Skywire™ LTE Cat 1 ELS31 Embedded Cellular Modem Datasheet

NimbeLink Corp

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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 25432	-30 to +85˚C	B4, B13	None	Verizon
NL-SW-LTE-GELS3-C	4.3.2.0 26xxx	-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.

● Gemalto's ELS31 Hardware Interface Specification
● Gemalto's ELS31 AT Command Set

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 complies with the popular XBEE® interface standard 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
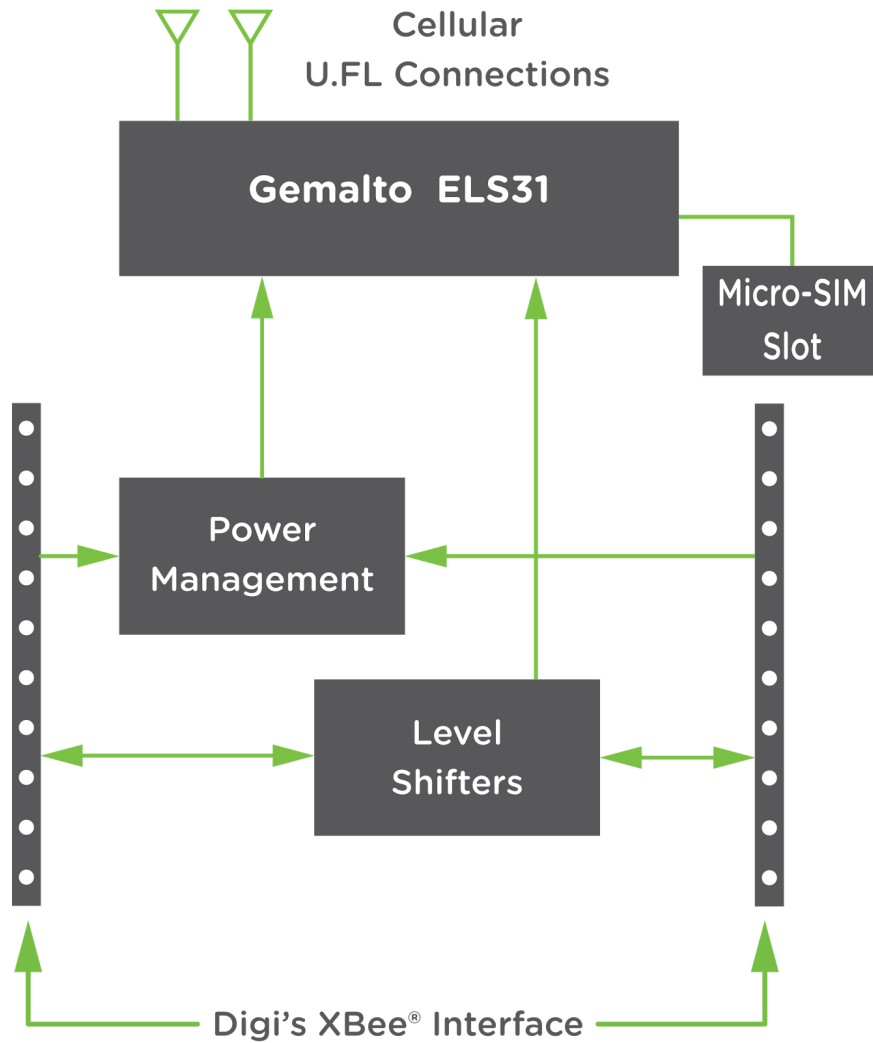
2. Technical Specifications

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: GND to 0.55V		VOH: 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: GND to 0.15V		VIH: VREF-0.4V to VREF	Must be implemented if USB not used, No connection
4	GND	Input	Ground Pin		0		Must be implemented
5	RESET_nIN	Input	Controls EMERG_RST input on Gemalto ELS31, tie low for a minimum of 100uS and released to activate. Internally pulled up to VCC. Drive with open collector output. Assert only in an emergency as the module will not gracefully exit the cellular network when asserted.		VREF		No connection
6	VUSB	Input	Supply for USB interface	4.4V	5V	5V	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: GND to 0.15V		VIH: VREF-0.4V 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: GND to 0.55V		VOH: VREF x 0.67 to VREF	No connection

