

# LTE

to test the EM7455 Card (+ NGFF Key-B Adapter) on the BPI-R3 (mPCIe Slot)

<https://www.bipom.com/documents/sierra/4117727%20AirPrime%20EM-MC74xx%20AT%20Command%20Reference%20r4.pdf>

Kernel-Options:

```
CONFIG_USB_USBNET=m
CONFIG_USB_SERIAL_OPTION=m
CONFIG_USB_SERIAL_QUALCOMM=m
CONFIG_USB_NET_CDC_MBIM=m
CONFIG_USB_NET_QMI_WWAN=m
```

Needed tools:

```
root@bpi-r3:~# apt install libqmi-utils libmbim-utils
```

i'm using a Congstar-SIM

APN-settings:

<https://forum.congstar.de/thread/46325-mobil-surfen-mit-congstar-manuelle-einstellungen-zum-mobil-en-internet-apn/>

Some information of different interface modes and which modules are required on Openwrt:

<https://forum.banana-pi.org/t/bpi-r3-information/12897/83?u=frank-w>

Openwrt:

luci-proto-qmi (recommended) or even luci-proto-modemmanager

## QMI-Mode

Step-by-step guide with qmicli:

<https://techship.com/faq/how-to-step-by-step-set-up-a-data-connection-over-qmi-interface-using-qmicli-and-in-kernel-driver-qmi-wwan-in-linux/>

```
root@bpi-r3:~# qmicli --device=/dev/cdc-wdm0 --get-expected-data-format
802-3
root@bpi-r3:~# qmicli --device=/dev/cdc-wdm0 --wda-get-data-format
[/dev/cdc-wdm0] Successfully got data format
      QoS flow header: no
      Link layer protocol: 'raw-ip'
      Uplink data aggregation protocol: 'disabled'
      Downlink data aggregation protocol: 'disabled'
      NDP signature: '0'
```

```
Downlink data aggregation max datagrams: '0'
Downlink data aggregation max size: '0'
root@bpi-r3:~# ip link set dev wwan0 down
root@bpi-r3:~# echo Y > /sys/class/net/wwan0/qmi/raw_ip
root@bpi-r3:~# ip link set dev wwan0 up

root@bpi-r3:~# qmicli --device=/dev/cdc-wdm0 -p --uim-verify-pin=PIN1,1234
[/dev/cdc-wdm0] PIN verified successfully

root@bpi-r3:~# qmicli --device=/dev/cdc-wdm0 -p --uim-get-card-status
[/dev/cdc-wdm0] Successfully got card status
Provisioning applications:
    Primary GW: slot '1', application '1'
    Primary 1X: session doesn't exist
    Secondary GW: session doesn't exist
    Secondary 1X: session doesn't exist
Slot [1]:
    Card state: 'present'
    UPIN state: 'not-initialized'
        UPIN retries: '0'
        UPUK retries: '0'
    Application [1]:
        Application type: 'usim (2)'
        Application state: 'ready'
        Application ID:
            A0:00:00:00:87:10:02:FF:49:94:20:89:03:10:00:00
        Personalization state: 'ready'
        UPIN replaces PIN1: 'no'
        PIN1 state: 'enabled-verified'
            PIN1 retries: '3'
            PUK1 retries: '10'
        PIN2 state: 'enabled-not-verified'
            PIN2 retries: '3'
            PUK2 retries: '10'

root@bpi-r3:~#

qmicli -p -v -d /dev/cdc-wdm0 --wds-stop-network=disable-autoconnect --
client-cid=37
qmicli -v -p --device=/dev/cdc-wdm0 --wds-set-ip-family=6
qmicli -d /dev/cdc-wdm0 --wds-get-profile-list=3gpp
qmicli -d /dev/cdc-wdm0 --wds-get-channel-rates
qmicli -d /dev/cdc-wdm0 --dms-set-fcc-authentication
qmicli -d /dev/cdc-wdm0 --dms-get-operating-mode
```

## MBIM-Mode

<https://gist.github.com/Juul/e42c5b6ec71ce11923526b36d3f1cb2c#connecting-using-mbim>

```
qmicli -d /dev/cdc-wdm0 --dms-set-fcc-authentication --device-open-mbim
mbimcli --device=/dev/cdc-wdm0 -p --enter-pin=$PIN1
mbim-network /dev/cdc-wdm0 start
mbimcli -d /dev/cdc-wdm0 -p --query-ip-configuration
ip addr add 10.22.186.x/30 dev wwan0
ip link set wwan0 up
ip route add default via 10.22.186.y
ping 8.8.8.8
mbim-network /dev/cdc-wdm0 stop
```

