

# Configuring Linux 'CDC\_NCM' for Skywire<sup>®</sup> LTE CAT4 Modem

NimbeLink Corp

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# 1. Introduction

## 1.1 Overview

This guide walks users through the steps for creating a CDC\_NCM connection over USB on the 4G LTE Cat 4 Skywire® modems.

This example has been tested on the following distributions of Linux:

- Debian GNU/Linux 8 (jessie) beaglebone 4.4.9-ti-r25

This example is written using Debian GNU/Linux 8 (jessie) beaglebone 4.4.9-ti-r25 using a Beaglebone Black and Nimbelink's Beaglebone Black Cape.

The 4G LTE Cat 4 Skywires do not support DHCP configuration between the module and the host computer. It is necessary to manually configure a network interface on the host computer in order to make use of the module as a data modem.

## 1.2 Applies to the Following Part Numbers

Orderable Device	Description	Manufacturer	Carrier	Network Type
<a href="#">NL-SW-LTE-S7588-V</a>	4G LTE CAT4 with HSPA+ Fallback	Nimbelink	Verizon	LTE
<a href="#">NL-SW-LTE-S7588-T</a>	4G LTE CAT4 with HSPA+ Fallback	Nimbelink	AT&T	LTE, GSM

## 1.3 Prerequisites



**This document assumes you have completed the initial setup of your modem and development kit. If you have not completed those steps, refer to the Skywire Development Kit User Manual and complete the modem setup before proceeding.**

**If you are using a device that is communicating via SSH, Telnet, or any other type of Ethernet interface, you must connect to it via USB or serial. Step 2.8 requires the Ethernet interface to be taken down.**

## 2. CDC\_NCM ON THE 4G LTE MODEM ON VERIZON

### 2.1 Overview

Section 2 details how to configure CDC\_NCM over USB for devices on the Verizon network. Users using devices on GSM carriers should refer to section 3. Users should read through the entire guide before implementing. Failure to follow the steps as outlined may cause the implementation of the CDC\_NCM over USB connection to fail. This tutorial will use picocom as the default terminal program to send AT commands to the modem.

## 2.2 Instructions

### 2.2.1 Connect the Modem to the Host over USB

Connect the computer to the modem over USB. On the Beaglebone Cape the user will need to connect the USB-mini port on the shield to the USB-A on the Beaglebone Black. Users using NimbeLink's Development Kit should connect J5 to the host computer to access the USB port of the Skywire.

Once the modem is attached to the computer, type the following command into the Terminal:

```
$ lsusb -t
```

```
root@beaglebone:~# lsusb -t
/: Bus 01.Port 1: Dev 1, Class=root_hub, Driver=musb-hdrc/lp, 480M
  |__ Port 1: Dev 2, If 0, Class=Hub, Driver=hub/4p, 480M
     |__ Port 1: Dev 3, If 0, Class=Communications, Driver=cdc_acm, 480M
     |__ Port 1: Dev 3, If 1, Class=CDC Data, Driver=cdc_acm, 480M
     |__ Port 1: Dev 3, If 2, Class=Communications, Driver=cdc_acm, 480M
     |__ Port 1: Dev 3, If 3, Class=CDC Data, Driver=cdc_acm, 480M
     |__ Port 1: Dev 3, If 4, Class=Communications, Driver=cdc_acm, 480M
     |__ Port 1: Dev 3, If 5, Class=CDC Data, Driver=cdc_acm, 480M
     |__ Port 1: Dev 3, If 6, Class=Communications, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 7, Class=CDC Data, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 8, Class=Communications, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 9, Class=CDC Data, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 10, Class=Communications, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 11, Class=CDC Data, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 12, Class=Communications, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 13, Class=CDC Data, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 14, Class=Vendor Specific Class, Driver=, 480M
```

