NL-SWDK2 User Manual

NimbeLink Corp

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1. Introduction

This document serves as the user manual for the Skywire Development Kit Version 2 platform. Throughout this document document the Skywire Development Kit Version 2 will be referred to by its abbreviated name, SWDK2, or by its part number, NL-SWDK2.

1.1 Contact Information

NimbeLink's goal is to make integrating Skywire™ modems into end-user applications as easy as possible. Please send any feedback, documentation requests, or technical support questions to NimbeLink's product support team at:

product.support@nimbelink.com

For purchasing information, please visit the "Part Ordering Information" section on the development kit's product page. Any additional sales questions or requests for quotation can be directed to NimbeLink's sales team at:

sales@nimbelink.com

1.2 Orderable Part Numbers

Orderable Device	Compatible Modems	Operating Temperature
NL-SWDK2	All Skywires*	-40˚C to +85˚C

*This modem is compatible with all Skywire modems using the standard Skywire interface. This development kit is not compatible with Skywire Nano products.

1.3 Additional Resources

- Skywire Software Developers Guide
- Skywire Hardware Developers Guide
- NL-SWDK2 Product Page
- NL-SWDK2 Datasheet
- NL-SWDK2 Schematic
- NL-SWDK2 Altium Design Files

1.4 Kit Contents

The SWDK2 development kit includes the following:

- 1x NL-SWDK2 development board
- 2x Taoglas TG.30.8113 Antennas
- 1x NimbeLink AT&T SIM
- 1x 12V Power Supply
- 1x Mini-B USB Cable

The development kit does not include a Skywire modem. Modems must be purchased separately.

2. Getting Started

The following section will guide users through the getting started process with a SWDK2 development kit in a Windows 10 environment.

2.1 Data Plans

Skywire cellular modems do not ship with active cellular data plans, unless they are part of NimbeLink's Skywire Bundled Dataplan Service.

Devices using NimbeLink's Bundled Data Plan Service ship with global coverage SIM's, on a 10 year, 500 MB bundled data plan that is pre-activated and ready to use out of the box.

If your modem did not come with a bundled data plan then you can activate a new Verizon or AT&T data plan by visiting http://go.nimbelink.com, creating an account, and then activating your Skywire there. Alternatively, you can also contact your preferred cellular carrier for assistance in setting up a data plan.

2.2 Access Point Names

Users will need to set an Access Point Name (APN) on their modem for it to be able to connect to a cellular carrier's network. The APN is determined by the cellular carrier and the type of data plan that is in use.

The table below contains a list of common APNs and their respective carriers. It is important to use the APN that corresponds to the proper carrier. Failure to do so will result in failed cellular network connections. Customers using non-NimbeLink data plans will need to contact their carriers for APN information.

Cellular Carrier	APN	Description
Verizon	`nimblink.gw12.vzwentp`	APN for go.nimbelink data plans using Verizon
AT&T	`iot0718.com.attz`	APN for go.nimbelink data plans using AT&T
Global	`nl2.nimbelink`	APN for NimbeLink 10 year bundled data plans

2.3 Development Kit Configuration

This development kit may be used as a stand alone development kit interfaced to a PC or as a shield connected to another development kit with a compatible Arduino shield interface.

The SW1 DIP switch will ship with a piece of tape covering the switches. This should be removed by the user upon getting started with the kit.

2.3.1 USB Interfaces

The development kit has two USB Mini-B connectors to allow for the use of the modem's serial UART AT command interface and/or the modem's USB interface.

The J5 USB interface is for connecting to the modem's USB interface. The USB interface will allow customers to connect to multiple different communication ports on the modem including:

- AT Command interfaces
- Debug interfaces for modem diagnostic tools
- GNSS NMEA streaming interfaces

The specific USB interfaces available will be modem specific and connecting to the USB interface will require that users download the modem's USB drivers from its product page.

The J14 interface will connect to the modem's USB to serial UART interface IC to access the modem's serial UART interface. The USB to serial UART interface IC used on the J14 USB interface is an FTDI FT234XD. The FTDI drivers for the FT234XD are available on FTDI's website.

2.3.2 UART Selection

The Skywire modem's UART interface is multiplexed to several different interfaces on the development kit to allow for easy interfacing with different host development kits and for accessing it through the USB to serial UART interface (J14).

