Airoha IoT SDK for RTOS GNSS Developers Guide

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Document Revision History

Revision	Date	Description
1.0	31 March 2016	Initial version. This version supports LinkIt 2523 HDK only.
1.1	30 June 2016	Add the GNSS average data size updated by the GNSS system.
1.2	09 September 2016	Add an option item for NMEA frequency setting.

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1. Introduction

Airoha IoT development platform for RTOS includes MT2523G with an add-on feature for the on-board Global Navigation Satellite System (GNSS) System-in-Package (SiP) that supports GPS, GLONASS, BeiDou, Galileo, QZSS and SBAS satellite navigation systems.

Airoha IoT SDK package with GNSS support occupies only 10kB RAM and 3kB ROM memory space on the platform's HDK. A flash memory of 64kB maximum configurable size is assigned for extended prediction orbit (EPO) data.

The IoT and Wearables applications with GNSS provide accurate positioning, power saving and extended prediction orbit (EPO) support. Examples are a smart watch and a smart tracker. At the end of this guide, you'll have strong knowledge on developing your own location-based applications with the GNSS connectivity support.

This document guides you through the following:

- Describing the GNSS module and its architecture.
- Transferring data in various formats and protocols with corresponding APIs and commands.
- Evaluating power and performance of the main supported features (low power features and EPO).
- Developing your own applications.

1.1. Architecture

The GNSS APIs are part of the Middleware, as shown in Figure 1. Reference applications are also provided to enable faster application development including EPO, Low Power Management and Tool Bridge. The EPO reference application demonstrates how to download EPO data through Bluetooth and how to send EPO data to the GNSS module. Low Power Management enables power control to switch between various power saving modes, such as periodic and GNSS Low Power (GLP) modes. Tool Bridge can be used to connect with the PC through UART to send GNSS debug logs.

GNSS driver APIs provide functions to control the status of the GNSS module including the GPIO controller to power on or off the GNSS module, read or write data and the initial configuration of the UART. GNSS APIs provide functions to acquire GNSS data. The data is directly read in National Marine Electronics Association (NMEA) sentence format using the NMEA Bridge.

The PMTK/NMEA Bridge enables to check validity of the commands and to provide a flow control for the UART write operation.

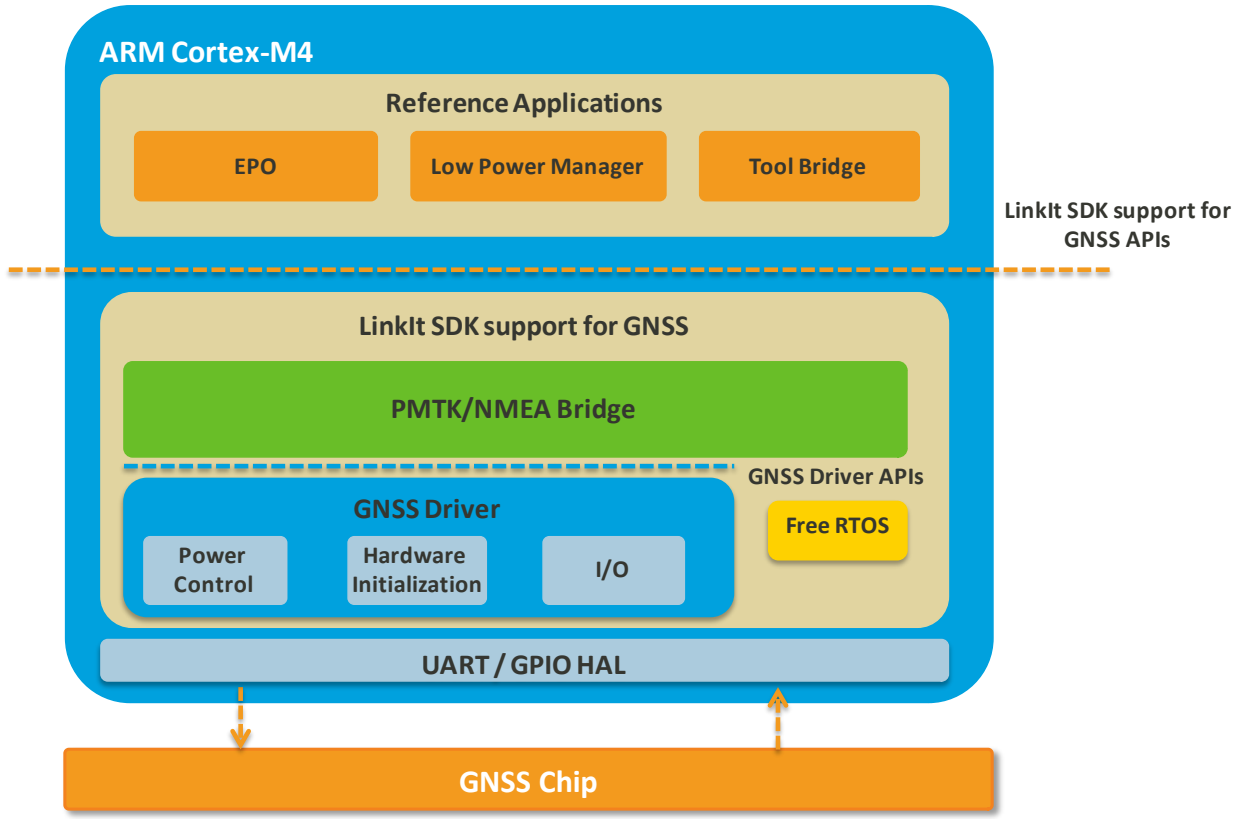

Figure 1. The architecture layout of the GNSS software stack

2. PMTK Commands

PMTK command is a MediaTek proprietary GNSS data transfer protocol. This protocol is used to configure the GNSS module's parameters, aiding information and to receive notifications from the GNSS module. The PMTK aligns with the NMEA sentence format to process data more conveniently.

2.1. PMTK packet format

The PMTK packet format with number of bytes allocated for each field is shown in Figure 2. The details of each field in the packet are provided in Table 1.

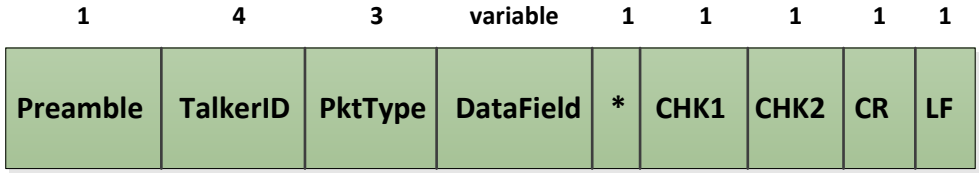

Figure 2. PMTK packet format with content and corresponding number of bytes

The maximum length of each packet is restricted to 255 bytes.

Table 1. PMTK packet content

Parameter	Description
Preamble	• One byte character. o Example, '$'.
TalkerID	• Four bytes character string. o Example, PMTK.
PktType	• Three bytes character string. o From 000 to 999. An identifier that specifies the decoding type for the packet.
DataField	• Has a variable length depending on the packet type. o A comma symbol ',' must be inserted before each datafield to help the decoder process the **DataField**.
*****	• One byte character. o The star symbol marks the end of the **DataField**.
CHK1, CHK2	• One byte character for each. o **CHK1** and **CHK2** are the checksum of the data between **Preamble** and '*****'.
CR, LF	• One byte ASCII data for each. o The two bytes are used to identify the end of a packet.

The PMTK command list for each packet type is given in Table 2. For more details on each command see section 2.2, “PMTK command details”.

