

VVDN LPRU



Low Power Radio Unit

USER MANUAL

Version Control

Name	Date	Version Number
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Revision History

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1. About This Document

This document would help to understand and operate the Low Power Radio Unit.

1.1 Intended Audience

The intended audiences for this document are End Users of this product.

1.2 Document Conventions

The different conventions used in this document are explained in the following table:

Convention	Description
	Do not touch/handle the board without proper ESD precautionary measures.
	The board is ROHS compliant
	Do not turn ON the board without terminations (Not applicable if internal Antenna is provided)
	Alert! Hot, Do not touch Please wait for sometime for RU to get cool after turned OFF

Table 1: Document Conventions

Sl. No	Abbreviations	Long form
1.	DU	Distributed Unit
2.	ESD	Electrostatic discharge

3.	FPGA	Field Programmable Gate Array
4.	GPS	Global Positioning System
5.	JTAG	Joint Test Action Group
6.	LED	Light Emitting Diode
7.	PCB	Printed Circuit Board
8.	QSPI	Quad Serial Peripheral Interface
9.	RF	Radio Frequency
10.	RU	Radio Unit
11.	SCS	Subcarrier Spacing
12.	UART	Universal Asynchronous Receiver-Transmitter
13.	USB	Universal Serial Bus

Table 2: Abbreviations

2. Product Overview

The Low Power Radio Unit (LPRU) is a single-board Optical to Radio interface solution for 5G low-power RU application, The RU has a digital and RF section realized in a single board, and the system can be used for improving 5G network coverage and can be cascaded into multiple stages.

2.1 Key Features and Specifications:

- Deployment Type: Indoor RU
- Radio Configuration: 1 CC, 100 MHz, 4Tx4R,
- IBW :200MHz
- OBW : 100MHz
- Supported Frequency bands: 3.55-3.7GHz
- Mode: Single Numerology, SCS 30KHz
- Antenna: Semi-directional / External
- Front haul: 10G over SFP+
- Powered using PoE++ Type 3 (IEEE PoE standard, 802.3bt) or 12V/5A DC Adaptor
- RF Power: 4x250mW
- O-RAN Split: 7-2a

2.2 Device Specification:

Radio Specification	
Band	3.55-3.7GHz,
Bandwidth	100MHz
Duplex Mode	TDD
Modulation	QAM 256/64/16/QPSK
Carriers	1
Sub Carrier Spacing	30KHz
RF Output power	24dBm/ 250mW
Connectivity Specification	
Data Link	10G SFP+
Interface Protocol O-RAN	FH Split 7.2
Power Specification	
Powering	PoE++ Type 3 , IEEE802.3bt or 12V/5A DC Adaptor
Max Power Consumption	51W (max)
Mechanical Specification	
Design Shape	Square
Product Dimension	250x213.5x92 mm
Weight	5.3 Kg (With mounting bracket)
Antenna Specification	
Antenna	External / Internal Antenna
Type	Semi Directional
Gain	6-9dBi
MIMO	4x4 (4T4R)
Environment Specification	

Ambient Temperature	0°C to +45°C
Storage Temperature	-40°C to +55°C
Cold Start Temperature	-20°C to +55°C
Humidity	5% to 95%
Environmental	IP31/ IP65 complaint
Operating Environment	Indoor/Outdoor equipment
Thermal dissipation	Convection
Installation Type	Ceiling or Wall mount

Table 3: Device Specification

2.3.1 RU Product Identification Format:

SKU	FREQ RANGE		Version	Description
SKU 2	3550 - 3700 MHz		A2	

2.3.2 RU Product HW Identification Format:

From the HW Side, Product Identification will be done through **Product Model No.**

Example:- If the Product model no is **VLRU-Gen3-3537-XX-AI**. In this model no, “**VLRU**” shows Project Name, “**Gen3**” shows Hardware Generation, “**3537**” shows RU Band, and “**XX**” shows AE(Antenna External) or AI (Antenna Internal). “**A**” shows the RU revision. “**I**” shows the environmental condition (**E** - Operating Temperature 5°C to 45°C & IP31, **I** - Operating Temperature -40°C to 55°C & IP65).

LPRU Series Model Number		
Customer	Band	Model Number
V - VVDN ¹	3537 - Band 3550 - 3700	VLRU-Gen3-3537-AE-AI

Table 4: Product identification format

3. What's in the Box?

The following list of primary items will be present in the box:

Low Power RU	5G Indoor Radio Unit	1
Installation & Bring-up Guide	Booklet/Soft copy for operational reference	1

Table 5: List of Items in the box

3.1 Default Accessories List

The following accessories are included with Low Power RU:

Items	Description	Qty
USB Cable	Console Cable – Type C USB Cable Part Number: DH-20M50052	1
Power Cord	8.20' (2.50m) Power Cord Black CEE 7/7, Right Angle To IEC 320-C13 H05VV-F Part Number:367003-D01	1
PoE Adapter²	Manufacturer part no: POE60U-1BTE-R	1
DC Adapter³	Module, Power, 90-264Vin AC, 12Vout/6.25A DC, 47-63MHz	1

¹ Device name “VLRU” will be changing depends on end customer.

² Either a PoE adaptor or DC adaptor will be included in the accessories box.

³ If the External antenna is chosen, SMA terminations will not be included in the accessories box.

Antenna⁽⁴⁾	Wideband Whip antenna 3.4 to 4.9GHz Part Number:2144290001 / W5150	4
Split 1	Mounting Split 1	1
Split 2	Mounting Split 2	1

Table 6: Device Accessories

3.2 Add-on Accessories List

The following add-on accessories are based on the customer's requirement with Low Power RU:

Items	Description	Qty
10G SFP Transceiver	Manufacturer part no: SFP-10G-SR ⁽²⁾	2
10G SFP Optical Cable	Cable Length: 1.5m	1
SMA Terminations	2W RF SMA terminations	4
Ethernet Cable	RJ45 Cat6 Network Ethernet Patch/LAN Cable, 3M/2M	1

Table 7: Device Accessories

⁴ The part number for the external antenna may change based on stock availability.



Fig 1 : 10G SFP Transceiver



Fig 2 : 10G SFP Optical Cable



Fig 3 : PoE Adapter



Fig 4 : DC Adapter

4. Outlook

Learn about LPRU hardware, assembly procedures, and how to get started with it.

4.1 Dimensions of Product

Dimension L x W: 250 x 213.5 (in mm).



Fig 4: Product Dimension

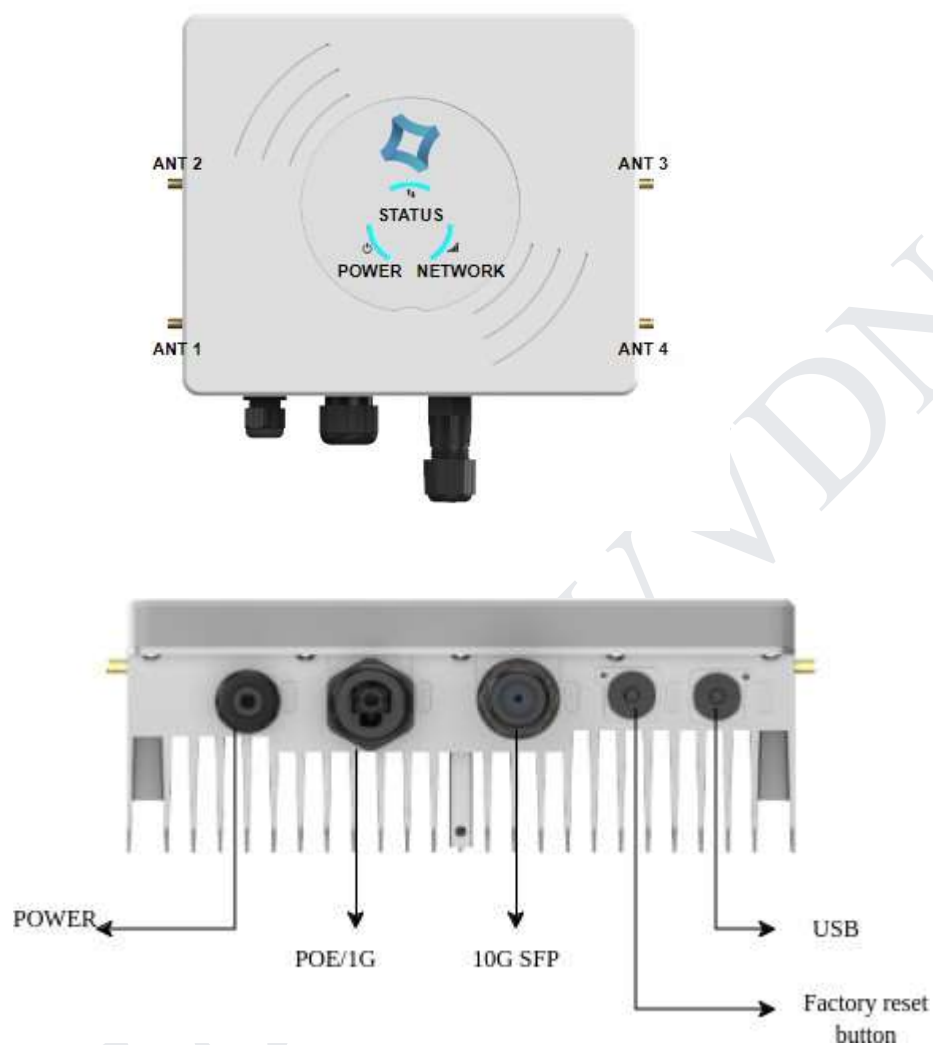
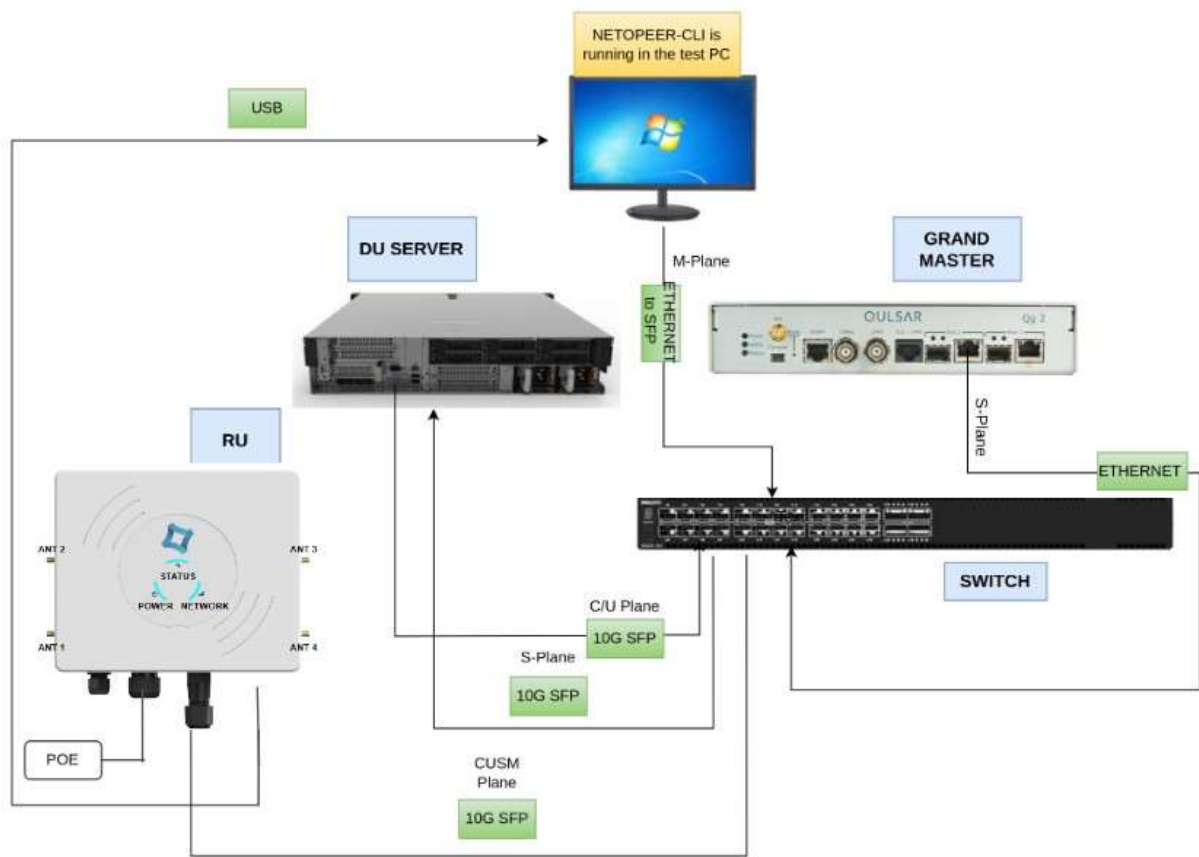


Fig 5 Antenna and FH details

4.2 LPRU Basic Setup Diagram



Setup Diagram

Fig 6:

Netopeer-cli is installed in another test pc for M plane connection establishment, or it can be installed in DU server.

This setup diagram is for M-Plane connection.

4.3 LPRU LED Notification

For all good conditions, all the Green LED will be in a stable state.

LED Blinking Status	Power LED Indications	Colour
Slow	Temperature Warning	RED
Fast	Factory Reset	
Stable	Initialisation Fault	
Slow	Software Upgrade Process	Green
Stable	RU Booted Successfully	

Table 7:Power led indication

Colour	Network LED		Status LED	
RED	Slow	DHCP Failure	Slow	PTP Sync Fail
	Fast	Factory Reset	Fast	Factory Reset
	Stable	Link Down	Stable	Software Upgrade Fail
Green	Slow	Software Upgrade process	Slow	Software Upgrade process
	Fast	Link UP, Trying DHCP	Fast	Reserved for Future
	Stable	Link UP + DHCP Ready	Stable	PTP UP
Blue	Stable	Power failure		
	stable	Power on		
	Stable	Thermal shutdown	Stable	Thermal shutdown

Table 8:Network and Status led notification

4.4 Software Version

The following command in the Netopeer Cli is required to check a current Software Version of VVDN_LPRU O-RU by using M Plane:

```
<get --filter-xpath /o-ran-software-management:software-inventory>
```

Output result:

```
get --filter-xpath /o-ran-software-management:software-inventory
DATA
<data xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <software-inventory xmlns="urn:o-ran:software-management:1.0">
    <software-slot>
      <name>swSlot1</name>
      <status>VALID</status>
      <active>true</active>
      <running>true</running>
      <access>READ_WRITE</access>
      <product-code>VVDN O-RU</product-code>
      <vendor-code>VN</vendor-code>
      <build-id>90f0b6c</build-id>
      <build-name>Test Release</build-name>
      <build-version>3.0.5</build-version>
      <files>
        <name>BOOT.BIN</name>
        <version>1.0.0</version>
        <local-path>/media/sd-mmcbk0p1/BOOT0001.BIN</local-path>
        <integrity>OK</integrity>
      </files>
      <files>
        <name>image.ub</name>
        <version>1.0.0</version>
        <local-path>/media/sd-mmcbk0p1/image0001.ub</local-path>
        <integrity>OK</integrity>
      </files>
      <files>
        <name>rootfs.tar.gz</name>
        <version>1.0.0</version>
        <local-path>/media/sd-mmcbk0p2/</local-path>
        <integrity>OK</integrity>
      </files>
    </software-slot>
    <software-slot>
      <name>swSlot2</name>
      <status>VALID</status>
      <active>false</active>
      <running>false</running>
      <access>READ_WRITE</access>
```

```

<running>false</running>
  <access>READ_WRITE</access>
  <product-code>VVDN=O-RU</product-code>
  <vendor-code>VN</vendor-code>
  <build-id>factory_img</build-id>
  <build-name>Beta Release</build-name>
  <build-version>3.0.5</build-version>
  <files>
    <name>BOOT.BIN</name>
    <version>1.0.0</version>
    <local-path>/media/sd-mmcblkOp1/BOOT0002.BIN</local-path>
    <integrity>OK</integrity>
  </files>
  <files>
    <name>image.ub</name>
    <version>1.0.0</version>
    <local-path>/media/sd-mmcblkOp1/image0002.ub</local-path>
    <integrity>OK</integrity>
  </files>
  <files>
    <name>rootfs.tar.gz</name>
    <version>1.0.0</version>
    <local-path>/media/sd-mmcblkOp3/</local-path>
    <integrity>OK</integrity>
  </files>
</software-slot>
<software-slot>
  <name>swRecoverySlot</name>
  <status>VALID</status>
  <active>false</active>
  <running>false</running>
  <access>READ_ONLY</access>
  <product-code>VVDN=O-RU</product-code>
  <vendor-code>VN</vendor-code>
  <build-id>factory_img</build-id>
  <build-name>Beta Release</build-name>
  <build-version>3.0.6</build-version>
  <files>
    <name>BOOT.BIN</name>

```

```
<version>1.0.0</version>
  <local-path>/media/sd-mmcblk0p1/BOOT0003.BIN</local-path>
  <integrity>OK</integrity>
</files>
<files>
  <name>image.ub</name>
  <version>1.0.0</version>
  <local-path>/media/sd-mmcblk0p1/golden.ub</local-path>
  <integrity>OK</integrity>
</files>
<files>
  <name>rootfs.tar.gz</name>
  <version>1.0.0</version>
  <local-path>/media/sd-mmcblk0p1/golden.ub</local-path>
  <integrity>OK</integrity>
</files>
</software-slot>
</software-inventory>
</data>

>
```

5. Device Setup

5.1 Hardware Installation

The LPRU can be mounted on the wall using a 4 x M3.5 screw to fix the bracket as shown below. After installation, check for RF coverage and change the mounting location.

