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Product name	Description	Version
LS2013I(F)-G	GNSS with magnetic sensor smart antenna module, 115200BPS	1.1

Datasheet of GNSS with magnetic sensor smart antenna module, LS2013I(F)-G

Top View

Bottom View

1 Introduction

LS2013I(F)-G products is complete standalone GNSS smart antenna module, including embedded patch antenna and GNSS receiver circuits with built-in magnetic sensor, 3-axial acceleration sensor , for use in automotive, unmanned aerial vehicle and fleet vehicle. The module can simultaneously acquire and track multiple satellite constellations that include GPS, GLONASS, GALILEO, QZSS and SBAS. It can provide you with superior sensitivity and performance even in urban canyon and dense foliage environment. Its far-reaching capability meets slow speed or pedestrian mode applications.

2 Features

- GNSS + magnetic sensor + 3-axial acceleration sensor
- MediaTek high sensitivity solution.
- Support 99-channel GNSS
- Capable of SBAS (WAAS, EGNOS, MSAS, GAGAN)
- Support GPS, GLONASS, GALILEO and QZSS
- Fast TTFF at low signal level.
- Low power consumption
- Built-in 12 multi-tone active interference canceller
- Free hybrid ephemeries prediction to achieve faster cold star
- Build-in gold capacitor to reserve system data for rapid satellite acquisition.
- Up to 10 Hz update rate
- Indoor and outdoor multi-path detection and compensation
- LED indicator for position fix and calibration indicators
- Built-in data logger

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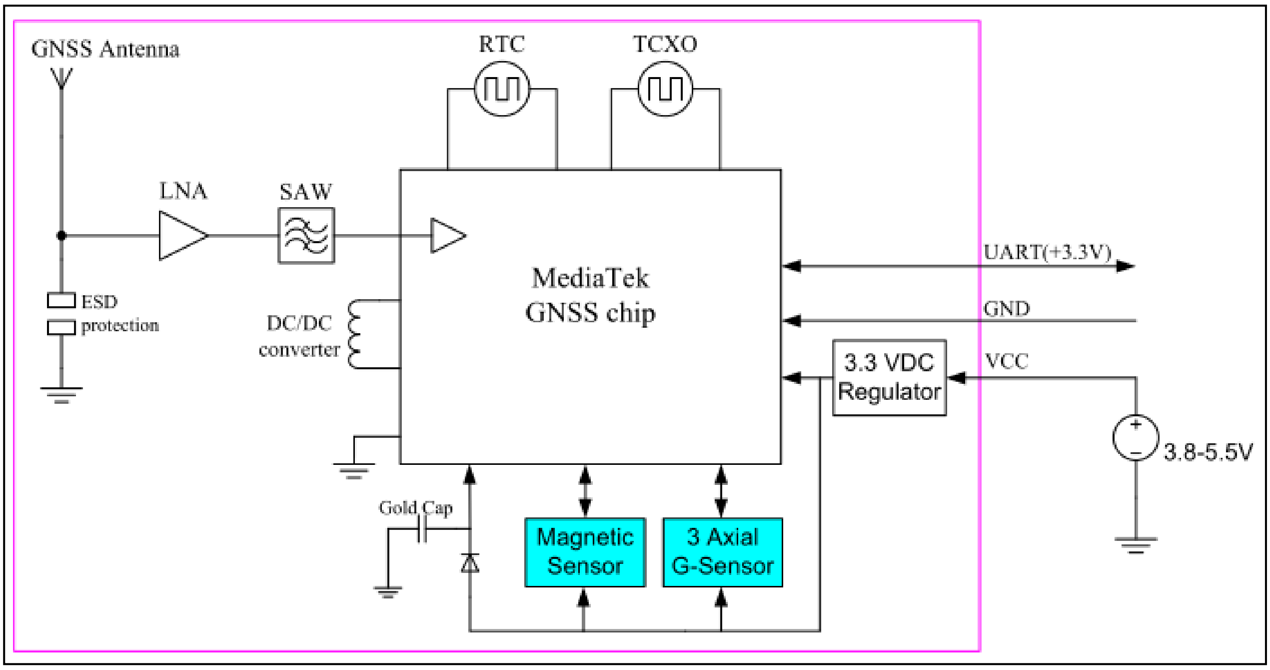
3 Application

- Personal positioning and navigation
- Automotive navigation, model aircraft navigation
- Unmanned aerial vehicle
- Marine navigation
- Surveying and mapping



