

# Skywire<sup>®</sup> CAT4 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-TC4NAG modems.

## 1.2 Orderable Part Numbers

Orderable Device	Cellular Carrier	Network Type
NL-SW-LTE-TC4NAG	AT&T, Verizon	LTE, 3G
NL-SWDK	Any	Any

## 1.3 Overview

The NL-SW-LTE-TC4NAG 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.

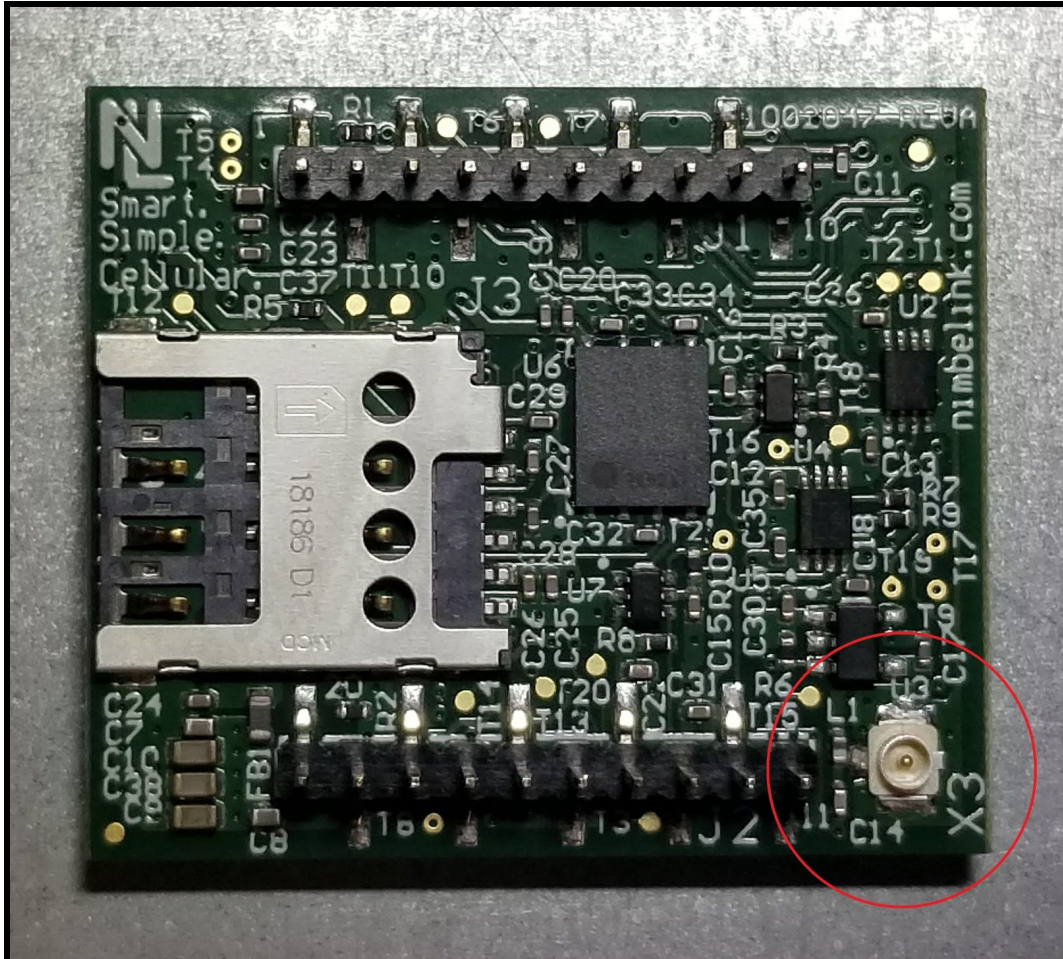
The modem's GPS requires the use of an active GPS antenna. The table below contains a list of recommended active GPS antennas:

Recommended Antenna	Manufacturer	Part Number
GPS/GALILEO Antenna, Internal	Taoglas	<a href="#">AP.17E.07.0064A</a>
GPS/GALILEO Antenna, External	Taoglas	<a href="#">AA.108.301111</a>

**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.

## 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-TC4NAG 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.

- **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](https://nimbelink.com/Documentation/Development_Kits/NL-SWDK/30005_NL-SWDK_UserManual.pdf)

## 3. Autonomous GPS vs AGPS

The NL-SW-LTE-TC4NAG 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-TC4NAG Skywire for Autonomous (Unassisted) GPS.