Note: Before mounting, kindly make sure to test if the desired installation location has good RF range coverage, like the middle of the ceiling of a room.

5.1.1 Ideal mounting location

The LPRU can be installed, preferably either on the Vertical wall or Ceiling. In Lab testing conditions, sufficient airflow shall be provided for thermal and RU performance.

5.1.2 Ideal Installation Height:

Above 2.13m/ 7ft from the ground for vertical wall or ~10ft for ceiling mounting.

5.1.3 Mounting Screw Holes:

If mounting to a wooden surface, fix the screw directly to the surface. If mounting to a masonry surface (bricks, concrete), insert wall plugs before screwing the mounting bracket to the wall.

5.1.4 Mounting the Device:

Secure the device on the bracket by screwing the LN screw provided firmly.

5.2 Software Installation

Before powering ON the RU, ensure all the RF ports are terminated with antenna or 50 Ohms load

5.2.1 Booting up the device

- Connect the POE++ jack to power the device (RJ45 Connector).
- Check for the LED indication.
- If the board is booted without any error, it will indicate Power LED Status to Green.

Types of Logins

Separate types of logins have different purposes. It is important that the user understands the difference so that the user can choose the login type as per use case. Each user has its own specific access control as per the oRAN compliance.

Username	Password
oranuser	oranuser

Table 9 Login credentials

5.2.2 Remote Configuration

Users can connect to LPRU by secure socket connection. The standard SSH daemon is running on the LPRU. Users need a network connection to the 10G interface. Establish SSH connection using any SSH client using host IP and credentials.

Note: Default IP of RU is 192.168.4.50 in FH

a) Prerequisite:

- Install any SSH client in the host (Linux) PC
- Network connection between LPRU and host PC
- Host PC and LPRU should be in the same network domain.

b) Procedure:

- Insert the below credentials,
- Hostname (RU name), example: operator
- IP address (remote IP address), <IP address of RU>
- Password, example: admin123
- ssh oranuser@<LPRU_IP_Address>
- Password: oranuser

5.3 WEB GUI Configuration

Commonly used browser for GUI login

1. Google Chrome

2. Firefox

Launch a web browser from a computer or wireless device that is connected to the network. In the address field of the web browser, enter the Fronthaul IP address.

If RU is configured for Static IP, then use 192.168.4.50 otherwise go for the dynamic ip assigned to eth1 interface.

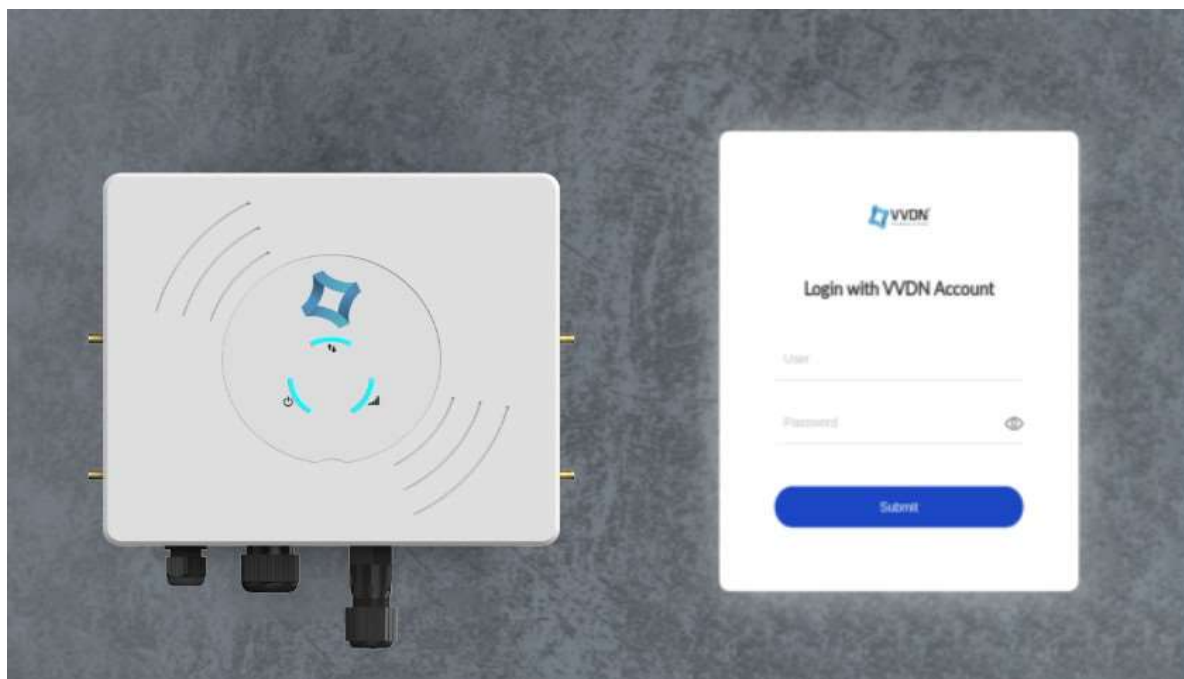


Fig 7: VVDN Account Login

[Login credentials refer section : 5.2.1](#)

5.3.1 Device Information

The device information dashboard will provide complete information about the Radio Unit. Once the Radio unit is live, the dashboard extracts the particulars in the Front end. Snippet attach for the reference

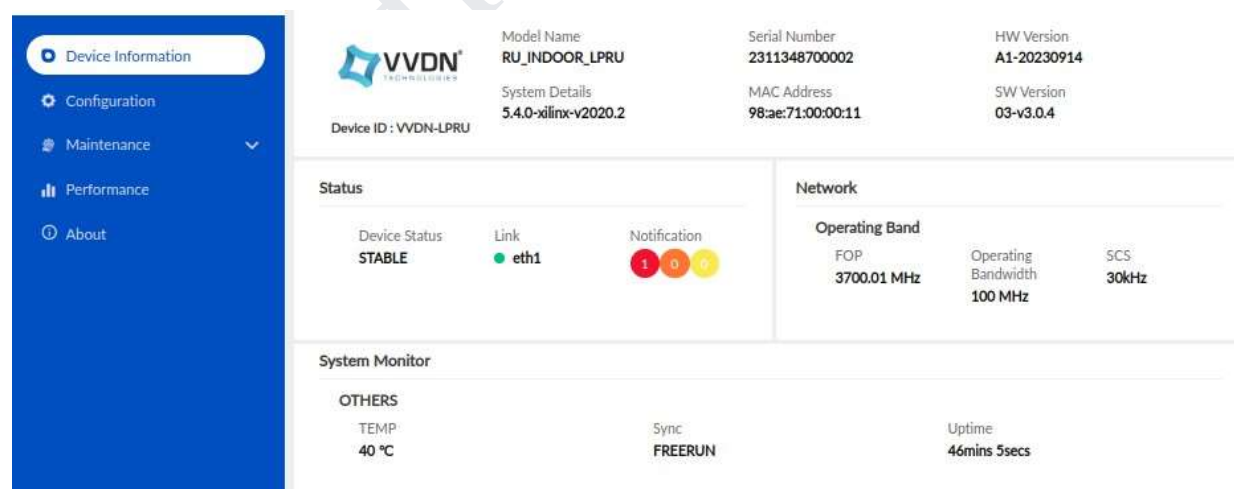


Fig 8: Device Information

- **Model Number:** Display the RU model number
- **Serial Number:** Display RU serial number
- **HW Version:** Display the HW version
- **System Details:** Display default System details incorporated with XILINX 2020.2
- **MAC address:** Display the RU's eth1 interface MAC address
- **SW version:** Display the installed SW version
- **Status:** Display the current status of RU
- **Network:** Display the operating band
- **System Monitor:** Display other parameters like temperature and PTP synchronization states like **LOCKED**, **FREERUN**, and **HOLDOVER**

Port Link Status:

	PORT	LINK STATUS
GREEN	eth1	Up
RED	eth1	Down

Table 8 : Interface Led details

Notification status

The bell icon displays the notification that are currently available in the Radio Unit

5.3.2 Configuration

The configuration section has the option to configure Sync, Fronthaul, and ORAN elementarily.

a)Sync

LPRU needs to be PTP synchronized with Grandmaster for the proper data transmission. As per oRAN, LPRU is supporting LLS-C1/LLS-C3 Configuration.

To select one or more synchronization input sources. The sync container allows the RU to list via an array of synchronization sources which it is capable of supporting **PTP and SyncE**.

User can trigger the Sync-related parameters using the below-mentioned attributes:

- **Domain number: Range (24-45)**
- **PTP Profile: Default(G_8275_1)**
- **Multicast mac Address: FORWARDABLE**

Note: LPRU is supporting only:

- *ITU-T standards G_8275_1 and G_8275_2 profile for the PTP synchronization.*
- LPRU supports only Multicast PTP profiles. Click the submit button to save the configuration*

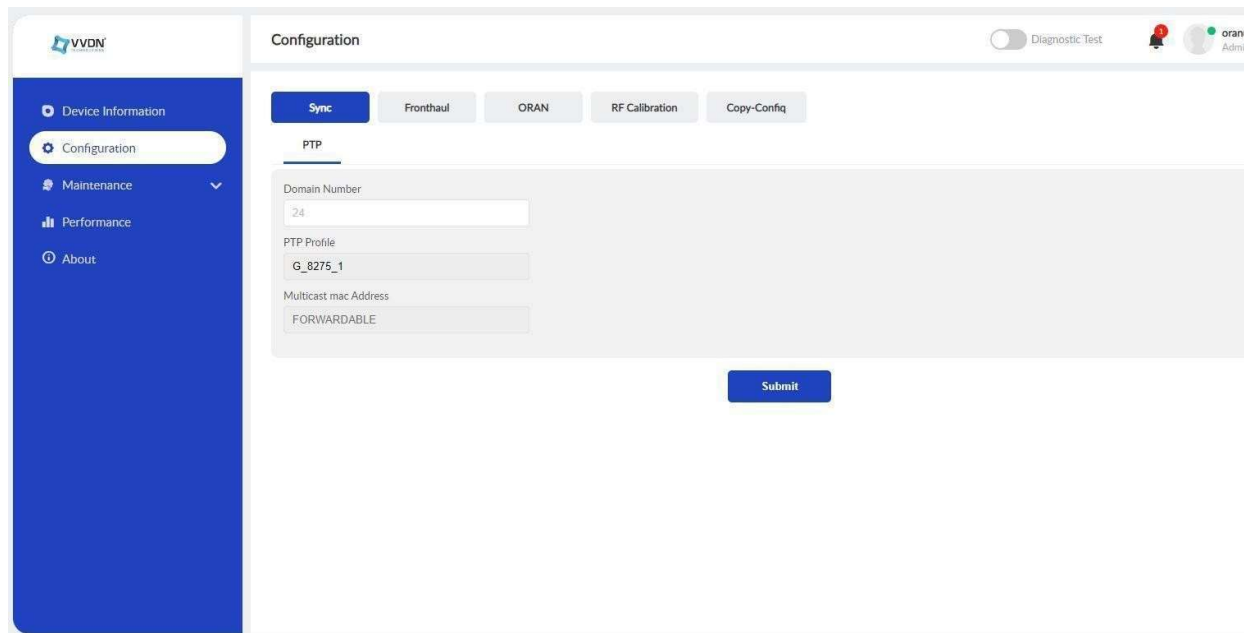


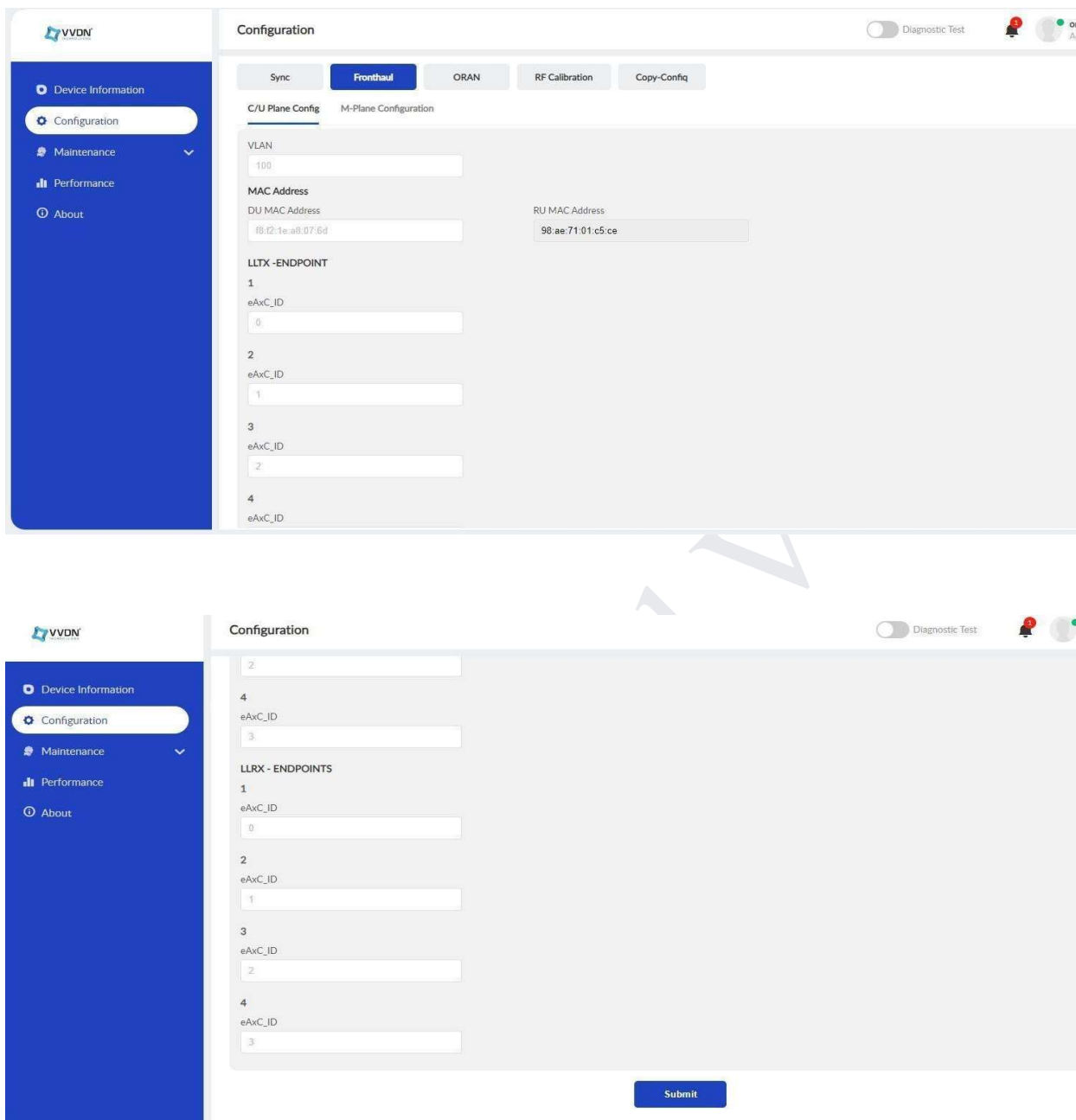
Fig 9: Sync Configuration

b) Fronthaul

1. CU Plane Configurations in RU for Fronthaul

The LPRU supports ORAN-WG4.CUS.0-v07.00 for CU planes. This provides an option to configure the CU Plane as follows:

- VLAN Enable/Disable: VLAN Range between 0-4095
- No VLAN needed for CU plane transmission.
- No provision for S plane VLAN currently
- MAC address: MAC address shall be retrieved when connected with the RU. Enter the DU MAC address based on the deployment.
- C- PLANE & U-PLANE: enhances more feasibility to user plane configuration module is provided below based on the Yang model mentioned in the ORAN Management Plane Specification
 - **DU port ID Bitmask: 65024**
 - **Band Selector ID Bitmask: 448**
 - **Component carrier ID BitMask: 56**
 - **RU port ID from the mentioned ranges displayed: 7**
 - **eAxC_ID: 1 to 4 for Downlink or uplink or PRACH**
- Click the submit button and you get a pop up mentioning your settings are saved.



The figure displays two screenshots of the VVDN configuration interface, showing the Fronthaul CU Plane configuration with VLAN settings.