4 GNSS specification

Chip	MediaTek MT3333	
Frequency	GPS, GALILEO, QZSS: L1 1575.42MHz, C/A code GLONASS: L1 1598.0625MHz ~ 1605.375MHz, C/A code	
Channels	Support 99 channels (33 Tracking, 99 Acquisition)	
Update rate	5Hz default, up to 10Hz	
Acquisition Time	Hot start (Open Sky)	1s (typical)
	Cold Start (Open Sky)	33s (typical)
Position Accuracy	Autonomous	2.5m CEP
	SBAS	2.5m (depends on accuracy of correction data)
Datum	WGS-84 (default)	
Max. Altitude	< 18,000 m, up to 50,000m by request	
Max. Velocity	< 515 m/s	
Protocol	NMEA 0183 ver 4.0	115200 bps, 8 data bits, no parity, 1 stop bits (default) 5Hz: GGA, GLL, GSA, RMC, VTG, HCHDG, PLSR 1Hz: GSV

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5 Magnetic sensor specification

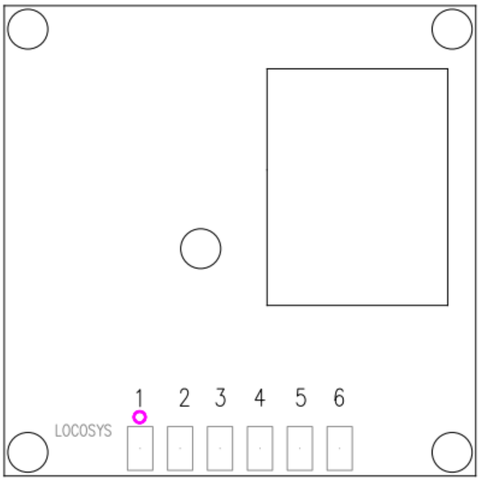
Maximum Measurable Magnetic Field Intensity	2000 µT (micro Tesla)
Magnetic Field Sensitivity (X, Y, Z)	0.3 µT/LSB
Sensitivity Axis Deviation	±5 (max.) degree after calibration
sampling time	1.3 ms (magnetic field intensity + temperature sampling)
Acceleration range	±2 g

6 LED indicator

Green LED flash (1Hz): GNSS position fix available

Red LED flash (1Hz): compass calibration complete

7 Pin assignment and descriptions



Bottom view

Fig 7.1 Pin assignment of LS2013I(F)-G

Pin#	Name	Type	Description
1	VCC	P	+5V power input
2	RX	I	Data input (3.3V_TTL)
3	TX	O	Data ouput (3.3V_TTL)
4	GND	P	Ground
5	N.C		No connection
6	N.C		No connection

8 DC & Temperature characteristics

8.1 Power consumption (continuous mode)

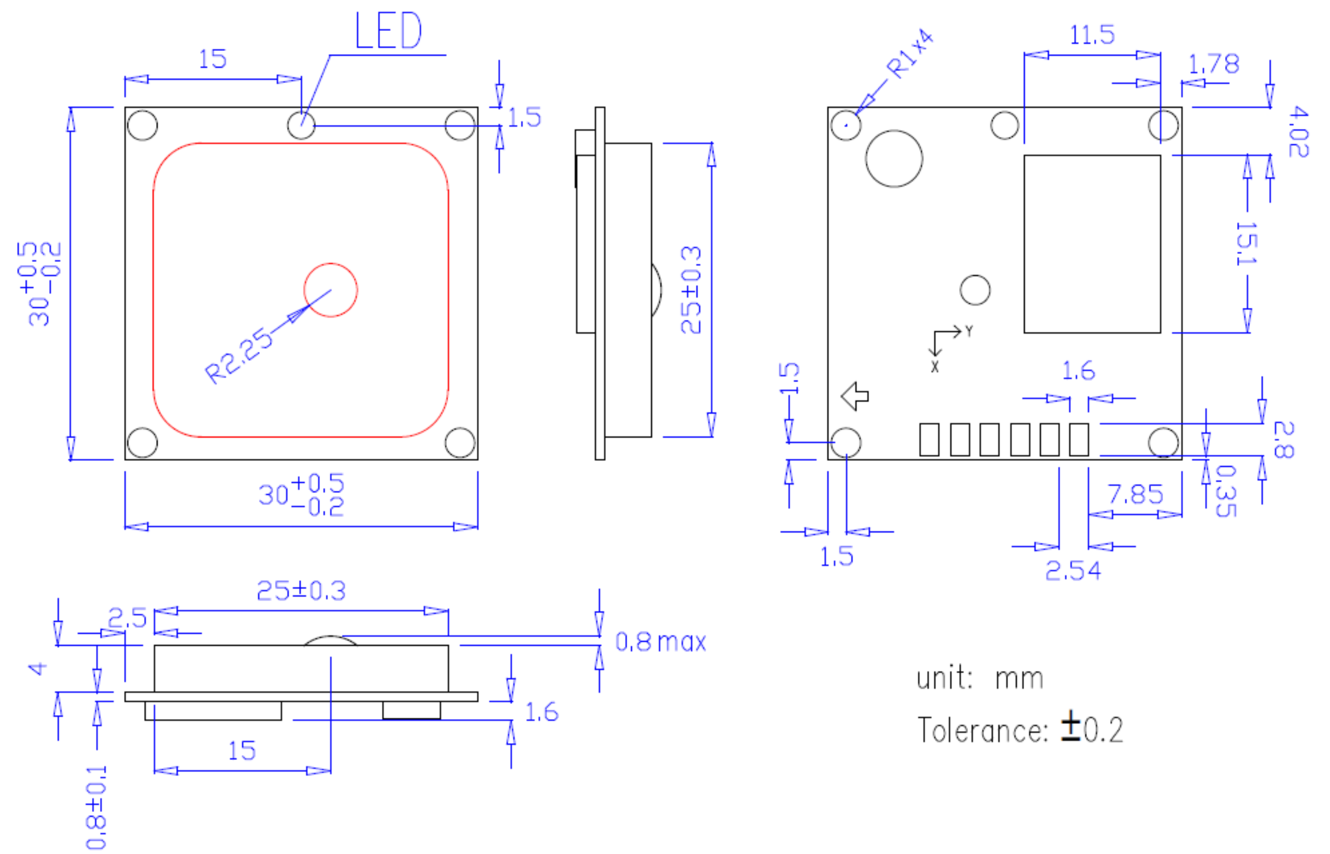
Parameter	Symbol	Product	Min.	Typ.	Max.	Units
Input voltage	VCC	LS2013I(F)-G	3.8	5.0	5.5	V
Input current	Icc	LS2013I(F)-G		29		mA

