Airgain

SKYWIRE 4G LTE CAT 1 BIS EMBEDDED CELLULAR MODEM

Networking Guide

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1 Introduction

1.1 Scope

The aim of this document serves as a guide for implementing ECM, RNDIS, and PPP with the Nimbelink Skywire® embedded modem. This guide will include instructions for both Windows and Linux operating systems.

Throughout this guide, some instructions and drivers will vary based on the module type. See the table in *Orderable Part Numbers* for more details.

1.2 Orderable Part Numbers

Orderable Device	Description	Carrier	Type	Network
NL-SWDK2	Skywire Development Kit 2	Any	Any	Any
NL-SW-LTE-TC1bisNAG	LTE (Cat 1 bis)	Any	Telit	LTE
NL-SW-LTE-QC1bisWWG	LTE (Cat 1 bis)	Any	Quectel	LTE

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2 Windows Networking

The following subsections provide setup instructions for the protocols on Windows: - Ethernet Control Model (ECM) - Remote Network Driver Interface (RNDIS) Specification - Point-to-Point (PPP) Dial-up

2.1 USB Drivers

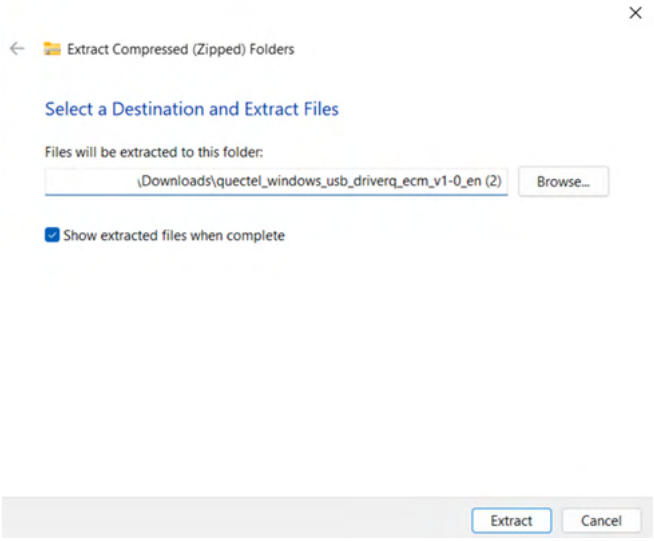
Install the appropriate drivers below depending on model and protocol:

Model	Proto-col(s)	Driver
NL-SW-LTE-QC1bisWWG	ECM	https://www.quectel.com/download/quectel_windows_usb_driverq_ecm_v1-0_en/
	RNDIS	https://www.quectel.com/download/quectel_lte_windows_usb_driver_rndis_v1-1/
NL-SW-LTE-TC1bisNAG	RNDIS	https://www.telit.com/evkevb-drivers/

Example: QC1bisWWG ECM Driver Installation

This section shows an example of the Windows installation process if using NL-SW-LTE-QC1bisWWG for ECM protocol. The USB driver installation process for other scenarios are similar. Follow the instructions provided with the drivers for more information.

1. Download the ECM driver for Windows listed in *USB Drivers*
2. Right-click on the ZIP file and click **Extract All...**
3. Choose the location to extract the ZIP file to and click **Extract**.



4. The extracted folder opens and shows an installation guide and driver subfolder.

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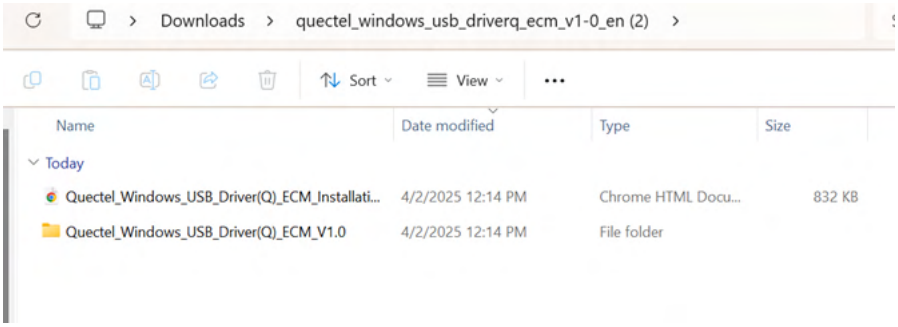
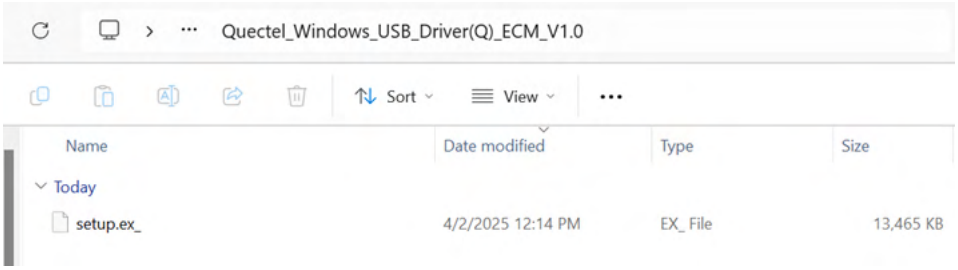
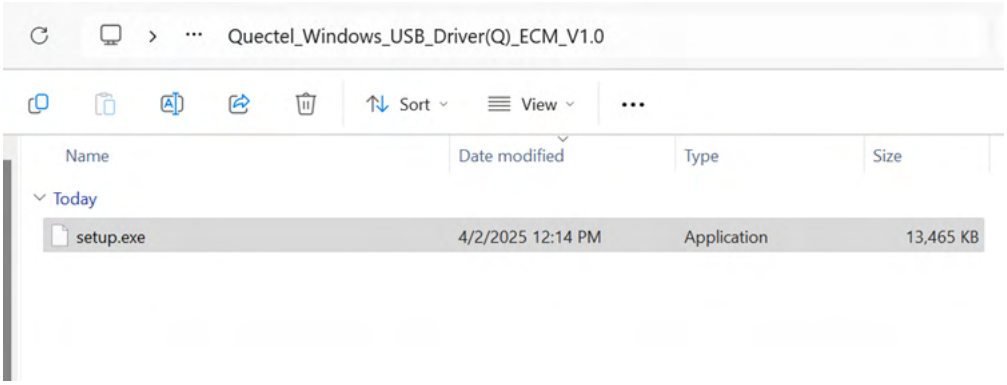


5. Double-click the subfolder and locate the file: **setup.exe_**:



6. Right-click the file, click **Rename**, and rename the file to **setup.exe**:



7. Double-click the .exe file to start driver installation.

> **Note**
>
> If Windows indicates the file is from an unknown publisher, click **Run anyway**

8. When the installation wizard appears, click **Next>** or choose a different installation folder.

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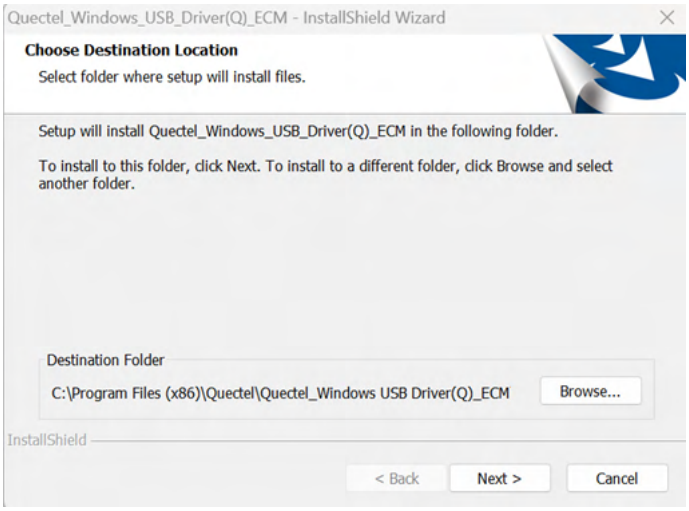
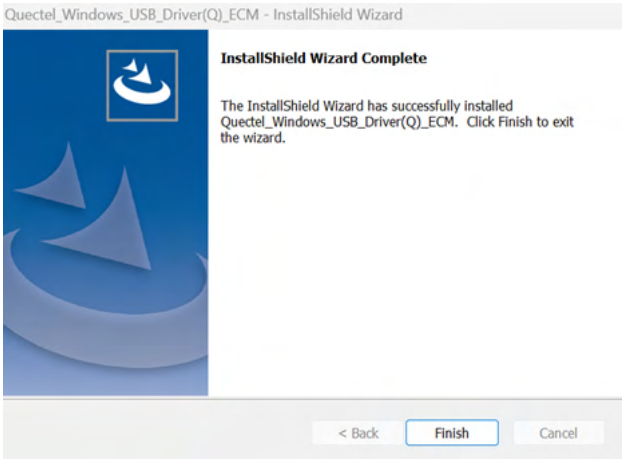


9. Click **Next>** again to continue with the installation.
10. After the driver is installed, click **Finish** when you should see this message:



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2.2 Ethernet Control Model (ECM)

Attention

Ensure that the appropriate drivers from *USB Drivers* are installed before proceeding to this section.

Note

This section applies to the NL-SW-LTE-QC1bisWWG only. The NL-SW-LTE-QC1bisWWG also supports ECM for Linux. Other modules support ECM for Linux but not Windows.

