



NL-SW-LTE-QGB96

Quick Start Guide

NimbeLink Corp
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1. Introduction

1.1. Scope of Document

The objective of this document is to provide the user a centralized location for everything they need to get their NL-SW-LTE-QBG96 Skywire modem up and running. The NL-SW-LTE-QBG96 Skywire modem will be referred to as, “QBG96” throughout this document.

1.1.1. NimbeLink Part Number

This guide was written under the assumption that the user has obtained a NimbeLink Skywire QBG96 modem and either has their own development hardware or has access to one of NimbeLink’s compatible IoT development kits. Key details regarding the QBG96 modem are listed below.

Orderable Device	Description	Carrier	Network Type
NL-SW-LTE-QBG96	Skywire, LTE-M, NB-IoT, 2G fallback, with GNSS	Verizon, AT&T, T-Mobile, Orange, Telstra, Telus, Vodafone	LTE-M, NB-IoT, GSM

1.1.2. Compatible NimbeLink Development Kits

For development, the Skywire Development Kit (NL-SWDK) is recommended for use with the QBG96 modem. If the user has integration or deployment issues, NimbeLink is able to provide better debugging support when the NL-SWDK is used. In addition, the NL-SWDK was used when creating the tutorials described in the remainder of this document. Some of the sections will apply equally to any development hardware, but the user may need to adapt other sections for their specific development setup.

All of the development kits listed below are compatible with the QBG96 modem and are available for purchase on [NimbeLink’s website](#).

NimbeLink Part	Description
NL-SWDK	Skywire Development Kit
NL-AB-BBBC	Skywire BeagleBone Black Cape
NL-AB-BBCL	Skywire BeagleBone Cape Lite
NL-AB-RPI	Skywire Raspberry Pi Adapter

Note: Please **do not** purchase the [Skywire LTE-M1 Development Kit](#) with the intent to use it with the QBG96 Skywire modem. The [Skywire LTE-M1 Development Kit](#) is not intended for use with the NL-SW-LTE-QBG96 modem and is different from the [Skywire Development Kit \(NL-SWDK\)](#) listed in the table above.

1.1.3. Lab Environment

This guide was written using the tools and equipment listed below:

- Windows PC, Windows 7 Professional
- Skywire Development Kit (NL-SWDK)
- Verizon LTE Cat M1 SIM card
- Verizon 4G LTE data plan purchased through Go.NimbeLink.com portal
- PuTTY Terminal Emulator, Release 0.70

1.2. Overview

The QBG96 modem contains the LTE-BG96 module manufactured by Quectel. The Quectel module operates on both LTE-M and the NB-IoT networks. Both of these networks were created to support IoT devices. Additional background information about LTE-M and NB-IoT networks will be provided later in this document. The QBG96 Skywire modem offers a theoretical maximum throughput of 375Kbps downlink and 375Kbps uplink and was designed specifically for low-power consumption IoT applications.

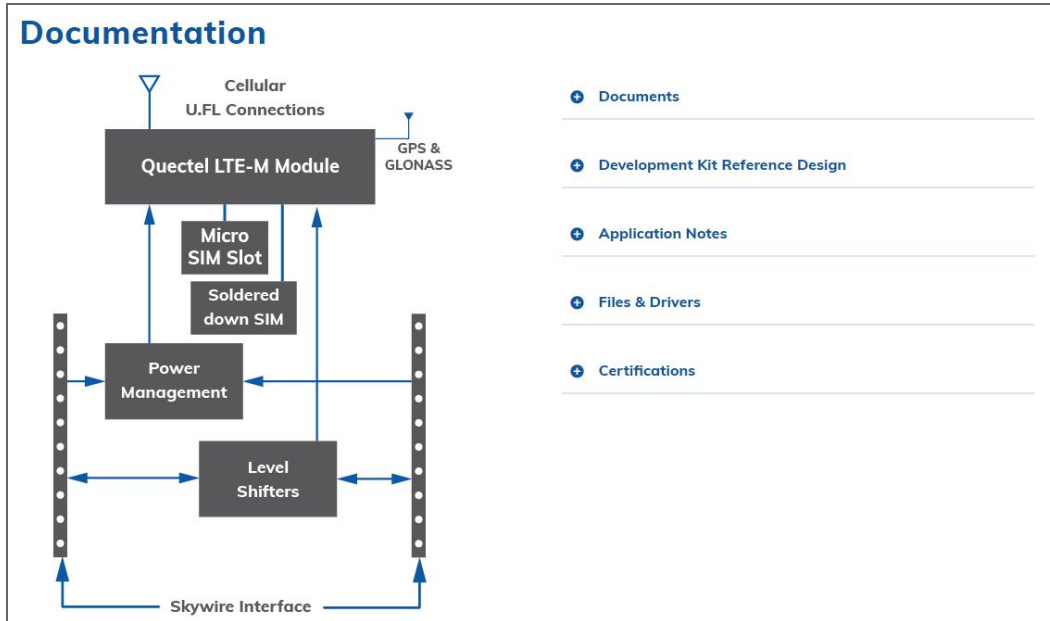
The QBG96 modem supports the following industry-standards:

- Global Navigation Satellite System (GNSS): GPS (United States), Galileo (EU), QZSS (Japan), Beidou/Compass (China), GLONASS (Russia)
- Communication Interfaces: UART, USB (USB 2.0 compliant), I2C
- Internet Protocols: PPP, TCP, UDP, SSL, TLS, FTP(S), HTTP(S), MQTT, QMI
- Operating Systems: USB driver support available for Windows 7/8/8.1/10, Linux 2.6/3.x/4.1, and Android 4.x/5.x/6.x/7.x.

2. Resources

2.1. NimbeLink Resources

The [NimbeLink QBG96 product page](#) is the best place to start for any reference material. Follow the link above and scroll to the section labeled, "Documentation", which is also shown in the image below.



To expand any of the headings, click on the “+” icon next to that heading. The modem’s *Datasheet* and the module’s *AT Command Manual* are listed under “Documents”. Links to the *Datasheet* and *AT Command Manual* are also provided below.

- [NimbeLink Skywire QBG96 Datasheet](#)
- [Quectel BG96 AT Command Manual](#)

2.2. Quectel Resources

Like the NimbeLink QBG96 product page, the [Quectel LTE BG96 Cat.M1/NB1 product page](#) is also an excellent place to look for additional reference material. Please note that for the BG96 module, Quectel has one main At command manual and several additional AT command manuals. If the main AT command manual does not have what you are looking for, you may need to download additional AT command manuals. For Quectel’s full breadth of documentation, please visit their product page and website. The *AT Command Manuals* are available for download at the bottom of their [product page](#).

Note: *Quectel requires that you create a user account before downloading any of their reference material.*

3. Getting Connected

3.1. Background Information

Both LTE-M and NB-IoT are types of cellular network technologies. Specifically, they fall under the category of a low power wide area network (LPWAN), which is a standard created by 3GPP, the main body in charge of developing mobile protocol standards. LTE-M and NB-IoT are more commonly known as LTE Cat M1 and Cat NB1, respectively. The QBG96 modem supports both standards.

