

# Skywire® LTE Cat 1 ELS31 Embedded Cellular Modem Datasheet

NimbeLink Corp

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| <b>PN 30122 rev 14</b>                 | <b>© NimbeLink Corp. 2018. All rights reserved. 2</b> |

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# 1. Introduction

## 1.1 Orderable Part Numbers

| Orderable Device  | Firmware Revision | Operating Temperature | Bands   | Fallback | Network Type |
|-------------------|-------------------|-----------------------|---------|----------|--------------|
| NL-SW-LTE-GELS3   | 4.3.1.0           | -30 to +85°C          | B4, B13 | None     | Verizon      |
| NL-SW-LTE-GELS3-B | 4.3.2.0 25421     | -30 to +85°C          | B4, B13 | None     | Verizon      |
| NL-SW-LTE-GELS3-C | 4.3.3.0 29979     | -30 to +85°C          | B4, B13 | None     | Verizon      |
| NL-SW-LTE-GELS3-D | 4.3.3.0 36343     | -30 to +85°C          | B4, B13 | None     | Verizon      |
| NL-SIM-COM        |                   | -35°C to +85°C        |         |          | Verizon      |
| NL-SIM-IND        |                   | -40°C to +105°C       |         |          | Verizon      |

*\*Extended Temperature range is -40 to +90°C, See Gemalto Documentation for Extended Temperature Behavior*

## 1.2 Additional Resources

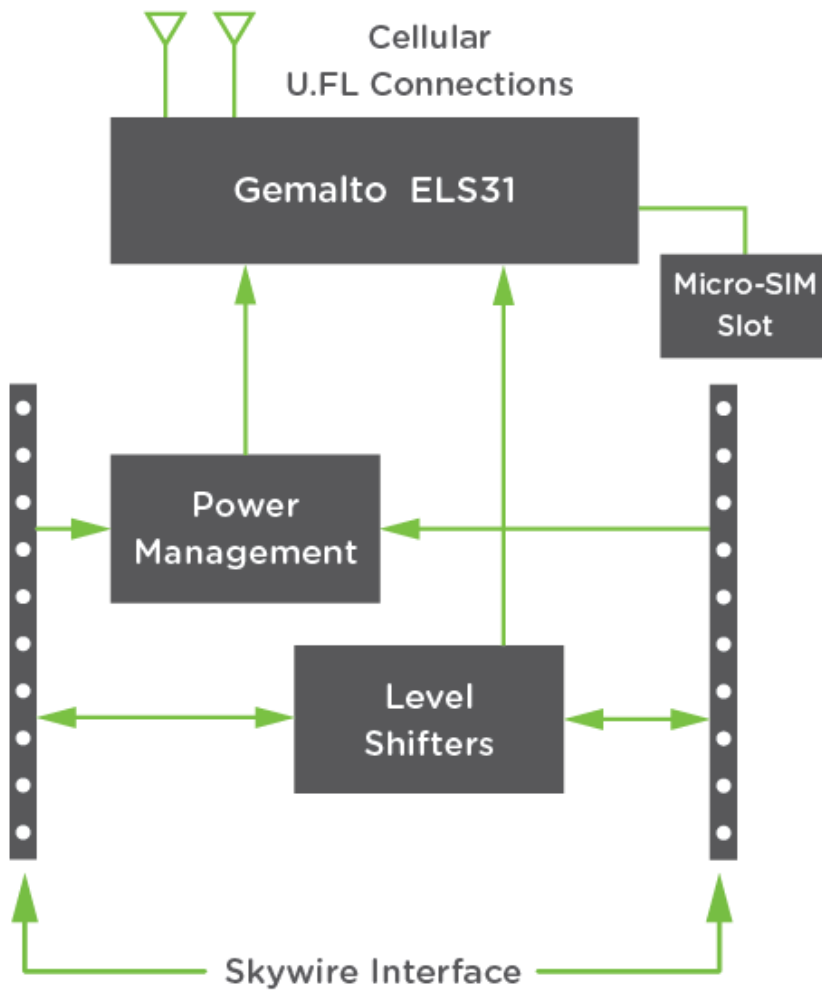
The following documents or documentation resources are referenced within this document.

