Skywire® Raspberry Pi Adapter User Manual

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1. Introduction

1.1 Overview

This document is the System Reference Manual for the Skywire® Raspberry Pi Adapter. Throughout the document Skywire Raspberry Pi Adapter will often be referred to as "the adapter," although it may be referred to by its full name.

The NimbeLink Skywire modem is available with bundled data plans from leading cellular carriers.

The Skywire cellular modem and antennas are sold separately.

Make sure you check NimbeLink's Skywire Raspberry Pi Adapter product page for the most up to date information.

This guide was written and tested using the 2017-04-10 Raspbian release.

1.2 Product Description

The Skywire Raspberry Pi Adapter allows Raspberry Pis to gain easy access to the Internet of Things (IoT) via any of the Skywire plug-in cellular modems. The Raspberry Pi is a low-cost, community-supported development platform that allows quick, easy application development. It accepts plug-in boards called "hats" or "adapters" that allow a wide variety of expanded capabilities. The Skywire Raspberry Pi Adapter supports any of NimbeLink's end-device certified Skywire plug-in cellular modems with optional bundled, no-contract cellular plans. In addition to cellular connectivity the adapter offers:

- A 5V Power Supply input via a 2.1mm DC barrel Jack
- Compatibility with the Raspberry Pi 3B and the Raspberry Pi Compute Module 3 I/O Board
- Two Grove sensor interfaces for unlimited sensor flexibility

Fast, easy prototyping made possible by the Skywire Raspberry Pi Adapter.

1.3 Orderable Parts

Number	Description	Manufacturer	Carrier	Network Type
NL-AB-RPI	Skywire Raspberry Pi Development Kit	NimbeLink		
NL-SW-LTE-SVZM20-ES	Skywire, 4G LTE CAT M1, Verizon, Engineering Sample	NimbeLink	Verizon	4G LTE
NL-SW-LTE-GELS3-C	Skywire, 4G LTE CAT 1, Verizon	NimbeLink	Verizon	4G LTE
NL-SW-LTE-WM14-B	Skywire, 4G LTE CAT 1, AT&T, T-Mobile	NimbeLink	AT&T, T-Mobile	4G LTE
NL-SW-LTE-TSVG	Skywire, 4G LTE CAT 3, w/ GNSS, Verizon	NimbeLink	Verizon	4G LTE
NL-SW-LTE-TNAG-B	Skywire, 4G LTE CAT 3, w/ GNSS, AT&T, T-Mobile	NimbeLink	AT&T, T-Mobile	4G LTE
NL-SW-LTE-S7588-T	Skywire, 4G LTE CAT 4, AT&T, T-Mobile	NimbeLink	Verizon	4G LTE
NL-SW-LTE-S7588-V	Skywire, 4G LTE CAT 4, Verizon	NimbeLink	AT&T, T-Mobile	4G LTE
TG.08.0113	Monopole Cellular Antenna	Taoglas		
TG.30.8113	Dipole Cellular Antenna	Taoglas		
SWI18-5-N-P6	5V 3A Power Supply	CUI		
709670110	11mm Snap-on Standoffs	Wurth Electronics		

