Foxconn RPQN O-RU Installation and Operating Guide

Project name: Local 5G NR System
Version: v1.9
Date: 2021/11/23

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Version History

REVISION CHART				
Version	Author	Reviewer	Date	Description of revision
v0.1	Andrew George Garcia	Ben	2020/8/19	Initial version of RPQN O-RU Installation and Operating Guide
v0.2	Garcia	Toru	2020/8/20	Typo correct and append more info
v0.3	Garcia	Toru	2020/8/20	Unified style and correct typos
v0.4	Garcia	Toru	2020/8/21	Refine the chapter 2
v0.5	Andrew Garcia	Toru	2020/8/21	Add reboot/shutdown procedure
v0.6	Garcia	Toru	2020/8/26	Add reset button and LED info
v0.7	Garcia/Joe /Blake	Garcia/Lief/ Toru	2020/11/18	Refine the information. Auto boot up. Add FAQ & Troubleshooting
v0.8	Jay/Joe	Lief	2020/11/24	Add sample app tutorial
v0.9	Joe/Blake	Lief	2020/12/03	Modify sample app tutorial about VLAN tag, VSA configuration to decode SSB, some term's definition in RU log
V1.0	Kevin/Jay/ Blake		2020/12/24	Power on sequence/Add normal operation and firmware image upgrade with M-plane/ V1.1.5q.432 support Multicast
V1.1	Ryan/Joe/ Kevin	Lief	2021/01/13	Add antenna port number, correct 7901 LO, internal/external antenna

v1.2	Kevin	Lief	2021/02/24	
v1.3	Blake			M-plane new feature list, ptp lock example, ptp profile configuration, power cycle to recover
v1.4	Kevin		2021/03/10	Modify firmware image upgrade flow
v1.5	Kevin		2021/06/28	Add firmware and FlexRAN version match table
v1.6	Kevin		2021/07/28	Add support bands. Add supported prach format B4. How to calculate Tx power? How to disable/enable DPD?
v.1.7	Lief		2021/10/08	Remove mounting kit section
v1.8	Lief		2021/11/18	Add model-name Add FCC statement Add limited power source statement
v1.9	Lief		2021/11/23	Add SFP+ statement

Table of Contents

1 List of packages

- Indoor RPQN O-RU
- Model name: RPQN-7801E, RPQN-7801I, RPQN-7800E, RPQN-7800I, RPQN-7901E, RPQN-7901I
- Antenna x 4 (For external antenna type O-RU)
- Accessories: Optional. Order separately.
  - 10Gb SFP+ GBIC
  - 1Gb Copper SFP
  - 12VDC AC Adapter Power cord
  - Mounting Kit

1.1 Overview of RPQN O-RU

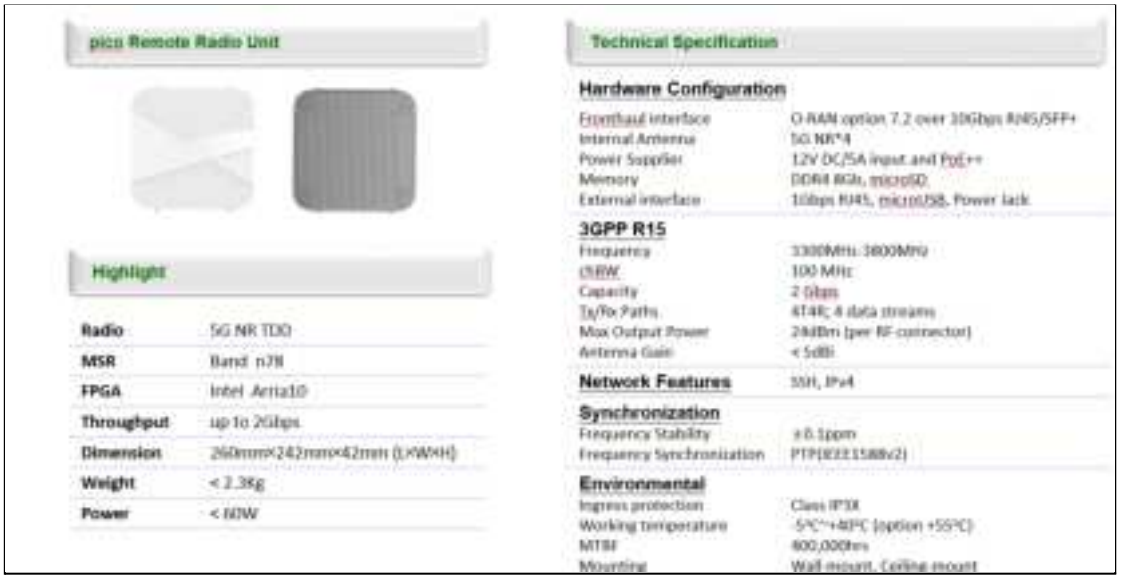


Figure 1 RPQN O-RU specs

1.2 Outlook

1.2.1 Indoor RPQN O-RU

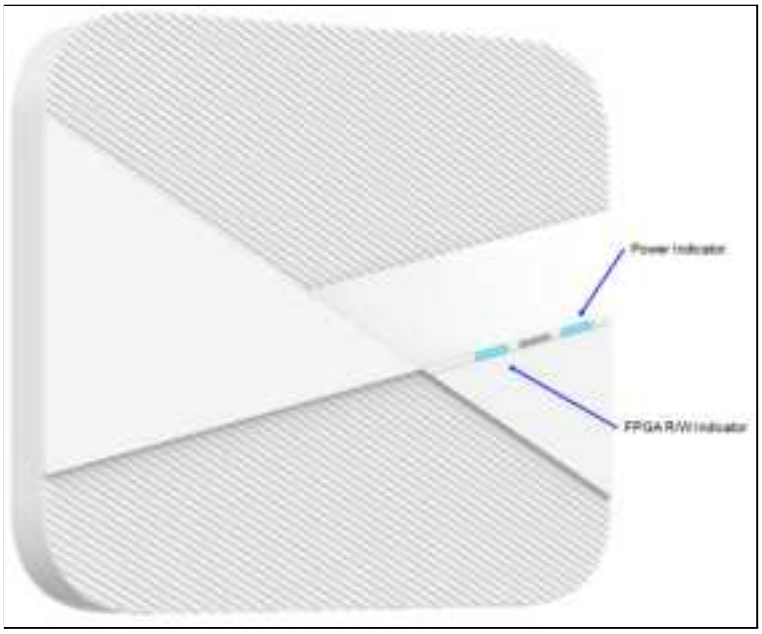


Figure 2 RPQN O-RU Interfaces

- **Right: Power indicator (LED for Power Status)**
- **Middle: System state indictor (LED for system Status)**
- **Left: Firmware image update indicator (LED for Link & Activity Status)**

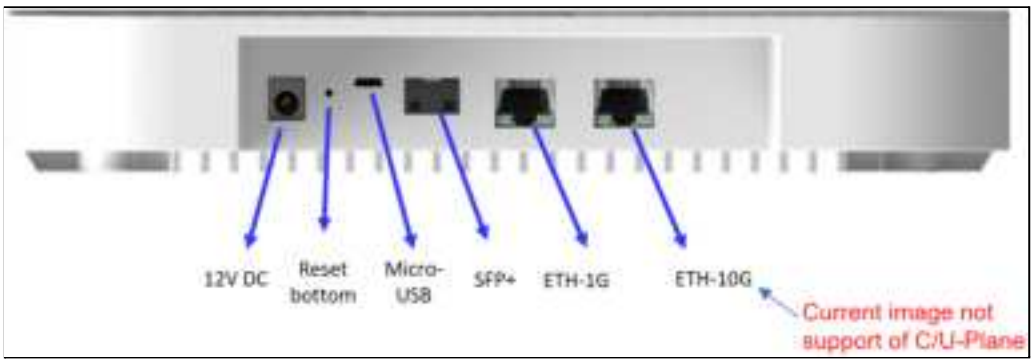


Figure 3 RPQN O-RU Interfaces

- **One 1Gbps Ethernet RJ-45 connector (support of S/M-Plane)**
- **One 10Gbps Ethernet RJ-45 connector (current software version not support of C/U-Plane)**
- **One 10Gbps SFP+ (support of C/U-Plane)**
- **Reset button, Micro USB**
- **Support PoE++ (10Gbps Ethernet RJ-45) or Power jack of 12VDC power adapter**

1.2.2 10Gb SFP+ optics (GBIC)

Figure 4 Accessories – 10Gb SFP+ optics

NOTE: Laser Class 1 optical transceiver shall be used only.

1.2.3 1Gb Active Copper SFP

Figure 5 Accessories – 1Gb Copper SFP

1.2.4 12VDC AC Adapter Power cord

Figure 6 Accessories – 12VDC AC Adapter Power cord

This product is intended to be supplied by a Listed Power Adapter or DC power source marked “L.P.S." (or "Limited Power Source"), rated 12 Vdc, 5A minimum, Tma = 0 degree C minimum. If need further assistance, please contact Foxconn for further information.

1.2.5 Mounting Kit

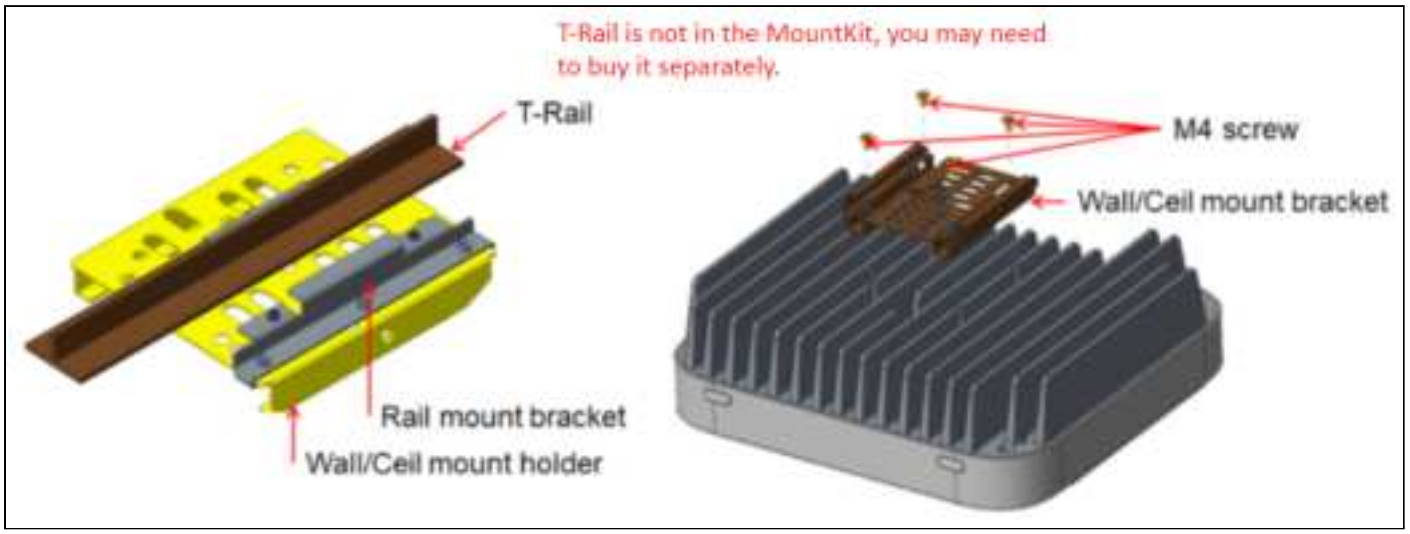


Figure 7 Accessories – Mounting Kit

1.3 Software Version

To show the current software version of RPQN O-RU. Please refer to the *4.1.2 RPQN O-RU setting*, by typing command "**cat /home/root/test/version.txt**", it may looks like below:

```
branch: master
version: c3ad3fe0608aac6d9d5c59d4c6945fca227f40e0
tag: v1.0.3q.431
```

In this example, the software version tag was **v1.0.3q.431**.

