AirPrime HL78xx GNSS Behavior

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1 Version

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2 Introduction

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3 Introduction

This document provides detailed descriptions for operating the AirPrime HL78xx's GNSS subsystem, and its limitations.

4 Glossary

Term/Initials	Definition
A-GNSS	Assisted GNSS
Assistance data	Server-provided satellite positioning and other data
CEP	Computed Ephemeris
Cold start	No GNSS assistance data available on the device (e.g. ephemeris, and clock-correction information)
DRX	Discontinuous Reception
eDRX	Extended DRX
Ephemeris	Satellite-provided satellite positioning data (current and predicted) and clock correction
GLONASS	Global Navigation Satellite System (Russian satellite navigation system)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System (American satellite navigation system)
Hot start	Valid ephemeris and clock corrections are available on the device.
Idle mode	Idle mode refers to the modem state when it has no dedicated channel allocated and it listens periodically to the paging channel according to its DRX or eDRX period.
LTE	Long Term Evolution
MAP	Modem Application Processor
NMEA	National Marine Electronics Association
PSM	Power Saving Mode
TTFF	Time to First Fix
URC	Unsolicited Result Code

5 HL78xx GNSS Overview

The HL78xx supports GPS and GLONASS satellite systems using dedicated hardware accelerators in a power and cost-efficient manner. The GNSS receiver shares certain hardware resources with the modem, which enables GNSS measurement slots to be efficiently scheduled based on the modem link state.

The primary use-case for the HL78xx is to allow GNSS positioning for asset management applications where infrequent position updates are required.

5.1 GNSS Components

The HL78xx module includes a GNSS subsystem, and the following features to use it:

- RF components used to support GNSS
- Baseband-processing hardware
- Software, running on a modem application processor (MAP), that manages the GNSS subsystem and performs part of the processing

5.2 Supported GNSS constellations

The GNSS subsystem supports the following constellation combinations:

- GPS
- GPS+GLONASS

The decision to use GPS or GPS+GLONASS is a balance of performance versus power consumption. Use the +GNSSCONF command to choose the appropriate constellation combination.

5.3 GNSS/LTE Co-Existence

The GNSS receiver cannot operate in parallel with LTE data transfer, since the receiver shares the LTE modem's RF Rx path.

Because LTE communication has a higher priority than GNSS:

- When GNSS is operating in LTE idle state (PSM or idle-eDRX), GNSS will automatically shut off when the LTE modem wakes (becomes active).
- When LTE is active, GNSS cannot be activated – the +GNSSSTART AT command will return the URC "+GNSSEV: 1,0".

Table 1: describes the GNSS operational capabilities for each LTE state.

Table 1: LTE States

HL78xx LTE State	Description	GNSS Operational
Modem OFF (+CFUN=0) or Flight Mode (+CFUN=4)	LTE modem is off	GNSS can be used.
PSM	3GPP power saving mode. LTE modem is unavailable, typically for a duration of a few hours.	GNSS can be used in PSM mode.
Idle-eDRX	LTE modem spends majority of time in idle state, waking infrequently (paging cycle) to check in with the network. When the LTE modem wakes, GNSS automatically shuts off. When the LTE modem returns to idle state, GNSS automatically restarts.	GNSS can operate only during idle periods. GNSS assistance data can be used to improve GNSS performance.
Active	LTE modem is active.	GNSS cannot be started/used while LTE is active. A `+GNSSEV: 1,0` URC will be received, indicating GNSS failed to start. To check if LTE is idle, see section 10.2 GNSS not started in LTE Idle (eDRX / DRX).

5.4 A-GNSS Support

The GNSS subsystem utilizes A-GNSS methods to enhance performance.

Since GNSS cannot co-exist with LTE data, A-GNSS is strictly MSB (Mobile-Station-Based), meaning the device calculates its own position autonomously, without having to get it by communicating with the server. For this reason, GNSS does not support Location Protocols, either Control-Plane or User-Plane (SUPL) since they require communication with a server in parallel to GNSS activity.

The HL78xx supports Assistance Data download from a server, allowing GNSS to Hot-Start without having to download Ephemeris from the satellites. This improves Time-To-First-Fix (TTFF) and reduces power consumption.

6 GNSS Subsystem Configuration Methods

The GNSS subsystem is configured using AT commands, as demonstrated in this section. For detailed command descriptons, refer to [1] AirPrime HL78xx AT Command Reference.

6.1 Configure Location Service and GNSS Receiver (Satellite Constellation Support)

The AT+GNSSCONF command configures the LNA_EN (external LNA) signal, and selects the supported satellite constellation(s).