Top Screenshot (C/U Plane Config):

- VLAN:** 100
- MAC Address:**
 - DU MAC Address: f8:12:1e:a8:07:6d
 - RU MAC Address: 98:ae:71:01:c5:ce
- LLTX - ENDPOINT:**
 - 1: eAxC_ID: 0
 - 2: eAxC_ID: 1
 - 3: eAxC_ID: 2
 - 4: eAxC_ID: 3

Bottom Screenshot (M-Plane Configuration):

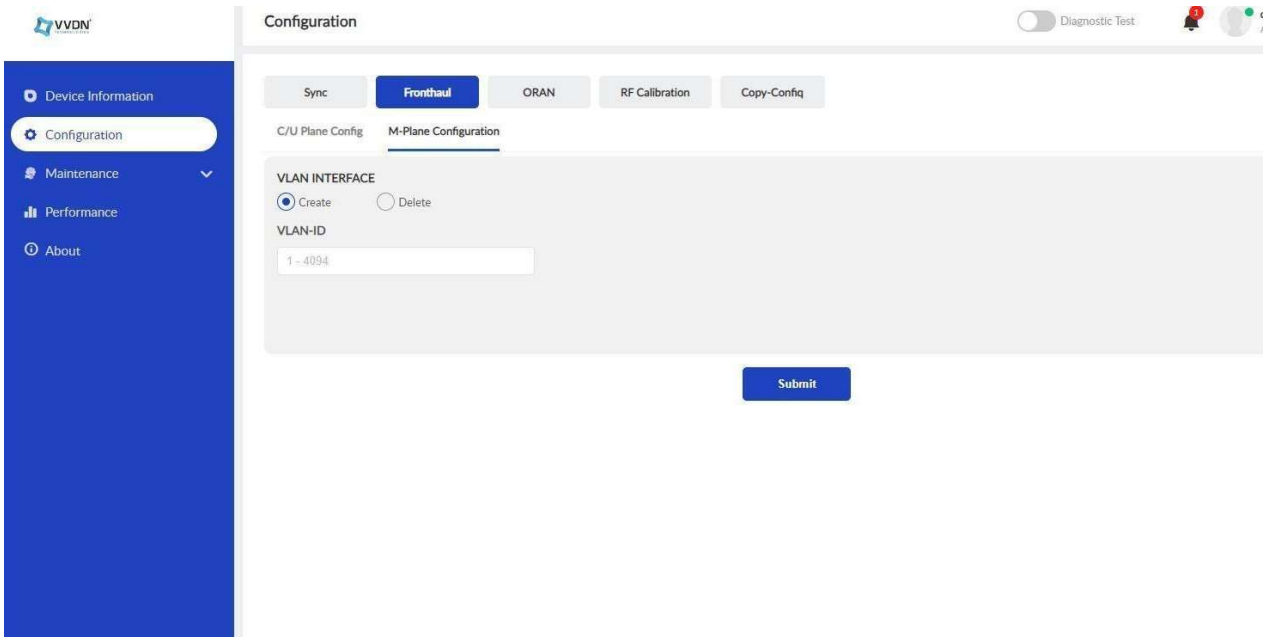
- LLRX - ENDPOINTS:**
 - 1: eAxC_ID: 0
 - 2: eAxC_ID: 1
 - 3: eAxC_ID: 2
 - 4: eAxC_ID: 3
- Submit** button is visible at the bottom right.

Fig 10: Fronthaul CU Plane configuration with VLAN

2) M Plane Configurations in RU for Fronthaul

The M-plane configuration section helps the user to configure the m-plane VLAN.

- **VLAN:** VLAN Range between **0-4095**
- Click the **submit** button, and you get a pop-up mentioning your settings are saved.



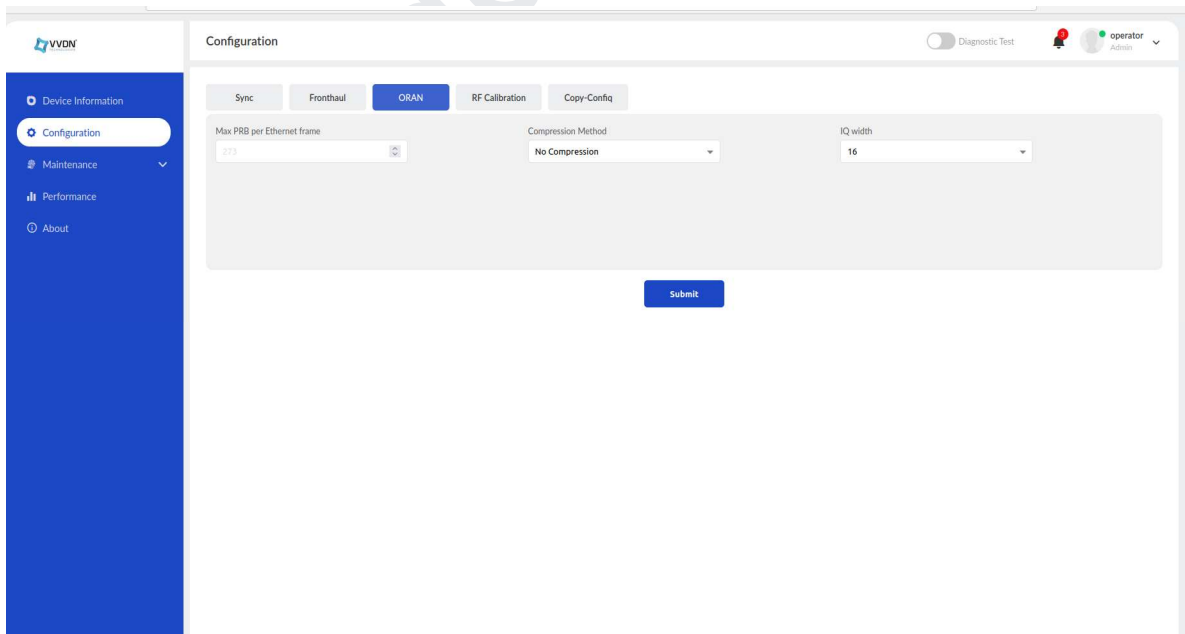
The screenshot shows the VVDN Configuration interface. On the left is a blue sidebar with navigation links: Device Information, Configuration (selected), Maintenance, Performance, and About. The main content area is titled 'Configuration' and has tabs for Sync, Fronthaul (selected), ORAN, RF Calibration, and Copy-Config. Under the Fronthaul tab, there are sub-tabs for C/U Plane Config and M-Plane Configuration (selected). The M-Plane Configuration section has a 'VLAN INTERFACE' section with 'Create' (selected) and 'Delete' radio buttons. Below this is a 'VLAN-ID' input field with the value '1-4094'. A 'Submit' button is at the bottom right of the configuration area. In the top right corner, there is a 'Diagnostic Test' toggle switch and a user profile icon labeled 'operator'.

Fig 11: Fronthaul M- Plane Configuration

c) ORAN

O-RAN Sections help the user to validate the below fronthaul parameters.

- Standard Maximum PRB per Ethernet frame can be allocated.
- IQ Width can range 16-bit No compression and 9,12 and 14 for BFP compression as per requirement



The screenshot shows the VVDN Configuration interface with the 'ORAN' tab selected. The sidebar is the same as in the previous figure. The main content area has tabs for Sync, Fronthaul, ORAN (selected), RF Calibration, and Copy-Config. The ORAN section contains three configuration fields: 'Max PRB per Ethernet frame' with a value of 273, 'Compression Method' with a dropdown menu set to 'No Compression', and 'IQ width' with a dropdown menu set to 16. A 'Submit' button is located at the bottom center of the configuration area. In the top right corner, there is a 'Diagnostic Test' toggle switch and a user profile icon labeled 'operator'.

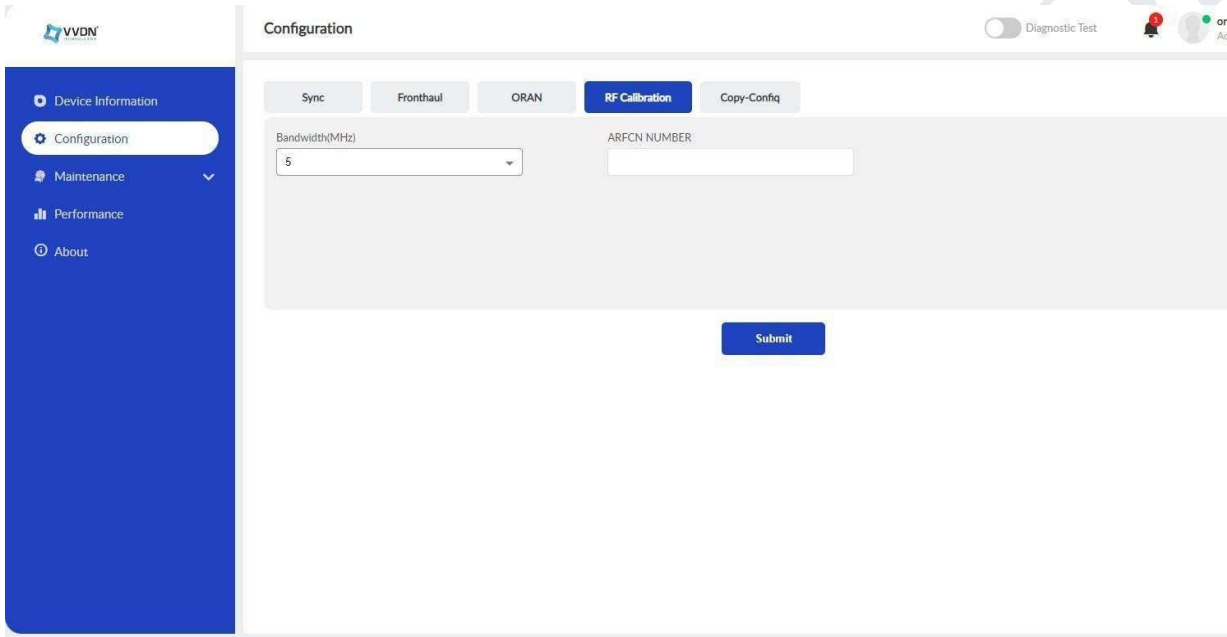
Fig 12: ORAN Configurations

Note: Make sure that the compression method is configured properly before sending data to LPRU from DU or DU emulator. By default, the compression method is configured as 16 bit uncompressed.

d) RF Calibration

RF calibration section helps the user to change following parameters

- To change the operating bandwidth of the RU and ARFCN value within the operation frequency


Fig 13: RF calibration Configurations

*ARFCN of center frequency chosen within the band eg : ARFCN : 646667, Freq : 3700.005 Mhz
Bandwidth within ibw/obw can be used.*

Once the changes are updated, copy the changes from running to startup and go for rebooting the RU to reflect the changes in RU.

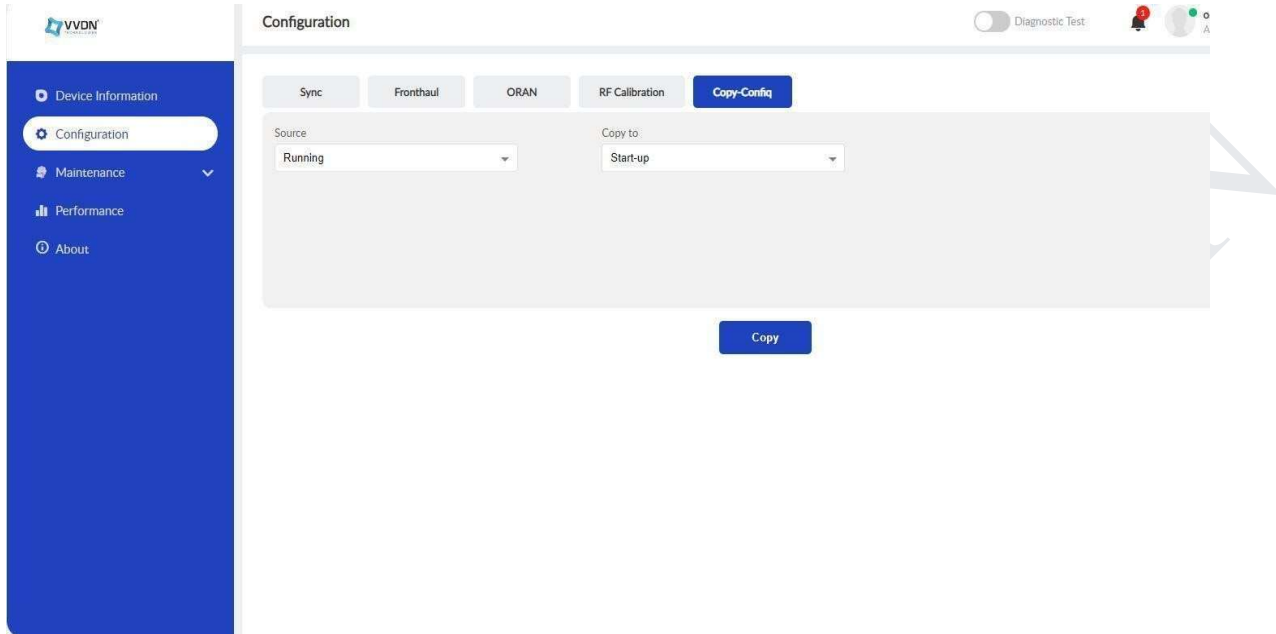


Fig 14: To copy Configurations

5.3.3 Maintenance

5.3.3.1 Management

The Management tab contains the below details,

- System
- Logs

System

System-level functions such as Reboot & Factory reset could be performed. Users can reboot or reset the radio unit from the system tab.

Follow the below instructions

- o Click Maintenance > Management > System >
- o Select Reboot for a soft reset of RU
- o Select Factory reset for the default setting

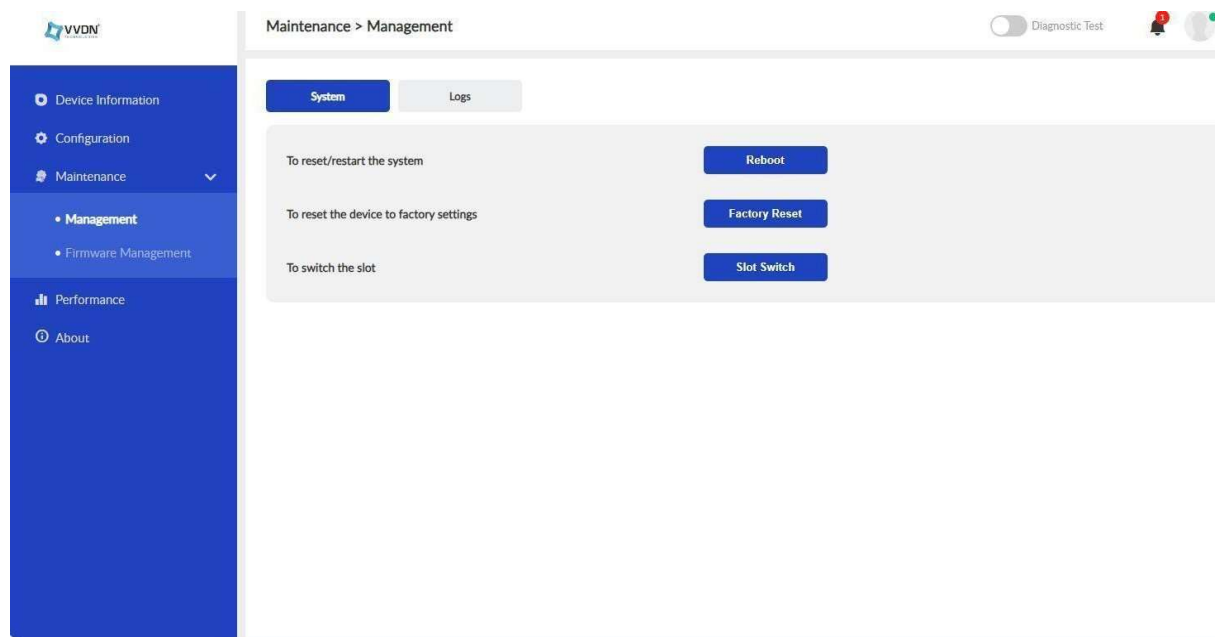


Fig 15: System Factory Reset and Reboot

Logs

The actual system log can be downloaded by the user for the system information. Click on the download icon for downloading the file

The file will be downloaded in the aforementioned format, Sample file name and format:
vvdn-gui-2023-11-22T08_57_16Z.log