The USB to serial interface will be automatically selected when a USB connection is powered on J14 and will override the selection switch for the other UART interfaces. This feature may be bypassed, if desired, by modifying the circuit board.

The interface selection for the Arduino interface is controlled by the switches ARD1 (SW1-1) and ARD2 (SW1-2) on SW1 according to the following logic table:

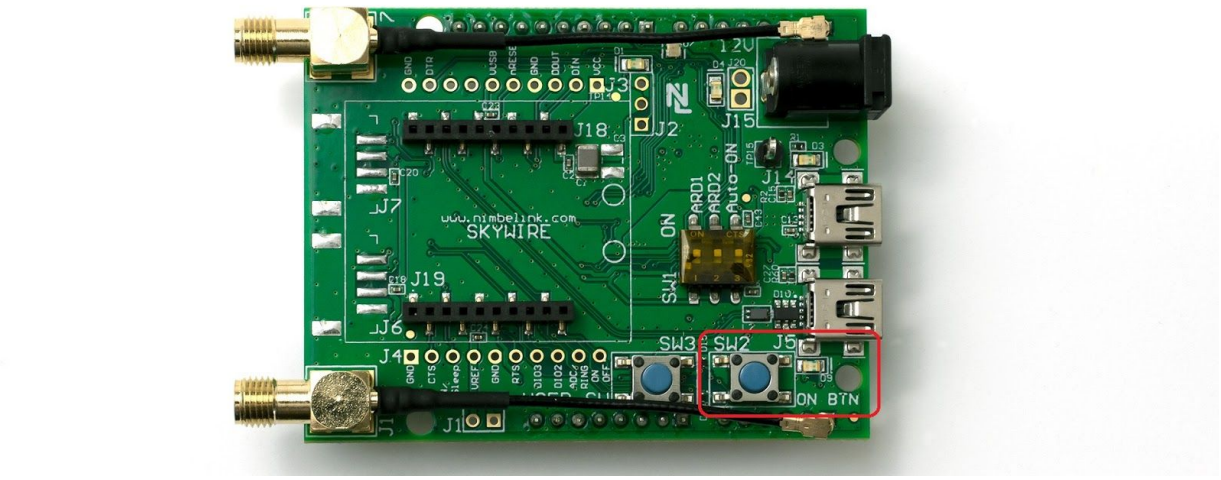
Interface Selection	ARD1 Position	ARD2 Position
Test Points (TP16-TP19)	OFF	OFF
Arduino Interface 1 (D0/D1)	ON	OFF
Arduino Interface 2 (D2/D8)	OFF	ON
USB to Serial Interface	ON	ON

Below is an image of the switch locations on SW1.

2.3.3 Modem Power On

The development kit can automatically boot the modem when power is applied by turning SW1-3/Auto-ON to the ON position. This will enable the development kit's built in automatic turn on circuit using a TI TPL5111DDCR (U1). This circuit will toggle the modem's ON_OFF pin low once for about 8 seconds after the 4.0V supply is applied. The automatic turn on circuit can be enabled or disable based using the SW1-3 DIP switch.

Users may also manually turn the modem on or off by disabling the auto turn on circuit by setting SW1-3 to the off position and then use SW2, labeled "ON BTN" on the circuit board, to manually pulse the modem's ON_OFF line low.



Users may use SW2 to turn off the modem or to turn the modem back on after a shutdown when the automatic turn on circuit is enabled.

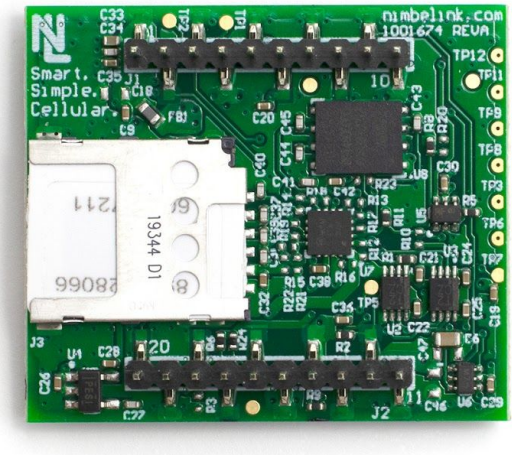
2.4 Connect to a PC

This section will guide users through setting up the SWDK2 and issuing AT commands to a Skywire modem. For this demonstration a NL-SW-LTE-QBG96 Skywire modem will be used, but users may use any modem that uses the standard Skywire interface.

