

Skywire 4G LTE Cat 4 APAC Embedded Cellular Modem Datasheet

NimbeLink Corp

Updated: May 2020



© NimbeLink Corp. 2020. All rights reserved.

NimbeLink Corp. provides this documentation in support of its products for the internal use of its current and prospective customers. The publication of this document does not create any other right or license in any party to use any content contained in or referred to in this document and any modification or redistribution of this document is not permitted.

While efforts are made to ensure accuracy, typographical and other errors may exist in this document. NimbeLink reserves the right to modify or discontinue its products and to modify this and any other product documentation at any time.

All NimbeLink products are sold subject to its published Terms and Conditions, subject to any separate terms agreed with its customers. No warranty of any type is extended by publication of this documentation, including, but not limited to, implied warranties of merchantability, fitness for a particular purpose and non-infringement.

NimbeLink is a registered trademark, and Skywire is a registered trademark, of NimbeLink Corp. All trademarks, service marks and similar designations referenced in this document are the property of their respective owners.

Table of Contents

Table of Contents	2
Introduction	4
Scope	4
Contact Information	4
Orderable Part Numbers	4
Additional Resources	4
Product Overview	5
Technical Specifications	5
Block Diagram	5
Electrical Specifications	6
Absolute Maximum and Minimum Ratings	6
Module Pinout for Connectors J1 and J2	6
Module Pinout for Connectors X1, X2, X3, J3	8
Typical Power Consumption	9
RF Specifications	11
Maximum RF Output Power	11
RX Sensitivity	11
4G LTE Uplink and Downlink Speeds	11
Mechanical Characteristics	12
Mechanical Drawing	12
Mechanical Specifications	12
Mating Connectors	13
Device Placement	13
Environmental Specifications	13
Design Considerations	14
Power Supply Design	14
Power Supply Requirements	14
Serial Communications	16
Serial UART Interface	16
USB Interface	16
VREF	17
nRESET	17
Power Control	18

ON_OFF Signal	18
Shutdown	19
Hardware Shutdown	19
Software Shutdown	19
ON/nSLEEP	20
Power Status Monitoring	20
Network Status Monitoring	20
Firmware Updates Over the Air (FOTA)	21
Dual-Image Firmware Information	21
Overview	21
GNSS	21
GNSS Antenna Requirements	22
Active GNSS Antenna Control	22
Cellular Antenna Requirements	23
Primary Antenna Requirements	23
Diversity Antenna Requirements	23
Antenna Placement	24
Recommended Antennas	24
Skywire Reference Design	24
Mounting Guidelines	25
Board-to-Board Connectors Approach	25
Mechanical Retention	25
Solder to Board Connection	26
Regulatory Information	27
Export Control Classification Number (ECCN)	27
Harmonized Tariff Schedule Code	27
Interference statement	27
Modification Statement	27
End Product Labeling Requirements	27

1. Introduction

1.1 Scope

This document serves as the hardware datasheet for the NL-SW-LTE-TC4APG Skywire® modem.

1.2 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 modem's [product page](#). Any additional sales questions or requests for quotation can be directed to NimbeLink's sales team at:

sales@nimbelink.com

1.3 Orderable Part Numbers

Orderable Device	Operating Temperature	4G LTE Bands	Fallback
NL-SW-LTE-TC4APG	-40°C to +85°C	LTE-FDD: B1, B3, B5, B8, B9, B18, B19, B26, B28	3G HSPA+: B1, B5, B6, B19, B8

1.4 Additional Resources

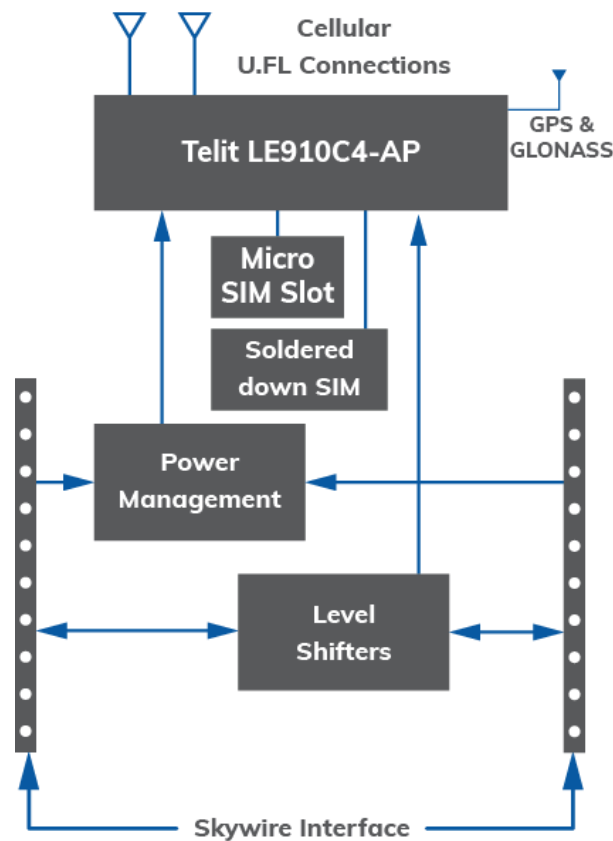
- [Skywire® 4G LTE CAT 4 APAC Embedded Modem Product Page](#)
- [Skywire® 4G LTE CAT 4 APAC AT Command Manual](#)
- [Skywire® 4G LTE CAT 4 APAC Application Notes](#)
- [Skywire® 4G LTE CAT 4 APAC 3D Model \(STEP\)](#)
- [NL-SWDK User Manual](#)
- [Skywire Hardware Design Developers Guide](#)
- [Skywire Hardware Design Checklist](#)
- [Skywire Software Developer's Guide](#)

1.5 Product Overview

NimbeLink, a global leader in embedded cellular modem technology and asset tracking solutions, has introduced the Skywire® 4G LTE CAT 4 APAC modem. This Skywire modem leverages Category 4 technology. This is the fastest and most cost-effective way to bring cellular connectivity to your IoT products in Asia-Pacific. The CAT 4 APAC modem delivers exceptional download and upload speeds and has fallback to 3G.