Note: The commands with “_SET_” are set commands, to set the GNSS configuration. The commands with “_Q_” are query commands, to query GNSS configuration set by the set commands with “_SET_”. The commands with “_DT_” are the response to the query commands.

Table 2. PMTK commands

Packet Type	Command	Description
000	PMTK_TEST	Test Packet
001	PMTK_ACK	Acknowledgment of the PMTK command
010	PMTK_SYS_MSG	Output system message
011	PMTK_TXT_MSG	Output text message
101	PMTK_CMD_HOT_START	Hot Start. Use all available data in the NVRAM.
102	PMTK_CMD_WARM_START	Warm Start. Don't use Ephemeris at start.
103	PMTK_CMD_COLD_START	Cold Start. Don't use Position, Almanacs and Ephemeris data at start.
104	PMTK_CMD_FULL_COLD_START	Full Cold Start. It’s essentially a Cold Start, in addition, it clears system/user configurations at start. It resets the GNSS module to the factory default.
127	PMTK_CMD_CLEAR_EPO	Erase EPO data stored in the flash memory
161	PMTK_CMD_STANDBY_MODE	Enter standby mode for power saving operation.
183	PMTK_LOCUS_QUERY_STATUS	Query whether GNSS is logging
184	PMTK_LOCUS_ERASE_FLASH	Erase the logged GNSS data on the flash
185	PMTK_LOCUS_STOP_LOGGER	Stop logging data
186	PMTK_LOCUS_LOG_NOW	Snapshot write log
187	PMTK_LOCUS_CONFIG	Configure the Locus settings with commands
220	PMTK_SET_POS_FIX	Position Fix Interval
223	PMTK_SET_AL_DEE_CFG	This command is used for setting periodic mode parameters and is used after PMTK225 command.
225	PMTK_SET_PERIODIC_MODE	Periodic power saving mode settings
250	PMTK_SET_DATA_PORT	Set data port input/output, data type and baud rate.
251	PMTK_SET_NMEA_BAUDRATE	Set NMEA port baud rate. Using PMTK251 command to setup baud rate setting, the setting will be back to default value under two conditions: • Full cold start command is issued • Enter standby mode
255	PMTK_SET_SYNC_PPS_NMEA	Enable or disable fixed NMEA output time in the PPS function (default is off)
262	PMTK_SET_GLP_MODE	Enable or disable GNSS Low Power (GLP) mode
263	PMTK_SET_NMEA_REPORT_INTERVAL	Set NMEA report interval (> 1sec) and check whether power saving mode is used.
264	PMTK_SET_NMEA_REPORT_CONDITION	Set the condition (valid fix) for NMEA report

Packet Type	Command	Description
285	PMTK_SET_PPS_CONFIG_CMD	Configure the PPS setting
286	PMTK_SET_AIC_CMD	Enable or disable active interference cancellation
299	PMTK_SET_OUTPUT_DEBUG	Enable or disable Debug log output
300	PMTK_API_SET_FIX_CTL	Set a fixed interval
313	PMTK_API_SET_SBAS_ENABLED	Enable the search for SBAS satellites
314	PMTK_API_SET_NMEA_OUTPUT	Set NMEA sentence output frequencies
326	PMTK_API_SET_PPS	This packet contains the local millisecond and phase where the PPS should be placed.
353	PMTK_API_SET_GNSS_SEARCH_MODE	Configure the GNSS module to start searching of which satellite system. The setting will be kept available when NVRAM data is valid.
355	PMTK_API_QUERY_GNSS_SEARCH_MODE	Get GLONASS, BeiDou and GALILEO search settings
356	PMTK_API_SET_HDOP_THRESHOLD	Set the HDOP threshold. If the HDOP value is larger than this threshold value, the position will not be fixed.
357	PMTK_API_GET_HDOP_THRESHOLD	Get the HDOP threshold
386	PMTK_API_SET_STATIC_NAV _THD	Set the speed threshold for static navigation. If the actual speed is below the threshold, output position remains the same and the output speed is zero. If the threshold value is set to 0, this function is disabled.
400	PMTK_API_Q_FIX_CTL	Query the rate of position fixing activity
413	PMTK_API_Q_SBAS_ENABLED	Query whether the SBAS is enabled.
414	PMTK_API_Q_NMEA_OUTPUT	Query current NMEA sentence output frequencies
500	PMTK_DT_FIX_CTL	Responds to commands PMTK300 and PMTK400
513	PMTK_DT_SBAS_ENABLED	Respond to PMTK413.
514	PMTK_DT_NMEA_OUTPUT	NMEA sentence output frequency setting response.
605	PMTK_Q_RELEASE	Query the firmware release information
607	PMTK_Q_EPO_INFO	EPO Data Valid day check
622	PMTK_Q_LOCUS_DATA	Output datalog
705	PMTK_DT_RELEASE	Response of firmware release information query
740	PMTK_DT_UTC	The packet contains current UTC time. Please do not use local time, as it has timezone offset.
741	PMTK_DT_POS	The packet contains reference location for the GNSS module.

2.2. PMTK command details

2.2.1. PMTK_TEST

Packet Type	000
Command	PMTK_TEST
Description	Test packet.
Data Field	None
Example	$PMTK000*32<CR><LF>

2.2.2. PMTK_ACK

Packet Type	001
Command	PMTK_ACK
Description	Acknowledgement of PMTK command.
Data Field	**$PMTK001,cmd,Flag*CS<CR><LF>** **cmd**. The command or packet type of the acknowledgement. **Flag**. "0", Invalid command / packet. "1", Unsupported command / packet type. "2", Valid command / packet, but action failed. "3", Valid command / packet, and action succeeded.
Example	$PMTK001,604,3*32<CR><LF>

2.2.3. PMTK_SYS_MSG

Packet Type	010
Command	PMTK_SYS_MSG
Description	System output message.
Data Field	"0", UNKNOWN "1", STARTUP "2", Notification for the host aiding EPO. "3", Notification for the transition to Normal mode completes successfully.
Example	$PMTK010,001*2E<CR><LF>

2.2.4. PMTK_TXT_MSG

Packet Type	011
Command	PMTK_TXT_MSG
Description	Output text message
Data Field	**$PMTK011,msg*CS<CR><LF>** **msg.** The system text message.
Example	$PMTK011,REFERENCE_STATION_NOT_READY*4E<CR><LF>

2.2.5. PMTK_CMD_HOT_START

Packet Type	101
Command	PMTK_CMD_HOT_START
Description	Hot Start. Use the available data in the NVRAM.
Data Field	None
Example	$PMTK101*32<CR><LF>

2.2.6. PMTK_CMD_WARM_START

Packet Type	102
Command	PMTK_CMD_WARM_START
Description	Warm Start. Not using Ephemeris data at start.
Data Field	None
Example	$PMTK102*31<CR><LF>

2.2.7. PMTK_CMD_COLD_START

Packet Type	103
Command	PMTK_CMD_COLD_START
Description	Cold Start. Not using the Position, Almanac and Ephemeris data at start.
Data Field	None
Example	$PMTK103*30<CR><LF>

2.2.8. PMTK_CMD_FULL_COLD_START

Packet Type	104
Command	PMTK_CMD_FULL_COLD_START
Description	Full Cold Start. In addition to Cold start, this command clears the system/user configurations at start. It resets the GNSS module to the factory default.
Data Field	None
Example	$PMTK104*37<CR><LF>