13	V180	Output	Signal drives high indicating the modem is on and ready for commands. (It can be idle, or in sleep mode)May also be used to power external level shifters to interface to DIO7 or DIO8. See ELS31 manual for additional information.	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 ELS31 modem 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 50 usec and then release to activate start sequence. Drive with open collector output. Internally pulled up to internal I/O rail with resistor. Do not use any external pull ups. **Note:** If you want modem to turn on automatically when power is applied, permanently tie this signal to GND. Must execute AT^SMSO to power down the modem.	0		1.8V	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 (nAh)	Notes
Socket Dial	0	31	-	156.46	615.69	333.89	Time elapsed: 7.6758s Test: Opening socket, making HTTP POST, reading HTTP response, closing socket, powering off Skywire.
Socket Dial	20	28	-	140.32	659.04	299.237	Time elapsed: 7.6764s Test: Opening socket, making HTTP POST, reading HTTP response, closing socket, powering off Skywire.
Socket Dial	40	19	-	141.82	755.11	302.44	Time elapsed: 7.6781s Test: Opening socket, making HTTP POST, reading HTTP response, closing socket, powering off Skywire.
Idle	0	31	-	48.6	378.23	12153.0	Registered on network, 15 minute sample period.
Idle - Lower Power	0	31	-	8.58	370.617	2086.78	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	Manufacture	Populated on Module	Recommended Mate	Mate Manufacture
J1, J2	3M	951110-2530-AR-PR	950510-6102-AR	3M
			Acceptable alternate: 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 for the specified time (at least 50 usec) and then released to start-up the module. After asserting the PWR_ON signal, software must wait for V180 to assert before attempting to communicate with the ELS31. To make module automatically start when power is applied, tie PWR_ON signal to GND permanently. See Gemalto Hardware User Guide for additional details regarding the PWR_ON signal.

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 recommend procedure. However, if that procedure is not followed when shutting down the Skywire™ (for example, if a power plug is removed), immediately reapplying power can put the modem into an unresponsive but recoverable state.

There are two procedures to follow to restore responsiveness to the modem:
1. After removing power, wait 15-30 seconds before reapplying power.
2. Use the RESET_nIN pin to use the emergency reset functionality of the Skywire™ to reset the modem.

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.

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 XBEE® form factor calls for two, 10 pin, 2mm pitch female receptacles.

There are many connector manufacturers that can be used; below is one readily available product:
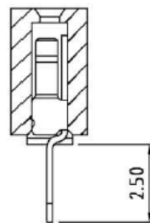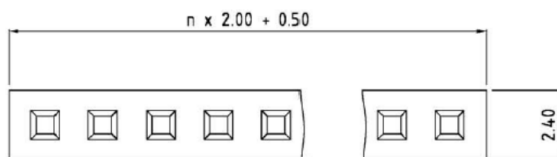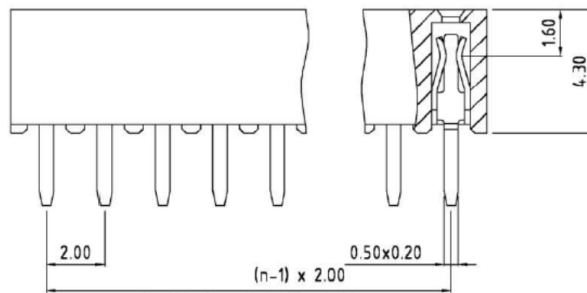
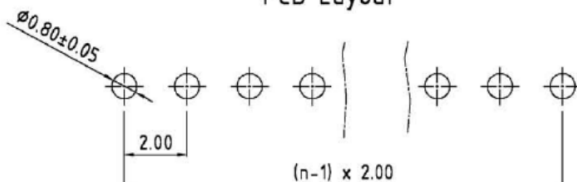Manufacturer: 3M   Alternate: Sullins Connector Solutions

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.