### first Test

```
root@bpi-r3:~# modprobe cdc_mbim

/etc/mbim-network.conf:
APN=internet.v6.telekom
PROXY=yes

root@bpi-r3:~# mbimcli --device=/dev/cdc-wdm0 --query-device-caps
[/dev/cdc-wdm0] Device capabilities retrieved:
    Device type: 'remote'
    Cellular class: 'gsm'
    Voice class: 'no-voice'
    SIM class: 'removable'
    Data class: 'umts, hsdpa, hsupa, lte'
    SMS caps: 'pdu-receive, pdu-send'
    Ctrl caps: 'reg-manual'
    Max sessions: '8'
    Custom data class: 'unknown'
    Device ID: '352733105743066'
    Firmware info: 'SWI9X30C_02.24.03.00'
    Hardware info: 'EM7455'
root@bpi-r3:~# mbim-network /dev/cdc-wdm0 start
Loading profile at /etc/mbim-network.conf...
    APN: internet.v6.telekom
    APN auth protocol: unset
    APN user: unset
    APN password: unset
    mbim-proxy: yes
Querying subscriber ready status 'mbimcli -d /dev/cdc-wdm0 --query-
subscriber-ready-status --no-close --device-open-proxy'...
[/dev/cdc-wdm0] Subscriber ready status retrieved: Ready state: 'device-
locked'
Subscriber ID: 'unknown' SIM ICCID: '89490200001355851497' Ready info:
```

```
'none' Telephone numbers: (0) 'unknown' [/dev/cdc-wdm0] Session not closed:
TRID: '4'
Saving state at /tmp/mbim-network-state-cdc-wdm0... (TRID: 4)
Querying registration state 'mbimcli -d /dev/cdc-wdm0 --query-registration-
state --no-open=4 --no-close --device-open-proxy'...
[/dev/cdc-wdm0] Registration status: Network error: 'unknown' Register
state: 'deregistered' Register mode: 'automatic' Available data classes:
'unknown' Curren
t cellular class: 'gsm' Provider ID: 'unknown' Provider name: 'unknown'
Roaming text: 'unknown' Registration flags: 'packet-service-automatic-
attach' [/dev/cdc-wdm0] Session not closed: TRID: '6'
Saving state at /tmp/mbim-network-state-cdc-wdm0... (TRID: 6)
Attaching to packet service with 'mbimcli -d /dev/cdc-wdm0 --attach-packet-
service --no-open=6 --no-close --device-open-proxy'...
error: operation failed: PinRequired
Saving state at /tmp/mbim-network-state-cdc-wdm0... (TRID: 8)
Starting network with 'mbimcli -d /dev/cdc-wdm0 --
connect=apn='internet.v6.telekom' --no-open=8 --no-close --device-open-
proxy'...
error: operation failed: PinRequired
Network start failed
[/dev/cdc-wdm0] Session not closed: TRID: '10'
Saving state at /tmp/mbim-network-state-cdc-wdm0... (TRID: 10)
root@bpi-r3:~#
```

so it looks like pin-problem and i tried this:

```
root@bpi-r3:~# mbimcli --device=/dev/cdc-wdm0 -p --enter-pin=1234
[/dev/cdc-wdm0] PIN operation successful
[/dev/cdc-wdm0] PIN info:
                PIN state: 'locked'
                PIN type: 'pin2'
                Remaining attempts: '3'
root@bpi-r3:~# mbim-network /dev/cdc-wdm0 start
Loading profile at /etc/mbim-network.conf...
    APN: internet.v6.telekom
    APN auth protocol: unset
    APN user: unset
    APN password: unset
    mbim-proxy: yes
Loading previous state from /tmp/mbim-network-state-cdc-wdm0...
    Previous Transaction ID: 10
error: no actions specified
Clearing state at /tmp/mbim-network-state-cdc-wdm0...
Querying subscriber ready status 'mbimcli -d /dev/cdc-wdm0 --query-
subscriber-ready-status --no-close --device-open-proxy'...
[/dev/cdc-wdm0] Subscriber ready status retrieved: Ready state:
'initialized' Subscriber ID: '26201704168zzzz' SIM ICCID:
'8949020000135585yyyy' Ready info: 'none' Telephone numbers: (1)
'+491512025xxxx' [/dev/cdc-wdm0] Session not closed:
TRID: '4'
```

```

Saving state at /tmp/mbim-network-state-cdc-wdm0... (TRID: 4)
Querying registration state 'mbimcli -d /dev/cdc-wdm0 --query-registration-
state
--no-open=4 --no-close --device-open-proxy'...
[/dev/cdc-wdm0] Registration status: Network error: 'unknown' Register
state: 'deregistered' Register mode: 'automatic' Available data classes:
'unknown' Current cellular class: 'gsm' Provider ID: 'unknown' Provider
name: 'unknown' Roaming
text: 'unknown' Registration flags: 'packet-service-automatic-attach'
[/dev/cdc-wdm0] Session not closed: TRID: '6'
Saving state at /tmp/mbim-network-state-cdc-wdm0... (TRID: 6)
Attaching to packet service with 'mbimcli -d /dev/cdc-wdm0 --attach-packet-
service --no-open=6 --no-close --device-open-proxy'...
error: operation failed: RadioPowerOff
Saving state at /tmp/mbim-network-state-cdc-wdm0... (TRID: 8)
Starting network with 'mbimcli -d /dev/cdc-wdm0 --
connect=apn='internet.v6.telekom' --no-open=8 --no-close --device-open-
proxy'...
error: operation failed: RadioPowerOff
Network start failed
[/dev/cdc-wdm0] Session not closed: TRID: '10'
Saving state at /tmp/mbim-network-state-cdc-wdm0... (TRID: 10)
root@bpi-r3:~#