2. Technical Specifications

2.1 Block Diagram



2.2 Electrical Specifications

2.2.1 Absolute Maximum and Minimum Ratings

To avoid potential damage to the modem, ensure that all voltages applied to the pins listed below do not fall outside of the ranges specified by the maximum and minimum ratings:

Parameter	Skywire Pin(s)	Min. Rating	Max. Raing
Main Power Supply ¹	VCC	3.4V	4.2V
I/O Voltage Reference	VREF	1.8V	5.5V
1.8V Referenced Signals	GPIO1, GPIO2, ON_OFF, nRESET	0 V	1.8V
VREF Referenced Signals	DIN, DOUT, DTR, RING, CTS, RTS	0 V	5.5V

1. Transient voltage drooping can occur on the VCC rail during normal modem operation. In order to prevent damage to the modem, transient voltage drops must not fall below 3.1V.

2.2.2 Module Pinout for Connectors J1 and J2

The following table details the pinout of the NL-SW-LTE-TC4APG Skywire modem, and recommended ratings for the Skywire interface on connectors J1 and J2. More details and design requirements for these pins are documented in [Section 3](#).

Pin	Name	Direction	Description	Min	Typ.	Max
1 (J1-1)	VCC	Input	Main Power Supply Pin	3.4V	3.8V	4.2V
2 (J1-2)	DOUT	Output	UART data out, I/O level tied to VREF, internally pulled up to VREF.	0V		VREF
3 (J1-3)	DIN	Input	UART data in, I/O level tied to VREF	VREF Range	VIL	VIH
				1.65V to 1.95V	VREF x 0.35V	VREF x 0.65
				2.3V to 2.7V	0.7V	1.7V
				3.0V to 3.6V	0.8V	2V
				4.5V to 5.5V	VREF x 0.3V	VREF x 0.7
4 (J1-4)	GND	Input	Ground Pin		0V	

Pin	Name	Direction	Description	Min	Typ.	Max
5 (J1-5)	nRESET	Input	Reset signal for the LE910C4 cellular module, active low, drive with an open collector transistor. See Section 3.4 for additional requirements.	VIL	0V	0.6V
				VIH	1.25V	1.8V
6 (J1-6)	VUSB	Input	USB connection detection	2.5V	5.0V	5.5V
7 (J1-7)	USB_P	I/O	USB differential data bus (+) Requires differential impedance of 90Ω.	Compliant with USB 2.0 standard specification.		
8 (J1-8)	USB_N	I/O	USB differential data bus (-) Requires differential impedance of 90Ω.	Compliant with USB 2.0 standard specification.		
9 (J1-9)	DTR	Input	Data terminal ready (sleep mode control), tied to internal reference voltage of 1.8V	VIL	0V	0.63V
				VIH	1.17V	5.5V
10 (J1-10)	GND	Input	Ground Pin		0V	
11 (J2-1)	GND	Input	Ground Pin		0V	
12 (J2-2)	CTS	Output	Modem "Clear to Send" hardware flow control output, open drain assertion, internally pulled up to VREF.	VREF Range	VIL	VIH
				1.65V to 1.95V	VREF x 0.35V	VREF x 0.65
				2.3V to 2.7V	0.7V	1.7V
				3.0V to 3.6V	0.8V	2V
				4.5V to 5.5V	VREF x 0.3V	VREF x 0.7
13 (J2-3)	ON/nSLEEP	Output	Modem status pin. See Section 3.6 for further information.	0V		1.8V
14 (J2-4)	VREF	Input	Voltage reference for offboard I/O signals.	1.65V	1.8V or 3.3V	5.5V

Pin	Name	Direction	Description	Min	Typ.	Max
15 (J2-5)	GND	Input	Ground Pin		0V	
16 (J2-6)	RTS	Input	Modem "Request to Send" hardware flow control input	VREF Range	VIL	VIH
				1.65V to 1.95V	VREF x 0.35V	VREF x 0.65
				2.3V to 2.7V	0.7V	1.7V
				3.0V to 3.6V	0.8V	2V
				4.5V to 5.5V	VREF x 0.3V	VREF x 0.7
17 (J2-7)	GPIO_3	I/O	Modem GPIO pin. 2-16 mA drive strength.	VIL	0V	0.6V
				VIH	1.25V	1.8V
				VOL	0V	0.45V
				VOH	1.4V	1.8V
18 (J2-8)	GPIO_2	I/O	Modem GPIO pin. 2-16 mA drive strength.	VIL	0V	0.6V
				VIH	1.25V	1.8V
				VOL	0V	0.45V
				VOH	1.4V	1.8V
19 (J2-9)	RING	Output	Modem Ring indicator pin. Open drain output, pulled up to VREF on Skywire. Pulled low when a new modem URC is available.	0V		VREF
20 (J2-10)	ON_OFF	Input	Modem On/Off signal, active low, drive with an open collector transistor. See Section 3.5 for additional requirements.	VIL	0V	0.2V
				VOH	0.7V	0.9V

Additional information on the Skywires pinout is available in Section 3.

2.2.3 Module Pinout for Connectors X1, X2, X3, J3

Connector Designator	Description	Connector Location
X1	Primary Cellular Antenna Connector	Top Side of Modem
X2	Diversity Cellular Antenna Connector	Top Side of Modem
X3	GPS / GNSS Antenna Connector	Bottom Side of Modem
J3	Micro SIM Connector (3FF)	Bottom Side of Modem

2.2.4 Typical Power Consumption

The values contained in Section 2.2.4 are provided as an example of typical current consumption behavior for NL-SW-LTE-TC4APG Skywires.

