SKYWIRE GLOBAL 4G LTE CAT 1 BIS, W/ GNSS EMBEDDED CELLULAR MODEM DATASHEET

Datasheet

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Table of Contents

1 Introduction

1.1 Scope

The aim of this document serves as a hardware reference datasheet for the NL-SW-LTE-QC1bisWWG Skywire® modem family. This document is updated often. Please be sure to download the latest version from Airgain's website.

1.2 Contact Information

Airgain's goal is to make integrating Skywire modems into your product as easy as possible. Please send any feedback, documentation requests, or technical support questions to the Airgain product support team at: product.support@airgain.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 sales team at: sales@airgain.com

1.3 Orderable Part Numbers

Orderable Device	Operating Temperature	4G LTE Bands	Fallback?	Applicable Networks
NL-SW-LTE-QC1bisWWG	-40 to +85˚C	**LTE-FDD**: B1, B2, B3, B4, B5, B7, B8, B12, B13, B18, B19, B20, B25, B26, B28, B66 **LTE-TDD:** B34, B38, B39, B40, B41	**N/A**	AT&T, Bell, Rogers, Telus, Verizon

Note: Due to evolving PTCRB cellular certification requirements, additional device testing may be required. Please contact your cellular carrier for more information

1.4 Additional Resources

- Skywire® Global 4G LTE Cat 1 bis Embedded Modem Product Page
- Skywire® Global 4G LTE Cat 1 bis AT Command Manual
- Skywire NL-SWDK2 User Manual
- Skywire Hardware Design Developers Guide
- Skywire Hardware Design Checklist
- Skywire Software Developers Guide

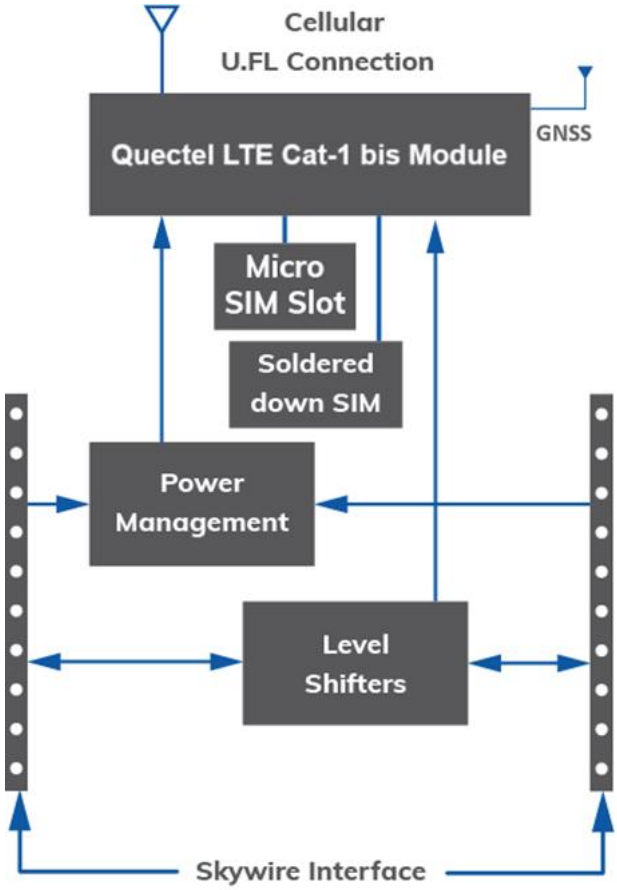
1.5 Product Overview

The Skywire® Global 4G LTE Cat 1 bis embedded modem is purpose-designed for IoT applications, particularly those requiring location-based functionality. Based on the Quectel EG916Q-GL module, it has full FCC, IC, and carrier end-device certifications*, which can save users months of testing and tens of thousands of dollars in cost. Like all Skywire modems, the QC1bisWWG is among the smallest embedded modems in

the industry and is compatible with a wide range of Skywire development kits and microprocessor shields, helping to accelerate product development and prototyping.

LTE Cat 1 bis modems have lower power requirements than Cat 1 or Cat 4 modems, making them ideal for battery operated, mobile, or off-grid applications. Depending on the application, they may be able to run for years unattended and without requiring a battery replacement or recharge.

1.6 Block Diagram



2 Technical Specifications

2.1 Electrical Specifications

2.1.1 Absolute Maximum and Minimum Ratings

Parameter	Signal	Minimum Rating	Maximum Rating
Main Power Supply	VCC	3.4V	4.3V
I/O Voltage Reference	VREF	1.8V	5.5V
USB	VUSB, USB_P, USB_N	3V	5.25V
1.8V Referenced Signals	GNSS_UART_TXD, GNSS_UART_RXD, ON_OFF, nRESET, STATUS_1V8	0V	1.8V
VREF Referenced Signals	DIN, DOUT, DTR, RING, CTS, RTS	0V	5.5V

2.1.2 Component Parameters

Parameter	Vaiue
Total Capacitance	242uF ± 20%
Total Inductance	857nH ± 20%

2.1.3 Typical Power Consumption

Mode	Signal Attenuation (dB)	RSRQ (dB)	RSRP (dBm)	Average Current (mA)	Peak Current (mA)	Charge Consumed (µAh)	Measurement Notes
Active Socket Dial - Normal SIM	0	-14	-101	18.8	601	35.1	Tested at 3.8V Time elapsed: 6.71s Test: Open socket, HTTP POST, read HTTP response, close socket
Active Socket Dial - Normal SIM	20	-13	-114	28.0	588	50.8	Tested at 3.8V Time elapsed: 6.54s Test: Open socket, HTTP POST, read HTTP response, close socket

