Skywire® SRC7611-4 LTE Modem GPS and AGPS App Note

NimbeLink Corp

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1. Introduction

1.1 Scope

This application note describes how to set up and use the built-in GPS functionality on NL-SW-LTE-SRC7611-4 modems.

This document assumes you have completed the Custom Password Application Note. If you have not completed those steps, refer to the NL-SW-LTE-SRC7611 Custom Password Application Note for details on how to accomplish these steps.

1.2 Orderable Part Numbers

Orderable Device	Cellular Carrier	Network Type
NL-SW-LTE-SRC7611-4	AT&T, Verizon	LTE, 4G
NL-SW-LTE-SRC7611-4NG-B	AT&T, Verizon	LTE, 4G
NL-SWDK	Any	Any

1.3 Overview

The NL-SW-LTE-SRC7611-4 Skywire supports unassisted GPS (Autonomous mode), as well as Assisted GPS mode (AGPS). This application note describes how to conduct a GPS location fix, as well as how to use AGPS to improve the overall process.

AGPS uses location data provided by the network to get a rough estimate of the approximate location of the modem before attempting to obtain a GPS fix. This location assistance data allows for a significantly faster Time-To-First-Fix (TTFF), which ultimately reduces the overall power consumption of a GPS location fix.

The modem's GPS requires the use of an active GPS antenna. The table below contains a list of recommended active GPS antennas:

Recommended Antenna	Manufacturer	Part Number
GPS/GALILEO Antenna, Internal	Airgain	CRJKS0010-LNA-G65U
GPS/GALILEO Antenna, External	Airgain	CRJKS0009-LNA-LM5X3000SMA

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Note: *Do not use a passive antenna with the modem (such as the antenna that comes with the Skywire Development Kit). Using a passive antenna or an incompatible antenna may cause irreversible damage to the modem's GPS interface, rendering it permanently inoperable.*

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2. Preliminary Modem Setup

Before using GPS, ensure that a compatible antenna has been attached to the modem's GPS antenna port, X3. The figure below depicts the location of this port on an NL-SW-LTE-SRC7611-4 Skywire:

Note: *A U.FL connector must be used when attaching the GPS antenna to X3.*

After the GPS antenna has been attached, place the modem into the baseboard, and power it on. Once the modem has booted, open up a terminal emulator program, and connect to the modem's USB or serial interface.

- ***SWDK2 Users:*** *Refer to the SWDK2 user manual for detailed setup instructions:*

  https://nimbelink.com/Documentation/Development_Kits/NL-SWDK2/1002634_NL-SWDK2_User_Manual.pdf

- ***SWDK Users:*** *Refer to the SWDK user manual for detailed setup instructions:*

  https://nimbelink.com/Documentation/Development_Kits/NL-SWDK/30005_NL-SWDK_UserManual.pdf

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3. Autonomous GPS vs AGPS

The NL-SW-LTE-SRC7611-4 has two modes of operation for the GPS receiver: Autonomous (Unassisted) GPS and Assisted GPS (AGPS). The difference between these two modes of operation are as follows:

Autonomous (Unassisted) GPS Mode:

- Involves only the use of the GPS receiver only to obtain a location fix.
- See Section 4 for Autonomous GPS instructions.

Assisted GPS Mode (AGPS):

- Uses assistance data obtained through the cellular network to aide in the GPS location fix process. This greatly reduces the Time-To-First-Fix (TTFF) of the GPS receiver.
- Section 5 for AGPS instructions.

Note: *Utilizing AGPS can help to reduce GPS lock times. However, AGPS will increase cellular data usage due to increased network activity caused by AGPS data requests.*

4. Autonomous (Unassisted) GPS

Section 4 describes how to set up the GPS receiver of an NL-SW-LTE-SRC7611-4 Skywire for Autonomous (Unassisted) GPS.

4.1 Verify the GPS LDO is Enabled

The NL-SW-LTE-SRC7611-4 Skywire has an onboard 3.3V LDO that is used to bias the GPS antenna port. The LDO must be enabled in order for the modem's GPS receiver to work properly. The LDO is enabled by default. The proceeding steps outline how to verify, disable and enable the GPS LDO.

