NL-SW-LTE-S7xxx Modems to NL-SW-LTE-TCxNAG Modems Migration Guide

NimbeLink Corp

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1. Introduction

The aim of this document is to serve as a migration guide from the NL-SW-LTE-S7648, NL-SW-LTE-S7618RD, NL-SW-LTE-S7588 modems to the NL-SW-LTE-TC1NAG and NL-SW-LTE-TC4NAG Skywire modems. Throughout this document, the NL-SW-LTE-S7648 will often be referred to as the "S7648", NL-SW-LTE-S7618RD as “S7618RD”, NL-SW-LTE-S7588 as “S7588”, NL-SW-LTE-TC1NAG as “TC1NAG”, and the NL-SW-LTE-TC4NAG as "TC4NAG".

This document is updated often. Please be sure to download the latest version from NimbeLink's website prior to beginning any design work.

1.1 Contact Information

NimbeLink’s goal is to make integrating the Skywire modem into your product as easy as possible. Please send any feedback, documentation requests, or technical support questions to NimbeLink’s product support team at:

product.support@nimbelink.com

For purchasing information, product selection or availability please visit the "Part Ordering Information" section on the modem’s product page. Any additional sales questions or requests for quotation can be directed to NimbeLink’s sales team at:

sales@nimbelink.com

1.2 Orderable Part Number

Orderable Device	Operating Temperature	Cellular Technologies	GNSS
NL-SW-LTE-TC1NAG	-40 to +85˚C	LTE CAT 1	GPS, GLONASS, BeiDou,Galileo,QZSS
NL-SW-LTE-TC4NAG	-40 to +85˚C	LTE CAT 4	GPS, GLONASS, BeiDou,Galileo,QZSS
NL-SW-LTE-S7618RD	-40 to +85˚C	LTE CAT 1	N/A
NL-SW-LTE-S7648	-40 to +85˚C	LTE CAT 1	N/A
NL-SW-LTE-S7588	-40 to +85˚C	LTE CAT 4	N/A

1.3 Additional Resources

- Skywire Hardware Design Developers Guide
- Skywire Hardware Design Checklist
- Skywire Software Developers Guide

2. Migration Overview

The TC1NAG provides a CAT 1 LTE replacement to the S7648 and S7618RD modems while the TC4NAG provides a CAT 4 LTE replacement to the S7588 modem. Both TCxNAG and S7xxx modems use the same 20 pin Skywire form factor and allow for easy migration between any of the Skywire modems.

TCxNAG modems are nearly identical to S7xxx modems in terms of cellular capability (bands, output power, etc.), but come with the benefit of additional features. Namely, dual carrier support (both ATT and Verizon) with one SKU of the part (see section 3.9 of the datasheet to change between the firmware for the different carriers), GNSS support and a soldered-down Verizon LTE SIM.

TCxNAG modems have an integrated GNSS receiver capable of utilizing several of the most common satellite technologies (GPS, GLONASS, etc.). The modems also have an LDO that can be used to supply 3.3V DC power to the X3 connector for implementations that make use of an active GNSS antenna.

TCxNAG modems have a soldered-down Verizon LTE SIM that can be used to supplement or replace the removable 3FF SIM card. A 3FF SIM card slot is also available on the TCxNAG modems. You may use either or both with the SIM card selection entirely controlled by AT commands, allowing for easy swapping of the SIM identity.

TCxNAG modems have a significantly different method for opening a socket dial. Please see the socket dial application note to guide you in modifying your code.

