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Hardware Compatibility	Product Line	IoT Modules	Series	EM7690	EM9291
				EM9190	EM9293
				EM9191	

Software Compatibility		Document Type	App Note	✓	Tech Note	

1 Version

This document may be updated over its lifetime. To ensure you design with the correct version, contact your Semtech representative for the latest version (see 10 Support).

2 Introduction

This document is provided to Semtech distributors and clients to aid more rapid development of embedded applications using the Semtech portfolio of cellular solutions. To request a new application/technical note, contact your regional Semtech Product Marketing Manager.

Note: In this document, EM9 refers to EM9 series modules (EM7690, EM9190, EM9191, EM9291 and EM9293).

3 Glossary

Term	Definition
A-GNSS	Assisted GNSS. This term is used interchangeably with A-GPS.
A-GPS	Assisted GPS. This term is used interchangeably with A-GNSS.
CTS	Certification Test Suite (for Android testing)
EM9	EM9 series module (EM7690, EM9190, EM9191, EM9291, EM9293)
LBS	Location Based Service
MO	Mobile-Originated
MS-A	SUPL Mobile Station-Assisted A-GNSS. Location fix is calculated on the SUPL server. Not widely supported due to computation demands on the server.
MS-B	SUPL Mobile Station-Based A-GNSS. Location fix is calculated on the module using assistance data that is downloaded from the SUPL server. Widely supported on public SUPL servers (e.g., supl.google.com).
NTP	Network Time Protocol
SUPL	Secure User-Plane Location (A-GNSS method)
TTFF	Time-to-First-Fix

Term	Definition
VSP	NMEA Virtual Serial Port
XTRA	Proprietary Qualcomm A-GNSS method

4 Scope

This document describes methods for obtaining location fixes and establishing continuous tracking sessions with EM9 modules.

Note: References to EM9 module support of GNSS functionality are current as of this document's publication date.

5 Location fixes

EM9 modules support standalone and assisted GNSS (A-GNSS) methods for obtaining location fixes and establishing continuous tracking sessions:

- Standalone GNSS — For this method, the EM9 module uses only GNSS satellite signals to obtain a single location fix ('single-shot') or establish a tracking session (series of location fixes) for greater accuracy.
- Assisted GNSS (A-GNSS) — For this method, the EM9 module uses a cellular network (WWAN) connection to download GNSS satellite system 'assistance' data (e.g., ephemeris, almanac, etc.) from a network operator-provided server. The module uses the assistance data to more quickly acquire signals from the GNSS satellite system, enabling a faster time-to-first-fix (TTFF) compared with standalone GNSS.

  EM9 modules support two A-GNSS types:

  - SUPL — SUPL (Secure User-Plane Location) is used to download assistance data from a SUPL server each time a location fix is initiated.

    SUPL A-GNSS functionality is network-dependent and categorized as follows:

    - Mobile Station Based (MS-B) — The network server provides assistance data to the EM9 module, which the module uses to calculate the positions of GNSS satellites and establish a fix. This is the most common method used.

      Note that if the SUPL assistance data is unavailable for some reason (e.g., a failed network connection, server outage, etc.), the module will fall back to standalone GNSS to obtain a location fix, enhanced by previously downloaded XTRA assistance data, if available).
    - Mobile Station Assisted (MS-A) — The network server calculates and provides the positions of GNSS satellites to the EM9 module to establish a fix. This method is less common, typically due to higher costs (computation time, quantity of data transferred, etc.).

      Note that if the SUPL assistance data is unavailable for some reason (e.g., a failed network connection, server outage, etc.), no fix will be reported, since the server does the location calculation.
  - XTRA — XTRA is a proprietary Qualcomm A-GNSS feature. XTRA initially downloads assistance data from an XTRA server, then automatically refreshes the data when required. Note that the assistance data remains usable for up to 7 days to enhance location fix attempts, without requiring a WWAN connection.

Important: *GNSS functionality must currently be active on the EM9 module to obtain location fixes (either single-shot or tracking session) — see 5.1 GNSS Permitted State for details.*

Table 1: Location fix methods comparison

Method	TTFF[a] (typical)	WWAN connection	Notes
Standalone GNSS	≤ 30 seconds	Not required	The module searches for and receives signal data from GNSS satellites to establish a location fix, without requiring a WWAN connection. Because the GNSS signals are low-speed, standalone GNSS has the longest TTFF of the supported location fix methods. (Note that previously-downloaded unexpired XTRA assistance data will be used if available, even if XTRA is currently disabled.)
SUPL	≤ TBD seconds	Always required, to obtain current assistance data.	▪ Typically, SUPL A-GPS results in a shorter TTFF than XTRA A-GPS, but requires the module to always have an active cellular connection, whereas XTRA A-GPS does not require an active connection until the assistance data needs to be refreshed. Note: If SUPL and XTRA are both available, SUPL will be used. ▪ Carriers may supply their own SUPL server. The customer must configure the EM9 module with the carrier's SUPL server details. ▪ Requires a WWAN connection for every location fix. ▪ The module calculates satellite positions using MS-B SUPL data, or the server calculates positions and provides them to the module. ▪ Note: It is theoretically possible that the module's location information could be aggregated by the provider of the SUPL server for their own usage. ▪ **Important:** Retrieving SUPL information from the Google SUPL server will consume some of the subscribed carrier's data plan allotment.
XTRA	≤ 13 seconds	Periodically required, to obtain updated assistance data when necessary	▪ Enables several times faster TTFF compared with standalone GNSS. ▪ EM9 module is preconfigured with XTRA server URL and other settings. ▪ Downloaded assistance data is used for up to 7 days; the module may refresh the data earlier if necessary.

a. Preliminary TTFF values shown are for a cold start with a WWAN connection. Note that GNSS fixes are affected by obstructions such as urban canyons, tree canopies, clouds, etc.