Then, type the following command into the Terminal:

```
$ dmesg
```

```
[ 12.535730] cdc_acm 1-1.1:1.0: ttyACM0: USB ACM device
[ 12.610741] cdc_ncm 1-1.1:1.6: MAC-Address: 00:00:11:12:13:14
[ 12.610770] cdc_ncm 1-1.1:1.6: setting rx_max = 16384
[ 12.702871] cdc_ncm 1-1.1:1.6 wwan0: register 'cdc_ncm' at usb-musb-hdrc.1.auto-1.1, Mobil
le Broadband Network Device (NO ARP), 00:00:11:12:13:14
[ 12.719382] cdc_acm 1-1.1:1.2: ttyACM1: USB ACM device
[ 12.742876] cdc_acm 1-1.1:1.4: ttyACM2: USB ACM device
[ 12.777699] usbcore: registered new interface driver cdc_acm
[ 12.777721] cdc_acm: USB Abstract Control Model driver for USB modems and ISDN adapters
[ 12.828187] cdc_ncm 1-1.1:1.8: MAC-Address: 00:00:11:12:13:16
[ 12.828216] cdc_ncm 1-1.1:1.8: setting rx_max = 16384
[ 12.851326] cdc_ncm 1-1.1:1.8 wwan1: register 'cdc_ncm' at usb-musb-hdrc.1.auto-1.1, Mobil
le Broadband Network Device (NO ARP), 00:00:11:12:13:16
[ 12.912555] cdc_ncm 1-1.1:1.10: MAC-Address: 00:00:11:12:13:18
[ 12.912586] cdc_ncm 1-1.1:1.10: setting rx_max = 16384
[ 12.964505] cdc_ncm 1-1.1:1.10 wwan2: register 'cdc_ncm' at usb-musb-hdrc.1.auto-1.1, Mobil
le Broadband Network Device (NO ARP), 00:00:11:12:13:18
[ 13.053013] cdc_ncm 1-1.1:1.12: MAC-Address: 00:00:11:12:13:1a
[ 13.053043] cdc_ncm 1-1.1:1.12: setting rx_max = 16384
[ 13.092323] cdc_ncm 1-1.1:1.12 wwan3: register 'cdc_ncm' at usb-musb-hdrc.1.auto-1.1, Mobil
le Broadband Network Device (NO ARP), 00:00:11:12:13:1a
[ 13.094079] usbcore: registered new interface driver cdc_ncm
[ 13.111872] usbcore: registered new interface driver cdc_wdm
[ 13.152318] usbcore: registered new interface driver cdc_mbim
```

The following devices should have been found by the host system

- 3 ACM Port devices: /dev/ttyACM $x$  ( $x=0,1,2$ )
- 4 NCM Network adapter devices: wwan $x$  ( $x=0,1,2,3$ )

These devices are used as follows:

- ttyACM0 and ttyACM2: Dialup network or AT commands
- ttyACM1: Multi functional debugging port that is not used in Linux
- wwan $x$ : IP Network Connections

## 2.2.2 Elevate to root

In order to make the changes necessary, it is necessary to login to the root account. To do so, type the following command into the Terminal:

```
$ sudo -i
```

followed by the Enter key. You will be prompted to enter your password: enter it, followed by the Enter key.

## 2.2.3 Configure the Modem for NCM mode

Connect to the modems AT command interpreter on the ttyACM0 port to issue AT command to the modem by issuing the following command to the linux host followed by the enter Key:

```
$ picocom -b 115200 /dev/ttyACM0
```

Once the host has connected to the modems AT command interpreter issue the following AT commands.

```
AT+CMEE=2
```

The modem should respond with:

```
OK
```

Then issue the following AT Command:

```
AT+COPS=0
```

The modem should respond with:

```
OK
```

Then issue the following AT Command:

```
AT+CGPIAF=1,0,0,0
```

The modem should respond with:

```
OK
```

Then issue the following AT Command:

```
AT+xdns=3,1
```

The modem should respond with:

```
OK
```

Next we will set the APN for the device. In this AT command, *nimblink.gw12.vzwentp* is the APN that the device is being configured to use. If you did not purchase your service through go.nimbelink.com, please check with your service provider on the correct APN for your device.