```

got a connection in MBIM-Mode:

```

root@bpi-r3:~# qmicli -d /dev/cdc-wdm0 --dms-set-fcc-authentication --
device-open-mbim
[/dev/cdc-wdm0] Successfully set FCC authentication
root@bpi-r3:~# mbimcli --device=/dev/cdc-wdm0 -p --enter-pin=1234
[/dev/cdc-wdm0] PIN operation successful

[/dev/cdc-wdm0] PIN info:
                PIN state: 'locked'
                PIN type: 'pin2'
        Remaining attempts: '3'
root@bpi-r3:~# mbim-network /dev/cdc-wdm0 start
Loading profile at /etc/mbim-network.conf...
        APN: internet.telekom
        APN auth protocol: PAP
        APN user: congstar
        APN password: cs
        mbim-proxy: yes
Querying subscriber ready status 'mbimcli -d /dev/cdc-wdm0 --query-
subscriber-ready-status --no-close --device-open-proxy'...
[/dev/cdc-wdm0] Subscriber ready status retrieved: Ready state:
'initialized' Subscriber ID: '262017041684242' SIM ICCID:
'89490200001355851497' Ready info: 'none' Telephone numbers: (1)
'+4915120251510' [/dev/cdc-wdm0] Session not closed: TRID: '4'
Saving state at /tmp/mbim-network-state-cdc-wdm0... (TRID: 4)
Querying registration state 'mbimcli -d /dev/cdc-wdm0 --query-registration-

```

```
state --no-open=4 --no-close --device-open-proxy'...
[/dev/cdc-wdm0] Registration status: Network error: 'unknown' Register
state: 'home' Register mode: 'automatic' Available data classes: 'lte'
Current cellular class: 'gsm' Provider ID: '26201' Provider name: 'congstar'
Roaming text: 'unknown' Registration flags: 'packet-service-automatic-
attach' [/dev/cdc-wdm0] Session not closed: TRID: '6'
Saving state at /tmp/mbim-network-state-cdc-wdm0... (TRID: 6)
Attaching to packet service with 'mbimcli -d /dev/cdc-wdm0 --attach-packet-
service --no-open=6 --no-close --device-open-proxy'...
Saving state at /tmp/mbim-network-state-cdc-wdm0... (TRID: 8)
Starting network with 'mbimcli -d /dev/cdc-wdm0 --
connect=apn='internet.telekom',auth='PAP',username='congstar',password='cs'
--no-open=8 --no-close --device-open-proxy'...
Network started successfully
Saving state at /tmp/mbim-network-state-cdc-wdm0... (TRID: 11)
root@bpi-r3:~# ip a s wwan0
11: wwan0: <BROADCAST,MULTICAST,NOARP> mtu 1500 qdisc noop state DOWN group
default qlen 1000
    link/ether 3e:06:6b:05:0a:17 brd ff:ff:ff:ff:ff:ff
root@bpi-r3:~# mbimcli -d /dev/cdc-wdm0 -p --query-ip-configuration

[/dev/cdc-wdm0] IPv4 configuration available: 'address, gateway, dns, mtu'
    IP [0]: '10.153.121.ip/29'
    Gateway: '10.153.121.gw'
    DNS [0]: '10.74.210.210'
    DNS [1]: '10.74.210.211'
    MTU: '1500'

[/dev/cdc-wdm0] IPv6 configuration available: 'address, gateway, dns, mtu'
    IP [0]: '2a01:598:808c:ba9c:c4e4:7a88:29ea:xxxx/64'
    Gateway: '2a01:598:808c:ba9c:93d:409b:3ddb:ee7'
    DNS [0]: '2a01:598:7ff:0:10:74:210:210'
    DNS [1]: '2a01:598:7ff:0:10:74:210:211'
    MTU: '1500'
root@bpi-r3:~# ip a s wwan0
11: wwan0: <BROADCAST,MULTICAST,NOARP> mtu 1500 qdisc noop state DOWN group
default qlen 1000
    link/ether 3e:06:6b:05:0a:17 brd ff:ff:ff:ff:ff:ff
root@bpi-r3:~# ip addr add 10.153.121.ip/29 dev wwan0
root@bpi-r3:~# ip link set wwan0 up
[ 357.976946] 8021q: adding VLAN 0 to HW filter on device wwan0
root@bpi-r3:~# ip route add default via 10.153.121.gw
root@bpi-r3:~# ip r
default via 10.153.121.gw dev wwan0
10.153.121.net/29 dev wwan0 proto kernel scope link src 10.153.121.ip
root@bpi-r3:~# ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=113 time=210 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=113 time=30.6 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=113 time=83.7 ms
^C
```

```
--- 8.8.8.8 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2002ms
rtt min/avg/max/mdev = 30.566/108.191/210.347/75.416 ms
root@bpi-r3:~#
```