The QBG96 supports the North American carriers listed in the table below. Please note the network technology currently supported by each carrier.

Carrier	LTE Cat M1	Cat NB1	How to Purchase SIM?	How to Purchase Data Plan?
Verizon	Yes	No	NimbeLink or Verizon	NimbeLink or Verizon
AT&T	Yes	No	NimbeLink or AT&T	NimbeLink or AT&T
T-Mobile	No	Yes	T-Mobile	T-Mobile

3.2. Setting Up the SIM

3.2.1. Purchasing the Correct SIM

As shown in the block diagram below, the QBG96 has a micro SIM slot and a soldered-down Verizon SIM. As a result, you can either use a physical SIM card, which is inserted into the micro SIM slot or you can use the Verizon eSIM that comes included with the modem. If you choose to use the Verizon eSIM, [Section 3.5.2](#) provides a tutorial on how to select the solder-down SIM.

If you need to purchase a T-Mobile SIM, you will need to purchase the SIM card directly through T-Mobile. The [T-Mobile SIM on NimbeLink's website](#) **will not** work with an NB-IoT device. If you need to purchase an AT&T or Verizon SIM card, QBG96 compatible SIMs are provided in the links below, otherwise you may purchase a SIM card directly through the respective carrier.

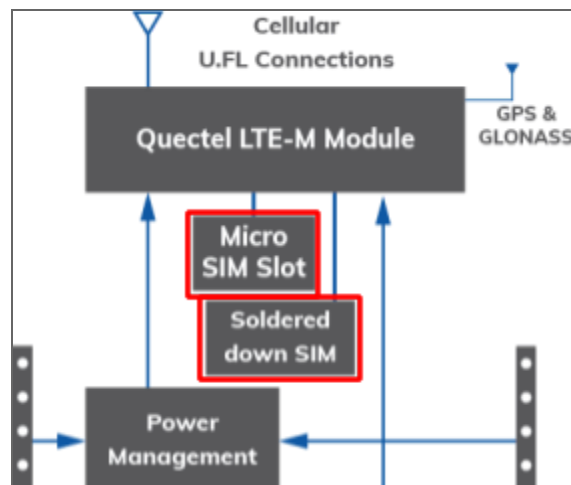
Verizon: <https://nimbelink.com/products/nl-sim-ver-m1/>

AT&T: <https://nimbelink.com/products/nl-sim-att-ctri/>

Note: The QBG96 modem uses a micro SIM slot, so please purchase either a Tri-Cut or 3FF sized SIM.

For development, purchasing a SIM card and data plan through NimbeLink is recommended over purchasing directly from a mobile carrier. If the user has integration or deployment issues,

NimbeLink is able to provide better debugging support when the SIM card and data plan are purchased through NimbeLink.



3.2.2. Purchasing a Data Plan

Once you have either purchased a SIM card or decided to use the Verizon eSIM, it's time to purchase a data plan and connect to your carrier's network. If you are planning to purchase a T-Mobile data plan, you'll need to purchase the plan directly through T-Mobile. If you are planning to use an AT&T or Verizon plan, you may purchase the plan directly through NimbeLink via the Go.NimbeLink.com portal or directly through the respective carrier.

If you are using a T-Mobile plan, please purchase it prior to proceeding to the next section. Otherwise, if you are using an AT&T or Verizon plan, you may proceed to the next section.

3.2.3. Activating the SIM and Data Plan

If you purchased a subscription plan through a carrier, you will need to activate your SIM card and subscription plan directly through that carrier. If this pertains to you, please move on to [Section 3.3](#).

3.2.3.1. Relevant Terminology

- IMEI or International Mobile Equipment Identity: An IMEI is a number unique to a single mobile device, like your cell phone. It is specific to the mobile hardware. **The IMEI value can be found on the label on the front of the QBG96 modem (shown below in the image on the right).**
- ICCID or Integrated Circuit Card Identifier: An ICCID is a number unique to a single SIM device, SIM card or eSIM, which explains why the label on the front of the QBG96 modem also lists an ICCID number. That number corresponds to the soldered-down eSIM that comes included with the modem. Otherwise, if a SIM card was purchased, **the**

ICCID value can be found on the SIM card packaging or on the SIM card itself (shown below in the images on the left).

Example of ICCID Location



Example of IMEI Location

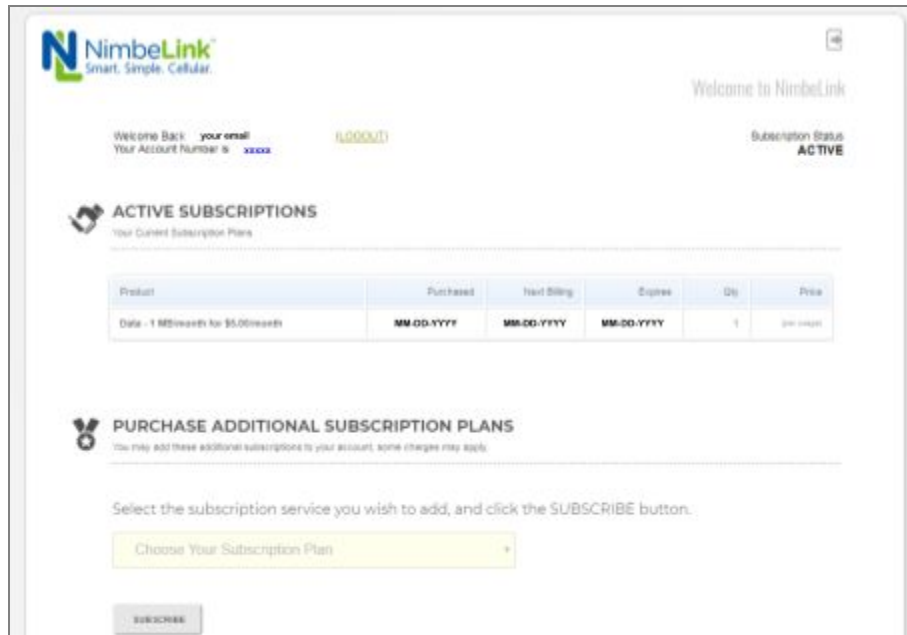


3.2.3.2 Procedure

To activate your device please follow the steps listed below.