Verify the GPS LDO is enabled by issuing the command:

```
AT!CUSTOM?
```

The modem will respond with a table:

```
!CUSTOM:

GPSENABLE     0x01

…             0x01

EXTGPSLNAEN   0x01

OK
```


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Ensure that "**EXTGPSLNAEN**" has a value of "**0x01**". The LDO is enabled by changing the state of one of the modem's custom settings. Issue the following commands to turn it on:

To enable the GPS LDO, issue the command:

```
AT!ENTERCND="<YourPassword>"

AT!CUSTOM="EXTGPSLNAEN",1
```

The modem will respond with:

```
OK
```

To disable the GPS LDO, issue the command:

```
AT!ENTERCND="<YourPassword>"

AT!CUSTOM="EXTGPSLNAEN",0
```

The modem will respond with:

```
OK
```

Note: *The GPS LDO setting persists after reboot.*

4.2 Start Autonomous GPS Location Services

Note: *Before using GPS, ensure that the modem's GPS LDO regulator has been enabled as per the instructions in Section 4.1. Failure to do so will result in the GPS receiver being unable to obtain a location fix.*

Instruct the modem to start the GPS receiver in Autonomous mode with default parameter values:

```
AT!GPSFIX=1,255,10
```

The modem will respond with:

```
OK
```

4.3 Obtaining GPS Location Data

After the location services start request has been made, the user can now query the location data reported by the GPS. Two different ways to obtain the GPS location data are described in the subsequent sections below.

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4.3.1 Requesting GPS Data via AT Command

The first way to obtain the GPS location data reported by the modem is to issue the following command:

AT!GPSLOC?

The modem will respond with the most recent location fix data generated by the GPS.

If the GPS currently has a lock, the **!GPSLOC?** URC will look something like this:

```
Lat: 45 Deg 6 Min 38.21 Sec N  (0x0080508C)
Lon: 93 Deg 18 Min 19.35 Sec W  (0xFEF69919)
Time: 2022 06 29 2 19:22:33 (GPS)
LocUncAngle: 0.0 deg  LocUncA: 23 m  LocUncP: 2 m  HEPE: 23.086 m
3D Fix
Altitude: 264 m  LocUncVe: 18.3 m
Heading: 0.0 deg  VelHoriz: 0.0 m/s  VelVert: 0 m/s
OK
```

If the GPS does not have a lock, the **!GPSLOC** URC will look something like this:

```
Not Available
OK
```

Note: *Even when the modem is not actively reporting GPS NMEA sentences with the "***AT!GPSFIX***" command, the GPS is still enabled. See* *Section 4.4* *for instructions regarding disabling the modem's GPS.*

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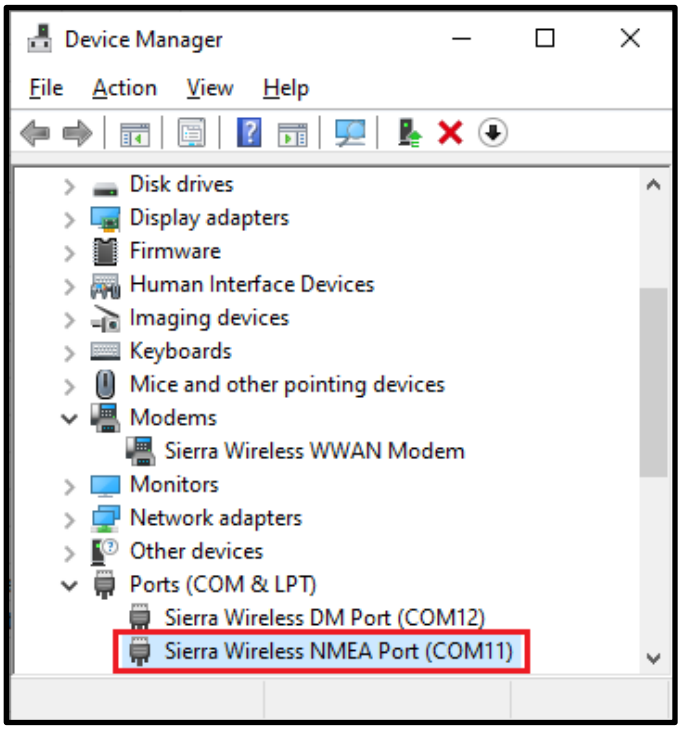
4.3.2 GPS Data Stream on Dedicated USB NMEA Port

An alternative to printing the NMEA sentence URC's directly to the active USB or serial port is to direct them to the dedicated NMEA port on the modem.

