

# Skywire® LTE CAT 1 S7648 Embedded Cellular Modem Datasheet

NimbeLink Corp

Updated: November 2018



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# Table of Contents

|  |           |
|--|-----------|
| <b>Table of Contents</b>                 | <b>2</b>  |
| <b>Introduction</b>                      | <b>4</b>  |
| Orderable Part Numbers                   | 4         |
| Additional Resources                     | 4         |
| Product Overview                         | 4         |
| Block Diagram                            | 5         |
| <b>Technical Specifications</b>          | <b>6</b>  |
| Electrical Specifications                | 6         |
| Absolute Maximum Ratings                 | 6         |
| Recommended Ratings & Module Pin out     | 6         |
| Connectors J1 and J2                     | 6         |
| Connectors J3, X1, X2                    | 7         |
| Typical Power Consumption                | 8         |
| Mechanical Specifications                | 8         |
| Mechanical Characteristics               | 8         |
| Mating Connectors                        | 9         |
| Device Placement                         | 9         |
| Environmental Specifications             | 9         |
| <b>Important Design Considerations</b>   | <b>10</b> |
| PWR_ON Signal                            | 10        |
| Power Supply Requirements                | 10        |
| Serial Communications                    | 10        |
| <b>Mounting Guidelines</b>               | <b>12</b> |
| Board-to-Board Connector Approach        | 12        |
| Solder-to-Board Connection Approach      | 14        |
| <b>Antenna Considerations</b>            | <b>15</b> |
| Primary Antenna Requirement              | 15        |
| Diversity Antenna Requirements           | 16        |
| Recommended Antennas                     | 16        |
| <b>Certifications</b>                    | <b>17</b> |
| Carrier Specific                         | 17        |
| Geography Specific                       | 17        |
| <b>Federal Regulatory Licensing</b>      | <b>17</b> |
| <b>End Product Labeling Requirements</b> | <b>17</b> |

# 1. Introduction

## 1.1 Orderable Part Numbers

| Orderable Device | Firmware Revision | Operating Temperature | Bands       | Carrier           | Network Type |
|------------------|-------------------|-----------------------|-------------|-------------------|--------------|
| NL-SW-LTE-S7648  | V04.02.A14        | -40 to +85°C          | B2, B4, B12 | AT&T,<br>T-Mobile | LTE          |

## 1.2 Additional Resources

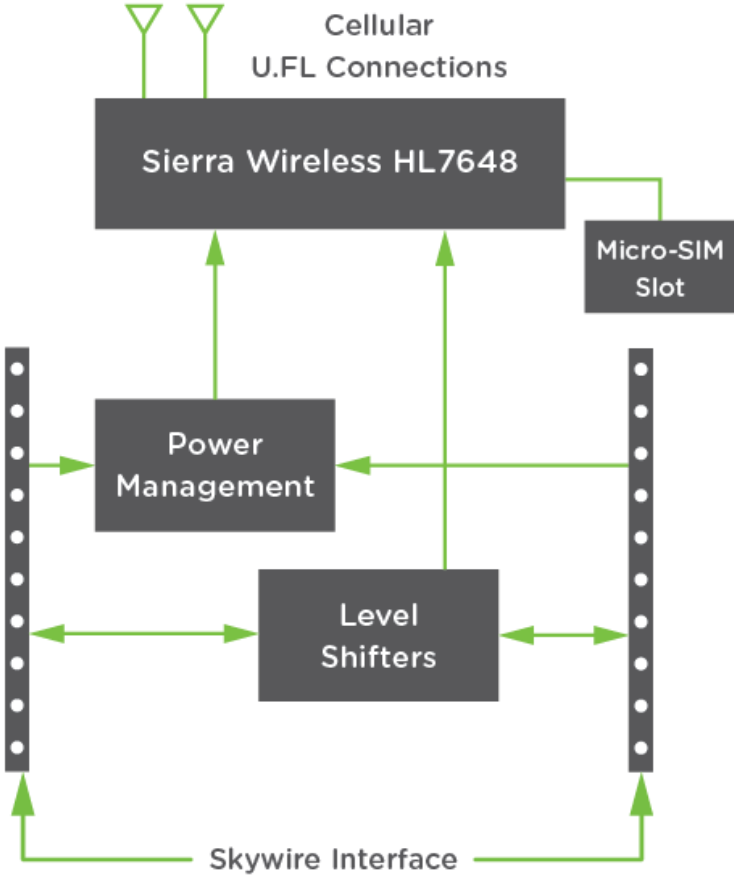
The following documents or documentation resources are referenced within this document.