Active Socket Dial - Normal SIM	30	-18	-123	54.9	706	106	Tested at 3.8V Time elapsed: 6.97s Test: Open socket, HTTP POST, read HTTP response, close socket
Active Socket Dial - Integrated SIM	0	-10	-101	16.0	577	52.0	Tested at 3.8V Time elapsed: 11.8s Test: Open socket, HTTP POST, read HTTP response, close socket
Active Socket Dial - Integrated SIM	20	-11	-108	19.4	642	74.9	Tested at 3.8V Time elapsed: 14.0s Test: Open socket, HTTP POST, read HTTP response, close socket
Active Socket Dial - Integrated SIM	30	-13	-119	24.1	633	135	Tested at 3.8V Time elapsed: 20.2s Test: Open socket, HTTP POST, read HTTP response, close socket
Off	0	N/A	N/A	267 (nA)	503 (nA)	22.2 (nAh)	Tested at 3.8V Issued AT+CFUN=0, AT+QPOWD, 5 minute sample
Idle	0	-12	-96	4.94	80.0	412	Tested at 3.8V Powered on and registered on the network, 5 minute sample

Mode	Signal Attenuation (dB)	RSRQ (dB)	RSRP (dBm)	Average Current (mA)	Peak Current (mA)	Average Charge (µAh)	Measurement Notes
eDRX – 10 second cycle	0	-13	-95	4.43	70.4	369	Tested at 3.8V, 10 second eDRX cycle, 5 minute sample

eDRX – 20 second cycle	0	-13	-95	4.31	60.5	360	Tested at 3.8V, 20 second eDRX cycle, 5 minute sample
eDRX – 40 second cycle	0	-13	-95	4.22	65.1	352	Tested at 3.8V, 40 second eDRX cycle, 5 minute sample
GNSS ON, Network OFF	0	N/A	N/A	35.7	61.4	2.98 (mAh)	Tested at 3.8V, AT+QGPS=1, AT+CFUN=0, 5 minute sample
GNSS ON, Network ON	0	-13	-95	36.5	90.0	3.04 (mAh)	Tested at 3.8V, AT+QGPS=1, AT+CFUN=1, 5 minute sample

2.1.4 Module Pinout for Connectors J1 and J2

The following table details the pinout of the NL-SW-LTE-QC1bisWWG Skywire modem, and recommended ratings for the Skywire interface on connectors J1 and J2. Further details and design requirements for these pins are documented in Section 3.

Pin	Name	Direction	Description		Min	Typ.	Max	If not used
1 (J1-1)	VCC	Input	Main Power supply		3.4V	3.8V	4.3V	Must be implemented
2 (J1-2)	DOUT	Output	UART data out, I/O level tied to VREF		0V		VREF	Must be implemented if USB not used
3 (J1-3)	DIN	Input	UART data in, I/O level tied to VREF	VREF Range	VIL		VIH	Must be implemented if USB not used
				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		Must be implemented
5 (J1-5)	nRESET	Input	1.8V Reset signal for the Quectel EG916Q-GL module. Must be driven with an open drain or open collector signal. This signal should only be used as a last resort.		VIL: GND to 0.5V			Must be implemented

6 (J1-6)	VUSB	Input	USB connection detection	3.0V	5.0V	5.25V	No connection
7 (J1-7)	USB_P	Analog I/O	USB differential data bus (+), Requires differential impedance of 90Ω.	Compliant with USB 2.0 standard specification.			No connection
8 (J1-8)	USB_N	Analog I/O	USB differential data bus (-), Requires differential impedance of 90Ω.	Compliant with USB 2.0 standard specification.			No connection
9 (J1-9)	DTR	Input	Data terminal ready (sleep mode control), tied to internal reference voltage of 1.8V	VIL: GND to 0.63V		VIH: 1.17V to 5.5V	Tie to GND with 100k resistor
10 (J1-10)	GND	Input	Ground Pin		0V		Must be implemented
11 (J2-1)	GND	Input	Ground Pin		0V		Must be implemented

Pin	Name	Direction	Description		Min	Typ.	Max	If not used
12 (J2-2)	CTS	Output	Clear to send		0V		VREF	No connection
13 (J2-3)	STATUS	Output	Indicates the current operation status of the EG916Q-GL module. Driven high when the module is on.		0V		1.8V	No connection
14 (J2-4)	VREF	Input	Voltage reference for offboard I/O signals.		0V	1.8V or 3.3V	5.5V	Must be implemented
15 (J2-5)	GND	Input	Ground Pin			0V		Must be implemented
16 (J2-6)	RTS	Input	Modem "Request to Send" hardware flow control input	VREF Range	VIL		VIH	No connection
				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)	GNSS_UART_RXD	Input	GNSS UART receive		1.8V			No connection

18 (J2-8)	GNSS_UART_TXD	Output	GNSS UART transmit	1.8V			No connection
19 (J2-9)	RING	Output	Ring Indicator Output. Normally high, ≥120ms low pulse when URC present. Open Drain output, 1M pull-up on modem.	VOL: 0 to 0.1V		VREF	No connection
20 (J2-10)	ON_OFF	Input	Modem On/Off signal. Must be driven with an open drain or open collector signal. See Section 3.5 for additional requirements.	VIL: 0V to 0.5V		2.3V	Must be implemented.

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

2.1.5 Module Pinout for Connectors J3, X1, X3

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

2.2 RF Specifications

Parameter		Value	
4G LTE Technology		Cat 1 bis	
4G LTE TX output power		23dBm ± 2dB	
4G LTE RX Sensitivity (10 MHz Bandwidth)	Band	Primary/3GPP SIMO (dBm)	LTE Technology
	B1	-98.6/-96.3	FDD
	B2	-99.4/-94.3	FDD
	B3	-98.9/-93.3	FDD
	B4	-98.6/-96.3	FDD
	B5	-99.1/-94.3	FDD
	B7	-97.4/-94.3	FDD
	B8	-99.3/-93.3	FDD
	B12	-99.5/-93.3	FDD