2.2.9. PMTK_CMD_CLEAR_EPO

Packet Type	127
Command	PMTK_CMD_CLEAR_EPO
Description	Erase the EPO data stored in the flash memory.
Data Field	None
Example	$PMTK127*36<CR><LF>

2.2.10. PMTK_CMD_STANDBY_MODE

Packet Type	161
Command	PMTK_CMD_STANDBY_MODE

Description	Enter standby modes (stop mode or sleep mode) for power saving.
Data Field	"0", Stop mode. "1", Sleep mode.
Example	$PMTK161,0*28<CR><LF>

2.2.11. PMTK_LOCUS_QUERY_STATUS

Packet Type	183
Command	PMTK_LOCUS_QUERY_STATUS
Description	Query the GNSS is in the log status or not.
Data Field	None
Return Value	**$PMTKLOX, Serial#, Type, Mode, Content, Interval, Reserve, Reserve, Status, Percent*CS<CR><LF>** **Serial#**: Logging serial number : 0~65535 **Type**: Logging type - 1: Overlap, 2: Full Stop **Mode**: Logging mode - 0x10 : Interval logger **Content**: Logging contents of configuration **Interval**: **Status**: Logging status – 1: Stop Logging, 2: Logging **Percentage**: Logging life used percentage.
Example	Input : PMTK183*38<CR><LF> Output : $PMTKLOG,7,1,10,A,15,0,0,0,38.57*20<CR><LF>

2.2.12. PMTK_LOCUS_ERASE_FLASH

Packet Type	184
Command	PMTK_LOCUS_ERASE_FLASH
Description	Erase the logged GNSS data on the flash.
Data Field	"1", erase the logged internal flash data.
Example	Input. PMTK184,1*22<CR><LF> Output. $PMTK001,184,3*3D<CR><LF>

2.2.13. PMTK_LOCUS_STOP_LOGGER

Packet Type	185
Command	PMTK_LOCUS_STOP_LOGGER
Description	Stop the data logging.
Data Field	"1", Stop logging. "0", Start logging.
Example	Input. PMTK185,1*23<CR><LF> Output. $PMTK001,185,3*3C<CR><LF>

2.2.14. PMTK_LOCUS_LOG_NOW

Packet Type	186

Command	PMTK_LOCUS_LOG_NOW
Description	Snapshot write log.
Data Field	"1", Snapshot data logging.
Example	Input. $PMTK186,1*20<CR><LF> Output. $PMTK001,186,3*3F<CR><LF>

2.2.15. PMTK_LOCUS_CONFIG

Packet Type	187
Command	PMTK_LOCUS_CONFIG
Description	Configure Locus settings by command.
Data Field	**$PMTK187, mode, setting*CS<CR><LF>** **mode**. "1", interval mode. **setting**. New setting instead of the original configuration, such as change to 5 seconds interval, as in the example below.
Example	Input: $PMTK187,1,5*38<CR><LF> Output: $PMTK001,187,3*3E<CR><LF>

2.2.16. PMTK_SET_POS_FIX

Packet Type	220
Command	PMTK_SET_POS_FIX
Description	Position Fix Interval.
Data Field	Position fix interval in milliseconds (ms). Must be more than 200ms.
Example	$PMTK220,1000*1F<CR><LF>

2.2.17. PMTK_SET_AL_DEE_CFG

Packet Type	223
Command	PMTK_SET_AL_DEE_CFG
Description	This command is used for setting periodic mode parameters and is used after PMTK225 command.
Data Field	**$ PMTK223, SV, SNR, Extension Threshold, Extension gap*CS<CR><LF>** **SV** (default value): 1 **SNR** (default value): 30 **Extension Threshold** (default value): 180000 ms, the range is from 40000 to 180000. **Extension gap** (default value): 60000 ms, the range is from 0 to 3600000. (Extension gap is the limitation between neighboring Dynamic Ephemeris Extension (DEE)).
Example	Periodic Standby mode. PMTK225,0 PMTK223,2,25,180000,60000 PMTK225,2,3000,12000,18000,72000

Apply commands PMTK223 and PMTK225 to enter the GNSS module's period mode as follows:

PMTK223,2,25,180000,60000 explained. (1) MTK GNSS module is in period mode, (2) two more satellites rise, (3) the signal noise ratio (SNR) of these two new rising satellites is all beyond 25dB. If these three conditions are met, the GNSS module will extend the runtime to **Extension Threshold** to decode the ephemeris, in this example, it's 180 seconds. The last parameter **Extension gap** is the interval to increase the runtime extension with 60 more seconds.

2.2.18. PMTK_SET_PERIODIC_MODE

Packet Type	225
Command	PMTK_SET_PERIODIC_MODE
Description	In **RUN** stage, the GNSS module measures and calculates the position. In **SLEEP** stage, the GNSS module may enter two different power saving modes. One is the **Periodic Standby Mode** and the other is **Periodic Backup Mode**. Due to hardware limitations, the maximum power down duration (**SLEEP**) is 2047 seconds. If the configured **SLEEP** interval is larger than 2047 seconds, the GNSS firmware automatically extends the interval using software. However, the GNSS system is powered on for the interval extension and powered down again after the extension is complete.
Data Field	**$ PMTK225, Type, Run time, Sleep time, Second run time, Second sleep time*CS<CR><LF>** **Type**. Set the operation mode to power saving. "0", Back to normal mode. "1", Periodic backup mode. "2", Periodic standby mode. "4", Perpetual backup mode. "8", Always Locate standby mode. "9", Always Locate backup mode. **Run time**. Duration in milliseconds (ms) to fix for (or attempt to fix for) before switching from running mode back to a minimum power sleep mode. "0", Disable. >= "1000", Enable, the range is from 1000 to 518400000. **Sleep time**. Interval in ms to exit the minimum power sleep mode and get a new position fix. The range is from 1000 to 518400000. **Second runtime**. Duration in ms to fix for (or attempt to fix for) before switching from running mode back to a minimum power sleep mode. "0", Disable. >= "1000", Enable, the range for the second set is 0 or from 1000 to 518400000. **Second sleep time**. Interval in ms to exit the minimum power sleep mode and get a new position fix. The range for the second set is 0 or from 1000 to 518400000.
Example	Commands to enter periodic modes. • Periodic Backup mode PMTK225,0 PMTK223,1,25,180000,60000 PMTK225,1,3000,12000,18000,72000 • Periodic Standby mode PMTK225,0 PMTK223,1,25,180000,60000 PMTK225,2,3000,12000,18000,72000

	Commands to enter Always Locate modes • Always Locate Standby o PMTK225,0 o PMTK225,8 • Always Locate Backup o PMTK225,0 o PMTK225,9

2.2.19. PMTK_SET_DATA_PORT

Packet Type	250
Command	PMTK_SET_DATA_PORT
Description	Set data port input/output data type and baud rate.
Data Field	**$PMTK250,InType,OutType,Baudrate*CS<CR><LF>** **InType**. Data port input data type "0", DPORT_IN_NONE (No data input) "1", DPORT_IN_RTCM (RTCM input) "3", DPORT_IN_NMEA (MTK NMEA) **OutType**. Data port input data type "0", DPORT_OUT_NONE (No data output) "3", DPORT_OUT_NMEA (MTK NMEA) **Baudrate**. Possible values are: 4800, 9600, 14400, 19200, 38400, 57600, 115200, 460800, 921600.
Example	$PMTK250,1,3,9600*16<CR><LF>