Issue the following AT command to the modem:

```
AT+CGDCONT=3,"IP","nimblink.gw12.vzwentp", ""
```

The modem should respond with:

```
OK
```



Once the APN is set activate a PDP context to pull the IP address and DNS information for the mode. Issue the following command followed by the enter key to activate a IP context:

**AT+CGACT=1,3**

The modem should respond with:

**OK**

Now that the PDP context is active, pull the IP address of the modem by issuing the following AT command followed by the enter key:

**AT+CGPADDR=3**

The modem should respond with the following:

**+CGPADDR: 3,"100.125.45.177"**

**OK**

In this example 100.125.45.177 is the PDP IPV4 address that the modem recieved from the network. This IP address with be different with every modem; record this IP address reported by the modem for use later on in this guide.

Now pull the DNS information by issuing the following command followed by the enter key:

**AT+XDNS?**

The modem should respond with the following:

**+XDNS: 1, "2001:4888:3A:FF00:304:D:0:0", "2001:4888:39:FF00:308:D:0:0"**

**+XDNS: 2, "0.0.0.0", "0.0.0.0"**

**+XDNS: 3, "198.224.182.135", "198.224.183.135"**

**+XDNS: 4, "0.0.0.0", "0.0.0.0"**

**OK**

The **+XDNS: 3, "198.224.182.135", "198.224.183.135"** line contains the two name servers for the modems DNS server. In this example they are **"198.224.182.135"**, and **"198.224.183.135"**. Record the IP addresses for the DNS servers specific to your modem for use later on in this guide.

## 2.2.4 Configure The Data Channel

Configure the data channel for the modem by issuing the following AT command followed by the enter key:

```
AT+XDATACHANNEL=1,1,"/USBCDC/0","/USBHS/NCM/1",2,3
```

The modem should respond with:

```
OK
```

This command configures the modem to route traffic over the user selected NCM path (data channel). For this example, NCM1 (wwan1) is the selected data path.

The NCM devices that the system found in 2.2.1 are mapped as follows:

/USBHS/NCM/0 corresponds to Network adapter "wwan0"

/USBHS/NCM/1 corresponds to Network adapter "wwan1"

/USBHS/NCM/2 corresponds to Network adapter "wwan2"

/USBHS/NCM/3 corresponds to Network adapter "wwan3"

This example routes data to wwan1 using ttyACM0. Users can configure the system to use ttyACM2 by changing the **"/USBCDC/0"** in the AT command to **"/USBCDC/2"**.

The ACM devices that the system found in 2.2.1 are mapped as follows:

/USBCDC/0 corresponds to "ACM0"

/USBCDC/2 corresponds to "ACM2"

Once the data channel has been configured exit out of picocom (use CNTL-A followed by CNTL-X) back to the host system then proceed to 2.2.5.

## 2.2.5 Configure a Network Interface on Linux

Before starting the data connection on the modem, users need to configure a network interface a network on the host system. Issue the following commands to the host system.

Bring down the wwan1 interface:

```
$ sudo ifconfig wwan1 down
```

Configure the wwan1 interface's IP address:

```
$ sudo ifconfig wwan1 -arp 100.125.45.177
```

The **100.125.45.177** address is the IP address of the modem that was reported in 2.2.4, this IP address is unique to each modem and needs to be checked when initiating the connection

Set wwan1 to be the default route:

```
$ sudo route add default wwan1
```

Next the DNS name servers need to be added to `/etc/resolv.conf`. Issue the following command to the host system to edit the `resolv.conf` file:

```
$sudo nano /etc/resolv.conf
```

Once the editor is open add the following two name servers to the bottom of the list:

```
nameserver 198.224.182.135
```

```
nameserver 198.224.183.135
```

The IP addresses for the name servers (**198.224.182.135, 198.224.183.135**) were obtained in section 2.2.4 when the **AT+XDNS?** command was issued. These IP addresses will be unique to the carrier/device being used and must be checked prior to configuring the `resolv.conf` file.