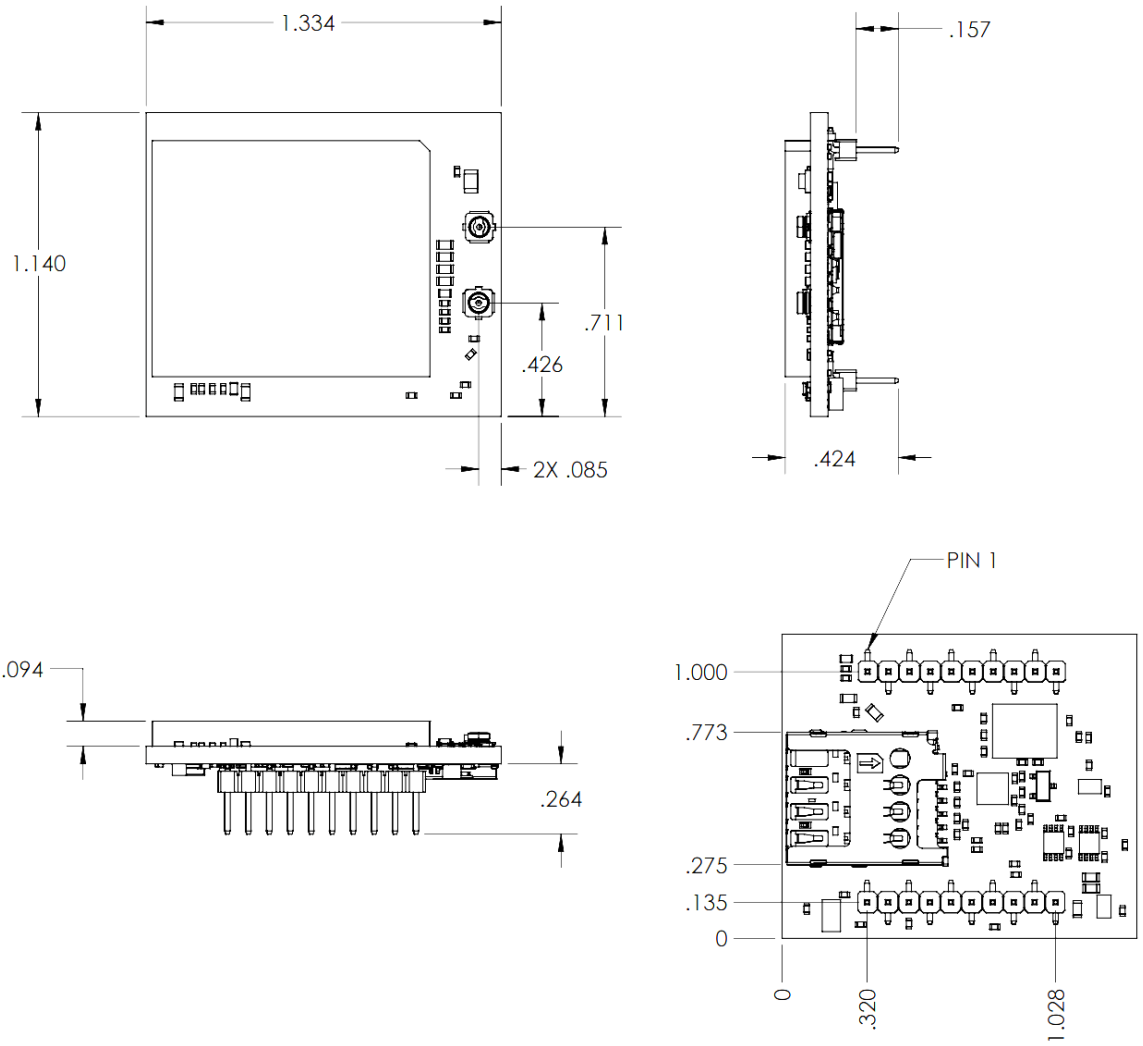
	B13	-98.3/-93.3	FDD
	B18	-99.3/-96.3	FDD
	B19	-99.1/-96.3	FDD
	B20	-99.8/-93.3	FDD
	B25	-99.4/-92.8	FDD
	B26	-98.9/-93.8	FDD
	B28	-98.6/-94.8	FDD
	B34	-99.2/-96.3	TDD
	B38	-97.6/-96.3	TDD
	B39	-99.8/-96.3	TDD
	B40	-98/-96.3	TDD
	B41	-97.7/-94.3	TDD
	B66	-98.6/-95.8	FDD
Peak Uplink and Downlink Speeds	Connection Type	Downlink	Uplink
	LTE-FDD	10 Mbps	5 Mbps
	LTE-TDD	8.96 Mbps	3.1 Mbps

2.3 Mechanical Specifications

2.3.1 Mechanical Characteristics

Parameter	Typical	Unit
Dimensions (excluding pin height, for solder to board applications)	29.0 x 33.90 x 6.8	mm
Dimensions (including pin height, for board-to-board connector applications)	29.0 x 33.90 x 10.8	mm
Weight	8	Grams
Connector Insertion/Removal	hundreds	Cycles

2.3.2 Mechanical Drawing



Units in inches.

2.3.3 Mating Connectors

Connector Designator	Manufacturer	Populated on Modem	Recommended Mate	Mate Manufacture
J1, J2	Pinrex	222-96-10GBE1	950510-6102-AR	3M

			Acceptable alternate: NPPN101BFCN-RC	Sullins Connector Solutions
J3	Molex	786463001	Micro SIM 3FF Size	Micro SIM Card
X1, X3	Hirose	U.FL-R-SMT(10)	MH113-MH1RP-01BJ1-0100	Samtec

2.3.4 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.

2.3.5 Environmental Specifications

Parameter	Min	Typical	Max	Unit	Note
Operating Temperature	-40	25	+85	˚C	N/A
Storage Temperature	-40	25	+90	˚C	N/A

3 Design Considerations

The following sections detail various design considerations that system designers should follow when designing the Skywire modem into their system. Airgain offers schematic and layout design reviews for customers integrating a Skywire modem into their design. For more details, please reach out to Airgain product support team at product.support@airgain.com

To aid with customer design efforts, Airgain has released a Skywire Hardware Developers Guide and a Design Checklist. These supplemental documents contain design guidelines and suggestions for customers designing Skywire modems into their hardware platforms. Airgain strongly suggests reviewing your hardware platform against these documents to ensure proper modem integration.