2 Regulation and Certification

2.1 Environmental and safety requirements

Environmental and safety requirements for Foxconn RPQN O-RU hardware installation.

Warning: Electric Shock.
Please notice that the RF ports should be connected to a 50 Ω load (for example, feeder with an antenna) before powering on the RPQN O-RU. The plastic caps delivered can provide electric shock protection in case RPQN O-RU is unintentionally power on. Please keep plastic caps remained in place for the unused RF ports.

Warning: Hot parts.
To avoid the risk of hot parts, please use the RPQN O-RU with caution, and wait at least 30 minutes before handling the RPQN O-RU after powering off.

NOTICE Only trained and qualified personnel are recommended to install, operate, maintain or handle the RPQN O-ORU, and please carefully read the safety information applicable to this product.

NOTICE Only install RPQN O-RU in a restricted access location, and meet the minimum requirements of RF exposure compliance distance.

2.2 Federal Communication Commission Interference Statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 35cm between the radiator & your body.

3 Cabling and assemble instruction

Below the figure shows the Foxconn SA L5G system.

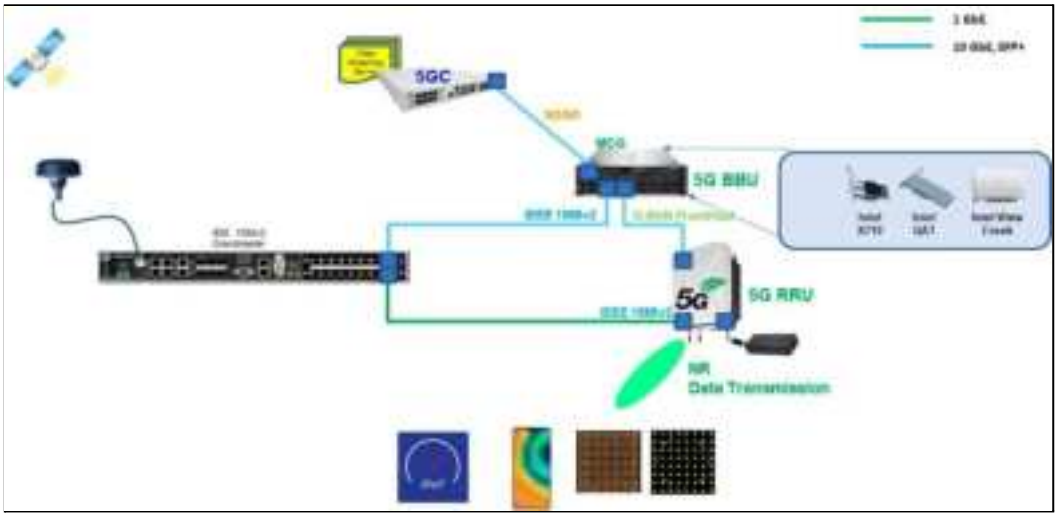


Figure 8 SA L5G System Architecture

3.1 RPQN O-RU cabling instruction

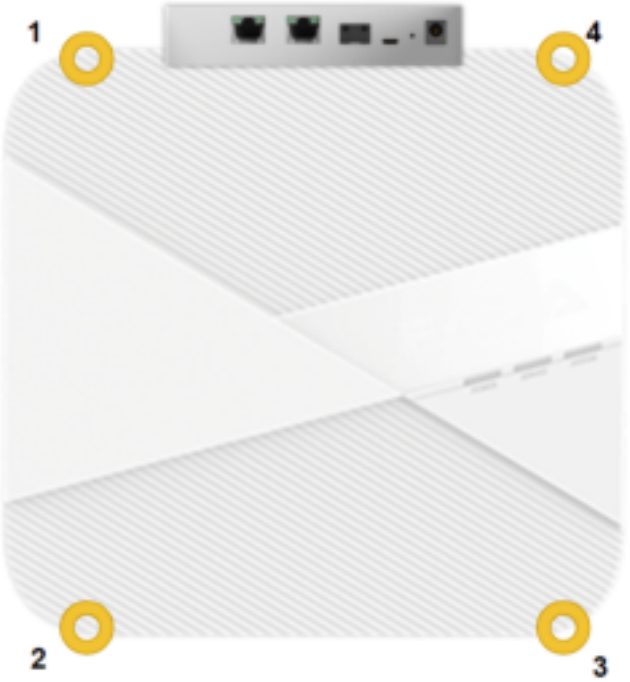
3.1.1 For O-RAN C/U-plane connection

- 10Gb SFP+ fiber cabling
  - Intel 10Gb Short Range Optics (model: E10GSFPSR, 850 nm wavelength) + multi-mode fiber, or
  - Intel 10Gb Long Range Optics (model: E10GSFPLR, 1310 nm wavelength) + single-mode fiber.
- 10Gb RJ-45 Ethernet cabling, recommend to use Cat 6A Ethernet cable.

3.1.2 For O-RAN S/M-plane connection

- 1Gb RJ-45 Ethernet cabling: recommend to use Cat 5E Ethernet cable.

3.1.3 Antenna port number



3.1.4 Power supply

- PoE++ via 10Gb RJ-45 Ethernet port: recommend to use Cat 6A Ethernet cable, or
- 12VDC power adapter: IN AC 100-240 V, 50/60 Hz, 2 A; OUT 12 V, 5 A.

3.1.5 Micro USB

- Micro USB: for RPQN O-RU debug console.

Figure 9 Example of cabling assemble

4 Operating instruction

4.1 Normal operation

4.1.1 PTP 1588v2 clock source setting

Before starting to use a RPQN O-RU, please set your PTP 1588v2 GM or BC correctly to match the design of RPQN O-RU. In the following example, a Qulsar QG2 GM is used. The following pictures referenced from Qulsar's user manual and the setting in the pictures may not be matched to RPQN O-RU's design.

- Step 1: Get or set the IP address of the port the RPQN O-RU to be connected (GM or BC). For example, the IP address of those two ports (GM/BC and RPQN O-RU) are 10.0.1.179 and **192.168.16.150**, respectively. If the port does not support DHCP, please remember to configure a proper IP with the same sub-net for RPQN O-RU later. Besides, RPQN O-RU does not support VLAN in PTP. Please disable the VLAN in GM/BC.

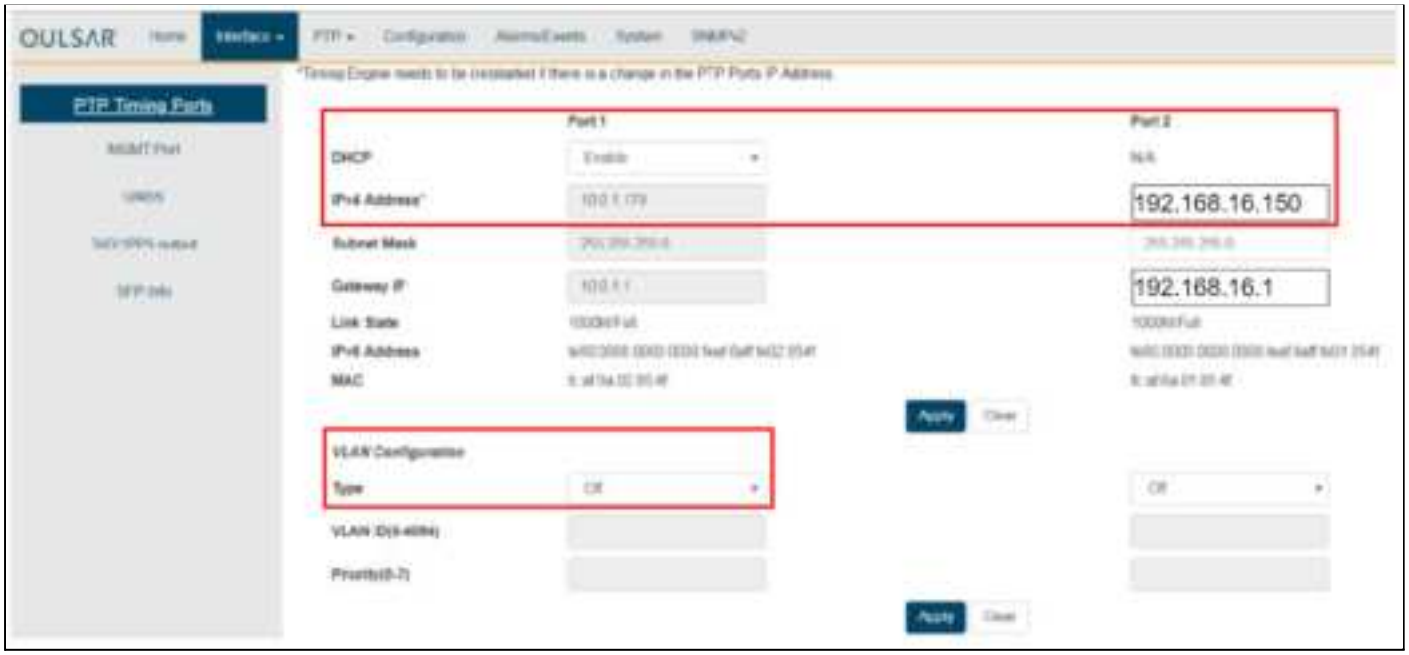


Figure 14 Get/Set IP address of PTP Clock Source GM or BC

- Step 2: Set GM/BC as an Ordinary clock, OFF the "Two Step" and set or get the domain number. The suggested value is **44**. If you choose other value, please set the same value in RPQN O-RU in the later step.