### 4.1 Enable the GPS Low-Dropout Regulator (LDO)

The NL-SW-LTE-TC4NAG Skywire uses a low-dropout regulator (LDO) to supply power to the active GPS antenna port. This LDO must be enabled in order for the modem's GPS receiver to function properly.

The LDO is enabled by changing the state of one of the modem's GPIO lines. Issue one of the following commands to turn it on:

```
AT#GPIO=5,1,1,0 // Turn on LDO, GPIO state will not persist after reset
```

```
AT#GPIO=5,1,1,1 // Turn on LDO, GPIO state will persist after reset
```

**Note:** Enabling the GPS LDO will increase the power consumption of the modem, even when the GPS isn't actively receiving location data. To save power, only turn the GPS LDO on when it is needed.

## 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$GPSSLR=2,3,,,,,1
```

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. Three different ways to obtain the GPS location data are described in the subsequent sections below.

### 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$GPSACP
```

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

If the GPS currently has a lock, the \$GPSACP URC will look something like this:

```
$GPSACP: 175416.000,4500.8556N,09327.7309W,1.2,  
306.2,3,166.5,0.0,0.0,210819,06,00
```

If the GPS does not have a lock, the \$GPSACP URC will look something like this:

```
$GPSACP: ,,,,,,1,,,,,
```

**Note:** Even when the modem is not actively reporting GPS NMEA sentences with the "AT\$GPSACP" command, the GPS is still enabled. See [Section 4.4](#) for instructions regarding disabling the modem's GPS.

### 4.3.2 GPS Data Stream on Main USB/Serial Port

In this mode, the NMEA sentences reported by the modem's GPS are printed directly to the serial or USB port that is being used for the AT interface.

The user will lose access to the AT interface until an escape sequence is typed. The escape sequence for the GPS is:

```
+++
```

Entering the escape sequence will halt the reporting of the NMEA sentences, and return control of the AT interface back to the user.

To enable this mode, issue the following AT command:

```
AT$GPSNMUN=3,1,0,0,0,0,0
```

The modem will respond with "CONNECT", and a stream of \$GPGGA URC's will begin to print to the active serial or USB port, continuing indefinitely until the escape sequence is entered. A typical stream of these URC's looks something like the following:

```
$GPGGA,,,,,0,,,M,,M,,*66 // The GPS hasn't locked yet
$GPGGA,,,,,0,,,M,,M,,*66
... // A cold-start GPS lock with clear LOS to
... // the sky can take upwards of 45 seconds
... // or longer (depending on local conditions)
$GPGGA,,,,,0,,,M,,M,,*66
$GPGGA,,,,,0,,,M,,M,,*66 // The GPS has obtained a lock
$GPGGA,141448.58,4500.875748,N,09327.736920,W,1,03,3.6,304.0,M,-33.0,M,,*55
$GPGGA,141449.00,4500.875741,N,09327.736907,W,1,03,3.6,303.9,M,-33.0,M,,*5B
$GPGGA,141451.00,4500.872949,N,09327.732998,W,1,03,4.8,301.1,M,-33.0,M,,*52
$GPGGA,141452.00,4500.875691,N,09327.732373,W,1,03,2.2,298.0,M,-33.0,M,,*5F
```

As described above, the NMEA sentence reporting can be disabled by entering the escape sequence:

```
+++
```

**Note:** Even if the automatic reporting of the NMEA sentences is disabled, the GPS receiver is still enabled in the background. See [Section 4.4](#) for instructions regarding disabling the modem's GPS.