- [Skywire® 4G LTE Cat 1 Verizon Product Page](#)
- [NL-SWDK User Manual](#)
- [4.3.3.0 AT Command Manual](#)

## 1.3 Product Overview

Add robust cellular connectivity to your M2M devices with scalable radio technology with Skywire line of modems including ELS31 based LTE solutions. Extensive experience in designing and building embedded product solutions makes the NimbeLink Skywire® embedded cellular modem the smallest on the market. It uses the popular Skywire interface and supports multiple LTE bands and fallback capability minimizing costs of hardware and network access. The module is designed for volume production and is intended for OEMs to embed into end equipment designs.

## 1.4 Block Diagram



## 2. Technical Specifications

### 2.1 Electrical Specifications

#### 2.1.1 Absolute Maximum Ratings

| Parameter             | Signal | Maximum Rating |
|-----------------------|--------|----------------|
| Main Power Supply     | VCC    | 5.5V           |
| I/O Voltage Reference | VREF   | 5.5V           |

#### 2.1.2 Recommended Ratings & Module Pin out

##### 2.1.2.1 Connectors J1 and J2

| Pin | Name      | Direction | Description                                                                                                                                                                                                                                          | Min                  | Typical | Max                         | If not used                                                                                                                              |
|-----|-----------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---------|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | VCC       | Input     | Main Power supply                                                                                                                                                                                                                                    | 3.0V                 | 3.9V    | 5.5V                        | Must be implemented                                                                                                                      |
| 2   | DOUT      | Output    | UART data out, I/O level tied to VREF                                                                                                                                                                                                                | VOL:<br>GND to 0.55V |         | VOH:<br>VREF x 0.67 to VREF | Must be implemented if USB not used, No connection                                                                                       |
| 3   | DIN       | Input     | UART data in, I/O level tied to VREF                                                                                                                                                                                                                 | VIL:<br>GND to 0.15V |         | VIH:<br>VREF-0.4 V to VREF  | Must be implemented if USB not used, No connection                                                                                       |
| 4   | GND       | Input     | Ground Pin                                                                                                                                                                                                                                           |                      | 0       |                             | Must be implemented                                                                                                                      |
| 5   | RESET_nIN | Input     | Emergency reset pin. Tie low for a minimum of 15 mS and released to activate. Internally pulled up to 3.8V. Drive with open collector output. Assert only in an emergency as the module will not gracefully exit the cellular network when asserted. | 0V                   | 3.8V    | 5.5V                        | Must be implemented if no other method of resetting the modem is available. Drive with open collector output such as a N-Channel Mosfet. |
| 6   | VUSB      | Input     | Supply for USB interface                                                                                                                                                                                                                             | 3.0V                 | 5V      | 5.25V                       | No connection                                                                                                                            |
| 7   | USB_D+    | I/O       | USB differential Data + signal                                                                                                                                                                                                                       |                      |         |                             | No connection                                                                                                                            |
| 8   | USB_D-    | I/O       | USB differential Data - signal                                                                                                                                                                                                                       |                      |         |                             | No connection                                                                                                                            |
| 9   | DTR       | Input     | Modem Data Terminal Ready input                                                                                                                                                                                                                      | VIL:<br>GND to 0.15V |         | VIH:<br>VREF-0.4 V to VREF  | Tie to GND                                                                                                                               |
| 10  | GND       | Input     | Ground Pin                                                                                                                                                                                                                                           |                      | 0       |                             | Must be implemented                                                                                                                      |
| 11  | GND       | Input     | Ground Pin                                                                                                                                                                                                                                           |                      | 0       |                             | Must be implemented                                                                                                                      |
| 12  | CTS       | Output    | Modem Clear to Send hardware flow control output                                                                                                                                                                                                     | VOL:<br>GND to 0.55V |         | VOH:<br>VREF x 0.67 to VREF | No connection                                                                                                                            |