## change Mode

Caution this may break functionality!

Make sure all known modules are loaded:

```
root@bpi-r3:~# modprobe qmi_wwan
root@bpi-r3:~# modprobe qcserial
root@bpi-r3:~# modprobe cdc_mbim
```

Get and switch mode (device open param should match your current Mode):

```
root@bpi-r3:~# qmicli -d /dev/cdc-wdm0 --device-open-mbim --dms-swi-get-usb-
composition
[/dev/cdc-wdm0] Successfully retrieved USB compositions:
      USB composition 6: DM, NMEA, AT, QMI
      [*] USB composition 8: DM, NMEA, AT, MBIM
      USB composition 9: MBIM

root@bpi-r3:~# qmicli -d /dev/cdc-wdm0 --device-open-qmi --dms-swi-get-usb-
composition
[/dev/cdc-wdm0] Successfully retrieved USB compositions:
      [*] USB composition 6: DM, NMEA, AT, QMI
      USB composition 8: DM, NMEA, AT, MBIM
      USB composition 9: MBIM

root@bpi-r3:~# qmicli -d /dev/cdc-wdm0 --device-open-mbim --dms-swi-set-usb-
composition 6
root@bpi-r3:~# qmicli -d /dev/cdc-wdm0 --device-open-qmi --dms-swi-set-usb-
composition 8
```

After that you will be prompted to set device offline and do reset.

```
qmicli ... --dms-set-operating-mode=offline
qmicli ... --dms-set-operating-mode=reset
```

and you should see unregister of current devices and register of new, here switch from QMI to MBIM:

```
[ 435.846807] usb 1-1.1: USB disconnect, device number 4
[ 435.852478] qcserial ttyUSB0: Qualcomm USB modem converter now
disconnected from ttyUSB0
[ 435.860767] qcserial 1-1.1:1.0: device disconnected
[ 435.866377] qcserial ttyUSB1: Qualcomm USB modem converter now
disconnected from ttyUSB1
```

```
[ 435.874650] qcserial 1-1.1:1.2: device disconnected
[ 435.880265] qcserial ttyUSB2: Qualcomm USB modem converter now
disconnected from ttyUSB2
[ 435.888540] qcserial 1-1.1:1.3: device disconnected
[ 435.893721] qmi_wwan 1-1.1:1.8 wwx269b6469dbbd: unregister 'qmi_wwan'
usb-11200000.usb-1.1, WWAN/QMI device
[ 443.533425] usb 1-1.1: new high-speed USB device number 5 using xhci-mtk
[ 443.763963] usb 1-1.1: config 1 has an invalid interface number: 12 but
max is 4
[ 443.771366] usb 1-1.1: config 1 has an invalid interface number: 13 but
max is 4
[ 443.778764] usb 1-1.1: config 1 has an invalid interface number: 13 but
max is 4
[ 443.786158] usb 1-1.1: config 1 has no interface number 1
[ 443.791544] usb 1-1.1: config 1 has no interface number 4
[ 443.799669] qcserial 1-1.1:1.0: Qualcomm USB modem converter detected
[ 443.806455] usb 1-1.1: Qualcomm USB modem converter now attached to
ttyUSB0
[ 443.814219] qcserial 1-1.1:1.2: Qualcomm USB modem converter detected
[ 443.820906] usb 1-1.1: Qualcomm USB modem converter now attached to
ttyUSB1
[ 443.828921] qcserial 1-1.1:1.3: Qualcomm USB modem converter detected
[ 443.835728] usb 1-1.1: Qualcomm USB modem converter now attached to
ttyUSB2
[ 443.898553] usbcore: registered new interface driver cdc_ether
[ 443.964054] usbcore: registered new interface driver cdc_ncm
[ 444.034077] cdc_mbim 1-1.1:1.12: cdc-wdm0: USB WDM device
[ 444.040007] cdc_mbim 1-1.1:1.12 wwan0: register 'cdc_mbim' at
usb-11200000.usb-1.1, CDC MBIM, 66:9b:64:69:db:bd
[ 444.050308] usbcore: registered new interface driver cdc_mbim
```