In customer applications, current consumption may vary, and is influenced by factors such as: signal quality, ambient temperature, battery/supply voltage, supply impedance, board capacity, and other factors.

Mode	Signal Attn. (dB)	RSSI (dBm)	LTE: RSRQ (dB) 3G: EC/IO (dB)	Peak Current (mA)	Average Current (mA)	Charge Consumed (mAh)	Measurement Notes
Active Socket Dial, 4G LTE	0	-51	-8	916.8 mA	83.5 mA	43.4 μAh	Tested at: 3.8V Time elapsed: 1.73 s Test: Open socket, HTTP POST, read response, close socket
	20	-71	-10	844.6 mA	113.8 mA	64.0 μAh	Tested at: 3.8V Time elapsed: 1.95 s Test: Open socket, HTTP POST, read response, close socket
	40	-89	-12	958.7 mA	136.7 mA	110.2 μAh	Tested at: 3.8V Time elapsed: 2.76 s Test: Open socket, HTTP POST, read response, close socket
Active Socket Dial, 3G HSPA+	0	-83	-5	449.4 mA	236.1 mA	127.7 μAh	Tested at: 3.8V Time elapsed: 1.95 s Test: Open socket, HTTP POST, read response, close socket
	20	-97	-8	594.2 mA	354.9 mA	236.5 μAh	Tested at: 3.8V Time elapsed: 2.40 s Test: Open socket, HTTP POST, read response, close socket
	40	-203	-11	576.9 mA	355.4 mA	301.7 μAh	Tested at: 3.8V Time elapsed: 3.05 s Test: Open socket, HTTP POST, read response, close socket

Mode	Signal Attn. (dB)	RSSI (dBm)	RSRQ (dB)	Peak Current (mA)	Average Current (mA)	Charge Consumed (mAh)	Measurement Notes
GPS Location Fix, Cold Start	0	-51	-8	805.9 mA	76.1 mA	413.2 μ Ah	Tested at: 3.8V Time elapsed: 37.8 s Test: GPS cold start, active GPS antenna, registered on LTE network, time-to-fix measurement
GPS Location Fix, Hot Start	0	-51	-8	166.4 mA	64.6 mA	8.5 μ Ah	Tested at: 3.8V Time elapsed: 29 s Test: GPS hot start, active GPS antenna, registered on LTE network, time-to-fix measurement
Idle, Registered on LTE network	0	-51	-8	837.6 mA	19.1 mA	1.6 mAh	Tested at: 3.8V Time elapsed: 300 s Test: 5 minute idle while modem is registered on network. Status LED enabled.
Idle, Unregistered on LTE network	0	-51	-8	104.5 mA	14.8 mA	1.2 mAh	Tested at: 3.8V Time elapsed: 300 s Test: 5 minute idle with AT+CFUN=4, and modem unregistered. Status LED enabled.
Off	0	-51	-8	525.4 μ A	4.4 μ A	365.0 nAh	Tested at: 3.8V Time elapsed: 300 s Test: Modem powered off with AT#SHDN.

2.3 RF Specifications

2.3.1 Maximum RF Output Power

Available Cellular Technologies and Max TX Power	
4G LTE Technology	4G LTE CAT 4
4G LTE TX Output Power	Class 3 (0.2W, 23dBm@1RB)
3G Technology	HSPA+
3G TX Output Power	Class 3 (0.25W, 24dBm)

2.3.2 RX Sensitivity

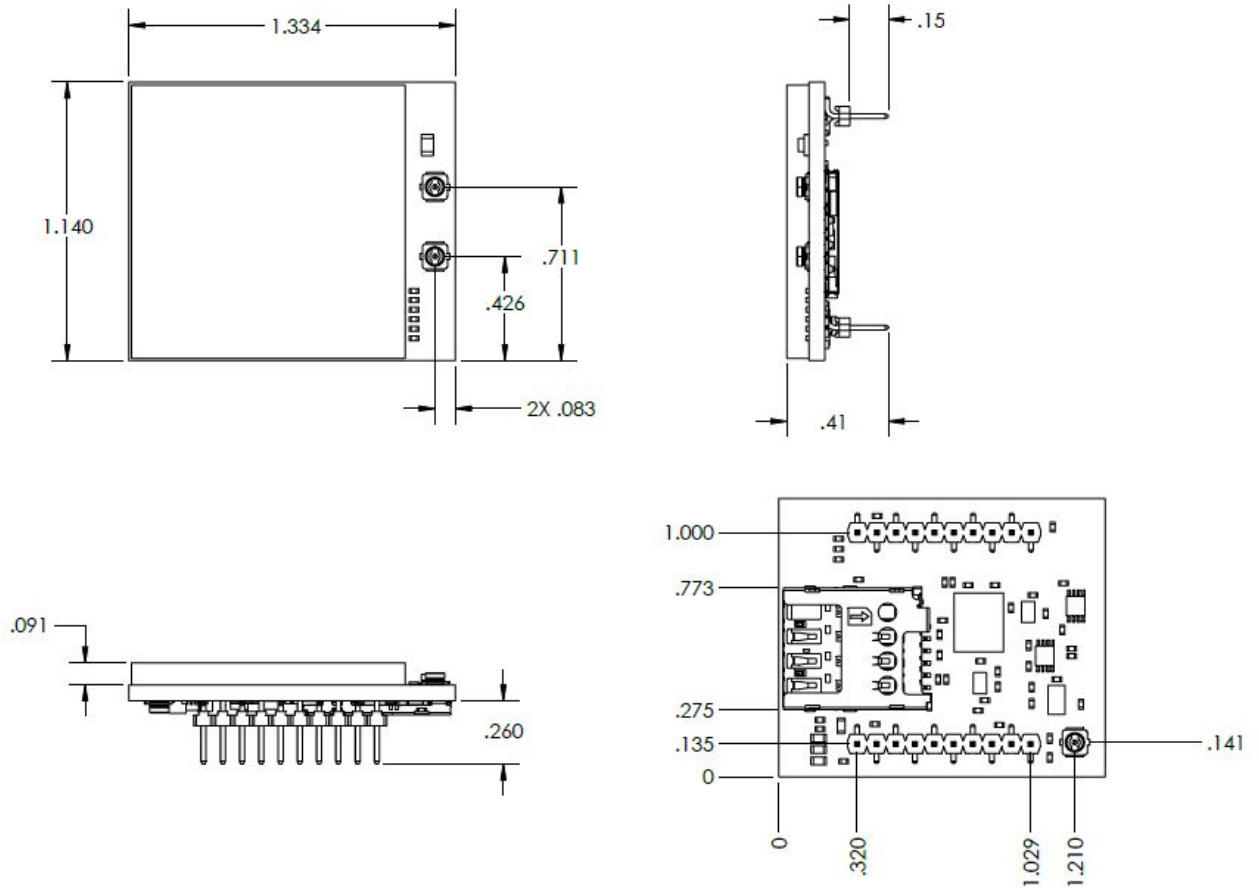
Available Cellular Technologies and RX Sensitivity	
4G	-101.0 dBm (@ 5 MHz BW)
3G	-111.0 dBm