- [Sending SMS](#)
- [Configuring linux 'pppd'](#)
- [Sending and Receiving Data Using Socket Dials](#)
- [Sierra's HL7648 Product Technical Resources](#)
- [Sierra's HL76xx AT Command Manual](#)
- [Sierra's HL7648 Verizon Firmware Update](#)

## 1.3 Product Overview

Add robust cellular connectivity to your M2M devices with scalable radio technology with the Skywire line of modems including HL7648 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-0.4V 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 RESET input on Sierra HL7648, tie low for a minimum of 20mS and released to activate. Internally pulled up to 1.8V. Drive with open collector output. Assert only in an emergency as the module will not gracefully exit the cellular network when asserted. | 0V                   |         | 1.8V                        | No connection                                      |
| 6   | VUSB      | Input     | Supply for USB interface  | 3.2V                 | 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:<br>GND to 0.15V |         | VIH:<br>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                                |

| Pin | Name   | Direction | Description   | Min                  | Typical      | Max                         | If not used          |
|-----|--------|-----------|---|----------------------|--------------|-----------------------------|----------------------|
| 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  | VGPIO  | 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 DIO5 or DIO7. See HL7648 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 HL7648 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:<br>GND to 0.15V |              | VIH:<br>VREF-0.4V to VREF   | Tie to GND           |
| 17  | DIO5   | I/O       | Programmable GPIO_05 on HL7648 module   | 0                    |              | 1.8V                        | No connection        |
| 18  | DIO7   | I/O       | Programmable GPIO_07 on HL7648 module   | 0                    |              | 1.8V                        | No connection        |
| 19  | ADC1   | Input     | ADC1 input on HL7648 module (10-bit resolution)   | 0                    |              | 1.2V                        | No connection        |
| 20  | PWR_ON | Input     | Modem PWR_ON signal. Assert low for at least 25 msec 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. <b>Note:</b> If you want modem to turn on automatically when power is applied, permanently tie this signal to GND. Must execute AT+CPOF 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

| Mode                 | Attenuation (dB) | RSRQ (dB) | RSRP (dBm) | Average Current (mA) | Peak Current (mA) | Charge Consumed ( $\mu$ Ah) | Measurement Notes  |
|----------------------|------------------|-----------|------------|----------------------|-------------------|-----------------------------|--|
| Active Socket Dial   | 0                | -6        | -82        | 133.842              | 334.759           | 56.616                      | <b>Tested at:</b> 3.8V<br><b>Time elapsed:</b> 3.046s<br>Open socket, HTTP POST, read HTTP response          |
| Active Socket Dial   | 20               | -8        | -102       | 136.744              | 676.025           | 66.716                      | <b>Tested at:</b> 3.8V<br><b>Time elapsed:</b> 3.514s<br>Open socket, HTTP POST, read HTTP response          |
| Active Socket Dial   | 40               | -12       | -118       | 192.542              | 751.784           | 92.184                      | <b>Tested at:</b> 3.8V<br><b>Time elapsed:</b> 3.347s<br>Open socket, HTTP POST, read HTTP response          |
| Off                  | 0                | -6        | -82        | 218.475 ( $\mu$ A)   | 7.207             | 5.512                       | <b>Tested at:</b> 3.8V<br><b>Time elapsed:</b> 180s<br>Modem powered off                                     |
| Idle                 | 0                | -6        | -82        | 35.171               | 239.429           | 884.983                     | <b>Tested at:</b> 3.8V<br><b>Time elapsed:</b> 180s<br>Idle whilst powered on and registered on the network  |
| Idle, Low Power Mode | 0                | -6        | -82        | 17.74                | 224.367           | 897.10                      | <b>Tested at:</b> 3.8V<br><b>Time Elapsed:</b> 180s<br>Registered on the network, DTR tied HIGH, AT+KSLEEP=0 |

## 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   | 0.4                  | oz     |
| Connector Insertion/Removal  | hundreds             | Cycles |

### 2.2.2 Mating Connectors

| Connector Designator | Manufacture | Populated on Module     | Recommended Mate                          | Mate Manufacture            |
|----------------------|-------------|-------------------------|---|-----------------------------|
| J1, J2               | 3M          | Pinrex<br>222-96-10GBE1 | NPPN101BFCN-RC                            | Sullins Connector Solutions |
|                      |             |                         | Acceptable Alternative:<br>950510-6102-AR | 3M                          |
| J3                   | Molex       | 786463001               | NL-SIM-COM                                | Nimbelink                   |
| 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 | Notes          |
|-----------------------|-----|---------|-----|------|----------------|
| Operating Temperature | -40 | 25      | +85 | °C   |                |
| Storage Temperature   | -40 | 25      | +85 | °C   |                |
| Operating Humidity    | 20  |         | 90  | %    | Non-condensing |