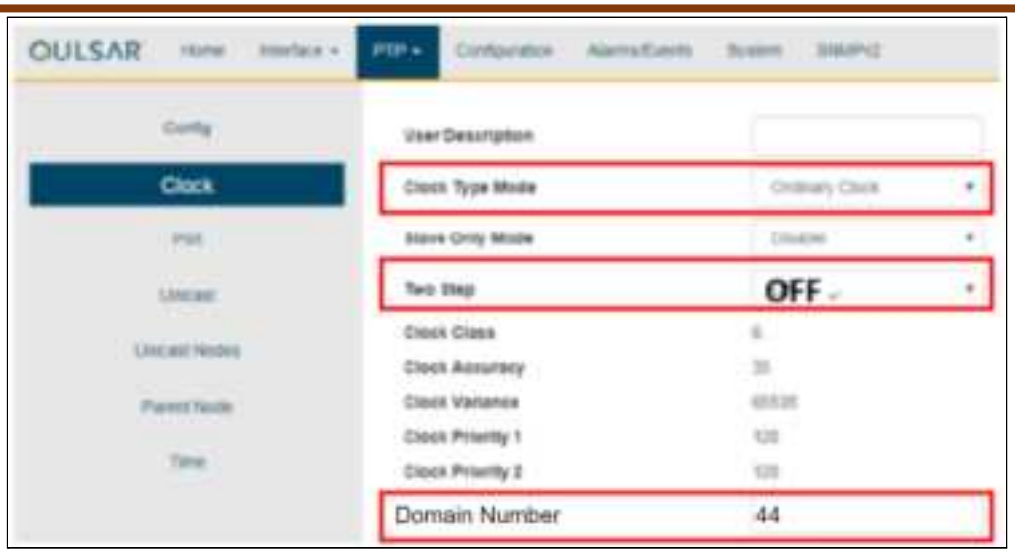


Figure 15 PTP Clock Source Parameter Setting

- Step 3: Set the PTP network protocol to IPv4 (UDP) and delay mechanism to End-to-End. Suggest to set “Sync Interval”, “Delay Request Interval” to 0, “Announce Interval” to 3 and “Announce Receipt Timeout to 3.
  NOTE: If the maximum announce interval supported in your GM is 0, please set the announce interval to 0 instead of 3

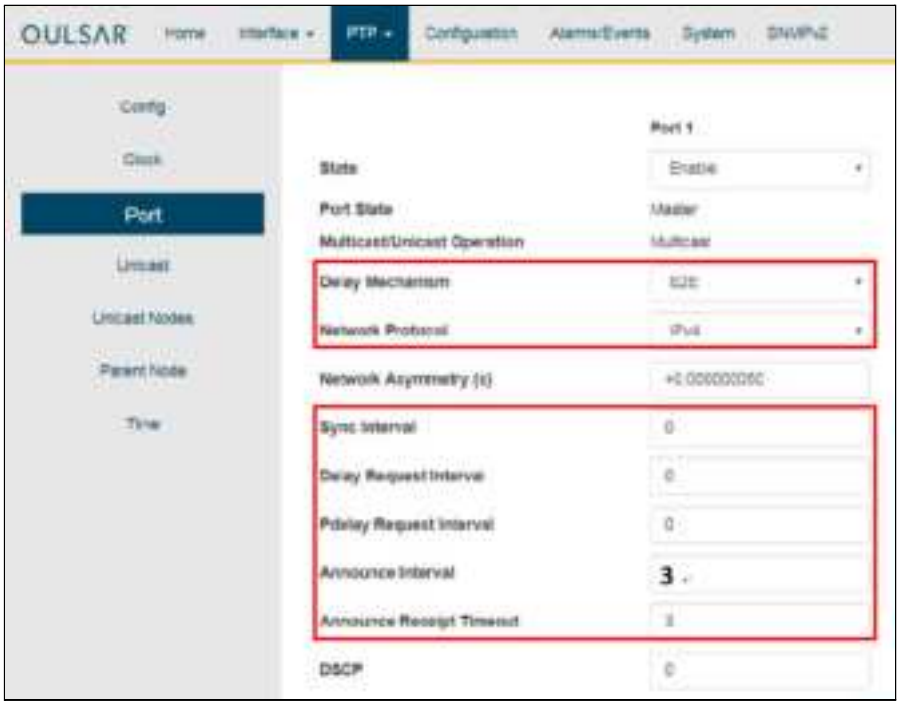


Figure 16 PTP Clock Source Port Setting

- Step 4: Please set the PTP operation to “Unicast” mode.

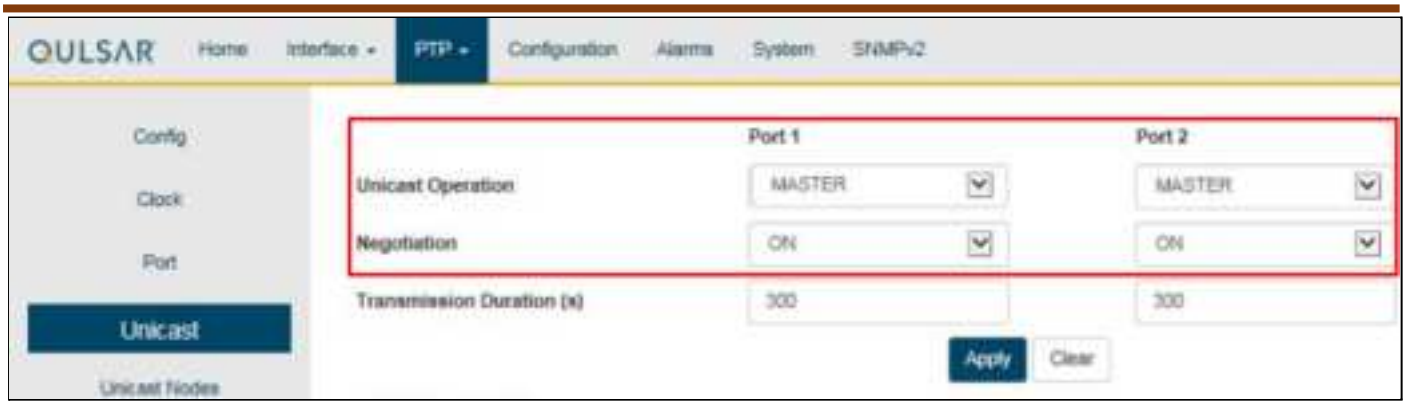


Figure 17 PTP Clock Source Set to Unicast Operation

4.1.2 Unicast and Multicast configuration

	G.8275.2 Unicast	G.8275.1 Multicast
logAnnounceInterval	-3 ~ 0	-3
logSyncInterval	-4 ~ 0	-4
operLogSyncInterval	0	0
logMinDelayReqInterval	0	-4
logMaxPdelayReqInterval	0	0

4.1.3 RPQN O-RU setting

- Step 1: Use a Micro-USB cable to connect to a RPQN O-RU from your PC
- Step 2: Start the tool “Device Manager” in your PC and check the COM port number of RPQN O-RU. For example, there is a USB Serial Port with COM port number 19 after RPQN O-RU is connected.

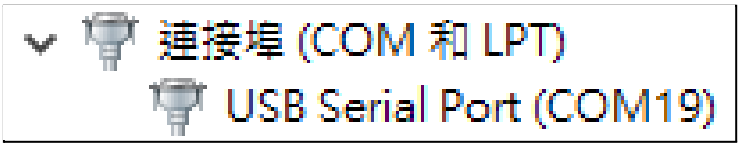


Figure 18 Example of COM Port in Device Manager

- Step 3: Start a terminal software such as “PuTTY” on your PC and select “Serial” protocol. The baud rate is 115200 and other configurations are shown below.

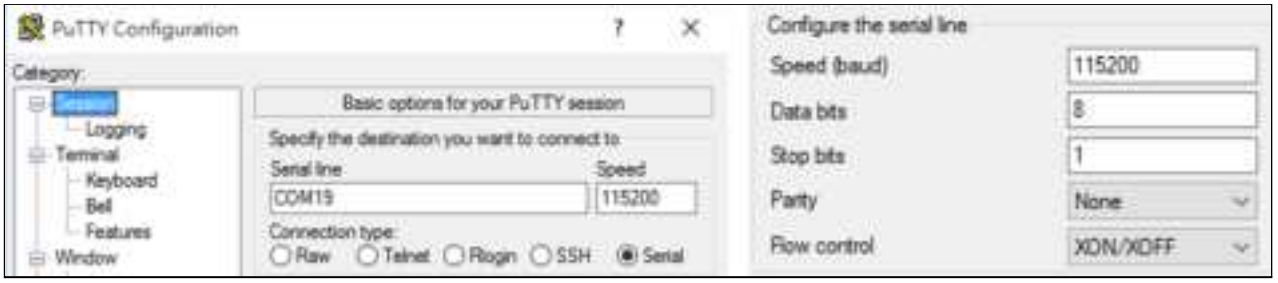


Figure 19 Baud Rate Setting of Serial Connection

- Step 4: Power on the RPQN O-RU and it would run initial boot-up process automatically.

Please DO NOT press any key when a down-count counter is shown in the boot-up process. After the following message is shown, the initial boot-up process is done correctly.

Figure 20 Example of Boot-up Process Success

- Step 5: Modify related configuration via:
  - Configuration file: **/home/root/sdcard/RRHconfig_xran.xml**, please reference step 5.1.
  - M-plane: please reference step 5.2. (The firmware version should > v1.0.3q.432)

- Step 5.1: In the terminal software window, use vi command to edit the configuration file, **/home/root/sdcard/RRHconfig_xran.xml**. Please keep the format the same as the default. For example, if a value is set in hexadecimal format, use the same format after changing to a different value. Besides, if a space character or a comma character is used, please do not remove them.