2.4.1 SIM Insertion

Insert the SIM card for the Skywire modem into the modem's 3FF SIM interface located on the bottom side of the modem. The gold contacts on the SIM should be inserted so they are facing the modem's PCB.

Some Skywire modems have onboard Verizon SIMs. If the user is using the onboard SIM for Verizon service this step can be skipped.



2.4.2 Modem Placement & Antenna Connectors

⚠ Make sure the Skywire is installed in the correct orientation in your host board. Failure to do so will damage the modem and void the warranty.

Skywire modems use U.FL RF connectors for connecting antennas to the modem's LTE and GNSS RF interfaces. U.FL connectors must be carefully handled to avoid damage and users should always use a U.FL extractor tool for connecting and disconnecting the U.FL connectors. The U.FL connectors should always be inserted and removed with a force that is perpendicular to the modem.

The Skywire modem's RF interfaces are labeled X1, X2, and X3. Each interface has a specific function as documented below. The locations of the interfaces may change depending on the modem and it is recommended that users carefully review the modem's documentation before connecting antennas before powering up the modem.

RF Interface	Function	Notes
X1	LTE Primary RF Antenna Interface (TX/RX)	This interface must have an antenna attached for network connectivity.
X2	LTE Diversity Antenna Interface (RX)	This interface must have an antenna attached for Cat 4+ products for carrier certification compliance and is strongly recommended for Cat 1+ devices.
X3	GNSS Antenna Interface	Do not connect to cellular antennas. This interface requires the use of an appropriate GNSS antenna. Review the modem's datasheet for GNSS antenna guidelines.

Users should not attempt to place the modem in the Skywire socket or attach the U.FL connectors while power is applied.

To seat the modem, align the Skywire modem's top side U.FL connectors with the two circles seen on the top of the SWDK2's Skywire socket.

⚠ Make sure that the modem's pins are properly aligned in the Skywire socket. Inserting the modem into the Skywire socket incorrectly can damage the modem.

Once the modem is seated users can attach the U.FL connectors. When viewing the development kit from the top, the modem's U.FI connectors should be in the middle of the development kit when mounted. An example photo of the modem placement with the U.FL connectors attached is below:

A common issue is accidentally inserting the modem with pins misaligned by one row. Check pin alignment BEFORE applying power to prevent modem damage.

2.4.3 Connect LTE Antennas

Connect the cellular antennas to the modem's X1 and X2 ports (if applicable) via the SMA jack on SWDK2's U.FL to SMA connectors.

Note: *LTE-M modems may have the GNSS X3 connector on the top side of the modem in place of a LTE diversity connector. Do not connect LTE antennas to the X3 GNSS antenna port as this may damage the GNSS interface.*

In this example the GNSS interface of the modem is left without an antenna.

2.4.4 Apply Power

The development kit can be powered through the barrel jack connector, J15, or through the Arduino interface's VIN pin. For this exercise, the development kit should be powered through the board's barrel jack connector using the provided 12V DC power supply. When power is applied the D4 LED will illuminate.

2.4.5 Connect USB

Connect the USB cable to the SWDK2's J14 interface.

The J14 interface will connect to the modem's USB to serial UART interface IC to access the modem's serial UART interface. The D3 LED will illuminate when USB is connected.

2.4.6 Modem Power On

The development kit can automatically boot the modem when power is applied if the automatic turn on circuit is enabled. Otherwise users should press the ON BTN to turn the modem on. Most modems will turn on with a 1 second press and hold of the ON BTN, but some modems, such as the TC4EU modem, may require 5 seconds. Please refer to the modem's datasheet for details on its ON_OFF timing.

2.4.7 AT Commands

Communication with cellular modems over the AT command interfaces is done via AT commands. Modems will typically support many of the 3GPP AT commands for basic functionality along with their own set of module vendor specific AT commands for checking network connectivity, transferring data, and performing diagnostics. AT commands for each modem are documented in their AT command manual, linked to on their product page.

To send AT commands to the modem open a terminal emulator program, such as Tera Term, to communicate with the modem.