8.2 Temperature characteristics

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

9 Mechanical specification

- LS2013I(F)-G



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10 Software interface

10.1 NMEA output message

Table 10.1-1 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

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

Table 10.1-2 contains the values for the following example:

$GNGGA,054506.000,2503.7191,N,12138.7473,E,2,18,0.66,126.1,M,15.3,M,0000,0000*7D

Table 10.1- 2 GGA Data Format

Name	Example	Units	Description
Message ID	$GNGGA		GGA protocol header (GNGGA)
UTC Time	054506.000		hhmmss.sss
Latitude	2503.7191		ddmm.mmmm
N/S indicator	N		N=north or S=south
Longitude	12138.7473		dddmm.mmmm
E/W Indicator	E		E=east or W=west
Position Fix Indicator	2		See Table 10.1-3 (2: DGPS(RTCM) or SBAS)
Satellites Used	18		Range 0 to 33
HDOP	0.66		Horizontal Dilution of Precision
MSL Altitude	126.1	mters	
Units	M	mters	
Geoid Separation	15.3	mters	
Units	M	mters	
Age of Diff. Corr.	0000	second	Null fields when DGPS is not used
Diff. Ref. Station ID	0000		
Checksum	*7D		
<CR> <LF>			End of message termination

Table 10.1-3 Position Fix Indicators

Value	Description
0	Fix not available or invalid
1	GNSS 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 10.1-4 contains the values for the following example:

$GPGLL,2503.7123,N,12138.7446,E,183015.000,A,D*59

Table 10.1-4 GLL Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GPGLL		GLL protocol header
Latitude	2503.7123		ddmm.mmmm
N/S indicator	N		N=north or S=south
Longitude	12138.7446		dddmm.mmmm
E/W indicator	E		E=east or W=west
UTC Time	183015.000		hhmmss.sss
Status	A		A=data valid or V=data not valid
Mode	D		A=autonomous, D=DGPS, E=DR, N=Data not valid
Checksum	*59		
<CR> <LF>			End of message termination

● GSA---GNSS DOP and Active Satellites

Table 10.1-5 contains the values for the following example:

*$GNGSA,A,3,23,21,16,19,09,27,31,,,,,,1.10,0.78,0.78*1F*

Table 10.1-5 GSA Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GNGSA		GSA protocol header
Mode 1	A		See Table 10.1-6
Mode 2	3		See Table 10.1-7
ID of satellite used	23		Sv on Channel 1
ID of satellite used	21		Sv on Channel 2
….			….
ID of satellite used			Sv on Channel 12
PDOP	1.10		Position Dilution of Precision
HDOP	0.78		Horizontal Dilution of Precision
VDOP	0.78		Vertical Dilution of Precision
Checksum	*1F		
<CR> <LF>			End of message termination

Table 10.1-6 Mode 1

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

Table 10.1-7 Mode 2

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

- **GSV---GNSS Satellites in View**

Table 10.*1-8* contains the values for the following example:

*$GPGSV,3,1,10,27,85,205,49,42,54,141,41,16,51,356,47,19,49,208,47*72*

*$GPGSV,3,2,10,23,46,281,46,31,33,111,45,09,25,308,43,21,12,059,39*75*

*$GPGSV,3,3,10,193,,,40,04,,,33*43*

*$GLGSV,2,1,06,85,71,078,37,75,43,003,38,86,41,186,43,74,35,076,44*6A*

*$GLGSV,2,2,06,84,26,032,30,66,07,306,35*6D*

Table 10.1-8 GSV Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GPGSV		GSV protocol header
Total number of messages[1]	3		Range 1 to 4
Message number[1]	1		Range 1 to 4
Satellites in view	10		
Satellite ID	27		Channel 1 (Range 01 to 196)
Elevation	85	degrees	Channel 1 (Range 00 to 90)
Azimuth	205	degrees	Channel 1 (Range 000 to 359)
SNR (C/No)	49	dB-Hz	Channel 1 (Range 00 to 99, null when not tracking)
….			….
Satellite ID	42		Channel 4 (Range 01 to 196)
Elevation	54	degrees	Channel 4 (Range 00 to 90)
Azimuth	141	degrees	Channel 4 (Range 000 to 359)
SNR (C/No)	41	dB-Hz	Channel 4 (Range 00 to 99, null when not tracking)
Checksum	*72		
<CR> <LF>			End of message termination

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

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● RMC---Recommended Minimum Specific GNSS Data

Table 10.1-9 contains the values for the following example:

$GNRMC,081419.000,A,2503.7150,N,12138.7463,E,0.01,0.00,160415,,,A*7B

Table 10.1-9 RMC Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GNRMC		RMC protocol header
UTC Time	081419.000		hhmmss.sss
Status	A		A=data valid or V=data not valid
Latitude	2503.7150		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12138.7463,		dddmm.mmmm
E/W Indicator	E		E=east or W=west
Speed over ground	0.01	knots	True
Course over ground	0.00	degrees	
Date	160415		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	*7B		
<CR> <LF>			End of message termination

● VTG---Course Over Ground and Ground Speed

Table 10.1-10 contains the values for the following example:

$GNVTG,172.67,T,,M,0.00,N,0.01,K,D*22

Table 10.1-10 VTG Data Format

Name	**Example**	**Units**	**Description**
Message ID	$GPVTG		VTG protocol header
Course over ground	172.67	degrees	Measured heading
Reference	T		True
Course over ground		degrees	Measured heading
Reference	M		Magnetic
Speed over ground	0.00,	knots	Measured speed
Units	N		Knots
Speed over ground	0.01	km/hr	Measured speed
Units	K		Kilometer per hour
Mode	D		A=autonomous, D=DGPS, E=DR, N=Data not valid
Checksum	*38		

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<CR> <LF>			End of message termination

10.2 Proprietary messages for magnetic sensor

- ### HCHDG---Deviation and Variation

The HCHDG heading contains the values for the following example:

$HCHDG,118.8,,,4.3,W*3C

Table 10.2-1 HCHDG Heading

Name	**Example**	**Units**	**Description**
Message ID	$HCHDG		
Heading	118.8	degree	Magnetic Sensor heading in degrees
Deviation		degree	Magnetic Deviation, degrees
Deviation Direction			Magnetic Deviation direction, E = Easterly, W = Westerly
Variation	4.3	degree	Magnetic Variation degrees
Variation Direction	W		Magnetic Variation direction, E = Easterly, W = Westerly
Checksum	*3C		
<CR> <LF>			End of message termination

- ### PLSR Compass Measurement Report 1---calibration and acceleration

The PLSR compass measurement report 1 contains the values for the following example:

*$PLSR,245,1,118.7,7,133,-10,-1,252,28,0,2*19*

Table 10.2-2 PLSR compass measurement report 1

Name	**Example**	**Units**	**Description**
Sentence ID	$PLSR,245,1		
Magnetic Direction	118.7	degree	Magnetic direction: 0-360 degree, north: 0
Calibration Status	7		0:none calibration 1:old calibration data loaded 7:new calibration complete, “Magnetic direction” is valid
Magnetic Field Intensity	133		magnetic Field Intensity: 0..1000
Acceleration X	-10	degree	Acceleration X:-512 to 511 (-2.0 G to + 2.0 G)
Acceleration Y	-1		Acceleration Y:-512 to 511 (-2.0 G to + 2.0 G)
Acceleration Z	252		Acceleration Z:-512 to 511 (-2.0 G to + 2.0 G)
Temperature	28	Celisus	Receiver temperature in Celsius(°C)
Mounting Mode[1]	0		Receiver mounting mode: 0..3, default 0 (see Table 10.2-3)
Calibration complete count	2		calibration complete count
Checksum	*19		
<CR> <LF>			End of message termination