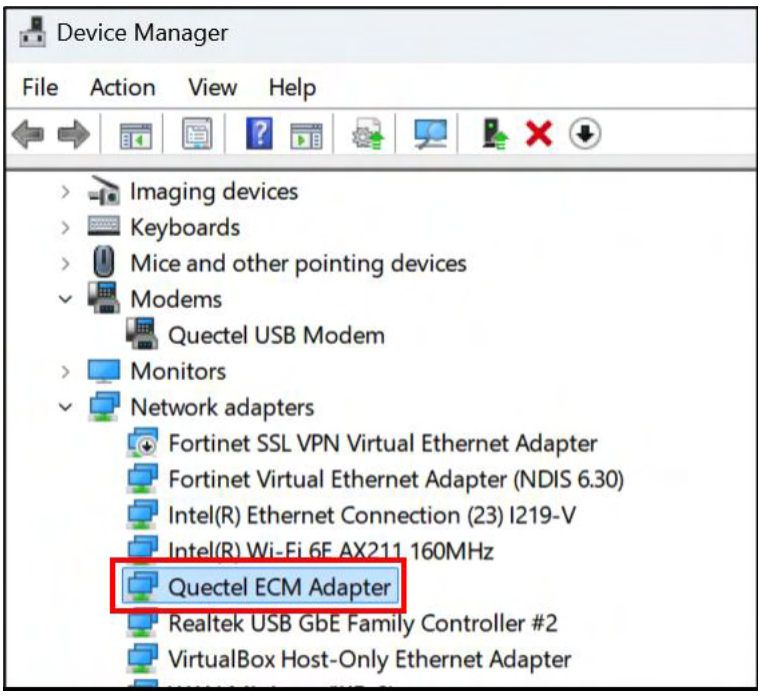
The ECM enables the QC1bisWWG to act as a network interface over USB. When configured as an ECM, the modem creates a network adapter on Windows to provide internet connectivity over USB.

Follow the steps below to set up the modem as an ECM:

1. Connect the QC1bisWWG modem to a Windows PC and verify registration with the cellular network. Once registration is verified, enter the following command to set the modem to ECM mode:

   AT+QCFG="usbnet",1

2. Open **Device Manager** in Windows, and confirm the modem appears as below:



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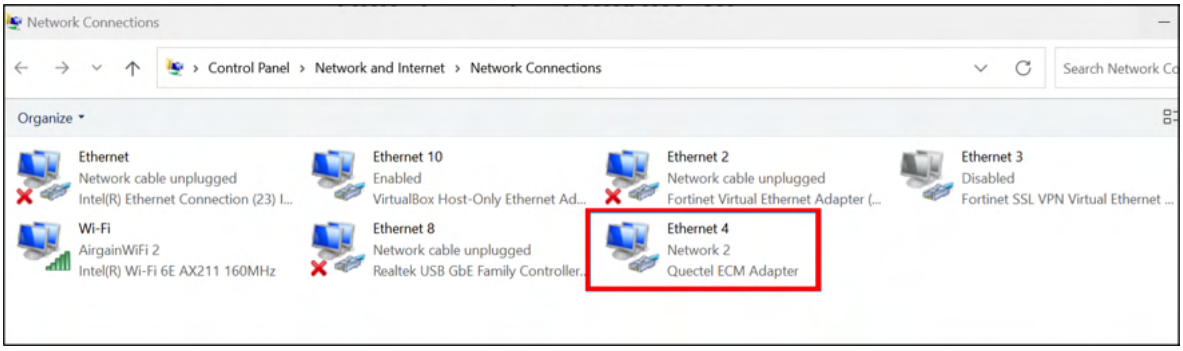
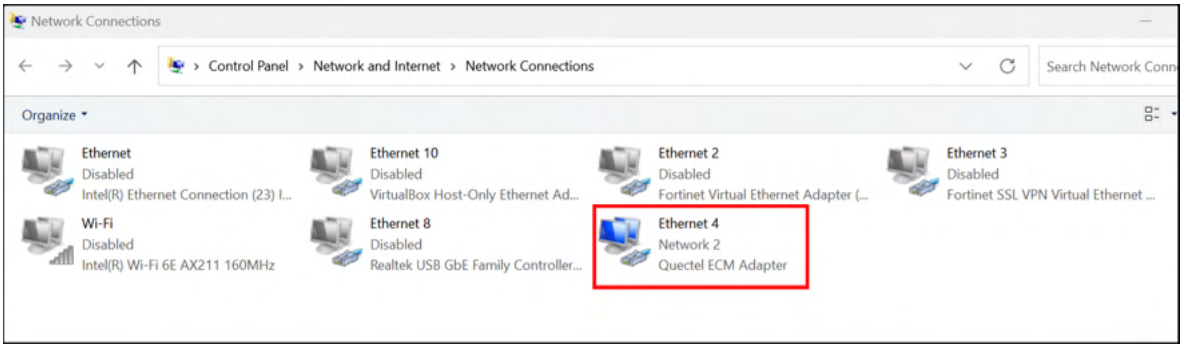
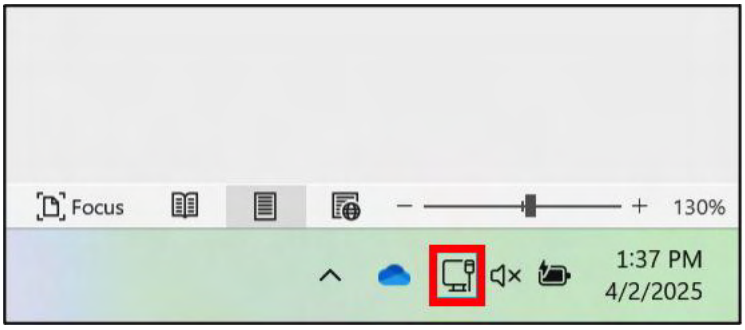
3. Once this is verified, search for “network connections” in the Windows search bar. Click **View network connections** when it appears and verify that an Ethernet connection named “Quectel ECM Adapter” is present:



4. Disable any network adapter(s) that already provide an internet connection, such as other Ethernet adapters or Wi-Fi connections. Only the **Quectel ECM Adapter** must be enabled:



Your Windows PC should now be connected to the Internet via the QC1bisWWG. To verify, hover over the network indicator on the Windows taskbar:



A popup indicates the PC is connected to the Internet via Network 2, which corresponds to the Quectel ECM Adapter:

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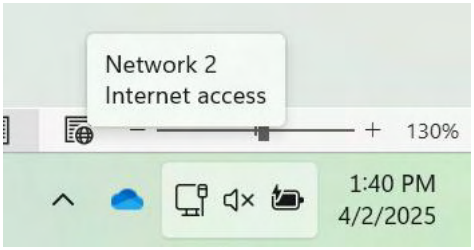

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2.3 Remote Network Driver Interface Specification (RNDIS)

Attention

Ensure that the appropriate drivers from *USB Drivers* are installed before proceeding to this section.

Note

If using a Skywire with a Quectel module, ensure any Windows ECM USB drivers are uninstalled before installing the Quectel RNDIS drivers.

RNDIS enables the Skywire to act as a virtual Ethernet adapter, communicating with TCP/IP protocols over USB to the Windows PC. The steps below illustrate how to set up the modem with RNDIS:

1. Connect the Skywire modem to a Windows PC and verify registration with the cell network. Once registration is verified, enter the following command to set the modem to RNDIS mode:

   For Quectel modems:

   ```
   AT+QCFG="USBNET", 3
   ```

   For Telit modems:

   ```
   AT#USBCFG=0
   AT#RNDIS=<Cid>,0
   ```

   Where *<Cid>* is the context ID used for internet access by the modem, typically in the range [1-6].