To configure the GNSS subsystem:

1. Configure the signal LNA_EN signal. When GNSS starts, external LNA is automatically enabled or disabled based on this configuration:
   - To enable external LNA (LNA_EN output signal is automatically driven), use:
     AT+GNSSCONF=1,1
   - To disable external LNA (LNA_EN output signal is always OFF), use:
     AT+GNSSCONF=1,0
2. Configure the satellite constellation(s):
   - To support GPS only, use:
     AT+GNSSCONF=10,0
   - To support GPS and GLONASS, use:
     AT+GNSSCONF=10,1

6.2 Configure NMEA Sentences

The AT+GNSSNMEA command enables NMEA sentences, and configures the NMEA output rate and the output port.

Syntax: AT+GNSSNMEA=[<output>], [<rate>], [<profile_mask>], [<nmea_mask>]

Enable/disable the NMEA sentence types with the <nmea_mask>, and set the output rate and port with the <rate> and <output> parameters.

Note: If <output> port 4 (the current port) is to be used, the command must be executed twice – the first call enables the desired NMEA sentence types, and the second call sets the output port to 4. This is required because as soon <output> port 4 is enabled, it immediately switches to DATA mode and will be used to output NMEA sentences.

To switch the port back to COMMAND mode, send +++ (without a CR LF).

For example:

- To configure the UART1 as the <output> port and enable GPGGA and GPGSA sentences, use:
  AT+GNSSNMEA=3,1000,0,3
- To configure the current port as the <output> port and enable GPGGA and GPGSA sentences, use:
  AT+GNSSNMEA=0,1000,0,3
  AT+GNSSNMEA=4

  The port immediately switches to DATA mode. (To switch back to command mode, send +++ without CR LF).

For a complete list of output ports and NMEA bit masks, refer to [1] AirPrime HL78xx AT Command Reference.

Note: To enable +GNSSLOC? output, and GNSS URC notifications for +GNSSSTART, the <nmea_mask> must enable at least GGA and GST for 3D fixes and RMC for GPS time (i.e. the minimum <nmea_mask> must be hex 49).

6.3 Assistance Data (A-GNSS)

AT commands are used to download, erase, or check the validity of server-generated assistance data. The commands used are firmware version-dependent.

If assistance data will be used, note the following characteristics and requirements:

- Assistance data can be obtained for up to 28 days in the future, and downloaded data size is ~10 KB / 1 day.
- Accuracy of assistance data decreases in relation to the prediction duration (i.e. the accuracy of assistance data after 3 days will be greater than the accuracy after 10 days)
- Although assistance data supports only GPS (not GLONASS), GNSS can still make use of GPS assistance data in hybrid mode (GPS+GLONASS).
- The system clock must be available to check the validity of downloaded assistance data. (To confirm the clock is available, use `AT+CCLK?`)
- When I-eDRX is configured with a paging cycle < 10 seconds, it is not recommended to perform a GNSS cold start. GNSS assistance data is recommended for use when starting GNSS in I-eDRX state.

6.3.1 Working with Assistance Data – Firmware version 4.6.2.0 and later

(A-GNSS is supported only with firmware version 4.6.2.0 and later.)

The command +GNSSAD is used to work with assistance data.

To download assistance data:

1. Establish an LTE connection. (Data connectivity is required to be able to download the assistance data.)
2. Download the assistance data:

   AT+GNSSAD=1,<number_of_days>

   Where <number_of_days> = 1, 2, 3, 7, 14, or 28.

   e.g. AT+GNSSAD=1,7 downloads assistance data for the next 7 days

To check the validity of downloaded assistance data, use:

AT+GNSSAD?
`+GNSSAD: <mode>,[<days>,<hours>,<min>]`

or

`ERROR` *(Indicates no assistance data is available on the device.)*

Where <mode> = 0 (delete) or 1 (download); <days>,<hours>,<min> = remaining time (validity) of downloaded assistance data.

To erase the downloaded assistance data, use:

AT+GNSSAD=0

7 GNSS Event Notifications

The +GNSSEV URC (notification) is issued automatically by the GNSS subsystem to notify the client whenever a GNSS event occurs or there is a change in position state.

Specifically, notifications are issued when:

- The GNSS subsystem initializes (or fails to initialize)
- The GNSS subsystem starts (or fails to start)
- The GNSS subsystem stops (or fails to stop)
- The GNSS position fix is lost (or not available), becomes available (predicted, 2-D, or 3-D), or changes due to an invalid position

Refer to [1] AirPrime HL78xx AT Command Reference for details.

8 Using GNSS

GNSS should be configured before starting the GNSS session. (Certain GNSS configuration commands are not allowed during the GNSS session and will return errors.) Note also that GNSS assistance data can be downloaded to improve GNSS performance – see section 6.3 Assistance Data (A-GNSS) for details.