- Skywire Hardware Developers Guide
- Skywire Hardware Design Checklist

3.1 Power Supply Requirements

NL-SW-LTE-QC1bisWWG modems will regularly consume high amounts of current on their Main Power Supply (Pin 1, VCC) input pins, up to 1.2A during LTE CAT1 transmits and receives. To maintain compatibility with other 4G Skywire modems, the baseboard power supply should be designed to support peak currents of at least 2 Amps. A 0.1 uF & 100uF low ESR ceramic capacitor should be placed on the baseboard near the VCC pin of the Skywire to ensure ample energy is available, with a low inductance path to the VCC pin.

Parameter	Value
Nominal Supply Voltage	3.8V
Operating Voltage Range	3.4V to 4.3V

NL-SW-LTE-QC1bisWWG modems have a normal operating voltage range of 3.4V to 4.3V, with a recommended input voltage of 3.8V. Extreme care must be taken to ensure that the modem power supply stays within the operating voltage range.

If there is a voltage drop or overshoot that exceeds the limits of the operating voltage range, it may cause damage to the modem and void the modem's warranty.

3.1.1 Power Supply Design Guidelines

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

- For most applications, a switching power supply is strongly recommended to supply power to the Skywire modem. This is because switching power supplies can rapidly respond to the sudden current demands of an LTE modem. To ensure compatibility with other Skywire modems, it is recommended to use a switching regulator capable of supporting up to 2A. Example designs using a switching DC/DC regulator can be found in the reference schematics below.
- To reduce EMI from the switching regulator, it is important to follow the design guidelines from the device manufacturer.
- Bypass ceramic capacitors (low ESR) with adequate capacity must be placed near the input to pin 1 (VCC) of the Skywire modem. It is recommended that the capacitor have a rated voltage of at least 2x the input voltage to the Skywire. A minimum of a 100 μF & 0.1 μF capacitor is recommended for all Skywire modems. The 0.1uF capacitor should be placed as close as possible to pin 1 of the Skywire modem, followed by the 100 μF capacitor.

- The PCB traces from the power regulator and the bypass capacitors must be at least 80 mils to ensure that there is a low impedance power delivery circuit available to the modem. This ensures that no significant voltage drops occur. Try to keep the trace as short as possible.
- A dedicated ground plane is recommended.
- Power supply input cables should be kept away from noise sensitive lines, such antennas.

Airgain offers multiple power supply reference designs to assist customers with their designs at no extra charge. Two of the designs are linked to below:

- NL-AB-BBCL Reference Schematic
- NL-SWDK2 Reference Schematic

Airgain highly recommends prototyping with a Skywire Development kit as opposed to a breadboard, which will not work with a Skywire modem. Please refer to the following application note, which explains this incompatibility in more detail:

- Prototyping with Cellular Modems and Modules

3.2 Serial Communications

The NL-SW-LTE-QC1bisWWG 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 for use by higher end systems with a native USB interface controller or operating system (Single board computers, Linux/Windows).

For designs that are only using the serial UART interface, Airgain recommends designers include test points or a non-populated USB connector footprint in their designs. This allows access to the modem's USB interface to enable 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). On the NL-SW-LTE-QC1bisWWG modem, 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 modem also supports RTS/CTS flow control on pins 12 (CTS) and 16 (RTS).

By default, the modem does have flow control enabled. To modify the flow control setting, please see the **AT+IFC** command in the AT command manual. 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-QC1bisWWG 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 following:

- The USB D± traces should be routed as a 90-ohm impedance differential pair.
- The USB D± traces should 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 is the VUSB detection pin that the modem uses to detect if a USB host controller has been connected to the modem. This pin must have a voltage between 3.0V and 5.25V (nominally 5V) applied to it to activate the USB interface. VUSB must be disconnected or asserted to ground before activating Power Saving Mode.

3.3 VREF

The VREF signal is connected to onboard buffers that level shift the main Skywire UART signals (DOUT/DIN/CTS/RTS) to 1.8V, which is the logic level of the cellular module. Attach the host system's I/O reference voltage to the VREF pin to seamlessly enable UART communication with the Skywire at any voltage up to 5.5V. The VREF pin will draw less than 1mA at 3.8V when the modem is powered. System designers should connect the reference voltage of their system to this pin. The VREF signal will draw less than 1mA when the modem is powered.

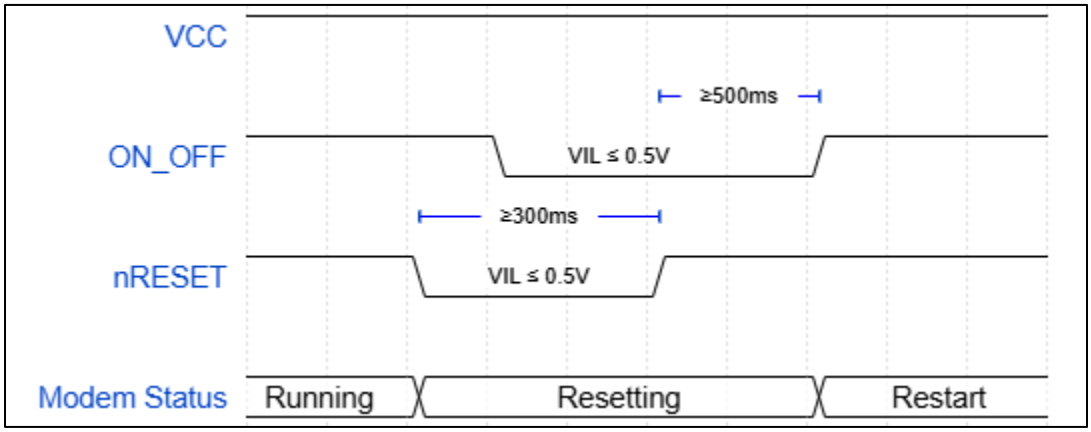
To enable low power operation, system designers should include a method of removing the voltage from VREF when the system is in Power Save Mode (PSM). One such method would be to power VREF from a GPIO or to have a P-CH MOSFET in the VREF signal path.