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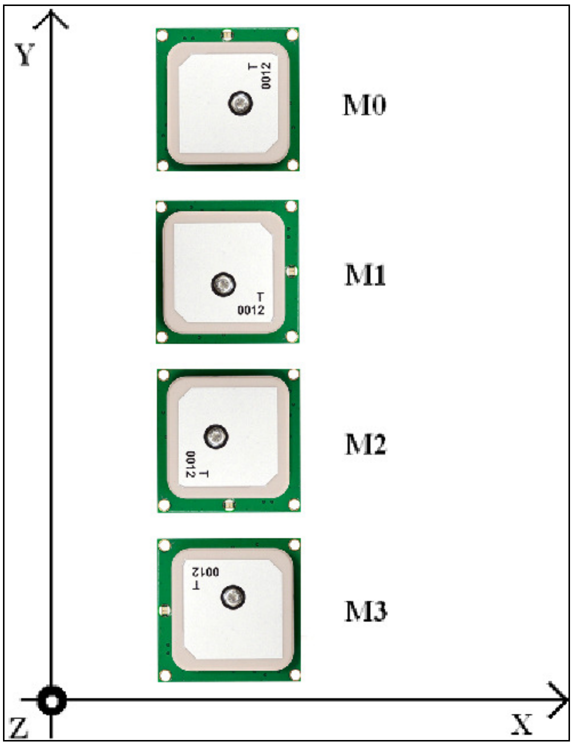
Table 10.2-3



● PLSR Compass Measurement Report 2---attitude

The PLSR compass measurement report 2 contains a set of the attitude vectors, each row of the matrix means attitude vector and it is normalized with 0x1000; the values for the following example:

$PLSR,245,2,2679,-3094,-194,3073,2686,-356,395,87,4079*22

Table 10.2-4 PLSR compass measurement report 2

Name	**Example**	**Units**	**Description**
Sentence ID	$PLSR,245,2		
Xx	2679		X acceleration data on X axis
Yx	-3094		Y acceleration data on X axis
Zx	-194		Z acceleration data on X axis
Xy	3073		X acceleration data on Y axis
Yy	2686		Y acceleration data on Y axis
Zy	-356		Z acceleration data on Y axis
Xz	395		X acceleration data on Z axis
Yz	87		Y acceleration data on Z axis
Zz	4079		Z acceleration data on Z axis
Checksum	*22		
<CR> <LF>			End of message termination

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- **GNSS speed---3D GNSS speed output (ECEF coordinate)**

The GNSS speed contains the values for the following example:

$PLSR,245,7,0,0,0*05

Table 10.2-5 GNSS speed output

Name	Example	Units	Description
Sentence ID	$PLSR,245,7		
GNSS speed(east)	0	cm/sec	
GNSS speed(north)	0	cm/sec	
GNSS speed(up)	0	cm/sec	
Checksum	*05		
<CR> <LF>			End of message termination

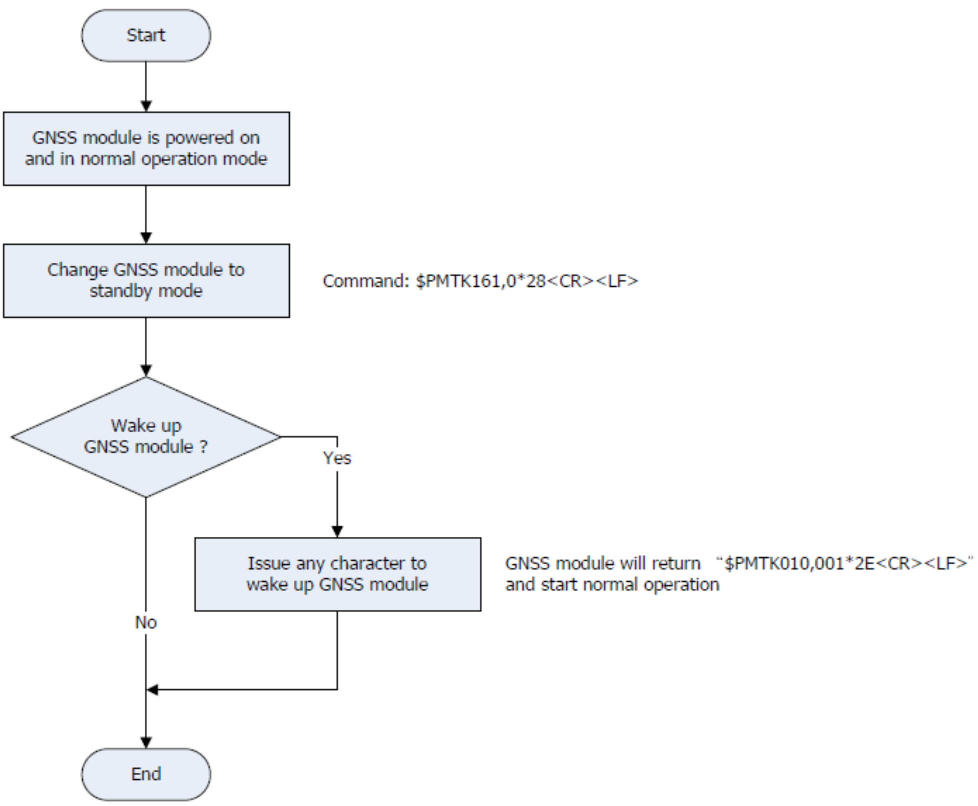
10.3 Proprietary NMEA input message

Please refer to MTK proprietary message.