To use GNSS, the LTE modem must be:

- Configured for minimum functionality, or
- Configured with Rx/Tx disabled, or
- In LTE idle state (Idle-DRX/eDRX)

For example, use the following procedure to configure and start a GNSS session, receive a position fix, stop the session and restore LTE functionality:

1. Check the current LTE modem configuration state:

   AT+CFUN?
   +CFUN=<state>

2. GNSS can be started if the current <state> is:
   - 0 – Minimum functionality
   - 4 – Rx/Tx disabled
   - 1 – Full functionality, but must be idle. Make sure the configured eDRX sleep (Idle) time is long enough to acquire a position fix.

3. Optionally, configure the NMEA sentences to be supported. Make sure the <nmea_mask> enables GGA, GST, and RCM. Also, to use the same port for AT commands and to receive NMEA messages, set <output>=0 now, and the correct port will be set after GNSS starts:

   AT+GNSSNMEA=<output>,<rate>,0,<nmea_mask> *(See [1] AirPrime HL78xx AT Command Reference for options.)*

   OK

4. Start the GNSS session:

   AT+GNSSSTART=0
   OK
   +GNSSEV: 0,1 *(Note: This indication does not appear during a hot start.)*
   +GNSSEV: 1,1 *or* +GNSSEV: 1,0 *(Note: If LTE is active, +GNSSEV:1,0 will be received, indicating GNSS failed to start.)*
   +GNSSEV: 3,0 *(Note: This indication does not appear during a hot start.)*
   +GNSSEV: 3,3

5. After the session has started, the following commands can be used if desired:
   - To begin receiving NMEA messages on the same port as AT commands are entered, use:

     AT+GNSSNMEA=4

     NMEA messages will begin appearing (see 8.1 Sample NMEA responses for examples).
     (To stop receiving NMEA messages on the port, send +++ to return to command mode.)
   - After receiving a URC indicating a GNSS position fix is available (+GNSSEV: 3,2 / +GNSSEV: 3,3), the following commands can be used if desired:
     - Display the TTFF of the last run:

       AT+GNSSTTFF?
       +GNSSTTFF: 39825, 39825
       OK
     - Display the position fix details:

       AT+GNSSLOC?
       +GNSSLOC:
       Latitude: 49 Deg 10 Min 43.83 Sec N
       Longitude: 123 Deg 5 Min 40.56 Sec W
       GpsTime: 2020 7 23 19:06:25

```
FixType: 3D
HEPE: 0.09 m
Altitude: 5.300 m
AltUnc: 0.0 m
Direction:
HorSpeed:
VerSpeed:

OK
```

6. Stop the GNSS session:

```
AT+GNSSSTOP
OK

+GNSSEV: 2,1
+GNSSEV: 3,0
```

7. At this point, GNSS is stopped and the LTE modem is still configured for <state>=0 or 4. To re-enable full LTE modem functionality (if desired), use:

```
AT+CFUN=1
OK
```

Note: GNSS cannot be started immediately after waking from hibernate. Allow ~1 second for the module to complete PDN (data connection) initialization before attempting to start GNSS.

8.1 Sample NMEA responses

This excerpt shows NMEA responses being received on the same port as AT commands are issued. AT the end of the excerpt, +++ is sent to return port to command mode.

```
…
AT+GNSSNMEA=0,1000,0,1FF   (Configure supported NMEA sentences and other options. Configuration must be done before starting GNSS.)
OK
AT+GNSSSTART=0   (Start GNSS)
OK

+GNSSEV: 0,1
+GNSSEV: 1,1
+GNSSEV: 3,0

AT+GNSSNMEA=4   (Use the current port (the AT port) to receive NMEA messages.))
CONNECT
$GPGGA,000006.00,4910.7293,N,12305.6759,W,0,00,1.2,-16.0,M,0.0,M,,*5B
$GPGLL,4910.7293,N,12305.6759,W,000006.00,V,N*6E
…
$GPZDA,201447.00,23,07,2020,,*64
$GPGST,201447.00,,1.0,0.9,26.7,1.0,0.9,2.2*4E

[Send escape sequence (+++) to switch port back to command mode.]

OK

+GNSSEV: 3,3
AT+GNSSSTOP
OK
```

9 GNSS Performance

Table 2: compares typical current consumption when GNSS is active and consumption when GNSS is possible (minimal LTE functionality).

For detailed non-GNSS current consumption information, and for GNSS performance data (sensitivity, TTFF, etc.), refer to [2] AirPrime HL780x Product Technical Specification.