|    |        |        |                                                                                                                                                                                                                                                    |                   |              |                         |                      |
|----|--------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------|-------------------------|----------------------|
| 13 | V180   | Output | Signal drives high indicating the modem is powered on. May also be used to power external level shifters to interface to DIO7 or DIO8. Io(max) =50 mA.                                                                                             | 0                 |              | 1.8V                    | No connection        |
| 14 | VREF   | Input  | Voltage reference for off board I/O signals. This signal drives the input voltage side of an onboard buffer which converts all external I/O voltage from VREF range to 1.8V range to drive the onboard cellular module.                            | 1.65V             | 1.8V or 3.3V | 5.5V                    | Must be implemented  |
| 15 | GND    | Input  | Ground Pin                                                                                                                                                                                                                                         |                   | 0            |                         | Must be implemented  |
| 16 | RTS    | Input  | Modem Request to Send hardware flow control input                                                                                                                                                                                                  | VIL: GND to 0.15V |              | VIH: VREF-0.4 V to VREF | Tie to GND           |
| 17 | DIO8   | I/O    | Programmable GPIO_08 on ELS31 module. See GPIO section for further details                                                                                                                                                                         | 0                 |              | 1.8V                    | No connection        |
| 18 | DIO7   | I/O    | Programmable GPIO_07 on ELS31 module. See GPIO section for further details                                                                                                                                                                         | 0                 |              | 1.8V                    | No connection        |
| 19 | ADC1   | Input  | ADC_IN1 input on ELS31 module (10bit resolution)                                                                                                                                                                                                   | 0                 |              | 1.8V                    | No connection        |
| 20 | PWR_ON | Input  | Modem PWR_ON signal. Assert low for at least 100 $\mu$ s and then release to activate start sequence. Drive with open collector output. Internally pulled up to internal 3.8V rail with 1M ohm pull-up resistor. See Section 3.1 for more details. | 0                 | 3.8V         | 5.5V                    | Must be implemented. |

### 2.1.2.2 Connectors J3, X1, X2

| Connector Designator | Description                  | Connector Location    |
|----------------------|------------------------------|-----------------------|
| J3                   | Micro SIM Connector          | Bottom Side of Module |
| X1                   | Primary Antenna Connection   | Topside of Module     |
| X2                   | Diversity Antenna Connection | Topside of Module     |

### 2.1.2.3 Typical Power Consumption

| Measurement        | Attenuation (dB) | AT+CSQ | Min Current (mA) | Average Current (mA) | Peak Current (mA) | Average Charge (μAh) | Notes                                                                                                                                              |
|--------------------|------------------|--------|------------------|----------------------|-------------------|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| Socket Dial        | 0                | 31     | -                | 156.46               | 615.69            | 333.89               | Tested at 3.8V<br>Time elapsed: 7.6758s<br>Test:<br>Opening socket, making HTTP POST, reading HTTP response, closing socket, powering off Skywire. |
| Socket Dial        | 20               | 28     | -                | 140.32               | 659.04            | 299.237              | Tested at 3.8V<br>Time elapsed: 7.6764s<br>Test:<br>Opening socket, making HTTP POST, reading HTTP response, closing socket, powering off Skywire. |
| Socket Dial        | 40               | 19     | -                | 141.82               | 755.11            | 302.44               | Tested at 3.8V<br>Time elapsed: 7.6781s<br>Test:<br>Opening socket, making HTTP POST, reading HTTP response, closing socket, powering off Skywire. |
| Off                | 0                | -      | -                | 44.276 (μA)          | 5.322             | 11.091               | Tested at 3.8V<br>Connected to power, power button not pressed. 15 minute sample.                                                                  |
| Idle               | 0                | 31     | -                | 48.6                 | 378.23            | 12153.0              | Tested at 3.8V<br>Registered on network, 15 minute sample period.                                                                                  |
| Idle - Lower Power | 0                | 31     | -                | 8.58                 | 370.617           | 2086.78              | Tested at 3.8V<br>Registered on network, 15 minute sample period. Cell tower pages Skywire about once every two seconds (non-configurable).        |