2. Open **Device Manager** in Windows, and confirm that the modem appears as below:

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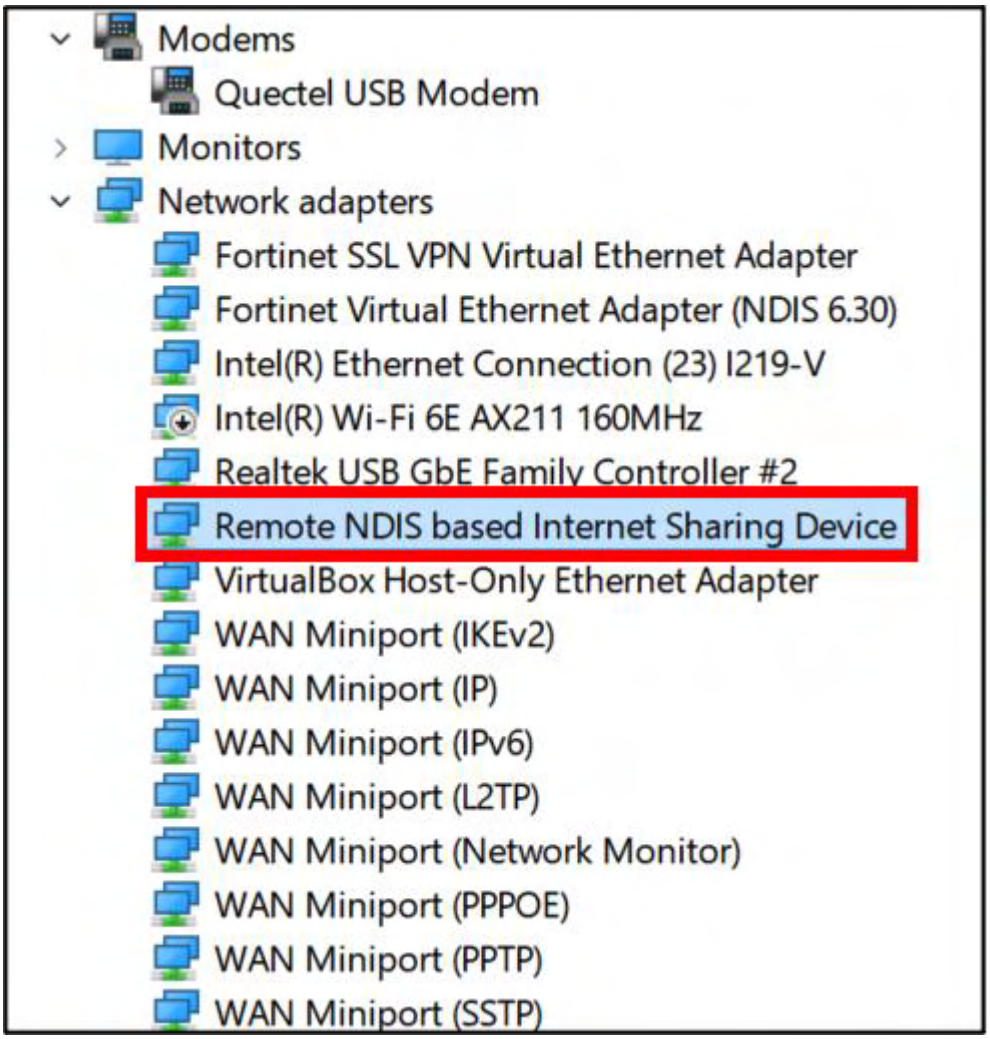
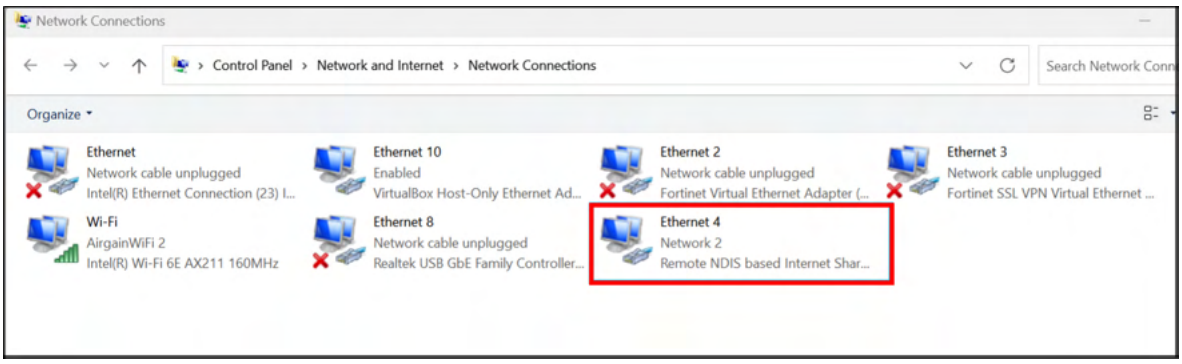


3. Once verified, search for "*network connections*" in the Windows search bar.
4. Click **View network connections** when it appears and verify that an Ethernet connection named "*Remote NDIS Based Internet Sharing Device*" is present:



5. Disable any network adapter(s) that already provide an internet connection, such as other Ethernet adapters or Wi-Fi connections. Only the **Remote NDIS Based Internet Sharing Device** must be enabled:

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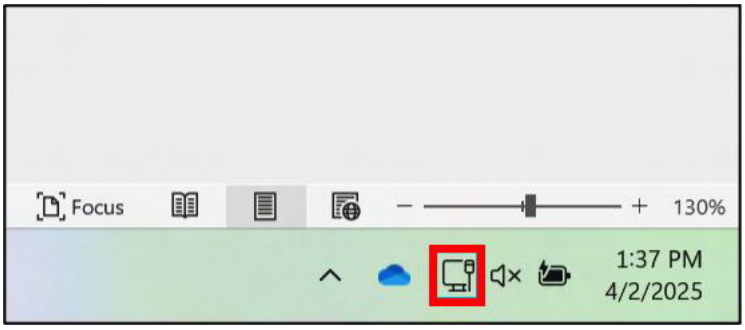
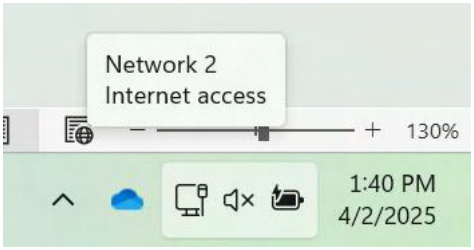
Your Windows PC should now be connected to the Internet. To verify, hover over the network indicator on the windows taskbar:



A popup indicates the PC is connected to the Internet via *Network 2*, which corresponds to the RNDIS device:



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2.4 Point-to-Point Protocol (PPP)

Attention

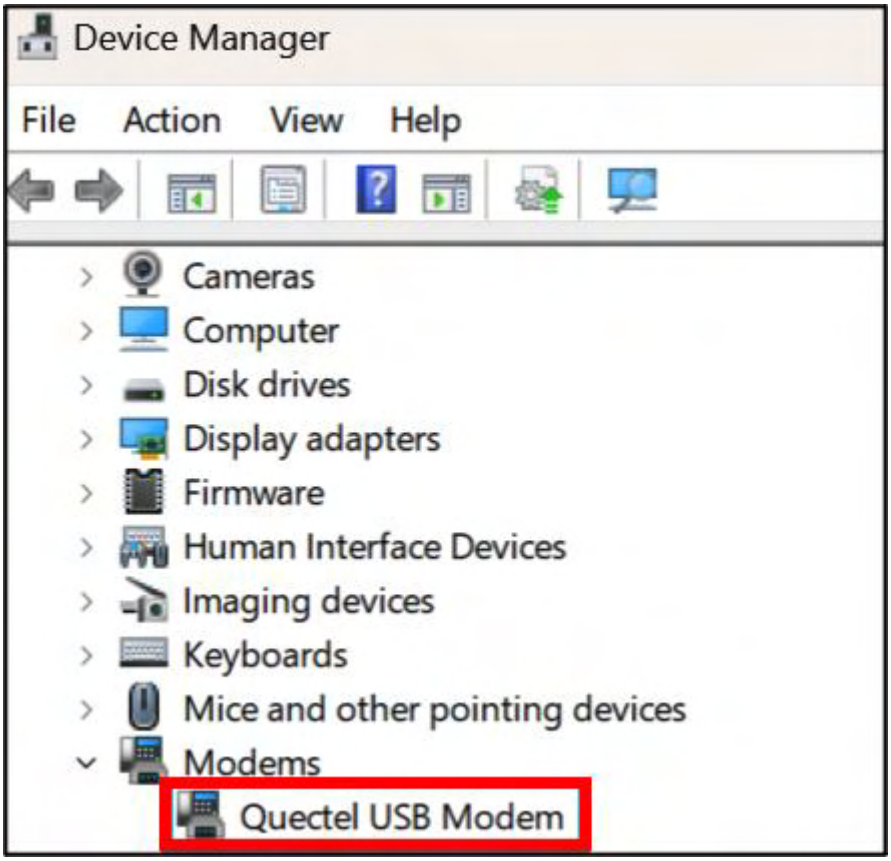
This section applies to the NL-SW-LTE-QC1bisWWG only.

The QC1bisWWG modem can also be used with PPP dial-up in Windows. The steps below show how to set up the QC1bisWWG as a dial-up connection:

Note

These steps use the Quectel ECM drivers, but the RNDIS drivers work as well.

1. Power on the modem and open **Device Manager**.
2. Navigate to **Modems** and ensure the **Quectel USB Modem** is present:



3. Once verified, search for *"Phone"* in the Windows search bar, and click **Phone and Modem**:

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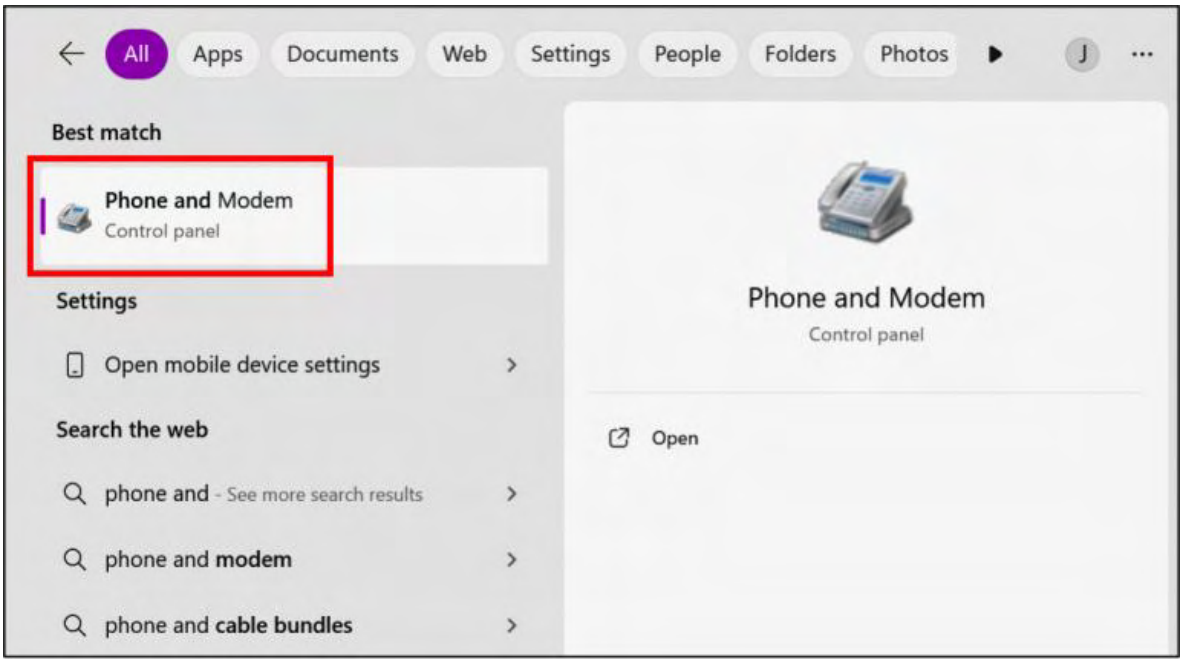
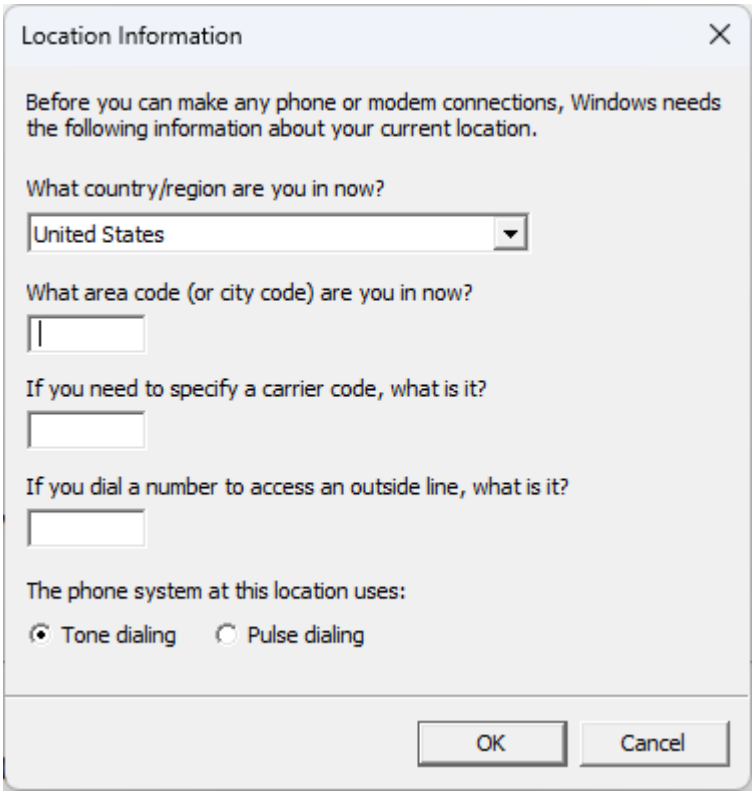


4. If prompted for an area code, enter the corresponding area code (or city code) in which you are testing; leave the other fields blank:



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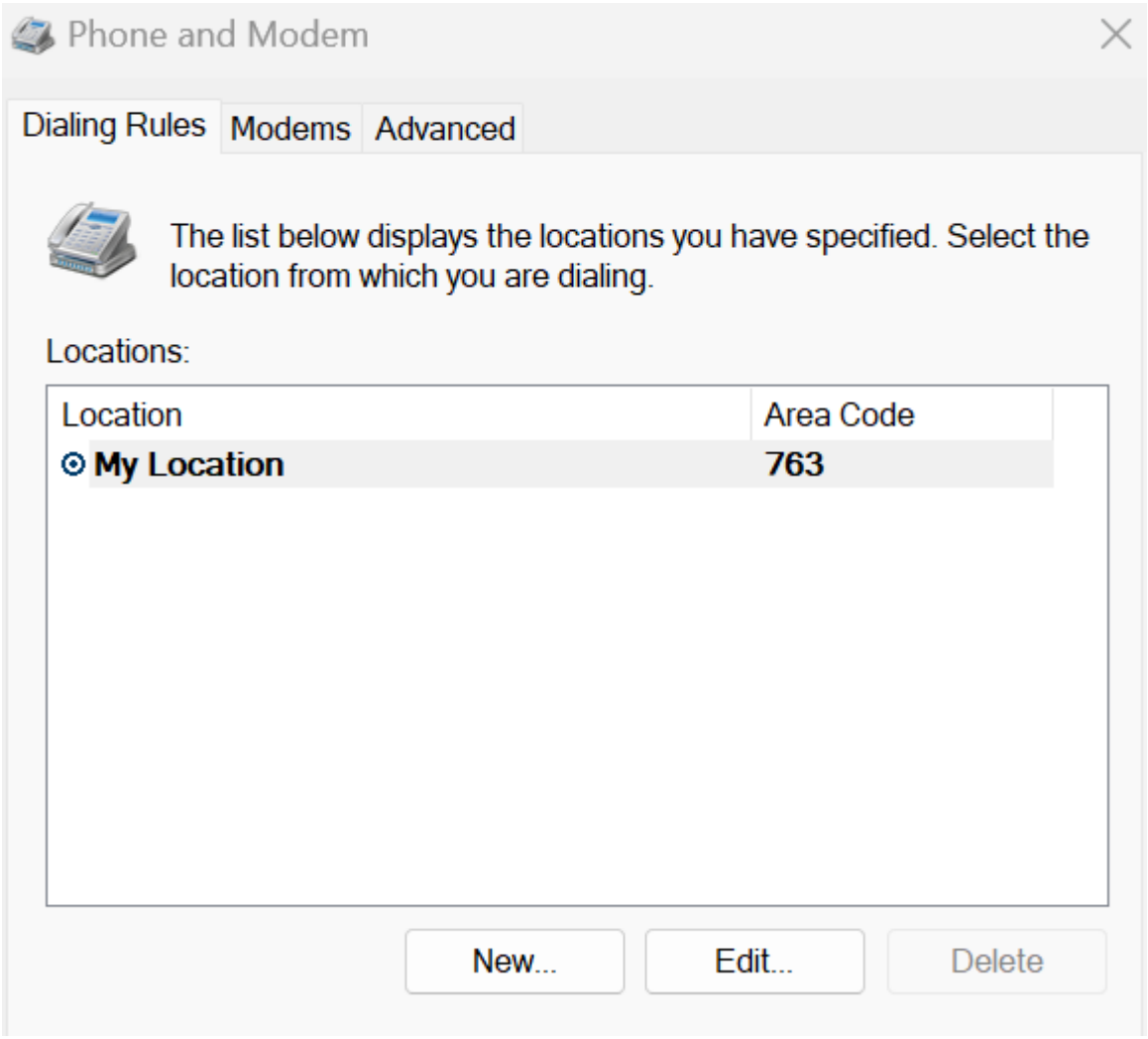

5. Select the **Modems** tab and verify that your modem appears as below:

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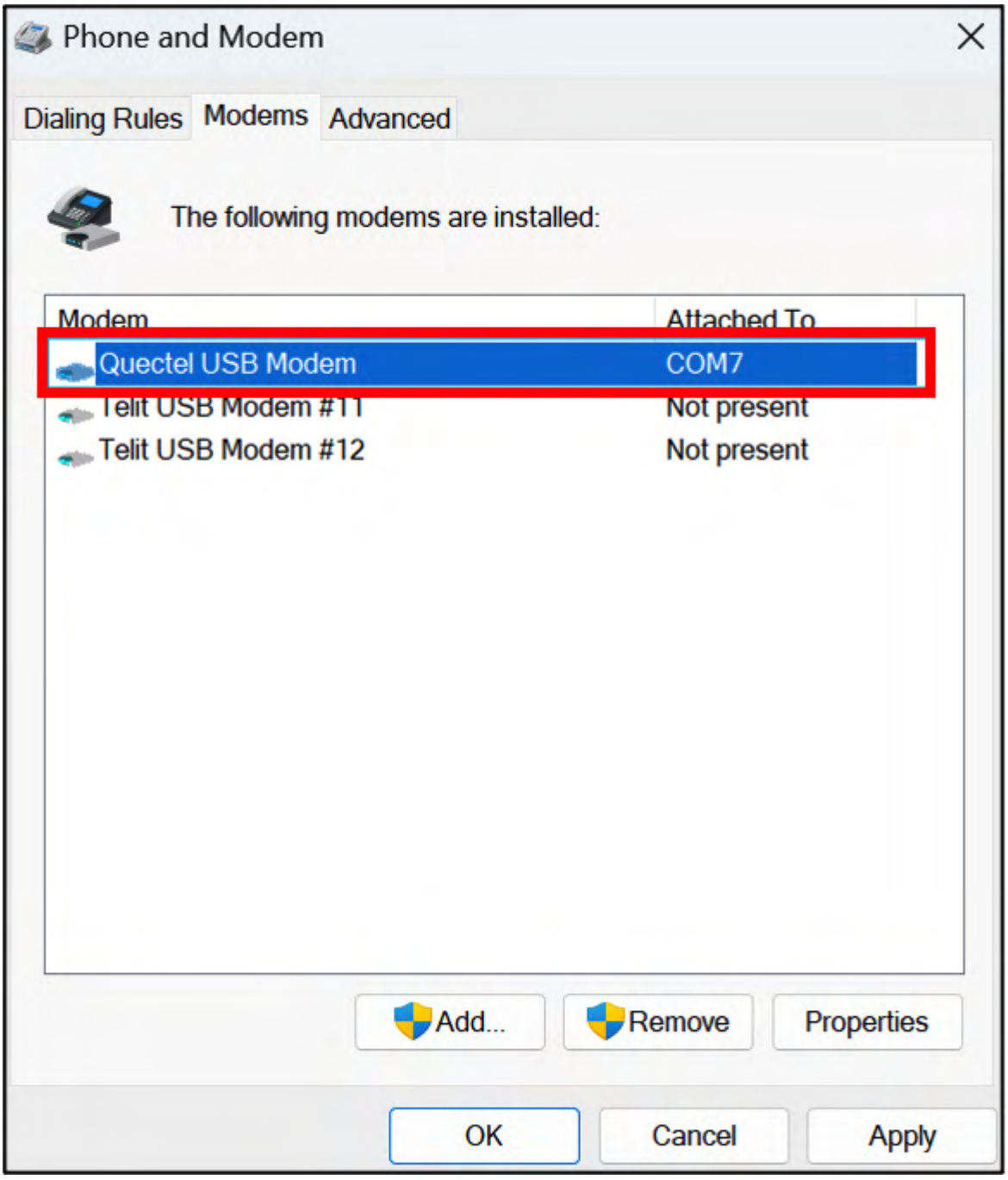

Note

The COM port may vary depending on your system.