1.4 Compatible Raspberry Pi Models

The following models of the Raspberry Pi have been tested and are confirmed to be compatible with the NL-AB-RPI. Additional Raspberry Pi models supporting the 40 pin GPIO interface are likely to be compatible, but have not been evaluated.
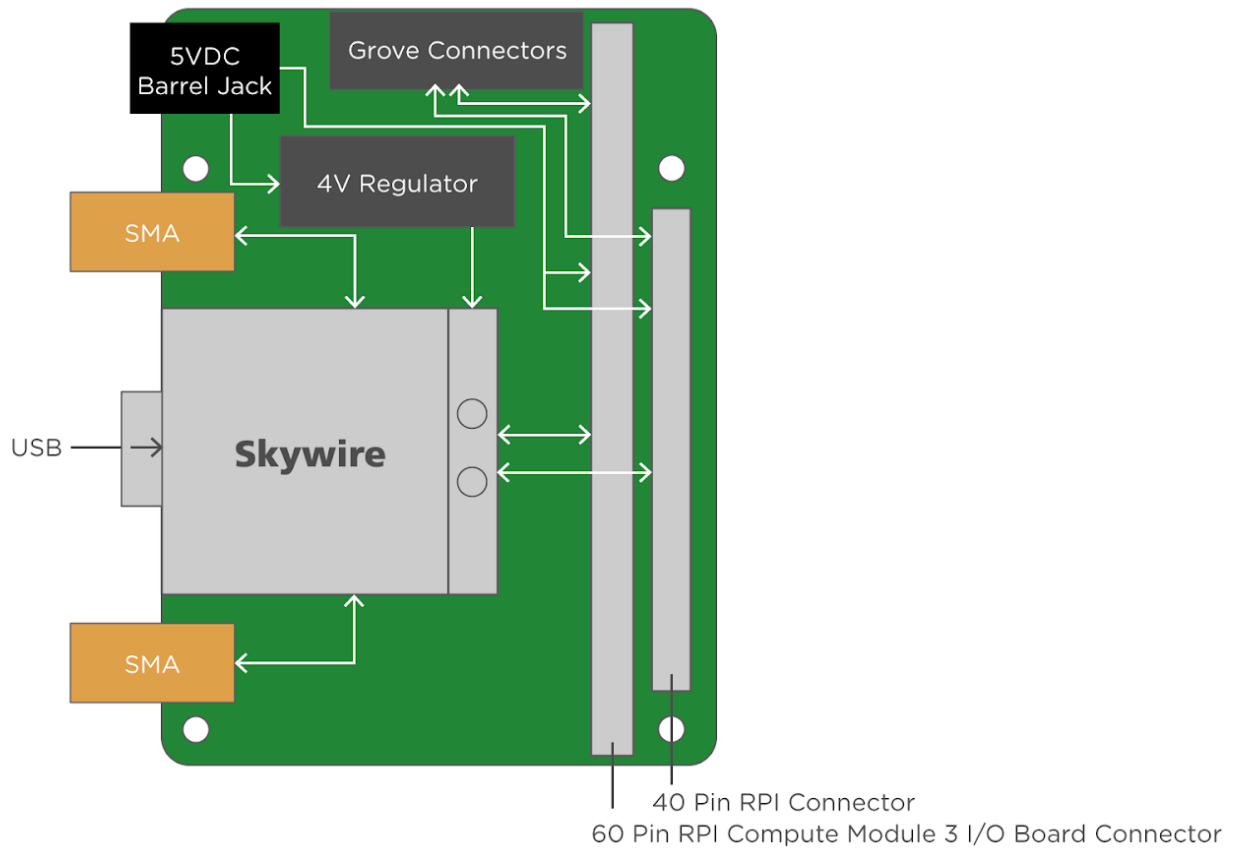
- Raspberry Pi 3
- Raspberry Pi Compute Module 3 I/O Board

1.5 Additional Resources

- NimbeLink's Skywire Raspberry Pi Development Kit Product Page

2. Technical Specifications

2.1. Block Diagram

2.2. Pinout

Connector	Direction	RPI GPIO Name	Connection	Notes
J8-3/J11-1	Input	GPIO02	J10 Grove I2C SDA	See Note 1
J8-5/J11-3	I/O	GPIO03	J10 Grove I2C SCL	See Note 1
J8-7/J11-4	Output	GPIO04	4V Regulator Enable	
J8-29/J11-11	I/O	GPIO05	J9 Grove GPIO5	See Note 1
J8-31/J11-13	I/O	GPIO06	J9 Grove GPIO6	See Note 1
J8-26/J11-15	Input	GPIO07	EEPROM WP	
J8-32/J11-25	Input	GPIO12	Skywire ON/Sleep	
J8-33/J11-27	I/O	GPIO13	Skywire ADC	
J8-8/J11-29	Output	GPIO14	Skywire DIN	
J8-10/J11-31	Input	GPIO15	Skywire DOUT	
J8-36/J11-33	Input	GPIO16	Skywire CTS	
J8-11/J11-35	Output	GPIO17	Skywire RTS	
J8-12/J11-37	Output	GPIO18	4V Regulator PG	
J8-15/J11-45	I/O	GPIO22	Skywire DIO2	See Note 1, 2
J8-16/J11-47	I/O	GPIO23	Skywire DIO3	See Note 1, 2
J8-18/J11-49	Input	GPIO24	Skywire ON-OFF	
J8-22/J11-51	Input	GPIO25	Skywire Reset	
J8-13/J11-55	Input	GPIO27	Skywire DTR	
J8-28/J11-3	Input	ID_SC	I2C ID SCL	
J8-27/J11-1	I/O	ID_SD	I2C ID SDA	

*Note 1: Not configured by DTO
*Note 2: Not connected by default, optional 0 ohm jumper can be connected to use the signal.
*Note 3: J8 is the adapters 40 pin connector for the RPI 3 and J11 is the 60 pin connector for the CM3 I/O board.