Socket Dial Application note

2.1 Comparison Table

2.1.1 CAT 1 Modems

Item	NL-SW-LTE-S7648	NL-SW-LTE-S7618RD	NL-SW-LTE-TC1NAG
Chipset	Intel XMM7120M	Intel XMM7120M	Qualcomm MDM9207
Module	Sierra Wireless HL7648	Sierra Wireless HL7618RD	Telit LE910C1-NF
Power Class	Power Class 3 (23dBm)	Power Class 3 (23dBm)	Power Class 3 (23dBm)
Supported Bands	LTE-FDD: B2/B4/B12	LTE-FDD: B4/B13	LTE-FDD: B2/B4/B5/B12/B13/B14/B66/B71 Fallback: 3G HSPA+: B2/B4/B5
GNSS	N/A	N/A	GPS, GLONASS, BeiDou, Galileo, QZSS
Input Voltage	3V to 5.5V	3V to 5.5V	3.4V to 4.2V
Current Requirements (Max)	2.0A	2.0A	2.0A
Temperature Range	-40 to +85˚C	-40 to +85˚C	-40 to +85˚C
Main UART Interface	Baud rates: 9600bps, 19200bps, 38400bps, 57600bps, 115200bps, 230400bps, 460800bps, 921600bps, 115200bps by default Flow control: RTS/CTS	Baud rates: 9600bps, 19200bps, 38400bps, 57600bps, 115200bps, 230400bps, 460800bps, 921600bps, 115200bps by default Flow control: RTS/CTS	Baud rates: 9600bps, 19200bps, 38400bps, 57600bps, 115200bps, 230400bps, 460800bps, 921600bps, 115200bps by default Flow control: RTS/CTS
USB Interface	USB 2.0 (Slave only) Full speed and high speed	USB 2.0 (Slave only) Full speed and high speed	USB 2.0 (Slave only) Full speed and high speed
Dimensions (mm)	29.0 x 33.60 x 10.73 mm	29.0 x 33.60 x 10.73 mm	29.0 x 33.9 x 10.7 mm
Weight (g)	8	8	8

2.1.2 CAT 4 Modems

Item	NL-SW-LTE-S7588	NL-SW-LTE-TC4NAG
Chipset	Intel XMM7160	Qualcomm MDM9207
Module	Sierra Wireless HL7588	Telit LE910C4-NF
Power Class	Power Class 3 (23dBm)	Power Class 3 (23dBm)
Supported Bands	CAT 4: LTE-FDD: B2/B4/B5/B13/B17 Fallback: 3G HSPA+: B2/B5	CAT 4: LTE-FDD: B2/B4/B5/B12/B13/B14/B66/B71 Fallback: 3G HSPA+: B2/B4/B5
GNSS	N/A	GPS, GLONASS, BeiDou, Galileo, QZSS
Input Voltage	3V to 5.5V	3.4V to 4.2V
Current Requirements (Max)	2.0A	2.0A
Temperature Range	-40 to +85˚C	-40 to +85˚C
Main UART Interface	Baud rates: 9600bps, 19200bps, 38400bps, 57600bps, 115200bps, 230400bps, 460800bps, 921600bps, 115200bps by default Flow control: RTS/CTS	Baud rates: 9600bps, 19200bps, 38400bps, 57600bps, 115200bps, 230400bps, 460800bps, 921600bps, 115200bps by default Flow control: RTS/CTS
USB Interface	USB 2.0 (Slave only) Full speed and high speed	USB 2.0 (Slave only) Full speed and high speed
Dimensions (mm)	29.0 x 33.60 x 10.73 mm	29.0 x 33.9 x 10.7 mm
Weight (g)	8	8

2.2 Pin Assignments

This section describes the pin assignments on the modems.

Pin #	NL-SW-LTE-S7648 NL-SW-LTE-S7618RD NL-SW-LTE-S7588			NL-SW-LTE-TC1NAG NL-SW-LTE-TC4NAG		
	Pin Name	IO	Description	Pin Name	IO	Description
1	VCC	Input	Main Power Supply	VCC	Input	Main Power Supply
2	DOUT	Output	Primary UART Data Output	DOUT	Output	Primary UART Data Output
3	DIN	Input	Primary UART Data Input	DIN	Input	Primary UART Data Input
4	GND	-	Ground	GND	-	Ground
5	RESET_nIN	Input	Emergency Reset Line	nRESET	Input	Emergency Reset Line
6	VUSB	Input	USB Voltage Detection	VUSB	Input	USB Voltage Detection
7	USB_D+	I/O	USB Differential Data Bus (+)	USB_P	I/O	USB Differential Data Bus (+)
8	USB_D-	I/O	USB Differential Data Bus (-)	USB_N	I/O	USB Differential Data Bus (-)
9	DTR	Input	Data Terminal Ready	DTR	Input	Data Terminal Ready
10	GND	-	Ground	GND	-	Ground
11	GND	-	Ground	GND	-	Ground
12	CTS	Output	Primary UART Clear to Send	CTS	Output	Primary UART Clear to Send
13	VGPIO	Output	Modem Status Pin	ON/nSLEEP	Output	Modem Status Pin
14	VREF	Input	Modem IO Voltage Reference	VREF	Input	Modem IO Voltage Reference
15	GND	-	Ground	GND	-	Ground
16	RTS	Input	Primary UART Request to Send	RTS	Input	Primary UART Request to Send
17	DIO5	I/O	Programmable GPIO Pin	GPIO_3	I/O	Programmable GPIO Pin
18	DIO7	I/O	Programmable GPIO Pin	GPIO_2	I/O	Programmable GPIO Pin
19	ADC1	Input	ADC Input	RING	Output	Ring Indicator
20	PWR_ON	Input	Modem ON/OFF Signal	ON_OFF	Input	Modem ON/OFF Signal