2.2.20. PMTK_SET_NMEA_BAUDRATE

Packet Type	251
Command	PMTK_SET_SYNC_PPS_NMEA
Description	Set the NMEA port baud rate with PMTK251 command. The setting is back to default value under the following two conditions. • Full cold start command is issued. • Enter standby mode.
Data Field	**$PMTK251,Baudrate*CS<CR><LF>** **Baudrate**. Possible values are: 0 (default), 4800, 9600, 14400, 19200, 38400, 57600, 115200, 230400, 460800, 921600.
Example	$PMTK251,38400*27<CR><LF>

2.2.21. PMTK_SET_SYNC_PPS_NMEA

Packet Type	255
Command	PMTK_SET_SYNC_PPS_NMEA
Description	Enable or disable fixed NMEA output time in pulse per second (PPS) function (default value is "0").
Data Field	"0", Disable. "1", Enable.
Example	$PMTK255,1*23<CR><LF>

2.2.22. PMTK_SET_GLP_MODE

Packet Type	262
Command	PMTK_SET_GLP_MODE
Description	Enable or disable the GLP mode. Note, that the GLP mode should be enabled within 10 sec after powering on the GNSS module.
Data Field	**$PMTK262, Enabled*CS<CR><LF>** **Enabled**. "0", Disable the GLP mode. "3", Enable the GLP mode.
Example	$PMTK262,3*2B<CR><LF>

2.2.23. PMTK_SET_NMEA_REPORT_INTERVAL

Packet Type	263
Command	PMTK_SET_NMEA_REPORT_INTERVAL
Description	Set the NMEA report interval (> 1 sec) and whether power saving mode is used.
Data Field	**$PMTK263, Interval, PowerSavingEnabled*CS<CR><LF>** **Interval**. Unit in seconds, integer interval is acceptable required for the NMEA report. "0", Reset the previous NMEA report interval setting and back to 1Hz NMEA report. **PowerSavingEnabled**: "0", No power saving mode is enabled. "1", Enable the power saving mode. (Interval <= 20 sec, the GLP mode is used; Interval > 20 sec, Periodic backup mode is used)
Example	Reset previous NMEA report interval setting. $PMTK263,0,0*35<CR><LF> Set NMEA report interval. $PMTK263,10,0*04<CR><LF>interval is 10 sec $PMTK263,10,1*05<CR><LF>interval is 10 sec and enable power saving mode $PMTK263,120,1*37<CR><LF>interval is 120 sec and enable power saving mode (Periodic backup mode is enabled, set $PMTK263,0,0 back to normal mode)

2.2.24. PMTK_SET_NMEA_REPORT_CONDITION

Packet Type	264
Command	PMTK_SET_NMEA_REPORT_CONDITION
Description	Set the condition (valid fix) for NMEA report.
Data Field	**$PMTK264, ValidFix*CS<CR><LF>** **ValidFix**. "0", Disable "report NMEA when position fix is valid (2D or 3D fix)". "1", Enable "report NMEA when position fix is valid (2D or 3D fix)".
Example	$PMTK264,1*2F<CR><LF>

2.2.25. PMTK_SET_PPS_CONFIG_CMD

Packet Type	285
Command	PMTK_SET_PPS_CONFIG_CMD

Description	Configure the PPS settings.
Data Field	**$PMTK285,PPSType,PPSPulseWidth*CS<CR><LF>** **PPSType**. Availability "0", Disable "1", After the first fix "2", 3D fix only "3", 2D/3D fix only "4", Always **PPSPulseWidth**. PPS Pulse Width (unit in ms).
Example	$PMTK285,2,100*23<CR><LF>

2.2.26. PMTK_SET_AIC_CMD

Packet Type	286
Command	PMTK_SET_AIC_CMD
Description	Enable or disable active interference cancellation function.
Data Field	**$PMTK286,Enabled*CS<CR><LF>** **Enabled**. Enable or disable "0", Disable. "1", Enable.
Example	$PMTK286,1*23<CR><LF>

2.2.27. PMTK_SET_OUTPUT_DEBUG

Packet Type	299
Command	PMTK_SET_OUTPUT_DEBUG
Description	Enable or disable the Debug log output.
Data Field	**$PMTK299,Enabled*CS<CR><LF>** **Enabled**. Enable or disable "0", Disable. "1", Enable.
Example	$PMTK299,1*2D<CR><LF>

2.2.28. PMTK_API_SET_FIX_CTL

Packet Type	300
Command	PMTK_API_SET_FIX_CTL
Description	Fixed interval setting.
Data Field	**$PMTK300,Fixinterval,0,0,0,0** **Fixinterval**: Unit in milliseconds, the range is from 100 to 10000.
Example	Set the fix interval to 1000 milliseconds. $PMTK300,1000,0,0,0,0
Return value	$PMTK001,300,3

2.2.29. PMTK_API_SET_SBAS_ENABLED

Packet Type	313
Command	PMTK_API_SET_SBAS_ENABLED
Description	Enable or disable searching for SBAS satellites.
Data Field	"0", Disable. "1", Enable.
Example	$PMTK313,1*2E<CR><LF>

2.2.30. PMTK_API_SET_NMEA_OUTPUT

Packet Type	314
Command	PMTK_API_SET_NMEA_OUTPUT
Description	Set the NMEA sentence output type and frequencies.
Data Field	There are seven data fields to present output frequencies for seven supported NMEA sentences individually. Supported NMEA Sentences. 0 NMEA_SEN_GLL, // GPGLL interval - Geographic Position - Latitude longitude 1 NMEA_SEN_RMC, // GPRMC interval - Recommended Minimum Specific GNSS Sentence 2 NMEA_SEN_VTG, // GPVTG interval - Course Over Ground and Ground Speed 3 NMEA_SEN_GGA, // GPGGA interval - GPS Fix Data 4 NMEA_SEN_GSA, // GPGSA interval - GNSS DOPS and Active Satellites 5 NMEA_SEN_GSV, // GPGSV interval - GNSS Satellites in View 17 NMEA_SEN_ZDA, // GPZDA interval – Time & Date Supported Frequency Settings. "-2", Keep current output setting "-1", Reset all NMEA output to default configuration "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
Example	Run this command to set the GLL output frequency and RMC once for every 1 position fix, and so on. $PMTK314,1,1,1,1,1,5,0,0,0,0,0,0,0,0,0,0,0,1,0*2D<CR><LF> To restore the system default settings, apply the following: $PMTK314,-1*04<CR><LF>

2.2.31. PMTK_API_SET_PPS

Packet Type	326
Command	PMTK_API_SET_PPS
Description	This packet contains the local time in milliseconds and phase where the PPS should be placed.