This is advantageous in that it allows the user to maintain control of the current AT interface, while still receiving GPS data on a secondary USB port.

To enable this method of GPS data reporting, first open a connection to the dedicated NMEA interface on the modem over USB. This port will be labeled "*Sierra Wireless NMEA Port*". An example of the enumeration of this port is shown below:



Note: *The modem's dedicated NMEA sentence port is only available through the modem's USB interface.*

Issue the following AT command to initiate a location services start request, with the GPS URC's routed to the "*Sierra Wireless NMEA Port*" USB port:

```
AT!GPSNMEACONFIG=1,255
```

Where "**1**" enables the NMEA reporting URC and "**255**" indicates the number of times to report in a second. The modem will begin to print the usual NMEA sentences on the dedicated NMEA interface at the same baud rate as the normal AT command port. Meanwhile, the AT command parser will remain active on the current serial or USB port.

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In the dedicated NMEA stream terminal, of URC's will begin to print to the active USB port, continuing indefinitely until the escape sequence is entered. A typical stream of these URC's looks something like the following:

```
$GAGGA,,,,,,0,,,,,,,,*77   // The GPS hasn't locked yet
$GAGGA,,,,,,0,,,,,,,,*77
…                           // A cold-start GPS lock with clear LOS to
…                           // the sky can take upwards of 45 seconds
…                           // or longer (depending on local conditions)
$GAGGA,,,,,,0,,,,,,,,*77    // The GPS has obtained a lock
$GPDTM,P90,,0000.000026,S,00000.000002,E,0.975,W84*4D
$GPGGA,194345.38,4506.633097,N,09318.328594,W,1,08,1.9,273.1,M,-33.0,M,,*5C
$GAGGA,194345.38,4506.633097,N,09318.328594,W,1,00,1.9,273.1,M,-33.0,M,,*45
$PQXFI,194345.03,4506.633097,N,09318.328594,W,273.1,7.47,5.24,1.23*4D
$GNGNS,194345.38,4506.633097,N,09318.328594,W,ANN,08,1.9,273.1,-33.0,,,V*53
```

Note: *Even if the automatic reporting of the NMEA sentences is disabled, the GPS receiver is still enabled in the background. See Section 5.7 for instructions regarding disabling the modem's GPS.*

The NMEA sentences will continue to print to the dedicated NMEA USB port until the Autonomous Location Service request is stopped. The next section describes how to do this.

4.4 Request the Status of a GPS Session

The Time-To-First-Fix (TTFF) can be read in addition to the status of the previous and current GPS fix session. The status command will also provide failure codes to aid in debugging.

To request the status of the GPS session enter the command:

```
AT!GPSSTATUS?
```


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Depending on fix status the modem may respond with:

```
Current time: 2022 06 29 2 19:26:03    //Response after first fix

2022 06 29 2 19:26:03 Last Fix Status    = NONE
2022 06 29 2 19:25:59 Fix Session Status = ACTIVE
No TTFF available
OK

Current time: 2022 06 29 2 19:26:08    //Response after second fix

2022 06 29 2 19:26:05 Last Fix Status    = SUCCESS
2022 06 29 2 19:26:05 Fix Session Status = SUCCESS
TTFF (sec) = 6
OK

Current time: 2022 06 29 2 19:26:38 //Response when AT!GPSEND=0 is sent

2022 06 29 2 19:26:05 Last Fix Status    = FAIL,  FAILCODE = 9
2022 06 29 2 19:26:05 Fix Session Status = FAIL,  FAILCODE = 9
No TTFF available
OK
```

Note: *A list of fail codes and their description can be found in* *Section 7.3*.