Note: *The pinout of the two modem families is identical, except for pin 19. The ADC input pin on S7xxx modems is replaced by the Ring indicator on TCxNAG modems.*

2.3 Functionality

2.3.1 RF Power Class

Both S7xxx and TCxNAG families of modems in this guide are Power Class 3 devices and support a maximum output power of +23 dBm.

2.3.2 AT Commands

S7xxx and TCxNAG modems use different AT command sets. However, there may be similarities, such as with standard 3GPP commands. Please refer to the corresponding AT command manuals for the modems listed below:

Modem	AT Command Manual
NL-SW-LTE-TCxNAG	https://nimbelink.com/Documentation/Skywire/4G_LTE_Cat_4_Telit/Telit_LE910Cx_AT_Commands_Reference_Guide.pdf
NL-SW-LTE-S7588	https://source.sierrawireless.com/resources/airprime/software/airprime_hl7588_at_commands_interface_guide/#sthash.2Xylnez0.dpbs
NL-SW-LTE-S7648	https://source.sierrawireless.com/resources/airprime/software/airprime_hl76xx_at_commands_interface_guide/#sthash.Ew5Wqv23.dpbs
NL-SW-LTE-S7618RD	https://source.sierrawireless.com/resources/airprime/software/airprime_hl76xx_at_commands_interface_guide/#sthash.iYtzTB37.dpbs

2.3.3 Power Requirements

The input voltage range for S7xxx modems is 3.0V to 5.5V with a typical power supply voltage of 3.9V, while TCxNAG modems is 3.4V to 4.2V. The VCC input for S7xxx and TCxNAG modems should have both a 100uF and a 0.1uF decoupling capacitor placed close to the VCC pin. Please refer to the modem's datasheet for further information on power requirements. NimbeLink offers multiple power supply reference designs in order to assist customers with their designs. Two of the designs are linked to below:

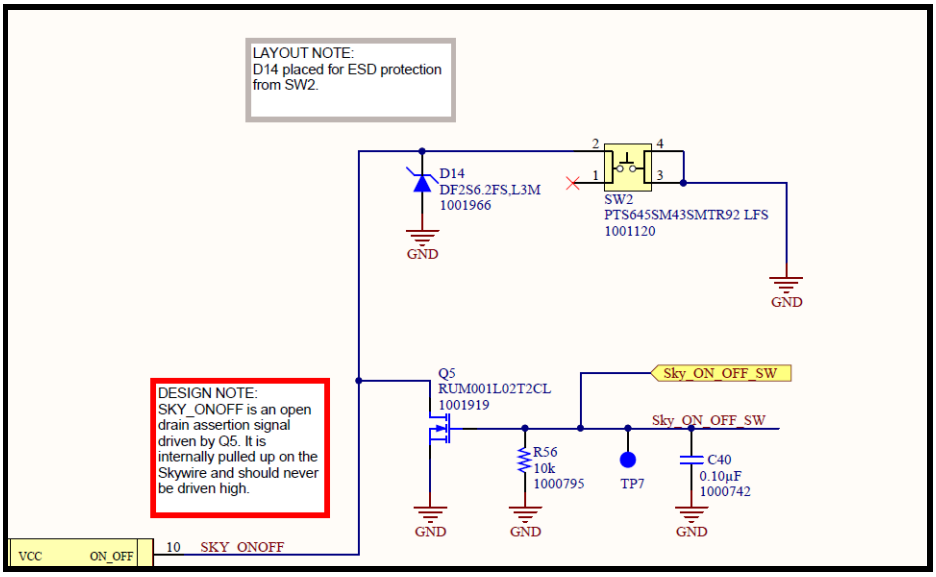
NL-SWDK2 Reference Schematic

NL-AB-BBCL Reference Schematic

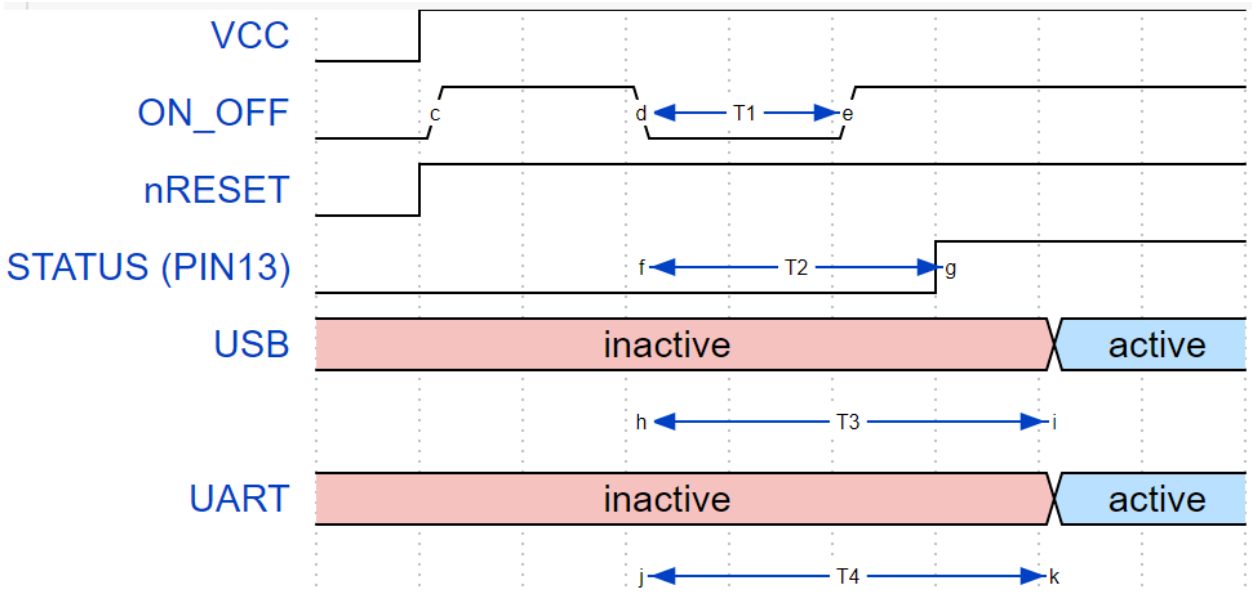
2.3.4 Power On

The method to power on S7xxx and TCxNAG modems is the same, but the assertion duration is different. To turn on either device, the modem's ON_OFF pin must be driven low with an open-drain assertion and released. This signal should never be driven high.

The following is a reference design example for the turn-on circuit for the modems:



The power-on timing for the two modems is different. The following figure shows the power-on scenarios and timing differences.



Modem	T1	T2	T3	T4
NL-SW-LTE-TCxNAG	≥1 s	~15 s	~20-28s	~20-28s
NL-SW-LTE-S7xxx	≥25 ms	<25 ms	≥7 s	≥7 s

2.3.5 Power Off

2.3.5.1 Power Off via AT command

Both modems may be powered down by AT command.