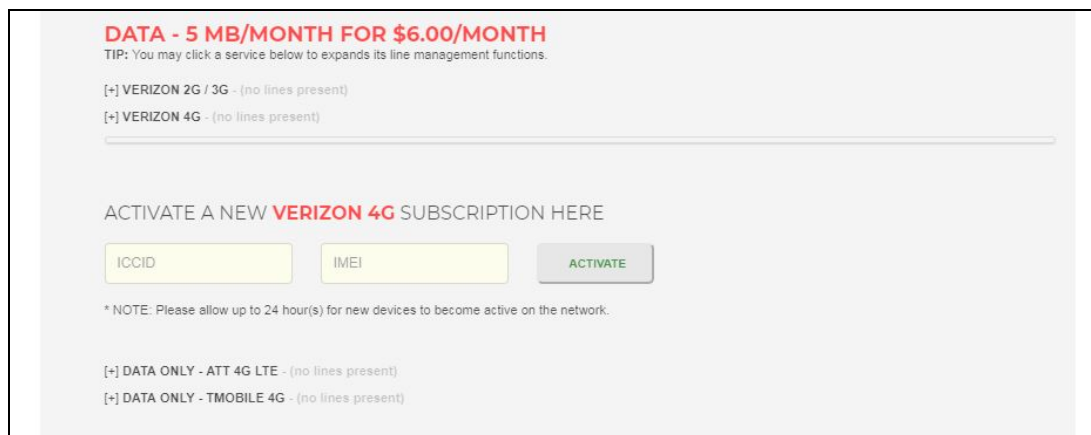
1. Navigate to the Go.NimbeLink.com portal. Please create a NimbeLink account before proceeding. This will involve creating a username and password and entering payment and shipping information. At this point, you have the option to add a subscription plan, but it is not required in order for you to create a NimbeLink account.
2. Once you have created a NimbeLink account. Please login to the Go.NimbeLink.com portal.
 - If you added a subscription plan when you created your NimbeLink account, your plan should be listed at the top of page. Please move on to the next step.
 - If you do not have a subscription plan, you will need to select a plan at this time. Under the section, "Purchase Additional Subscription Plans", please select a plan

from the drop-down menu and click “Subscribe”. The web page should reload with the new plan listed at the top of page. Please move on to the next step.



Note: Adding a new subscription plan **does not** mean you will immediately be charged for the new plan. You will only be charged once a device is activated using the plan.

- Under the section, “My Services and Equipment”, your active subscription plan(s) will be shown in large red font. Within the active subscription plan there will be a list of available carriers. Click on the “[+]” icon next to your chosen network carrier. Please make sure you select a **4G plan**.
- A menu will open with two entries for the IMEI and ICCID, as shown in the image below. Enter your IMEI and ICCID and when ready click, “Activate”. Please note that after you activate your device, you will begin to be charged for the selected subscription plan.



- After selecting “Activate”, you should see something similar to the image below. Your device is now active, as evident by the "Active" status. You may add a “Nickname” if you like, but it is not required.

MY SERVICES and EQUIPMENT
 Manage your equipment here. To Change a Nickname, just edit the text and tab out!

DATA - 5 MB/MONTH FOR \$6.00/MONTH
 TIP: You may click a service below to expand its line management functions.

[+] VERIZON 2G / 3G - (no lines present)
 [+] VERIZON 4G - (no lines present)

START DATE	ICCID	IMEI	STATUS	NICKNAME
01/09/2019	< 20 Digit ICCID >	< 15 Digit IMEI >	ACTIVE	< Your Nickname >

ACTIVATE A NEW **VERIZON 4G** SUBSCRIPTION HERE

ICCID [] IMEI [] ACTIVATE []

* NOTE: Please allow up to 24 hour(s) for new devices to become active on the network.

[+] DATA ONLY - ATT 4G LTE - (no lines present)
 [+] DATA ONLY - TMOBILE 4G - (no lines present)

For any additional questions regarding using the Go.NimbeLink.com portal, please refer to the [Go.NimbeLink.com User Manual](#).

3.2.4. Soldered-Down Verizon eSIM

The NL-SW-LTE-QBG96 modem has the ability to select between the soldered-down Verizon eSIM or the SIM card slot. By default, the modem is configured to attempt to use the SIM card slot. However, users can select which SIM the modem is using by controlling the onboard SIM selection switch with AT commands. Please see [Section 3.5.2](#) for more details on configuring the modem to use the soldered-down eSIM.

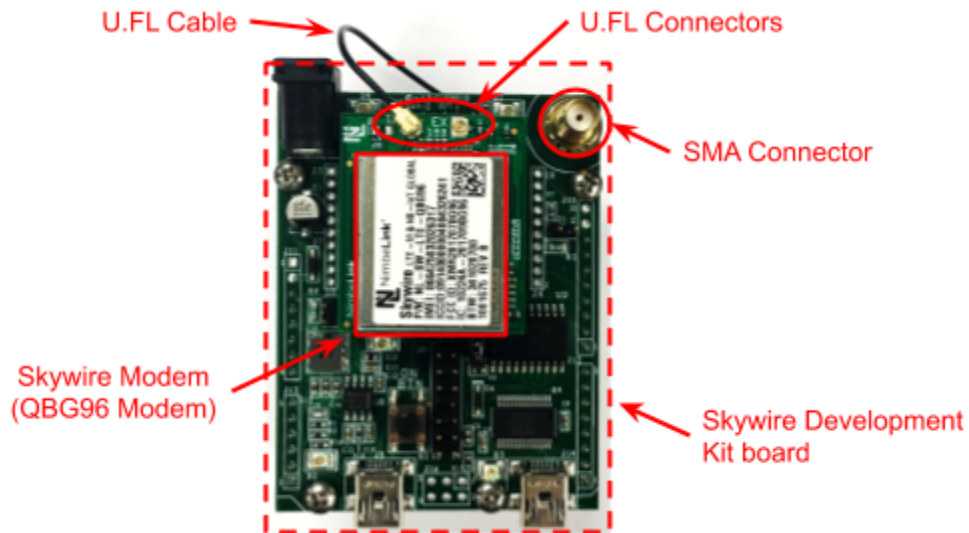
3.3. Setting-Up the Modem and the NL-SWDK

3.3.1. Attaching the QBG96 Modem to the NL-SDWK

To mount your QBG96 modem follow the steps listed below. Please reference the diagram shown below if you are unsure of any of the subsequent steps.

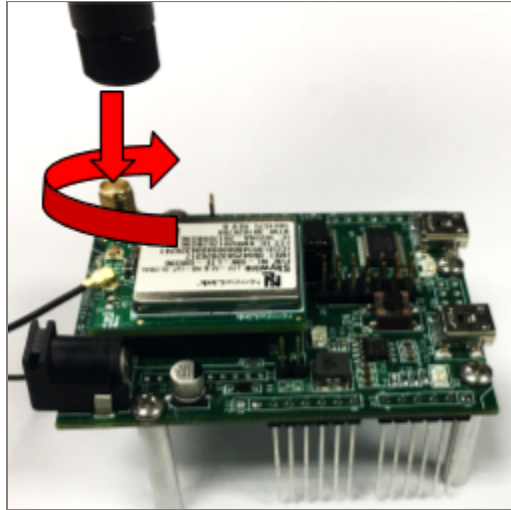
- Gather the following:
 - Skywire Development Kit board
 - Skywire Modem (QBG96 Modem)
- If you are using a SIM card and it has been activated, please insert the SIM card into the SIM card slot J3, located on the bottom of the Skywire modem.