3. Getting Started

The following steps will walk users through how to set up their Raspberry Pi 3 for use with the Skywire Raspberry Pi Adapter.

This guide is written with an expectation that users are experienced with interfacing with the Raspberry Pi. Users who have not used a Raspberry Pi before should review the Raspberry Pi Foundation's getting started documentation before attempting this guide.

The Skywire Raspberry Pi Adapter will automatically configure the Raspberry Pi's serial port to be used for connecting to the Skywire modem. The Raspberry Pi's serial console must be disabled.

To access the Raspberry Pi's console it is recommended that users configure their RPI to allow for SSH over a direct Ethernet connection between a PC and the Raspberry Pi, as detailed in section 3.1.

Users are recommended to configure their Raspberry Pi for SSH and to disable the serial console before connecting the Skywire Adapter to their Raspberry Pi. This allows users to do the pre-configurations steps for disabling the serial port and configuring SSH over the GUI interface, SSH (if already configured) or through the serial port. During these steps users will need to power their Raspberry Pi through its usb power interface.

3.1. SSH

The following steps will walk users through how to configure their Raspberry Pi and their Windows PC to allow for SSH over a direct Ethernet connection. Both the PC and the Raspberry Pi will be configured to to have static IPs on the same subnet.

For additional instructions on how to enable SSH on a Raspberry Pi please refer to the Raspberry Pi Foundation's SSH documentation.

3.1.1. Configure the Raspberry Pi to allow SSH.
1. Enter *sudo raspi-config* in a terminal window.
2. Select Interfacing Options.
3. Navigate to and select SSH.
4. Select Yes.
5. Select Ok.
6. Select Finish.

3.1.2. Configure the Raspberry Pi's Ethernet to have a static IP.
1. Enter *sudo nano /etc/dhcpcd.conf* in a terminal window.
2. Add the following to the bottom of the file:

   interface eth0

   static ip_address=192.168.0.10/24

   static routers=192.168.0.1

   static domain_name_servers=192.168.0.1

   static domain_name_servers=8.8.8.8

3. Exit the editor by pressing CTRL+X then save your changes by pressing 'Y' and then hitting enter.
4. Restart the Raspberry Pi.

3.1.3. Configure your PC to have a static IP in the same subnet.
1. Open Network and sharing center.
2. Select *change adapter settings*.
3. Right click the Ethernet interface that the RPI will be attached to and select properties.
4. Double click on *Internet Protocol Version 4 (TCP/IPV4)*.
5. Select the "Use the following IP address" option and enter the following:

   IP Address: 192.168.0.11

   Subnet Mask: 255.255.255.0

   Default Gateway: 192.168.0.1

6. Select OK.

3.1.4. **Test the SSH Connection.**
1. Open a terminal program, such as Tera Term, on the PC.
2. SSH into the RPI at the 192.168.0.10 IP address.

3.2. Disable the Serial Console

Once SSH is working, disable the serial console.

3.2.1. Enter *sudo raspi-config* in a terminal window.

3.2.2. Select Interfacing Options.

3.2.3. Navigate to and select Serial.

3.2.4. Select No to disable the serial console.

3.2.5. Select yes to enable hardware serial port.

3.2.6. Select Ok.

3.2.7. Choose Finish.

3.2.8. Reboot to save changes.
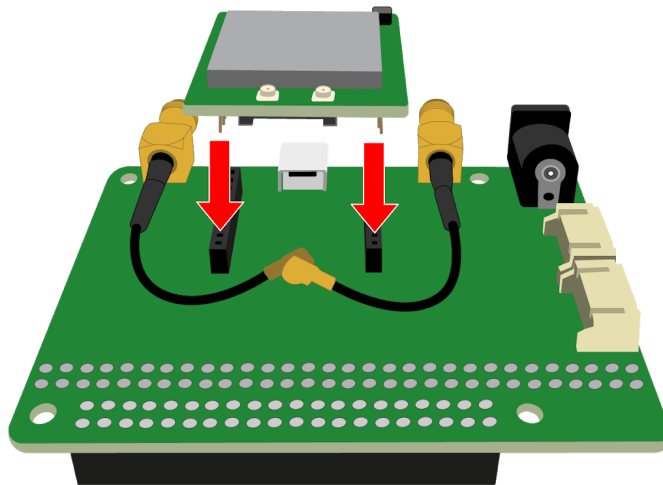
3.3. Activate Modem (one-time step)

Your Skywire cellular modem does not ship with an active cellular plan. NimbeLink provides reduced rate cellular data plans for Skywire products. To activate a data plan, please visit go.nimbelink.com to set up a data plan account.