2.3.3 4G LTE Uplink and Downlink Speeds

4G LTE Peak Uplink and Downlink Speeds	
Uplink	50 Mbps
Downlink	150 Mbps

2.4 Mechanical Characteristics

2.4.1 Mechanical Drawing



Dimensions are in inches unless noted.

2.4.2 Mechanical Specifications

Parameter	Typical	Unit
Dimensions	29.0 x 33.9 x 10.7	mm
	1.140 x 1.334 x 0.41	Inches
Weight	8	Grams
Connector Insertion/Removal	hundreds	Cycles

2.4.3 Mating Connectors

Connector Designator	Manufacturer	Populated on Skywire	Recommended Mate	Mate Manufacturer
J1, J2	3M	951110-2530-AR-PR	950510-6102-AR	3M
			NPPN101BFCN-RC	Sullins Connector Solutions
J3	Molex	786463001	Micro SIM 3FF Size	Micro SIM Card
X1, X2	Hirose	U.FL-R-SMT(10)	CAB.011	Taoglas

2.4.4 Device Placement

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

2.4.5 Environmental Specifications

Parameter	Min	Typical	Max	Unit	Note
Operating Temperature	-40	+25	+85	°C	
Storage Temperature	-40	+25	+90	°C	
Operating Humidity	20		90	%	Non-condensing

3. Design Considerations

Section 3 describes important considerations that system designers should follow when utilizing a Skywire modem in a new or existing design.

NimbeLink offers free schematic and layout design reviews for customers integrating Skywire modems into their designs. Contact the following email for information:

product.support@nimbelink.com.

3.1 Power Supply Design

[Section 3.1](#) contains information regarding proper power supply design for users who are designing their own baseboard for a Skywire modem. In order to ensure proper modem operation and prevent potential damage, it is crucial to follow each of the requirements listed in this section.

3.1.1 Power Supply Requirements

The NL-SW-LTE-TC4APG Skywire has a normal operating voltage range of 3.40V to 4.20V, with a recommended input voltage of 3.80V. This modem will regularly consume high amounts of current on its main power supply inputs (Pin 1, VCC) and must have a well designed power supply that can support peak transient currents up to 2 Amps.

Parameter	Symbol	Min	Typ	Max	Unit
Operating Voltage Range	VCC	3.40	3.8	4.20	V
Current Consumption*	I_{VCC}	-	400	2000	mA

*Current consumption values depend on network configuration and are not under the modems control.

Designers must ensure that the supply voltage does not drop outside of the normal operating range at all times during modem operation. Failure to do so may cause the modem to brownout, which can cause permanent damage to the modem and void the modem's warranty.

When designing the power supply for a Skywire modem it is recommended to adhere to the following design guidelines:

- Use a DC-DC switching power supply that is capable of supplying up to 2A of current to the Skywire.
 - Switching power supplies are able to rapidly respond to the sudden current demands of an LTE modem.
 - It is recommended to use a regulator with an output voltage of 3.8V.

- To reduce EMI from the switching regulator, follow the manufacturer design guidelines closely.
- Place a minimum of a 0.1 μF low ESR ceramic capacitor and 100 μF low ESR ceramic capacitor close to the VCC pin of the Skywire.
 - The 0.1 μF capacitor should be placed as close as possible to the VCC pin of the Skywire followed by the 100 μF capacitor.
 - The capacitors should be rated to at least twice the output voltage of the switching regulator.
 - See the reference schematics below for example power supply circuits.
- Ensure that there is a low impedance power path from the baseboard power supply to the VCC pin of the Skywire.
 - Use at least an 80 mil trace width for the power supply trace to the VCC pin. However, the wider the trace, the better.
 - An increased trace width will lower the inductance of the trace, improving the ability of the power supply to meet the transient current spikes of up to 2A during cellular network activity.
- Use a dedicated ground plane on the baseboard.
- Power supply input cables should be kept away from noise sensitive signal lines, such as antennas or USB traces.