6. Open **Control Panel**, navigate to **Network and Internet > Network and Sharing Center**, and click **Set up a new connection or network**:

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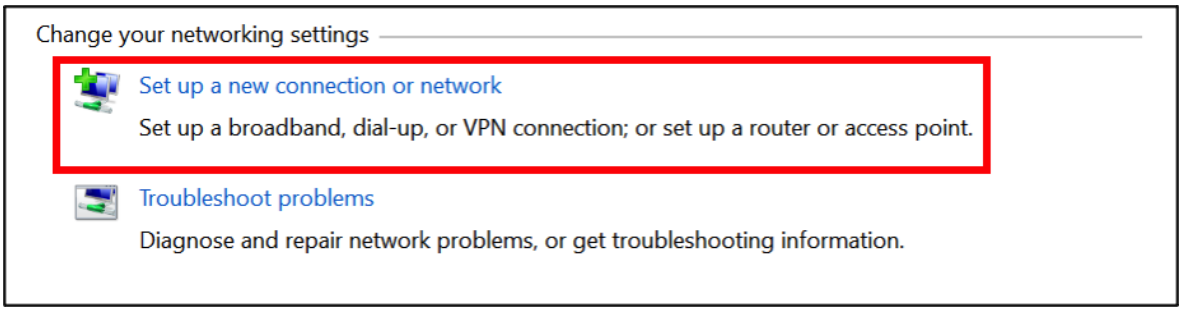
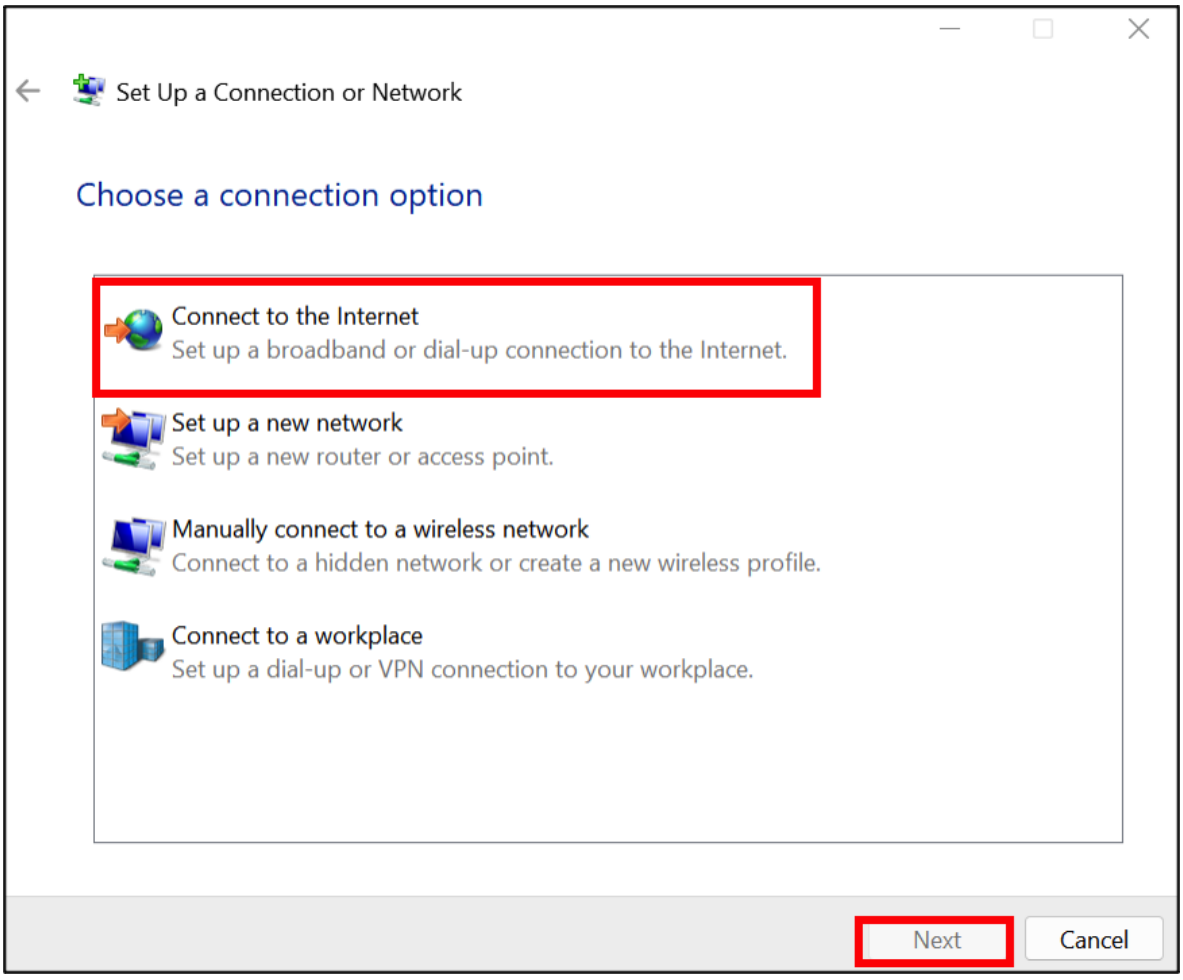


7. In the **Set Up a Connection or Network** window that appears, select **Connect to the internet** and click **Next**:



8. Click **Set up a new connection anyway** and then click **"Dial-up"**.
9. In the **Dial-up phone number** field, enter a number such as **"*99#"**, and click **Connect**:

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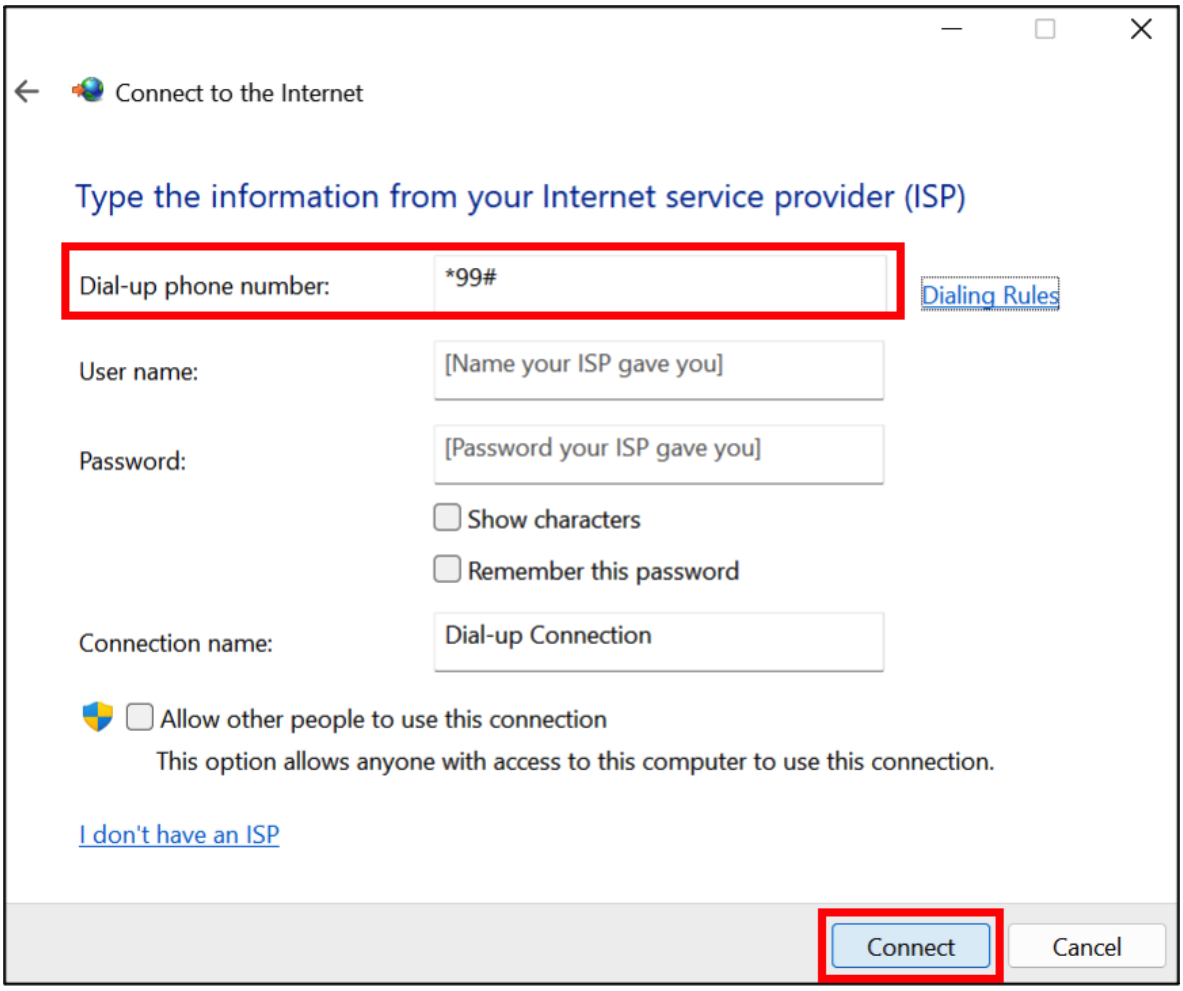