3.4 nRESET Signal

If the modem becomes unresponsive, pin 5 (nRESET) can be grounded along with pin 20 (ON_OFF) to unconditionally shut down the modem. When nRESET and ON_OFF are grounded, the modem will cease all ongoing operations and reset itself. Please note, the modem will not gracefully detach itself from the cellular network before resetting when these pins are asserted.

Network providers request that a device gracefully detach from the network before shutting down. Accordingly, this functionality should only be used as an emergency reset when the modem is not responding to commands.

To unconditionally shut down the modem, tie the nRESET signal low for at least 300ms, and the ON_OFF signal low for at least 500ms. The following figure shows the reset timing for the modem:



It is necessary that this signal be connected to the host system. It should be driven with an open collector output from the host system or a discrete open collector transistor. To avoid damaging the modem, this signal must never be driven high with a push-pull I/O pin.

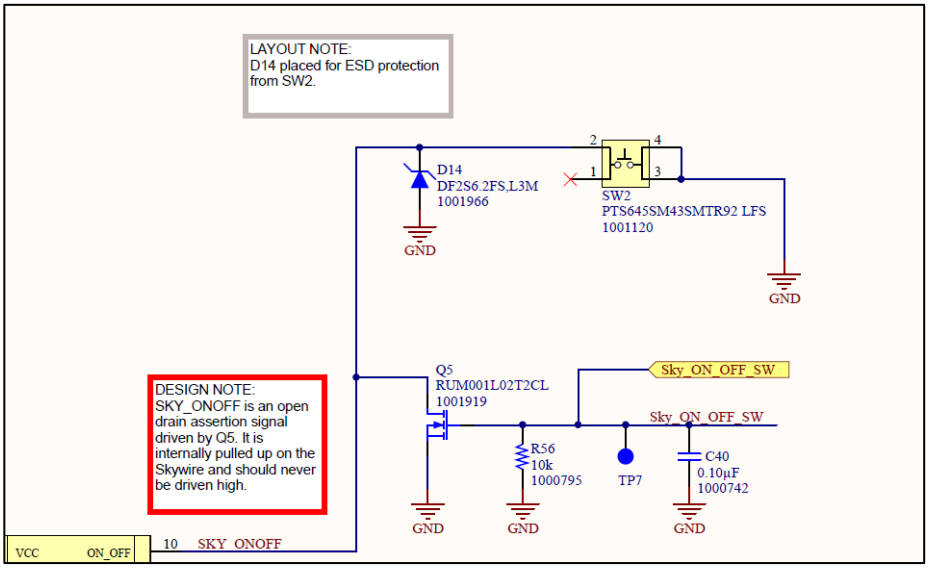
In high noise (high EMI) environments, it is recommended to place a 0.01-0.1 uF capacitor on the nRESET line near the J1 connector.

3.5 Power Control

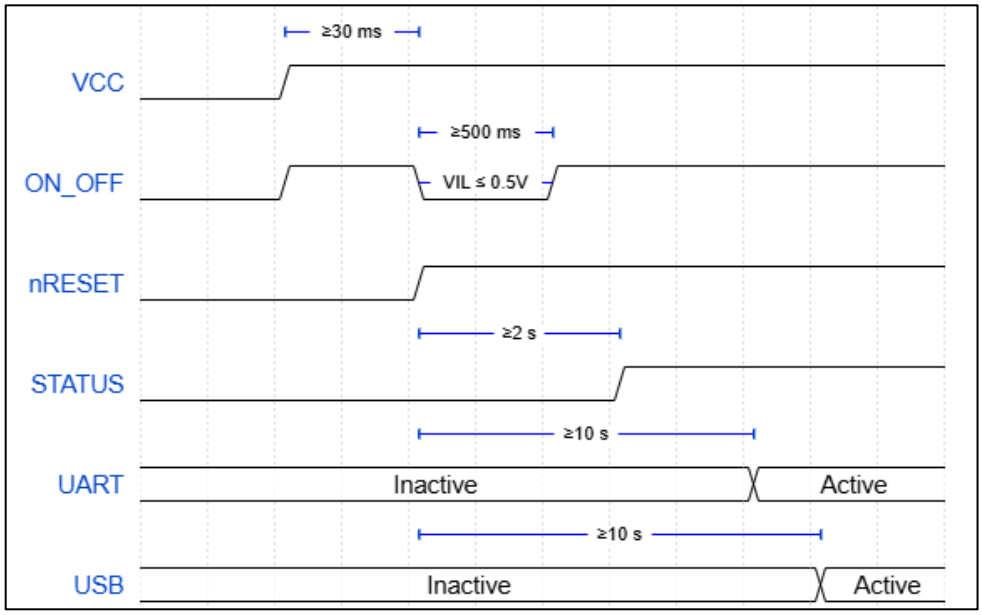
3.5.1 ON_OFF Signal

The ON_OFF signal on pin 20 is used to trigger the modem to turn on, and to turn the modem off. This signal is a 1.8V referenced IO and must be driven by an open-drain assertion. Do drive this pin high nor apply a pullup resistor.

The following is a reference design example for the turn-on circuit for the modem using either an open drain assertion with a N-Channel MOSFET or a button.

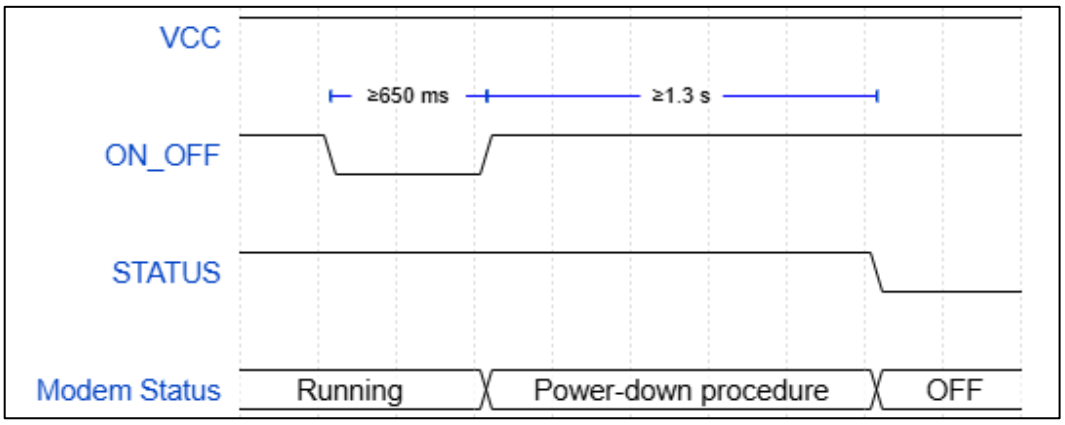


To conserve power, the onboard cellular module does not automatically start up when power is applied. The baseboard design must supply a means to assert a logic-low level on the ON_OFF pin. To initiate the startup procedure, tie ON_OFF to ground for at least 500 ms.