NimbeLink offers multiple reference designs in order to assist customers with their designs at no charge. Two of the designs are linked to below:

NL-AB-BBCL Reference Schematic:

https://nimbelink.com/Documentation/Development_Kits/NL-AB-BBCL/20057s_NL-AB-BBCL_SCH.PDF

NL-SWDK Reference Schematic:

https://nimbelink.com/Documentation/Development_Kits/NL-SWDK/20002_NL-SWDK_Schematic.pdf

While prototyping with the modem, it is recommended to use a Skywire development kit, as opposed to a breadboard. Please refer to the following application note on why breadboards might cause problems and how to fix them:

Prototyping with Cellular Modems and Modules:

https://nimbelink.com/Documentation/Skywire/1001619_Breadboard_WhitePaper.pdf

3.2 Serial Communications

The NL-SW-LTE-TC4APG modem has two communication paths: serial (UART) and USB. The serial UART interface is targeted for applications using lower speed 8/16/32 bit microcontrollers that do not have a USB interface or easily-available USB interface drivers.

The USB interface for the modem is meant to be used by higher-end systems with a native USB interface controller or operating system, like single-board computers running Linux or Windows.

For designs that are only using the serial UART interface, NimbeLink recommends including test points or a non-populated USB connector footprint in the design. This allows optional access to the modem's USB interface, which enables easy debugging and firmware updates.

3.2.1 Serial UART Interface

All Skywire modems support a serial UART interface with transmit and receive on pins 2 (DOUT) and 3 (DIN), respectively.

On NL-SW-LTE-TC4APG modems, the baud rate defaults to 115200 Baud 8N1. If a different baud rate is required, it can be changed with the "AT+IPR" command, as defined in the AT command manual. The syntax of the "AT+IPR" command is as follows:

AT+IPR=<rate>

Where "<rate>" is any supported baud rate listed in the AT command manual.

The modem also supports hardware flow control (RTS/CTS) on pins 12 (CTS) and 16 (RTS). By default, the modem does have flow control enabled.

To modify the flow control setting, see the "AT&K" command from the AT command manual. The syntax of the "AT&K" command is as follows:

AT&K<x>

Where "<x>" is replaced either "0" to disable flow control, or "3" to enable flow control.

It is recommended that any designs using the serial UART interface connect the RTS/CTS flow control lines to the host microcontroller and enable them in their application.

3.2.2 USB Interface

The NL-SW-LTE-TC4APG Skywire modem supports a USB 2.0 interface on pins 6 (VUSB), 7 (USB_P), and 8 (USB_N).

Systems connecting to the modem's USB interface must observe proper design practices for connecting to a high speed USB device including, but not limited to:

- The USB D± traces should be routed as a 90 ohm impedance differential pair.
- The USB D± traces should be length matched.
- USB trace lengths should be minimized.
- USB differential pairs should be carefully routed to ensure they have a continuous return path beneath the traces. Do not route differential pairs over splits in ground or power planes.
- If the USB signals will be used off-board, ESD protection should be implemented near the off-board connector.

Pin 6 (VUSB) is the pin that the modem uses to detect if a USB host controller has been connected to the modem. This pin has an internal pulldown and must have a voltage between 2.5V and 5.5V applied to it in order to activate the USB interface. The VUSB pin will draw less than 5mA when connected.

3.3 VREF

The VREF signal (pin J2-4) drives the input voltage side of an on-board buffer which converts external I/O voltage from the VREF range to the 1.8V range in order to drive the onboard cellular module.

System designers should connect the reference voltage of their system to this pin. The VREF signal will typically draw less than 5mA when the modem is powered, however this will depend on the host systems serial interface configuration.

If the baseboard powers down the modem at any time, it should also concurrently remove the reference voltage from the VREF pin.

3.4 nRESET

In the event that the modem becomes unresponsive, pin 5 (nRESET) can be grounded to unconditionally shut down the modem. When pin 5 is grounded, the modem will cease all ongoing operations and unconditionally shut down. The modem will need the ON_OFF signal applied again to power on after a nRESET condition.

Users can monitor the ON/nSLEEP pin to determine if the modem has powered down.

In most cases, network providers request that a device gracefully detach from the network before shutting down. Repeated use of the nRESET pin violates this request. As such, the nRESET pin should only be used as a last resort when the modem is not responding to AT commands.

Repeated failure to gracefully detach from the network during shutdown may result in the device being blacklisted from the network for a period of time, or indefinitely.

The nRESET signal is an active low signal. The signal is internally pulled up to the modem's internal 1.8V rail. Do not apply a voltage to this pin other than connecting it to ground.

To unconditionally shut down the modem with the nRESET signal, assert a logic-low level on nRESET using an open-drain or open-collector circuit for at least 200 ms, and then release.

If the signal is unused, it can be left floating, however, it is highly recommended that the signal be connected to the host system.

In high noise (high EMI) environments, NimbeLink recommends that designers place a 0.01 μF - 0.1 μF capacitor on the nRESET line near the J1 connector of the Skywire.