A message stating *"The connection to the Internet is ready to use"*‘ appears:

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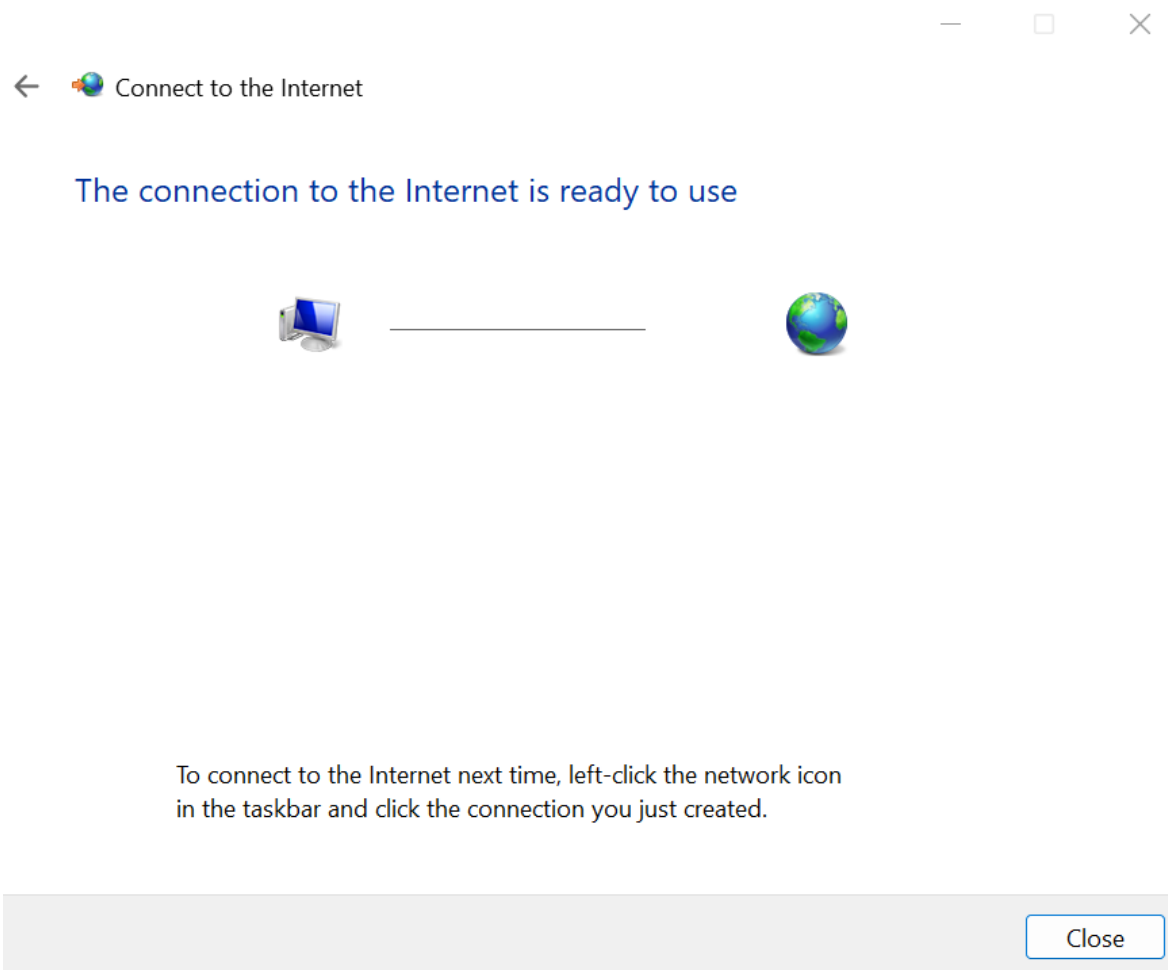

Note

If this step fails, verify the Quectel driver (ECM/RNDIS) installation and ensure the *AT+QCFG="usbnet"* command is set to the correct protocol:

AT+QCFG="usbnet",1 – sets the device to ECM mode

AT+QCFG="usbnet",3 – sets the device to RNDIS mode.

Reboot the device after issuing the command.

10. Open **Network Connections** in Windows and ensure that the **Dial-up Connection** is shown with the **Quectel USB Modem**:

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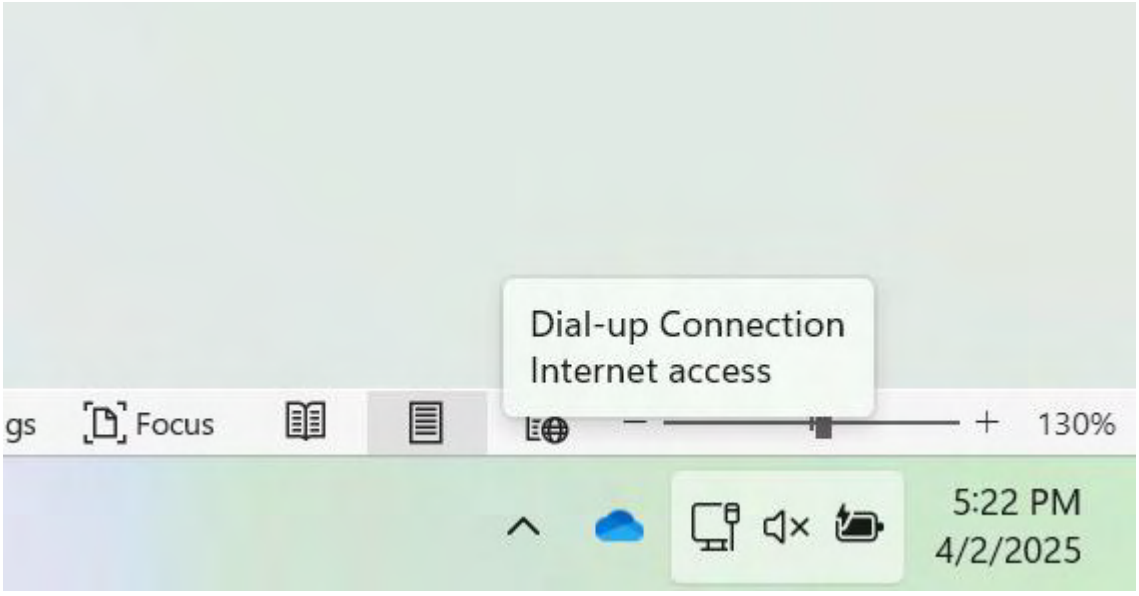
11. Hover over the Windows network icon to display the dial-up connection:



A dial-up connection is now successfully set up. If the popup shows another network, ensure that other network adapters are disabled.

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3 Linux Networking

The following subsections provide setup instructions for the protocols on Linux: - Ethernet Control Model (ECM) - Remote Network Driver Interface (RNDIS) Specification - Point-to-Point (PPP) Dial-up

3.1 USB Drivers

Follow the guides below according to the model:

Model	Driver
NL-SW-LTE-QC1bisWWG	https://www.quectel.com/download/quectel_lte5g_linux_usb_driver_v1-0-2/
NL-SW-LTE-TC1bisNAG	https://www.telit.com/evkevb-drivers/

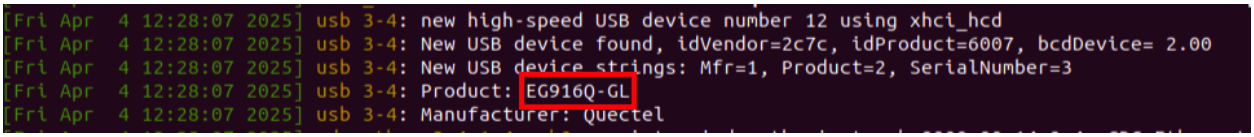
Note

Linux driver Installation may differ based on your Linux distribution or processor.

These drivers may not be required if your Linux PC recognizes the device. To check if the PC recognizes the device, open a terminal and invoke the following command to enable kernel/driver logs:

```
dmesg -Tw
```

A modem corresponding to the Skywire model should appear in the list. The image below shows an example for the NL-SW-LTE-QC1bisWWG, showing the EG916Q-GL.



If the module is not recognized, the drivers need to be installed.

3.2 Ethernet Control Model (ECM)

Attention

This section assumes that Linux USB drivers have already been installed, and the modem is registered on the network. If this driver has not been installed, see *USB Drivers*.

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ECM enables the modem to act as a network interface over USB. When configured for ECM, the modem creates a network adapter on Linux to provide internet connectivity over USB. The steps below illustrate how to set up the modem as an ECM:

> **Note**
>
> To issue commands to the modem, you can use a terminal emulator program of your choice. This documentation uses Picocom, a Linux terminal emulator program. For more information regarding Picocom setup/usage, visit Picocom's GitHub.

1. Open two terminals and invoke the following command in the first terminal to stream messages generated by the kernel and device drivers:

   ```
   dmesg -Tw
   ```

   > **Note**
   >
   > The second terminal is used to issue subsequent commands in the steps below.

2. Connect the modem to a Linux PC over serial/USB and verify registration with the cell network.
3. Enter the following command to set the modem to ECM mode:

   For Quectel modems:

   ```
   AT+QCFG="usbnet",1
   ```

   For Telit modems:

   ```
   AT#USBCFG=1
   AT#ECM=<Cid>,0
   ```

   Where *<Cid>* is the context ID used for internet access.