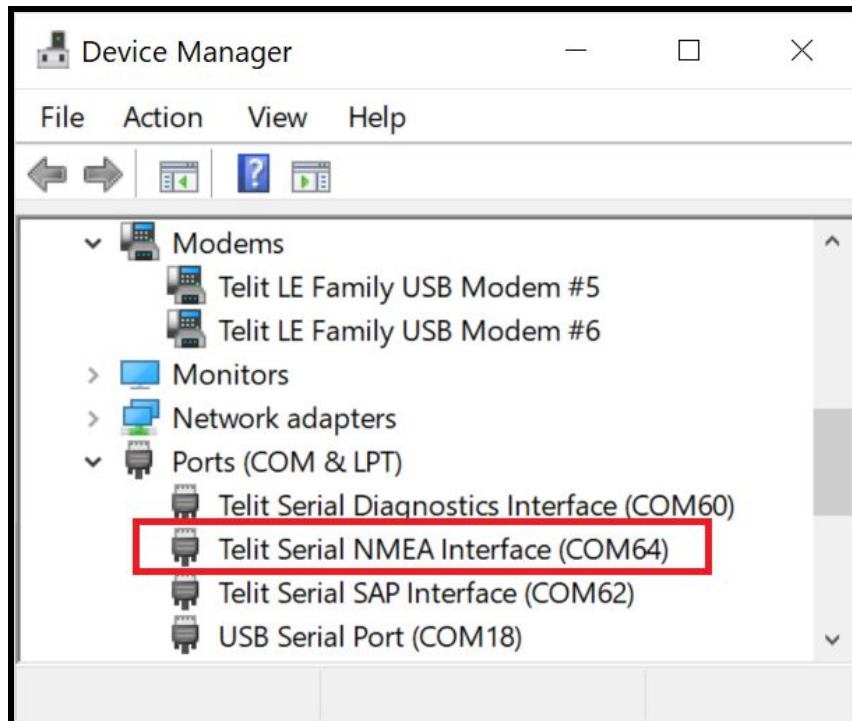


### 4.3.3 GPS Data Stream on Dedicated USB NMEA Port

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 "*Telit Serial NMEA Interface*". 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 "*Telit Serial NMEA Interface*" USB port:

```
AT$GPSNMUN=2,1,0,0,0,0,0
```

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.

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 End the GPS Location Service Request

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

```
AT$GPSSTOP=0
```

The modem will respond with:

```
OK
```

This will turn off the GPS, and will halt the generation of any new location data.

## 4.5 Disabling the GPS LDO

To finish shutting down the GPS interface, it is recommended to disable the GPS LDO. To do so, issue one of the following commands:

```
AT#GPIO=5,0,1,0 // Turn off LDO, GPIO state will not persist after reset
```

```
AT#GPIO=5,0,1,1 // Turn off LDO, GPIO state will persist after reset
```

**Note:** *It is not required to disable the GPS LDO, however this will result in power savings during modem operation.*

## 4.6 Clear the Stored GPS Data

If desired, any stored location data can be cleared from the modem. Issue the following command:

```
AT$GPSR=0
```

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.*

## 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#SHDN
```

The modem will respond with: **OK**

The ON\_nSLEEP 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-TC4NAG 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.

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

## 5.1 Enable the GPS Low-Dropout Regulator (LDO)

The NL-SW-LTE-TC4NAG Skywire uses a low-dropout regulator (LDO) to supply power to the active GPS antenna port. This LDO must be enabled in order for the modem's GPS receiver to function properly.

The LDO is enabled by changing the state of one of the modem's GPIO lines. Issue one of the following commands to turn it on:

```
AT#GPIO=5,1,1,0 // Turn on LDO, GPIO state will not persist after reset
```

```
AT#GPIO=5,1,1,1 // Turn on LDO, GPIO state will persist after reset
```

## 5.2 Configure the SUPL Connection Parameters

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

First, enable SUPL transport:

```
AT$SUPLSEC=1
```

The modem will respond with:

```
OK
```

Configure the modem to use SUPL 2.0:

```
AT$SUPLV=2
```

The modem will respond with: **OK**

Enable AGPS on the Skywire:

```
AT$AGPSEN=1
```

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 one of the following AT commands to the modem:

```
AT$SLP=1,"supl.google.com:7275" OR
```

```
AT$SLP=1,"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$LCSLK=1,1 // AT&T FW image
```

```
AT$LCSLK=1,3 // 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-TC4NAG datasheet contains information regarding the dual image firmware:*