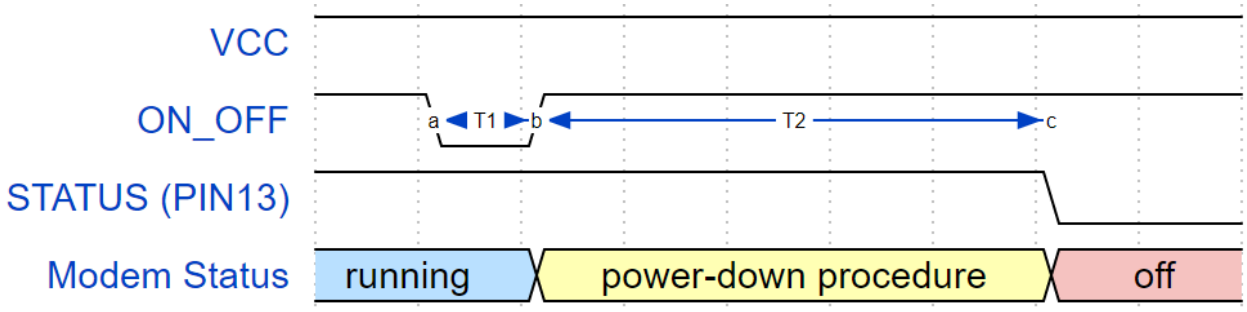
For TCxNAG modems, the AT command **"AT#SHDN"** can be issued over either USB or serial to power down the modem. S7xxx modems can be powered down in a similar fashion via the AT command **"AT+CPWROFF"**.

These commands will force the modem to properly detach from the network and allow the firmware to save important data before shutting down. The shutdown process, including the network detach, will typically take several seconds. The total shutdown time will depend on how long the network detach takes. If an immediate power down is required, TCxNAG users should use the fast shutdown option documented in TCxNAG modem's AT command manual. S7xxx modems do not have a fast shutdown option.

To avoid firmware corruption, the power supply for S7xxx and TCxNAG modems cannot be disconnected before the STATUS output pin (VGPIO and ON/nSLEEP, respectively) is driven low by the module.

2.3.5.2 Power Off via ON_OFF

TCxNAG modems may be powered off by toggling the ON_OFF pin low, with an open drain assertion, for a period of time when the modem is operating. S7xxx modems ***cannot*** be powered down via the ON_OFF pin and must be powered down using the AT interface. The power-down timing is illustrated in the figure and table below.

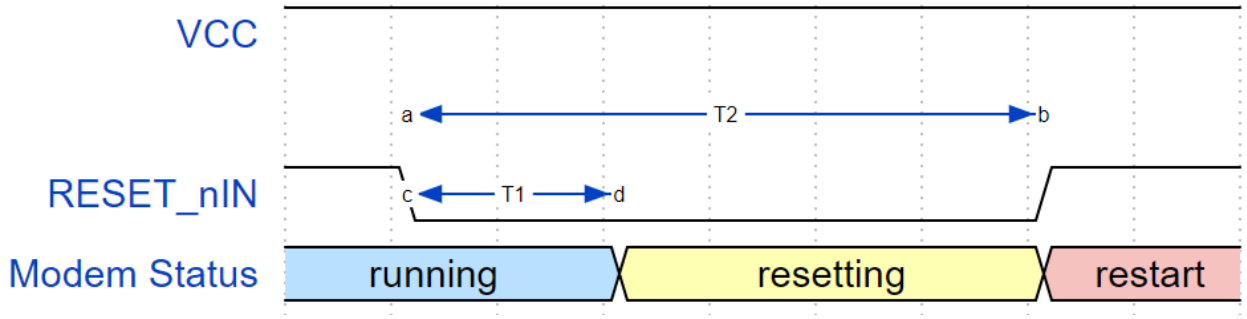


Modem	T1	T2
NL-SW-LTE-TCxNAG	≥2.5 s	~15 s

2.3.6 Reset

S7xxx modems can be reset by driving the reset (RESET_nIN) line low with an open-drain for a period of time. The reset line should only be used as a last resort recovery method when the modem is unresponsive.

The following figure and table shows the reset timing for S7xxx modems.



Modem	T1	T2
NL-SW-LTE-S7xxx	≥20 ms	≥2 s

TCxNAG modems require a different process to perform a hardware reset. In the event that the modem becomes unresponsive, pin 5 (nRESET) can be grounded to unconditionally shut down the modem. When pin 5 is grounded, the modem will cease all ongoing operations and unconditionally shut down.

To unconditionally shut down TCxNAG modems with the nRESET signal, assert a logic-low level on nRESET using an open-drain or open-collector output for at least 200 ms, and then release. The modem will need the ON_OFF signal applied again to power on after a nRESET condition. The reset line should only be used as a last resort recovery method when the modem is unresponsive.