3. Carefully seat your Skywire into the board's Skywire socket U1. Take care to ensure that the pins are correctly aligned. Failure to properly align the pins may damage your Skywire. The side of the module with the U.FL connectors should be closest to the edge of the SWDK.
4. Line up your Skywire's cellular U.FL connectors on the side of the board closest to the SMA connector. Always insert and remove the U.FL connector with a force perpendicular to the board. There are two U.FL connectors, labeled X1 and X3. Attach the U.FL cable to connector X1 on the Skywire.
5. If you are intending to use a separate GPS antenna, you will need an external U.FL to SMA cable (not included in the NL-SWDK). Otherwise, you may disregard this step. Connector X3 is available for a GPS antenna. If you have an external U.FL to SMA cable, attach the U.FL end to connector X3 and the SMA end to the GPS antenna.



3.3.2. Attaching the Antenna to the Baseboard

Screw the antenna into the SMA connector in a clockwise direction as shown in the image below.



3.3.3. Powering Up the Device

Please follow the steps listed below to properly power-up the device.

1. Plug in the 12V Power Supply to connector J15.
2. Plug the USB cable into connector J14 and into the PC; regular USB and high-speed USB ports are both acceptable.



3. Press and hold button S1 for approximately 1 second to power on the modem. After about 4 seconds, LED D1 should stay on. If LED D1 stayed on, you are ready to begin interfacing with your device!



3.4. Connecting the Modem to a PC

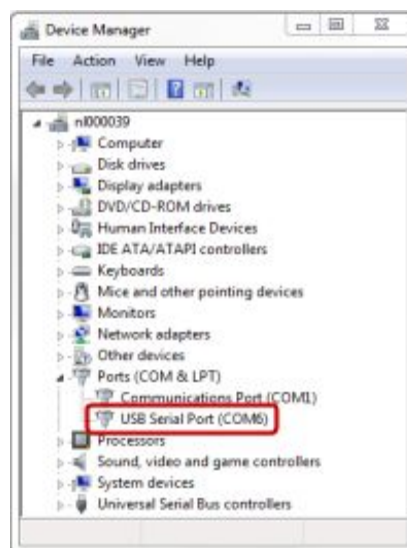
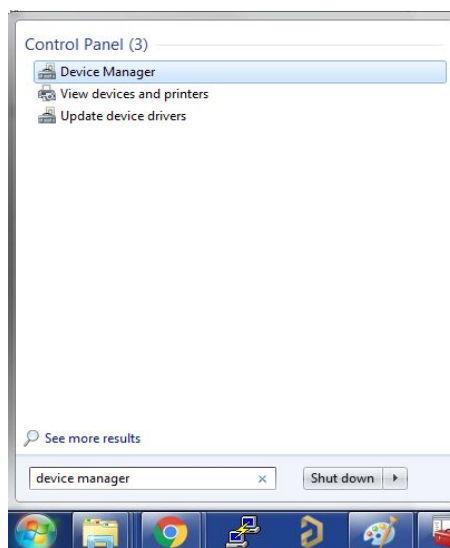
3.4.1. Establishing a Serial Connection

You will need a terminal emulator program, such as *Tera Term* or *PuTTY*, on your computer to communicate with your device using a serial connection. If you do not have such a program, please follow the links below to download either *Tera Term* or *PuTTY*.

Tera Term: <https://osdn.net/projects/ttssh2/releases/>

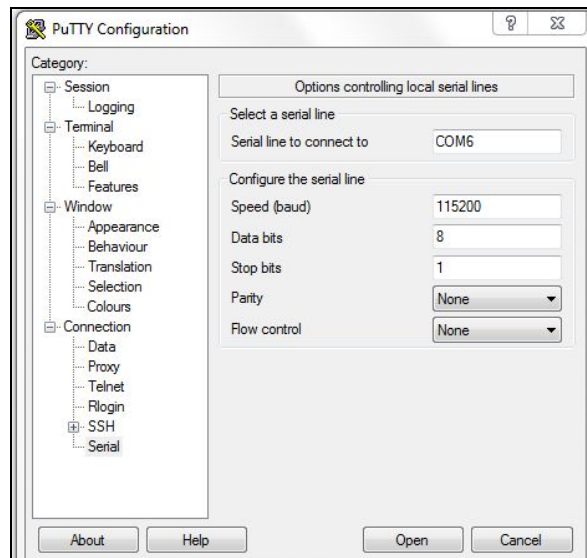
PuTTY: <https://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html>

COM ports are assigned differently on each PC. To determine which COM port was assigned to your device, you will need to open *Device Manager*, a built-in Windows application. Open the *Windows Start Menu* and type, “device manager”. Click on the *Device Manager* application that comes up, as shown in the image on the left below. With *Device Manager* open, expand the heading, “Ports (COM & LPT)”, and record the COM port that was assigned to your device. In this tutorial, COM6 was assigned to the test device, as shown in the image on the right below.



Open your terminal emulator program (PuTTY, Tera Term, etc.) and navigate to the “Serial” category, as shown in the image below. The serial settings should be set to the following values:

Baud Rate:	115,200 bps
Data:	8bit
Parity:	none
Stop:	1bit
Flow Control:	none



After you have configured the serial port with the settings listed above, select “Open”. A command prompt terminal should open automatically. You are now ready to communicate with your device!

3.4.2. Testing the Serial Communication

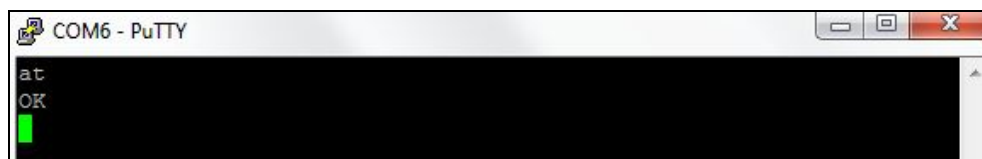
The following set of AT commands are quite useful. Therefore, these commands will be used to verify that you successfully established a serial connection with the modem:

a. Verify basic communication with the modem

Command: **AT**

Response: **OK**

As you can see from the image below, AT commands are **not** case sensitive.



b. Enable Error Result Codes and turn on Verbose mode

Command: AT+CMEE=2

Response: OK

If a command is entered incorrectly, by default the modem will output the type of error committed followed by a numerical error code. Turning on verbose mode, as we did above, outputs the error value in english instead of a numerical value. The example below shows the three different formats of error results codes, and demonstrates the usefulness of verbose mode.

```
AT+CMEE=0
OK
AT+CPIN?
ERROR
AT+CMEE=1
OK
AT+CPIN?
+CME ERROR: 10
AT+CMEE=2
OK
AT+CPIN?
+CME ERROR: SIM not inserted
█
```

c. Query CCID:

Command: AT+QCCID

Response: <15 digit CCID>

d. Query IMEI:

Command: AT+CGSN

Response: <10 digit IMEI>

Now that you are able to communicate with your device, it's time to get your device on the network!