4.5 End the GPS Location Service Request

To end the GPS location service request, issue the following command:

```
AT!GPSEND=0
```

The modem will respond with:

```
OK
```

This will end the active GPS session and halt any collection of new data.

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4.6 Clear the Stored GPS Data

If desired, any stored location data can be cleared from the modem. This will also clear the TTFF. Issue the following commands:

First enter the password command to unlock the modem

AT!ENTERCND=”<YourPassword>”

The modem will respond with:

OK

Next enter the command:

AT!GPSCOLDSTART

The modem will respond with:

OK

This will reset the GPS back to its factory default state, clearing all saved data.

Note: *This command is helpful to use when comparing the GPS lock times of AGPS vs. Autonomous GPS, for instance. This command also clears the status of* ***AT!GPSSTATUS?***

4.7 Power Off the Modem

If desired, the modem can be powered off by tying the ON_OFF pin low for at least 2.5 seconds, or by sending the following AT command to the modem:

AT+CPWROFF

The modem will respond with:

OK

The VGPIO pin can be monitored to determine if the modem has powered down. This pin will be driven low when the modem has fully powered off. Shutdown typically takes no more than 10 seconds to complete.

5. Assisted GPS (AGPS)

Section 5 describes how to set up the GPS receiver of an NL-SW-LTE-SRC7611-4 Skywire for Assisted GPS (AGPS).

Assisted GPS uses Secure User-Plane Location (SUPL) technology in order to significantly improve the TTFF of a GPS receiver.

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The GPS assistance data is stored on SUPL servers, and is accessible to the modem after it has registered on the network. In this example, Google and Nokia's SUPL servers are utilized as the source of assistance data for the modem.

5.1 Verify the GPS LNA is Enabled

The NL-SW-LTE-SRC7611-4 Skywire has an onboard 3.3V LDO that is used to bias the GPS antenna port. The LDO must be enabled in order for the modem's GPS receiver to work properly. The LDO is enabled by default. The proceeding steps outline how to verify, disable and enable the GPS LDO.

Verify the GPS LDO is enabled by issuing the command:

```
AT!CUSTOM?
```

The modem will respond with a table:

```
!CUSTOM:

GPSENABLE        0x01

…                0x01

EXTGPSLNAEN      0x01

OK
```

Ensure that "**EXTGPSLNAEN**" has a value of "**0x01**". The LDO is enabled by changing the state of one of the modem's custom settings. Issue the following commands to turn it on:

To enable the GPS LDO issue the command:

```
AT!ENTERCND="<YourPassword>"

AT!CUSTOM="EXTGPSLNAEN",1
```

The modem will respond with:

```
OK
```

To disable the GPS LDO, issue the command:

```
AT!ENTERCND="<YourPassword>"

AT!CUSTOM="EXTGPSLNAEN",0
```

The modem will respond with:

```
OK
```

Note: *The GPS LDO setting persists after reboot.*

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5.2 Configure the SUPL Connection Parameters

Before attempting to use AGPS, the configuration for the modem must be set:

Configure the modem to use SUPL 2.0:

```
AT!GPSSUPLVER=2
```

The modem will respond with:

```
OK
```

Choose a SUPL server for the GPS location request. Both Nokia and Google offer SUPL servers for public use. Send the following AT commands to the modem:

```
AT!ENTERCND="<YourPassword">

AT!GPSSUPLURL="supl.google.com:7276" OR

AT!GPSSUPLURL="supl.nokia.com:7275"
```

The modem will respond with:

```
OK
```

Finally, a PDP context must be locked for the modem's Location Services (LCS). Choose the AT command with the PDP context ID (CID) that corresponds to the selected firmware image and active SIM card:

```
AT!GPSLBSAPN=1,0x18,"IPV4V6","[APN]"  // AT&T FW image

AT!GPSLBSAPN=1,0x18,"IPV4V6","[APN]" // Verizon FW image
```

5.3 Configure and Activate PDP Context

Once AGPS is enabled and the parameters for the SUPL server are set, configure and activate a PDP context to start a data session.