3.4. Attaching the adapter

The following steps will detail how to connect the Skywire to the Raspberry Pi.
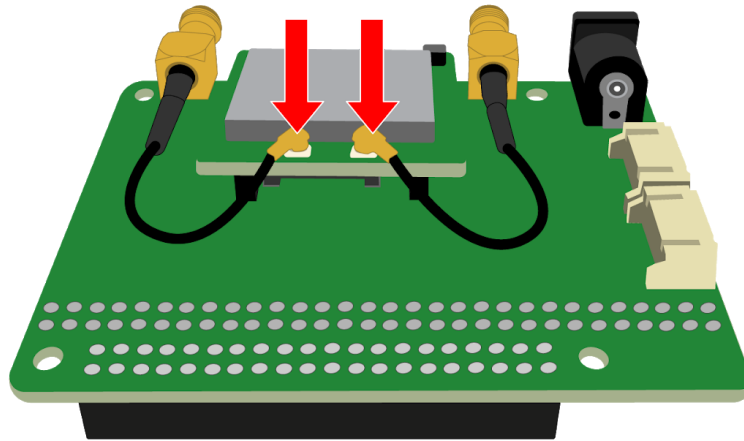
3.4.1. Skywire Placement

Mount the Skywire on the adapter with the Skywire's U.FL connectors towards the middle of the board. The U.Fl connectors should line up with the two circles on the adapters silkscreen.
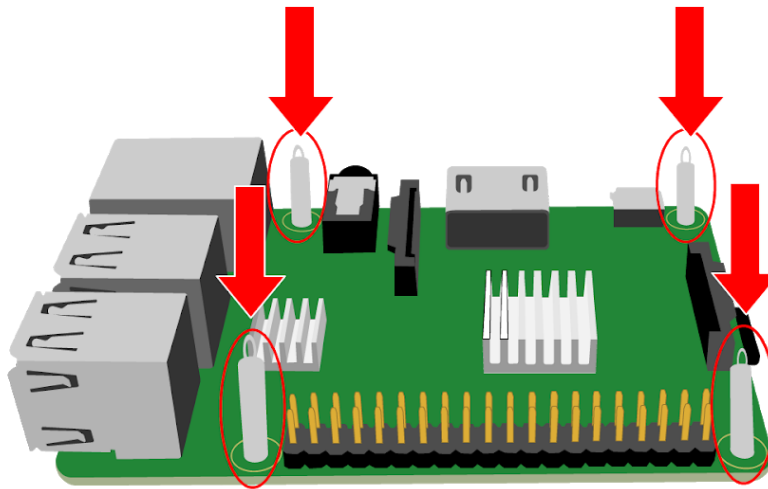
3.4.2. Connect the U.FL Antenna Cables

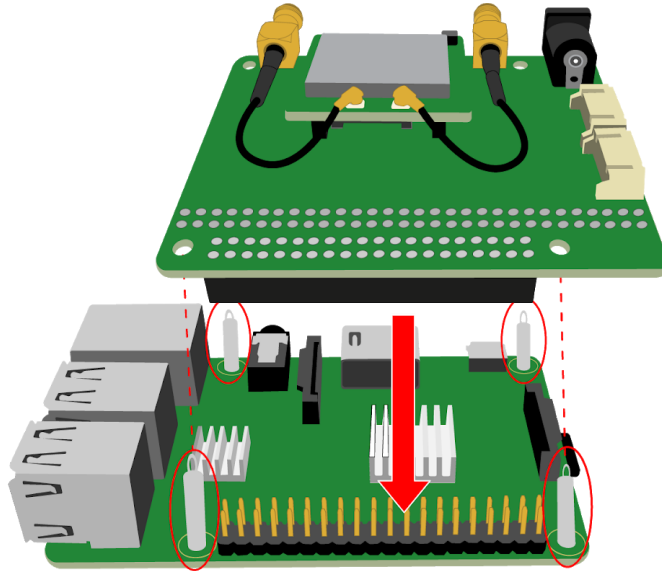Attach the U.FL antenna cables to the Skywire.