3.5. Connecting the Modem on the Network

3.5.1. Background Information

This section is designed to introduce you to a few key terms and help you understand what's required to set up a network connection.

There are two main steps that need to be completed in order to establish a cellular network connection:

1. SIM Activation -- As mentioned in [Section 3.2](#), there are two different categories of SIMs, physical SIM cards and eSIMs.
 - SIM Card: If you are using a physical SIM card, but have yet to activate it, you will not be able to complete this section. Please refer to [Section 3.2](#) before proceeding.

- eSIM: If you are using the soldered down Verizon eSIM that comes included with the QBG96 modem, [Section 3.5.2](#) will walk you through the process of setting it up.
2. PDP Context Configuration -- A brief description of a PDP context is given below. More details will be given in [Section 3.5.3](#).
- PDP context, which stands for Packet Data Protocol context, is a data structure that contains the user's session information. Essentially a PDP context is a container that holds information the network needs before you are allowed access.
 - Two pieces of information are required to correctly set up a PDP context, the name of your APN, and the type of IP address you are using (IPV4, IPV6, or IPV4V6).

3.5.2. Selecting the Soldered-Down SIM (eSIM)

If you are using a SIM card you may skip this section.

By default, the modem is configured to attempt to use the SIM card slot. However, you can use AT commands to select which SIM the modem uses. To configure the modem to use the soldered-down SIM, issue the following commands in the order they appear below:

a. Turn off cellular functionality:

Command: **AT+CFUN=0**

Response: **OK**

b. Configure modem to use soldered-down SIM

Command: **AT+QCFG="gpio", 1, 26, 1, 0, 0, 1**

Response: **OK**

Command: **AT+QCFG="gpio", 3, 26, 1, 1**

Response: **OK**

c. Turn on cellular functionality:

Command: **AT+CFUN=1**

Response: **OK**

If you do not want to use the soldered-down SIM and would like to revert back to using a physical SIM card, issue the following commands in the order they appear below:

a. Turn off cellular functionality:

Command: **AT+CFUN=0**

Response: OK

b. Configure modem to use SIM card slot:

Command: AT+QCFG="gpio",1,26,1,0,0,1

Response: OK

Command: AT+QCFG="gpio",3,26,0,1

Response: OK

c. Turn on cellular functionality:

Command: AT+CFUN=1

Response: OK

Note: The GPIO states will persist after reset. The settings will be saved and the AT commands listed above will not need to be issued each time the modem is powered on. However, be aware that firmware updates may overwrite saved GPIO states.

3.5.3. Setting up a PDP Context

As stated in [section 3.5.1](#) above, to set up a PDP context, you'll need the name of the APN and the type of IP address you are using. The sections below will help you determine both of these parameters.

3.5.3.1. Determining the APN

An APN or Access Point Name is the name of the gateway you are using that enables you to connect to another computer network, such as the Internet. Every cellular carrier (Verizon, AT&T, T-Mobile, etc.) has several APNs they allow their customers to use depending on the needs of the customer. For example, Verizon has a specific APN that is required if you want to establish a basic Internet connection through your device. You provide Verizon with a correct APN name, and then Verizon handles everything required to successfully access the Internet over cellular.



The Skywire modems can be set up to use different APNs. Your APN may be a standard name defined by your cellular provider. If you are unsure of your APN, your cellular data plan provider should be able to provide you with the correct APN. Otherwise, you can always contact NimbeLink Product Support at product.support@nimbelink.com to help identify your APN.

Verizon

As previously stated, if you are using Verizon as your carrier it is strongly recommended that you purchase a data plan through Go.NimbeLink.com. Doing so gives you access to NimbeLink's private network and therefore, an added layer of network security. In this case, the APN will be:

NIMBLINK.GW12.VZWENTP

Note: There is no "E" in the Verizon APN above. The Verizon APN, "NIMBLINK", **does not** share the same spelling as the company name, "NIMBELINK".

If you purchased your Verizon data plan anywhere other than Go.NimbeLink.com, you will need to get your APN from Verizon by contacting your account representative. Common Verizon APNs are listed below. These came directly from Verizon's website. As you can see, the APN described above falls into the second *Definition*, where "xx" is replaced with "nimblink.gw12".

Verizon Access Point Name Definitions:

APN Definition	Usage
vzwinternet	Required for general Internet connections.
xx.vzwentp	Used for connections to mobile private networks. Note "xx" would be replaced by the Verizon assigned account name.
xx.vzwstatic	Used for static IP connections. Note "xx" would be replaced by an appropriate static IP pool identifier, which typically corresponds to a geographic region, e.g. "mw01.vzwstatic" for a region in the Midwest.

AT&T

As previously stated, if you are using AT&T as your carrier it is strongly recommended that you purchase a data plan through Go.NimbeLink.com. Doing so gives you access to NimbeLink's private network and therefore, an added layer of network security. In this case, the APN will be:

IOT0718.COM.ATTZ

If you purchased your AT&T data plan anywhere else than Go.NimbeLink.com, you will need to get your assigned APN from AT&T by contacting your account representative.

T-Mobile

If you purchased a T-Mobile data plan, you will need to contact T-Mobile or your service provider to determine your T-Mobile APN.

Once again, if you need additional assistance determining your APN, please contact NimbeLink Product Support at product.support@nimbelink.com.

3.5.3.2. Determining the IP Type

IP or Internet Protocol specifies the format and the addressing scheme for devices to communicate over a network. There are three IP versions used today on cellular Modems, IPv4, IPv6, and IPv4v6. IPv4 (Internet Protocol version 4) uses a 32 bit address while IPv6 (Internet Protocol version 6) uses a 128 bit address. An IP address is required for any device to connect to the Internet. The newest IP version, IPv6, was required because IPv4 addresses were running out. IPv4v6 is a dual-stack IP type, which means that the device can operate using either IPv4 or IPv6.

The QBG96 is capable of using IPv4v6, which reduces the need to determine the specific IP type. Therefore, use **IPv4v6** when setting up the PDP context.

3.5.3.3. Defining the PDP Context

Now, it's finally time to set up the PDP context using the information gathered throughout the previous two sections.

You cannot change the parameters of an active PDP context, therefore, to ensure that there are no active PDP contexts, we will disable all cellular functionality.

a. Turn off cellular functionality:

Command: **AT+CFUN=0**

Response: **OK**

Next, use the APN and IP Type you determined to configure the PDP context. In addition, the BG96 module has multiple configurable PDP contexts, each one described by a particular context ID (CID). Therefore, we need to indicate which PDP context we wish to configure by specifying the context ID. For the QBG96 the context ID should be set to **1**.

b. Configure the PDP context:

Command: **AT+CGDCONT=1, "IPV4V6", "YOUR APN NAME HERE"**

Response: **OK**

c. Confirm the PDP context was successful set:

Command: **AT+CGDCONT?**

Response: **+CGDCONT: 1, "IPV4V6", "YOUR APN NAME HERE",.....**
 +CGDCONT: [cid, IP Type, APN Name,....]