## 2.2.6 Start the Data Connection

Now that the host system is configured, the data connection can be started. Connect to the modems AT command interpreter on the ttyACM0 port to issue AT command to the modem by issuing the following command to the linux host followed by the enter Key:

```
$ picocom -b 115200 /dev/ttyACM0
```

Once the host has connected to the modems AT command interpreter issue the following AT commands.

```
AT+CGDATA="M-RAW_IP",3
```

The modem should respond with:

```
OK  
CONNECT
```

Once the data connection has been started, immediately exit out of picocom (use CNTL-A followed by CNTL-X) without sending any additional AT commands.

## 2.2.7 Test the Network Connection

The modem is now connected as a network device to the host system. Test the modems connectivity by pinging Google's DNS server by entering the following into the host systems terminal:

```
$ ping 8.8.8.8
```

The traffic generated by the pings will appear as RX/TX bytes on the wwan1 interface in the ifconfig of the host system

## 3. CDC\_NCM ON THE 4G LTE MODEM ON GSM CARRIERS

### 3.1 Overview

Section 2 details how to configure CDC\_NCM over USB for devices using GSM carriers (AT&T, KORE, T-Mobile, etc...). Users using devices on Verizon should refer to section 2.

Users should read through the entire guide before implementing. Failure to follow the steps as outlined may cause the implementation of the CDC\_NCM over USB connection to fail. This tutorial will use picocom as the default terminal program to send AT commands to the modem.

## 3.2 Instructions

### 3.2.1 Connect the Modem to the Host over USB

Connect the computer to the modem over USB. On the Beaglebone Cape the user will need to connect the USB-mini port on the shield to the USB-A on the Beaglebone Black. Users using NimbeLink's Development Kit should connect J5 to the host computer to access the USB port of the Skywire.

Once the modem is attached to the computer, type the following command into the Terminal:

```
$ lsusb -t
```

```
root@beaglebone:~# lsusb -t
/: Bus 01.Port 1: Dev 1, Class=root_hub, Driver=musb-hdrc/1p, 480M
  |__ Port 1: Dev 2, If 0, Class=Hub, Driver=hub/4p, 480M
     |__ Port 1: Dev 3, If 0, Class=Communications, Driver=cdc_acm, 480M
     |__ Port 1: Dev 3, If 1, Class=CDC Data, Driver=cdc_acm, 480M
     |__ Port 1: Dev 3, If 2, Class=Communications, Driver=cdc_acm, 480M
     |__ Port 1: Dev 3, If 3, Class=CDC Data, Driver=cdc_acm, 480M
     |__ Port 1: Dev 3, If 4, Class=Communications, Driver=cdc_acm, 480M
     |__ Port 1: Dev 3, If 5, Class=CDC Data, Driver=cdc_acm, 480M
     |__ Port 1: Dev 3, If 6, Class=Communications, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 7, Class=CDC Data, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 8, Class=Communications, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 9, Class=CDC Data, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 10, Class=Communications, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 11, Class=CDC Data, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 12, Class=Communications, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 13, Class=CDC Data, Driver=cdc_ncm, 480M
     |__ Port 1: Dev 3, If 14, Class=Vendor Specific Class, Driver=, 480M
```