## troubleshooting

In my case no device is recognized by driver (no serial ttyUSBx too). Fixed this by adding usb-id in qcserial and qmi\_wwan driver.

But before i tried these steps:

i saw in dmesg only this (also after cold-reset):

```
[ 3.592655] usb 1-1.1: new high-speed USB device number 4 using xhci-mtk
[ 3.823392] usb 1-1.1: config 1 has an invalid interface number: 8 but
max is 3
[ 3.830719] usb 1-1.1: config 1 has no interface number 1
```

with this i have got access to the AT-Interface:

lsusb:

```
Bus 001 Device 004: ID 413c:81c2 Dell Computer Corp. DW5811e Snapdragon™ X7
```



## LTE

unlock ttyUSBx with option-module:

```
root@bpi-r3:~# modprobe option
[ 229.747728] usbcore: registered new interface driver option
[ 229.753429] usbserial: USB Serial support registered for GSM modem (1-port)

root@bpi-r3:~# echo 413c 81c2 >/sys/bus/usb-serial/drivers/option1/new_id
[ 300.293186] option 1-1.1:1.0: GSM modem (1-port) converter detected
[ 300.299755] usb 1-1.1: GSM modem (1-port) converter now attached to ttyUSB0
[ 300.307011] option 1-1.1:1.2: GSM modem (1-port) converter detected
[ 300.313657] usb 1-1.1: GSM modem (1-port) converter now attached to ttyUSB1
[ 300.320968] option 1-1.1:1.3: GSM modem (1-port) converter detected
[ 300.327741] usb 1-1.1: GSM modem (1-port) converter now attached to ttyUSB2
[ 300.336533] option 1-1.1:1.8: GSM modem (1-port) converter detected
[ 300.343262] usb 1-1.1: GSM modem (1-port) converter now attached to ttyUSB3
```

now only with "minicom -D /dev/ttyUSB2". (commandmode with Ctrl+AA, because already via Minicom on the R3)

ATE1

OK

AT!ENTERCND="A710"

OK

AT!CUSTOM?

!CUSTOM:

GPSENABLE	0x04
GPSSEL	0x01
IPV6ENABLE	0x01
SIMLPM	0x01
USBSERIALENABLE	0x01
SINGLEAPNSWITCH	0x01

OK

AT!USBCOMP?

Config Index: 1

Config Type: 1 (Generic)

Interface bitmask: 0020010D (diag,nmea,modem,rmnet0,ubist)

OK

AT!USBCOMP=?

!USBCOMP:

AT!USBCOMP=<Config Index>,<Config Type>,<Interface bitmask>

<Config Index> - configuration index to which the composition applies, s

<Config Type> - 1:Generic, 2:USBIF-MBIM, 3:RNDIS

config type 2/3 should only be used for specific

Sierra

customized VID/PID should use config type 1

<Interface bitmask> - DIAG - 0x00000001,

NMEA - 0x00000004,

MODEM - 0x00000008,

RMNET0 - 0x00000100,

RMNET1 - 0x00000400,

MBIM - 0x00001000,

e.g.

10D - diag, nmea, modem, rmnet interfaces enabled

1009 - diag, modem, mbim interfaces enabled

The default configuration is:

```
at!usbcomp=1,1,10F
```

```
OK
```

can't set default-mode, but the following fixes it and go back to mbim-mode after a cold-boot (ttyUSB accessible via options-module too)

```
AT!USBCOMP=1,1,100D
```

```
OK
```

```
AT!RESET
```

```
OK
```

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