Besides the context ID, IP Type, and APN, all other information may be ignored.

Example: The example below is for a Verizon data plan purchased through Go.NimbeLink.com.

Command: **AT+CGDCONT=1, "IPV4V6", "NIMBLINK.GW12.VZWENTP"**
Response: **OK**

Please note that the quotations are used with both the IP type and the APN.

Command: **AT+CGDCONT?**
Response: **+CGDCONT: 1, "IPV4V6", "nimblink.gw12.vzwentp",**

At this point, the PDP context has been configured, but not activated. Before activating the PDP context, two conditions should be evaluated. First, you will need to test the signal strength of your chosen cellular network. Second, you will need to confirm that you are registered on the cellular network. The next two sections will walk you through testing network signal strength and confirming network registration.

3.5.4. Testing the Signal Strength

Cellular functionality of the modem was turned off in the previous section. Therefore, the first step is to turn back on cellular functionality.

a. Turn on cellular functionality:

Command: **AT+CFUN=1**
Response: **OK**

b. Check the received signal strength:

Command: **AT+QCSQ**
Response: **+QCSQ: <sysmode>, <rssi>, <rsrp>, <sinr>, <rsrq>**

3.5.4.1. Description of Parameters

- **sysmode**: The system mode is the current cellular service mode, i.e. “CAT-M1”, “CAT-NB1”, or “GSM”. If the device is not using any service network or the service mode is uncertain, "NOSERVICE" will be returned as the query result.
- **rssi**: The RSSI or Received Signal Strength Indicator is a measurement of the total average Radio Frequency (RF) power present in the received radio signal at the mobile device.
- **rsrp**: The RSRP or Reference Signal Received Power is a measurement of average power from a single cell-specific reference signal within a specific frequency bandwidth. The value returned is a logarithmic value. The values are in increments of 1/5th a decibel (dB) and range from 0 to 250, which translates to -20dB to +30dB.
- **sinr**: The SINR or signal-to-interference-plus-noise ratio is the power of the signal divided by the sum of the interference power (from all the other interfering signals) and the power of the background noise.

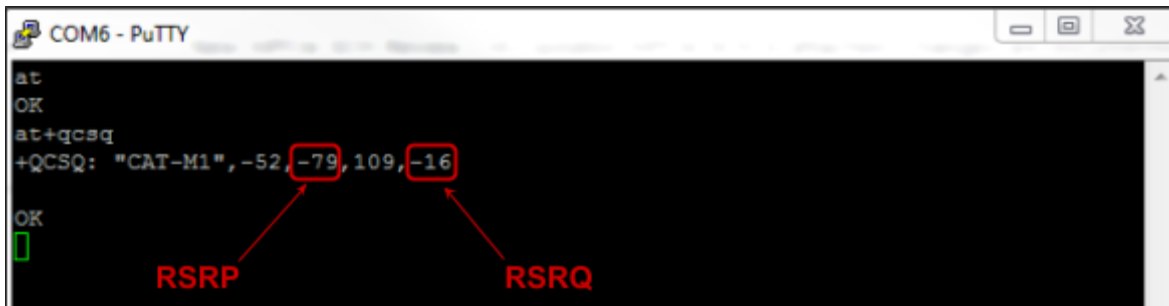
- **rsrq**: The RSRQ or the Reference Signal Received Quality is a measurement that indicates the quality of the received reference signal calculated using the RSRP and the RSSI values described above.

3.5.4.2. Power and Quality of Signal

The RSRP and RSRQ parameters are typically the best indicators of signal strength. The values of RSRP and RSRQ are returned as raw values (dB or dBm). Please see the table below for signal strength estimates based on the raw values.

Returned RSRP Value (Signal Power)	Estimated Signal Strength	Returned RSRQ Value (Signal Quality)	Estimated Signal Strength
RSRP < -100 dBm	Marginal	RSRQ < -19.5 dB	Marginal
-100 dBm ≤ RSRP < -90 dBm	Fair	-19.5 dB ≤ RSRQ < -15 dB	Fair
-90 dBm ≤ RSRP < -80 dBm	Good	-15 dB ≤ RSRQ < -10 dB	Good
≥ -80 dBm	Excellent	≥ -10 dB	Excellent

For the example shown below, the RSRP is “Excellent” while the RSRQ is “Fair”.



3.5.5. Confirming Network Registration

If you successfully set up the PDP context and determined your signal strength is acceptable, the next step is to confirm that you are registered with the network. Network registration should have occurred automatically. Network registration acts like a handshake between the modem and the cell tower, indicating that the SIM card successfully authenticated with the network and the cell tower agrees that you are capable of joining its network. To confirm Network Registration occurred, enter the command below.

a. Query network registration status:

Command: AT+CEREG?

Response: +CEREG: <n>, <status>

Where <n>=[0,1,2,4] and <status>=[0,1,2,3,4,5]. The default is <n>=0. If network registration was successful, <status>=1 or <status>=5, where a 1 indicates that you

are registered and on your home network (same network as your data plan) and a 5 indicates that you are registered, but roaming on a different network.

Therefore, you will likely see one of the following:

```
Command: AT+CEREG?  
Response: +CEREG: 0,1 //Registered, on home network  
  
Command: AT+CEREG?  
Response: +CEREG: 0,5 //Registered, roaming
```

If you are not registered, the value of **<status>** will either be a 0, 2, 3. As stated above, network registration typically occurs automatically, but in some instances the modem needs to be compelled to register on the network. If this is the case for you, please enter the command below.

b. Attach modem to the network:

```
Command: AT+CGATT=1  
Response: OK
```

If you would like to know the network technology (2G, 3G, 4G LTE) of your current connection, or you are roaming and you would like to know which network you are roaming on, enter the command below.

c. Query network technology and carrier:

```
Command: AT+COPS?  
Response: +COPS: <mode>,<format>,<oper>,<Act>
```

You may ignore the values returned for **<mode>** and **<format>**. The **<oper>** parameter is your network operator, which is another name for the cellular carrier. The **<Act>** parameter is your access technology selected, which will be either **<Act>=0** for GSM (2G), **<Act>=8** for LTE Cat M1, or **<Act>=9** for LTE Cat NB1.

Example: Please see the example below for further clarification.

```
Command: AT+COPS?  
Response: +COPS: 0,0,"Verizon Wireless",8
```

3.5.6. Activating a PDP Context

If you set up the PDP context, checked your network signal strength, and confirmed network registration, you are ready to activate the PDP context.

a. Activate PDP context:

Command: **AT+QIACT=1 //Activate CID 1**
Response: **OK**

b. Confirm PDP context was activated:

Command: **AT+QIACT?**
Response: **+QIACT: 1,1,1, YOUR IP ADDRESS HERE**

Where the first value specifies the context ID, **CID 1**, and the second value indicates the state of the context ID, a **1** meaning active. You may ignore the third value returned.