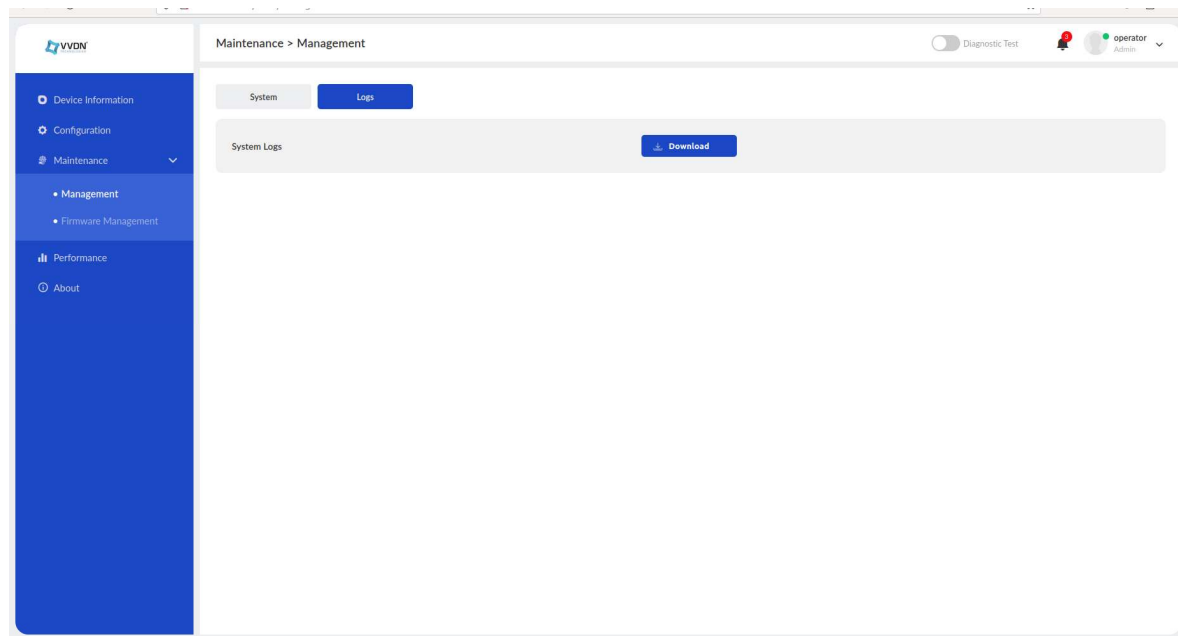


Fig 16: Real-Time System Logs

5.3.3.2 Firmware Upgrade

For the LPRU remotely, users can upgrade the firmware from any remote SFTP server. Users need to enter the valid details and credentials as follows:

- a) **Username:** Valid username of the SFTP server.
- b) **IP Address:** Remote server IP address.
- c) **Password:** Remote server password.
- d) **File:** Remote file location path where the software files are located. (.zip)
- e) **Public Key:** Public Key for the remote server needs to be validated for the software changes in LPRU.
 - a. To access the Public key of the sftp server, follow the steps below
 - b. `$cat /etc/ssh/ssh_host_rsa_key.pub`

[illegible]

Fig 17: Public key of the sftp server

Note: Below is the RSA public key of the sftp server, in which the key that comes within the bracket is only required here.

ssh-rsa

[/AAAB3NzaCIyc2EAAAADAQABAAQDkr9yVoc2uRPc4t2SeTjIJ3qO8ZfOvFIJJJoPrR3FirgWK/zPFmQ4ugzhCTHzEvTB39d/IJM5Ns8Igvsw53O6b72XMBST8StYfOKLWFCjOYvotyMPfolNu9JA2a8Hpun4cA7/LPDCOPOJVV523x83XZMgKsiB4c7jIgmVCHLOVZmPLGhNcaVFEXM8OvGM+m4XLnAXcyOfHh2K7IUB6Htt9igrxvzigxXY9PDsnZTsTQlYARh2K2Sm/7vJZZY/fRM8TfZrCo6BsY+Ljl+FrD/p9Z+mOgacsgfGkbXUBP6bl+wprxGhZ4NnI0k7KviHflanaD5wgQ2NNGLOGYLAvE5V3KyF/](#)
root@CICDPC230120

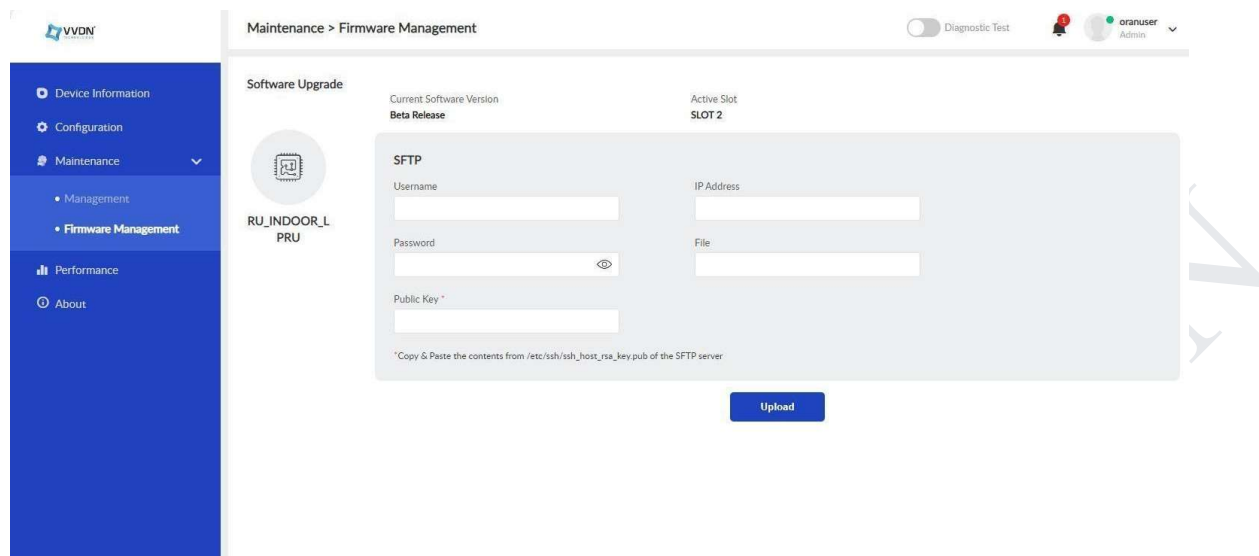


Fig 18 : Software Validation Dashboard without Details

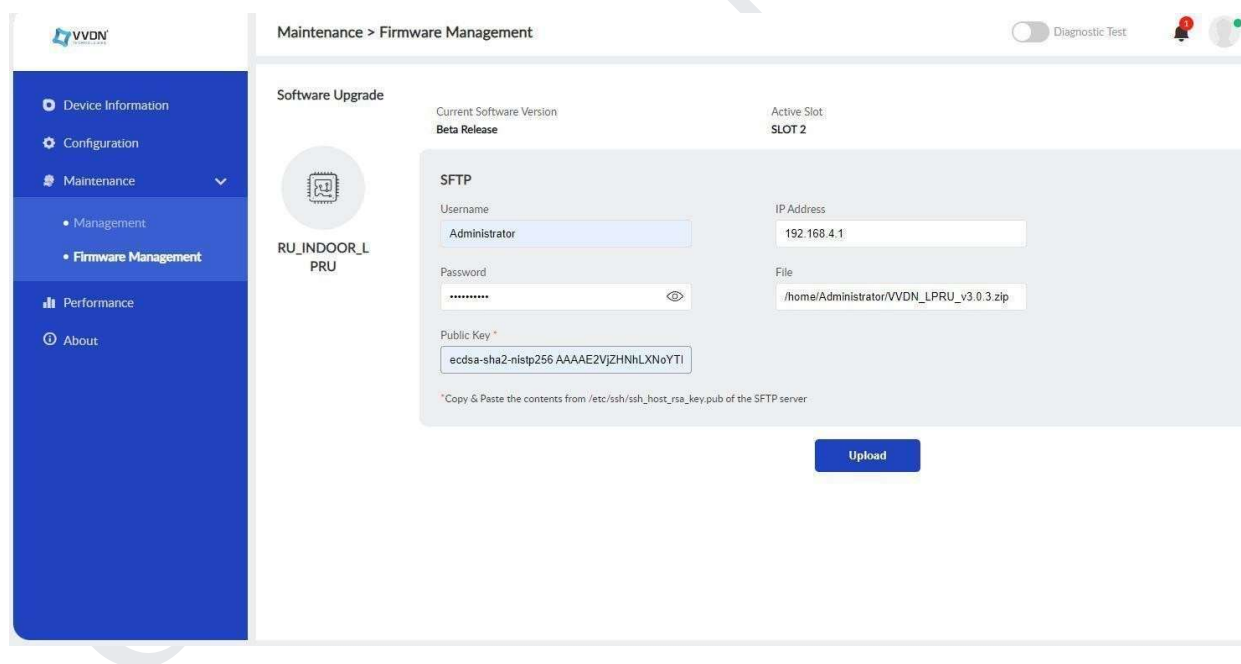


Fig 19: Software Validation Dashboard

5.3.4 Performance

The Performance tab displays the throughput for Downlink & Uplink in Mbps.

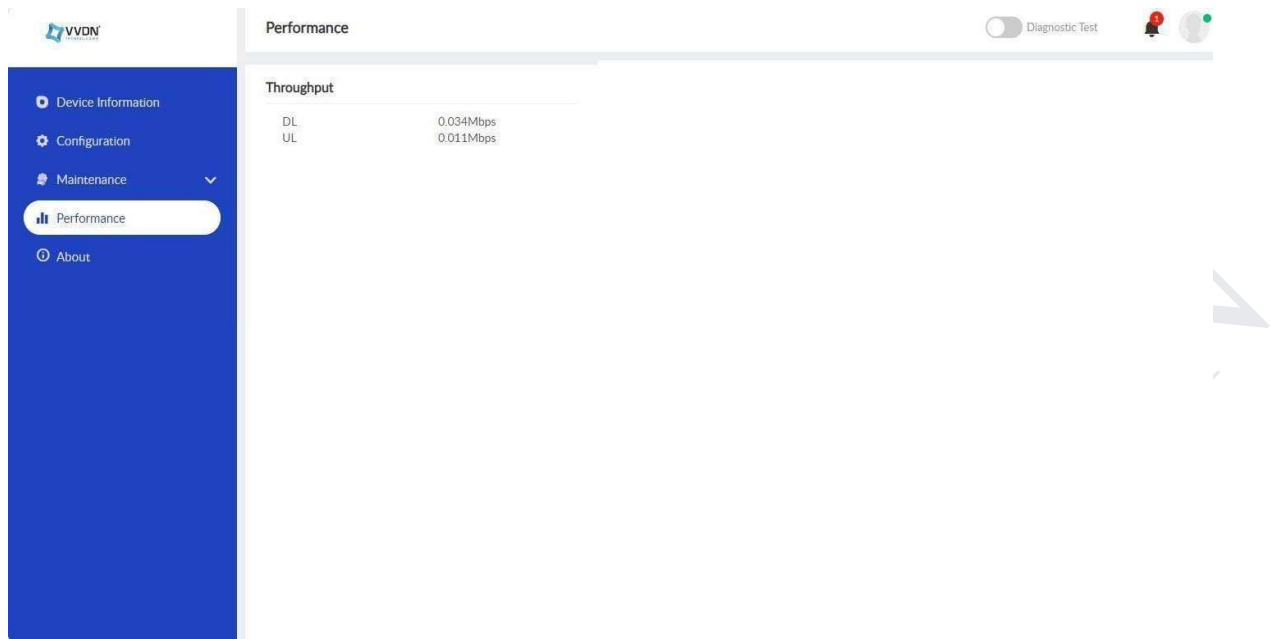


Fig 20: Performance Dashboard

5.3.5 About

Details about the Manufacturer, Split version, Operating power, Licence version and copyright is displayed on this “About page”

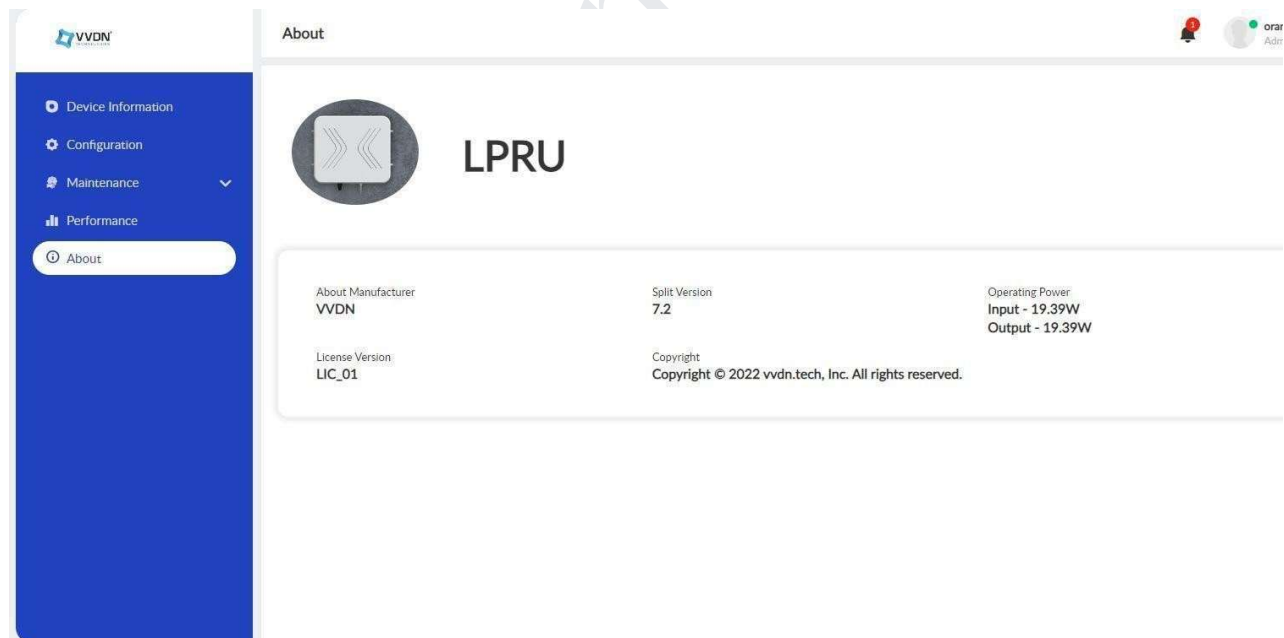


Fig 21: About Tab

Diagnostic Test

Users can perform Troubleshooting and Debugging mechanisms via Web GUI; it takes a time period less than 60 sec. In the **diagnostic test**, we get the **interface validation** results. This section helps the user to validate the following interfaces,

- i2c
- spi
- 10G
- JESD

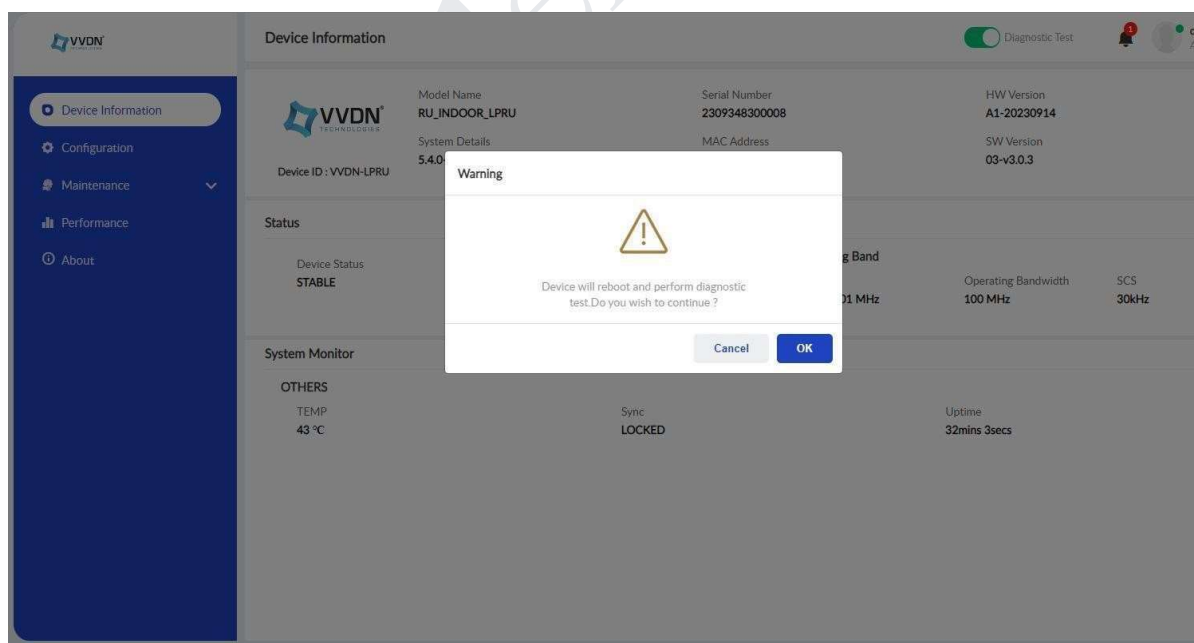
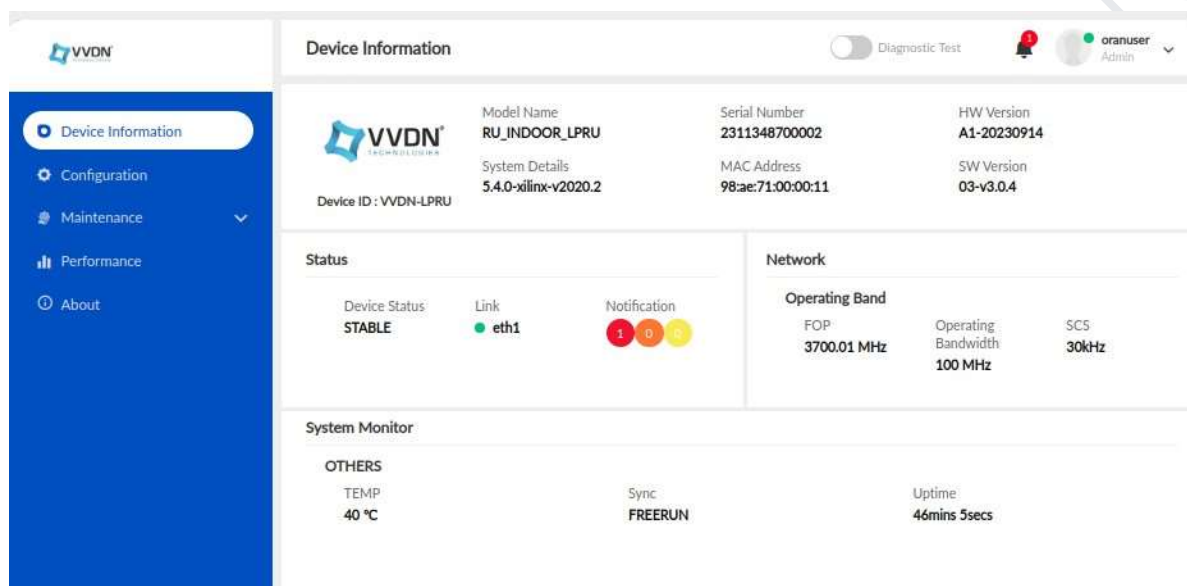