If you do not have a terminal emulator program, you can download Tera Term here: https://ttssh2.osdn.jp/index.html.en

Your PC may have multiple COM ports. Select appropriate USB COM port to communicate with the development kit.

Note: Your device may not show up on the port list due to a missing driver. Refer to Section 2.3.1 for instructions on installing a driver.

You may need to adjust the Serial Settings. These can be accessed in Tera Term by going *Setup>Serial Port*. They can also be updated in Putty by navigating *Connection>Serial.* Serial Settings should be as follows (these are the default settings):

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

2.4.7.1 Test Serial Communication

In the terminal program, type the command:

AT

followed by the Enter key, and the terminal should respond with:

OK

You may need to turn echo on in order to see what you are typing. If you type the command:

AT

and do not see it being typed on your screen, hit the Enter key, and type the following command:

ATE1

followed by the Enter key, and the terminal program should respond with:

OK

Type the following command:

AT

to verify you can see the command you are typing. After pressing the Enter key, the terminal program will respond with:

OK

2.4.7.2 Enable Verbose Error Mode

On occasion, users may run into an error output where the modem outputs "**ERROR**" to an AT command. Users may enable verbose verbose error mode to see what error code is occurring by issuing the following command:

AT+CMEE=2

After pressing the Enter key, the terminal program will respond with:

OK

2.4.7.3 Cellular Functionality

Some modems may boot into airplane mode or have their cellular functionality turned off. To verify that the cellular functionality is turned on issue the following command:

AT+CFUN?

followed by the Enter key, and the terminal program should respond with:

+CFUN: <x>

OK

Where x is the functionality parameter. If it is set to a value other than 1 then the user will need to put the modem back into full functionality mode with the AT+CFUN=1 command.

2.4.7.4 Check SIM Communication

Some modems will support dual SIM interfaces, typically with a solder down SIM on the modem along with the 3FF SIM interface. Users should check the datasheet for their device for instructions on selecting their desired SIM interface.

Verify that the modem can read the SIM card by issuing the AT command for your specific modem family located in the chart below.

Modem	Command	Response
NL-SW-LTE-TC4NAG NL-SW-LTE-TC4APG	AT+ICCID	**+CCID: xxxxxxxxxxxxxxxxxxx** **OK**
NL-SW-LTE-GELS3-x	AT+CCID	**+CCID: "xxxxxxxxxxxxxxxxxxx",""** **OK**
NL-SW-LTE-QBG96 NL-SW-LTE-QBG95	AT+QCCID	**+QCCID: xxxxxxxxxxxxxxxxxxx** **OK**
All other modems	AT+CCID	**+CCID: xxxxxxxxxxxxxxxxxxx** **OK**

If the modem responds with **ERROR** or "**+CME ERROR: SIM failure**" please check that the SIM is properly seated, that the correct SIM interface is selected(if the modem supports dual SIMs), that cellular functionality is enabled (AT+CFUN=1), and verify that the SIM does not require a PIN. If it still responds with an error, and further assistance is needed, please contact NimbeLink for assistance.

2.4.7.5 PDP Context APN Configuration

Before a modem can communicate on the cellular network it must have its PDP context configured with the APN. Devices using Verizon should have the APN automatically pushed to the device within a few minutes of the first pairing of the modem and SIM on the network. In the event that this does not occur the APN can be manually set.

***Note**: If the PDP context is in use by an active connection it can not be modified until the PDP context is deactivated, however if the PDP context is active then this typically indicates the APN is correctly set. To deactivate a PDP context please see the context activation command for your modem (AT#SGACT for Telit based modems, AT+QIACT for Quectel based modems, AT^SICA for Gemalto based modems, and AT+CGACT for Sierra based modems) or turn off the cellular TX/RX interface by issuing AT+CFUN=4 on non-Telit based modems modems.*

2.4.7.5.1 Verizon Cat1+ Devices

Verizon LTE Cat 1 or higher devices should use PDP context 3 for their data connections and manual APN configuration. Contexts 1, 2, 4, 5, and 6 are used for other services (SMS, registration, ect…) on Verizon and these PDP contexts should not be altered. Doing so may cause the modem to fail to register with the network.

To manually set the APN follow these steps.

Get a snapshot of the current PDP context APN configurations prior to editing them in case an incorrect setting is entered. Type the command:

AT+CGDCONT?