***Note:** In the response, there may be additional context IDs included in the response other than **CID 1**. This is okay, but only **CID 1** is of concern.*

Example: The example below uses a random IP address taken from the BG96 AT command manual.

Command: **AT+QIACT?**
Response: **+QIACT: 1,1,1,"10.76.51.180"**

If you received all of the expected responses, congratulations, you have successfully set up a PDP context!

3.6. Next Steps

At this point, you have accomplished the main goal of this tutorial: connecting your QBG96 modem to a cellular network to gain mobile Internet access. You verified Internet connectivity in [Section 3.5.6](#) by confirming the assignment of an IP address to your device. Now that network setup and testing is complete, you are ready to start developing with your QBG96 modem. [Section 4](#) provides a few options to help further familiarize yourself with the device.

4. Applications

This section describes a few common applications of the QBG96 modem. A separate guide is available for each of the applications described below. Please reference the application notes relevant for your intended use.

4.1. Socket Dial

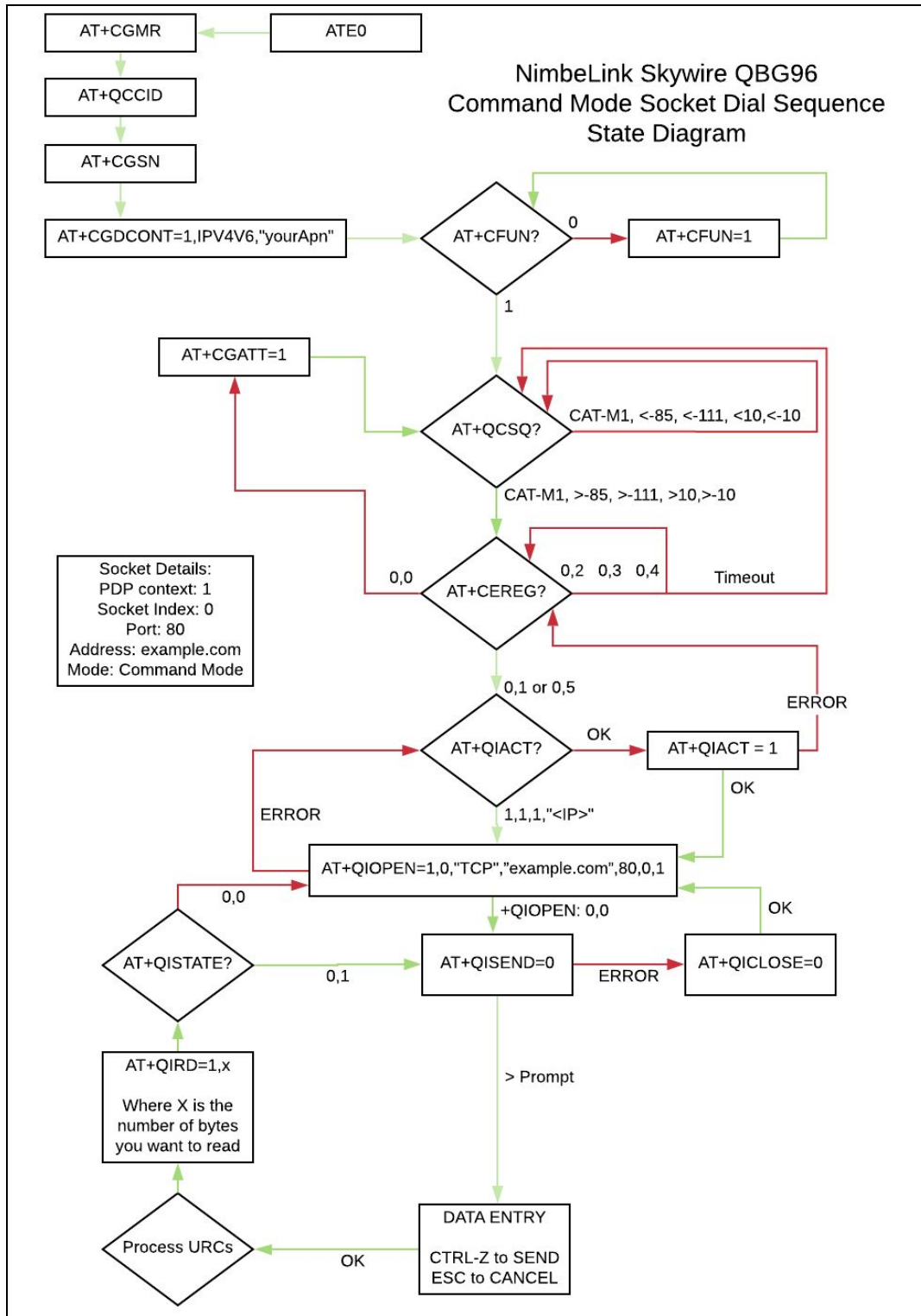
Sockets are commonly used for client and server interaction. Typical system configuration places the server on one machine, with the clients on other machines. The clients connect to the server, exchange information, and then disconnect. For example, an Internet application would involve an Internet client host, like you, requesting information from an Internet server host, like Google.com

A socket has a typical flow of events. The socket on the server side waits for requests from a client. To do this, the server first establishes (binds) an address that clients can use to find the

server. When the address is established, the server waits for clients to request a service. Data exchange takes place when a client connects to the server through a socket. The server performs the client's request and sends the relay or data back to the client.

Socket dials are a useful process for uploading or downloading information from a website or database using HTTP (HyperText Transfer Protocol) syntax. Please see the QBG96's [Socket Dial](#) application note for a detailed tutorial on how to send and receive data with your device using a socket dial. The examples presented in the [Socket Dial](#) application note use HTTP, which utilizes TCP, to transfer data between your device (client) and dweet.io (web server).

The socket dial flowchart, shown below, is a useful resource to reference while walking through the [Socket Dial](#) application note.



4.2. SMS Messaging

SMS or Short Messaging Service is a standard that was defined in the 1980s for text messaging on cell phones and other mobile devices. Standard SMS messages are limited to 160 characters and can only be sent over cellular networks, which is one of the main differences between SMS and Internet-Protocol based messaging services like iMessage, WhatsApp, etc.

SMS service is available on Verizon's M1 network, but is not available on AT&T's network. Please see the QBG96's [SMS](#) application note for a detailed tutorial on how to send SMS messages with your device.

