

# Skywire® 4G LTE Cat M1 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-TG1WWG modems.

## 1.2 Orderable Part Numbers

Orderable Device	Cellular Carrier	Network Type
NL-SW-LTE-TG1WWG	AT&T, Verizon	LTE, 4G
NL-SWDK	Any	Any

## 1.3 Overview

The NL-SW-LTE-TG1WWG 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.

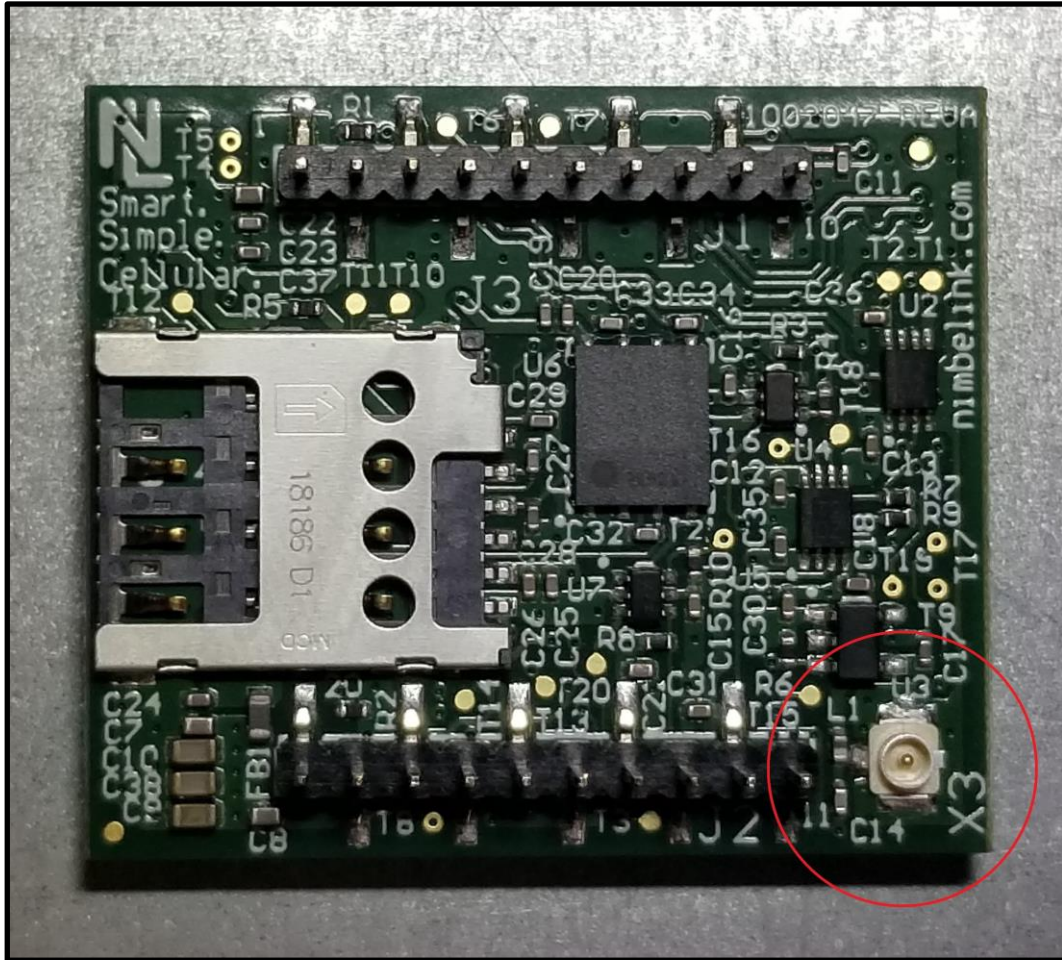
The modem's GPS requires the use of an active GPS antenna. The table below contains a list of recommended active GPS antennas:

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

**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-TG1WWG 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-TG1WWG 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.



Due to the limitations of the cellular chipset used by the module, it is not possible to use cellular and GNSS at the same time.

If GNSS priority is enabled (`AT$GPSCFG=0,0`) and the GPS Controller is configured to power on at startup (`AT$GPSP=1`, `AT$GPSSAV`) the modem will fail to register until the GPS Controller is turned OFF with the command: `AT$GPSP=0`

### 4. Autonomous (Unassisted) GPS

Section 4 describes how to set up the GPS receiver of an NL-SW-LTE-TG1WWG Skywire for Autonomous (Unassisted) GPS.

#### 4.1 Enable the GPS Controller

The NL-SW-LTE-TG1WWG Skywire uses an internal GPS Controller to supply power to the active GPS antenna port. This GPS Controller must be enabled in order for the modem's GPS receiver to function properly.

The GPS Controller is enabled by issuing an AT command to the modem. Issue one of the following commands to turn it on:

**AT\$GPSP=1** // Turns on GPS Controller, does not persist after reset

**AT\$GPSSAV** // Saves the Controller configuration, persists after reset

**Note:** Enabling the GPS Controller 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 Controller on when it is needed.