5.1 GNSS Permitted State

GNSS fix attempts (single-shot and tracking session) are usually permitted, but will be denied if any of the following conditions are met:

- !CUSTOM "GPSENABLE" customization:
  - If the <value> is 0, GNSS is disabled.
  - If the <value> is 4 and the module's GPS_DISABLE pin is ON (asserted), GNSS is disabled.
- !CUSTOM "GPSLPM" customization:
  - If the <value> is 1 and the modem is in low power mode (LPM), GNSS is disabled.

For example:

```
at!custom?
            !CUSTOM:
            GPSENABLE 0x04   ←GNSS is permitted unless the GPS_DISABLE pin is ON.
            GPSLPM 0x01   ←GNSS is permitted unless the module is in LPM.
            IMCONFIG 0x02
            ...
OK
```

For additional !CUSTOM customization details, refer to *[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)*.

To check whether GNSS is disabled and why, use either of the following methods:

- Use !GNSSPERMITTEDSTATE to check the permitted state. If the permitted state is 0 (not permitted), a list of 'Disable votes' fields indicates the conditions that can disable GNSS — '1' indicates the condition is keeping GNSS disabled.

  For example, in this case GNSS is not permitted for two reasons — the GPS_DISABLE pin (WDIS_2) is ON) and the module is in LPM:

  ```
  at!gnsspermittedstate?
  Permitted: 0  ←GNSS is not permitted because the GPS_DISABLE pin (WDIS_2) is ON and the module is in LPM.
  Disable votes: WDIS_2:1, LPM:1, CARRIER:0, GPSENABLECUST:0
  OK
  ```

  For a more detailed example, see 6.3 GNSS Permitted States examples.
- Check the QMI_SWILOC_GET_GNSS_PERMITTED_STATE object.

5.2 Location Fix Methods

5.2.1 Standalone GNSS

For standalone GNSS, the EM9 module uses only GNSS satellite signals to calculate satellite positions and lock on to obtain the location fix. The module does not use a WWAN connection.

Note: If valid (i.e., unexpired) XTRA assistance data has been downloaded, the module uses this to improve the TTFF even if XTRA is currently disabled. If conducting TTFF testing, use the !GPSCLRASSIST AT command to clear the stored XTRA assistance data.

Table 2 summarizes available methods (AT commands, QMI objects, SDK APIs) for configuring the EM9 module to use standalone GNSS.

For examples of AT commands in use, see 6.1.1 Example — Standalone GNSS location fix and 6.1.2 Example — Standalone GNSS tracking session.

Table 2: Standalone-specific Configuration Methods

Functionality	AT command[a]	QMI Object[b]	SDK API[c]
Initiating Assisted Fixes			
Initiate location fix	!GPSFIX=1,x,x	QMI_LOC_SET_OPERATION_MODE + QMI_LOC_START	pack_loc_Start/ unpack_loc_Start pack_loc_SetOperationMode/ unpack_loc_SetOperationMode
Initiate tracking session	!GPSTRACK=1,x,x,x,x		
A-GNSS Configuration			
Disable XTRA A-GNSS	!GPSXTRADATAENABLE=0		

a. For AT command details, refer to *[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10).*
b. For QMI object details, refer to *[2] QMI LOC 2.155 for MPSS (Doc# 80-16656-17 Rev. AB).*
c. For SDK API details, refer to *[4] Software Integration and Development Guide For Linux USB Platforms (Doc# 41114212).*

5.2.2 SUPL

For SUPL A-GNSS, the cellular network provider maintains a server that stores assistance information (orbital details such as ephemeris and almanac) for GNSS satellites. Depending on the network provider's server configuration, the assistance information will be available to the EM9 module in one or both of the following ways when the module initiates a location fix or tracking session:

- Mobile station-based (MS-B):
  - **a.** The EM9 module uses a WWAN connection to connect to the SUPL server, and requests assistance data for GNSS satellites.
  - **b.** The server downloads the requested assistance data to the EM9 module.
  - **c.** The module uses the assistance data to calculate GNSS satellite positions and establish the location fix.
- Mobile station-assisted (MS-A):
  - **a.** The EM9 module uses a WWAN connection to connect to the SUPL server, and requests that the server calculate GNSS satellite positions.
  - **b.** The server calculates GNSS satellite positions based on its own data (including local conditions based on the cell towers local to the module) and data supplied in the module's request.
  - **c.** The server downloads the GNSS satellite position details to the module.
  - **d.** The module uses the position information to establish the fix.