Fig 22: Diagnostic Test

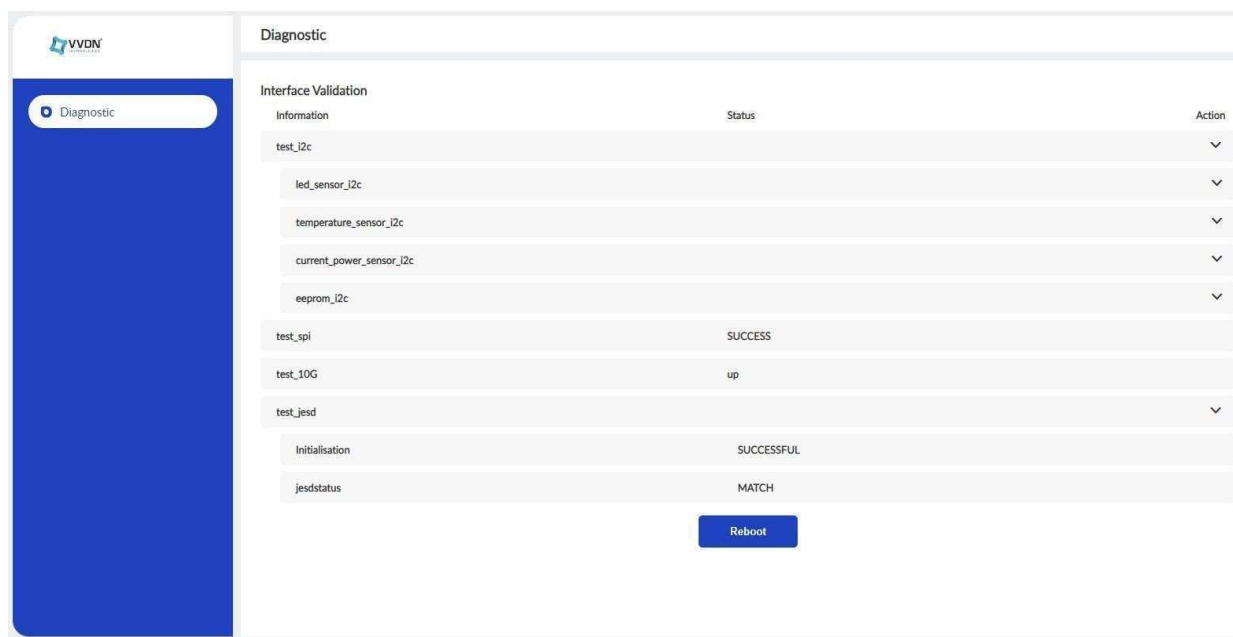


Fig 23:

Diagnostic Test Result

6. Startup Configurations

Before powering ON the RU, ensure all the RF ports are terminated.

6.1. Booting up the device

- Connect the Power adapter, Voltage -48v Current 15 Amps
- Check for the LED indication.
- If the board is booted without any error, it will indicate Power LED Status to Green.

6.2. Remote Configuration

Users can connect to LPRU using Mplane connection. Users need a network connection to the 10G interface.

O-RU will be in static mode with IPv4 address 192.168.4.50 by default. Mode can be changed via CLI.

Steps for changing the mode via CLI are as follows:

1. To access CLI manager, use “telnet 192.168.4.50 8888”.
2. Enter login credentials as username : oranuser and password : oranuser.
3. get-IfaceStatus :It will show the status of the management interface.

4. Set-Ipv4Static can be used to set a static IPv4 address along with arguments IPv4 address, net mask and broadcast address. [example usage : set-Ipv4Static 192.168.4.40 255.255.255.0 192.168.4.255].
5. Set-Ipv6Static can be used to set a static IPv6 address along with arguments IPv6 address and prefix length. [example usage :set-Ipv6Static 3ffe:501:CAFE::A001:1012 64].
6. set-IfaceDhcp will set the interface as dynamic for both IPv4 and IPv6.

6.3. Prerequisite

- Install Netopeer client in the host PC
- Network connection between LPRU and Host PC
- Host PC and LPRU should be in the same network domain.

6.5. Netconf Client Installation

Netopeer2 is a server for implementing network configuration management based on the NETCONF Protocol. This is the second generation, originally available as the [Netopeer project](#). Netopeer2 is based on the NETCONF and YANG libraries - [libyang](#) and [libnetconf2](#). The Netopeer2 server uses [sysrepo](#) as a NETCONF datastore implementation.

Requirements

- [libyang](#)
- [libnetconf2](#)
- [sysrepo](#)
- [netopeer2-cli](#)

6.5.1. Compilation and installation:

Install necessary packages for netopeer2

```
sudo apt-get update
sudo apt-get upgrade
sudo apt-get install git
sudo apt install snapd
sudo snap install sysrepo-netopeer-gen
sudo apt install openssl
sudo apt install libssh-4 libssh-dev
sudo apt install libgcrypt20-dev
sudo apt install libcrypto++-dev
sudo apt install libssl-dev
sudo apt-get install zlib1g-dev
sudo apt-get install build-essential
sudo apt-get install g++
sudo apt-get install cmake
```

To install netopeer-cli version 2 yang modules as follows.**1. libssh (checkout to 0.7.5 branch from git repo)**

```
$ git clone http://git.libssh.org/projects/libssh.git
$ cd libssh; mkdir build; cd build
$ cmake ..
$ rm -rf CMakeCache.txt
$ make install
$ make install -j8
$ make
```

2. libyang([v1.0.240](#))

Note : dependency on libpcr (install libpcr : sudo apt-get install libpcr3-dev libpcr3)

Install .tar file instead of cloning and extract

```
$ cd libyang-1.0.240; mkdir build; cd build
$ cmake ..
$ rm -rf CMakeCache.txt
$ make
$ make install
```

3. libnetconf2([v1.1.46](#))**Install .tar file instead of cloning and extract**

```
$ cd libnetconf2-1.1.46
$ mkdir build; cd build
$ cmake ..
$ rm -rf CMakeCache.txt
$ make
$ make install
```

4. sysrepo([v1.4.140](#))**Install .tar file instead of cloning and extract**

```
$ cd sysrepo-1.4.140
$ mkdir build; cd build
$ cmake ..
$ rm -rf CMakeCache.txt
$ make
$ make install
```

5. Netopeer server and client([Version 1.1.76](#))

Install .tar file instead of cloning and extract

```
--server installation;  
$ cd netopeer2-1.1.76  
$ mkdir build; cd build  
$ cmake ..  
$ rm -rf CMakeCache.txt  
$ sudo ldconfig  
$ make  
$ make install
```

Note : server make install may fail with the error (/usr/local/bin/sysrepoctl: error while loading shared libraries: libsysrepo.so.5: cannot open shared object file: No such file or directory CMake Warning (dev) at cmake_install.cmake:61 (if):

given arguments: 127 etc)
put ldconfig command and then proceed with make install

```
$ sudo ldconfig  
$ make  
$ make install
```

To install netopeer-cli version 7 yang modules as follows.

```
1. libssh (checkout to 0.7.5 branch from git repo)  
$ git clone http://git.libssh.org/projects/libssh.git  
$ cd libssh; mkdir build; cd build  
$ cmake ..  
$ rm -rf CMakeCache.txt  
$ make install  
$ make install -j8  
$ make  
2. libyang(v2.1.4)
```

Note : dependency on libpcr (install libpcr : sudo apt-get install libpcr3-dev libpcr3)

Install .tar file instead of cloning and extract

```
$ cd libyang-2.1.4; mkdir build; cd build  
$ cmake ..  
$ rm -rf CMakeCache.txt  
$ make
```

```
$ make install
```

```
3. libnetconf2(v2.1.25)
```

Install .tar file instead of cloning and extract

```
$ cd libnetconf2-2.1.25
```

```
$ mkdir build; cd build
```

```
$ cmake ..
```

```
$ rm -rf CMakeCache.txt
```

```
$ make
```

```
$ make install
```

```
4. sysrepo(v2.2.12)
```

Install .tar file instead of cloning and extract

```
$ cd sysrepo-1.4.140
```

```
$ mkdir build; cd build
```

```
$ cmake ..
```

```
$ rm -rf CMakeCache.txt
```

```
$ make
```

```
$ make install
```

```
5. Netopeer server and client(v2.1.49)
```

Install .tar file instead of cloning and extract

```
--server installation;
```

```
$ cd netopeer2-2.1.49
```

```
$ mkdir build; cd build
```

```
$ cmake ..
```

```
$ rm -rf CMakeCache.txt
```

```
$ sudo ldconfig
```

```
$ make
```

```
$ make install
```

Note : server make install may fail with the error (/usr/local/bin/sysrepoctl: error while loading shared libraries: libsysrepo.so.5: cannot open shared object file: No such file or directory

CMake Warning (dev) at cmake_install.cmake:61 (if)

given arguments: 127.etc)

put ldconfig command and then proceed with make install

```
$ sudo ldconfig
```

```
$ make
```

```
$make install
```

6.6 Procedure

DHCP server will assign a dynamic ip to the 10G interface, then Follow below-mentioned commands for connecting via Netopeer

```
>netopeer2-cli
>listen --ssh --login <username>
```

- Insert any one of the credentials in [table 9](#)

6.7 Firmware upgrade via M Plane

Note:- For reference refer ORAN spec- O-RAN.WG4.MP.0-v07.00

6.7.1. Firmware upgrade using v7 yang modules

6.7.1.1. Software Download

```
subscribe --filter-xpath /o-ran-software-management:download-event
```

Download

```
>user-rpc
```

```
<software-download xmlns="urn:o-ran:software-management:1.0">
<remote-file-path>sftp://<username>@<ip_address>:22/<file_path></remote-file-path>
  <password>
    <password><PASSWORD></password>
  </password>
</software-download>
```

Note:

Remote File path Location:

<username of Linux PC>@<IP address of Linux PC>:22/<Specify the software image location in linux PC>
Password:Linux PC's Password

6.7.1.2. Software Install

```
subscribe --filter-xpath /o-ran-software-management:install-event
```

Install

```
>user-rpc
```

```
<software-install xmlns="urn:o-ran:software-management:1.0">  
  <slot-name>SLOT_NUMBER(ex:swSlot2)</slot-name>  
</software-install>
```

6.7.1.3. Software Activate

```
subscribe --filter-xpath /o-ran-software-management:activation-event
```

Activate

```
>user-rpc
```

```
[OBJ]
```

```
<software-activate xmlns="urn:o-ran:software-management:1.0">  
  <slot-name>SLOT_NUMBER(ex:swSlot2)</slot-name>  
</software-activate>
```

6.7.1.4. Software Reset

Reset

```
>user-rpc
```

```
<reset xmlns="urn:o-ran:operations:1.0"></reset>
```

6.8. Performance management via M Plane

Note: Push U-plane XML sec-6.9 before running the performance management

6.8.1.o-ran-performance-management.yang Module for V2 Netopeer-cli yang.

```
edit-config --target running --config --defop replace
```

```
<performance-measurement-objects xmlns="urn:o-ran:performance-management:1.0">
  <enable-SFTP-upload>true</enable-SFTP-upload>
  <enable-random-file-upload>false</enable-random-file-upload>
  <remote-SFTP-uploads>
    <remote-SFTP-upload-path>sftp://username@ip_address:22/file_upload_path</remote-SFTP-upload-path>

    <password>
      <password>DU_PASSWORD</password>
    </password>
    <server>
      <keys>
        <algorithm>rsa2048</algorithm>
        <public-key>[PUBLIC_KEY]</public-key>
      </keys>
    </server>
  </remote-SFTP-uploads>
  <rx-window-measurement-interval>10</rx-window-measurement-interval>
  <transceiver-measurement-interval>10</transceiver-measurement-interval>
  <notification-interval>10</notification-interval>
  <file-upload-interval>10</file-upload-interval>
  <rx-window-measurement-objects>
    <measurement-object>RX_ON_TIME</measurement-object>
    <active>true</active>
    <object-unit>EAXC_ID</object-unit>
    <report-info>COUNT</report-info>
  </rx-window-measurement-objects>
  <rx-window-measurement-objects>
    <measurement-object>RX_EARLY</measurement-object>
    <active>true</active>
    <object-unit>EAXC_ID</object-unit>
    <report-info>COUNT</report-info>
  </rx-window-measurement-objects>
  <rx-window-measurement-objects>
    <measurement-object>RX_LATE</measurement-object>
    <active>true</active>
    <object-unit>EAXC_ID</object-unit>
```

```

    <report-info>COUNT</report-info>
</rx-window-measurement-objects>
<rx-window-measurement-objects>
    <measurement-object>RX_CORRUPT</measurement-object>
    <active>true</active>
    <object-unit>EAXC_ID</object-unit>
    <report-info>COUNT</report-info>
</rx-window-measurement-objects>
<rx-window-measurement-objects>
    <measurement-object>RX_TOTAL</measurement-object>
    <active>true</active>
    <object-unit>EAXC_ID</object-unit>
    <report-info>COUNT</report-info>
</rx-window-measurement-objects>
<rx-window-measurement-objects>
    <measurement-object>RX_DUPL</measurement-object>
    <active>true</active>
    <object-unit>EAXC_ID</object-unit>
    <report-info>COUNT</report-info>
</rx-window-measurement-objects>
<transceiver-measurement-objects>
    <measurement-object>RX_POWER</measurement-object>
    <active>true</active>
    <report-info>MAXIMUM</report-info>
    <object-unit>PORT_NUMBER</object-unit>
    <function>RAW</function>
</transceiver-measurement-objects>
<transceiver-measurement-objects>
    <measurement-object>TX_POWER</measurement-object>
    <active>true</active>
    <report-info>MAXIMUM</report-info>
    <object-unit>PORT_NUMBER</object-unit>
    <function>RAW</function>
</transceiver-measurement-objects>
<transceiver-measurement-objects>
    <measurement-object>TX_BIAS_COUNT</measurement-object>
    <active>true</active>
    <report-info>MAXIMUM</report-info>
    <object-unit>PORT_NUMBER</object-unit>
    <function>RAW</function>
</transceiver-measurement-objects>
<transceiver-measurement-objects>
    <measurement-object>VOLTAGE</measurement-object>
    <active>true</active>
    <report-info>MAXIMUM</report-info>

```

```

<object-unit>PORT_NUMBER</object-unit>
<function>RAW</function>
</transceiver-measurement-objects>
<transceiver-measurement-objects>
  <measurement-object>TEMPERATURE</measurement-object>
  <active>true</active>
  <report-info>MAXIMUM</report-info>
  <object-unit>PORT_NUMBER</object-unit>
  <function>RAW</function>
</transceiver-measurement-objects>
</performance-measurement-objects>

```

Remote File path Location:

<username of Linux PC>@<IP address of Linux PC>:22/<Specify the software image location in linux PC>

Password:Linux PC's Password

Public Key refer section 5.3.3.2

To activate performance management :