10.4 Examples to configure the power mode of GNSS module

10.4.1 Standby mode

User can issue software command to make GNSS module go into standby mode that consumes less than 500uA current. GNSS module will be awaked when receiving any byte. The following flow chart is an example to make GNSS module go into standby mode and then wake up.



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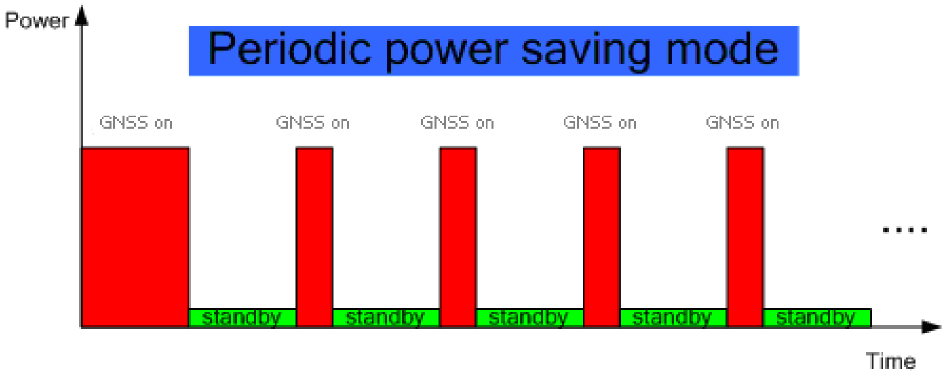
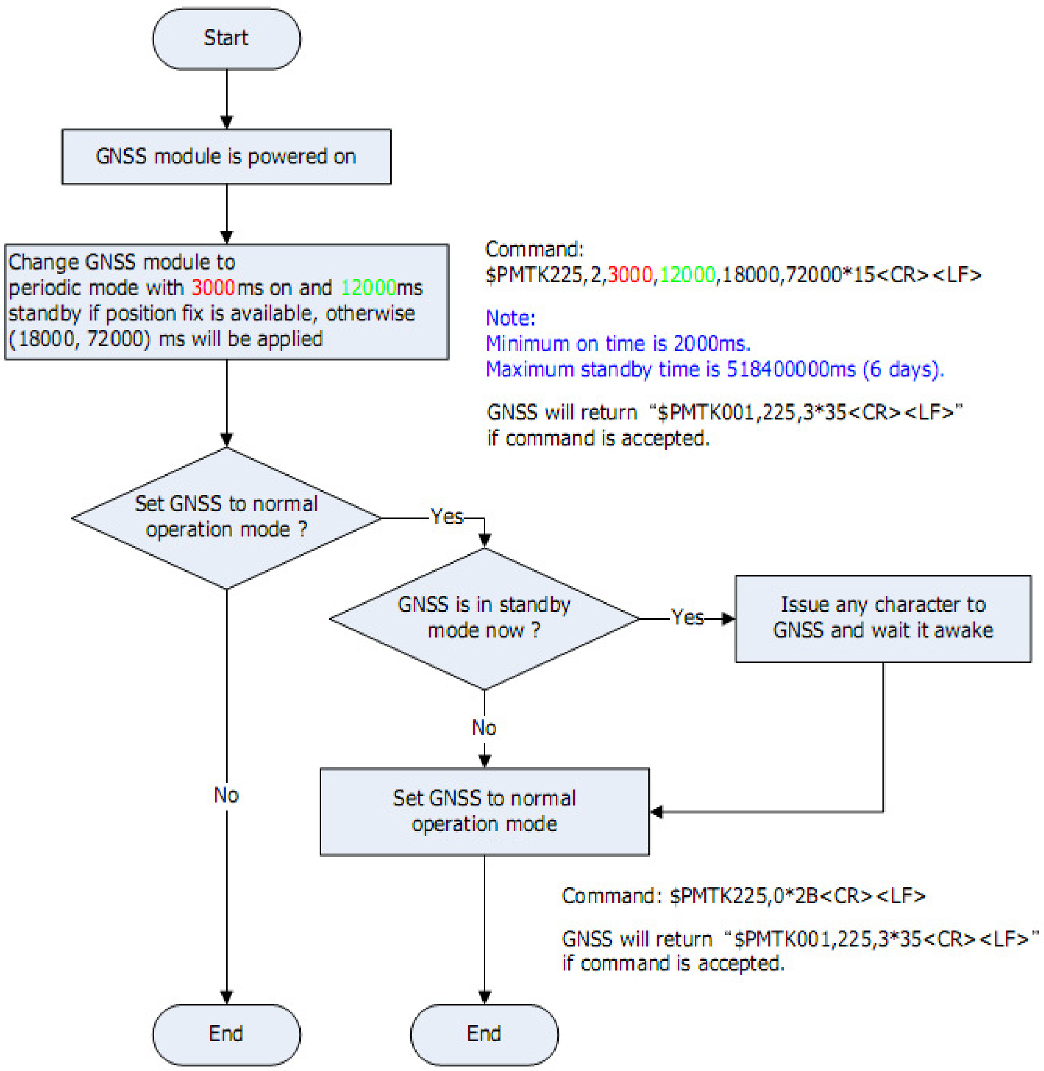
10.4.2 Periodic mode