For example, the Google SUPL server supports only MS-B. Other network operators may support MS-B only, MS-A only, or both MS-B and MS-A. (For Google SUPL server settings, see Table 5, Google SUPL Server, on page 19.)

EM9 SUPL support details:

- Supported versions: Up to SUPL 2.0.4. (Note: To make sure the EM9 module will work with SUPL version 1 and version 2 servers, use the command !GPSSUPLVER to confirm the module is configured for SUPL version 2 support, which is backward-compatible for version 1.)
- EM9 supports both MS-B and MS-A.

Table 3 summarizes available methods (AT commands, QMI objects, SDK APIs) for configuring the EM9 module to use SUPL A-GNSS. For examples of the AT commands in use, see 6.2.1 Example — Standalone GNSS vs. SUPL A-GNSS location fix

Table 3: SUPL-specific A-GNSS Configuration Methods

Functionality	AT command[a]	QMI Object[b]	SDK API[c]
Server Configuration			
Set SUPL version	!GPSSUPLVER	QMI_LOC_GET_PROTOCOL_CONFIG_PARAMETERS QMI_LOC_SET_PROTOCOL_CONFIG_PARAMETERS	pack_loc_GetProtocolConfigParams/ unpack_loc_GetProtocolConfigParams
Set SUPL URL and port	!GPSSUPLURL	QMI_LOC_GET_SERVER QMI_LOC_SET_SERVER	pack_loc_SLQSLOCGetServer/ unpack_loc_SLQSLOCGetServer pack_loc_SLQSLOCSetServer/ unpack_loc_SLQSLOCSetServer
SUPL certificate management	n/a	QMI_LOC_INJECT_SUPL_CERTIFICATE QMI_LOC_DELETE_SUPL_CERTIFICATE	pack_loc_InjectSuplCertificate/ unpack_loc_InjectSuplCertificate pack_loc_DeleteSuplCertificate/ unpack_loc_DeleteSuplCertificate
	Note: Semtech pre-configures Carrier PRIs with the SUPL certificate if one was provided by the carrier. Typically, certificate injection/deletion would only be required to populate the SUPL credentials for generic carriers.		
SUPL connection management and status	n/a	QMI_LOC_EVENT_LOCATION_SERVER_CONNECTION_REQ QMI_LOC_INFORM_LOCATION_SERVER_CONN_STATUS	unpack_loc_EventLocationServConnect_Ind pack_loc_InformLocServConnStatus/ unpack_loc_InformLocServConnStatus

Table 3: SUPL-specific A-GNSS Configuration Methods (Continued)

Functionality	AT command[a]	QMI Object[b]	SDK API[c]
Configure APN for SUPL	!GPSLBAPN	n/a	n/a
Configure transport security (SSL, SHA256, etc.)	!GPSTRANSSEC	QMI_LOC_GET_PROTOCOL_CONFIG_PARAMETERS QMI_LOC_SET_PROTOCOL_CONFIG_PARAMETERS	pack_loc_GetProtocolConfigParams/ unpack_loc_GetProtocolConfigParams
Set minimum SSL cert key length	!GNSSCERTKEYLENMIN	n/a	n/a
Configure login for VZW SUPL server	AT!GNSSAPPINFO	n/a	n/a
Set accuracy settings for assisted fixes (low-accuracy, high-accuracy, assistance data allowed)	!GPSMOLRSETTING	n/a	n/a
Inject Position	n/a	QMI_LOC_INJECT_POSITION	pack_loc_SLQSLOCInjectPosition unpack_loc_SLQSLOCInjectPosition unpack_loc_InjectPositionCallback_Ind
Initiating Assisted Fixes			
Initiate MS-B fix	!GPSFIX=2,x,x	QMI_LOC_SET_OPERATION_MODE + QMI_LOC_START	pack_loc_Start/unpack_loc_Start pack_loc_SetOperationMode/ unpack_loc_SetOperationMode
Initiate MS-B tracking session	!GPSTRACK=2,x,x,x,x		
Initiate MS-A fix	!GPSFIX=3,x,x		
Initiate MS-A tracking session	!GPSTRACK=3,x,x,x,x		
A-GNSS Configuration			
Report reference location from an assisted fix as valid, even if the fix fails	!CUSTOM=GPSREFLOC	n/a	n/a
Disable XTRA A-GNSS	!GPSXTRADATAENABLE=0		

a. For AT command details, refer to *[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10).*
b. For QMI object details, refer to *[2] QMI LOC 2.155 for MPSS (Doc# 80-16656-17 Rev. AB).*
c. For SDK API details, refer to refer to *[4] Software Integration and Development Guide For Linux USB Platforms (Doc# 41114212).*

5.2.3 XTRA

To obtain an XTRA A-GNSS fix:

1. The EM9 module uses a WWAN connection to connect to the XTRA server, and requests assistance data for GNSS satellites.
2. The XTRA server returns the assistance data (time, and orbital details such as ephemeris and almanac).

3. The module uses the assistance data to calculate satellite positions and establish the fix.
(Note: XTRA assistance data is usable for up to 7 days, but the module refreshes the data whenever necessary by reconnecting and downloading new data from the server when a location fix is initiated.)