3.4.3. RPI Standoffs

Place standoffs for the adapter on the Raspberry Pi 3B (optional, but recommended).
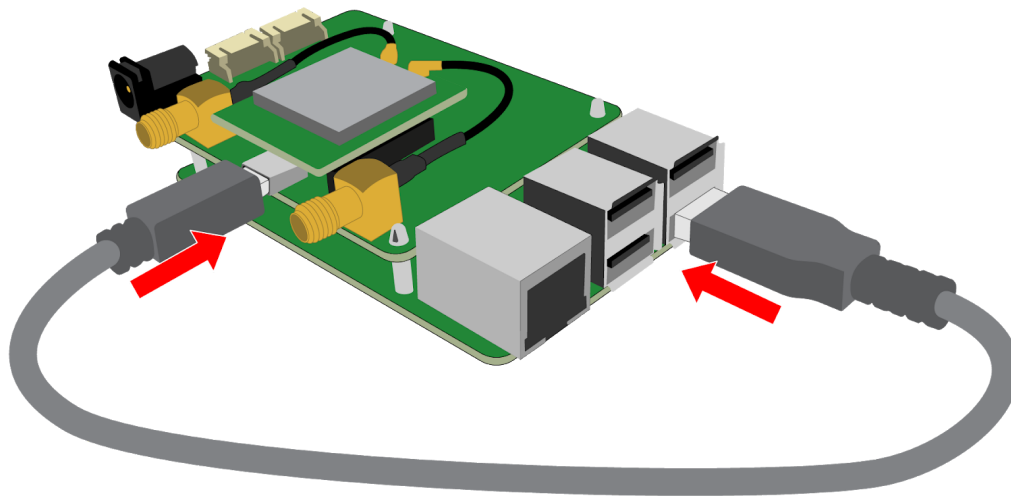
3.4.4. Adapter Placement

Align the adapters J8 header with the Raspberry Pi's J8 header and gently press the two boards together to connect them. If standoffs are being used, ensure that they are properly aligned.
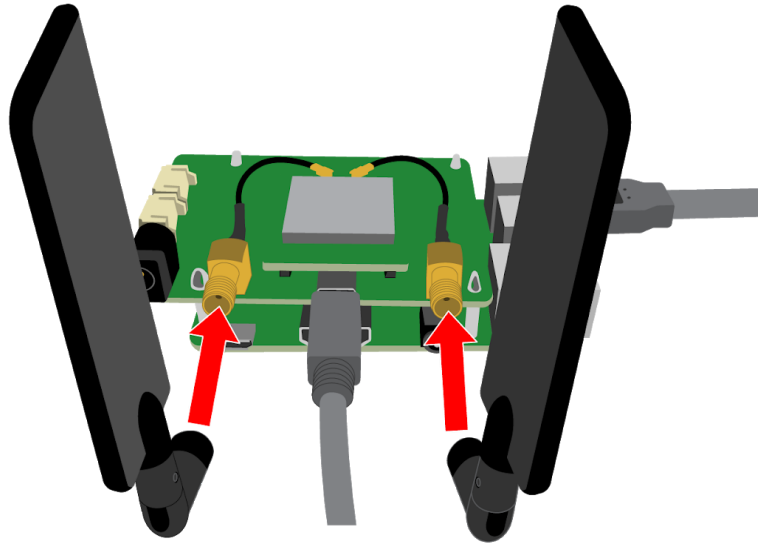

3.4.5. Connect USB

Connect the Skywire's USB interface to the Raspberry Pi's.