Note: *Ensure that the active firmware image corresponds to the SIM card in use. Section 3.9 of the NL-SW-LTE-SRC7611-4 datasheet contains information regarding the dual image firmware:*

https://nimbelink.com/Documentation/Skywire/4G_LTE_Cat_4_DualCarrier/1002884_NL-SW-LTE-SRC7611_Datasheet.pdf

Issue one of the following AT commands to set a PDP context on the modem. Be sure to replace **"[APN]"** with the proper APN for the chosen SIM card:

```
AT+CGDCONT=1,"IPV4V6","[APN]"    // AT&T FW image

AT+CGDCONT=3,"IPV4V6","[APN]"    // Verizon FW image
```


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The modem will respond with: **OK**

Next, activate the PDP context with one of the following commands:

```
AT+CGACT=1,1     // AT&T FW image
AT+CGACT=1,3     // Verizon FW image
```

The modem will respond with:

```
OK
```

Verify the modem has obtained an IP address using the command:

```
AT+CGPADDR
```

The modem will respond with:

```
AT&T Firmware Configuration:
    +CGPADDR: 1,xxx.xxx.xxx.xxx
    OK
Verizon Firmware Configuration:
    +CGPADDR: 3,xxx.xxx.xxx.xxx
    OK
```

5.4 Start AGPS Location Services

Once the modem has registered, start the AGPS location services request:

```
AT!GPSFIX=2,255,10
```

The modem will respond with:

```
OK
```

5.5 Obtaining GPS Location Data

After the location services start request has been made, the user can now query the location data reported by the GPS. Two different ways to obtain the GPS location data are described in the subsequent sections below.

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5.5.1 Requesting GPS Data via AT Command

The first way to obtain the GPS location data reported by the modem is to issue the following command:

```
AT!GPSLOC
```

The modem will respond with the most recent location fix data generated by the GPS. If the GPS currently has a lock, the **!GPSLOC?** URC will look something like this:

```
Lat: 45 Deg 6 Min 37.74 Sec N  (0x00805074)

Lon: 93 Deg 18 Min 18.93 Sec W  (0xFEF6992F)

Time: 2022 06 29 2 19:29:00 (GPS)

LocUncAngle: 0.0 deg  LocUncA: 36 m  LocUncP: 8 m  HEPE: 36.878 m

3D Fix

Altitude: 278 m  LocUncVe: 31.7 m

Heading: 0.0 deg  VelHoriz: 0.0 m/s  VelVert: 0
```

If the GPS does not have a lock, the **!GPSLOC** URC will look something like this:

```
Not Available

OK
```

Note: *Even when the modem is not actively reporting GPS NMEA sentences with the "***AT!GPSLOC***" command, the GPS is still enabled. See Section 5.7 for instructions regarding disabling the GPS data collection.*

5.5.2 GPS Data Stream on Dedicated USB NMEA Port

An alternative to printing the NMEA sentence URC's directly to the active USB or serial port is to direct them to the dedicated NMEA port on the modem.

This is advantageous in that it allows the user to maintain control of the current AT interface, while still receiving GPS data on a secondary USB port.

To enable this method of GPS data reporting, first open a connection to the dedicated NMEA interface on the modem over USB. This port will be labeled "*Sierra Wireless NMEA Port*". An example of the enumeration of this port is shown below:

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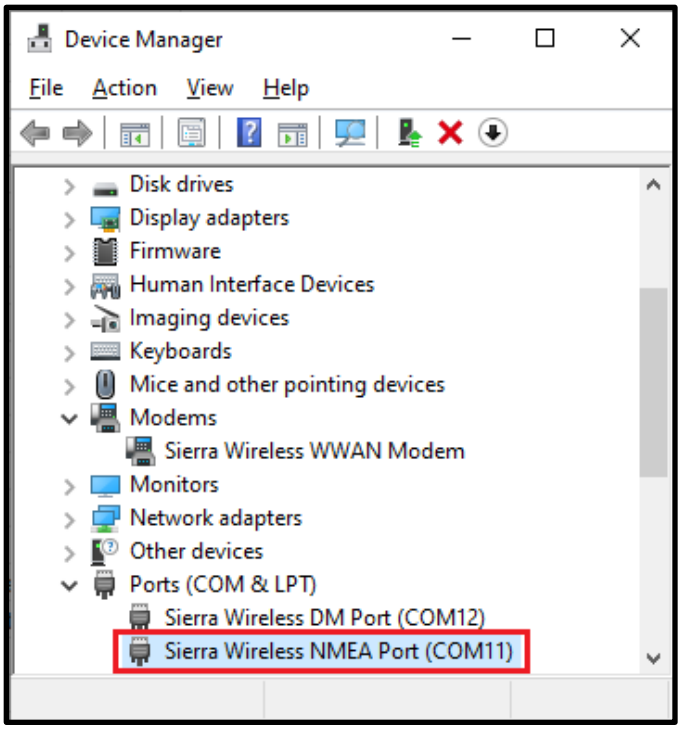

Note: *The modem's dedicated NMEA sentence port is only available through the modem's USB interface.*

Issue the following AT command to initiate a location services start request, with the GPS URC's routed to the "*Sierra Wireless NMEA Port*" USB port:

```
AT!GPSNMEACONFIG=1,255
```

Where "**1**" enables the NMEA reporting URC and "**255**" indicates the number of times to report in a second. The modem will begin to print the usual NMEA sentences on the dedicated NMEA interface at the same baud rate as the normal AT command port. Meanwhile, the AT command parser will remain active on the current serial or USB port.

In the dedicated NMEA stream terminal, of URC's will begin to print to the active USB port, continuing indefinitely until the escape sequence is entered. A typical stream of these URC's looks something like the following:

```
$GAGGA,,,,,,0,,,,,,,,*77    // The GPS hasn't locked yet
$GAGGA,,,,,,0,,,,,,,,*77
…                            // A cold-start GPS lock with clear LOS to
…                            // the sky can take upwards of 45 seconds
```


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```
…                                  // or longer (depending on local conditions)
$GAGGA,,,,,,0,,,,,,,,*77           // The GPS has obtained a lock
$GPDTM,P90,,0000.000026,S,00000.000002,E,0.975,W84*4D
$GPGGA,194345.38,4506.633097,N,09318.328594,W,1,08,1.9,273.1,M,-33.0,M,,*5C
$GAGGA,194345.38,4506.633097,N,09318.328594,W,1,00,1.9,273.1,M,-33.0,M,,*45
$PQXFI,194345.03,4506.633097,N,09318.328594,W,273.1,7.47,5.24,1.23*4D
$GNGNS,194345.38,4506.633097,N,09318.328594,W,ANN,08,1.9,273.1,-33.0,,,V*53
```

Note: *Even if the automatic reporting of the NMEA sentences is disabled, the GPS receiver is still enabled in the background. See Section 5.7 for instructions regarding disabling the modem's GPS.*

The NMEA sentences will continue to print to the dedicated NMEA USB port until the Autonomous Location Service request is stopped. The next section describes how to do this.

5.6 Request the Status of a GPS Session

The Time-To-First-Fix (TTFF) can be read in addition to the status of the previous and current GPS fix session. The status command will also provide failure codes to aid in debugging.

To request the status of the GPS session enter the command:

```
AT!GPSSTATUS?
```

Depending on fix status the modem may respond with:

```
Current time: 2022 06 29 2 19:26:03    //Response after first fix

2022 06 29 2 19:26:03 Last Fix Status    = NONE
2022 06 29 2 19:25:59 Fix Session Status = ACTIVE
No TTFF available
OK

Current time: 2022 06 29 2 19:26:08    //Response after second fix
```


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```
2022 06 29 2 19:26:05 Last Fix Status    = SUCCESS
2022 06 29 2 19:26:05 Fix Session Status = SUCCESS
TTFF (sec) = 6
OK

Current time: 2022 06 29 2 19:26:38 //Response when AT!GPSEND=0 is sent

2022 06 29 2 19:26:05 Last Fix Status    = FAIL,  FAILCODE = 9
2022 06 29 2 19:26:05 Fix Session Status = FAIL,  FAILCODE = 9
No TTFF available
OK
```

Note: *A list of fail codes and their description can be found in* *Section 7.3.*

5.7 End the GPS Location Service Request

To end the GPS location service request, issue the following command:

```
AT!GPSEND=0
```

The modem will respond with:

```
OK
```

This will end the active GPS session and halt any collection of new data.