Data Field	**$PMTK326,PPS_BY_USER,Local_ms,phase*CS<CR><LF>** **PPS_BY_USER** "1", PPS output by user. "0", PPS automatic output. **Local_ms.** Local receiver time tick. Range is from 0 to 4294967295 (2^{32}-1). **Phase.** Time tick phase range is from 0 to 262143.
Example	$PMTK326,1,1345,555*3F<CR><LF>

2.2.32. PMTK_API_SET_GNSS_SEARCH_MODE

Packet Type	353
Command	PMTK_API_SET_GNSS_SEARCH_MODE
Description	Configure the receiver to start searching for satellites. The setting is available when the NVRAM data is valid.
Data Field	**$PMTK353, GPS_Enabled, GLONASS_Enabled, GALILEO_Enabled, GALILEO_FULL_Enabled, BEIDOU_Enabled*CS<CR><LF>** **GPS_Enabled**: "0", disable (DO NOT search GPS satellites). "1", or non-ZERO: search GPS satellites. **GLONASS_Enabled**: "0", disable (DO NOT search GLONASS satellites). "1", or non-ZERO: search GLONASS satellites. **GALILEO_Enabled**: "0", disable (DO NOT search GALILEO satellites). "1", or non-ZERO: search GALILEO satellites. **GALILEO_FULL_Enabled**: "0", disable (DO NOT search GALILEO FULL mode satellites). "1", or non-ZERO: search GALILEO satellites. **BEIDOU_Enabled**: "0", disable (DO NOT search BEIDOU satellites). "1", or non-ZERO: search BEIDOU satellites.
Example	$PMTK353,0,1,0,0,0*2A : Search GLONASS satellites only. $PMTK353,1,0,0,0,0*2A : Search GPS satellites only. $PMTK353,1,1,0,0,0*2B : Search GPS and GLONASS satellites. $PMTK353,1,1,1,0,0*2A : Search GPS GLONASS, GALILEO satellites. $PMTK353,0,0,0,0,1*2A : Search BEIDOU satellites only. $PMTK353,1,0,0,0,1*2B : Search GPS and BEIDOU satellites.
Note	GLONASS only, BeiDou only and GALILEO only mode is only for testing purpose. Use GPS and GLONASS or GPS and BeiDou in your applications, GLONASS and BeiDou cannot be enabled at the same time.

2.2.33. PMTK_API_QUERY_GNSS_SEARCH_MODE

Packet Type	355
Command	PMTK_API_QUERY_GNSS_SEARCH_MODE
Description	This command is to get GLONASS, BeiDou and GALILEO search settings.
Data Field	None
Example	$PMTK355*31
Return Value	$PMTK001,353,3,0,1,0 //"$PMTK001,355,3,GLON_Enable,BEIDOU_Enable,GALILEO_Enable" The BeiDou search mode is enabled.

2.2.34. PMTK_API_SET_HDOP_THRESHOLD

Packet Type	356
Command	PMTK_API_SET_HDOP_THRESHOLD
Description	This command is to set the HDOP threshold. If the HDOP value is larger than this threshold value, the position will not be fixed.
Data Field	**$PMTK356,HDOPThreshold*CS<CR><LF>** **HDOPThreshold**: "0": Disable this function. Other value: Enable set the HDOP threshold
Example	$PMTK356,0.8
Return Value	$PMTK356,0.8 Set OK!*5F

2.2.35. PMTK_API_GET_HDOP_THRESHOLD

Packet Type	357
Command	PMTK_API_GET_HDOP_THRESHOLD
Description	This command is to get the HDOP threshold.
Data Field	**$PMTK357,HDOPThreshold*CS<CR><LF>** **HDOPThreshold**. "0", Disable this function. **Other value.** Enable.
Example	$PMTK357
Return Value	$PMTK357,0.8*39

2.2.36. PMTK_API_SET_STATIC_NAV _THD

Packet Type	386
Command	PMTK_API_SET_STATIC_NAV _THD
Description	Set the speed threshold for static navigation. If the actual speed is below the threshold, 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	**$PMTK386, speed_threshold*CS<CR><LF>** **Speed_threshold**. 0~2 m/s. The minimum is 0.1 m/s, the maximum is 2.0 m/s.
Example	$PMTK386, 0.4*19<CR><LF>

2.2.37. PMTK_API_Q_FIX_CTL

Packet Type	400
Command	PMTK_API_Q_FIX_CTL
Description	Query the rate of position fixing activity.
Data Field	None.
Return Value	PMTK_DT_FIX_CTL
Example	$PMTK400*36<CR><LF>

2.2.38. PMTK_API_Q_SBAS_ENABLED

Packet Type	413
Command	PMTK_API_Q_SBAS_ENABLED
Description	Query the status of SBAS to check if it is enabled or not.
Data Field	None.
Return Value	PMTK_DT_SBAS_ENABLED
Example	$PMTK413*34<CR><LF>

2.2.39. PMTK_API_Q_NMEA_OUTPUT

Packet Type	414
Command	PMTK_API_Q_NMEA_OUTPUT
Description	Query current NMEA sentence output frequencies.
Data Field	None.
Return Value	PMTK_DT_NMEA_OUTPUT
Example	$PMTK414*33<CR><LF>

2.2.40. PMTK_DT_FIX_CTL

Packet Type	500
Command	PMTK_DT_FIX_CTL
Description	Control the rate of position fixing activity.
Data Field	**FixInterval**: Position fix interval. (ms). [>= 200]
Example	$PMTK500,1000,0,0,0,0*1A<CR><LF>

2.2.41. PMTK_DT_SBAS_ENABLED

Packet Type	513
Command	PMTK_DT_SBAS_ENABLED
Description	Enable or disable searching for SBAS satellites.
Data Field	**Enabled**. Enable or disable “0”, Disable. “1”, Enable.
Example	$PMTK513,1*28<CR><LF>

2.2.42. PMTK_DT_NMEA_OUTPUT

Packet Type	514

Command	PMTK_DT_NMEA_OUTPUT
Description	The NMEA sentence output frequency configuration.
Data Field	There are total of 19 data fields that present output frequencies for the 19 supported NMEA sentences individually. See section 2.2.30, “PMTK_API_SET_NMEA_OUTPUT” for the supported NMEA sentences and frequency settings.
Example	$PMTK514,1,1,1,1,1,5,1,1,1,1,1,1,0,1,1,1,1,1,1*2A<CR><LF>

2.2.43. PMTK_Q_RELEASE

Packet Type	605
Command	PMTK_Q_RELEASE
Description	Query the firmware release information.
Data Field	None
Return Value	PMTK_DT_RELEASE
Example	$PMTK605*31<CR><LF>

2.2.44. PMTK_Q_EPO_INFO

Packet Type	607
Command	PMTK_Q_EPO_INFO
Description	EPO Data Valid day check.
Data Field	None
Example	$PMTK607*33<CR><LF>

2.2.45. PMTK_Q_LOCUS_DATA

Packet Type	622
Command	PMTK_Q_LOCUS_DATA
Description	Use Locus tool to retrieve the logging data from the NVRAM.
Data Field	None

2.2.46. PMTK_DT_RELEASE

Packet Type	705
Command	PMTK_DT_RELEASE
Description	Firmware release information.
Data Field	**$PMTK705,ReleaseStr,Build_ID,Product_Model,(SDK_Version,)*CS<CR><LF>** **ReleaseStr**. Firmware release name and version. “3318”, Mcore_x.x “3329”, AXN_x.x

	Build_ID. Build ID set for firmware version control. **Product_Model**. Product Model set for product identification. **SDK_Version**. Display the SDK version if the firmware has the SDK version.
Example	$PMTK705,AXN_0.2,1234,ABCD,*14<CR><LF>

2.2.47. PMTK_DT_UTC

Packet Type	740
Command	PMTK_DT_UTC
Description	The packet contains current UTC time. Please do not use local time, which has time-zone offset. To have faster TTFF, the accuracy of reference UTC shall be better less than 3 seconds.
Format	**$PMTK740,YYYY,MM,DD,hh,mm,ss*CS<CR><LF>** (See Table 3)
Example	$PMTK740,2010,2,10,9,0,58*05<CR><LF> The packet indicates that the current UTC time is 2010/Feb/10 09:00:58.