EM9 XTRA support details:
- XTRA is enabled by default on all EM9 modules (i.e., it will automatically be used)
- XTRA server details are pre-configured

Table 4 summarizes available methods (AT commands, QMI objects, SDK APIs) for configuring the EM9 module to use XTRA A-GNSS. For examples of the AT commands in use, see 6.2.2 Example — Standalone GNSS vs. XTRA A-GNSS location fix

Table 4: XTRA-specific A-GNSS Configuration Methods

Functionality	AT command[a]	QMI Object[b]	SDK API[c]
Server Configuration			
Enable/disable version check	n/a	QMI_LOC_SET_XTRA_VERSION_CHECK	TBD
Enable/disable/configure XTRA data download (some customers do not want it because of firewall/routing issues)	!GPSXTRADATAENABLE		
Configure automatic download of NTP (Network Time Protocol) time	!GPSXTRATIMEENABLE		TBD
Query XTRA status	!GPSXTRASTATUS	QMI_LOC_QUERY_XTRA_INFO	pack_loc_QueryXtraInfo/ unpack_loc_QueryXtraInfo
Modify XTRA data URL (usually only needed for emergencies)	!GPSXTRADATAURL	n/a	n/a
Modify time URL	!GPXSTRATIMEURL		
Enable/disable NTP time injection	!GPSXTRATIMEENABLE	n/a	n/a
Inject XTRA data and PCID	!GPSXTRAINITDNLD	QMI_LOC_INJECT_XTRA_DATA QMI_LOC_INJECT_XTRA_PCID	pack_loc_InjectXtraData/ unpack_loc_InjectXtraData pack_loc_InjectXtraPcid/ unpack_loc_InjectXtraPcid
Inject UTC Time	!GPSXTRATIME	QMI_LOC_INJECT_UTC_TIME	pack_loc_SLQSLOCInjectUTCTime unpack_loc_SLQSLOCInjectUTCTime unpack_loc_InjectUTCTimeCallback_Ind
Manage XTRA-T sessions	n/a	QMI_LOC_SET_XTRA_T_SESSION_CONTROL QMI_LOC_GET_XTRA_T_SESSION_CONTROL	pack_loc_SetXtraTSessionControl/ unpack_loc_SetXtraTSessionControl pack_loc_GetXtraTSessionControl/ unpack_loc_GetXtraTSessionControl

Table 4: XTRA-specific A-GNSS Configuration Methods (Continued)

Functionality	AT command[a]	QMI Object[b]	SDK API[c]
Initiating Assisted Fixes			
Initiate fix	!GPSFIX=1,x,x	QMI_LOC_SET_OPERATION_MODE + QMI_LOC_START	pack_loc_Start/unpack_loc_Start pack_loc_SetOperationMode/ unpack_loc_SetOperationMode
Initiate tracking session	!GPSTRACK=1,x,x,x,x		

a. For AT command details, refer to *[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10).*
b. For QMI object details, refer to *[2] QMI LOC 2.155 for MPSS (Doc# 80-16656-17 Rev. AB).*
c. For SDK API details, refer to *[4] Software Integration and Development Guide For Linux USB Platforms (Doc# 41114212).*

5.3 Location fix (Single-shot and Tracking session) Procedure

The following is a basic procedure for obtaining standalone (unassisted) or A-GNSS (assisted) single-shot location fixes or continuous tracking sessions:

1. Configure the module for standalone or A-GNSS use:

Tip: *Use the query versions of the commands below to check the current settings and record them in case you need to restore them later.*

- To perform standalone fixes or sessions:
  i. Use !GPSXTRADATAENABLE to disable XTRA A-GNSS.
- To perform SUPL A-GNSS fixes or sessions:
  i. For carriers using a Generic PRI, check with the carrier to find out required SUPL server details (URL, port, and SUPL version). (Note: Carrier PRIs are typically configured with the carrier's required SUPL server details.)
  ii. Use !GPSSUPLURL to make sure the module is configured with the correct SUPL server URL.
  iii. Use !GPSSUPLVER to make sure the module is configured to use the same SUPL version number as the server.
  iv. Use !GPSLBSAPN to make sure the correct GPS location based service (LBS) APNs are configured for supported RATs.
  v. Use !GPSTRANSSEC to make sure the module's GPS transport security settings (enable/disable security, select cryptographic protocol and hash function) are correctly configured for the SUPL server.
- To perform XTRA A-GNSS fixes or sessions:
  i. Check with the carrier to find out required XTRA server details (data server and time server URLs and related settings).
  ii. Use !GPSXTRADATAENABLE to enable XTRA A-GNSS.
  iii. Use !GPSXTRADATAURL to confirm that the XTRA data server URL is correctly configured.
  iv. Use !GPSXTRATIMEENABLE to confirm that the use of an XTRA time server is enabled. This enables retrieval of SNTP time information to improve fix accuracy and speed. (Note: This is necessary when UMTS is being used.)
  v. Use !GPSXTRATIMEURL to confirm the XTRA time server URL is correctly configured.