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



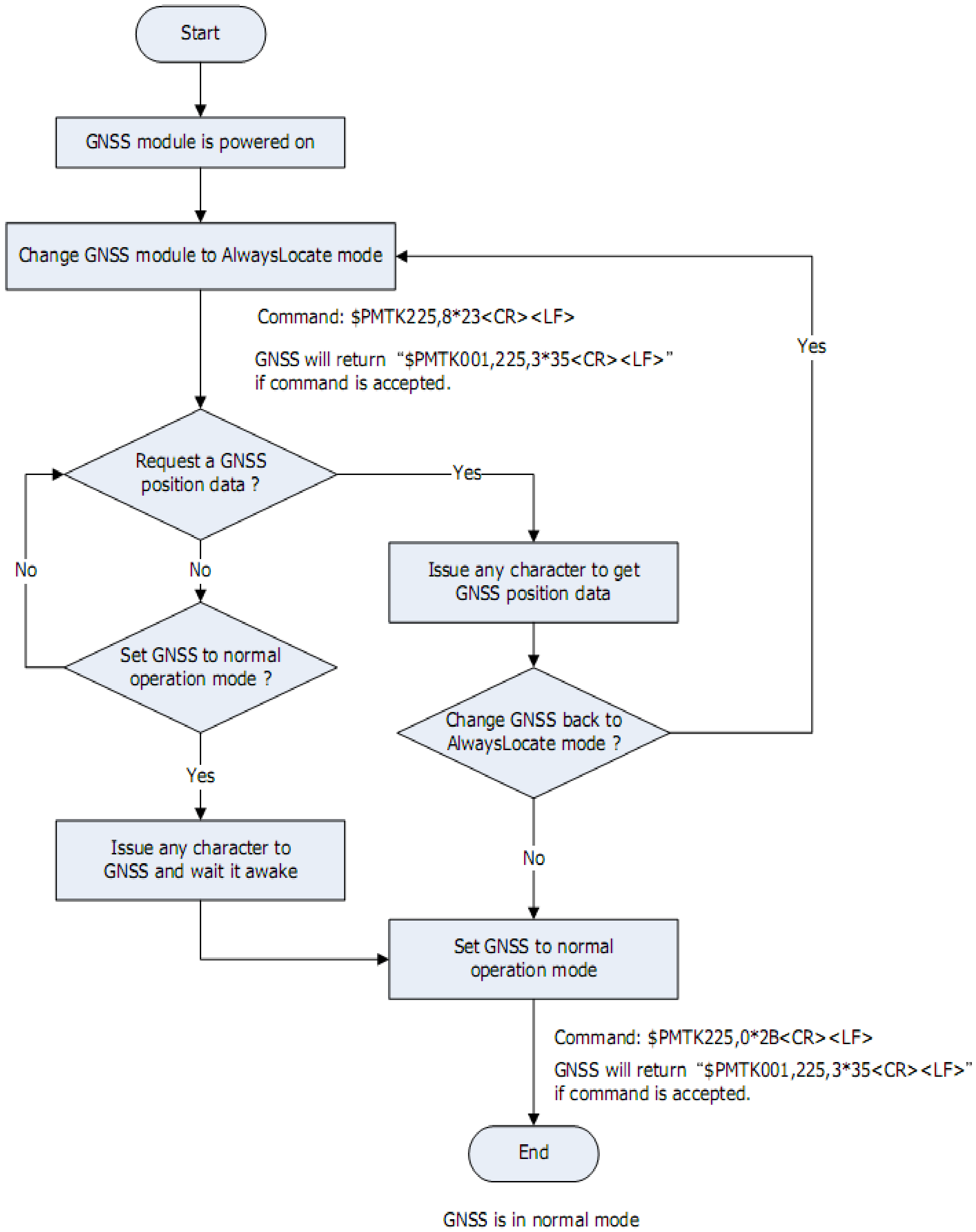
The following flow chart is an example to make GNSS module go into periodic mode and then back to normal operation mode.