## 3. Important Design Considerations

### 3.1 PWR\_ON Signal

To conserve power, the HL7648 does not automatically startup when power is applied. The baseboard design must supply a means to assert the PWR\_ON signal for the specified time (at least 25 msec) and then released to startup the module. After asserting the PWR\_ON signal, software must wait for VGPI0 to assert before attempting to communicate with the HL7648. To make the module start automatically when power is applied, tie PWR\_ON signal to GND permanently. See the Sierra Hardware User Guide for additional details regarding the PWR\_ON signal:

[https://source.sierrawireless.com/resources/airprime/hardware\\_specs\\_user\\_guides/airprime\\_hl7618rd\\_product\\_technical\\_specification/](https://source.sierrawireless.com/resources/airprime/hardware_specs_user_guides/airprime_hl7618rd_product_technical_specification/)

### 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 100  $\mu$ F 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:

[https://nimbelink.com/Documentation/Development\\_Kits/NL-SWDK/20002\\_NL-SWDK\\_Schematic.pdf](https://nimbelink.com/Documentation/Development_Kits/NL-SWDK/20002_NL-SWDK_Schematic.pdf)

### 3.3 Serial Communications

The HL7648 can communicate over UART and/or USB. An ideal design must implement one or both serial interfaces in order to interface with the modem.

## 3.4 LED

The Skywire has an on-board LED, D1, connected to the HL7648 on GPIO10. The state of the LED can be asserted by issuing the following AT command:

```
AT+KGPI0=10,1 //Turn on LED
```

```
AT+KGPI0=10,0 //Turn off LED
```

## 3.5 FOTA

LTE networks are constantly being updated, improved, and enhanced with new features. Therefore, carriers tend to make frequent network changes. Most of these changes will not negatively affect network connected devices, but occasionally an update will prevent an unprepared device from re-connecting to the network permanently.

To account for these future changes, FOTA (Firmware over the Air) capability is being added to all cellular modules by manufacturers. Accordingly, NimbeLink supports this functionality in the entire Skywire family of embedded modems. However, it is often required that designers implement support for FOTA in their device's firmware.

Any Skywire developer must ensure that their device firmware can accommodate FOTA updates after deployment. Failure to do so may result in network connectivity interruptions in the event of a network change.

Should a device be rendered unable to connect to the cellular network after an update, it is impossible to resolve the issue using FOTA. In this case, the only way to fix the connectivity issue would be to physically update the device over a serial connection.

FOTA Instructions are available by contacting NimbeLink's product support team at [product.support@nimbelink.com](mailto:product.support@nimbelink.com).

## 4. Mounting Guidelines

Skywire embedded cellular modems support two connection methods: board-to-board connectors and the solder-to-board method.

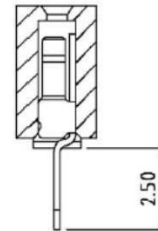
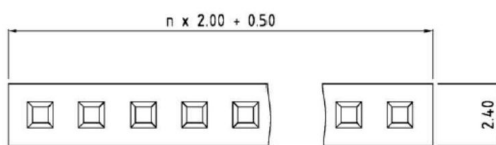
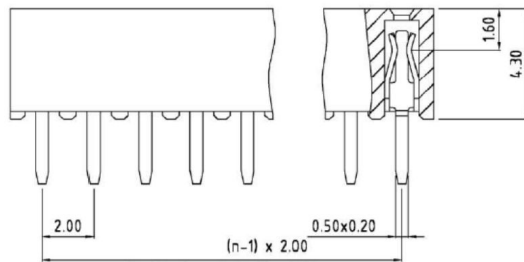
### 4.1 Board-to-Board Connector Approach

The Skywire interface utilizes two, 10 pin, 2mm pitch female receptacles. Many connector manufacturers can be used; below are two readily available products:

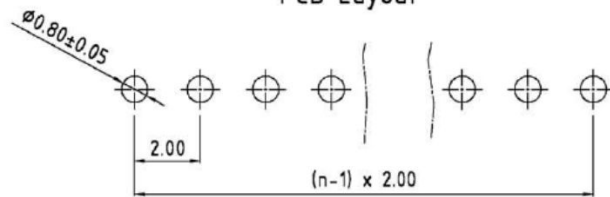
**Manufacturer:** Sullins Connector Solution, **Part Number:** NPPN101BFCN-RC

**Manufacturer:** 3M, **Part Number:** 950510-6102-AR

Please refer to the figures below for diagrams of typical board-to-board connectors.