2. If any configuration changes were made in step 1, use !RESET to reset the module and apply the changes.
3. Use !GPSEND to make sure there are no GPS processes running.
4. Optionally, use !GPSCLRASSIST to clear existing SUPL and XTRA assistance data from the module so that a cold start for GPS acquisition will occur when the next GPS session starts, which will cause up-to-date assistance data to be obtained from the appropriate server (SUPL or XTRA).
5. Start a single-shot location fix or a tracking session:

- Single-shot — Use !GPSFIX to start a single-shot location fix by specifying the fix type (standalone (for standalone or stand-alone plus XTRA A-GNSS); MS-based or MS-assisted for SUPL A-GNSS), a timeout value and a maximum distance accuracy.
- Tracking session: — Use !GPSTRACK to start a GNSS tracking session by specifying the fix type (standalone for standalone or standalone plus XTRA A-GNSS; MS-based or MS-assisted for SUPL A-GNSS), a timeout value per fix, a maximum distance accuracy and the interval between fix attempts, and configure the session for continuous fixes or a specific number of fixes.

6. After starting the location fix or tracking session:
   - Use !GPSSTATUS to check the current status of the latest fix attempt.
   - After a fix completes successfully, use !GPSLOC to get the calculated location data.
   - For tracking sessions, use !GPSLOCREPORT to get !GPSLOC results at scheduled intervals.
   - If the location fix or tracking session is in progress, optionally use !GPSSATINFO to get live satellite data for troubleshooting GNSS issues. (e.g., if a fix cannot be obtained, the satellite data may be useful in determining if the problem may be a firmware or hardware issue)

   For example:

```
at!gpssatinfo?
at!gpssatinfo?
NO SAT INFO   ←Fix cannot be obtained because a tracking session is not running

OK

at!gpssatinfo?
Satellites in view:  17 (2022 04 14 3 07:29:54)   ←Tracking session is running, satellites in view
* SV:  1  ELEV: 40  AZI:  306  SNR: 31
* SV: 10  ELEV: 36  AZI:   93  SNR: 24
* SV: 23  ELEV:  5  AZI:   98  SNR: 24
* SV: 24  ELEV:  5  AZI:   31  SNR: 35
* SV: 32  ELEV: 74  AZI:   74  SNR: 35
* SV: 24  ELEV:  5  AZI:   31  SNR: 24
* SV: 74  ELEV: 23  AZI:   77  SNR: 27
* SV: 73  ELEV: 17  AZI:   28  SNR: 36
* SV: 81  ELEV: 34  AZI:  322  SNR: 41
* SV: 72  ELEV: 41  AZI:   51  SNR: 34
* SV:244  ELEV: 33  AZI:  297  SNR: 25
* SV:237  ELEV: 22  AZI:   62  SNR: 39
* SV:212  ELEV: 20  AZI:  320  SNR: 33
* SV:302  ELEV:  6  AZI:   72  SNR: 36
* SV:325  ELEV:  6  AZI:   27  SNR: 35
* SV:333  ELEV: 36  AZI:  310  SNR: 35
* SV:195  ELEV: 17  AZI:  303  SNR: 28

OK
```

6 Appendix — AT command examples

6.1 Standalone (unassisted) GNSS location fix examples

6.1.1 Example — Standalone GNSS location fix

```
at!gpsfix=1,255,500 ← Start a standalone fix: '1' = standalone, '255' = timeout, '500' = accuracy
OK

at!gpsstatus? ← Check the fix status.
Current time: 2024 06 21 1 18:43:21

2024 06 21 1 18:43:21 Last Fix Status = NONE   ← A location fix has not been completed.
2024 06 21 1 18:39:57 Fix Session Status = ACTIVE   ← The location fix started at 18:39:57 and
                                                      is still in progress after 204 s at 18:43:21.

No TTFF available
OK

at!gpsstatus? ← Check the status again, which indicates the fix failed. In this example, this occurred because the module
                is in a GPS 'dead zone' (e.g., in an urban canyon, a tunnel, etc.)
Current time: 2024 06 21 1 18:49:37

2024 06 21 1 18:44:12 Last Fix Status = FAIL, FAILCODE = 12     ← The location fix timed out
2024 06 21 1 18:44:12 Fix Session Status = FAIL, FAILCODE = 12    (failcode=12) after 255 s.

No TTFF available
OK

at!gpsstatus? ← Check the status again (after moving to a location with better signal).
Current time: 2024 06 21 1 18:56:58

2024 06 21 1 18:56:48 Last Fix Status = SUCCESS      ← The location fix completed successfully.
2024 06 21 1 18:56:48 Fix Session Status = SUCCESS

TTFF (sec) = 58 ← The standalone location fix was obtained after 58 seconds.
OK

at!gpsloc? ← Get the location fix data.
Lat: 49 Deg 16 Min 58.39 Sec N (0x008C2EB4)
Lon: 123 Deg 6 Min 29.04 Sec W (0xFEA1D371)
Time: 2024 06 21 1 18:57:08 (GPS)
LocUncAngle: 0.0 deg LocUncA: 190 m LocUncP: 17 m HEPE: 190.759 m
3D Fix
Altitude: 110 m LocUncVe: 200.4 m
Heading: 0.0 deg VelHoriz: 0.0 m/s VelVert: 0 m/s

OK
```

Note: If the fix was still in progress or had failed, !gpsloc? (in the previous example) would have returned "Not available."
For example:

```
at!gpsloc?
Not Available   ←No information is available yet, because the Location fix is still in progress or has failed.

OK
```