When the modem's UART interface is ready (Active) for AT commands the interface will output a 'RDY' URC.

If the modem is currently running, the ON_OFF pin can be pulled low for ≥650 ms to initiate a power-down sequence.



3.5.2 Power Monitoring

Applications can check to see if the modem has powered up by reading the logic state on pin 13 (STATUS). When the modem is powered up and running, pin 13 will be driven high to 1.8 V. When the modem is not running, this pin will be logic level low. The STATUS pin will go high approximately 2 seconds after the ON_OFF pin is asserted. Power should not be removed from the modem until the STATUS pin has gone low during the shutdown procedure.

3.5.3 Shutdown

The modem should be shut down in a controlled manner, to gracefully disconnect it from the network. Failure to do so violates carrier requirements. In rare events, failure to properly shut down the modem could render the modem inoperable due to firmware corruption.

To gracefully shut down the modem, the host system should do the following:

- Shut down the modem with the **AT+QPOWD=1** command. This command will gracefully disconnect the modem from the network and shut down the modem. This process will take no longer than a couple of seconds. After this command is issued, the host system should cease any communications with the modem.
- If power is to be cut from the modem, ensure that the host system is not back powering the modem through any of the modem's I/O lines.
- Users should monitor the STATUS pin (as described in Section 3.5.2) to ensure the modem has powered down.
- Remove VREF (if VCC is being removed).
- Remove VCC.

In the event of power failure, the modem may need to be shut down faster than the **AT+QPOWD=1** command can manage. To immediately power down the modem in the event of power failure, the **AT+QPOWD=0** command can be used to force a fast shutdown.

3.6 Network Status Monitoring

To conserve power, the NL-SW-LTE-QC1bisWWG does not have a status LED. It is recommended to monitor the modem's network status using AT commands and the serial interface.

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 will not negatively affect devices connected to those networks, but occasionally an update will prevent an unprepared device from reconnecting to the network permanently.

The NL-SW-LTE-QC1bisWWG modem supports FOTA to account for future network changes and to allow for modem firmware to be updated remotely. Airgain highly recommends that system designers implement provisions to accommodate 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. The only way to recover functionality is to physically update the device firmware.

FOTA Instructions are available by contacting Airgain's Product Support team at product.support@airgain.com.

3.8 SIM Selection

The NL-SW-LTE-QC1bisWWG modem can select between a soldered-down SIM, or a removable SIM inserted into the SIM card slot on the modem.

By default, the modem is configured 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. When the SIM selection is switched, the modem's RF system will need to be toggled with the AT+CFUN command.

To configure the modem to use the soldered down SIM issue the following commands to the modem in the order they appear below:

AT+CFUN=0

AT+QGPIOCFGEX=1,11,1,3,0

AT+QGPIOCFGEX=3,11,1

AT+CFUN=1

To configure the modem to use the SIM in the SIM card socket issue the following commands to the modem in the order they appear below:

AT+CFUN=0

AT+QGPIOCFGEX=1,11,1,1,0

AT+QGPIOCFGEX=3,11,0

AT+CFUN=1

Note: GPIO states will persist after reset, and the above AT commands will not need to be reissued each time the modem is powered on. Firmware updates may overwrite saved GPIO states, however.

To check what SIM is selected issue the following command:

AT+QGPIOCFG=2,11

The modem will respond with:

+QGPIOCFGEX: x

OK

Where x is the value of the SIM interface GPIO control pin. If x=1 then the soldered down SIM is selected. If x=0 then the 3FF SIM socket is selected.

3.9 GNSS

The onboard Quectel EG916Q-GL module includes aNL-SW-LTE-QC1bisWWG includes a fully integrated global navigation satellite system solution that supports GPS, GLONASS, Galileo, BDS and QZSS. The modem supports both passive GNSS antennas and active antennas with a gain at the modem's RF connector of > 0 dBi. The QC1bisWWG also has an onboard low-dropout regulator (LDO) that can be used to provide 3.3VDC power to the antenna connector when using an active GNSS antenna.

The modem supports NMEA protocol, and outputs NMEA sentences at a 1Hz data update rate via the USB interface by default.

The requirements for the GNSS antenna are available in Section 3.9.2.

3.9.1 GNSS Performance

The following table shows the GNSS performance of the Quectel EG916Q-GL module used on the modem.

Parameter	Description	Conditions	Typ.	Unit
Sensitivity (GNSS)	Cold Start	Autonomous	-148	dBm
	Reacquisition	Autonomous	-160	dBm

	Tracking	Autonomous	-166	dBm
TTFF (GNSS)	Cold Start (Open Sky)	Autonomous	24.96	seconds
		AGPS enabled	11.3	seconds
	Warm Start (Open Sky)	Autonomous	24.36	seconds
	Hot Start(Open Sky)	Autonomous	2.22	seconds
Accuracy (GNSS)	CEP-50	Autonomous (Open Sky)	2.5	meter

3.9.2 GNSS Antenna Requirements

Item	Value
Frequency Range	1559 – 1609 MHz
Impedance	50 Ω
Polarization	RHCP or linear
VSWR	≤ 2 (Typ.)
Active Antenna Noise Figure	< 1.5 dB
Active Antenna Embedded LNA Gain	< 17 dB
GNSS Frequency	Frequency
GPS	1575.42 ± 1.023 MHz (L1)
GLONASS	1597.5 – 1605.8 MHz (L1)
BDS	1561.098 ± 2.046 MHz (B1I)
QZSS	1575.42 ± 1.023 MHz (L1)
Galileo	1575.42 ± 2.046 (E1)

3.9.3 Active GNSS Antenna Control

A 3.3VDC, 100 mA power rail is available on the modem to bias the GPS line to power the modem. Control of the GNSS power source is done via GPIO08 on the modem. To conserve power, the GNSS power is off by default.