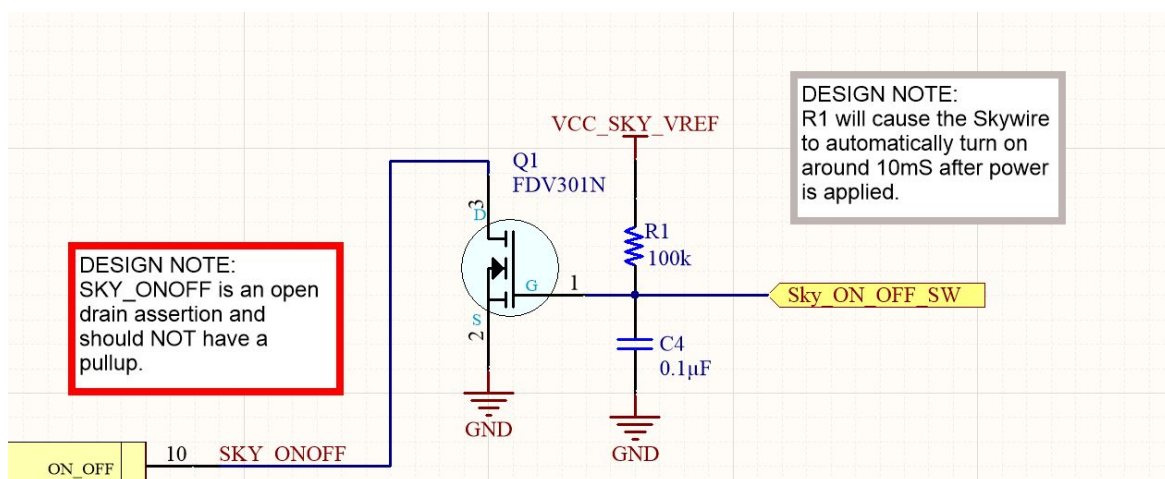
3.5 Power Control

3.5.1 ON_OFF Signal

The ON_OFF signal on pin 20 is used to trigger the modem to turn on and off. Do not power this pin or apply a pullup resistor. Doing so may prevent the modem from booting, or may cause damage to the modem.

This signal is internally pulled up; users will typically see around 800 mV on the pin's output. The maximum current draw for this pin is 0.1mA.

To conserve power, the on-board cellular module does not automatically boot when power is applied. Therefore, the baseboard design must supply a means to assert a logic-low level on the ON_OFF pin using an open-drain or open-collector circuit. An example circuit is shown in the image below.



To initiate the startup procedure, tie ON_OFF to ground for at least 1 second.

To power down the modem, tie the ON_OFF pin to ground for at least 2.5 seconds.

Users can monitor the ON/nSLEEP pin to determine if the modem has powered down, this will typically take around 15 seconds for a controlled shutdown.

Tying the ON_OFF signal directly to ground to make the modem boot up when power is applied will cause the modem to automatically boot back up after a shutdown command is issued. This may prevent the modem from being able to shut down when the system is being powered off.

If the modem attempts to boot up while power is being removed it may suffer irreversible firmware corruption. NimbeLink recommends users actively control this signal or use a one-shot circuit to apply the ON_OFF signal when power is applied.

3.5.2 Shutdown

The modem may be properly powered off using one of the following methods:

- Hardware shutdown using the ON_OFF signal.
- Shutdown using the "AT#SHDN" command.

Both of the shutdown options will force the modem to issue a detach request to the network, which informs the network that the device will be unreachable for an indefinite time. After issuing this request, the modem will power down.

For power sensitive applications, it is also recommended to remove VCC and VREF from the Skywire after it has powered down. When the modem is powered down, the user must ensure that the modem is not being back-powered by any of its I/O lines.

Be sure to shut down the modem in a controlled manner, so as to allow the modem to gracefully detach from the network. Repeated failure to gracefully detach from the network during shutdown may result in the device being blacklisted from the network for a period of time, or indefinitely.

The duration of the shutdown process may vary and can be 15 seconds or longer. The host system should monitor the ON/nSLEEP pin to determine when the modem has powered down.

3.5.2.1 Hardware Shutdown

To shut down the modem using the hardware shutdown, tie the ON_OFF signal low for 2.5 seconds. Use the same open-drain or open-collector circuitry for power-on.

3.5.2.2 Software Shutdown

The modem can be shut down via AT command by issuing the "AT#SHDN" command to modem. When shutting down the modem via AT command, the ON_OFF signal must not be grounded.

3.6 ON/nSLEEP

NL-SW-LTE-TC4APG features a status LED that is connected to the ON/nSLEEP signal (pin J2-3). The ON/nSLEEP pin on the modem may be used for the following functions:

- Monitor power on status of the modem.
- Network Status monitoring

By default the pin is configured to monitor the network status of the modem.

3.6.1 Power Status Monitoring

To configure the ON/nSleep to function as a Power Status Monitor, issue the following AT commands to the modem:

```
AT#SLED=1
```

```
AT#SLEDSAV
```

3.6.2 Network Status Monitoring

To configure the ON/nSleep to function as a Network Status Monitor, issue the commands below. **Note:** This is the firmware default state for this pin.

```
AT#SLED=2
```

```
AT#SLEDSAV
```

This AT command will enable the ON/nSLEEP signal to drive the status LED with the behavior listed in the table below:

Device Status	LED Behavior
Device Off	Permanently Off
Idle, Not Registered	Permanently On
Registered in Idle, with Power Saving	Fast Blinking (blinking period depends on network status)
Registered with Full Network Service	Slow Blinking (3 second period, $T_{ON} = 1s$)

Note: The configuration of ON/nSLEEP as the status LED is not saved across resets. To save a modified configuration across reboots the "AT#SLEDSAV" command must be issued.

3.7 Firmware Updates Over the Air (FOTA)

LTE networks are constantly being updated, improved, and enhanced with new features. As a result, carriers are making frequent network changes. Most changes will not negatively affect devices connected to those networks, but occasionally an update will prevent an unprepared device from reconnecting to the network permanently.

To account for these future changes, FOTA (Firmware Over the Air) capability is being added to cellular modules by each manufacturer. NimbeLink supports this functionality in the entire Skywire family of embedded modems. Therefore, it is highly recommended that designers implement provisions to accommodate for FOTA processes.

Failure to accommodate FOTA processes may result in interruptions in cellular connectivity in the event of network changes. If a device can no longer access the network, FOTA cannot be used to remedy the problem. In this case, the only way to recover device functionality is to physically update the device firmware.

FOTA instructions are available by contacting NimbeLink's product support team at product.support@nimbelink.com.