Table 3. UTC time format

Name	Unit	Range	Description
$PMTK740			Reference UTC Time
YYYY	year	> 1980	UTC time: year in 4 digits
MM	month	1 - 12	UTC time: month
DD	day	1 - 31	UTC time: day
hh	hour	0 - 23	UTC time: hour
mm	minute	0 - 59	UTC time: minute
ss	second	0 - 59	UTC time: second
CS			8-bit accumulative checksum of all bytes in-between the $ and * characters in hexadecimal

2.2.48. PMTK_DT_POS

Packet Type	741
Command	PMTK_DT_POS
Description	The packet contains reference location for the GNSS module.
Format	**$PMTK741,Lat,Long,Alt,YYYY,MM,DD,hh,mm,ss *CS<CR><LF>** (see Table 4)
Example	$PMTK741,24.772816,121.022636,160,2011,8,1,08,00,00 The packet indicates that the GNSS receiver is at latitude 24.772816 degrees, longitude 121.022636 degrees, and altitude 160m.
Note	GNSS module will check the range for the following parameters: • Latitude: -90.0 ~ 90.0 • Longitude: -180.0 ~ 180.0

Table 4. Reference location format

Name	Unit	Range	Description
$PMTK741			Reference location without accuracy information.

Name	Unit	Range	Description
Lat	degree	-90.0 ~ 90.0	WGS84 geodetic latitude. NOTE: suggest to express this value in floating-point with 6 decimal points Minus: south; Plus: north
Long	degree	-180.0 ~ 180.0	WGS84 geodetic longitude. NOTE: suggest to express this value in floating-point with 6 decimal points Minus: west; Plus: east
Alt	m	---	WGS84 ellipsoidal altitude.
YYYY	year	> 1980	Reference UTC time: year in 4 digits
MM	month	1 - 12	Reference UTC time: month
DD	day	1 - 31	Reference UTC time: day
hh	hour	0 - 23	Reference UTC time: hour
mm	minute	0 - 59	Reference UTC time: minute
ss	second	0 - 59	Reference UTC time: second
CS			8-bit accumulative checksum of all bytes in-between the $ and * characters in hexadecimal

3. Supported features

This section introduces the key features of the GNSS module that provide improved GNSS performance, EPO and Location Low Energy (LLE).

3.1. EPO

EPO (Extended Prediction Orbit) is one of MediaTek innovations, an off-line server based Assisted GPS (A-GPS) solution. It is the world's leading technology that supports up to 30 days of satellite orbit predictions.

EPO can improve TTFF significantly. The architecture layout of the EPO is shown in Figure 3 and the process is described in the upcoming sections.

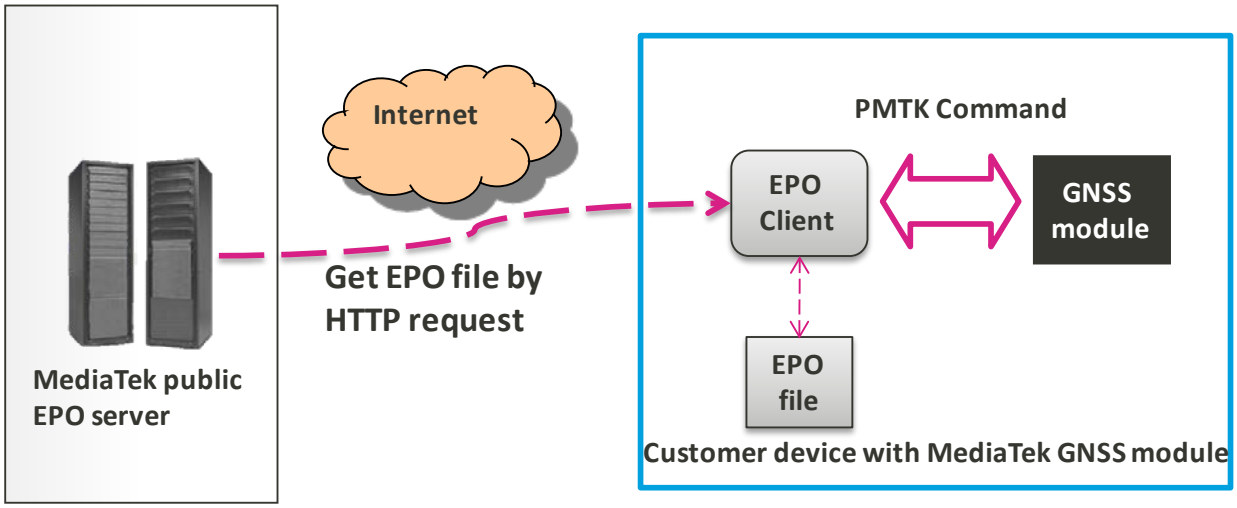

Figure 3. EPO data flow

3.1.1. EPO download

MediaTek public server provides the EPO file to devices that support Airoha GNSS module. To get the EPO file use, for example, 2523G module, a smart phone, PC or another client. To send the EPO data to the target device use Bluetooth, COM Port an SD Card, etc. An example download flow is shown in Figure 4, where the EPO file is downloaded on the smartphone and sent to the target device using Bluetooth notification service.

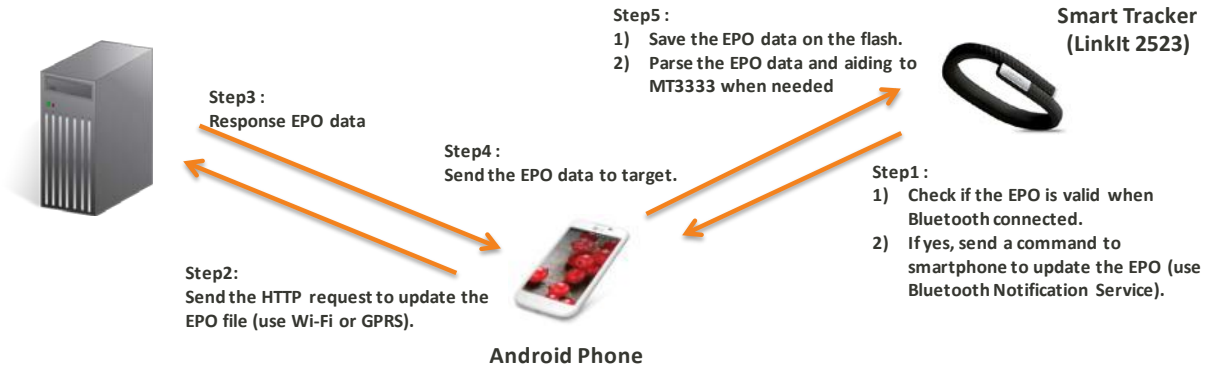

Figure 4. EPO download flow

3.1.2. EPO aiding

This section provides details on EPO aiding. After power on, the Airoha IoT SDK with GNSS support will output a start-up message `GPS_NOTIFY_TYPE_POWER_ON_CNF` to notify the application that the initialization is complete and the device is ready to receive PMTK commands. The device will then send the assistance data according to the message sequence shown in Figure 5. The assistance data includes time and the EPO data. If any of the assistance data is not available at the application, the application has to skip sending that data. For example, if the system time of the application is invalid or the EPO data is corrupt, these assistance data shouldn't be sent to the GNSS module. It's recommended to send segment one of all satellites before sending segment two in the EPO data. The GNSS module will try to use segment one to get the first fix. The maximum possible data size including time, position and 64 EPO assistance data messages is `11600` bytes.

In the original design, the purpose of acknowledgement (ACK) packets is to prevent an overflow of the UART buffer on the GNSS module. Current firmware design is improved; the host software doesn't need to take care of ACK packets. The assistance messages can be sent without waiting for any ACK messages. The ACK message format is "`$PMTK001,XXX,3*CS`", where XXX is the packet type to be acknowledged, 3 is the success (3) or failure (2) status, and CS is the NMEA checksum. For example, "`$PMTK001,721,3*34`" means the PMTK721 command is successfully received. Check the ACK result during production testing stage to verify the UART reliability.