3.4.6. Attach Antennas

Connect the cellular antennas to the adapter.
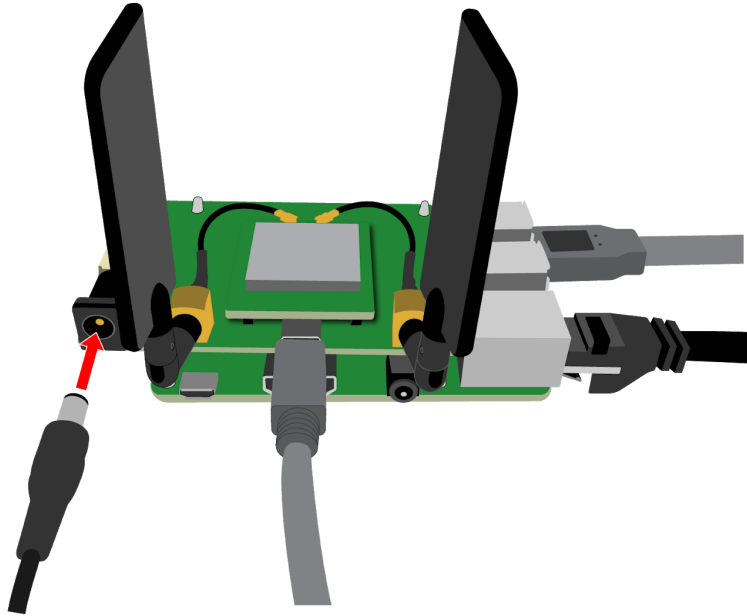

3.4.7. Attach the Ethernet cable

Attach an Ethernet connection to the RPI to allow for local SSH connection.
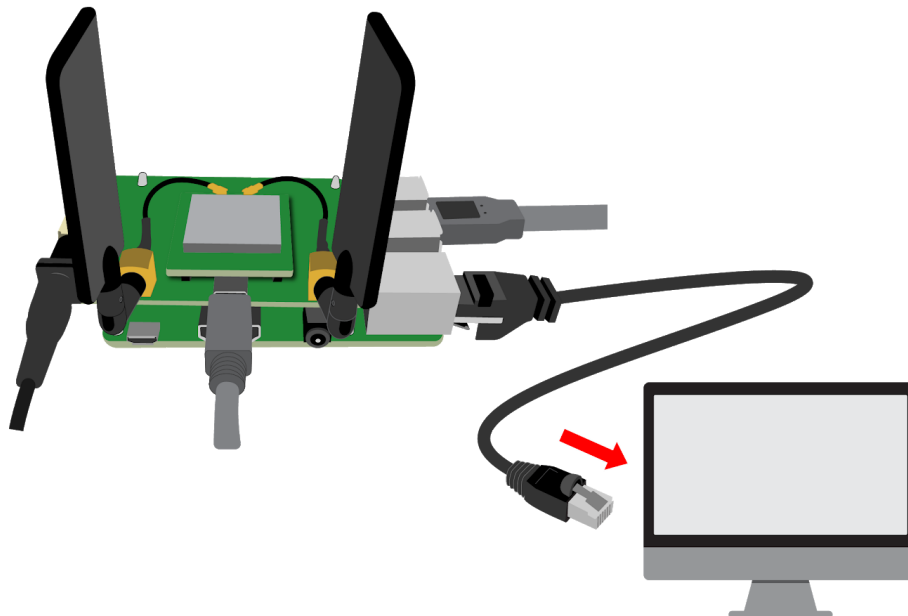
3.4.8. Apply Power

Connect +5VDC to the adapter's barrel Jack (J5). The adapter will pass the 5V power though J8 to supply the Raspberry Pi.

3.5. Connect

Connect the RPI's Ethernet to your computer's Ethernet then SSH to the Raspberry Pi over the Ethernet connection

3.6. Device Tree Overlay

The adapter's GPIO pins are automatically configured by the adapter Device Tree Overlay (DTO). You can check the system log to see if the DTO was loaded for the adapter by issuing:

`root@raspberrypi:~# cat /proc/device-tree/hat/product`

This command will query the system's device tree manager to see if it has loaded a device tree for an attached adapter. If the command is successful the system will display the name of the adapter that is attached.

If the adapter did successfully load you will see the following when you query the system:

`root@raspberrypi:~# cat /proc/device-tree/hat/product`

***RPI Skywire Adapter*`root@raspberrypi:~#`**

Due to formatting issues, the name of the adapter will not have a new line generated after it and the name will appear before the consoles prompt.

If the adapter's DTO did not successfully load you will see the following:

`root@raspberrypi:~# cat /proc/device-tree/hat/product`

`cat: /proc/device-tree/hat/product: No such file or directory`

3.7. Skywire Serial Interfacing

The adapter's Device Tree Overlay contained in its EEPROM will automatically configure the Raspberry Pi's UART to connect to the modem, with flow control (RTS/CTS). The DTO will configure the Raspberry Pi to use the hardware serial connection (ttyAMA0) with the Skywire. On the Raspberry Pi 3 it will reroute the WIFI/Bluetooth module to ttyS0.

