface)**




- **LS23036 (RS232 interface)**



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# Document change list

## Revision 1.0

- First release on Oct. 25, 2007.

## Revision 1.0 to Revision 1.1 (July 20, 2009)

- Changed GPS chip from MT3318 to MT3329 on page 2.
- Added “Support AGPS” on page 1.
- Changed channels from 32 to 66 on page 2.
- Changed update rate from “up to 5Hz” to “up to 10Hz” on page 2.
- Changed hot start time from “2s (typical)” to “<2s (typical)” on page 2.
- Changed cold start time from 36s to 35s on page 2.
- Added “Note 1” on page 2.
- Changed typical current of LS23030 from 47mA to 29mA on page 9.
- Changed typical current of LS23032 from 46mA to 34mA on page 9.
- Changed typical current of LS23033 from 46mA to 34mA on page 10.
- Changed typical current of LS23035 from 46mA to 34mA on page 10.
- Changed typical current of LS23036 from 46mA to 34mA on page 10.

## Revision 1.1 to Revision 1.2 (February 10, 2012)

- Changed GPS chip from MT3329 to MT3339 on page 2.
- Added the description of hybrid ephemeris prediction in the section 1.
- Added several new features in the section 2.
- Changed hot start time from < 2s to < 1s on page 2.
- Changed cold start time from 35s to 32s on page 2.
- Changed Max. Altitude from 18,000m to 50,000m on page 2.
- Changed the range of satellite ID in GSV message from 32 to 196 on page 5.
- Added “N = data not valid, R=Coarse Position, S=Simulator” in GLL, RMC and VTG message.
- Added section 5.3, 5.4 and 5.5.
- Changed typical current of LS23030 from 29mA to 22mA in the section 8.1.
- Changed typical current of LS23032, LS23033, LS23035 and LS23036 from 34mA to 19mA in the section 8.1.

## Revision 1.2 to Revision 1.3 (April 19, 2018)

- Added “PPS over USB” on page1
- Added 1 PPS over USB for timing application feature in section 2
- Added Linux/Android support feature in section 2
- Added Compatible with GPSD PPS support feature in section 2
- Added High-Quality NTP time server application in section 3
- Added PPS Signal Accuracy specification in section 4
- Added “Note 2” on page 2.



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- Added section 6 “How to make sure LS23030’s PPS over USB is working in Linux Ubuntu?”

Revision 1.3 to Revision 1.4 (October 5, 2018)

- Added alternative cable pictures because the alternative appearance of cable strain relief of connector side has slight differences with original. If customer concerns with this part dimensions, please contact with us in advance.



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