4.3. PPP

PPP or Point-to-Point Protocol is a computer network protocol that provides a standard way to transport multiprotocol data over two directly connected (point-to-point) computers. If your host device is a traditional PC, Linux, or RTOS environment, PPP is the recommended approach to use the QBG96. Internet traffic does not require a physical connection between two communicating devices. The protocol used for Internet traffic, TCP/IP, is a packet-switching network, meaning that the data being transmitted is broken up into several packets before being routed on the network. The packets are all routed to the same address, but may take a different route to get there. As a result, packet-switching networks do not rely on a single physical connection between the two communicating devices. PPP has a wide variety of uses since there are many physical mediums for point-to-point connectivity, such as simple serial cables, mobile phones and telephone lines. For example, PPP provides a way for Internet service providers (ISPs) to use a physical connection, such as a phone line, to route Internet traffic to the customer's residence. PPP can also be used to set up a secure connection, such as an encrypted Virtual Private Network (VPN).

Please see the QBG96's [PPP](#) application note for a detailed tutorial on how to send and receive data with your device using PPP.

4.4. TLS Using AWS IoT

TLS or Transport Layer Security is sometimes referred to as SSL/TLS because TLS was preceded by SSL (Secure Sockets Layer). TLS is the standard security technology for establishing an encrypted link between a web server and a browser. This link ensures that all data passed between the web server and browsers remain private. SSL is an industry standard and is used by millions of websites in the protection of customer online transactions.

Please see the QBG96's [AWS IoT SSL/TLS](#) application note for a detailed tutorial on how to configure the modem and set up a secure connection with Amazon Web Services (AWS).

4.5. GNSS (GPS) Location Services

GPS or Global Positioning System is the Global Navigation Satellite System (GNSS) technology used in the United States and owned by the U.S. government. It provides geolocation and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to orbiting satellites.

Depending on the geographic location, the GNSS technology used in that region may be different. For example, Galileo is used in the EU, QZSS is used in Japan, Beidou/Compass is used in China, and GLONASS is used in Russia.

Please see the QBG96's [GPS](#) application for a detailed tutorial on how to set up and configure the modem to receive GPS data.

4.6. Power Save Mode

LTE CAT-M1 brings additional power saving features to cellular modems that were not previously available. Power Save Mode allows the Skywire to drastically reduce its power consumption by entering a low power state, while maintaining its registered status on the cellular network.

The ability for the Skywire to retain its registered status on the network is advantageous in that it eliminates the need for the modem to constantly have to re-register on the network each time it exits a low power state.

In PSM mode, the device must be woken up in order to send and receive data. The device can be woken up by temporarily grounding the ON_OFF pin of the Skywire, or by pressing the ON_OFF button on the SWDK for a few seconds. In addition, the Skywire modem has two internal timers that control the duration of each stage of PSM mode - Low Power State and Wake State.

Please see the QBG96's [Power Saving Mode](#) application note for a detailed tutorial on how to set up and use the modem's PSM features.

5. Appendix

5.1. AT Commands

5.1.1. AT Command Basics

There are four types of commands you can issue to the modem. The four types are described in the table below. Not all AT commands will have every type of command available (test, read, write, execute). This will make more sense after reviewing the table below.

Type	Syntax	Function
Test Command	AT+<x>=?	Returns a list of acceptable values the user can assign to the parameter, i.e. values that are okay to use with the <i>Write Command</i> .
Read Command	AT+<x>?	Returns the currently set value of the parameter.
Write Command	AT+<x>=<...>	Sets the parameter to the value defined by the user's entry.
Execution Command	AT+<x>	Returns the value of a non-variable parameter. This type of parameter is affected by internal processes of the modem. A non-variable parameter cannot be changed with a user entry.

Variable Parameter Example: The "CFUN" parameter was selected to demonstrate the different types of commands for a variable parameter.

Type	Syntax	Description
Test Command	AT+<x>=?	<i>Command:</i> AT+CFUN=? <i>Response:</i> +CFUN: (0,1,4), (0,1) Tells you that the first parameter may be set to 0, 1, or 4 and the second to 0 or 1.
Read Command	AT+<x>?	<i>Command:</i> AT+CFUN? <i>Response:</i> +CFUN: 1 Tells you that CFUN is currently set to 1, meaning that the modem is set in full functionality mode.
Write	AT+<x>=<...>	<i>Command:</i> AT+CFUN=4

Command		<p><i>Response:</i> OK</p> <p>Tells you that CFUN was successful changed to 4, meaning that the modem is now in airplane mode. Notice how the second parameter was not defined. It is common for a command to have several optional parameters.</p>
Execution Command	AT+<x>	<p><i>Command:</i> AT+CFUN <i>Response:</i> ERROR</p> <p>Tells you that the <i>Execution Command</i> type is not available for the CFUN command. This makes sense since CFUN is a variable parameter set by the user.</p>

Non-variable Parameter Example: The "**CGPADDR**" parameter was selected to demonstrate the different types of commands for a non-variable parameter.

Type	Syntax	Description
Test Command	AT+<x>=?	<p><i>Command:</i> AT+CGPADDR=? <i>Response:</i> +CGPADDR: (1)</p> <p>Gives you a list of defined context IDs, which in the case of the QBG96, CID 1 will most likely be the only cid defined.</p>
Read Command	AT+<x>?	<p><i>Command:</i> AT+CGPADDR? <i>Response:</i> ERROR</p> <p>Tells you that the <i>Read Command</i> type is not available for the CGPADDR command. This makes sense since CGPADDR is a non-variable parameter affected by internal processes of the modem and cannot be set to a given value by the user.</p>
Write Command	AT+<x>=<...>	<p><i>Command:</i> AT+CGPADDR=1 <i>Response:</i> +CGPADDR: 10.76.51.180</p> <p>Returns the IP Address of the specified PDP context In this case CID 1.</p>
Execution Command	AT+<x>	<p><i>Command:</i> AT+CGPADDR <i>Response:</i> +CGPADDR: 10.76.51.180</p> <p>Returns the IP Address of the all defined PDP contexts. In this case only CID 1 is defined and therefore, it is the only value returned.</p>

5.1.2. Useful AT Commands

AT Command	Function
AT	Verify communication with UART
ATE1	Enable local echo
AT+QPOWD	Power down the modem
AT+CMEE=2	Enable verbose ERROR messages
AT+CGMR	Query firmware version
AT+CGSN	Query IMEI
AT+QCCID	Query ICCID
AT+CFUN?	Query RF functionality status
AT+CFUN=1	Set to full functionality
AT+CFUN=4	Disable both transmitting and receiving RF signals (Set to airplane mode)
AT+CFUN=0	Set to minimum functionality
AT+CGDCONT?	Query PDP context configuration
AT+CGACT?	Query PDP context activation status
AT+CGACT=1,<cid>	Activate PDP context
AT+CGACT=0,<cid>	Deactivate PDP context
AT+CGPADDR	Query PDP context IP addresses
AT+CGPADDR=1	Query PDP context <cid> 1 IP address
AT+CEREG?	Query network registration status
AT+COPS?	Query current network operator (carrier and type of network)
AT+COPS=?	Scan for visible networks
AT+QCSQ	Query RSRP and RSRQ from antenna
AT+CNUM	Query network provided mobile device number