  - Set:

    1. BBU's MAC address in the field "RRH_DST_MAC_ADDR".
    2. RU's MAC address in the field "RRH_SRC_MAC_ADDR".

```
<!-- RRH_DST_MAC_ADDR: Destination MAC address, fill with 6 bytes and separate each others by colon -->
RRH_DST_MAC_ADDR = 00:11:22:33:44:66
<!-- RRH_SRC_MAC_ADDR: Source MAC address, fill with 6 bytes and separate each others by colon -->
RRH_SRC_MAC_ADDR = aa:bb:cc:dd:ee:ff
```

Figure 21 Set BBU MAC Address to Be Connected with RPQN O-RU

  - Set the VLAN ID for C-plane and U-plane, respectively.
    The default value is 0x0001 and 0x0002.

```
<!-- RRH_C_PLANE_VLAN_TAG: C-plane V-LAN tag express by hex number -->
RRH_C_PLANE_VLAN_TAG = 0x0001
<!-- RRH_U_PLANE_VLAN_TAG: U-plane V-LAN tag express by hex number -->
RRH_U_PLANE_VLAN_TAG = 0x0002
```

Figure 22 Set VLAN Tag ID for C/U-Plane

- Set the LO frequency of RPQN O-RU (in kHz).
  1. RXXN-4100: 2593000 (2496~2690MHz)
  2. RXXN-7800: 3352260 (3300~3600MHz)
  3. RXXN-7801: 3749700 (3700~3800MHz)
  4. RXXN-7901: 4849860 (4800~4900MHz)

```
<!-- RRH_LO_FREQUENCY_KHZ: Tx and Rx PLL LO Frequency in kHz(internal or external LO) -->
RRH_LO_FREQUENCY_KHZ = 3352260
```

Figure 23 Set LO Frequency

- Set the GM's IP address and domain number.

```
<!-- RRH_PTPV2_GRAND_MASTER_IP: IP address of grand-master -->
RRH_PTPV2_GRAND_MASTER_IP = 192.168.16.150
<!-- RRH_PTPV2_SUB_DOMAIN_NUM: The sub-domain number -->
RRH_PTPV2_SUB_DOMAIN_NUM = 44
```

Figure 24 Set PTP Clock Source IP Address to be Connected with RPQN O-RU

For other fields in the RRHconfig_xran.xml, you can keep it in default.

- Step 5.2: To connect to the NETCONF Server of RRH when M-plane is activated from a NETCONF client, please use "root/root" to login for username and password respectively. For example, we use a NETCONF Client named "yangcli" to connect to NETCONF server.
  - a. Set BBU's MAC address from NETCONF Client with xpath "/processing-elements/ru-elements/transport-flow/eth-flow/o-du-mac-address" with the name"PE0" of ru-element's name in processing elements.

```
yangcli root@172.10.73.84> replace /processing-elements/ru-elements/transport-flow/eth-flow/o-du-mac-address

Filling mandatory leaf /processing-elements/ru-elements/transport-flow/eth-flow/o-du-mac-address:
Enter string value for leaf <o-du-mac-address>
yangcli root@172.10.73.84:replace> 00:11:22:33:44:66

Filling key leaf /processing-elements/ru-elements/name:
Enter string value for leaf <name>
yangcli root@172.10.73.84> PE0

RPC OK Reply 3 for session 6:
```

  - b. Set the VLAN ID for C-plane and U-plane, respectively. The default value is 1 and 2.

    To modify the VLAN ID of C-plane and U-plane, the xpath is "/interfaces/interface/vlan-id" and the name of interface is "iC" and "iU" for C-plane and U-plane.
    There is an xpath "/processing-elements/ru-elements/transport-flow/eth-flow/vlan-id" needs to modified if VLAN ID of interface "iU" changed. It must be aligned to the VLAN

ID of U-plane.

```
yangcli root@172.18.73.84> replace /interfaces/interface/vlan-id

Filling optional leaf /interfaces/interface/vlan-id:
Enter uint16 value for leaf <vlan-id>
yangcli root@172.18.73.84:replace> 1

Filling key leaf /interfaces/interface/name:
Enter string value for leaf <name>
yangcli root@172.18.73.84> iC

RPC OK Reply 4 for session 6:

yangcli root@172.18.73.84> replace /interfaces/interface/vlan-id

Filling optional leaf /interfaces/interface/vlan-id:
Enter uint16 value for leaf <vlan-id>
yangcli root@172.18.73.84:replace> 2

Filling key leaf /interfaces/interface/name:
Enter string value for leaf <name>
yangcli root@172.18.73.84> iU

RPC OK Reply 5 for session 6:

yangcli root@172.18.73.84> replace /processing-elements/ru-elements/transport-flow/eth-flow/
o-du-mac-address  ru-mac-address    vlan-id
yangcli root@172.18.73.84> replace /processing-elements/ru-elements/transport-flow/eth-flow/vlan-id

Filling mandatory leaf /processing-elements/ru-elements/transport-flow/eth-flow/vlan-id:
Enter leafref value for leaf <vlan-id>
yangcli root@172.18.73.84:replace> 2

Filling key leaf /processing-elements/ru-elements/name:
Enter string value for leaf <name>
yangcli root@172.18.73.84> PE0

RPC OK Reply 6 for session 6:
```

- c. Set the LO frequency of RRH (in Hz). The xpath is "/user-plane-configuration/tx-array-carriers/center-of-channel-bandwidth" with the name "TX-Ca0" of tx-array-carries.

```
yangcli root@172.18.73.84> replace /user-plane-configuration/tx-array-carriers/center-of-channel-bandwidth

Filling mandatory leaf /user-plane-configuration/tx-array-carriers/center-of-channel-bandwidth:
Enter uint64 value for leaf <center-of-channel-bandwidth>
yangcli root@172.18.73.84:replace> 4500000000

Filling key leaf /user-plane-configuration/tx-array-carriers/name:
Enter string value for leaf <name>
yangcli root@172.18.73.84> TX-Ca0

RPC OK Reply 2 for session 6:
```

-

- d. Set the GM's IP address and domain number, the xpath are "/sync/ptp-config/g-8275-2-config/master-ip-configuration/ip-address" and "/sync/ptp-config/domain-number". To set "/sync/ptp-config/g-8275-2-config/master-ip-configuration/ip-address" with NETCONF Client, the key of xpath "/sync/ptp-config/g-8275-2-config/master-ip-configuration/local-priority" must set as "128" as default.

```
yangcli root@172.18.73.84> replace /sync/ptp-config/g-8275-2-config/master-ip-configuration/ip-address

Filling optional leaf /sync/ptp-config/g-8275-2-config/master-ip-configuration/ip-address:
Enter string value for leaf <ip-address>
yangcli root@172.18.73.84:replace> 192.168.33.150

Filling key leaf /sync/ptp-config/g-8275-2-config/master-ip-configuration/local-priority:
Enter uint8 value for leaf <local-priority>
yangcli root@172.18.73.84> 128

RPC OK Reply 7 for session 6:
```

To let the RRH applies the new configurations, please reboot the RRH.

```
yangcli root@172.18.73.84> reset
```

- Step 6: Check IP related configuration via:
  - IP Configuration: "ifconfig" command to check, please reference step 6.1.
  - M-plane: please reference step 6.2. (The firmware version should > v1.0.3q.432)

- Step 6.1: Use a network cable to connect RPQN O-RU and GM/BC you use. If the GM/BC supports DHCP server, RPQN O-RU should get an IP address after connecting. You can use "ifconfig" command to check. If the GM/BC does not support DHCP server, please use "ifconfig eth0 xxx.xxx.xxx.xxx netmask 255.255.255.0" to configure the RPQN O-RU's IP address. Please make sure to use the same sub-net number as the GM/BC uses.
- Step 6.2: Use a network cable to connect RRH and GM or BC you use. If the GM supports DHCP, RRH should get an IP after connecting. When the M-plane is activated, you can use "./set_oam_mode -e" command to enable DHCP. If the GM does not support DHCP, please use "./set_oam_mode -e IP_ADDR 255.255.0.0 GATEWAY_IP_ADDR" to configure the RRH's IP. Please make sure to use the same sub-net number as the GM uses. Then please reboot the RRH.

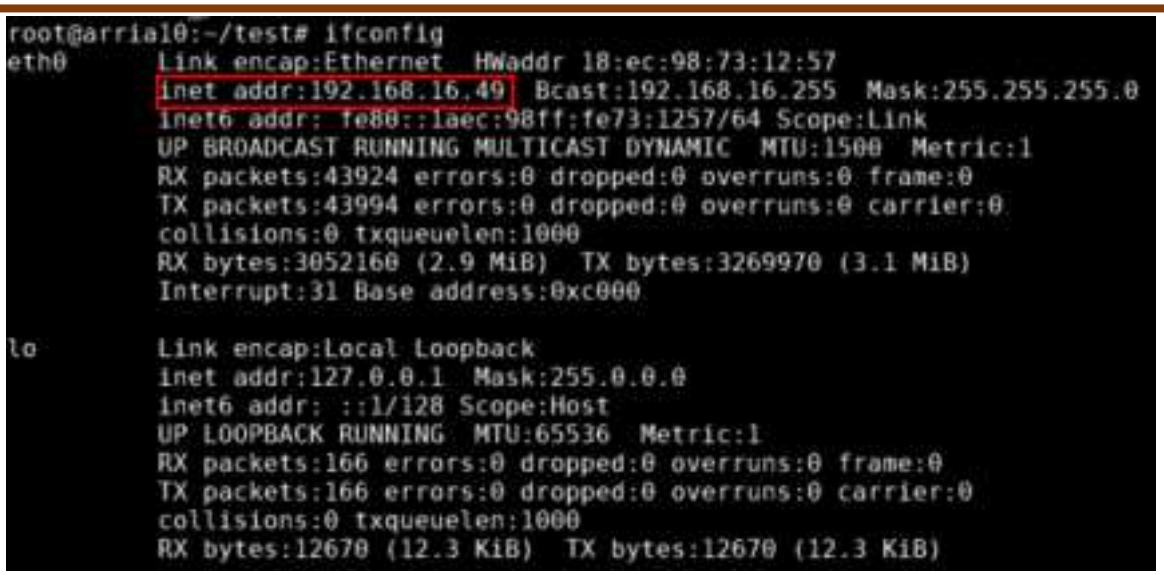


Figure 25 Subnet Mask Confirmation

Note: You can use the “ping” command to make sure that the link connects correctly.

- Step 7: After finishing the above configuration, go to the “~/test” folder and run command “./init_rrh_config_enable_cuplane” to start the normal process of RPQN O-RU.