3.8 Dual-Image Firmware Information

3.8.1 Overview

The NL-SW-LTE-TC4APG has a multi-image firmware that allows the user to switch between NTT, Docomo, KDDI, Softbank, and Telstra firmware images. These firmware images are swapped using the "AT#FWSWITCH" command.

Note: When swapping the active firmware image, the selection can be made to persist after reset by storing it in Non-Volatile Memory (NVM).

3.9 GNSS

The NL-SW-LTE-TC4APG Skywire features a built-in GNSS system that is capable of receiving the entire spectrum of GNSS systems available, including GPS, GLONASS, BeiDou, Galileo, and QZSS.

An active GNSS antenna must be used with the NL-SW-LTE-TC4APG Skywire. The requirements for the GNSS antenna are available in [Section 3.9.1](#).

3.9.1 GNSS Antenna Requirements

It is required to use an active GPS antenna with the following specifications:

Item	Value
Antenna Type	GPS only
Antenna Gain	17 dB (typical)
Operating Voltage	3.3 VDC
Maximum Current	100 mA

Applications utilizing GLONASS require a GNSS pre-filter with the following specs:

Item	Value
Characteristic Impedance	50 Ω
Insertion Loss (1575.42–1576.42 MHz)	1.4 dB (max)
Insertion Loss (1565.42–1585.42 MHz)	2.0 dB (max)
Insertion Loss (1597.5515–1605.886 MHz)	2.0 dB (max)

3.9.2 Active GNSS Antenna Control

A 3.3 VDC, 100 mA LDO regulator is available on the Skywire, and can be used to supply power to an external active GNSS antenna.

Control of the power supply for the active GNSS antenna is managed using GPIO5 on the modem. To conserve power, this regulator is turned off by default.

To turn on the regulator and power the external active GNSS antenna, issue one of the following commands to the modem.

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

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

To disable the power to the external GNSS antenna, issue one of the following commands to the modem:

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

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

3.10 Cellular Antenna Requirements

The NL-SW-LTE-TC4APG Skywire modem supports a primary cellular antenna connection and a diversity antenna connection. These connectors are U.FL connectors, and are labeled as X1 and X2, respectively.

The modem's primary antenna interface, X1, supports both TX and RX communication. The diversity antenna interface is an input for a second RX antenna to improve radio sensitivity. According to carrier requirements, both the primary and the diversity antenna must be implemented.

Note: Many antennas require the use of a U.FL to SMA cable, such as the [Taoglas CAB.011](#).

3.10.1 Primary Antenna Requirements

Section 3.10.1 contains the requirements for the chosen primary antenna. Follow these requirements closely in order to ensure ideal modem operation, and to avoid potential damage to the Skywire during operation.

Required Primary Antenna Specifications	
Impedance	50 Ω
Gain	< 3 dBi
Input Power	\geq 24 dBm Average Power
VSWR Absolute Max ¹	\leq 10:1
VSWR Recommended ²	\leq 2:1

1. Limit to avoid permanent damage
2. Limit to fulfill all regulatory requirements

3.10.2 Diversity Antenna Requirements

The table below contains required specifications for the diversity antenna.

Required Diversity Antenna Specifications	
Impedance	50 Ω
VSWR Recommended ¹	\leq 2:1

1. Limit to obtain maximum sensitivity

3.10.3 Antenna Placement

The modem's cellular antenna placement will directly affect the modem's performance. It is vital that system designers carefully consider the placement of the antenna and follow all of the guidelines and specifications set by the antenna manufacturer. The following guidelines are general recommendations for antenna installation:

- The antenna must have an impedance of 50 ohms.
- Keep the antenna cable as short as possible.
- The antenna must not be installed inside a metal enclosure, nor near metal objects unless specified by the antenna manufacturer.
- The antenna must be installed according to the manufacturer's instructions.
- Antenna gain must not exceed the values indicated in the regulatory requirements in [Section 5.7](#).
- Antenna integration should optimize antenna efficiency. Antennas are recommended to have >50% efficiency on all frequency bands.
- Antenna should not be mounted near noisy EM devices.

3.10.4 Recommended Antennas

Regulatory approval may be required for the cellular antennas used with this modem depending on the region it is used in. Please contact NimbeLink's product support team for additional information.

3.11 Skywire Reference Design

NimbeLink offers free reference schematic and layout files as examples of how to integrate Skywire modems into various systems. Schematics, design files, gerber files, and tutorials for a variety of different systems can be found on the Skywire Development Kits webpage: <https://nimbelink.com/development-kits/>

4. Mounting Guidelines

Skywire cellular modems support multiple connection methods. The two primary methods are board-to-board connectors and soldering directly to the baseboard.