The modem should respond with:

+CGDCONT: 1,"IPV4V6","ims","",0,0,0,0

+CGDCONT: 2,"IPV4V6","vzwadmin","",0,0,0,0

+CGDCONT: 3,"IPV4V6","vzwinternet","",0,0,0,0

+CGDCONT: 4,"IPV4V6","vzwapp","",0,0,0,0

+CGDCONT: 5,"IPV4V6","","",0,0,0,1

+CGDCONT: 6,"IPV4V6","vzwclass6","",0,0,0,0

OK

Issued the following command followed by the enter key to change the APN in the third PDP context:

AT+CGDCONT=3,"<IPTYPE>","<APN>"

Where **<IPTYPE>** is IP (for IPV4), IPV4V6, or IPV6 and **<APN>** is the APN provided by your cellular data plan vendor. Most devices should use IPV4V6 for their data plan, but this will depend on what IP type the cellular data plan is configured to support.

Verify that the APN has been changed by checking the PDP context configuration. Type the command followed by the enter key:

AT+CGDCONT?

The modem should respond with:

+CGDCONT: 1,"IPV4V6","ims","",0,0,0,0

+CGDCONT: 2,"IPV4V6","vzwadmin","",0,0,0,0

+CGDCONT: 3,"<IPTYPE>","<APN>","",0,0,0,0

+CGDCONT: 4,"IPV4V6","vzwapp","",0,0,0,0

+CGDCONT: 5,"IPV4V6","","",0,0,0,1

+CGDCONT: 6,"IPV4V6","vzwclass6","",0,0,0,0

OK

2.4.7.5.2 LTE M1 and Non-Verizon LTE Cat 1+ Device APN Configuration

LTE M1 devices on all carriers and non-Verizon LTE Cat 1+ devices typically use PDP context 1 for their data connections and manual APN configuration.

LTE Cat 1+ non-Verizon devices will need to have their APN manually configured. LTE M1 devices can either have their APN manually entered or be configured to request the APN from the cellular network each time the modem connects by leaving the APN blank.

Note: Some carrier SIMs may load APNs into the PDP contexts upon boot. These APNs may not be the correct APN for the customer's data plan and will need to be configured on each bootup.

To manually set the APN follow these steps. Issue the following command followed by the Enter key to change the APN in the first PDP context:

AT+CGDCONT=1,"<IPTYPE>","<APN>"

Where **<IPTYPE>** is IP (for IPV4), IPV4V6, or IPV6 and **<APN>** is the APN provided by your cellular data plan vendor. Most devices should use IPV4V6 for their data plan, but this will depend on what IP type the cellular data plan is configured to support.

Verify that the APN has been changed by checking the PDP context configuration. Type the command followed by the enter key:

AT+CGDCONT?

The modem should respond with:

+CGDCONT: 1,"<IPTYPE>","<APN>","",0,0,0,0

OK

2.4.7.6 Signal Quality

Cellular modems offer several signal quality metrics for determining if a device has a good, poor, or bad connection with the network. These signal metrics are Received Signal Strength Indicator (RSSI), Reference Signal Received Power (RSRP), and Reference Signal Received Quality (RSRQ). RSSI measurements are available for 2G, 3G, and 4G connections while RSRP/RSRQ measurements are only available for 4G connections.

These three signal quality metrics differ as follows:

- RSSI is a measurement that looks at the wide band RF power coming into the modem from all sources, including all noise and interference from other sources.
- RSRP looks at the average of the RF power in the passband that the modem and the tower are using to communicate and can be used to determine how good the signal power is between the tower while excluding noise and interference from other sources.
    - A poor RSRP signal can indicate that the modem is in a poor coverage zone or there is an issue with the antenna connection.
- RSRQ indicates the quality of the connection between the tower and modem by measuring the quality of a received reference signal sent from the tower to the modem.
    - A poor RSRQ signal can be an indication that there is noise interfering with the modem's communication.

For 4G connections it is best to rely on the RSRQ and RSRP measurements as they provide a more granular perspective on the cellular connection. Applications using 4G devices that have 2G/3G fall back should also check RSSI in the event the modem falls back to a 2G/3G network.

The table below shows the mapping of signal quality to the returned values from the modem. Devices will typically start seeing some occasional connectivity issues, such as dropped connections, when the signal quality is in the lower end of the "Fair" signal quality range. When the modem is in the poor signal quality range connectivity may be problematic.