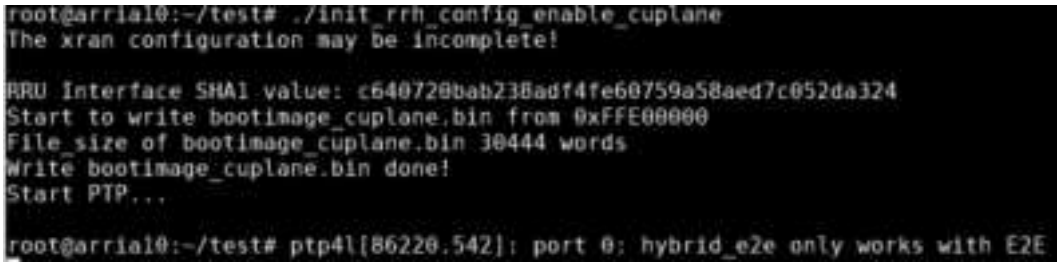


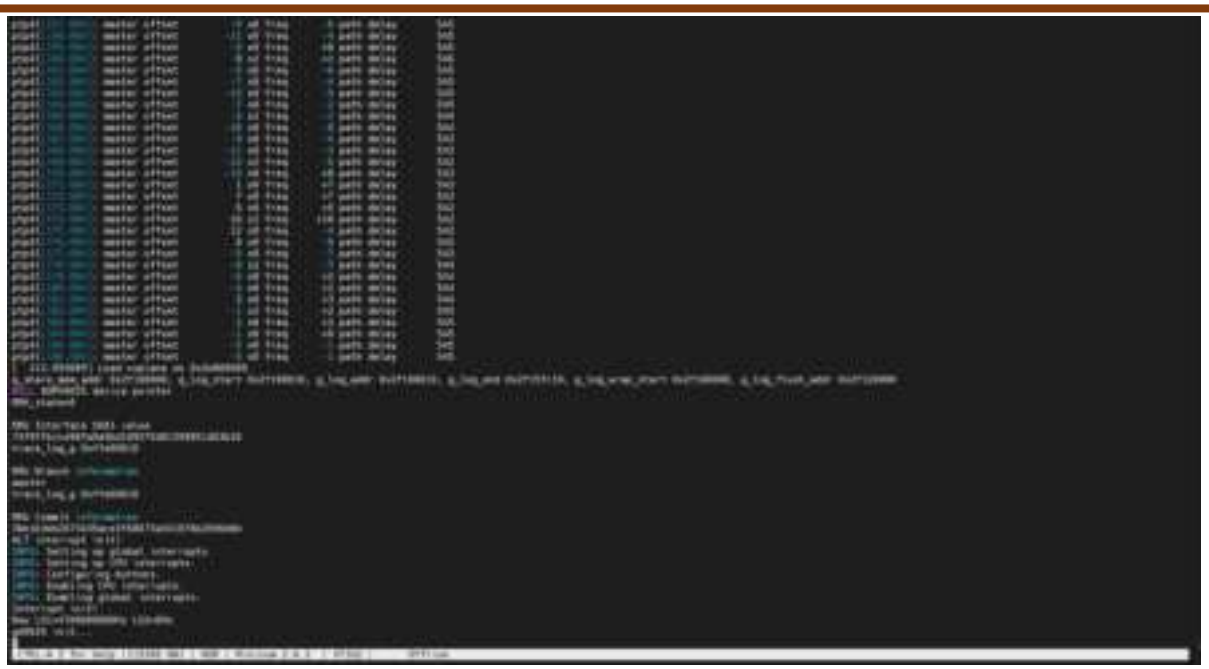
Figure 26 Start up the RPQN O-RU

Within about one minute, the following messages are shown. If there is no message shown like below, please check if the GM/BC’s IP and domain number in RRHconfig_xran.xml are the same as those in GM/BC.

Figure 27 Example of PTP Sync Up

If you want to re-run “init_rrh_config_enable_cuplane” command after correcting some setting issue, please power cycle the RPQN O-RU and go to step 6 to set the IP address and then you can re-run the command.

- Step 8: After master offset converge to **-40~40**, it will start to initialize C/U-plane



- Step 9: When the following messages are shown, the RPQN O-RU has done the normal process and can start to work with a BBU.

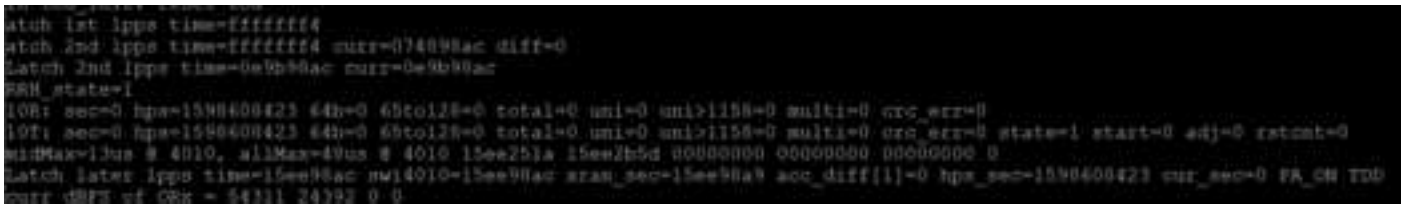


Figure 28 Example of RPQN O-RU Start up Success

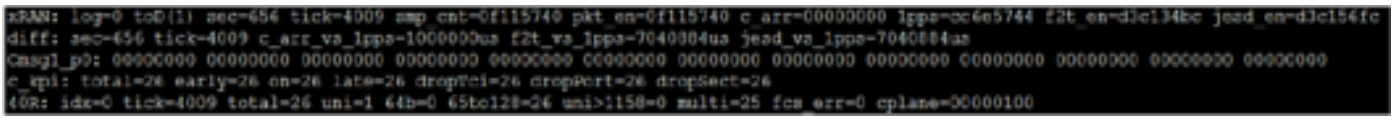


Figure 29 Example of xRAN packet coming to O-RU

- Step 10: When you power cycle the RPQN O-RU, you can start the RPQN O-RU from step 6 if the GM/BC's setting and LO frequency is not changed.

- Step 11: Please make sure ALL of RF connectors have been connected to loads exactly before a BBU starts to send data to a RPQN O-RU.
  - Please make sure a BBU stops sending any data to a RPQN O-RU before loads of RF connectors are released.
  - If a load is not connected well when a BBU is sending data, RF components may be damaged. Users have to be responsible for the consequences.

4.1.4 Works with Multicast PTP

Work start from **VERSION: v1.1.5q.432**

1. **(conditional)** If you have already enabled M-plane(**v1.1.4q.432**) before, you need to disable it first.
   `./set_oam_mode -d`
2. Download firmware .tgz file and move it to RRH ***/home/root/test/***
3. Unzip file `tar xzvf v1.1.5q.432.tgz`
4. Update firmware `./data_restore v1.1.5q.432`
5. Go to folder ***v1.1.5q.432***, run script `./install_patch.run`
6. Modify ***/home/root/sdcard/RRH_config_xran.xml***
   i. Change mode to multicast

```
<!-- RRH_PTPV2_GRAND_MASTER_MODE: 0: Unicast, 1:Multicast -->
RRH_PTPV2_GRAND_MASTER_MODE = 1
```

   ii. Change domain number (align with GM)

```
<!-- RRH_PTPV2_SUB_DOMAIN_NUM: The sub-domain number -->
RRH_PTPV2_SUB_DOMAIN_NUM = 24
```

7. Once the ptp start to sync, After ptp locked, it will start to enable C/U-plane

```
ptp4l[112.611]: rms    9 max   11 freq     -3 +/-   1 delay   298 +/-   2
ptp4l[113.620]: rms    8 max    8 freq     +0 +/-   0 delay   297 +/-   0
ptp4l[114.611]: rms   10 max   11 freq     +0 +/-   0 delay   298 +/-   1
ptp4l[115.630]: rms    8 max   11 freq     +0 +/-   0 delay   297 +/-   2
ptp4l[116.611]: rms    5 max    8 freq     +1 +/-   1 delay   297 +/-   1
ptp4l[117.611]: rms    8 max   12 freq     -7 +/-   7 delay   300 +/-   2
ptp4l[118.611]: rms    7 max    8 freq     -6 +/-   1 delay   296 +/-   1
ptp4l[119.611]: rms   11 max   12 freq     -4 +/-   0 delay   300 +/-   1
ptp4l[120.611]: rms   13 max   21 freq    -18 +/-  41 delay   300 +/-   1
ptp4l[121.611]: rms   11 max   11 freq     +0 +/-   0 delay   300 +/-   0
ptp4l[122.611]: rms   11 max   11 freq     +0 +/-   0 delay   300 +/-   0
ptp4l[123.611]: rms   10 max   11 freq     +0 +/-   0 delay   299 +/-   0
[  148.494758] Load cuplane on 0x2e800000
NULL ADRV9025 device pointer
RRH_state=0

RRU Interface SHA1 value
74f9ffb1ce98fa9d4bd109575d01399851d53b26

RRU Branch information
master
RRU Commit information
0fafdb573911fafd3a0279f522646450cc548de0
ALT interrupt init!
INFO: Setting up global interrupts.
INFO: Setting up CPU interrupts.
INFO: Configuring buttons.
INFO: Enabling CPU interrupts.
INFO: Enabling global interrupts.
Interrupt init!
New LO1=3352260000Hz LO2=0Hz
ad9025 init...
```

4.1.5 Reboot and Shutdown

If rebooting or shutting down a RPQN O-RU is needed, a user must connect the RPQN O-RU via terminal software to run the command, "./reboot.sh" or "./shutdown.sh" respectively. There are two methods to do that.

P.S. If O-RU cannot return to normal state, please **POWER CYCLE** O-RU.

4.1.6 Remote Connection via GM/BC

The first method is via a GM/BC if the GM/BC supports IP routing or forwarding.

- Step 1: To set IP address of a user's PC followed the description in *4.1.2 RPQN O-RU setting*. For example, the IP address can be 192.168.16.50 for the user's PC where the IP address of a RPQN O-RU above is 192.168.16.49.
- Step 2: Users can use the command "ping" to check if an echo is replied. If yes, users can create a remote connection to the RPQN O-RU as follows.

```
[andrew@localhost Desktop]$ ssh root@192.168.2.49
Last login: Thu Aug 29 03:27:36 2019 from 192.168.17.49
mount /dev/mmcblk0p1 to ~/sdcard
mount: /dev/mmcblk0p1 is already mounted or /home/root/sdcard busy
       /dev/mmcblk0p1 is already mounted on /home/root/sdcard
root@arria10:~/test#
```

Figure 30 Example of RPQN O-RU Remote Connection Success

- Step 3: After a remote connection is established, the user can enter "./reboot.sh" or "./shutdown.sh" to reboot or shut down the RPQN O-RU.

4.1.7 Remote Connection via directly connect

The second method to connect RPQN O-RU is to directly connect both RPQN O-RU and the user's PC by setting the correct IP address of a user's PC.

- Step 1: Eject the network cable from a GM/BC and plug into the user's PC.
- Step 2: Set the IP address of the user's PC as the same as the IP address of the GM/BC, which the RPQN O-RU connects to. For example, user can set the IP to 192.168.16.150 as the example in *4.1.2 RPQN O-RU setting*.
- Step 3: Users can use the command "ping" to check if an echo is replied. If yes, users can create a remote connection to the RPQN O-RU and then enter "./reboot.sh" or "./shutdown.sh" to reboot or shut down the RPQN O-RU.
- Step 4: After that, restore the network cable back to the GM/BC.

4.2 Firmware image upgrade

- Step 1: Use a Micro-USB cable to connect to a RPQN O-RU from your PC
- Step 2: Start the tool “Device Manager” in your PC and check the COM port number of RPQN O-RU. For example, there is a USB Serial Port with COM port number 19 after RPQN O-RU is connected.