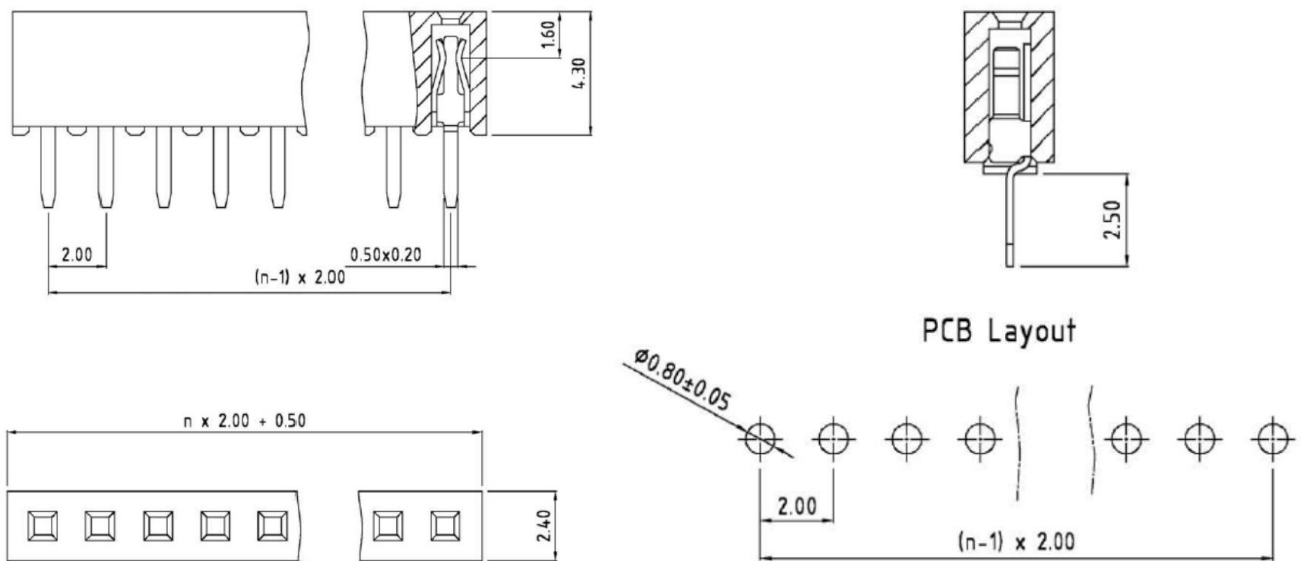
4.1 Board-to-Board Connectors Approach

The Skywire interface calls for two 10-pin, 2mm pitch, female receptacles spaced 22 mm apart. There are many connector manufacturers that can be used. Below is one readily available product:

Manufacturer: Sullins Connector Solutions

Part Number: NPPN101BFCN-RC

Typical part drawing and footprint information for the NPPN101BFCN-RC connector:



4.1.1 Mechanical Retention

Certain applications where the modem is mounted on the host board using the connector approach detailed in Section 4.1 may need to mechanically secure the Skywire modem and its SIM card in order to prevent the modem from vibrating out of the mating connectors.

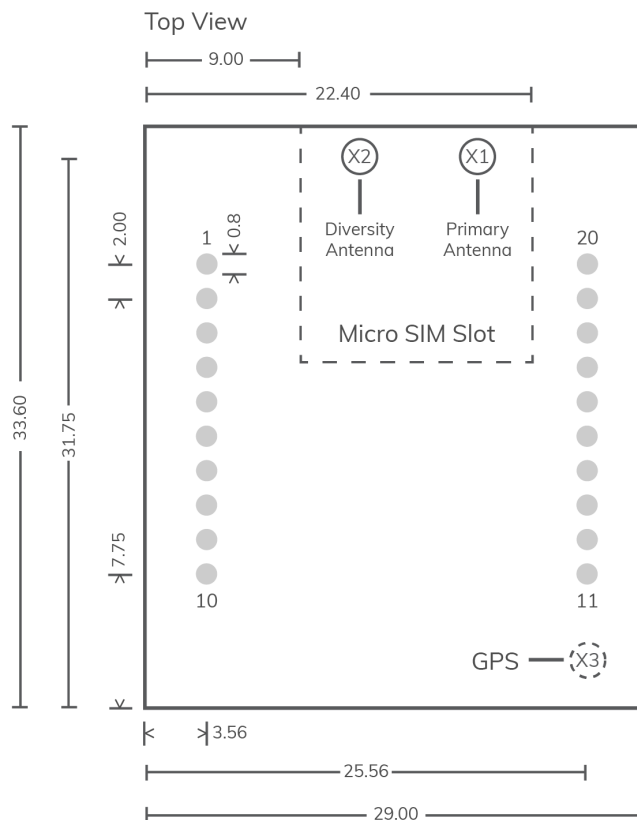
Skywire modems do not have any dedicated attachment points for securing to the host board. However, it can easily be secured by one of the following methods:

- Zip ties
- Foam tape mounted on the Skywire to press against the enclosure. Users must ensure that the foam tape is not compressing the modem's shielding can.
- Mechanical retention of the modem and SIM by the enclosure (example below)
 - https://nimbelink.com/Documentation/Skywire/1001460_Mechanical_Retention_Enclosure.pdf
- Solder the Skywire to the host board (as described in Section 4.2)

4.2 Solder to Board Connection

Skywires can be soldered directly to a PCB. The PCB should be designed with two rows of ten 0.8mm plated through holes spaced 2mm apart. The two rows should be 22mm apart. See the figure below for the recommended footprint.

All measurements are in millimeters. U.FL locations are marked with circles, X1 and X2 are on the top of the board. J3 is the Micro SIM card slot on the bottom side of the board.



5. Regulatory Information

Customers utilizing the NL-SW-LTE-TC4APG should reach out to NimbeLink's product support for additional details on end product labeling requirements and testing requirements for the Asia Pacific markets.

5.1 Export Control Classification Number (ECCN)

ECCNs are five character alphanumeric designations used on the Commerce Control List (CCL) to identify dual-use items for export control purposes. An ECCN categorizes items based on the nature of the product, i.e. type of commodity, software, or technology and its respective technical parameters.

ECCN for All Skywire Modems: 5A992.c

5.2 Harmonized Tariff Schedule Code

HTS Code: 8517.62.0010

5.3 Interference statement

This device complies with Part 15 of the FCC Rules and Industry Canada licence-exempt RSS standards. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

5.4 Modification Statement

Nimbelink has not approved any changes or modifications to this device by the user. Any changes or modifications could void the user's authorization to operate the equipment.

5.5 End Product Labeling Requirements

End Product Labeling Requirements for this modem will vary depending on the region it is used in. Please contact NimbeLink's product support team with details on your deployment region for additional information.