To turn on the DC power to the GNSS antenna, and save it in this state across power off, issue the following commands to the modem:

AT+QGPIOCFGEX=1,8,1,1,0

AT+QGPIOCFGEX=3,8,0

To turn off the DC power to the GNSS antenna, and save this state after power off, issue the following commands to the modem:

AT+QGPIOCFGEX=1,8,1,3,0

AT+QGPIOCFGEX=3,8,1

Note: GPIO states will persist after reset, and the above AT commands will not need to be reissued each time the modem is powered on. Firmware updates may overwrite saved GPIO states, however.

To turn on the DC power to the GNSS antenna, and NOT save it in this state across power off, issue the following commands to the modem:

AT+QGPIOCFG=1,8,1,1,0

AT+QGPIOCFG=3,8,0

3.9.4 GNSS Antenna Placement

- The antenna must be installed according to the antenna manufacturer's instructions to obtain the maximum performance of the GNSS receiver.
- The antenna location must be evaluated carefully if operating in conjunction with any other antenna or transmitter.
- The antenna must not be installed inside metal cases or near any obstacle that may degrade features like antenna lobes and gain.
- Keep the antenna and the antenna cabling away from any power supply lines, noisy EM devices, and wireless RF lines.

3.9.5 Recommended Antennas

While Skywire modems will work with antennas from other manufacturers, the following antennas have been designed specifically to work with Skywire.

Type	Manufacturer	Part Number
GPS/GALILEO Antenna, Internal	Airgain	CRJKS0010-LNA-G65U

GPS/GALILEO Antenna, External[1,2]	Airgain	CRJKS0009-LNA-LM5X3000SMA

Note 1: U.FL to SMA adapter required.
Note 2: To meet the maximum gain requirements of the modems GNSS interface an attenuator may be required for external two stage LNA GNSS antennas. Please consult an RF engineer for assistance.

3.10 Cellular Antenna Requirements

NL-SW-LTE-QC1bisWWG modems support one primary cellular antenna connection for RX & TX communication via the X1 connector on the top of the modem. The X1 connector is a U.FL connector. Many antennas will require the use of a U.FL to SMA cable, such as the Samtec MH113-MH1RP-01BJ1-0100.

3.10.1 Primary Antenna Requirements

Depending on the frequency band(s) provided by the network operator, the customer shall use the most suitable antenna for that/those band(s):

Item	Value		
Frequency Range	Band	Uplink (MHz)	Downlink (MHz)
	LTE-FDD B1	1920 – 1980	2110 – 2170
	LTE-FDD B2	1850 – 1910	1930 – 1990
	LTE-FDD B3	1710 – 1785	1805 – 1880
	LTE-FDD B4	1710 – 1755	2110 – 2155
	LTE-FDD B5	824 – 849	869 – 894
	LTE-FDD B7	2500 – 2570	2620 – 2690
	LTE-FDD B8	880 – 915	925 – 960
	LTE-FDD B12	699 – 716	729 – 746
	LTE-FDD B13	777 – 787	746 – 756
	LTE-FDD B18	815 – 830	860 – 875
	LTE-FDD B19	830 – 845	875 – 890
	LTE-FDD B20	832 – 862	791 – 821
	LTE-FDD B25	1850 – 1915	1930 – 1995
	LTE-FDD B26	814 – 849	859 – 894
	LTE-FDD B28	703 – 748	758 – 803
	LTE-TDD B34	2010 – 2025	2010 – 2025
	LTE-TDD B38	2570 – 2620	2570 – 2620
	LTE-TDD B39	1880 – 1920	1880 – 1920
	LTE-TDD B40	2300 – 2400	2300 – 2400
	LTE-TDD B41	2496 – 2690	2496 – 2690
	LTE-FDD B66	1710 – 1780	2110 – 2180

VSWR	≤ 2 (Typ.)
Efficiency	> 30%
Gain	1 dBi
Max Input Power	50 W
Input Impedance	50 Ω
Cable Insertion Loss (<1 GHz)	< 1 dB
Cable Insertion Loss (1 – 2.3 GHz)	< 1.5 dB
Cable Insertion Loss (>2.3 GHz)	< 2 dB

Note: Any antennas used with the modem will need to comply with the Wireless Notice detailed in Section 5.7.

3.10.2 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 the guidelines & specifications set by the antenna manufacturer. The following guidelines are general recommendations for antenna installation:

- Make sure the antenna has 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.
- Antenna integration should optimize antenna efficiency. Antennas are recommended to have >30% efficiency on all frequency bands.
- Additional FCC/IC testing may be required for applications where the antenna is located closer than 20cm from the body.
- If the device antenna is located farther than 20cm from the human body and there is no co-located transmitter, the Quectel FCC/IC approvals can be re-used by the end-product
- Antenna should not be mounted near noisy EM devices.

3.10.3 Recommended Antennas

While Skywire modems will work with antennas from other manufacturers, the following antennas have been designed specifically to work with Skywire.

Type	Manufacturer	Part Number
Internal Cellular Antenna	Airgain	F47AGCHA-G150U
External Cellular Antenna [1]	Airgain	ET56AGBJA

Note: U.FL to SMA adapter required.

For Airgain's full line of compatible antennas, please refer to the following link: Airgain Antenna Listings.

3.11 Skywire Reference Design

Airgain 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 Tools webpage.