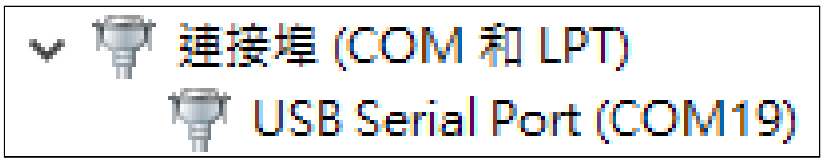


Figure 31 Example of COM Port in Device Manager

- Step 3: Start a terminal software such as “PuTTY” on your PC and select “Serial” protocol. The baud rate is 115200 and other configurations are shown below.

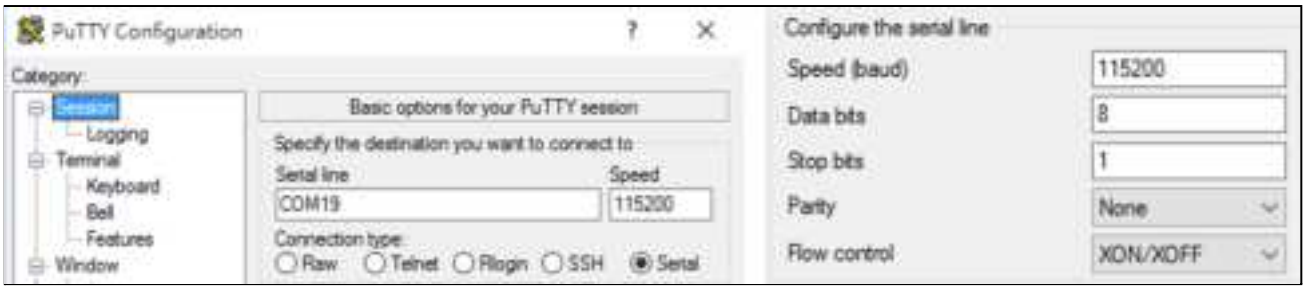


Figure 32 Baud Rate Setting of Serial Connection

- Step 4: Power on the RPQN O-RU and it would run initial boot-up process automatically. Please DO NOT press any key when a down-count counter is shown in the boot-up process. After the following message is shown, the initial boot-up process is done correctly.

Figure 33 Example of Boot-up Process Success

- Step 5: Next, your PC and RPQN O-RU must be located on the same network and there must be a DHCP server in that network to allocate IP to your PC and the RPQN O-RU automatically. After connecting RPQN O-RU to the network, use the command, “ifconfig”, to check what IP address the RPQN O-RU gets.

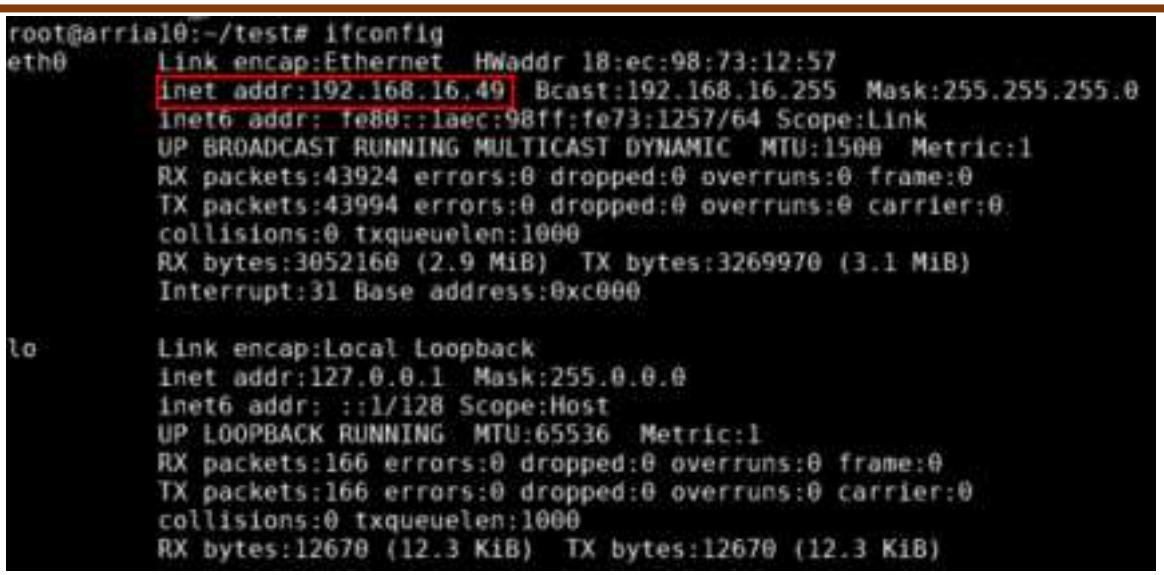


Figure 34 Subnet Mask Confirmation

- Step 6: After the IP address is obtained, use WINSCP at the PC side to connect RPQN O-RU. After v1.4.12q.524, it needs a password. In non-oam mode, the default password is "123456". If ever enabled OAM, the default password will be "cj/6c93zj4g4d;".

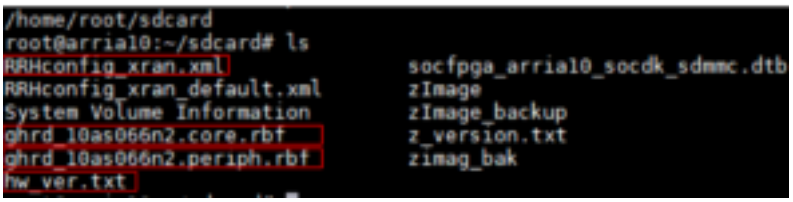
  BACKUP the original files before any updating.

  - Backup the following 3 files under ***/home/root/test***,

    1. bootimage_cuplane.bin
    2. init_rrh_config_enable_cuplane
    3. version.txt

  - Backup the following 4 files under ***/home/root/sdcard*** folder,

    1. ghrd_10as066n2.core.rbf
    2. ghrd_10as066n2.periph.rbf
    3. RRHconfig_xran.xml
    4. hw_ver.txt



- Step 7: Update configuration via:
  - Firmware files: Upload the firmware installation file to ***/home/root/test*** by WINSCP or any SFTP tools.
  - M-plane: please reference step 11 to step 13. (The firmware version should above v1.0.3q.432)

- Step 8: Go back to the Putty window. Before running the installation program, **please check if the spare disk space is larger than 100MBytes.** If not, please clean up the disk to get enough space for installation.
- Step 9: Change directory to **/home/root/test** and execute:

```
1. chmod 755 firmware_name.run
2. ./firmware_name.run
```

```
root@arria10:~/test/fw_upgrade# chmod 755 install_oam_v1_3_8q_32.run
root@arria10:~/test/fw_upgrade# ./install_oam_v1_3_8q_32.run

Start to install v1.3.8q.52...
Current folder = /home/root/test/fw_upgrade

org=d9fdf50d7197b37f7151e7d8631fa21aa2358de8
new=e300d65e7ed3fe9a147a31dfe3fb047266348442

org=bb66bc4ac9d617dab5ec57975155bd03a2f94c0a
new=3718c24fbb1457a6fb7cea6654a20f68be60f032
Enter new UNIX password: Retype new UNIX password: passwd: password updated successfully

Change to Non-OAM mode.  Ready to reboot...
```

- Step 10: Connect the network cable back to the GM/BC port and do the normal operations in the section *4.1.2 RPQN O-RU setting*.

4.2.1 Enable OAM mode

- Step 11: After the installation is done, the RRH would be re-booted automatically.
  If the re-booting is done, please use the following command to activate OAM mode with flexible IP assigned by a DHCP server because the default RRH mode does not apply M-plane feature:

  ```
  ./set_oam_mode -e
  ```

- Step 12: If the GM or BC doesn't support DHCP server and a static IP has to assign to RRH manually, please use the following command to set static IP, gateway and activate OAM mode.

  ```
  ./set_oam_mode -e IP_ADDR 255.255.0.0 GATEWAY_IP_ADDR
  ```

- Step 13: After rebooting, the installation is done and RRH will automatically run M-plane.

4.2.2 Disable OAM mode

- Disable OAM mode:

  ```
  ./set_oam_mode -d
  ```

4.2.3 OAM mode command

Command script at /home/root/test/set_oam_mode
root@arria10:~/test# ./set_oam_mode -h Usage: set_oam_mode [OPTION...] [IP ADDR] [NETMASK] [GATEWAY ADDR] This command can change the RRH mode to OAM or NON-OAM mode. Examples: set_oam_mode -d #Disable OAM mode set_oam_mode -e #Enable OAM mode set_oam_mode -e 192.168.33.49 #Enable OAM mode set_oam_mode -e 192.168.33.49 255.255.0.0 #Enable OAM mode set_oam_mode -e 192.168.33.49 255.255.0.0 192.168.33.150 #Enable OAM mode Main options: -d: Disable OAM mode -e: Enable OAM mode -h: Help

4.2.4 List of M-plane Features

Version v1.1.4q.432

- 1. Transport and Handshake in IPv4 Environment
  - DHCP Enable/Disable
  - VLAN Settings (Searching Range/VLANs)
  - Static IP Settings (Interface IP/Network Mask IP)
  - Static CallHome IP & Port settings
  - Getting CallHome IP from DHCP option 43(only if DHCP is enabled)
- 2. Software Upgrade (Download, Installation, Activation)
  - Download: Download an image from a SFTP server site.
  - Installation: Install a downloaded image of a slot.
  - Activation: Activate an installed image of a slot.
- 3. Supervision implementation to check connectivity between NETCONF Server and Client
  - User could reset the watchdog timer after receiving the Notification from RRH (NETCONF Server)
- 4. User Management
  - Users could create users which belong to the specified groups.
- 5. Alarm Management
  - Subscribe: NETCONF Client subscribes with RRH (NETCONF Server) for getting notifications generated from RRH.
  - Active Alarm Lists: NETCONF Client could get active alarm lists from RRH.
- 6. U-Plane Configurations
  - Static profiles of RRH now.

- LO frequency is configurable.

- 7. S Plane Configurations
  - GM IP settings of the YANG module 'o ran sync.yang'.
- 8. VLAN ID settings for C Plane & U Plane
  - Configurable VLAN ID s for the interfaces 'iC' (C Plane) and 'iU' (U Plane).

Version v1.2 .6q.432

Add new features:

- 1. S Plane Configurations
  - G.8275.1 profile support
  - PTP status support
- 2. Delay Management Profile
  - Static profile support only
- 3. Log Management
  - Troubleshooting log support
- 4. U Plane Configurations
  - TX/RX Arrays support
  - Configurable gain settings of TX/RX array carriers
- 5. RU information
- 6. Heartbeat for RRU M Plane service
  - Check if the service is still alive every 30 seconds.
  - Will restart the service in 30 seconds if the service isn't alive.
  - The configuration will be set to default values if the service cannot be restart successfully in 5 times.