Technology	2G, 3G, 4G	LTE Only	LTE Only
Signal Quality	RSSI (dBm)	RSRQ (dB)	RSRP (dBm)
Excellent	RSSI > -70	RSRQ ≥-8	RSRP > -80
Good	-70 > RSSI ≥ -85	-8 ≥ RSRQ ≥ -12	-80 ≥ RSRP ≥ -90
Fair	-85 > RSSI ≥ -100	-8 ≥ RSRQ ≥ -12	-90 ≥ RSRP ≥ -100
Poor	RSSI < -100	RSRQ <-12	RSRP < -100

To check the RSSI signal quality on a modem issue the following AT command to the modem:

AT+CSQ

Followed by the enter key. The modem should respond with:

+CSQ: <x>,<y>

OK

where xx is the signal strength of the antenna, and yy is the bit error rate in percent. Typical values are as follows:

Values of <y>	Bit Error Rate (in percent)
0	Less than 0.2%
1	0.2% to 0.4%
2	0.4% to 0.8%
3	0.8% to 1.6%
4	1.6% to 3.2%
5	3.2% to 6.4%
6	6.4% to 12.8%
7	More than 12.8%
99	Not known or not detectable

Values of <x>	Relative Signal Strength
0 – 9	Poor: <= -95 dBm
10 – 14	OK: -93 dBm to -85 dBm
15 – 19	Good: -83 dBm to -75 dBm
20 – 30	Excellent: -73 dBm to -53 dBm
31	Excellent: -51 dBm or greater
99	Not known or not detectable

The modem's bit error rate will only be detectable during data transfers and will be not known when the modem is idle.

To check the RSRP and RSRQ signal quality on your modem, issue the AT command for your specific modem located in the table below:

Modem	Command	Response
NL-SW-LTE-QBG96 NL-SW-LTE-QBG95	**AT+QCSQ**	**+QCSQ: <sysmode>,<value1>,<value2>,<value3>,<value4>** **OK**
All other modems	**AT+CESQ**	**+CESQ: <rxlev>, <ber>, <rscp>, <ecno>, <rsrq>, <rsrp>** **OK**

The signal quality parameters for the QBG96 and QBG95 modems are as follows:

<sysmode>	<value1>	<value2>	<value3>	<value4>
"NOSERVICE"				
"GSM"	<gsm_rssi>			
"CAM-M1"	<lte_rssi>	<lte_rsrp>	<lte_sinr>	<lte_rsrq>
"eMTC"	<lte_rssi>	<lte_rsrp>	<lte_sinr>	<lte_rsrq>
"CAT-NB1"	<lte_rssi>	<lte_rsrp>	<lte_sinr>	<lte_rsrq>

Parameter	Notes
<gsm_rssi>,<lte_rssi>	An integer indicating the received signal strength. These parameters are available for GSM and LTE modes, respectively.
<lte_rsrp>	An integer indicating the reference signal received power (RSRP). This parameter is available for LTE mode.
<lte_sinr>	An integer indicating the signal to interference plus noise ratio (SINR). Logarithmic value of SINR. Values are in 1/5th of a dB.The range is 0-250 which translates to -20dB -+30dB.
<lte_rsrq>	An integer indicating the reference signal received quality (RSRQ) in dB.

The signal quality parameters for all other modems are as follows:

Parameter	Notes	
<rxlev>		Received signal strength level (see 3GPP TS 45.008 subclause 8.1.4). For 2G networks only.
	0	rssi < -110 dBm
	1	-110 dBm ≤ rssi < -109 dBm
	2	-109 dBm ≤ rssi < -108 dBm
	...	...
	61	-50 dBm ≤ rssi < -49 dBm
	62	-49 dBm ≤ rssi < -48 dBm
	63	-48 dBm ≤ rssi
	99	Not known or not detectable or if the current serving cell is not a GERAN cell
<ber>		Bit error rate (in percent). For 2G networks only.
	0-7	RXQUAL values in the table in 3GPP TS 45.008 sub clause 8.2.4.
	99	Not known or not detectable or if the current serving cell is not a GERAN cell
<rscp>		Received signal code power (see 3GPP TS 25.133 subclause 9.1.1.3 and 3GPP TS 25.123 subclause 9.1.1.1.3). For 3G networks only.
	0	rscp < -120 dBm
	1	-120 dBm ≤ rscp < -119 dBm
	2	-119 dBm ≤ rscp < -118 dBm
	...	...
	94	-27 dBm ≤ rscp < -26 dBm
	95	-26 dBm ≤ rscp < -25 dBm
	96	-25 dBm ≤ rscp
	255	255 - not known or not detectable or if the current serving cell is not a UTRA cell
<ecno>		Ratio of the received energy per PN chip to the total received power spectral density (see 3GPP TS 25.133 subclause). For 3G networks only.