4 Mounting Guidelines

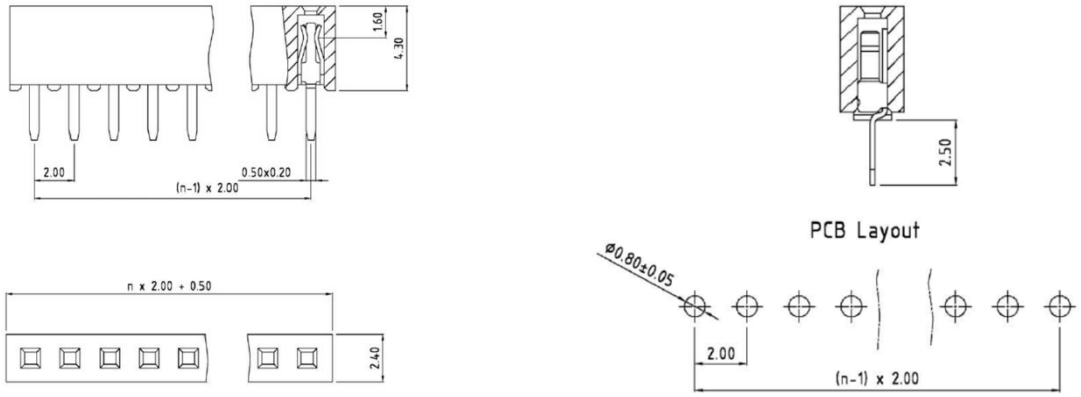
Skywire embedded cellular modems support multiple connection methods. The two primary methods are board-to-board connectors and soldering directly to the baseboard.

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:



When using the recommended connector, ensure that any baseboard components placed under the Skywire (between the baseboard header pin connectors) are no taller than 4 mm. However, please note that the maximum component height may change based on the chosen baseboard connector.

4.1.1 Mechanical Retention

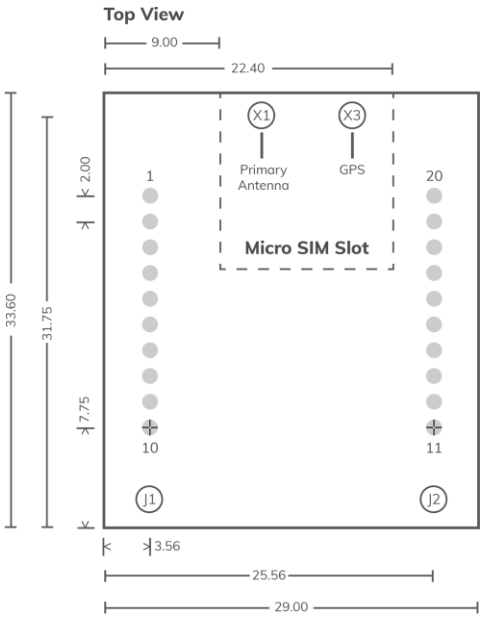
Certain applications where the modem is mounted on the host board using the connector approach detailed in section 4.1 may need to mechanically secure the Skywire modem & its SIM card to prevent the modem from vibrating out of the mating connectors. Skywire modems do not have any dedicated attachment 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
- Mechanical retention of the modem & SIM by the enclosure (example)
- Solder the Skywire to the host board (as described in Section 4.2)

4.2 Solder to Board Connection

Alternatively, 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. See the figure below for the recommended footprint.

Note: All measurements are in millimeters. U.FL connectors X1 and X3 are on the top side of the board. Micro SIM card slot J3 is on the bottom of the board.



When using soldering directly to a PCB, ensure that any baseboard components placed under the Skywire (between the baseboard header pin connectors) are no taller than 0.5 mm.

5 Regulatory information

5.1 Carrier Specific Certifications

NL-SW-LTE-QC1bisWWG: PTCRB, AT&T, Verizon (In Progress), Rogers, Telus, Bell

Note: Due to evolving PTCRB cellular certification requirements, additional device testing may be required. Please contact your cellular carrier for more information.

5.2 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

5.3 Harmonized Tariff Schedule Code

HTS Code: 8517.62.0010

5.4 REACH/RoHS Compliance

The NL-SW-LTE-QC1bisWWG modem family complies with REACH and the RoHS (Restriction of Hazardous Substances) directive of the European Union, EU Directive 2015/863/EU.

5.5 Interference statement

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

5.6 FCC & IC Compliance

If the modem's antenna is located farther than 20cm from the human body and there are no adjacent transmitters, the FCC/IC approvals of the on-board Quectel EG916Q-GL cellular module can be reused by the end-product.

Should the modem's antenna be mounted closer than 20cm from the human body or if there are adjacent transmitters, additional FCC/IC testing may be required for the end-product.

NL-SW-LTE-QC1bisWWG modems make use of the on-board Quectel module's FCC & IC identification numbers.

Orderable Device	FCC ID	IC ID (certification number)
NL-SW-LTE-QC1bisWWG	XMR2023EG916QGL	10224A-023EG916QGL

The FCC certificate is available at the following link by searching for the FCCID listed above:

https://www.fcc.gov/oet/ea/fccid

The IC ID certificate is available at the following link by searching for the IC ID listed above:

https://sms-sgs.ic.gc.ca/equipmentSearch/searchRadioEquipments?execution=e1s1&lang=en

5.7 Wireless Notice

To maintain FCC/IC radiation exposure limits set forth for an uncontrolled environment alongside carrier specific certifications the antennas cannot exceed the maximum gain levels listed here:

Band	Max Antenna Gain (dBi)
LTE Band 2	8.0
LTE Band 4	5.0
LTE Band 5	9.4
LTE Band 7	8.0
LTE Band 12	8.7
LTE Band 13	9.2
LTE Band 25	8.0
LTE Band 26	9.4
LTE Band 38	8.0
LTE Band 41	8.0
LTE Band 66	5.0

5.8 Modification Statement

Airgain 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.

5.9 End-Product Labeling Requirements

End products utilizing NL-SW-LTE-QC1bisWWG modems should be labeled with the following information:

Device Uses Approved Radio: NL-SW-LTE-QC1bisWWG

Contains FCC ID: XMR2023EG916QGL

Contains IC: 10224A-023EG916QGL

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

6 Document Version Information

Revision	Description	Date
1	Initial Release	02/05/2025