Give **TRUE** in every <active> leaf in the xml

To deactivate performance management :

Give **FALSE** in every <active> leaf in the xml

Table

measurement-group	measurement-object	report-info	object-unit	Note
transceiver-stats	RX_POWER	max and time	PORT_NUMBER	Type decimal64 including 4 fraction-digits for max , min , first and latest . A parameter date-and-time is reported for each additionally. Configurable parameters: function , bin-count , lower-bound , upper-bound are defined. For more detail see B.1.1 and B.1.2. Type uint32 is used for frequency-table .
	TX_POWER	min and time		
	TX_BIAS_COUNT	first and time		
	VOLTAGE	latest and time		
	TEMPERATURE	frequency-table		
rx-window-stats	RX_ON_TIME	count	RU, TRANSPORT, or EAXC_ID	Type yang: counter64 is used for the count. When object-unit is EAXC_ID, TRANSPORT is reported as additional parameter for EAXC_ID.
	RX_EARLY			
	RX_LATE			
	RX_CORRUPT			
	RX_DUPL			
	RX_TOTAL			

10:Supported Counters

6.8.2.o-ran-performance-management.yang Module for V 7 Netopeercli yang.

edit-config --target running --config --defop replace

```
<performance-measurement-objects xmlns="urn:o-ran:performance-management:1.0">
  <enable-SFTP-upload>true</enable-SFTP-upload>
  <enable-random-file-upload>>false</enable-random-file-upload>
  <remote-SFTP-uploads>
    <remote-SFTP-upload-path>sftp://username@ip_address:22/file_upload_path</remote-SFTP-upload-path>
    <password>
      <password>DU_PASSWORD</password>
    </password>
  </remote-SFTP-uploads>
  <rx-window-measurement-interval>20</rx-window-measurement-interval>
  <transceiver-measurement-interval>20</transceiver-measurement-interval>
  <notification-interval>20</notification-interval>
  <file-upload-interval>20</file-upload-interval>
  <rx-window-measurement-objects>
    <measurement-object>RX_ON_TIME</measurement-object>
    <active>true/false</active>
    <object-unit>EAXC_ID</object-unit>
    <report-info>MAXIMUM</report-info>
  </rx-window-measurement-objects>
  <rx-window-measurement-objects>
    <measurement-object>RX_EARLY</measurement-object>
    <active>true/false</active>
    <object-unit>EAXC_ID</object-unit>
    <report-info>MAXIMUM</report-info>
  </rx-window-measurement-objects>
  <rx-window-measurement-objects>
    <measurement-object>RX_LATE</measurement-object>
    <active>true</active>
    <object-unit>EAXC_ID</object-unit>
    <report-info>MAXIMUM</report-info>
  </rx-window-measurement-objects>
  <rx-window-measurement-objects>
```

```
<measurement-object>RX_CORRUPT</measurement-object>
<active>true/false</active>
<object-unit>EAXC_ID</object-unit>
<report-info>MAXIMUM</report-info>
</rx-window-measurement-objects>
<rx-window-measurement-objects>
  <measurement-object>RX_TOTAL</measurement-object>
  <active>true/false</active>
  <object-unit>EAXC_ID</object-unit>
  <report-info>MAXIMUM</report-info>
</rx-window-measurement-objects>
<transceiver-measurement-objects>
  <measurement-object>RX_DUPL</measurement-object>
  <active>true/false</active>
  <report-info>MAXIMUM</report-info>
  <object-unit>PORT_NUMBER</object-unit>
</transceiver-measurement-objects>
<transceiver-measurement-objects>
  <measurement-object>TX_POWER</measurement-object>
  <active>true/false</active>
  <report-info>MAXIMUM</report-info>
  <object-unit>PORT_NUMBER</object-unit>
</transceiver-measurement-objects>
<transceiver-measurement-objects>
  <measurement-object>TX_BIAS_COUNT</measurement-object>
  <active>true/false</active>
  <report-info>MAXIMUM</report-info>
  <object-unit>PORT_NUMBER</object-unit>
</transceiver-measurement-objects>
<transceiver-measurement-objects>
  <measurement-object>VOLTAGE</measurement-object>
  <active>true/false</active>
  <report-info>MAXIMUM</report-info>
  <object-unit>PORT_NUMBER</object-unit>
</transceiver-measurement-objects>
<transceiver-measurement-objects>
  <measurement-object>TEMPERATURE</measurement-object>
  <active>true/false</active>
  <report-info>MAXIMUM</report-info>
  <object-unit>PORT_NUMBER</object-unit>
</transceiver-measurement-objects>
```

```
</performance-measurement-objects>
```

Note:

Remote File path Location:

<username of Linux PC>@<IP address of Linux PC>:22/<Specify the software image location in linux PC>

Password:Linux PC's Password

Public Key refer section 5.3.3.2

To activate performance management :

Give *TRUE* in every <active> leaf in the xml

To deactivate performance management :

Give *FALSE* in every <active> leaf in the xml

6.9. U plane configuration via M Plane

6.9.1.o-ran-uplane-conf.yang Module

```
edit-config --target running --config --defop replace
```

```
<user-plane-configuration xmlns="urn:o-ran:uplane-conf:1.0">
  <low-level-tx-links>
    <name>lltxlink0</name>
    <processing-element>element1</processing-element>
    <tx-array-carrier>txarraycarrier0</tx-array-carrier>
    <low-level-tx-endpoint>slltx-endpoint0</low-level-tx-endpoint>
  </low-level-tx-links>
  <low-level-tx-links>
    <name>lltxlink1</name>
    <processing-element>element1</processing-element>
    <tx-array-carrier>txarraycarrier0</tx-array-carrier>
    <low-level-tx-endpoint>slltx-endpoint1</low-level-tx-endpoint>
  </low-level-tx-links>
  <low-level-tx-links>
    <name>lltxlink2</name>
    <processing-element>element1</processing-element>
    <tx-array-carrier>txarraycarrier0</tx-array-carrier>
    <low-level-tx-endpoint>slltx-endpoint2</low-level-tx-endpoint>
  </low-level-tx-links>
  <low-level-tx-links>
    <name>lltxlink3</name>
    <processing-element>element1</processing-element>
    <tx-array-carrier>txarraycarrier0</tx-array-carrier>
```

```

<low-level-tx-endpoint>sltx-endpoint3</low-level-tx-endpoint>
</low-level-tx-links>

<low-level-rx-links>
  <name>llrxlink0</name>
  <processing-element>element1</processing-element>
  <rx-array-carrier>rxarraycarrier0</rx-array-carrier>
  <low-level-rx-endpoint>slrx-endpoint0</low-level-rx-endpoint>
</low-level-rx-links>
<low-level-rx-links>
  <name>llrxlink1</name>
  <processing-element>element1</processing-element>
  <rx-array-carrier>rxarraycarrier0</rx-array-carrier>
  <low-level-rx-endpoint>slrx-endpoint1</low-level-rx-endpoint>
</low-level-rx-links>
<low-level-rx-links>
  <name>llrxlink2</name>
  <processing-element>element1</processing-element>
  <rx-array-carrier>rxarraycarrier0</rx-array-carrier>
  <low-level-rx-endpoint>slrx-endpoint2</low-level-rx-endpoint>
</low-level-rx-links>
<low-level-rx-links>
  <name>llrxlink3</name>
  <processing-element>element1</processing-element>
  <rx-array-carrier>rxarraycarrier0</rx-array-carrier>
  <low-level-rx-endpoint>slrx-endpoint3</low-level-rx-endpoint>
</low-level-rx-links>

<low-level-tx-endpoints>
  <name>sltx-endpoint0</name>
  <compression>
    <compression-type>STATIC</compression-type>
    <iq-bitwidth>16</iq-bitwidth>
  </compression>
  <cp-length>352</cp-length>
  <cp-length-other>288</cp-length-other>
  <offset-to-absolute-frequency-center>0</offset-to-absolute-frequency-center>
  <number-of-prb-per-scs>
    <scs>KHZ_30</scs>
    <number-of-prb>273</number-of-prb>
  </number-of-prb-per-scs>
  <e-axcid>
    <o-du-port-bitmask>65024</o-du-port-bitmask>
    <band-sector-bitmask>448</band-sector-bitmask>
    <ccid-bitmask>56</ccid-bitmask>
  </e-axcid>

```

```
<ru-port-bitmask>7</ru-port-bitmask>
<eexc-id>1</eexc-id>
</e-axcid>
</low-level-tx-endpoints>
<low-level-tx-endpoints>
  <name>slltx-endpoint1</name>
  <compression>
    <compression-type>STATIC</compression-type>
    <iq-bitwidth>16</iq-bitwidth>
  </compression>
  <cp-length>352</cp-length>
  <cp-length-other>288</cp-length-other>
  <offset-to-absolute-frequency-center>0</offset-to-absolute-frequency-center>
  <number-of-prb-per-scs>
    <scs>KHZ_30</scs>
    <number-of-prb>273</number-of-prb>
  </number-of-prb-per-scs>
  <e-axcid>
    <o-du-port-bitmask>65024</o-du-port-bitmask>
    <band-sector-bitmask>448</band-sector-bitmask>
    <ccid-bitmask>56</ccid-bitmask>
    <ru-port-bitmask>7</ru-port-bitmask>
    <eexc-id>2</eexc-id>
  </e-axcid>
</low-level-tx-endpoints>
<low-level-tx-endpoints>
  <name>slltx-endpoint2</name>
  <compression>
    <compression-type>STATIC</compression-type>
    <iq-bitwidth>16</iq-bitwidth>
  </compression>
  <cp-length>352</cp-length>
  <cp-length-other>288</cp-length-other>
  <offset-to-absolute-frequency-center>0</offset-to-absolute-frequency-center>
  <number-of-prb-per-scs>
    <scs>KHZ_30</scs>
    <number-of-prb>273</number-of-prb>
  </number-of-prb-per-scs>
  <e-axcid>
    <o-du-port-bitmask>65024</o-du-port-bitmask>
    <band-sector-bitmask>448</band-sector-bitmask>
    <ccid-bitmask>56</ccid-bitmask>
    <ru-port-bitmask>7</ru-port-bitmask>
    <eexc-id>3</eexc-id>
  </e-axcid>
```

```

</low-level-tx-endpoints>
<low-level-tx-endpoints>
  <name>slltx-endpoint3</name>
  <compression>
    <compression-type>STATIC</compression-type>
    <iq-bitwidth>16</iq-bitwidth>
  </compression>
  <cp-length>352</cp-length>
  <cp-length-other>288</cp-length-other>
  <offset-to-absolute-frequency-center>0</offset-to-absolute-frequency-center>
  <number-of-prb-per-scs>
    <scs>KHZ_30</scs>
    <number-of-prb>273</number-of-prb>
  </number-of-prb-per-scs>
  <e-axcid>
    <o-du-port-bitmask>65024</o-du-port-bitmask>
    <band-sector-bitmask>448</band-sector-bitmask>
    <ccid-bitmask>56</ccid-bitmask>
    <ru-port-bitmask>7</ru-port-bitmask>
    <eaxc-id>4</eaxc-id>
  </e-axcid>
</low-level-tx-endpoints>

<low-level-rx-endpoints>
  <name>sllrx-endpoint0</name>
  <compression>
    <compression-type>STATIC</compression-type>
    <iq-bitwidth>16</iq-bitwidth>
  </compression>
  <cp-length>352</cp-length>
  <cp-length-other>288</cp-length-other>
  <offset-to-absolute-frequency-center>0</offset-to-absolute-frequency-center>
  <number-of-prb-per-scs>
    <scs>KHZ_30</scs>
    <number-of-prb>273</number-of-prb>
  </number-of-prb-per-scs>
  <ul-fft-sampling-offsets>
    <scs>KHZ_30</scs>
  </ul-fft-sampling-offsets>
  <e-axcid>
    <o-du-port-bitmask>65024</o-du-port-bitmask>
    <band-sector-bitmask>448</band-sector-bitmask>
    <ccid-bitmask>56</ccid-bitmask>
    <ru-port-bitmask>7</ru-port-bitmask>
    <eaxc-id>1</eaxc-id>
  </e-axcid>

```

```

</e-axcid>
<non-time-managed-delay-enabled>true</non-time-managed-delay-enabled>
</low-level-rx-endpoints>
<low-level-rx-endpoints>
  <name>sllrx-endpoint1</name>
  <compression>
    <compression-type>STATIC</compression-type>
    <iq-bitwidth>16</iq-bitwidth>
  </compression>
  <cp-length>352</cp-length>
  <cp-length-other>288</cp-length-other>
  <offset-to-absolute-frequency-center>0</offset-to-absolute-frequency-center>
  <number-of-prb-per-scs>
    <scs>KHZ_30</scs>
    <number-of-prb>273</number-of-prb>
  </number-of-prb-per-scs>
  <ul-fft-sampling-offsets>
    <scs>KHZ_30</scs>
  </ul-fft-sampling-offsets>
</e-axcid>
  <o-du-port-bitmask>65024</o-du-port-bitmask>
  <band-sector-bitmask>448</band-sector-bitmask>
  <ccid-bitmask>56</ccid-bitmask>
  <ru-port-bitmask>7</ru-port-bitmask>
  <eaxc-id>2</eaxc-id>
</e-axcid>
<non-time-managed-delay-enabled>true</non-time-managed-delay-enabled>
</low-level-rx-endpoints>
<low-level-rx-endpoints>
  <name>sllrx-endpoint2</name>
  <compression>
    <compression-type>STATIC</compression-type>
    <iq-bitwidth>16</iq-bitwidth>
  </compression>
  <cp-length>352</cp-length>
  <cp-length-other>288</cp-length-other>
  <offset-to-absolute-frequency-center>0</offset-to-absolute-frequency-center>
  <number-of-prb-per-scs>
    <scs>KHZ_30</scs>
    <number-of-prb>273</number-of-prb>
  </number-of-prb-per-scs>
  <ul-fft-sampling-offsets>
    <scs>KHZ_30</scs>
  </ul-fft-sampling-offsets>
</e-axcid>

```

```

<o-du-port-bitmask>65024</o-du-port-bitmask>
<band-sector-bitmask>448</band-sector-bitmask>
<ccid-bitmask>56</ccid-bitmask>
<ru-port-bitmask>7</ru-port-bitmask>
<eexc-id>3</eexc-id>
</e-axcid>
<non-time-managed-delay-enabled>true</non-time-managed-delay-enabled>
</low-level-rx-endpoints>
<low-level-rx-endpoints>
  <name>sllrx-endpoint3</name>
  <compression>
    <compression-type>STATIC</compression-type>
    <iq-bitwidth>16</iq-bitwidth>
  </compression>
  <cp-length>352</cp-length>
  <cp-length-other>288</cp-length-other>
  <offset-to-absolute-frequency-center>0</offset-to-absolute-frequency-center>
  <number-of-prb-per-scs>
    <scs>KHZ_30</scs>
    <number-of-prb>273</number-of-prb>
  </number-of-prb-per-scs>
  <ul-fft-sampling-offsets>
    <scs>KHZ_30</scs>
  </ul-fft-sampling-offsets>
</e-axcid>
  <o-du-port-bitmask>65024</o-du-port-bitmask>
  <band-sector-bitmask>448</band-sector-bitmask>
  <ccid-bitmask>56</ccid-bitmask>
  <ru-port-bitmask>7</ru-port-bitmask>
  <eexc-id>4</eexc-id>
</e-axcid>
  <non-time-managed-delay-enabled>true</non-time-managed-delay-enabled>
</low-level-rx-endpoints>
<tx-array-carriers>
  <name>txarraycarrier0</name>
  <absolute-frequency-center>[ARFCN]</absolute-frequency-center>
  <center-of-channel-bandwidth>[CENTER FREQUENCY]</center-of-channel-bandwidth>
  <channel-bandwidth>[BANDWIDTH]</channel-bandwidth>
  <active>ACTIVE</active>
  <gain>0</gain>
  <downlink-radio-frame-offset>0</downlink-radio-frame-offset>
  <downlink-sfn-offset>0</downlink-sfn-offset>
  <rw-duplex-scheme>TDD</rw-duplex-scheme>
  <rw-type>NR</rw-type>
</tx-array-carriers>

```

```
<rx-array-carriers>
  <name>rxarraycarrier0</name>
  <absolute-frequency-center>[ARFCN]</absolute-frequency-center>
  <center-of-channel-bandwidth>[CENTER FREQUENCY]</center-of-channel-bandwidth>
  <channel-bandwidth>[BANDWIDTH]</channel-bandwidth>
  <active>ACTIVE</active>
  <downlink-radio-frame-offset>0</downlink-radio-frame-offset>
  <downlink-sfn-offset>0</downlink-sfn-offset>
  <gain-correction>0</gain-correction>
  <n-ta-offset>25600</n-ta-offset>
</rx-array-carriers>
</user-plane-configuration>
```

Note: For 4T4R the eAxC ID mapping is

PDSCH- 0,1,2,3

PUSCH-0,1,2,3

PRACH-4,5,6,7

*ARFCN of center frequency chosen within the band eg : ARFCN : 646667, Freq : 3700.005 Mhz
Bandwidth within ibw/obw can be used.*

Note: We need to push the ACTIVE leaf in the U-plane each time after the RU gets synchronized.