6.1.2 Example — Standalone GNSS tracking session

```
at!gpstrack=1,255,500,1000,60 ← Start a tracking session: '1' = standalone, '255' = timeout, '500' = accuracy,
                                '1000' = fixcount (1-999 = # of fixes, 1000 = continuous), '60's = fix rate (# of seconds
                                between fix attempts)
OK

at!gpsstatus? ← Check the fix status.
Current time: 2024 06 21 1 19:04:20
2024 06 21 1 19:04:20 Last Fix Status = NONE   ← A location fix has not been completed.
2024 06 21 1 19:04:17 Fix Session Status = ACTIVE   ← The location fix started at 19:04:17 and is still in
                                                      progress after 3 s at 19:04:20.
No TTFF available

OK

at!gpsstatus? ← Check the status again.
Current time: 2024 06 21 1 19:06:03
2024 06 21 1 19:05:22 Last Fix Status = SUCCESS      ← The location fix completed successfully.
2024 06 21 1 19:05:22 Fix Session Status = ACTIVE
TTFF (sec) = 49 ← The location fix was obtained after 49 seconds.

OK

at!gpsloc? ← Get the location fix data.
Lat: 49 Deg 16 Min 56.86 Sec N (0x008C2E65)
Lon: 123 Deg 6 Min 29.48 Sec W (0xFEA1D35A)
Time: 2024 06 21 1 19:06:40 (GPS)
LocUncAngle: 57.0 deg LocUncA: 117 m LocUncP: 37 m HEPE: 122.711 m
2D Fix
Altitude: 47 m LocUncVe: 138.6 m
Heading: 9.1 deg VelHoriz: 2.7 m/s VelVert: 0.0 m/s

OK

at!gpstrack=1,255,500,1000,60 ← Step (1)—Start a tracking session: '1' = standalone, 255 = timeout, 500 = accuracy
                                1000 = fixcount (1-999 = # of fixes, 1000 = continuous), 60 = fix rate (# of seconds
                                between fix attempts)
OK

at!gpsloc? ← For example purposes, wait a few minutes for the fix to be refined, then get the location data again.
Lat: 49 Deg 16 Min 58.87 Sec N (0x008C2ECD)
Lon: 123 Deg 6 Min 28.92 Sec W (0xFEA1D377)
Time: 2024 06 21 1 19:11:43 (GPS)
```

```
LocUncAngle: 0.0 deg LocUncA: 134 m LocUncP: 11 m HEPE: 134.450 m
3D Fix
Altitude: 77 m LocUncVe: 53.0 m
Heading: 0.0 deg VelHoriz: 0.0 m/s VelVert: 0 m/s

OK
```

↓ ***Note:*** *Optionally, instead of checking !GPSLOC reports manually, use !GPSLOCREPORT to automatically invoke !GPSLOC and send the results to the AT port every <timer> seconds.*

```
at!gpslocreport=30
OK
[every 30 seconds, receive !GPSLOC details]


!GPSLOC
Lat: 49 Deg 16 Min 57.31 Sec N (0x008C2E7C)
Lon: 123 Deg 6 Min 29.62 Sec W (0xFEA1D353)
Time: 2024 06 21 1 19:14:40 (GPS)
LocUncAngle: 103.0 deg LocUncA: 79 m LocUncP: 34 m HEPE: 86.005 m
2D Fix
Altitude: 39 m LocUncVe: 69.7 m
Heading: 0.4 deg VelHoriz: 0.2 m/s VelVert: 0.0 m/s


```

↓ ***Note:*** *If automatic reporting is not required, stop it by setting the !gpslocreport <timer> to 0:*

```
at!gpslocreport=0  ← Disable the GPS location reporting.
OK
```

6.2 A-GNSS examples

6.2.1 Example — Standalone GNSS vs. SUPL A-GNSS location fix

--- Make sure SUPL configurations are correct (For this example, the server is at supl.google.com and uses SUPL v2.0) ---

at!gpssuplver? ← *Check that the module will use the same SUPL version as the SUPL server.*
```
!GPSSUPLVER: 2
OK
```

at!gpssuplurl ← *Check that the correct URL is set for the SUPL server.*
```
supl.google.com:7275
OK
```

at!gpslbsapn? ← *Make sure the cellular network's LBS APN is correctly configured.*
```
0x18, IPV4V6, "m2minternet.apn"
OK
```

at!gpsxtradataenable? ← *Make sure XTRA is disabled so a standalone fix will be done.*
```
XTRA Data Enabled: 0 ← XTRA is currently disabled
XTRA Data Retry Number: 10
XTRA Data Retry Interval: 120
XTRA Data Autodownload Enabled: 1
XTRA Data Autodownload Interval: 168
XTRA Data Validity Time: 168
OK
```

at!gpsclrassist=1,1,1,1,1 ← *Clear assistance data so that a cold start will be done for the next GPS acquisition.*
```
OK
```

at!gpsfix=1,255,255 ← *Do a standalone fix.*
```
OK
```

at!gpsstatus? ← *Check whether the fix is complete.*
```
Current time: 2024 10 13 3 20:20:42
2024 10 13 3 20:20:42 Last Fix Status = NONE
2024 10 13 3 20:20:33 Fix Session Status = ACTIVE
No TTFF available
OK
```