Top View
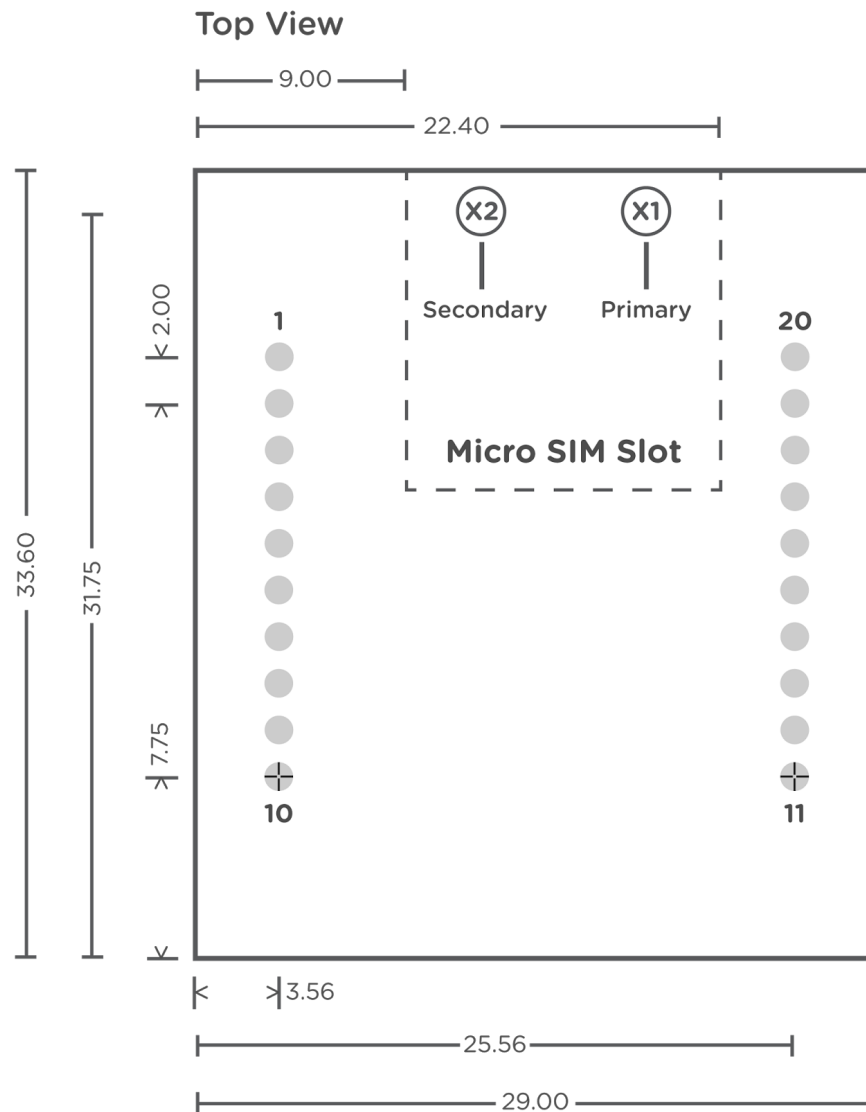
5. Antenna Considerations

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 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 LTE B13(700c): 10MHz
Impedance	50 ohm

5.3 Recommended Antennas

Type	Manufacturer	Part Number
Primary & Diversity	Taoglas[1]	TG.30.8113
Primary & GPS	Taoglas[1]	MA.301.A.AB.001

Note 1: U.FL to SMA adapter required.

For applications not using the recommended antennas developers will need to ensure that the selected antenna(s) must meet the following gain requirements:

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.

NL-SW-LTE-GELS3 (and all Skywire Modems): 5A992.a

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.