6.10. Interface configuration via M Plane

6.10.1.o-ran-interface.yang Module for V7 yang modules.

```
edit-config --target running --config --defop merge
```

```
<interfaces xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces">
  <interface>
    <name>eth1.100(interface_name.valn)</name>
    <type xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type">ianaift:l2vlan</type>
    <enabled>true</enabled>
    <base-interface xmlns="urn:o-ran:interfaces:1.0">eth1</base-interface>
    <vlan-id xmlns="urn:o-ran:interfaces:1.0">100(valn)</vlan-id>
    <mac-address xmlns="urn:o-ran:interfaces:1.0">[MAC_ADDRESS]</mac-address>
    <port-reference xmlns="urn:o-ran:interfaces:1.0">
      <port-name>ru-port0</port-name>
      <port-number>0</port-number>
```

```

    </port-reference>
  </interface>
</interfaces>

```

6.10.2.o-ran-interface.yang Module for V7 yang modules.

```

<interfaces xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces">
  <interface>
    <name>eth1(name_of_the_eth_interface)</name>
    <type xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type">ianaift:ethernetCsmacd</type>
    <enabled>true</enabled>
    <ipv4 xmlns="urn:ietf:params:xml:ns:yang:ietf-ip">
      <enabled>true</enabled>
      <forwarding>false</forwarding>
      <m-plane-marking xmlns="urn:o-ran:interfaces:1.0">18</m-plane-marking>
    </ipv4>
    <l2-mtu xmlns="urn:o-ran:interfaces:1.0">1500</l2-mtu>
    <vlan-tagging xmlns="urn:o-ran:interfaces:1.0">true</vlan-tagging>
    <class-of-service xmlns="urn:o-ran:interfaces:1.0">
      <u-plane-marking>7</u-plane-marking>
      <c-plane-marking>7</c-plane-marking>
      <m-plane-marking>2</m-plane-marking>
      <s-plane-marking>7</s-plane-marking>
      <other-marking>1</other-marking>
      <enhanced-uplane-markings>
        <up-marking-name>uplane</up-marking-name>
        <enhanced-marking>7</enhanced-marking>
      </enhanced-uplane-markings>
    </class-of-service>
    <mac-address xmlns="urn:o-ran:interfaces:1.0">RU_MAC_ADDRESS</mac-address>
    <port-reference xmlns="urn:o-ran:interfaces:1.0">
      <port-name>ru-port1</port-name>
      <port-number>1</port-number>
    </port-reference>
  </interface>
  <interface>
    <name>eth1.100(name_of_the_vlan_interface_to_be_created)</name>
    <type xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type">ianaift:l2vlan</type>
    <enabled>true</enabled>
    <ipv4 xmlns="urn:ietf:params:xml:ns:yang:ietf-ip">
      <enabled>true</enabled>

```

```

<forwarding>>false</forwarding>
<address>
  <ip>192.168.3.45(ip_of_the_vlan_interface)</ip>
  <netmask>255.255.255.0</netmask>
</address>
<m-plane-marking xmlns="urn:o-ran:interfaces:1.0">18</m-plane-marking>
</ipv4>
<base-interface xmlns="urn:o-ran:interfaces:1.0">eth0(FH_Interface_LPRU)</base-interface>
<vlan-id xmlns="urn:o-ran:interfaces:1.0">100(vlan_id)</vlan-id>
<mac-address xmlns="urn:o-ran:interfaces:1.0">RU_MAC_ADDRESS</mac-address>
<port-reference xmlns="urn:o-ran:interfaces:1.0">
  <port-name>ru-port1</port-name>
  <port-number>1</port-number>
</port-reference>
</interface>
</interfaces>

```

6.11. Processing element via M Plane

```
edit-config --target running --config --defop replace
```

```

<processing-elements xmlns="urn:o-ran:processing-element:1.0">
  <transport-session-type>ETH-INTERFACE</transport-session-type>
  <ru-elements>
    <name>element1</name>
    <transport-flow>
      <interface-name>eth1.100(name_of_the_vlan_interface)</interface-name>
      <eth-flow>
        <ru-mac-address>RU_MAC_ADDRESS</ru-mac-address>
        <vlan-id>100(vlan_id)</vlan-id>
        <o-du-mac-address>DU_MAC_ADDRESS</o-du-mac-address>
      </eth-flow>
    </transport-flow>
  </ru-elements>
</processing-elements>

```

6.12. Transceiver configuration via M Plane

edit-config --target running --config --defop replace

```
<port-transceivers xmlns="urn:o-ran:transceiver:1.0">
  <port-transceiver-data>
    <interface-name>eth1</interface-name>
    <port-number>1</port-number>
    <name>ru-port1</name>
    <present>true</present>
    <vendor-id>Syrotech</vendor-id>
    <vendor-part>GOXP-8596-02</vendor-part>
    <vendor-rev>V0</vendor-rev>
    <serial-no>SY2210-OLC0716</serial-no>
    <SFF8472-compliance-code>rev10.2-diagnostics</SFF8472-compliance-code>
    <connector-type>lucent-connector</connector-type>
    <identifier>sfp</identifier>
    <nominal-bitrate>103</nominal-bitrate>
    <low-bitrate-margin>0</low-bitrate-margin>
    <high-bitrate-margin>0</high-bitrate-margin>
    <rx-power-type>avp</rx-power-type>
    <rx-power>0.4287</rx-power>
    <tx-power>0.5889</tx-power>
    <tx-bias-current>7.93</tx-bias-current>
    <voltage>3.3348</voltage>
  </port-transceiver-data>
</port-transceivers>
</data>
```

6.13. mplane-int.yang configuration via M plane

6.13.1. Mplane-int.yang for v2 yang modules

edit-config --target running --config --defop replace

```
<mplane-info xmlns="urn:o-ran:mplane-interfaces:1.0">
  <m-plane-interfaces>
    <m-plane-ssh-ports>
      <call-home-ssh-port>4334</call-home-ssh-port>
      <server-ssh-port>830</server-ssh-port>
    </m-plane-ssh-ports>
  </m-plane-interfaces>
</mplane-info>
```

```

</m-plane-ssh-ports>
</m-plane-interfaces>
</mplane-info>

```

6.13.2. Mplane-int.yang for v7 yang modules

```
edit-config --target running --config --defop replace
```

```

<mplane-info xmlns="urn:o-ran:mplane-interfaces:1.0">
  <searchable-mplane-access-vlans-info>
    <searchable-access-vlans>100</searchable-access-vlans>
    <vlan-range>
      <lowest-vlan-id>1</lowest-vlan-id>
      <highest-vlan-id>4094</highest-vlan-id>
    </vlan-range>
    <scan-interval>100</scan-interval>
  </searchable-mplane-access-vlans-info>
  <m-plane-interfaces>
    <m-plane-sub-interfaces>
      <interface-name>eth1.100</interface-name>
      <sub-interface>100</sub-interface>
    </m-plane-sub-interfaces>
    <m-plane-ssh-ports>
      <call-home-ssh-port>4334</call-home-ssh-port>
      <server-ssh-port>830</server-ssh-port>
    </m-plane-ssh-ports>
    <m-plane-tls-ports>
      <call-home-tls-port>4335</call-home-tls-port>
      <server-tls-port>6513</server-tls-port>
    </m-plane-tls-ports>
  </m-plane-interfaces>
  <configured-client-info>
    <mplane-ipv4-info>
      <mplane-ipv4>ex:192.168.4.15(ip_for_the_created_vlan_interface)</mplane-ipv4>
    </mplane-ipv4-info>
  </configured-client-info>
</mplane-info>

```

```
<port>830</port>
</mplane-ipv4-info>
<mplane-ipv6-info>
  <mplane-ipv6>fe80::7a7d:f3ff:fe01:12e9</mplane-ipv6>
  <port>830</port>
</mplane-ipv6-info>
<mplane-fqdn>vvdntech</mplane-fqdn>
</configured-client-info>
</mplane-info>
```

6.14. O-ran-troubleshooting configuration via M plane

6.14.1. Start Troubleshooting

user-rpc

```
<start-troubleshooting-logs xmlns="urn:o-ran:troubleshooting:1.0">
</start-troubleshooting-logs>
```

6.14.2. Stop Troubleshooting

user-rpc

```
<stop-troubleshooting-logs xmlns="urn:o-ran:troubleshooting:1.0">
</stop-troubleshooting-logs>
```

6.15.o-ran-trace configuration via M plane

6.15.1. Start Trace

user-rpc

```
<start-trace-logs xmlns="urn:o-ran:trace:1.0">
```

```
</start-trace-logs>
```

6.15.2. Stop Trace

```
user-rpc
```

```
<stop-trace-logs xmlns="urn:o-ran:trace:1.0">
</stop-trace-logs>
```

6.16. o-ran-supervision configuration via M Plane

```
<supervision-watchdog-reset xmlns="urn:o-ran:supervision:1.0">
  <supervision-notification-interval>60</supervision-notification-interval>
  <guard-timer-overhead>10</guard-timer-overhead>
</supervision-watchdog-reset>
```

6.17. o-ran-usermgmt configuration via M plane

```
edit-config --target running --config --defop replace
```

```
<data xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <users xmlns="urn:o-ran:user-mgmt:1.0">
    <user>
      <name>oranuser</name>
      <account-type>PASSWORD</account-type>
      <enabled>true</enabled>
    </user>
  </users>
</data>
```

```
get --filter-xpath /o-ran-usermgmt:users/user
```

6.18. o-ran-hardware configuration via M Plane

6.18.1. o-ran-hardware v7 yang modules.

```
get --filter-xpath /ietf-interfaces:interfaces
```

```
<data xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <interfaces xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces">
    <interface>
      <name>lo</name>
      <type xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type">ianaift:ethernetCsmacd</type>
      <enabled>true</enabled>
      <oper-status>up</oper-status>
      <phys-address>00:00:00:00:00:00</phys-address>
      <statistics>
        <in-octets>200</in-octets>
        <in-discards>0</in-discards>
        <in-errors>0</in-errors>
        <out-octets>200</out-octets>
        <out-discards>0</out-discards>
        <out-errors>0</out-errors>
      </statistics>
      <ipv4 xmlns="urn:ietf:params:xml:ns:yang:ietf-ip">
        <enabled>true</enabled>
        <address>
          <ip>127.0.0.1</ip>
          <netmask>255.0.0.0</netmask>
        </address>
      </ipv4>
      <last-cleared xmlns="urn:o-ran:interfaces:1.0">2020-05-20T06:09:57+05:30</last-cleared>
      <mac-address xmlns="urn:o-ran:interfaces:1.0">00:00:00:00:00:00</mac-address>
    </interface>
    <interface>
      <name>eth0</name>
      <type xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type">ianaift:ethernetCsmacd</type>
```

```

<enabled>true</enabled>
<oper-status>up</oper-status>
<phys-address>98:ae:71:00:00:22</phys-address>
<statistics>
  <in-octets>0</in-octets>
  <in-discards>0</in-discards>
  <in-errors>0</in-errors>
  <out-octets>0</out-octets>
  <out-discards>0</out-discards>
  <out-errors>0</out-errors>
</statistics>
<ipv4 xmlns="urn:ietf:params:xml:ns:yang:ietf-ip">
  <enabled>true</enabled>
  <address>
    <ip>192.168.1.10</ip>
    <netmask>255.255.255.0</netmask>
  </address>
</ipv4>
<last-cleared xmlns="urn:o-ran:interfaces:1.0">2020-05-20T06:09:57+05:30</last-cleared>
<l2-mtu xmlns="urn:o-ran:interfaces:1.0">1500</l2-mtu>
<mac-address xmlns="urn:o-ran:interfaces:1.0">98:ae:71:00:00:22</mac-address>
<port-reference xmlns="urn:o-ran:interfaces:1.0">
  <port-name>ru-port0</port-name>
  <port-number>0</port-number>
</port-reference>
</interface>
<interface>
  <name>eth1</name>
  <type xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type">ianaift:ethernetCsmacd</type>
  <enabled>true</enabled>
  <oper-status>up</oper-status>
  <phys-address>98:ae:71:00:00:11</phys-address>
  <statistics>
    <in-octets>81552</in-octets>
    <in-discards>0</in-discards>
    <in-errors>0</in-errors>
    <out-octets>877739</out-octets>
  </statistics>
</interface>

```

```

    <out-discards>0</out-discards>
    <out-errors>0</out-errors>
  </statistics>
  <ipv4 xmlns="urn:ietf:params:xml:ns:yang:ietf-ip">
    <enabled>true</enabled>
    <forwarding>>false</forwarding>
    <address>
      <ip>192.168.4.50</ip>
      <netmask>255.255.255.0</netmask>
    </address>
    <m-plane-marking xmlns="urn:o-ran:interfaces:1.0">18</m-plane-marking>
  </ipv4>
  <last-cleared xmlns="urn:o-ran:interfaces:1.0">2020-05-20T06:09:57+05:30</last-cleared>
  <l2-mtu xmlns="urn:o-ran:interfaces:1.0">1500</l2-mtu>
  <vlan-tagging xmlns="urn:o-ran:interfaces:1.0">true</vlan-tagging>
  <class-of-service xmlns="urn:o-ran:interfaces:1.0">
    <u-plane-marking>7</u-plane-marking>
    <c-plane-marking>7</c-plane-marking>
    <m-plane-marking>2</m-plane-marking>
    <s-plane-marking>7</s-plane-marking>
    <other-marking>1</other-marking>
  </class-of-service>
  <mac-address xmlns="urn:o-ran:interfaces:1.0">98:ae:71:00:00:11</mac-address>
  <port-reference xmlns="urn:o-ran:interfaces:1.0">
    <port-name>ru-port1</port-name>
    <port-number>1</port-number>
  </port-reference>
</interface>
<interface>
  <name>eth1.100</name>
  <type xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type">ianaift:l2vlan</type>
  <enabled>true</enabled>
  <oper-status>up</oper-status>
  <phys-address>98:ae:71:00:00:11</phys-address>
  <statistics>
    <in-octets>0</in-octets>
    <in-discards>0</in-discards>

```

```

<in-errors>0</in-errors>
<out-octets>5101</out-octets>
<out-discards>0</out-discards>
<out-errors>0</out-errors>
</statistics>
<ipv4 xmlns="urn:ietf:params:xml:ns:yang:ietf-ip">
  <enabled>true</enabled>
  <forwarding>>false</forwarding>
  <address>
    <ip>10.10.0.1</ip>
    <netmask>255.255.255.0</netmask>
  </address>
  <m-plane-marking xmlns="urn:o-ran:interfaces:1.0">18</m-plane-marking>
</ipv4>
<last-cleared xmlns="urn:o-ran:interfaces:1.0">2020-05-20T06:09:57+05:30</last-cleared>
<base-interface xmlns="urn:o-ran:interfaces:1.0">eth1</base-interface>
<vlan-id xmlns="urn:o-ran:interfaces:1.0">100</vlan-id>
<mac-address xmlns="urn:o-ran:interfaces:1.0">98:ae:71:00:00:11</mac-address>
<port-reference xmlns="urn:o-ran:interfaces:1.0">
  <port-name>ru-port1</port-name>
  <port-number>1</port-number>
</port-reference>
</interface>
</interfaces>
</data>

```

6.18.2. o-ran-hardware v7 yang modules.

```

<hardware xmlns="urn:ietf:params:xml:ns:yang:ietf-hardware">
  <component>
    <energy-saving-enabled>true</energy-saving-enabled>
    <last-service-date>11-08-2023</last-service-date>
    <o-ran-name>ru_hw_component_name</o-ran-name>

```

```
</component>
```

```
</hardware>
```

```
get --filter-xpath /ietf-hardware:hardware
```

6.19. o-ran-operations configuration via M plane

```
edit-config --target running --config --defop replace
```

```
<operational-info xmlns="urn:o-ran:operations:1.0">
  <clock>
    <timezone-name>Asia/Kolkata</timezone-name>
    <timezone-utc-offset>+0530</timezone-utc-offset>
  </clock>
  <re-call-home-no-ssh-timer>60</re-call-home-no-ssh-timer>
</operational-info>
```

```
get --filter-xpath /o-ran-operations:operational-info
```

6.20. O-ran-file-management configuration via M plane

6.20.1 o-ran-file-management configuration For V2 based yang modules

6.20.1.1 O-ran-file-management: file-download

```
user-rpc
```

```
<file-download xmlns="urn:o-ran:file-management:1.0">
  <local-logical-file-path>/home/root</local-logical-file-path>
  <remote-file-path>sftp://user_name@host_ip[file_path]</remote-file-path>
  <password>
    <password>*****</password>
  </password>
  <server>
    <keys>
```

```
<algorithm>rsa2048</algorithm>
<public-key>[public_key]</public-key>
</keys>
</server>
</file-download>
```