PCB Layout

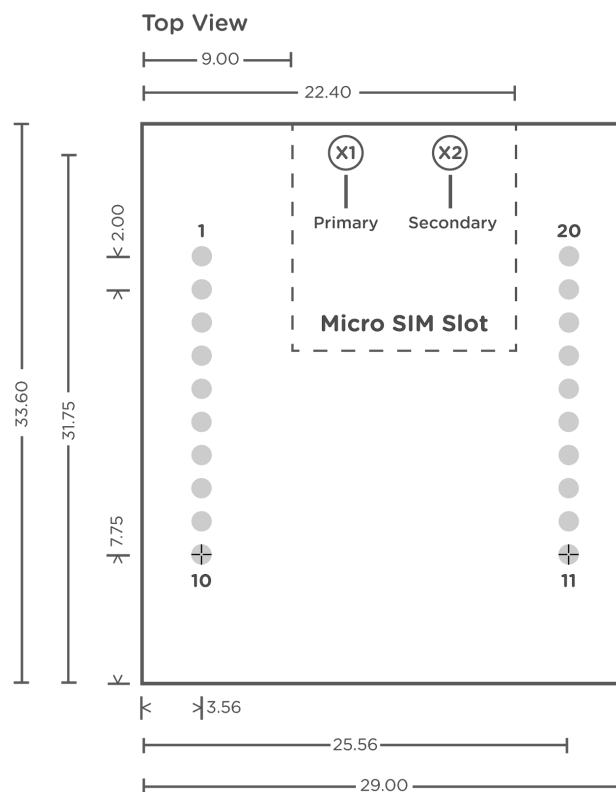


## 4.2 Solder-to-Board Connection Approach

The second method of connection is soldering the module directly to the main board.

The PCB should be designed with two rows of ten, 0.8 mm plated through-holes spaced 2mm apart, with each row spaced 22mm. See the drawing below for a recommended footprint.

**Note:** U.FL locations are marked with circles, X1 and X2 are located on the top side of board, J3 is the micro SIM card slot on bottom side of board, and all measurements are in millimeters.



# 5. Antenna Considerations

Designers should review the latest HL7648 Hardware User Guide to ensure the following information is up to date:

[https://source.sierrawireless.com/resources/airprime/hardware\\_specs\\_user\\_guides/airprime\\_hl7618rd\\_product\\_technical\\_specification/](https://source.sierrawireless.com/resources/airprime/hardware_specs_user_guides/airprime_hl7618rd_product_technical_specification/)

## 5.1 Primary Antenna Requirements

| Primary Antenna Requirements |  |
|------------------------------|--|
| Frequency Range              | Depending on the frequency bands provided by the network operator, the customer shall use the most suitable antenna for those bands  |
| Bandwidth                    | <b>LTE B2:</b><br>Transmit: 1850 to 1910 MHz<br>Receive: 1930 to 1990 MHz<br><br><b>LTE B4:</b><br>Transmit: 1710 to 1755 MHz<br>Receive: 2110 to 2155 MHz<br><br><b>LTE B12:</b><br>Transmit: 699 to 716 MHz<br>Receive: 729 to 746 MHz |
| Impedance                    | 50 ohm   |
| Input Power                  | >24dB  |
| VSWR Max                     | 1.5:1  |

## 5.2 Diversity Antenna Requirements

| RX Diversity Antenna Requirements |   |
|-----------------------------------|---|
| Frequency Range                   | Depending on the frequency bands provided by the network operator, the customer shall use the most suitable antenna for those bands   |
| Bandwidth                         | <p><b>LTE B2:</b><br/>Transmit: 1850 to 1910 MHz<br/>Receive: 1930 to 1990 MHz</p> <p><b>LTE B4:</b><br/>Transmit: 1710 to 1755 MHz<br/>Receive: 2110 to 2155 MHz</p> <p><b>LTE B12:</b><br/>Transmit: 699 to 716 MHz<br/>Receive: 729 to 746 MHz</p> |
| Impedance                         | 50 ohm  |
| VSWR Max                          | 1.5:1   |

## 5.3 Recommended Antennas

| Type                | Manufacturer         | Part Number |
|---------------------|----------------------|-------------|
| Primary & Diversity | Taoglas <sup>1</sup> | TG.30.8113  |

**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 Band | Max Gain (dBi) |
|----------------|----------------|
| LTE Band 2     | 8.01           |
| LTE Band 4     | 5.00           |
| LTE Band 12    | 8.70           |

## 6. Certifications

### 6.1 Carrier Specific

NL-SW-LTE-S7648, PTCRB, AT&T 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-S7648

**Contains FCC ID:** N7NHL7648 and **IC ID:** 2417C-HL7648

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.