Table 2: Typical Power Consumption

HL78xx State	Typical consumption
Booting	~96.5 mA
LTE modem – Minimum functionality (AT+CFUN=0)	~27 mA
GNSS active (AT+GNSSSTART=0)	~60.5 mA

10 Troubleshooting

This section provides troubleshooting suggestions for specific GNSS issues.

10.1 Issue: No Position Fix Information Available

The +GNSSLOC? and +GNSSTTFF? commands both return information about the last position fix, or indicate that a fix is not available:

- Position fix not available:

```
AT+GNSSLOC?
+GNSSLOC:
FIX NOT AVAILABLE

OK
AT+GNSSTTFF?
+GNSSTTFF: -30, -30   ("-30, -30" indicates no 2D fix and no 3D fix available)

OK
```

- Position fix available:

```
AT+GNSSLOC?
+GNSSLOC:
Latitude: 49 Deg 10 Min 43.78 Sec N
Longitude: 123 Deg 5 Min 40.32 Sec W
GpsTime: 2020 10 28 17:50:41
FixType: 3D
HEPE: 0.14 m
Altitude: 9.000 m
AltUnc: 0.0 m
Direction:
HorSpeed:
VerSpeed:

OK

AT+GNSSTTFF?
+GNSSTTFF: 4193, 4193   ("4193, 4193" indicates number of ms since 2D and 3D fixes were obtained)
OK
```

Note: GNSS URCs indicate when 2D and 3D fixes are available:
- *3D Fix – "+GNSSEV: 3,3"*
- *2D Fix – "+GNSSEV: 3,2"*

If a fix is not available:

- Make sure all NMEA sentences are enabled:

  AT+GNSSNMEA=0,1000,0,1FF
  OK

- Make sure the antenna is properly connected and open sky is available (e.g. unobstructed view for satellite acquisition). The GNSS subsystem requires at least 40 seconds for a cold start with good satellite visibility to acquire a position Fix.
- If a fix is still not available, check for satellite availability – to obtain a position fix, at least four satellites must be available with SNR > 25.

  Use the %IGNSSINFO="SAT" command, which provides satellite information. The command/response format is:

  AT%IGNSSINFO="SAT"
  %IGNSSINFO: <num_satellites>
  [%IGNSSINFO: <PRN>,<elevation>,<azimuth>,<SNR>]

  Example (Satellites found, fix can be obtained):

  AT%IGNSSINFO="SAT"
  %IGNSSINFO: 8 *(8 satelites found)*
  %IGNSSINFO:08,36,300,**27**
  %IGNSSINFO:10,83,306,**33**
  %IGNSSINFO:11,12,310,18
  %IGNSSINFO:20,56,070,**30**
  %IGNSSINFO:21,25,301,**31**
  %IGNSSINFO:23,59,063,**29**
  %IGNSSINFO:27,51,251,**29**
  %IGNSSINFO:32,32,187,**27**

  OK

  Example (Satellites found, no fix can be obtained since only 3 have SNR>25):

  AT%IGNSSINFO="SAT"
  %IGNSSINFO: 8 *(8 satelites found)*
  %IGNSSINFO:08,36,300,14
  %IGNSSINFO:10,83,306,**33**
  %IGNSSINFO:11,12,310,18
  %IGNSSINFO:20,56,070,21
  %IGNSSINFO:21,25,301,**31**
  %IGNSSINFO:23,59,063,19
  %IGNSSINFO:27,51,251,**29**
  %IGNSSINFO:32,32,187,11

  OK

  Example (no satellites found, no fix can be obtained):

  AT%IGNSSINFO="SAT"
  %IGNSSINFO: 0 *(No satelites found)*

  OK

10.2 GNSS not started in LTE Idle (eDRX / DRX)

A GNSS session cannot start if there is background LTE activity (such as the paging cycle).

If GNSS will not start when the LTE modem is configured for full functionality:

- Confirm that LTE is in idle state before starting GNSS:

  AT%STATUS="RRC"
  RRC: IDLE

  OK

- Set the eDRX cycle to at least 40 seconds when doing a GNSS cold start.
  For example, to set the eDRX cycle to 81.92 seconds, use:
  AT+CEDRXS=2,4,5

  OK

Note: In eDRX/DRX mode, the GNSS RF signal is disrupted every paging window. This leads to higher TTFF.

Note: TTFF is higher after waking up from the hibernate cycle due to clock drift. In hibernate mode, the clock is switched to a lower resolution clock to save power.

Note: To ensure GNSS data is saved after a position Fix, wait at least 250 ms before allowing the device to enter hibernation.

11 Reference Documents

	Title	Document #
[1]	AirPrime HL78xx AT Command Reference	41111821
[2]	AirPrime HL780x Product Technical Specification	41113770

12 Support

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13 Document History

Level	Date	History
1	December 03, 2020	Creation

14 Legal Notice

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