   The output should look similar to the following:

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```
Type [C-a] [C-h] to see available commands
Terminal ready
at+qcfg="usbnet",1
OK
at
OK
at+qpowd
OK

POWERED DOWN
^boot.rom□□v□□!\n
RDY
at
OK
at+qcfg="usbnet"
+QCFG: "usbnet",1

OK
```

4. Enter the following command to reboot the modem:

```
AT+CFUN=1,1
```

The modem should now be configured to ECM mode.

The terminal that outputs the kernel and device drivers, updates when the device reboots and displays messages similar to the following:

```
[Fri Apr  4 12:28:07 2025] usb 3-4: new high-speed USB device number 12 using xhci_hcd
[Fri Apr  4 12:28:07 2025] usb 3-4: New USB device found, idVendor=2c7c, idProduct=6007, bcdDevice= 2.00
[Fri Apr  4 12:28:07 2025] usb 3-4: New USB device strings: Mfr=1, Product=2, SerialNumber=3
[Fri Apr  4 12:28:07 2025] usb 3-4: Product: EG916Q-GL
[Fri Apr  4 12:28:07 2025] usb 3-4: Manufacturer: Quectel
[Fri Apr  4 12:28:07 2025] cdc_ether 3-4:1.4 usb0: register 'cdc_ether' at usb-0000:00:14.0-4, CDC Ethernet Device, 22:89:84:6a:96:ab
[Fri Apr  4 12:28:08 2025] cdc_ether 3-4:1.4 enp0s20u4i4: renamed from usb0
```

This indicates that the kernel recognized the module and loaded the *cdc_ether* driver for use in ECM mode.

5. Invoke *ifconfig* to display all active network adapters connected to the system:

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```
root@nimbelink-test-4:/etc/ppp/peers# ifconfig
enp0s20u4i4: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 192.168.10.2  netmask 255.255.255.0  broadcast 192.168.10.255
        inet6 fe80::32e7:e1bd:d9fe:ed92  prefixlen 64  scopeid 0x20<link>
        ether 22:89:84:6a:96:ab  txqueuelen 1000  (Ethernet)
        RX packets 2  bytes 356 (356.0 B)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 38  bytes 5528 (5.5 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

enp4s0: flags=4099<UP,BROADCAST,MULTICAST>  mtu 1500
        ether b4:b5:2f:7a:36:a8  txqueuelen 1000  (Ethernet)
        RX packets 0  bytes 0 (0.0 B)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 0  bytes 0 (0.0 B)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

enx8cae4cfa6bba: flags=4099<UP,BROADCAST,MULTICAST>  mtu 1500
        ether 8c:ae:4c:fa:6b:ba  txqueuelen 1000  (Ethernet)
        RX packets 0  bytes 0 (0.0 B)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 0  bytes 0 (0.0 B)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

wlo1: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 192.168.1.109  netmask 255.255.252.0  broadcast 192.168.3.255
        inet6 fe80::4946:21ba:eae7:97eb  prefixlen 64  scopeid 0x20<link>
        ether 08:3e:8e:87:b5:01  txqueuelen 1000  (Ethernet)
        RX packets 923378  bytes 1213134699 (1.2 GB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 435613  bytes 44670575 (44.6 MB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

root@nimbelink-test-4:/etc/ppp/peers#
```

Note

If the command isn't available, invoke *sudo apt install net-tools* to install it.

The *enp0s20u4i4* adapter corresponds to the modem as shown above:

```
[Fri Apr  4 12:28:07 2025] cdc_ether 3-4:1.4 usb0: register 'cdc_ether' at usb-0000:00:14.0-4, CDC Ethernet Device, 22:89:84:6a:96:ab
[Fri Apr  4 12:28:08 2025] cdc_ether 3-4:1.4 enp0s20u4i4: renamed from usb0
```

6. If the *enp0s20u4i4* adapter isn't shown, enter the following command to activate the network adapter:

```
ifconfig enp0s20u4i4 up
```

Note

Network adapter naming may vary based on your system. View the kernel log to see applicable adapter naming.

7. Enter the following command to test the internet connection:

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```
ping 8.8.8.8 -I <network adapter name>
```

This command pings a publicly-accessible IP, in this case: *8.8.8.8*, which is one of Google's primary DNS servers.

The following screenshot shows an example of pinging via the ECM adapter, where *<network adapter name>* is set to *enp0s20u4i4*:

```
root@nimbelink-test-4:/# ping 8.8.8.8 -I enp0s20u4i4
PING 8.8.8.8 (8.8.8.8) from 192.168.10.2 enp0s20u4i4: 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=114 time=271 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=114 time=111 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=114 time=148 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=114 time=128 ms
64 bytes from 8.8.8.8: icmp_seq=5 ttl=114 time=126 ms
64 bytes from 8.8.8.8: icmp_seq=6 ttl=114 time=125 ms
64 bytes from 8.8.8.8: icmp_seq=7 ttl=114 time=144 ms
64 bytes from 8.8.8.8: icmp_seq=8 ttl=114 time=125 ms
64 bytes from 8.8.8.8: icmp_seq=9 ttl=114 time=122 ms
^C
--- 8.8.8.8 ping statistics ---
9 packets transmitted, 9 received, 0% packet loss, time 8008ms
rtt min/avg/max/mdev = 111.027/145.114/271.739/46.040 ms
root@nimbelink-test-4:/#
```

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3.3 Remote Network Driver Interface Specification (RNDIS)

Attention

This section assumes that Linux USB drivers have already been installed, and the modem is registered on the network. If this driver has not been installed, see *USB Drivers*.

RNDIS enables the modem to act as a virtual Ethernet adapter and communicate with TCP/IP protocols over USB to the Linux PC. The steps below show how to set up the modem with RNDIS:

Note

To issue commands to the modem, you can use a terminal emulator program of your choice. This documentation uses Picocom, a Linux terminal emulator program. For more information regarding Picocom setup/usage, visit Picocom's GitHub.

1. Open two terminal windows and issue the following command in the first terminal:

   ```
   dmesg -Tw
   ```

   This streams messages generated by the kernel and device drivers.

   Note

   The second terminal is used to issue subsequent commands in the steps below.

2. Connect the modem to a Linux PC over serial/USB and verify registration with the cellular network.
3. Invoke the following command to set the modem to RNDIS mode:

   For Quectel modems:

   ```
   AT+QCFG="usbnet",3
   ```

   For Telit modems:

   ```
   AT#USBCFG=0
   AT#RNDIS=<Cid>,0
   ```

   Where *<Cid>* is the context ID used for internet access.

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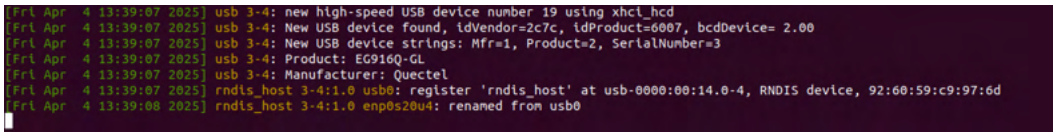
4. Invoke the following command to reboot the modem:

```
AT+CFUN=1,1
```

The modem should now be configured in RNDIS mode.

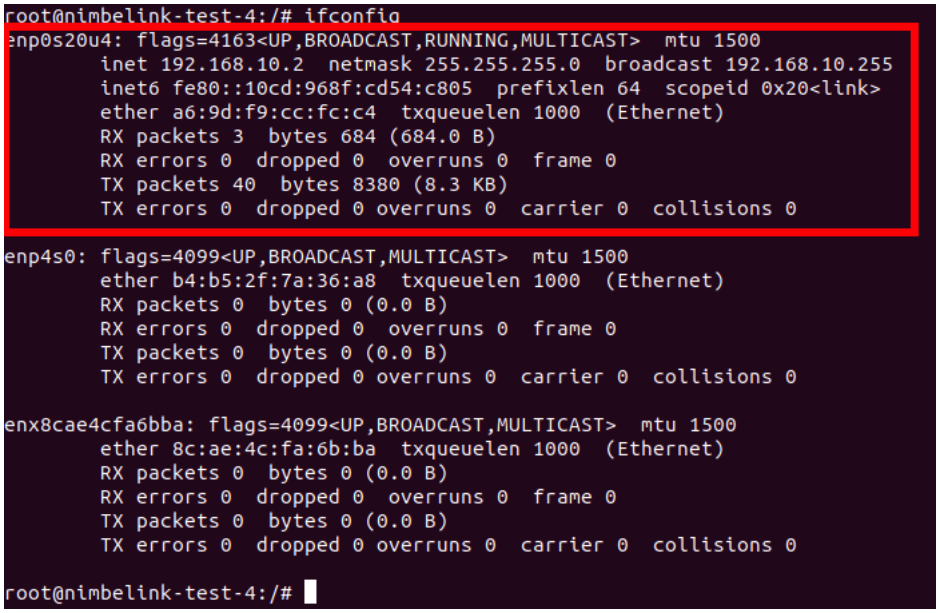
The terminal that outputs kernel and device drivers updates when the device reboots and displays messages similar to the following:



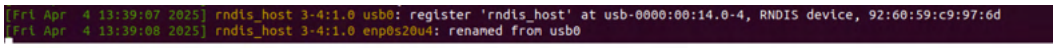
This indicates that the kernel recognized the module and loaded the rndis_host driver for use with RNDIS mode.

5. Invoke *ifconfig* to display all active network adapters connected to the system:

> **Note**
>
> If the command isn't available, invoke *sudo apt install net-tools* to install it.



The *enp0s20u4* adapter corresponds to the modem as shown above:



6. If the *enp0s20u4* adapter isn't shown, enter the following command to activate the network adapter:

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```
ifconfig enp0s20u4 up
```

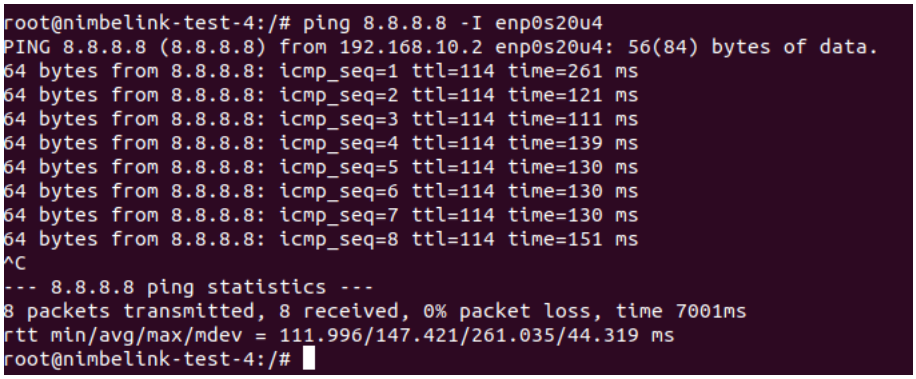
> **Note**
>
> Network adapter naming may vary based on your system. View the kernel log to see applicable adapter naming.