## 2.2 Mechanical Specifications

### 2.2.1 Mechanical Characteristics

| Parameter                                                                    | Typical              | Unit   |
|------------------------------------------------------------------------------|----------------------|--------|
| Dimensions (excluding pin height, for solder to board applications)          | 29.0 x 33.60 x 6.63  | mm     |
| Dimensions (including pin height, for board to board connector applications) | 29.0 x 33.60 x 10.73 | mm     |
| Weight                                                                       | 0.3                  | oz     |
| Connector Insertion/Removal                                                  | hundreds             | Cycles |

### 2.2.2 Mating Connectors

| Connector Designator | Manufacturer | Populated on Module | Recommended Mate                        | Mate Manufacturer           |
|----------------------|--------------|---------------------|-----------------------------------------|-----------------------------|
| J1, J2               | 3M           | 951110-2530-AR-PR   | 950510-6102-AR                          | 3M                          |
|                      |              |                     | Acceptable alternate:<br>NPPN101BFCN-RC | Sullins Connector Solutions |
| J3                   | Molex        | 786463001           | Micro SIM Card                          | Micro SIM Card              |
| X1, X2               | Hirose       | U.FL-R-SMT(10)      | CAB.011                                 | Taoglas                     |

### 2.2.3 Device Placement

⚠ Make sure the Skywire is installed in the correct orientation; failure to do so will damage the device and void the warranty.

## 2.3 Environmental Specifications

| Parameter             | Min | Typical | Max | Unit | Note           |
|-----------------------|-----|---------|-----|------|----------------|
| Operating Temperature | -30 | 25      | +85 | °C   |                |
| Extended Temperature* | -40 | 25      | +90 | °C   |                |
| Operating Humidity    | 20  |         | 90  | %    | Non-condensing |

\* See Gemalto Documentation for Extended Temperature Behavior

## 3. Important Design Considerations

### 3.1 PWR\_ON Signal

To conserve power, the ELS31 does not automatically start up when power is applied. The baseboard design must supply a means to assert the PWR\_ON signal low for at least 100 uS and then released to start-up the module. After asserting the PWR\_ON signal, the modem will boot. The modem will send the URC ^SYSSTART that notifies the host application when the first AT command can be sent to the module. The boot time for the modem averages ~20 seconds. User software must wait for ^SYSSTART before attempting to communicate with the GELS3 modem.

To make module automatically start when power is applied the PWR\_ON signal can be tied to GND with a 0-10K pull down.

### 3.2 Power Supply Requirements

The module will regularly consume high amounts of current on the Main Power Supply (VCC), up to 1.5A during active transmits and receives. The baseboard power supply should be designed to support peak currents up to 2 Amps. A 100uF capacitor should be placed near the VCC pin on the module to ensure ample energy is available, with a low inductance path to the VCC pin. For example power supply designs, there are multiple references available. See the NimbeLink Skywire Development Kit schematic for a switching regulator example.

### 3.3 Serial Communications

The ELS31 can communicate over UART and/or USB. Design should implement one or both serial interfaces to be able to send commands to the modem.

### 3.4 LED

The Skywire has an on board LED D1 connected to ELS31 on GPIO5. This is helpful for checking the network status and debugging.

To setup the LED, issue the command:

**AT^SCFG="GPIO/mode/SYNC","std"**

For a solid-on LED when the Skywire is registered on the network, issue:

**AT^SLED=1**

For a blinking LED when the Skywire is registered on the network, issue:

**AT^SLED=2**

For specific LED behavior and blink timings (if applicable), please consult the NL-SW-LTE-GELS3 AT Command Manual section for the **AT^SLED** command.