To test the communication launch a terminal interface from the Raspberry Pi to the modem. In this example we'll use picocom to interface to the modem.

Picocom is not installed on the Raspberry Pi by default. To install Picocom connect the Raspberry Pi to the internet and run the following command to install picocom:

```
# sudo apt-get install picocom
```

On the Raspberry Pi's command line enter the following command:

```
# picocom -b 115200 -f h /dev/ttyAMA0
```

followed by the Enter key, this will launch picocom with a serial terminal connection to the modems UART port. The 115200 value is the default baudrate on most Skywire modems. Users using the NL-SW-LTE-VZM2x Skywire modems should use a baud rate of 921600.

Once picocom (or the terminal program of your choosing) has launched, issue the following command to the modem to test the UART connection:

```
AT
```

Followed by the Enter key. The modem should respond with:

OK

```
root@raspberrypi:~# picocom -b 115200 -f h /dev/ttyAMA0
picocom v1.7

port is          : /dev/ttyAMA0
flowcontrol      : RTS/CTS
baudrate is      : 115200
parity is        : none
databits are     : 8
escape is        : C-a
local echo is    : no
noinit is        : no
noreset is       : no
nolock is        : no
send_cmd is      : sz -vv
receive_cmd is   : rz -vv
imap is          :
omap is          :
emap is          : crcrlf,delbs,

Terminal ready
at
OK
```

3.8. Skywire USB Interfacing

Connector J4 on the adapter allows users to connect their Raspberry Pi directly to the Skywire's USB interface using a mini-B USB Cable. Each Skywire has a unique USB interface and users should consult the datasheet for the specific Skywire modem they're using for more details on interfacing to the modem over USB. In general users can interface with the Skywire's USB interface in the same manner as the UART when using the adapter.

Users developing with the NL-SW-LTE-VZM2x 4G LTE Cat M1 modems will need to use the modem's serial port for communication as its USB interface is for firmware updates only.

Users can set up the modems to provide a seamless network interface to their BeagleBone. Depending on the modem a different protocol, such as PPP, CDC-ETH, CDC-NCM, or QMI will be required. To set up the network connection for your modem please refer to the guide listed below for your modem. Please note that this list is not exhaustive of the reference materials for the Skywire modems and additional application notes may be available under your modem's product page in the Application Notes section.

- NL-SW-LTE-GELS3-C: Sending and Receiving Data with CDC-ECM
- NL-SW-LTE-GELS3-C: Sending and Receiving data with PPPd
- NL-SW-LTE-WM14-B: Sending and Receiving data with CDC-ETHER
- NL-SW-LTE-TSVG: Sending and Receiving data with PPPd
- NL-SW-LTE-TSVG: Sending and Receiving data with QMI
- NL-SW-LTE-TNAG: Sending and Receiving data with PPPd
- NL-SW-LTE-TNAG: Sending and Receiving data with QMI
- NL-SW-LTE-S7588-T: Sending and Receiving Data with CDC-NCM
- NL-SW-LTE-S7588-T: Sending and Receiving data with PPPd
- NL-SW-LTE-S7588-V: Sending and Receiving Data with CDC-NCM
- NL-SW-LTE-S7588-V: Sending and Receiving data with PPPd

3.9. Grove Connectors

There are two Grove Connectors onboard the adapter that allow users to attach additional digital Grove sensors. Grove connector J9 connects to GPIO5/GPIO6 to provide two GPIOs and connector J10 connects to the Raspberry Pi's I2C pins. The adapter's DTO does not load pin configurations for J15 and J16, but many distributions will automatically configure I2C1 at boot.

NOTE: Applications using the Grove connectors on NL-AB-RPI adapter board with PCB revision 1001430 REV A are affected by Errata 1001468.

4. Additional Resources

- [Skywire Cellular Modems Product Page](#)
- [Sending and Receiving files with FTP](#)
- [Sending and Receiving data with Socket Dials](#)
- [Sending and Receiving SMS messages](#)
- [Sending GPS data using Python](#)
- [Defining PDP Contexts MSCs](#)
- [Streaming Video over LTE on BBC](#)
- [Starting PPP at Boot](#)
- [Starting PPP with SSH over Ethernet](#)