7. Enter the following command to test the internet connection by pinging via the adapter:

```
ping 8.8.8.8 -I <network adapter name>
```

This command pings a publicly-accessible IP, in this case: *8.8.8.8*, which is one of Google's primary DNS servers.

The following screenshot shows an example of pinging through the RNDIS adapter, where *<network adapter name>* is set to *enp0s20u4*:



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3.4 Point to Point Protocol (PPP) Introduction

PPP is a communications protocol used to directly connect two devices together without any other networking devices placed in between. PPP is a data link layer protocol and is designed to work with multiple network layer protocols, such as Internet Protocol (IP).

The following subsections describe how to set up PPP on a modem and Linux PC:

- PPP Script GitHub Repository
- Create PPP Scripts
- Edit the Scripts

PPP Script GitHub Repository

Airgain provides the following library of PPP scripts on GitHub for customer use:

https://github.com/NimbeLink/skywire-ppp-scripts

To clone the repository, navigate to any desired directory, and invoke the following command in the terminal:

```
git clone https://github.com/NimbeLink/skywire-ppp-scripts.git
```

Airgain recommends downloading this repository and following the instructions on the GitHub page to set up the scripts.

Alternatively, copy the contents of the PPP scripts directly from an internet browser into */etc/ppp/peers* on the Linux PC's filesystem.

Create PPP Scripts

To create PPP scripts, ensure you're the root user, identify the pair of PPP scripts that correspond to your SIM card carrier and model, and copy them into the */etc/ppp/peers* directory.

The commands below demonstrate this operation, assuming that the PPP script repository was cloned into the root user's home directory.

Copy the relevant scripts to the ppp peers folder:

```
cp ~/skywire-ppp-scripts/vzw-<model>* /etc/ppp/peers
```

AT&T Users:

```
cp ~/skywire-ppp-scripts/att-<model>* /etc/ppp/peers
```

Copy all scripts:

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```
cp ~/skywire-ppp-scripts/* /etc/ppp/peers
```

To verify if the copy operation was successful, check that the relevant NL-SW-LTE-QC1bisWWG PPP scripts listed below are present in */etc/ppp/peers*:

Model	Verizon PPP Scripts	AT&T PPP Scripts
NL-SW-LTE-QC1bisWWG	vzw-QC1bisWWG vzw-QC1bisWWG-chat	att-QC1bisWWG att-QC1bisWWG-chat
NL-SW-LTE-TC1bisNAG	vzw-TC1bisNAG vzw-TC1bisNAG-chat	vzw-TC1bisNAG vzw-TC1bisNAG-chat

Edit the PPP "x-y-chat" Script

Before using the scripts, edit the *x-y-chat* file and add the proper access point name (APN) for the cellular connection, where *x* is *<carrier>* and *y* is *<modem>*:

Open the file in a text editor, and find one of the following lines based on your provider:

AT&T Users:

```
OK AT+CGDCONT=1,"IP","[apn]"
```

Verizon Users:

```
OK AT+CGDCONT=3,"IP","[apn]"
```

Where *[apn]* is the proper APN for the chosen SIM card and cellular carrier.

The below example shows contents of a possible *vzw-TC1bisNAG-chat* file:

```
# vzw-TC1bisNAG-chat

TIMEOUT 35
ECHO ON
'' \rATZ
OK 'ATQ0 V1 E1 S0=0 &C1 &D2'
OK AT+CGDCONT=3,"IPV4V6","NIMBLINK.GW12.VZWENTP"
OK AT+CEREG?;+CESQ;+CGDCONT?;+CFUN?
OK ATD*99***3#
CONNECT ''
```

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Edit the PPP “x-y” Script

You may need to update the *x-y* file to reflect the proper port for the PPP session, where *x* is *<carrier>* and *y* is *<modem>*.

Open the file in a text editor, and if necessary, change the line with */dev/ttyUSB3* to reflect the port to which the modem is enumerated. For example, if the modem is enumerated to the */dev/ttyACM0* port, then specify */dev/ttyACM0* in the file.

3.5 PPP Procedure

The subsections below describe how to set up and work with PPP on Linux:

- Take Down Network Interfaces
- Start the PPP Session
- Test the PPP Session
- Close the PPP Session

Take Down Network Interfaces

Taking down other network interfaces is a quick way to ensure that internet traffic is routed through the PPP interface. Other methods can be used as well. Follow the steps below to sever the communication path over Ethernet with the Linux PC:

1. Invoke *ifconfig* to list all currently active network interfaces.

   Note

   If the command isn’t available, invoke sudo apt install net-tools to install it.

2. Take note of each populated entry in the output from *ifconfig*.
3. Invoke the following command to take down each interface that may provide an internet connection to the Linux PC:

   ```
   ifconfig [interface] down
   ```

   Replace [interface] with the name of the interface to disable. Common network interfaces are eth#, enp#s#, wlan#, wwan#, etc.

4. Once the network interfaces have been disabled, invoke the following command to check the PC’s internet connectivity:

   ```
   ping 8.8.8.8 -c 5
   ```

   This instructs the Linux PC to ping Google’s public DNS server five times. If all the relevant network interfaces have been disabled, the ping at-

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tempts fail.

If the ping attempts succeed, invoke ifconfig [interface] down to verify that all relevant network interfaces are disabled.

Once all sources of internet connectivity are disabled, the PPP session can be tested properly.

Start the PPP Session

Invoke the following command to start the PPP session:

```
pon [ppp script]
```

Replace “[ppp script]” with one of the following filenames, depending on the model and carrier:

Model	Carrier	Script
NL-SW-LTE-QC1bisWWG	VZW	vzw-QC1bisWWG
	AT&T	att-QC1bisWWG
NL-SW-LTE-TC1bisNAG	VZW	vzw-TC1bisNAG
	AT&T	att-TC1bisNAG

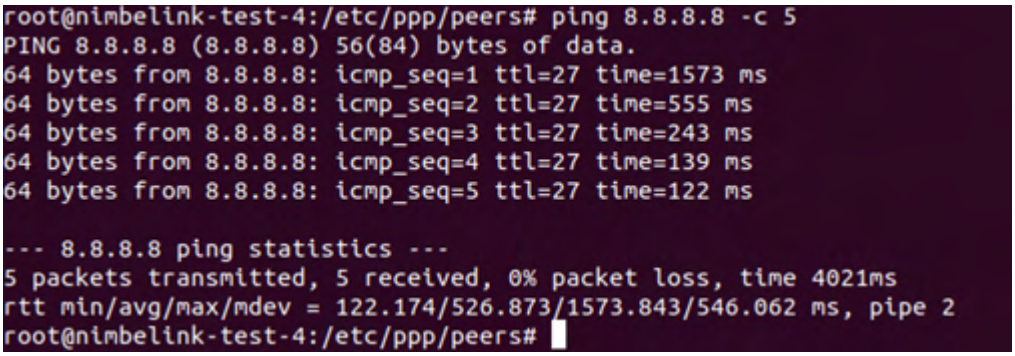
This command starts the pppd daemon to configure the PPP connection, and sets it as the default network connection.

Note

Ensure the modem does not have an active PDP context when starting the PPP script. This causes the PPP script to encounter an error and freeze up.

Test the PPP Session

Invoke *ping 8.8.8.8 -c 5*‘ again to test that the PPP connection is working properly. If the PPP session is successful, the response looks similar to the following:



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Close the PPP Session

To close the PPP connection, invoke the following command:

```
poff
```

> **Note**
>
> It's a good idea to close a PPP session whenever it's no longer needed. This prevents accidental usage of cellular data.

3.6 PPP Troubleshooting

If the PPP scripts become unresponsive:

Ensure the modem is freshly powered up, or rebooted each time a PPP session is started.

If the PPP scripts timeout:

This type of error is generally caused by attempting to start the PPP session too soon after the modem has booted:

```
root@nimbelink-test-4:/etc/ppp/peers# pon att-QC1bisWWG

RDY
Script /usr/sbin/chat -v -f /etc/ppp/peers/att-QC1bisWWG-chat finished (pid 9474), status = 0x3
Connect script failed
root@nimbelink-test-4:/etc/ppp/peers#
```

To fix this, wait 5 to 10 seconds after the modem becomes responsive before starting the PPP scripts.

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4 Document Version Information

Revision	Description	Date
1	Initial Release	2025-04-07
2	Airgain updates	2025-07-03
3	Added NL-SW-LTE-TC1bisNAG	2025-10-27

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