GNSS satellites will occasionally encounter maneuver or clock adjustment. These events may cause the original orbit prediction error and result in positioning bias if the GNSS module is not aware of them. To resolve this problem, the GNSS firmware can detect the events automatically and save them without notifying the application. The GNSS module filters out bad EPO assistance data from the host automatically. This auto-handling function requires continuous power supply of the GNSS NVRAM when the main power is off.

To disable the EPO, don't send any assistance data to the GNSS module. In this case, the GNSS runs autonomously to get a GNSS fix without any external aiding.

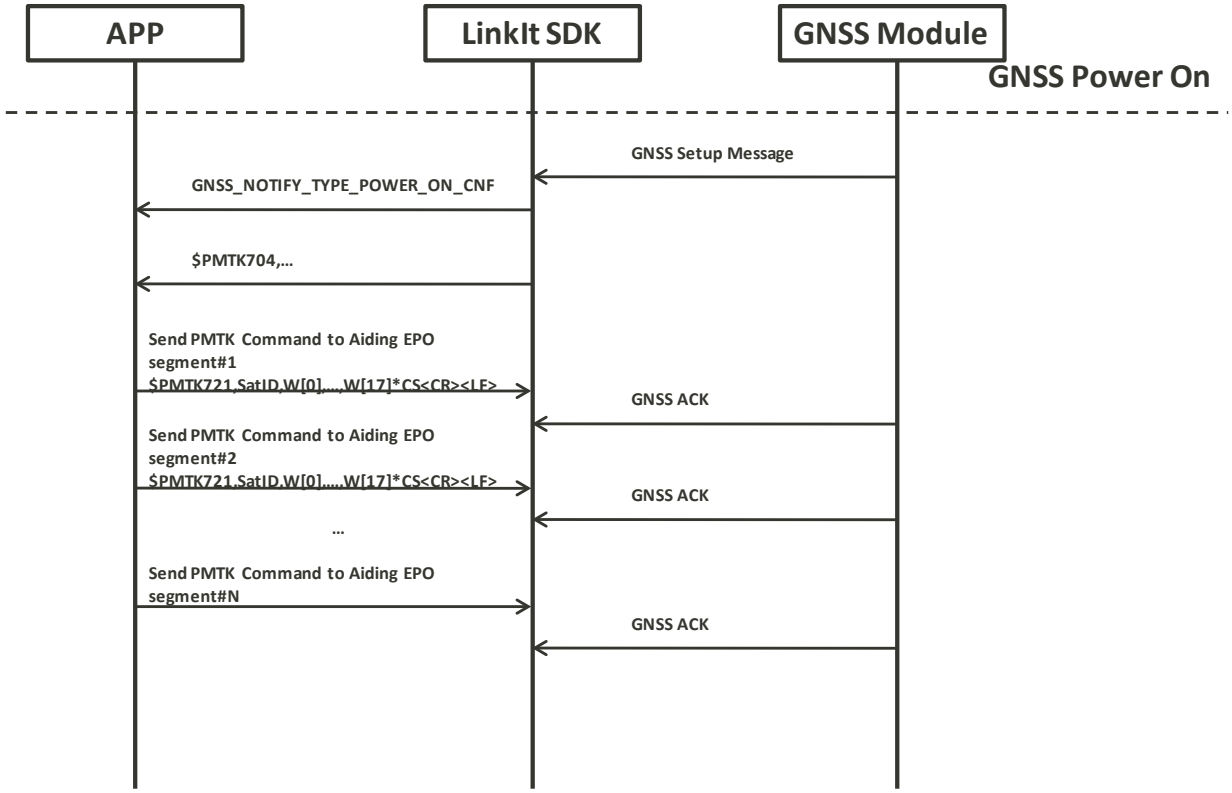

Figure 5. How to send EPO data to GNSS module

3.1.3. Time for parse EPO

Apply the following recommendations in your implementation to synchronize the system time with the GNSS time:

1) Implement a NMEA parser to use $GPRMC to retrieve the UTC date, time, and positioning information. If the status field, the second field after $GPRMC, is not "A" (Active), the sentence should be ignored.

2) The time zone of UTC time is GMT. The time zone may be different from your time zone. Use proper system time functions to avoid time zone mismatch. For example, you may need to use `gmtime()` instead of `localtime()`.

3) If the host system allows the user to change the system time, it's recommended to keep a valid flag and a time-offset variable. The time-offset variable is always the time offset of user-adjustable system time and GNSS time. The valid flag marks the validity of the time-offset variable. For example, if the GNSS fix is not achieved, the value of time-offset variable is meaningless. In this case, the valid flag should be marked as false. If the valid flag is false, the time assistance data (PMTK740) shouldn't be sent to the GNSS module during power-up.

4) Adjust the system time at the first GNSS fix. After that, the system time could be adjusted intermittently, such as for every 10 minutes under a valid GNSS fix.

3.2. Low power features

The SDK provides different operating modes for the GNSS module:

1) Normal mode. In this mode, the GNSS module is always on. The NMEA data is updated every 1s. This mode has no low power consideration.

2) Periodic mode. In this mode, the GNSS module enters to sleep mode then periodically switches back on. Configure the mode using PMTK255 command. Can be applied when a periodic update of 1s or above is required. The GNSS module updates the NMEA data every Ns based on user configuration.

3) On/Off mode. In this mode, the GNSS module is powered off for low power consumption, then it powers on after a certain period (suggested 60s).

4) GLP mode. In this mode, the GNSS module enters sleep mode using the GNSS signal state. Configure this mode using PMTK262 command. The GNSS module updates the NMEA data for every 1s with low power consumption.

For the low power mode, the Airoha IoT SDK provides an example code at `<sdk_root>\project\mt2523_hdk\apps\gnss_get_location\src\gnss_app.c`. as a reference for your application development.

4. Create a Location Based Application

This section provides reference materials on how to create your first GNSS and EPO assisted applications.

4.1. Your first GNSS application

1) Create a project.
    - Follow the instructions in Airoha IoT SDK Getting Started guide to create and build your new project.
2) Create a GNSS app.
    - Apply `<sdk_root>\project\mt2523_hdk\apps\gnss_get_location\src\gnss_app.c` as a reference application for your implementation.
3) Customize your application.
    - Change the configuration based on your requirements.
    - Replace the function `gnss_demo_app_location_handle()`, with your own implementation.

Note: Do not measure the NMEA data in the `gnss_driver_callback_func()` because of ISR loading. Send a message to the GNSS task to manipulate the received NMEA data.

4.2. EPO project

EPO parser source code is provided for your reference under `<sdk_root>\project\mt2523_hdk\apps\gnss_get_location\src\epo_demo.c`. It provides details on how to extract the correct EPO segment from an EPO file and how to construct PMTK messages.

EPO download source code is also provided for your reference under `<sdk_root>\project\mt2523_hdk\apps\gnss_get_location\src\epo_download.c.` It demonstrates how to connect with smartphone using Bluetooth notification service and save data into the flash memory.

5. Appendix A: NMEA Sentence

NMEA sentences are used to describe position information reported by the GNSS module. The first word of the sentence is called a data type, defines the interpretation of the rest of the sentence. Each data type has its own unique interpretation and is defined in the NMEA standard. Data format is same as PMTK command. The differences are the sentence ID (see Table 5) and talker ID (see Table 6).