Then, type the following command into the Terminal:

```
$ dmesg
```

```
[ 12.535730] cdc_acm 1-1.1:1.0: ttyACM0: USB ACM device
[ 12.610741] cdc_ncm 1-1.1:1.6: MAC-Address: 00:00:11:12:13:14
[ 12.610770] cdc_ncm 1-1.1:1.6: setting rx_max = 16384
[ 12.702871] cdc_ncm 1-1.1:1.6 wwan0: register 'cdc_ncm' at usb-musb-hdrc.1.auto-1.1, Mobile Broadband Network Device (NO ARP), 00:00:11:12:13:14
[ 12.719382] cdc_acm 1-1.1:1.2: ttyACM1: USB ACM device
[ 12.742876] cdc_acm 1-1.1:1.4: ttyACM2: USB ACM device
[ 12.777699] usbcore: registered new interface driver cdc_acm
[ 12.777721] cdc_acm: USB Abstract Control Model driver for USB modems and ISDN adapters
[ 12.828187] cdc_ncm 1-1.1:1.8: MAC-Address: 00:00:11:12:13:16
[ 12.828216] cdc_ncm 1-1.1:1.8: setting rx_max = 16384
[ 12.851326] cdc_ncm 1-1.1:1.8 wwan1: register 'cdc_ncm' at usb-musb-hdrc.1.auto-1.1, Mobile Broadband Network Device (NO ARP), 00:00:11:12:13:16
[ 12.912555] cdc_ncm 1-1.1:1.10: MAC-Address: 00:00:11:12:13:18
[ 12.912586] cdc_ncm 1-1.1:1.10: setting rx_max = 16384
[ 12.964505] cdc_ncm 1-1.1:1.10 wwan2: register 'cdc_ncm' at usb-musb-hdrc.1.auto-1.1, Mobile Broadband Network Device (NO ARP), 00:00:11:12:13:18
[ 13.053013] cdc_ncm 1-1.1:1.12: MAC-Address: 00:00:11:12:13:1a
[ 13.053043] cdc_ncm 1-1.1:1.12: setting rx_max = 16384
[ 13.092323] cdc_ncm 1-1.1:1.12 wwan3: register 'cdc_ncm' at usb-musb-hdrc.1.auto-1.1, Mobile Broadband Network Device (NO ARP), 00:00:11:12:13:1a
[ 13.094079] usbcore: registered new interface driver cdc_ncm
[ 13.111872] usbcore: registered new interface driver cdc_wdm
[ 13.152318] usbcore: registered new interface driver cdc_mbim
```

The following devices should have been found by the host system

- 3 ACM Port devices: /dev/ttyACM $x$  ( $x=0,1,2$ )
- 4 NCM Network adapter devices: wwan $x$  ( $x=0,1,2,3$ )

These devices are used as follows:

- ttyACM0 and ttyACM2: Dialup network or AT commands
- ttyACM1: Multi functional debugging port that is not used in linux
- wwan $x$ : IP Network Connections

### 3.2.2 Elevate to root

In order to make the changes necessary, it is necessary to login to the root account. To do so, type the following command into the Terminal:

```
$ sudo -i
```

followed by the Enter key. You will be prompted to enter your password: enter it, followed by the Enter key.

### 3.2.3 Configure the Modem for NCM mode

Connect to the modems AT command interpreter on the ttyACM0 port to issue AT command to the modem by issuing the following command to the linux host followed by the enter Key:

```
$ picocom -b 115200 /dev/ttyACM0
```

Once the host has connected to the modems AT command interpreter issue the following AT commands.

```
AT+CMEE=2
```

The modem should respond with:

```
OK
```

Then issue the following AT Command:

```
AT+CGPIAF=1,0,0,0
```

The modem should respond with:

```
OK
```

Then issue the following AT Command:

```
AT+xdns=1,1
```

The modem should respond with:

```
OK
```

Next we will set the APN for the device. In this AT command, **C1.KOREM2M.COM** is the APN that the device is being configured to use. If you did not purchase your service through go.nimbelink.com, please check with your service provider on the correct APN for your device.

Issue the following AT command to the modem:

```
AT+CGDCONT=1,"IP","C1.KOREM2M.COM", ""
```

The modem should respond with:

```
OK
```

Once the APN is set activate a PDP context to pull the IP address and DNS information for the mode. Issue the following command followed by the enter key to activate a IP context:

```
AT+CGACT=1,1
```

The modem should respond with:

```
OK
```



Now that the PDP context is active, pull the IP address of the modem by issuing the following AT command followed by the enter key:

**AT+CGPADDR=1**

The modem should respond with the following:

**+CGPADDR: 1,"10.132.248.239"**

**OK**

In this example **10.132.248.239** is the PDP IPV4 address that the modem received from the network. This IP address will be different with every modem; record this IP address reported by the modem for use later on in this guide.