[https://nimbelink.com/Documentation/Skywire/4G\\_LTE\\_Cat\\_4\\_Telit/1002147\\_NL-SW-LTE-TC4NAG\\_Datasheet.pdf](https://nimbelink.com/Documentation/Skywire/4G_LTE_Cat_4_Telit/1002147_NL-SW-LTE-TC4NAG_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
```

The modem will respond with: **OK**

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

```
AT#SGACT=1,1 // AT&T FW image
```

```
AT#SGACT=3,1 // Verizon FW image
```

The modem will respond with:

```
#SGACT: <IP_ADDR>
```

Where "<IP\_ADDR>" is replaced with the IP address of the modem on the network.

## 5.4 Start AGPS Location Services

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

```
AT$GPSSLSR=1,1,,,,,2
```

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. Three different ways to obtain the GPS location data are described in the subsequent sections below.

### 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$GPSACP
```

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

```
$GPSACP: 175416.000,4500.8556N,09327.7309W,1.2,  
306.2,3,166.5,0.0,0.0,210819,06,00
```

If the GPS does not have a lock, the **\$GPSACP** URC will look something like this:

```
$GPSACP: ,,,,,,1,,,,,
```

**Note:** Even when the modem is not actively reporting GPS NMEA sentences with the "AT\$GPSACP" command, the GPS is still enabled. See [Section 5.7](#) for instructions regarding disabling the modem's GPS.

### 5.5.2 GPS Data Stream on Main USB/Serial Port

In this mode, the raw NMEA sentences reported by the modem's GPS are printed directly to the serial or USB port that is being used for the AT interface.

In this mode, the user will lose access to the AT interface until an escape sequence is typed. The escape sequence for the GPS is:

```
+++
```

Entering the escape sequence will halt the reporting of the NMEA sentences, and return control of the AT interface back to the user.

To enable this mode, issue the following AT command:

```
AT$GPSNMUN=3,1,0,0,0,0,0
```

The modem will respond with "CONNECT", and a stream of \$GPGGA URC's will begin to print to the active serial or USB port, continuing indefinitely until the escape sequence is entered. A typical stream of these URC's looks something like the following:

```
$GPGGA,,,,,0,,,M,,M,,*66 // The GPS hasn't locked yet
$GPGGA,,,,,0,,,M,,M,,*66
... // A cold-start GPS lock with clear LOS to
... // the sky can take upwards of 45 seconds
... // or longer (depending on local conditions)
$GPGGA,,,,,0,,,M,,M,,*66
$GPGGA,,,,,0,,,M,,M,,*66 // The GPS has obtained a lock
$GPGGA,141448.58,4500.875748,N,09327.736920,W,1,03,3.6,304.0,M,-33.0,M,,*55
$GPGGA,141449.00,4500.875741,N,09327.736907,W,1,03,3.6,303.9,M,-33.0,M,,*5B
$GPGGA,141451.00,4500.872949,N,09327.732998,W,1,03,4.8,301.1,M,-33.0,M,,*52
$GPGGA,141452.00,4500.875691,N,09327.732373,W,1,03,2.2,298.0,M,-33.0,M,,*5F
```

As described above, the NMEA sentence reporting can be disabled by entering the escape sequence: +++