Note: The average data volume is 460 bytes per each update, when the GNSS update rate is 1Hz. The total volume is calculated as $460 * \text{update rate in bytes}$.

Figure 6. NMEA sentence format

Table 5. Sentence ID

Sentence ID	Description
GGA	Global Positioning System Fix Data
GLL	Geographic Position, Latitude and Longitude
GSA	GNSS DOP and Active Satellites
GSV	GNSS Satellites In View
RMC	Recommended Minimum Specific GNSS Data
VTG	Course Over Ground & Ground Speed
GRS	GNSS Range Residuals
GST	GNSS Pseudo Range Error Statistics

Table 6. Talker ID

Talker ID	Description
GP	GPS
GL	GLONASS
BD	BeiDou
GN	Multi-GNSS

5.1. NMEA Sentence

The NMEA sentence format is presented in Table 7, Table 8, Table 9, Table 10, Table 11, Table 12, Table 13 Table 14.

5.1.1. GGA

GGA - Global Positioning System Fix Data

```
$--GGA,hhmmss.ss,llll.ll,a,yyyyy.yy,a,x,xx,x.x,x.x,M,x.x,M,x.x,xxxx*hh
```

Table 7. GGA description

Item	Description	Data Length
hhmmss.sss	UTC of position	10
llll.llll,a	Latitude - N/S	11
yyyyy.yyyy,a	Longitude - E/W	12
x	GPS Quality indicator	1
xx	Number of satellites in use, 00-26, may be different from the number in view	2
x.xx	Horizontal dilution of precision	4
xxxxx.x,M	Altitude re: mean-sea-level (geoid), meters	9
xxx.x,M	Geoidal separation, meters	7
xxxx	Age of Differential GPS data	4
xxxx	Differential reference station ID, 0000-1023	4

5.1.2. GLL

GLL - Geographic Position, Latitude and Longitude

$--GLL,llll.ll,a,yyyyy.yy,a,hhmmss.ss,A,a*hh

Table 8. GLL description

Item	Description	Data Length
llll.llll,a	Latitude - N/S	11
yyyyy.yyyy,a	Longitude - E/W	12
hhmmss.sss	UTC of position	10
A	Status A = Data valid/V = Data not valid	1
a	Mode Indicator	1

5.1.3. GSA

GSA - GNSS DOP and Active Satellites

$--GSA,a,x,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,x.x,x.x,x.x*hh

Table 9. GSA description

Item	Description	Data Length
a	Mode: M = Manual, forced to operate in 2D or 3D mode A = Automatic, allowed to automatically switch 2D/3D	1
x	Mode: 1 = Fix not available, 2 = 2D, 3 = 3D	1
xx	ID numbers1 of satellites used in solution	3 * 12
xx.xx	Position Dilution of Precision (PDOP)	5
xx.xx	Horizontal Dilution of Precision (HDOP)	5
xx.xx	Vertical Dilution of Precision (VDOP)	5

5.1.4. GSV

GSV – GNSS Satellites In View

`$--GSV,x,x,xx,xx,xx,xxx,xx,.....,xx,xx,xxx,xx*hh`

Table 10. GSV description

Item	Description	Data Length
x	Total number of sentences	1
x	Sentence number	1
xx	Total number of satellites in view	2
xx	Satellite ID number	3
xx	Elevation, degrees, 90o maximum	2
xxx	Azimuth, degrees True, 000 to 359	3
xx	Signal Noise Ratio (SNR) (C/No) 00-99 dB-Hz, null when not tracking	2

5.1.5. RMC

RMC – Recommended Minimum Specific GNSS Data

`$--RMC,hhmmss.ss,A,llll.ll,a,yyyyy.yy,a,x.x,x.x,xxxxxx,x.x,a,a*hh`

Table 11. RMC description

Item	Description	Data Length
hhmmss.sss	UTC of position fix	10
A	Status A = Data valid, V = Navigation receiver warning	1
llll.llll,a	Latitude - N/S	11
yyyyy.yyyy,a	Longitude - E/W	12
xxxx.xx	Speed over ground, knots	7
xxx.xx	Course Over Ground, degrees True	6
xxxxxx	Date: ddmmyy	6
,a	Magnetic variation, degrees E/W1	2
a	Mode Indicator	1

5.1.6. VTG

VTG – Course over Ground & Ground Speed

`$--VTG,x.x,T,x.x,M,x.x,N,x.x,K,a*hh`

Table 12. VTG description

Item	Description	Data Length
xxx.xx,T	Course over ground, degrees True	8
,M	Course over ground, degrees Magnetic	2
xxxx.xx,N	Speed over ground, knots	9
xxxx.xx,K	Speed over ground, km/hr	9

Item	Description	Data Length
a	Mode Indicator	1

5.1.7. GRS

GRS – GNSS Range Residuals

$--GRS,hhmmss.ss,x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x*hh

Table 13. GRS description

Item	Description	Data Length
hhmmss.sss	UTC time of the GGA or GNS fix associated with this sentence	10
x	Mode: 0 = residuals were used to calculate the position given in the matching GGA or GNS sentence 1 = residuals were recomputed after the GGA or GNS position was computed	1
x.xx	Range residuals in meters for satellites used in the navigation solution1, 2. Order must match order of the satellite ID3 numbers in GSA. When GRS is used GSA and GSV are generally required	4*12

5.1.8. GST

GST – GNSS Pseudo Range Error Statistics (Disable)

$--GST,hhmmss.ss,x.x,x.x,x.x,x.x,x.x,x.x,x.x*hh

Table 14. GST description

Item	Description	Data Length
hhmmss.sss	UTC time of the GGA or GNS fix associated with this sentence.	10
xxxxx	RMS value of the standard deviation of the range inputs to the navigation process. Range inputs include pseudo ranges & DGNSS corrections.	5
xxxxx	Standard deviation of semi-major axis of error ellipse (meters)	5
xxxxx	Standard deviation of semi-minor axis of error ellipse (meters)	5
xxx	Orientation of semi-major axis of error ellipse (degrees from true north)	3
xxxxx	Standard deviation of latitude error (meters)	5
xxxxx	Standard deviation of longitude error (meters)	5
xxxxx	Standard deviation of altitude error (meters)	5

6. Appendix B: Acronyms and Abbreviations

The list of terminology used in this document is given in Table 15.

Table 15. Acronyms and abbreviations

Abbreviation/Term	Expansion/Definition
EPO	Extended Prediction Orbit
LLE	Location Low Energy
TTFF	Time To First Fix
CTTFF	Cold Start TTFF. Cold Start -- GNSS module starts without any cached data. (Without reference Time / Location / Ephemeris / Almanac).
WTTFF	Warm Start TTFF. Warm Start -- GNSS module starts with some cached data. (With reference Time / Location / Almanac, but not Ephemeris).
HTTFF	Hot Start TTFF. Hot Start -- GNSS module start with more effective cached data. (With reference Time / Location / Ephemeris, no need Almanac).
SIP	System-in-Package
MIPS	Million Instructions Per Second
GLP	GNSS Low Power is a low power mode for 1Hz positioning.
PMTK	PMTK is MediaTek's specific NMEA format usage to send commands to the GNSS module.
GNSS	Global Navigation Satellite System
RTC	A real-time clock
SNR	Signal noise ratio
PPS	Pulse per second
PDOP	Position Dilution of Precision
HDOP	Horizontal Dilution of Precision
VDOP	Vertical Dilution of Precision
CNR	Carrier-To-Noise Ratio
SNR	Signal Noise Ratio
DEE	Dynamic Ephemeris Extension