A/ ← *Check again.*
```
Current time: 2024 10 13 3 20:22:24
2024 10 13 3 20:20:59 Last Fix Status = SUCCESS
2024 10 13 3 20:20:59 Fix Session Status = SUCCESS
TTFF (sec) = 26 ← Standalone fix completed successfully in 26 seconds.

OK
```

at!gpsclrassist=1,1,1,1,1 ← *Clear assistance data so that a cold start will be done for the next GPS acquisition.*
```
OK
```

at!gpsfix=2,255,255 ← *Do SUPL MS-B fix.*
```
OK
```

```
at!gpsstatus? ← Check whether the fix is complete.
Current time: 2024 10 13 3 20:22:59
2024 10 13 3 20:22:39 Last Fix Status = SUCCESS
2024 10 13 3 20:22:39 Fix Session Status = SUCCESS
TTFF (sec) = 2 ← SUPL MS-B fix completed successfully in 2 seconds (compared with 26 s for the standalone fix)
OK
```

6.2.2 Example — Standalone GNSS vs. XTRA A-GNSS location fix

--- Make sure XTRA configurations are correct ---

at!entercnd="<key>" ← *Unlock password-protected AT commands (e.g., GNSS commands).*
OK

at!gpsxtradataenable? ← *Make sure XTRA is disabled so a standalone fix will be done.*
XTRA Data Enabled: 0
XTRA Data Retry Number: 10
XTRA Data Retry Interval: 120
XTRA Data Autodownload Enabled: 1
XTRA Data Autodownload Interval: 168
XTRA Data Validity Time: 168
OK

at!gpsxtratimeenable? ← *Make sure XTRA time-related settings are correctly configured.*
XTRA Time Info Enabled: 1
XTRA Time Uncertainty Threshold: 12500
XTRA Time Delay Threshold: 1000
OK

at!gpsxtradataurl? ← *Make sure the correct URLs are used for the XTRA data servers. (Shown here: default server URLs)*
XTRA Primary Server: "https://path1.xtracloud.net/xtra3Mgrbeji.bin"
XTRA Secondary Server: "https://path2.xtracloud.net/xtra3Mgrbeji.bin"
XTRA Tertiary Server: "https://path3.xtracloud.net/xtra3Mgrbeji.bin"
OK

at!gpsxtratimeurl? ← *Make sure the correct URLs are used for the XTRA time servers. (Shown here: default server URLs)*
XTRA SNTP Primary Server: "time.xtracloud.net"
XTRA SNTP Secondary Server: "time.xtracloud.net"
XTRA SNTP Tertiary Server: "time.xtracloud.net"
OK

at!gpsend=0,255 ← *Make sure there are no GNSS fixes running.*
OK

at!gpsclrassist=1,1,1,1,1 ← *Clear assistance data so that a cold start will be done for the next GPS acquisition.*
OK

at!gpsfix=1,255,255 ← *Do a standalone fix.*
OK

at!gpsstatus? ← *Check whether the fix is complete.*
Current time: 2024 10 13 3 20:51:03
2024 10 13 3 20:51:03 Last Fix Status = NONE
2024 10 13 3 20:51:00 Fix Session Status = ACTIVE
No TTFF available
OK

A/ ← *Check again.*
2024 10 13 3 20:51:29 Last Fix Status = SUCCESS
2024 10 13 3 20:51:29 Fix Session Status = SUCCESS
TTFF (sec) = 29 ← *Standalone fix completed successfully in 29 seconds.*

at!gpsxtradataenable=1 ← *Enable XTRA for use with the next location fix.*
OK

at!reset ← *Reset to make the XTRA enable take place.*
OK

at!entercnd="<key>" ← *Unlock password-protected AT commands (e.g., GNSS commands).*
OK

at!gpsend=0,255 ← *Make sure there are no GNSS fixes running.*
OK

at!gpsclrassist=1,1,1,1,1 ← *Set values to clear specific assistance data in the modem. To do a cold start for the next GPS acquisition, set all values to '1'.*
OK

at!gpsfix=1,255,255 ← *Do a standalone fix enhanced by XTRA.*
OK

at!gpsstatus? ← *Check whether the fix is complete.*
```
Current time: 2024 10 13 3 20:53:56
2024 10 13 3 20:53:56 Last Fix Status = NONE
2024 10 13 3 20:53:51 Fix Session Status = ACTIVE
No TTFF available
OK
```

A/ ← *Check again.*
```
Current time: 2024 10 13 3 20:54:25
2024 10 13 3 20:53:56 Last Fix Status = SUCCESS
2024 10 13 3 20:53:56 Fix Session Status = SUCCESS
TTFF (sec) = 6 ← XTRA-assisted location fix completed in 6 seconds (compared with 29 for the standalone fix)
OK
```

6.3 GNSS Permitted States examples

The following example demonstrates the !GNSSPERMITTEDSTATE command.