10.4.3 AlwaysLocate™ mode

AlwaysLocate™ is an intelligent controller of periodic mode. Depending on the environment and motion conditions, GNSS 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 GNSS module until the host CPU needs the GNSS position data. The following flow chart is an example to make GNSS module go into AlwaysLocate^Tm mode and then back to normal operation mode.

Note: AlwaysLocate™ is a trade mark of MTK.



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10.5 Data logger

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

10.6 Examples to configure the update rate of GNSS module

The GNSS 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, GNSS 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	$PMTK314,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF>
Only RMC at 1Hz	$PMTK314,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF>
Only VTG at 1Hz	$PMTK314,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF>
Only GGA at 1Hz	$PMTK314,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF>
Only GSA at 1Hz	$PMTK314,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF>
Only GSV at 1Hz	$PMTK314,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0*29<CR><LF>
Only ZDA at 1Hz	$PMTK314,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0*29<CR><LF>
RMC, GGA, GSA	$PMTK314,0,1,0,1,1,5,0,0,0,0,0,0,0,0,0,0,0,0,0*2C<CR><LF>

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at 1Hz and GSV at 0.2Hz	
If the command is correct and executed, GNSS module will output message $PMTK001,314,3*36<CR><LF>	

After the GNSS 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, GNSS 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.

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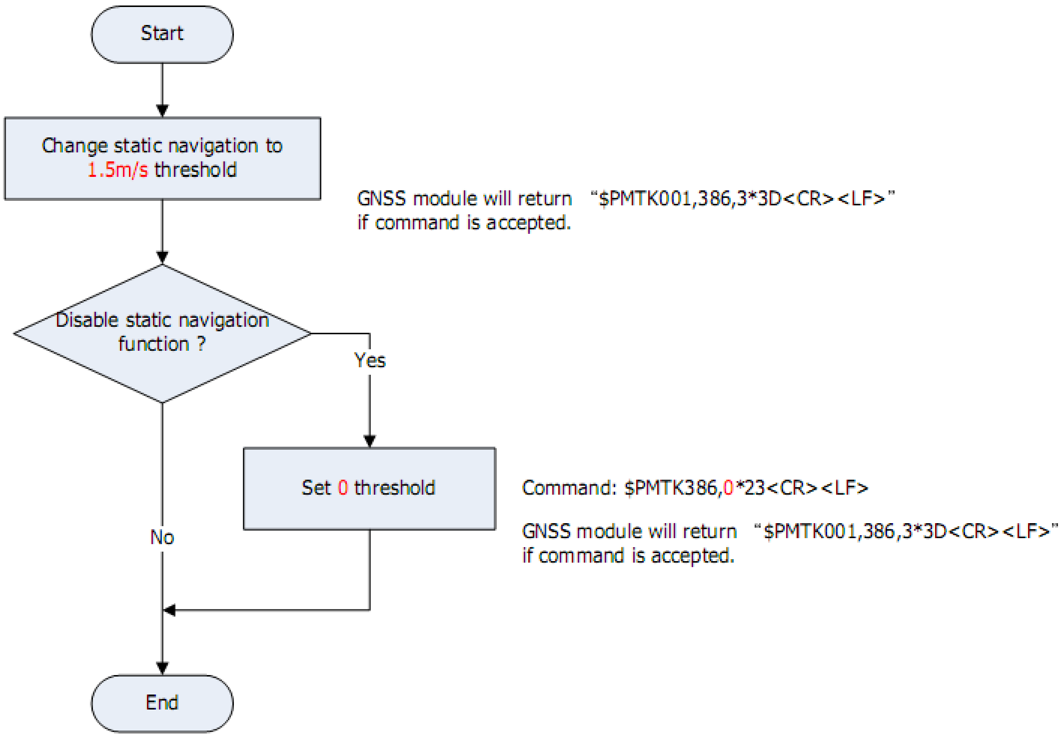
10.7 Configure the static navigation parameter

The output position of GNSS 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 GNSS position if the threshold is 1.5m/s. It is better to disable this function by setting threshold to 0 for pedestrian navigation.

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.



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Document change list

Revision 1.0

- First release on Mar 9, 2016.

Revision 1.1 (Revised on August 19, 2016)

- Revised the tolerance of the module length and width from ±0.2mm to +0.5mm and -0.2mm in the section 9
- Revised the height of shielding top to board from 2.2mm to 1.6mm in the section 9