	0	Ec/Io < -24 dB
	1	-24 dB ≤ Ec/Io < -23.5 dB
	2	-23.5 dB ≤ Ec/Io < -23 dB
	...	...
	47	-1 dB ≤ Ec/Io < -0.5 dB
	48	-0.5 dB ≤ Ec/Io < 0 dB
	49	0 dB ≤ Ec/Io
	255	Not known or not detectable or if the current serving cell is not a UTRA cell
<rsrq>		Reference signal received quality (see 3GPP TS 36.133 subclause 9.1.7). For 4G networks only.
	0	rsrq < -19.5 dB
	1	-19.5 dB ≤ rsrq < -19 dB
	2	-19 dB ≤ rsrq < -18.5 dB
	...	...
	32	-4 dB ≤ rsrq < -3.5 dB
	33	-3.5 dB ≤ rsrq < -3 dB
	34	-3 dB ≤ rsrq
	255	Not known or not detectable or if the current serving cell is not a EUTRA cell.
<rsrp>		Reference signal received power (see 3GPP TS 36.133 subclause 9.1.4). For 4G networks only.
	0	rsrp < -140 dBm
	1	-140 dBm ≤ rsrp < -139 dBm
	2	-139 dBm ≤ rsrp < -138 dBm
	...	...
	95	-46 dBm ≤ rsrp < -45 dBm
	96	-45 dBm ≤ rsrp < -44 dBm
	97	-44 dBm ≤ rsrp
	255	Not known or not detectable or if the current serving cell is not a EUTRA cell

2.4.7.7 Network Registration

Before a modem can send or receive data it must register on a home or roaming network. There are three different commands for checking network registration, each designed for a specific cellular technology:

- AT+CEREG
  - Used to check registration on Evolved Packet System (EPS) for 4G (EUTRAN) networks .
- AT+CGREG
  - Used to check GPRS (Packet Switched) registration for GPRS/EDGE (2G/GERAN), and UMTS/HSPA/HSDPA (3G/UTRAN) networks.
  - Some LTE devices may reflect 4G network registration on this command.
- AT+CREG
  - Used to check GSM (Circuit Switched) network registration for 2G GSM networks.
  - Some LTE devices may reflect 4G network registration on this command.

Devices with 2G or 3G fallback should also be checking to see if the device has registered on a 2G/3G network. In the event the modem is in an area with no LTE coverage and it falls back to 2G or 3G it may show that its LTE registration (the AT+CEREG response) was denied, not registered and searching, or not registered and it has given up attempting, but its 2G or 3G registration was successful.

To check if a device has registered on a network issue the AT command from the table below for the desired network technology, followed by the enter key:

Access Technology	Command	Response
4G	**AT+CEREG?**	**+CEREG: 0,<stat>** **OK**
3G/2G GPRS	**AT+CGREG?**	**+CGREG: 0,<stat>** **OK**
2G GSM	**AT+CREG?**	**+CREG: 0,<stat>** **OK**

<stat> is the network registration status. The values of stat are available in the modem's AT command manual and are also listed below for convenience.

<stat>	Parameter
0	Not registered. MT is not currently searching an operator to register to.
1	Registered, home network.
2	Not registered, but MT is currently trying to attach or searching for an operator to attach to.
3	Registration denied.
4	Unknown.
5	Registered, roaming.

If the modem has successfully registered it should have a **<stat>** response of **1** or **5**. Many modems and carriers will require that the APN is correctly set before it can register on the network.

Note: If the modem's AT+CEREG response is 4 (unknown), then it may have registered on a 2G network. Make sure to check the AT+CREG response in this event.

Once the modem has registered on the network users can issue the following AT command to check what carrier and access technology the modem has registered on.