Starting with the following customization settings:

```
at!custom?
            !CUSTOM:
            GPSENABLE 0x04   ←GNSS is permitted unless the GPS_DISABLE pin is ON.
            GPSLPM 0x01   ←GNSS is permitted unless the module is in LPM.
            IMCONFIG 0x02
            IPV6ENABLE 0x01
            SIMHOTSWAPDIS 0x02
            UIM2ENABLE 0x01
            SIMLPM 0x01
            SCRUBEN 0x01
            CSDDISABLE 0x01
            UIMAUTOSWITCH 0x01
OK
```

a. GNSS is currently permitted (the GPS_DISABLE pin is OFF and the module is not in LPM):

```
at!gnsspermittedstate?
Permitted: 1   ←GNSS is permitted. (No voters are blocking GNSS.)

OK

at!gpsfix=1,255,255
OK   ←Standalone GNSS location fix initiated successfully.
```

b. The host sets the GPS_DISABLE pin ON, causing GNSS to not be permitted:

```
--- Host device sets the GPS_DISABLE pin ON ---

at!gnsspermittedstate?
Permitted: 0   ←GNSS is not permitted because the GPS_DISABLE pin (WDIS_2 in the response) is ON.
Disable votes: WDIS_2:1, LPM:0, CARRIER:0, GPSENABLECUST:0
OK

at!gpsfix=1,255,255
ErrCode = 26   ←Standalone GNSS location fix attempt denied.
OK
```

c. The host then put the module into LPM. GNSS is now also not permitted for two reasons (GPS_DISABLE pin ON, and LPM):

```
at+cfun=0   ←The module is put into LPM.
OK

at!gnsspermittedstate?
Permitted: 0   ←GNSS is not permitted because the GPS_DISABLE pin (WDIS_2) is ON and the module is in LPM.
Disable votes: WDIS_2:1, LPM:1, CARRIER:0, GPSENABLECUST:0
OK
```

d. Finally, the host explicitly disables GNSS:

```
at!custom="GPSENABLE",0   ←GNSS is explicitly disabled. This also causes GPS_DISABLE (WDIS_2) to be ignored.
OK

at!gnsspermittedstate?
Permitted: 0   ←GNSS is not permitted because the GPS_DISABLE pin (WDIS_2) is ON and the module is in LPM.
Disable votes: WDIS_2:0, LPM:1, CARRIER:0, GPSENABLECUST:1
OK
```

7 Appendix — Server-specific Details

Table 5: Google SUPL Server

Server configuration	Value
Server URL	supl.google.com
Port	7275 (Default port, unsecure) 7276 (Secure port)
SUPL version	2.0
Assistance method	MS-B

8 References

Semtech

[1] Image Switching — M2M Developer's Guide (Doc# 4118344)

[2] QMI LOC 2.155 for MPSS (Doc# 80-16656-17 Rev. AB)

[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)

[4] Software Integration and Development Guide For Linux USB Platforms (Doc# 41114212)

9 AT Commands

The following AT commands are referenced in this application / technical note.

Table 6: AT Commands — Summary

AT Command	Description	Reference
!CUSTOM	Set / return customization settings ▪ GPSENABLE — Enable / disable GNSS ▪ GPSLPM — Enable / disable GPS in Low Power Mode ▪ GPSREFLOC — Enable / disable reference location reporting	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10) (except GPSREFLOC)
!ENTERCND	Enable access to password-protected commands	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)
!GNSSAPPINFO	Configure Verizon SUPL server parameters	
!GNSSCERTKEYLENMIN	Set SSL certificate length	
!GNSSPERMITTEDSTATE	Query GNSS feature permitted state	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)
!GPSCLRASSIST	Clear specific GPS assistance data	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)
!GPSEND	End an active session	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)
!GPSFIX	Initiate GPS position fix	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)
!GPSLBSAPN	Set GPS LBS APNs	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)
!GPSLOC	Return last known location of the modem	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)
!GPSLOCREPORT	Set GPS location report timer during active tracking session	
!GPSMOLRSETTING	Configure supported MO-LR settings	
!GPSSATINFO	Request satellite information	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)
!GPSSTATUS	Request current status of a position fix session	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)

Table 6: AT Commands — Summary (Continued)

AT Command	Description	Reference
!GPSSUPLURL	Set/report SUPL server URL	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)
!GPSSUPLVER	Set/report SUPL server version	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)
!GPSTRACK	Initiate local tracking (multiple fix) session	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)
!GPSTRANSSEC	Configure GPS transport security	
!GPSXTRADATAENABLE	Enable/disable XTRA and configure data-related settings	
!GPSXTRADATAURL	Configure XTRA data server URLs	
!GPSXTRAINITDNLD	Inject XTRA data into the GNSS engine	
!GPSXTRASTATUS	Request GPSOne XTRA status	
!GPSXTRATIME	Inject GPS time into the GNSS engine	
!GPSXTRATIMEENABLE	Configure XTRA time-related settings	
!GPSXTRATIMEURL	Configure XTRA SNTP server URLs	
!RESET	Reset modem	[3] EM9 Series AT Command Reference (Doc# 41113480 Rev.10)

10 Support

For direct clients: contact your Semtech FAE

For distributor clients: contact your distributor FAE

For distributors: contact your Semtech FAE

11 Document History

Revision number	Release date	Changes
1	January 2025	Creation

12 Legal Notice

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