Version v1.3.8q.52

Add new features:

- 1. Trace Log Management (o ran trace

Fix bugs:

- 1. Fix notification payload error of file management response content.
- 2. Correct the value of the leaf sync state and supported reference types of the module o ran sync.yang

4.3 How to use the sample app to verify O-RU working properly or not?

The sample app was built based on the O-RAN SC bronze 1.1 release. It can simulate DL/UL I/Q data patterns as BBU.

While you are using sample app with O-RU:

- If you can see normal spectrum waveform and constellation, it means PTP sync status, O-RU and front-haul connection were correctly configured.
- If not, you may need to check PTP configuration, O-RU software/hardware/configuration, front-haul connection.

The software name would be: *oran_bronze_release_v1.1_sample_app.tar.gz*

4.3.1 Operation steps

1. Untar gz file
   a. *# tar zxvf oran_bronze_release_v1.1_sample_app.tar.gz*
   b. You will get **o-du** directory
   c. Take **/root/o-du** as an example.

2. Before running sample-app, you have to use DPDK to bind the VFs of 10GbE NIC used for C/U-plane
   a. Assume your NIC information as below:
      i. Name: ***enp216s0f1***
      ii. PCIe address: ***0000:d8:0a***
   b. Create VF for CU-Plane
      i. # ip link set enp216s0f1 vf 0 vlan 2
      ii. # ip link set enp216s0f1 vf 1 vlan 1
      iii. # ip link set enp216s0f1 vf 0 mac 00:11:22:33:44:66
      iv. # ip link set enp216s0f1 vf 1 mac 00:11:22:33:44:66
   c. Modify *./o-du/phy/fhi_lib/app/dpdk.sh* according to your setup

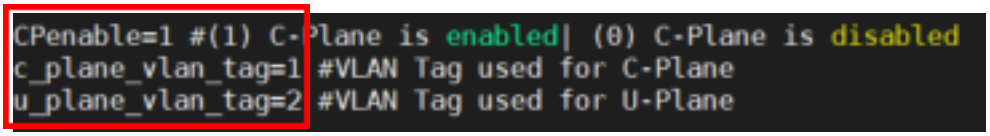
```
# Ethernet device name used to connect to RU (Please change according to your setting)
ethdevice=enp216s0f1

# PCIe address of network devices using DPDK-compatible driver (Please change
# according to your setting)
pcieaddr="d8:0a.0 d8:0a.1"

dpdk_iodev=igb_uio

# MAC address DPDK used to bind (Please change according to your setting)
macaddr=00:11:22:33:44:66
```

3. Enable DPDK for once after system reboot
   a. *# cd ./o-du/phy*
   b. *# source setupenv.sh*
   c. *# cd fhi_lib/app*
   d. Make sure the 10GbE fiber cable is connected between the BBU and RRH
   e. *# ./dpdk.sh*
   (0000:d8:0a.0 and 0000:d8:0a.1 are example, you should see the PCIe address of the 10GbE NIC on BBU)

```
Network devices using DPDK-compatible driver
============================================
0000:d8:0a.0 'XL710/X710 Virtual Function 154c' drv=igb_uio unused=i40evf,vfio-pci
0000:d8:0a.1 'XL710/X710 Virtual Function 154c' drv=igb_uio unused=i40evf,vfio-pci
```

4. Edit setupenv.sh
   a. *# cd ./o-du/phy*
   b. *# vi setupenv.sh*
   c. Change *DIR_ROOT=/root*

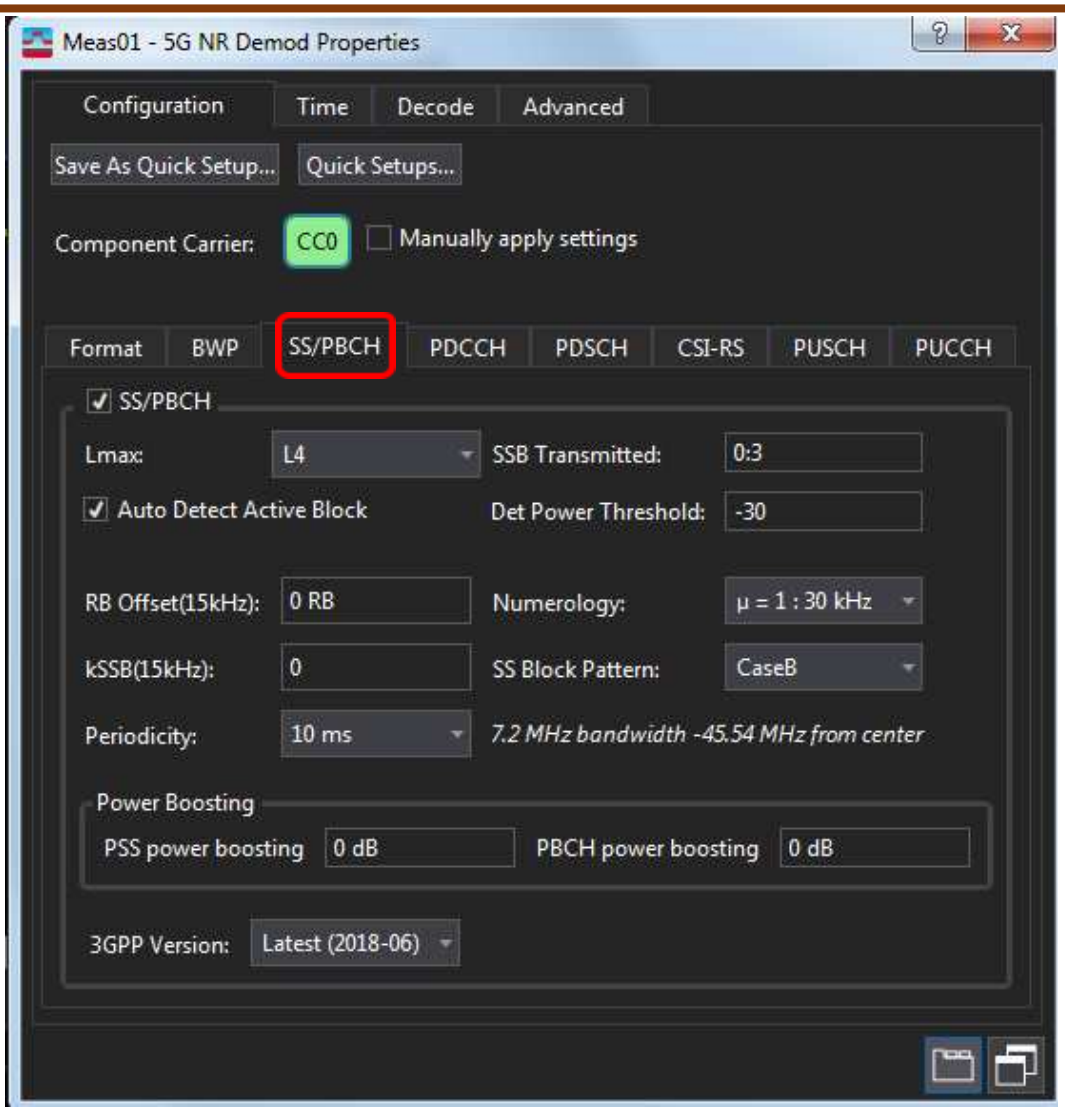
5. Set duMac and ruMac address and VLAN tag according to your setting.
   a. # cd ./o-du/phy/fhi_lib/app/usecase/mu1_100mhz
   b. edit config_file_o_du.dat



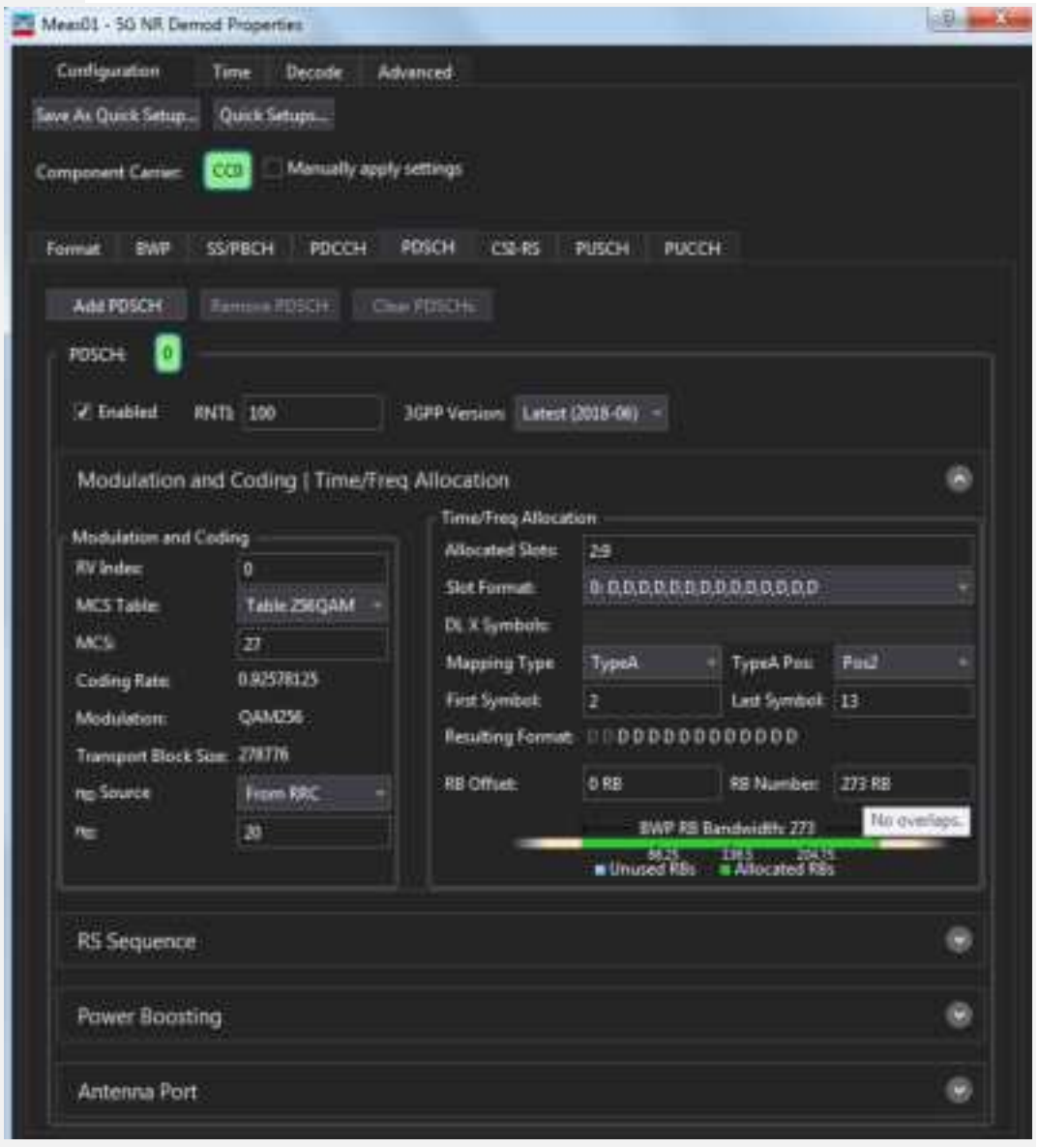
6. Set PCIe address of network devices using DPDK-compatible driver
   a. # cd ./o-du/phy
   b. # source setupenv.sh
   c. # cd fhi_lib/app
   d. edit run_o_du.sh