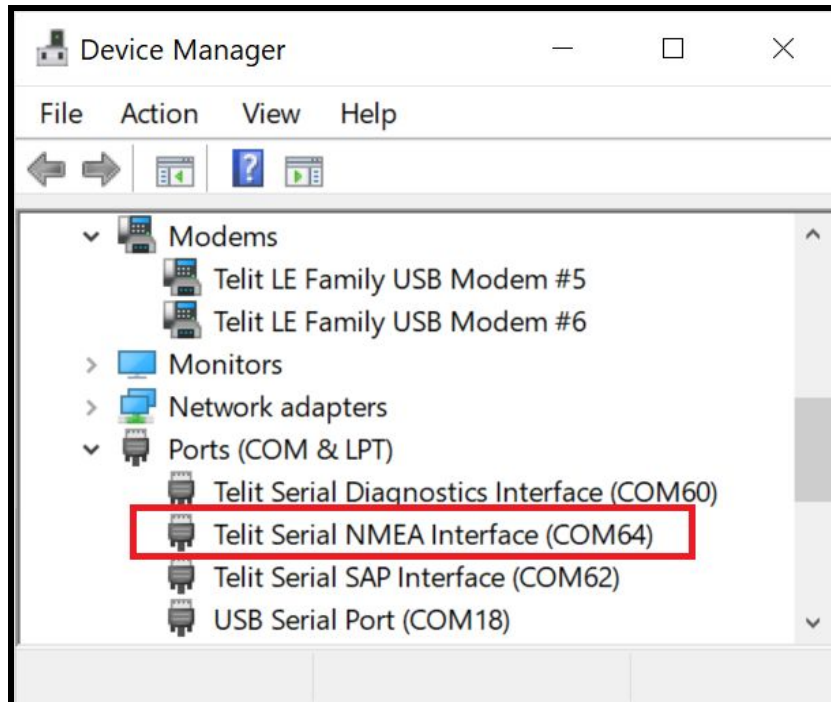
**Note:** Even if the automatic reporting of the NMEA sentences is disabled, the GPS receiver is still enabled in the background. See [Section 5.7](#) for instructions regarding disabling the modem's GPS.

### 5.5.3 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 "Telit Serial NMEA Interface". An example of the enumeration of this port is shown below:



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

Issue the following AT command to initiate a location services start request, with the GPS URC's routed to the "Telit Serial NMEA Interface" USB port:

```
AT$GPSNMUN=2,1,0,0,0,0,0
```

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.

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

## 5.6 End the GPS Location Service Request

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

```
AT$GPSSTOP=0
```

The modem will respond with:

```
$GPSSLSR: SUPL ERROR,15
```

This will turn off the GPS, and will halt the generation of any new location data.

## 5.7 Disabling the GPS LDO

To finish shutting down the GPS interface, it is recommended to disable the GPS LDO. To do so, issue one of the following commands:

```
AT#GPIO=5,0,1,0 // Turn off LDO, GPIO state will not persist after reset
```

```
AT#GPIO=5,0,1,1 // Turn off LDO, GPIO state will persist after reset
```

**Note:** It is not required to disable the GPS LDO, however this will result in power savings during modem operation.

## 5.8 Clear the Stored GPS Data

If desired, any stored location data can be cleared from the modem. Issue the following command:

```
AT$GPSR=0
```

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

**Note:** This command is helpful to use when comparing the GPS lock times of AGPS vs. Autonomous GPS, for instance.

## 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#SHDN
```

The modem will respond with:

```
OK
```

The ON\_nSLEEP 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.
  - Verify that the chosen antenna is suitable for the GPS frequencies supported by the modem.
    - See the "GNSS Antenna Requirements" section of the NL-SW-LTE-TC4NAG [datasheet](#).

## AGPS-Specific Troubleshooting:

If the modem reports "\$GPSSLSR: SUPL ERROR,15" when issuing an AGPS location service request start with the "AT\$GPSSLSR" command:

- Be sure to use the "AT\$GPSSLSR=1,1,,,,,2" command as opposed to "AT\$GPSSLSR=1,0,,,,,2" or "AT\$GPSSLSR=1,2,,,,,2"
  - That is, ensure that the second argument to the above command is "1" and not "0" or "2".
- If the solution in the first bullet point doesn't fix the problem, try using a different SUPL server for the AGPS session.

If the "AT\$GPSNMUN" command has been issued to begin receiving the AGPS location data, but no URC's are printed to the serial or USB port:

- This behavior usually occurs when AGPS is enabled, but the modem is not registered on the network.
  - Ensure that the modem is registered on the network with the "AT#SGACT" command, and then reattempt.

# 7. Appendix

## 7.1 AT Commands Used

- \$SUPLSEC:** Enable SUPL transport
- \$SUPLV:** Set the SUPL version to use
- \$AGPSEN:** Assisted GPS enable
- \$SLP:** Update SLP server address
- \$LCSLK:** Lock PDP context for LCS use
- \$GPSNMUN:** Unsolicited NMEA Data Configuration
- \$GPSSLSR:** GPS Start Location Service Request
- +CGDCONT:** Define PDP Context
- #SGACT:** 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