Command: **AT+COPS?**
Response: **+COPS: <mode>[,<format>[,<oper>][,<Act>]]**

OK

Parameter	Notes
<mode>	Modem registration mode. 0 - Automatic 1 - Manual Operator Selection 2 - Manual Deregister from network. 3 - set only <format> parameter and ignore <oper> setting 4 - Manual/Automatic
<format>	Formatting configuration for <oper> 0 - Alphanumeric long form (max 16 digits). 1 - Short format alphanumeric <oper>. 2 - Numeric <oper>.
<oper>	Network Operator name per <format> setting.
<Act>	Access technology selected. 0 - GSM 1 - GSM Compact 2 - UTRAN 7 - E-UTRAN (LTE Cat 1+) 8 eMTC (LTE CAT M1) 9 LTE NB-IoT

2.4.7.8 Activate PDP Context

This step will activate the modem's PDP context and cause the modem to have an active connection with the network and it will then be able to move data. Before being able to activate the PDP context the modem must have an active data plan, be registered on a home or roaming network, have the correct APN configuration, and have good signal quality. If the modem doesn't meet these requirements then it won't be able to reliably connect to the network.

To activate the PDP context issue the appropriate AT command for your modem in the table below followed by the enter key:

Modem	Command	Response
NL-SW-LTE-QBG96 NL-SW-LTE-QBG95	**AT+QIACT=1**	**OK**
NL-SW-LTE-TC4NAG (AT&T Firmware) NL-SW-LTE-TC4EU NL-SW-LTE-TC4APG	**AT#SGACT=1,1**	**#SGACT: <IPV4>,<IPV6>** **OK**
NL-SW-LTE-TC4NAG (VZW Firmware)	**AT#SGACT=3,1**	**#SGACT: <IPV4>,<IPV6>** **OK**
NL-SW-LTE-S7648 NL-SW-LTE-S7588-T	**AT+CGACT=1,1**	**OK**
NL-SW-LTE-S7588-V NL-SW-LTE-S7618RD	**AT+CGACT=1,3**	**OK**
NL-SW-LTE-GELS3	**AT^SICA=1,3**	**OK**

Where **<IPV4>** is the modem's IPV4 address assigned by the network and **<IPV6>** is the modem's IPV6 address assigned by the network. The modem will display either an IPV4, IPV6, or both IP addresses depending on how the data plan with the carrier is configured. Not all modems will display the IP address with the PDP activation.

On occasion the PDP context activation might fail and output an error message. If this occurs users should immediately attempt to retry as the network may have been busy during the attempt. If the error persists please check the signal quality, network registration status, and APN configuration or contact NimbeLink for assistance.

To verify that the modem activated the PDP context and pulled an IP address from the network issue the appropriate AT command for your modem in the table below followed by the enter key:

Modem	Command	Response
NL-SW-LTE-QBG96 NL-SW-LTE-QBG95	**AT+CGPADDR=1**	**+CGPADDR: 1,"<IP>"** **OK**
NL-SW-LTE-TC4NAG (AT&T Firmware) NL-SW-LTE-TC4EU NL-SW-LTE-TC4APG	**AT+CGPADDR=1**	**+CGPADDR: 1,"<IP>"** **OK**
NL-SW-LTE-TC4NAG (VZW Firmware)	**AT+CGPADDR=3**	**+CGPADDR: 3,"<IP>"** **OK**
NL-SW-LTE-S7648 NL-SW-LTE-S7588-T	**AT+CGPADDR=1**	**+CGPADDR: 1,"<IP>"** **OK**
NL-SW-LTE-S7588-V NL-SW-LTE-S7618RD	**AT+CGPADDR=3**	**+CGPADDR: 3,"<IP>"** **OK**
NL-SW-LTE-GELS3*	**AT+CGPADDR=3**	**+CGPADDR: 3,"<IP>"** **OK**

*This modem will only display the local, internal IP address and not the cellular carrier network IP address.

3. Next Steps

Once the modem is communicating with your PC you are ready to start developing with your Skywire modem. Common application examples, including socket dials, SMS messaging, and PPP and other OS networking examples, are available for each Skywire modem on their product page under the application notes section.

- Skywire Modem Overview Page

4. Version Information

Revision	Notes	Date
1	- Initial Release.	2021/01/07