5.8 Clear the Stored GPS Data

If desired, any stored location data can be cleared from the modem. This will also clear the TTFF. Issue the following command:

```
AT!GPSCOLDSTART
```

The modem will respond with:

```
OK
```

This will reset the GPS back to its factory default state, clearing all saved location data.

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Note: *This command is helpful to use when comparing the GPS lock times of AGPS vs. Autonomous GPS, for instance. This command also clears the status of* ***AT!GPSSTATUS?***

5.9 Power Off the Modem

If desired, the modem can be powered off by tying the ON_OFF pin low for at least 2.5 seconds, or by sending the following AT command to the modem:

```
AT+CPWROFF
```

The modem will respond with:

```
OK
```

The VGPIO pin can be monitored to determine if the modem has powered down. This pin will be driven low when the modem has fully powered off. Shutdown typically takes no more than 10 seconds to complete.

6. Troubleshooting

General Troubleshooting:

If the modem fails to achieve a GPS position lock after several minutes:

- Ensure that the GPS antenna has Line of Sight (LOS) to the sky.
    - Buildings, mountains, solid objects, metal enclosures, etc. can attenuate GPS signals.
- Ensure that the GPS LDO has been enabled. The modem's GPS receiver will not work unless the LDO is turned on.
    - See Section 4.1 for details.
- Ensure that the modem is using a compatible GPS antenna.
    - See the table of recommended antennas for ideas.
    - See the "*GNSS Antenna Requirements*" section of the NL-SW-LTE-SRC7611-4 datasheet.

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7. Appendix

7.1 AT Commands Used

!ENTERCND:	Unlock password protected Commands
!CUSTOM:	Enable/Disable modem customizations
!GPSFIX:	GPS Start Location Service Request
!GPSLOC:	Query most recent location data
!GPSSTATUS:	Query status of the active GPS session
!GPSNMEACONFIG:	Unsolicited NMEA Data Configuration
!GPSEND:	End GPS Location Service Request
!GPSCOLDSTART:	Clear all location data
!GPSSUPLVER:	Set the SUPL version to use
!GPSSUPLURL:	Update SLP server address
!GPSLBSAPN:	Set APN for Assisted GPS Use
+CGDCONT:	Define PDP Context
+CGACT:	PDP Context Activation

7.2 Acronyms

GPGGA:	Global Positioning System Fix Data
GPGLL:	Geographical Position - Latitude/Longitude
GPGSA:	GPS DOP and Active Satellites
NMEA:	National Marine Electronics Association

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7.3 Error Codes

Error Code	Description
0	Phone is offline
1	No service
2	No connection with PDE (Position Determining Entity)
3	No data available
4	Session Manager is busy
5	Reserved
6	Phone is GPS-locked
7	Connection failure with PDE
8	Session ended because of error condition
9	User ended the session
10	End key pressed from UI
11	Network session was ended
12	Timeout (for GPS search)
13	Conflicting request for session and level of privacy
14	Could not connect to the network
15	Error in fix
16	Reject from PDE
17	GPS is disabled
18	Ending session due to E911 call
19	Server error
20	Reserved
21	Reserved
22	Unknown system error
23	Unsupported service
24	Subscription violation
25	Desired fix method failed
26	Reserved
27	No fix reported because no Tx confirmation was received
28	Network indicated normal end of session
29	No error specified by the network
30	No resources left on the network
31	Position server not available
32	Network reported an unsupported version of protocol

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8. Document Version Information

Revision	Description	Date
1	- Initial Release	10/21/2022
2	- Added NL-SW-LTE-SRC7611-4NG-B	03/08/2024

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