## 3.5 GPIO Control

GPIO control is added to the design with Revision 4.3.2.0 firmware.

Modem interface Pin 17 can be driven high or low using the following AT commands:

Setup pin configuration:

**at^scfg="GPIO/mode/PULSE","gpio"**

**^SCFG: "GPIO/mode/PULSE","gpio"**

**OK**

Disconnect GPIO:

**at^scpin=0,7**

Set GPIO as output driving high(1.8V):

**at^scpin=1,7,1,1**

Disconnect GPIO:

**at^scpin=0,7**

Set GPIO as output driving low(0V):

**at^scpin=1,7,1,0**

## 3.6 Power Off

In order to properly power off the modem, you need to issue the following AT command:

**AT^SMSO**

If shutdown properly occurs, you will receive:

**^SMSO: MS OFF**

**OK**

**^SHUTDOWN**

Do not remove power from the Skywire until after the:

**^SHUTDOWN**

response is received, otherwise you may lose data. In addition, do not issue any AT commands after issuing this command.

## 3.7 Power Cycling

Shutting down the Skywire using the method described in Section 3.6 is the recommended shutdown procedure. However, if during a power cycle the VCC voltage level does not drop below 0.5V before the modem is restarted, or during operation an unwanted voltage drop occurs that causes VCC to fall below the operating level, but not below 0.5V, the modem might not properly reboot, because its reset condition was not reached.

In this scenario it is recommended to reset the module with RESET\_nIN after startup. If the modem is configured to automatically boot when power is applied (ON\_OFF is connected to GND/pulled low) then the RESET\_nIN signal may be generated automatically using an external reset monitor

If the RESET\_nIN pin is not available users will need to wait for the VCC rail to discharge below 0.5V before reapplying power.

Please note: Using the RESET\_nIN pin is only recommended as a last resort for resetting the Skywire, as it forcibly removes the Skywire from the cellular network.

## 3.8 Internal Firewall

By default, the NL-SW-LTE-GELS3 has an internal firewall enabled that is configured to prevent all inbound connections to systems connected to the modem. The instructions to allow two-way connections are available under NDA.

To obtain these instructions, contact Product Support at [product.support@nimbelink.com](mailto:product.support@nimbelink.com).

If you do not have an NDA with us currently, please fill out and sign the form linked below and include it in your support inquiry. Please make sure to fill out all blanks in the form or the NDA will not be approved.

[https://nimbelink.com/Documentation/Skywire/1001463\\_Document-Guide.pdf](https://nimbelink.com/Documentation/Skywire/1001463_Document-Guide.pdf)

## 3.9 Firmware Over-The-Air Updates (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 connecting to the network, permanently.

To account for these future changes, FOTA capability is being added to all cellular modules by each module manufacturer, and NimbeLink supports this

functionality in the Skywire family of embedded modems. However, there is often a requirement to implement support for this FOTA functionality in your device firmware.

As a developer using the Skywire modem, it is required that your device firmware plan to accommodate FOTA updates after deployment. Failure to do so may result in interruption of your device's cellular connectivity if the carriers implement a network change. If the device can no longer access the network, FOTA cannot be used to resolve the situation after the fact. The only way to restore connectivity will be physical access to the device to perform the updates directly on the devices.

If you have any questions or concerns, please email [product.support@nimbelink.com](mailto:product.support@nimbelink.com)

### 3.10 RESET\_nIN

The RESET\_nIN signal is internally connected to the modem's processor. A low level for more than 15mS will trigger the modem to reset. It is internally pulled up to 3.8V via a 10K ohm resistor. The RESET\_nIN signal should only be used when the modem is not responding to commands for more than 5 seconds. Asserting the RESET\_nIN signal causes the loss of all information stored in the modems volatile memory. Therefore it should only be used in case of emergency (e.g. if the modem is not responding or it reset/shutdown via AT commands fail).

## 4. Mounting Guidelines

The Skywire embedded cellular modem supports 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.