## 4.2 Obtaining GPS Location Data

After the GPS Controller has been powered on, 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.

### 4.2.1 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.

### 4.2.2 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 End the GPS Location Service Request

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

```
AT$GPSP=0
```

The modem will respond with:

```
OK
```

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

## 4.4 Disabling the GPS Controller at Startup

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

```
AT$GPSP=0    //Turn off GPS Controller, does not persist after reset
```

```
AT$GPSRST    //Resets the Controller configuration to the default, off
              //Persists after reset
```

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

## 4.5 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.

## 4.6 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-TG1WWG 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.

### 5.1 Configure GNSS Startup Priority

Before attempting to use AGPS, the real-time clock must be set properly. To expedite the location fix, the modem can be configured to prioritize GNSS at startup.

First, verify the real-time clock is set properly:

**AT+CCLK?**

The modem will respond with:

**+CCLK: "22/06/14,08:21:17-20"**

**OK**

Configure to prioritize GNSS at startup

**AT\$GPSCFG=0,0**

The modem will respond with:

**OK**

Enable AGPS on the Skywire:

**AT\$AGNSS=0,1**

The modem will respond with:

**OK**

Next reboot the modem:

**AT#REBOOT**

The modem will respond with:

**OK**

And then reboot.

Verify that the **\$GPSCFG** was retained:

**AT\$GPSCFG?**

The modem will respond with:

**\$GPSCFG: 0,1,1,0,1**

Verify that the **\$AGNSS** was retained:

**AT\$AGNSS?**

The modem will respond with:

**\$AGNSS: 0,1,1**

## 5.2 Enable the GPS Controller

The NL-SW-LTE-TG1WWG Skywire uses an internal GPS Controller to supply power to the active GPS antenna port. This GPS Controller must be enabled in order for the modem's GPS receiver to function properly.

The GPS Controller is enabled by issuing an AT command to the modem. Issue one of the following commands to turn it on:

**AT\$GPSP=1** // Turn on GPS Controller, does not persist after reset

## 5.3 Configure and Activate PDP Context

Once AGPS is enabled and GNSS is prioritized, 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-TG1WWG datasheet contains information regarding the dual image firmware:

<https://nimbelink.com/Documentation/Skywire/4G LTE Cat 4 Telit/1002147 NL-SW-LTE-TG1WWG 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 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.

### 5.4.1 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.

### 5.4.2 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 15 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 End the GPS Location Service Request

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

```
AT$GPSR=0
```

The modem will respond with:

```
OK
```

This will halt the generation of any new location data.

## 5.6 Restore Default Startup Priority

To restore default GNSS priority on the modem, the configuration must be applied and the modem rebooted. To do this issue the command:

```
AT$GPSCFG=0,1
```

The modem will respond with:

```
OK
```

Next disable the AGPS with the command:

```
AT$AGNSS=0,0
```

The modem will respond with:

```
OK
```

**Note:** If GNSS priority is enabled (`AT$GPSCFG=0,0`) and the GPS Controller is configured to power on at startup (`AT$GPSP=1`, `AT$GPSSAV`) the modem will fail to register until the GPS Controller is turned OFF with the command: `AT$GPSP=0`

## 5.7 Shutdown GPS Controller and Restore Defaults

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

```
AT$GPSP=0 // Turn off GPS Controller, does not persist after reset
```

```
AT$GPSRST // Resets the Controller configuration to default, off  
//persists after reset
```

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

## 5.8 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 Controller 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-TG1WWG [datasheet](#).

## AGPS-Specific Troubleshooting:

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

<b>\$GPSP:</b>	Turns the GPS Controller on or off
<b>\$GPSSAV:</b>	Saves the GPS configuration for <b>\$GPSP</b> and <b>\$GPSNUM</b>
<b>\$GPSACP:</b>	Returns the last GPS position acquired
<b>\$GPSRS:</b>	Resets the GPS Controller configuration
<b>\$GPSCFG:</b>	Configures the run time priority of GNSS
<b>\$AGNSS:</b>	Assisted GPS enable
<b>\$GPSNMUN:</b>	Unsolicited NMEA Data Configuration
<b>+CGDCONT:</b>	Define PDP Context
<b>+CCLK:</b>	Queries the real-time clock
<b>#REBOOT:</b>	Properly detaches from the network and reboots the modem
<b>#SHDN:</b>	Properly detaches from the network and shuts down the modem

## 7.2 Acronyms

<b>GPGBA:</b>	Global Positioning System Fix Data
<b>GPGLL:</b>	Geographical Position - Latitude/Longitude
<b>GPGBA:</b>	GPS DOP and Active Satellites
<b>NMEA:</b>	National Marine Electronics Association

## 8. Document Version Information

Revision	Description	Date
1	Initial release	10/21/22