2.3.7 SIM Interfaces

The SIM interface on S7xxx and TCxNAG modems meet ETSI and IMT-2000 requirements. Both S7xxx and TCxNAG modems support 1.8V/3.0V U(SIM) cards. TCxNAG modems are designed to support both an external 3FF SIM and an onboard MFF2 Verizon SIM. The modems will default to using the external 3FF SIM interface.

2.3.7.1 Soldered-Down SIM (TCxNAG Only)

To enable the soldered-down SIM interface, issue the following commands:

```
AT#ENSIM2=1

AT#ENHRST=1,0
```

The modem will immediately reboot after entering the last command. When the modem becomes responsive again, the soldered-down SIM interface will now be enabled. The SIM enable command and SIM selection commands will not persist across carrier firmware switches with the "**AT#FWSWITCH**" command and must be reissued after the new firmware selection is loaded.

Note 1: Even after issuing the "**AT#ENSIM2=1**" command and rebooting, the 3FF SIM card interface will still be activated and selected.

Note 2: The "**#ENSIM2: x**" setting is saved in NVM, and will persist across device resets and power-ons. Additionally, the modem must reboot in order to save any changes made to this setting.

1. 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=4

AT#HSEN=1

AT#ENSIM2=1

AT#SIMSELECT=2

AT+CFUN=1
```

To instruct the modem to use the 3FF SIM Card in the SIM slot, issue the following AT commands:

```
AT+CFUN=4

AT#HSEN=1

AT#SIMSELECT=1

AT+CFUN=1
```

Note 1: Be sure to issue "**AT+CFUN=4**" each time before swapping the active SIM. This will allow the modem to gracefully detach from the network before swapping its SIM.

Note 2: The "**`#SIMSELECT:`**" setting is saved in NVM, and will persist after device resets and power-ons.

2. If desired, the soldered-down SIM interface can be disabled using the following commands:

   `AT#ENSIM2=0`

   `AT#ENHRST=1,0`

The modem will immediately reboot after entering the last command. When the modem becomes responsive again, the soldered-down SIM interface will now be disabled.

Note 1: After issuing the "**`AT#ENSIM2=0`**" command, the modem will set its SIM selection state to: "**`#SIMSELECT: 1`**"

Note 2: The "**`#ENSIM2: x`**" setting is saved in NVM, and will persist across device resets and power-ons. Additionally, the modem must reboot in order to save any changes made to this setting.

2.3.8 UART Interfaces

Both S7xxx and TCxNAG modems support a single, primary UART interface with hardware flow control on Skywire pins 2 (DOUT), 3 (DIN), 12 (CTS), and 16 (RTS). This interface is internally level shifted to the VREF voltage provided to the modem. The default baud rate for the modem's UART interface is 115200 8N1. The primary UART interface is used for data transmission and AT command communication.

2.3.9 USB Interfaces

S7xxx and TCxNAG modems both support a USB 2.0 interface and can only be used as a slave device. Both modems support high speed (480 Mbps) and full speed (12 Mbps) operation.

2.3.10 RF Antenna Interfaces

2.3.10.1 Cellular

Both S7xxx and TCxNAG modems support a primary and diversity LTE RF interface (X1 and X2, respectively) on the top side of the modem. The modems are designed to use 50 ohm impedance antennas.

Note: The locations of X1 and X2 are swapped on the TCxNAG family of modems relative to the S7xxx family of modems. Please refer to Section 2.3.12 for a diagram of the connections.

2.3.10.2 GNSS (TCxNAG Only)

TCxNAG modems have a GNSS antenna connector (X3) on the bottom side of the modem. The modem's GNSS interface is designed to support the use of active GNSS antennas. A 3.3VDC, 100 mA source is available on the modem to bias the GNSS line in order to power the active antenna. Control of the GNSS power source is done via AT command to conserve power; the GNSS power is off by default. The command sequence for both modems is the same.

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

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

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

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

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


2.3.11 Application Notes

Documentation for various applications for both S7xxx and TCxNAG modems, including socket dials, PPP, and CDC_ETH, are available through the NimbeLink website.

2.3.11.1 Supported Networking Interfaces

The following table illustrates the compatibility of both modem families when using networking interfaces:

Modem Family	PPP	ECM	QMI	RNDIS	MBIM	NCM
S7xxx	X				X	X
TCxNAG	X	X	X	X	X	

2.3.11.2 S7xxx Application Notes

S7xxx Socket Dials:
https://nimbelink.com/Documentation/Skywire/4G_LTE_Cat_4/30228_NL-SW-LTE-S7588_SocketDial.pdf

S7xxx PPP:
https://nimbelink.com/Documentation/Skywire/4G_LTE_Cat_4/30222_NL-SW-LTE-S7588_PPP.pdf

S7xxx NCM:
https://nimbelink.com/Documentation/Skywire/4G_LTE_Cat_4/30248_NL-SW-LTE-S7588_NCM.pdf

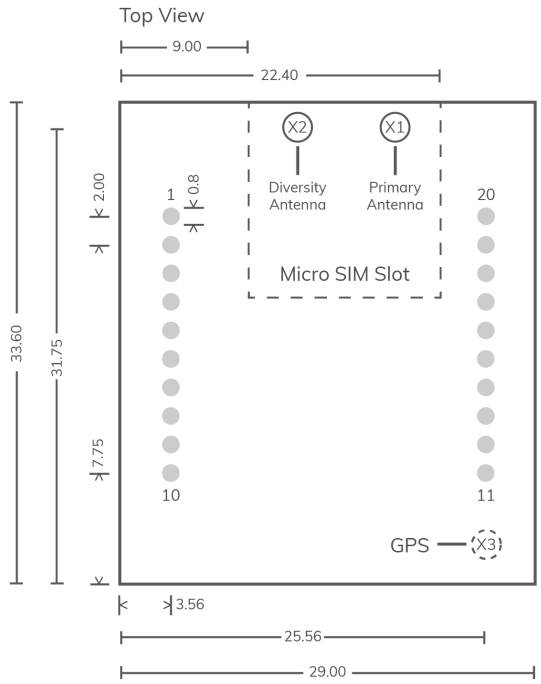
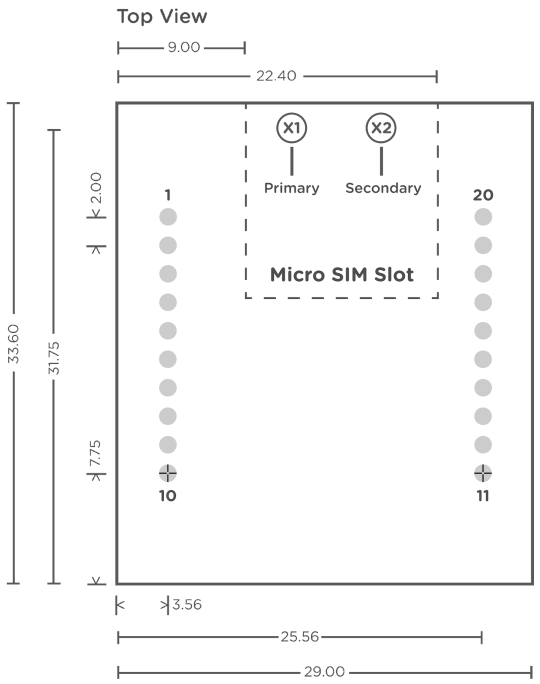
2.3.11.3 TCxNAG Application Notes

TCxNAG Socket Dials:
https://nimbelink.com/Documentation/Development_Kits/NL-SWDK/30050_NL-SWDK_SocketDialExample.pdf

TCxNAG Linux Networking Guide (PPP, ECM, MBIM, QMI):
https://nimbelink.com/Documentation/Skywire/4G_LTE_Cat_4_Telit/1002199_NL-SW-LTE-TC4NAG_Linux_Networking_Guide.pdf

2.3.12 Skywire Footprint

Both S7xxx and TCxNAG modems use the same 20 pin Skywire interface and have the same mechanical footprint as shown in the figure below.

NL-SW-LTE-TC1NAG NL-SW-LTE-TC4NAG	NL-SW-LTE-S7648 NL-SW-LTE-S7618RD NL-SW-LTE-S7588
	

The primary and diversity antenna locations are swapped on TCxNAG modems relative to S7xxx modems. Please ensure your antenna configuration can support this difference.

3. Document Version Information

Revision	Description	Date
1	-Initial Release	2021/08/18