There are many connector manufacturers that can be used; below is one readily available product:

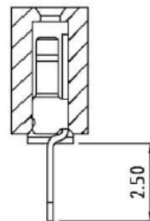
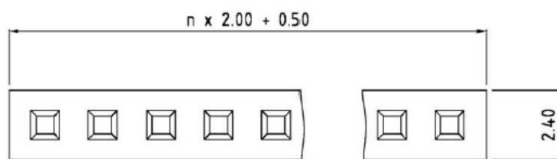
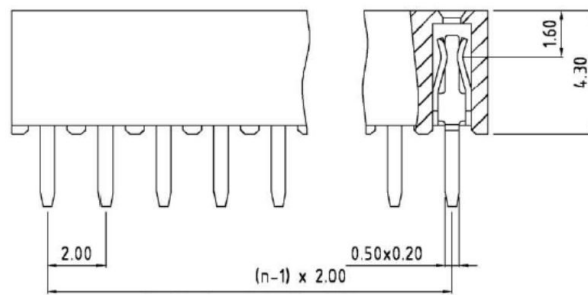
Manufacturer: 3M

Alternate: Sullins Connector Solutions

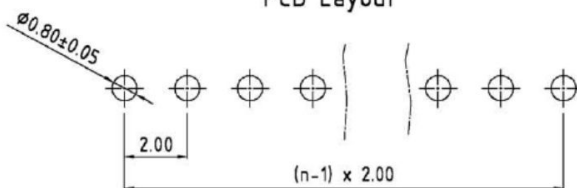
Part Number: 950510-6102-AR

Alternate P/N: NPPN101BFCN-RC

Typical part drawing and footprint information:

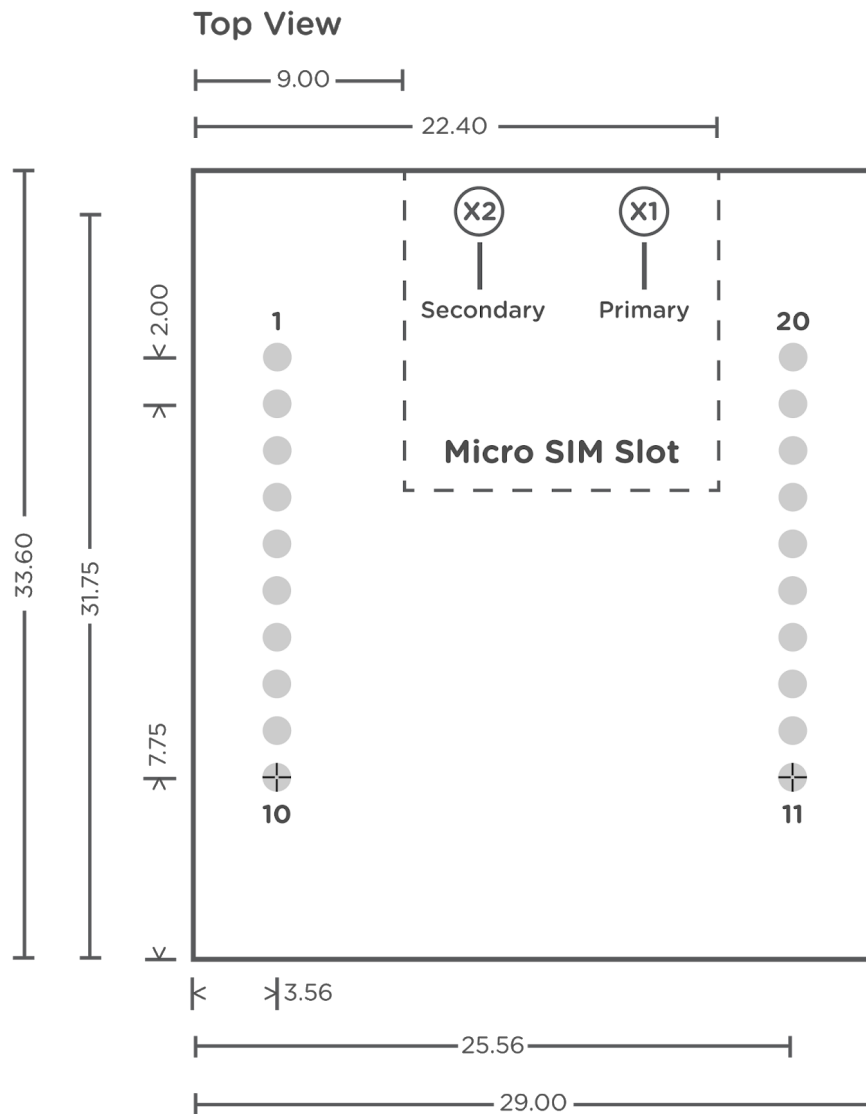


PCB Layout



## 4.2 Solder to Board connection approach

The module can be soldered directly to a PCB. The PCB should be designed with two rows of ten, 0.8mm plated thru holes spaced 2mm apart. The two rows should be 22mm apart. See drawing for recommended footprint. Measurements are in millimeters. U.FL locations are marked with circles, X1 and X2 on top side of board, J3 is Micro SIM card slot on bottom side of board.



## 5. Antenna Considerations

### 5.1 Primary Antenna Requirements

Designers should review latest ELS31 Hardware User Guide to ensure the information is up to date.

| PRIMARY ANTENNA REQUIRMENTS |                                                                                                                                     |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Frequency Range             | Depending on the frequency bands provided by the network operator, the customer shall use the most suitable antenna for those bands |
| Bandwidth                   | LTE B4(1700): 445MHz<br>LTE B13(700c): 41MHz                                                                                        |
| Impedance                   | 50 ohm                                                                                                                              |
| Input Power                 | >24dB                                                                                                                               |

### 5.2 Diversity Antenna Requirements

Designers should review latest ELS31 Hardware User Guide to ensure the information is up to date.

| RX DIVERSITY ANTENNA REQUIRMENTS |                                                                                                                                     |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Frequency Range                  | Depending on the frequency bands provided by the network operator, the customer shall use the most suitable antenna for those bands |
| Bandwidth                        | LTE B4(1700): 45MHz<br>LTE B13(700c): 10MHz                                                                                         |
| Impedance                        | 50 ohm                                                                                                                              |

## 5.3 Recommended Antennas

| Type                | Manufacturer         | Part Number     |
|---------------------|----------------------|-----------------|
| Primary & Diversity | Taoglas <sup>1</sup> | TG.30.8113      |
| Primary & GPS       | Taoglas <sup>1</sup> | MA.301.A.AB.001 |

**Note 1:** U.FL to SMA adapter required.

For applications not using the recommended antennas, developers must ensure that the selected antenna(s) meet certain requirements. In order to maintain FCC and carrier specific certifications the antennas cannot exceed the maximum gain levels listed here:

| Frequency     | Max Gain (dBi) |
|---------------|----------------|
| 700 MHz Band  | 10.41 dBi      |
| 1700 MHz Band | 6.5 dBi        |

## 6. Certifications

### 6.1 Carrier Specific

NL-SW-LTE-GELS3

Verizon OD Certified

### 6.2 Geography Specific

Federal Communications Commission (FCC47) part 22, 24

Complies with FCC47 Part 15 Class B Radiated and Conducted Emissions

## 7. Federal Regulatory Licensing

### 7.1 Export Control Classification Number (ECCN)

ECCNs are five character alpha-numeric 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.

All Skywire Modems: 5A992.c

## 7.2 Harmonized Tariff Schedule Code

HTS Code: 8517.62.0010

# 8. End Product Labeling Requirements

Device Uses Approved Radio: NL-SW-LTE-GELS3

Contains FCC ID: QIPELS31-V and IC ID: 7830A-ELS31V.

This device complies with Part 15 of the FCC Rules. 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.