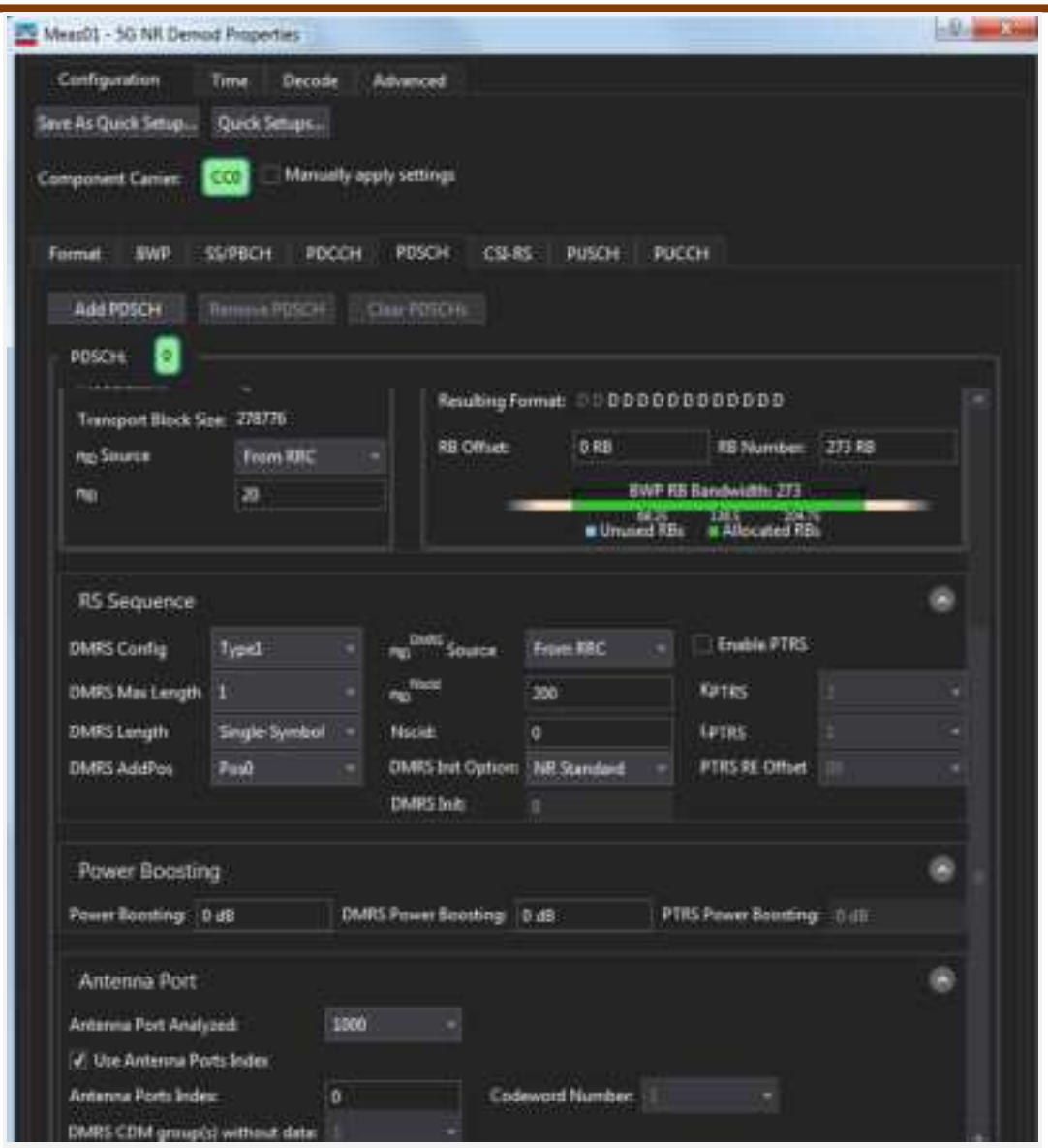
   e. # ./run_o_du.sh

   f. Modify the configuration of VSA(vector signal analyzer)
      i. SS/PBCH



ii. PDSCH





```
Start XRAN traffic
Set debug stop 1, debug stop count 0
O-DU: thread_run start time: 01/01/70 17:40:11.000000005 UTC (500)
Start C-plane DL 71 us after TTI  [trigger on sym 2]
Start C-plane UL 200 us after TTI  [trigger on sym 0]
Start U-plane DL 196 us before OTA [offset  in sym -5]
Start U-plane UL 75 us OTA         [offset  in sym 3]
C-plane to U-plane delay 125 us after TTI
Start Sym timer 71428 ns
interval_us 500
+-------------------------------------+
| Press 1 to start 5G NR XRAN traffic |
| Press 2 reserved for future use     |
| Press 3 to quit                     |
+-------------------------------------+
[o-du][rx       0 pps       0 kbps       0][tx       0 pps       0 kbps       0] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Total 0] IO Util: 44.13 %
[o-du][rx       0 pps       0 kbps       0][tx       0 pps       0 kbps       0] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Total 0] IO Util: 44.12 %
[o-du][rx       0 pps       0 kbps       0][tx       0 pps       0 kbps       0] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Total 0] IO Util: 44.13 %
[o-du][rx       0 pps       0 kbps       0][tx       0 pps       0 kbps       0] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Total 0] IO Util: 88.23 %
[o-du][rx       0 pps       0 kbps       0][tx       0 pps       0 kbps       0] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Total 0] IO Util: 44.12 %
[o-du][rx       0 pps       0 kbps       0][tx       0 pps       0 kbps       0] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Total 0] IO Util: 44.11 %
[o-du][rx       0 pps       0 kbps       0][tx       0 pps       0 kbps       0] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Total 0] IO Util: 44.09 %
[o-du][rx    5478 pps    5478 kbps       0][tx   31948 pps   31948 kbps       0] [on_time 5478 early 0 late 0 corrupt 0 pkt_dupl 66 Total 5478] IO Util: 44.82 %
[o-du][rx   38678 pps   33200 kbps  138655][tx  226364 pps  194416 kbps 1593307] [on_time 38678 early 0 late 0 corrupt 0 pkt_dupl 466 Total 38878] IO Util: 47.76 %
[o-du][rx   71878 pps   33200 kbps  172569][tx  420780 pps  194416 kbps 1991027] [on_time 71878 early 0 late 0 corrupt 0 pkt_dupl 866 Total 71878] IO Util: 47.66 %
[o-du][rx  105078 pps   33200 kbps  172569][tx  615196 pps  194416 kbps 1991027] [on_time 105078 early 0 late 0 corrupt 0 pkt_dupl 1266 Total 105078] IO Util: 47.65 %
[o-du][rx  138278 pps   33200 kbps  172569][tx  809612 pps  194416 kbps 1991027] [on_time 138278 early 0 late 0 corrupt 0 pkt_dupl 1666 Total 138278] IO Util: 47.64 %
[o-du][rx  171478 pps   33200 kbps  172569][tx 1004022 pps  194410 kbps 1991027] [on_time 171478 early 0 late 0 corrupt 0 pkt_dupl 2066 Total 171478] IO Util: 47.61 %
[o-du][rx  204678 pps   33200 kbps  172569][tx 1198444 pps  194422 kbps 1991027] [on_time 204678 early 0 late 0 corrupt 0 pkt_dupl 2466 Total 204678] IO Util: 47.62 %
[o-du][rx  237878 pps   33200 kbps  172569][tx 1392860 pps  194416 kbps 1991027] [on_time 237878 early 0 late 0 corrupt 0 pkt_dupl 2866 Total 237878] IO Util: 47.61 %
[o-du][rx  271078 pps   33200 kbps  172569][tx 1587276 pps  194416 kbps 1991027] [on_time 271078 early 0 late 0 corrupt 0 pkt_dupl 3266 Total 271078] IO Util: 47.62 %
[o-du][rx  304278 pps   33200 kbps  172569][tx 1781692 pps  194416 kbps 1991027] [on_time 304278 early 0 late 0 corrupt 0 pkt_dupl 3666 Total 304278] IO Util: 47.61 %
[o-du][rx  337478 pps   33200 kbps  172569][tx 1976108 pps  194416 kbps 1991027] [on_time 337478 early 0 late 0 corrupt 0 pkt_dupl 4066 Total 337478] IO Util: 47.63 %
[o-du][rx  370678 pps   33200 kbps  172569][tx 2170516 pps  194408 kbps 1991027] [on_time 370678 early 0 late 0 corrupt 0 pkt_dupl 4466 Total 370678] IO Util: 47.62 %
[o-du][rx  403878 pps   33200 kbps  172569][tx 2364932 pps  194416 kbps 1991027] [on_time 403878 early 0 late 0 corrupt 0 pkt_dupl 4866 Total 403878] IO Util: 47.62 %
[o-du][rx  437078 pps   33200 kbps  172569][tx 2559356 pps  194424 kbps 1991027] [on_time 437078 early 0 late 0 corrupt 0 pkt_dupl 5266 Total 437078] IO Util: 47.62 %
[o-du][rx  470278 pps   33200 kbps  172569][tx 2753772 pps  194416 kbps 1991027] [on_time 470278 early 0 late 0 corrupt 0 pkt_dupl 5666 Total 470278] IO Util: 47.64 %
[o-du][rx  503478 pps   33200 kbps  172569][tx 2948188 pps  194416 kbps 1991027] [on_time 503478 early 0 late 0 corrupt 0 pkt_dupl 6066 Total 503478] IO Util: 47.61 %
[o-du][rx  536678 pps   33200 kbps  172569][tx 3142596 pps  194408 kbps 1991027] [on_time 536678 early 0 late 0 corrupt 0 pkt_dupl 6466 Total 536678] IO Util: 47.61 %
```