Now pull the DNS information by issuing the following command followed by the enter key:

**AT+XDNS?**

The modem should respond with the following:

At+xdns?

**+XDNS: 1, "174.47.40.106", "174.47.20.106"**

**+XDNS: 2, "0.0.0.0", "0.0.0.0"**

**+XDNS: 3, "0.0.0.0", "0.0.0.0"**

**OK**

The **+XDNS: 1, "174.47.40.106", "174.47.20.106"** line contains the two name servers for the modem's DNS server. In this example they are **"174.47.40.106"**, and **"174.47.20.106"**. Record the IP addresses for the DNS servers specific to your modem for use later on in this guide.

### 3.2.4 Configure The Data Channel

Configure the data channel for the modem by issuing the following AT command followed by the enter key:

```
AT+XDATACHANNEL=1,1,"/USBCDC/0","/USBHS/NCM/1",2,1
```

The modem should respond with:

```
OK
```

This command configures the modem to route traffic over the user selected NCM path (data channel). For this example, NCM1 (wwan1) is the selected data path.

The NCM devices that the system found in 2.2.1 are mapped as follows:

/USBHS/NCM/0 corresponds to Network adapter "wwan0"

/USBHS/NCM/1 corresponds to Network adapter "wwan1"

/USBHS/NCM/2 corresponds to Network adapter "wwan2"

/USBHS/NCM/3 corresponds to Network adapter "wwan3"

This example routes data to wwan1 using ttyACM0. Users can configure the system to use ttyACM2 by changing the **"/USBCDC/0"** in the AT command to **"/USBCDC/2"**.

The ACM devices that the system found in 2.2.1 are mapped as follows:

/USBCDC/0 corresponds to "ACM0"

/USBCDC/2 corresponds to "ACM2"

Once the data channel has been configured exit out of picocom (use CNTL-A followed by CNTL-X) back to the host system then proceed to 2.2.5.

### 3.2.5 Configure a Network Interface on Linux

Before starting the data connection on the modem, users need to configure a network interface a network on the host system. Issue the following commands to the host system.

Bring down the wwan1 interface:

```
$ sudo ifconfig wwan1 down
```

Configure the wwan1 interface's IP address:

```
$ sudo ifconfig wwan1 -arp 10.132.248.239
```

The **10.132.248.239** address is the IP address of the modem that was reported in 2.2.4, this IP address is unique to each modem and needs to be checked when initiating the connection

Set wwan1 to be the default route:

```
$ sudo route add default wwan1
```

Next the DNS name servers need to be added to /etc/resolv.conf. Issue the following command to the host system to edit the resolv.conf file:

```
$ sudo nano /etc/resolv.conf
```

Once the editor is open add the following two name servers to the bottom of the list:

```
nameserver 174.47.40.106
```

```
nameserver 174.47.20.106
```

The IP addresses for the name servers ("**174.47.40.106**", "**174.47.20.106**") were obtained in section 2.2.4 when the **AT+XDNS?** command was issued. These IP addresses will be unique to the carrier/device being used and must be checked prior to configuring the resolv.conf file.

### 3.2.6 Start the Data Connection

Now that the host system is configured, the data connection can be started. Connect to the modems AT command interpreter on the ttyACM0 port to issue AT command to the modem by issuing the following command to the linux host followed by the enter Key:

```
$ picocom -b 115200 /dev/ttyACM0
```

Once the host has connected to the modems AT command interpreter issue the following AT commands.

```
AT+CGDATA="M-RAW_IP",1
```

The modem should respond with:

```
OK  
CONNECT
```

Once the data connection has been started immediately exit out of picocom (use CNTL-A followed by CNTL-X) without sending any additional AT commands.

### 3.2.7 Test the Network Connection

The modem is now connected as a network device to the host system. Test the modems connectivity by pinging Google's DNS server by entering the following into the host systems terminal:

```
$ ping 8.8.8.8
```

The traffic generated by the pings will appear as RX/TX bytes on the wwan1 interface in the ifconfig of the host system