Note:**Remote File path Location:**

<username of Linux PC>@<IP address of Linux PC>:22/<Specify the software image location in linux PC>

Password:Linux PC's Password

Public Key refer section 5.3.3.2

6.20.1.2 O-ran-file-management: file-upload

(Note: File size should not exceed the free memory space in the RU)

user-rpc

```
<file-upload xmlns="urn:o-ran:file-management:1.0">
<local-logical-file-path>[file_path]</local-logical-file-path>
<remote-file-path>sftp://user_name@host_ip[remote_file_path]</remote-file-path>
<password>
  <password>*****</password>
</password>
<server>
  <keys>
    <algorithm>rsa2048</algorithm>
    <public-key>[public_key]</public-key>
  </keys>
</server>
</file-upload>
```

6.20.1.3 O-ran-file-management: retrieve-file-list

user-rpc

```
<retrieve-file-list xmlns="urn:o-ran:file-management:1.0">
  <logical-path>/home/root/</logical-path>
  <file-name-filter>user*</file-name-filter>
</retrieve-file-list>
```

6.20.2 o-ran-file-management configurationFor V7 based yang modules

6.20.2.2 O-ran-file-management: file-download

```
subscribe --filter-xpath /o-ran-file-management:file-download-event
```

user-rpc

```
<file-download xmlns="urn:o-ran:file-management:1.0">
  <local-logical-file-path>/home/root/</local-logical-file-path>
  <remote-file-path>sftp://username@ip_address:22/file_path</remote-file-path>
  <password>
    <password>DU_PASSWORD</password>
  </password>
</file-download>
```

Note:

Remote File path Location:

<username of Linux PC>@<IP address of Linux PC>:22/<Specify the software image location in linux PC>

Password:Linux PC's Password

6.20.2.2 O-ran-file-management: file-upload

```
subscribe --filter-xpath /o-ran-file-management:file-upload-event
```

user-rpc

```
<file-upload xmlns="urn:o-ran:file-management:1.0">
  <local-logical-file-path>/home/root/name_of_the_file</local-logical-file-path>
  <remote-file-path>sftp://username@ip_address:22/file_upload_path</remote-file-path>
  <password>
    <password>DU_PASSWORD</password>
  </password>

</file-upload>
```

Note:

Remote File path Location:

*<username of Linux PC>@<IP address of Linux PC>:22/<Specify the software image location in linux PC>
Password:Linux PC's Password*

6.20.2.3 O-ran-file-management: retrieve-file-list

user-rpc

```
<retrieve-file-list xmlns="urn:o-ran:file-management:1.0">
  <logical-path>/home/root/</logical-path>
  <file-name-filter>*</file-name-filter>
</retrieve-file-list>
```

7. VVDN RU and OAI DU

7.1 Setup Diagram

7.1.1 Setup for LLS-C3

Below is a setup diagram for using LPRU with OAI DU with the PTP C3 configuration mode.

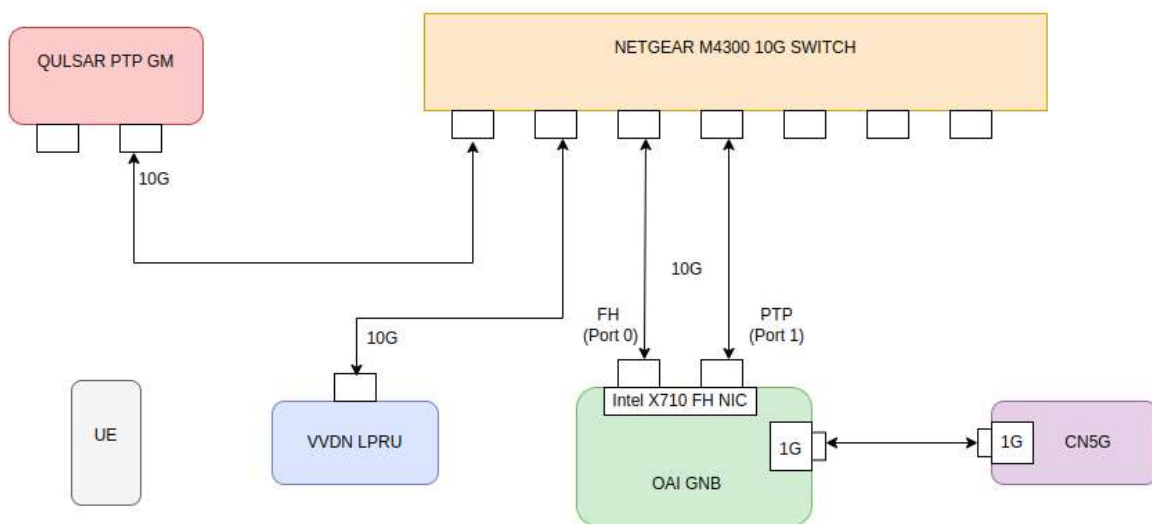


Fig 24 Setup Diagram for OAI in LLS-C3

The NIC card used in this setup above for PTP LLS-C3 mode is Intel X710 NIC.

The Core network and the OAI GNB can be used on the same server if needed. The table shows the details of the server in which both CN5G and OAI GNB has been implemented.

7.1.2 Setup for LLS-C1

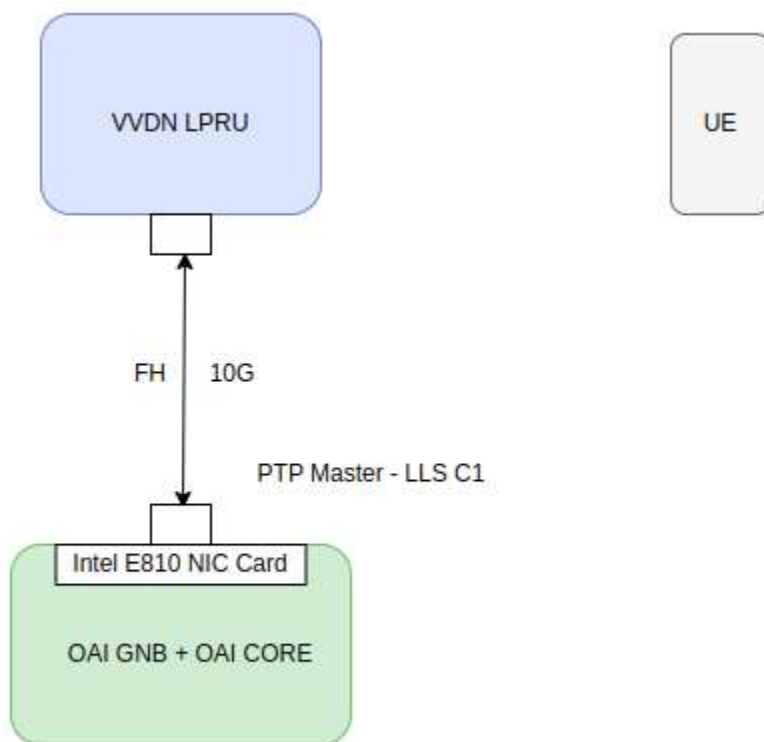


Fig 25 OAI Setup in LLS-C1

This diagram shows the setup used in LLS-C1 configuration mode. The NIC card used for the same is Intel E810 NIC card

7.2 Hardware Requirements

Component	Purpose
Intel X710 NIC Card / Intel E810 NIC Card	- Intel X710 is used for FH and PTP interface in LLS-C3 configuration - Intel E810 NIC is used for FH in LLS-C1 Interface. PTP Master is running on E810 NIC card
Qulsar GM	Used as Grand Master in LLS-C3 Configuration

Netgear M430 10G Switch	Used as Fronthaul switch in LLS-C3 mode
Supermicro AS-1014S-WTRT/any CPU with 20 core	OAI Server for Fronthaul and CN5G
User Equipment	Amarisoft UE Emulator, One Plus 9 5G, Samsung S22 or S23

Table 11: Hardware details

7.2 Software Requirements

- The RU image version for Gen3 which has been tested with the OAI stack is 3.0.5
- The current tested branch for OAI is [use_msgq_new_fhidriver_build_fix](#)
- The current driver version of the E810 NIC card is ice-1.12.7. This is used in C1 configuration
- To download the ice-1.12.7.tar.gz driver using below link:
<https://www.intel.com/content/www/us/en/download/19630/intel-network-adapter-driver-for-e810-series-devices-under-linux.html>
- For Firmware Upgrade details will be available in the below link:
<https://www.intel.com/content/www/us/en/download/15084/intel-ethernet-adapter-complete-driver-pack.html>

The below table shows the software details of the OAI server used.

Component	Version
Ubuntu for 5 G NR gNB DU	Ubuntu version 22.04 LTS with GCC version 11.3.0 on OAI setup
Kernel for 5G NR gNB DU	5.15.0-1045-realtime on OAI Setup
RT Linux Patch for 5G NR gNB DU	5.15.0-1045-realtime #9-Ubuntu SMP PREEMPT_RT on OAI Setup
OAI GNB Tested Branch	use_msgq_new_fhidriver_build_fix
E810 NIC card current driver version	ice-1.12.7

Table 12: Software Details

More server details along with number of cores and the NUMA nodes are shown below in images

```

root@vvdn-AS-1014S-WTRT:/home/vvdn# lscpu
Architecture:          x86_64
CPU op-mode(s):        32-bit, 64-bit
Address sizes:          48 bits physical, 48 bits virtual
Byte Order:             Little Endian
CPU(s):                 64
On-line CPU(s) list:    0-63
Vendor ID:              AuthenticAMD
Model name:             AMD EPYC 7713 64-Core Processor
CPU family:             25
Model:                  1
Thread(s) per core:     1
Core(s) per socket:     64
Socket(s):              1
Stepping:               1
Frequency boost:        enabled
CPU max MHz:            3720.7029
CPU min MHz:            1500.0000
BogoMIPS:               4000.14
  
```

Fig 26 OAI Server Details

```

NUMA:
NUMA node(s):          1
NUMA node0 CPU(s):     0-63
  
```

Fig 27 NUMA nodes in server

7.3 OAI DU Configurations

- There are 2 configuration files for OAI DU branch `use_msgq_new_fhdriver_build_fix` namely
 - `1x1.config_oai_static_vvdn.dat`
 - `1x1.config_band78.fr1.273PRB.conf`
- These two files are for single layer only. Same configuration can be edited for 2 layers.
- Currently 16-bit No compression is used in OAI
- Ad MAC address of RU in the .dat file in OAI DU as shown below. DU MAC address configured in RU should be same as that configured in OAI DU.

```

# Eth 0
duMac0=00:11:22:33:44:66 # assigned MAC of O-DU VF
ruMac0=78:7d:f3:01:12:d1 # O-RU VF for O-RU app
duMac1=00:11:22:33:44:66 # assigned MAC of O-DU VF
ruMac1=78:7d:f3:01:12:d1 # O-RU VF for O-RU app
  
```

Fig 28 MAC address in OAI configuration file

- Configure frequency range according to the RU center frequency in the .conf file of OAI DU
- In the below case the RU centre frequency must be given as 3.691380 GHz

```
# this is 3300.24 + 134*12*30e3 = 3348.48 MHz (5G NR GSCN: 7741)
absoluteFrequencySSB = 643392
dl_frequencyBand = 78;
# this is 3300.24 MHz
dl_absoluteFrequencyPointA = 642816
```

Fig 29 Frequency Configuration in OAI config file

- Prach configuration index used is 159 and Prach format used is B4 Format
- Slot format used is DDDSU as shown in below image

```
sSlotConfig0=0,0,0,0,0,0,0,0,0,0,0,0,0,0 # (0) - DL (1) - UL (2) - GUARD
sSlotConfig1=0,0,0,0,0,0,0,0,0,0,0,0,0,0 # (0) - DL (1) - UL (2) - GUARD
sSlotConfig2=0,0,0,0,0,0,0,0,0,0,0,0,0,0 # (0) - DL (1) - UL (2) - GUARD
sSlotConfig3=0,0,0,0,0,0,2,2,2,2,1,1,1,1 # (0) - DL (1) - UL (2) - GUARD
sSlotConfig4=1,1,1,1,1,1,1,1,1,1,1,1,1,1 # (0) - DL (1) - UL (2) - GUARD
```

Fig 30 Slot Format

- Below are the timing parameters used for VVDN_LPRU with OAI

Delay Parameter	
<!-- RU Settings -->	<!-- O-DU Settings -->
<Tadv_cp_dl>125</Tadv_cp_dl>	<!-- Transmission Window Fast C-plane DL -->
<!-- Reception Window C-plane DL-->	<T1a_min_cp_dl>285</T1a_min_cp_dl>
<T2a_min_cp_dl>285</T2a_min_cp_dl>	<T1a_max_cp_dl>470</T1a_max_cp_dl>
<T2a_max_cp_dl>429</T2a_max_cp_dl>	<!-- Transmission Window Fast C-plane UL -->
<!-- Reception Window C-plane UL-->	<T1a_min_cp_ul>285</T1a_min_cp_ul>
<T2a_min_cp_ul>285</T2a_min_cp_ul>	<T1a_max_cp_ul>429</T1a_max_cp_ul>
<T2a_max_cp_ul>429</T2a_max_cp_ul>	<!-- Transmission Window U-plane -->
<!-- Reception Window U-plane -->	<T1a_min_up>125</T1a_min_up>
<T2a_min_up>125</T2a_min_up>	<T1a_max_up>350</T1a_max_up>
<T2a_max_up>375</T2a_max_up>	<!-- Reception Window U-plane-->
<!-- Transmission Window U-plane -->	<Ta4_min>110</Ta4_min>
<Ta3_min>130</Ta3_min>	<Ta4_max>180</Ta4_max>
<Ta3_max>170</Ta3_max>	

Fig 31 Timing Parameters

7.4 Steps to Run OAI Setup

- OAI 5G Core has to be started after the server is booted up.

```
root@vvdn-AS-1014S-WTRT:/home/vvdn# ./core_run.sh
[+] Running 11/11
✓ Network demo-oai-public-net Created
✓ Container oai-nrf Started
✓ Container asterisk-ims Started
✓ Container mysql Started
✓ Container oai-udr Started
✓ Container oai-udm Started
✓ Container oai-ausf Started
✓ Container oai-amf Started
✓ Container oai-smf Started
✓ Container oai-spgwu-tiny Started
✓ Container oai-ext-dn Started
```

Fig 32 Docker run output

- User must ensure all docker containers are running using command
 - `docker ps -a`
- No containers should be in 'Exited' status in above command
- User has to set profile to 'realtime' for high performance
 - `tuned-adm profile realtime`
- Run PTP and PHC2SYS in C1 or C3 mode as per setup used
- For C1 Mode:**

```
taskset -c 22 ptp4l -i enp65s0f0 -m -2 -f /home/vvdn/PTP4l/linuxptp/configs/default.cfg
taskset -c 22 phc2sys -s enp65s0f0 -m -c CLOCK_REALTIME -O 0
```
- For C3 Mode:**

```
taskset -c 22 ptp4l -i enp65s0f0 -m -2 -f /home/vvdn/PTP4l/linuxptp/configs/default_c3.cfg
taskset -c 22 phc2sys -s enp65s0f0 -w -m -R 8 -f /home/vvdn/PTP4l/linuxptp/configs/default_c3.cfg
```
- Note:** For C3 configuration user must change PTP configuration in default.cfg to clientOnly=1 and serverOnly=0
- After ensuring proper PTP synchronization(PHC offset should be between -100 and +100) of DU and RU, the user must first make the carriers active in the RU via M-Plane. Execute following command in RU first.


```
sysrepocfg -X -d running
```
- If <active>INACTIVE</active> is present then the carrier is inactive and it has to be activated using the below commands.

```
<tx-array-carriers>
  <name>txarraycarrier0</name>
  <absolute-frequency-center>643452</absolute-frequency-center>
  <center-of-channel-bandwidth>3651780000</center-of-channel-bandwidth>
  <channel-bandwidth>100000000</channel-bandwidth>
  <active>INACTIVE</active>
  <gain>0.0</gain>
  <downlink-radio-frame-offset>0</downlink-radio-frame-offset>
  <downlink-sfn-offset>0</downlink-sfn-offset>
</tx-array-carriers>
<rx-array-carriers>
  <name>rxarraycarrier0</name>
  <absolute-frequency-center>643452</absolute-frequency-center>
  <center-of-channel-bandwidth>3651780000</center-of-channel-bandwidth>
  <channel-bandwidth>100000000</channel-bandwidth>
  <active>INACTIVE</active>
  <downlink-radio-frame-offset>0</downlink-radio-frame-offset>
  <downlink-sfn-offset>0</downlink-sfn-offset>
  <gain-correction>0.0</gain-correction>
  <n-ta-offset>25600</n-ta-offset>
</rx-array-carriers>
```

netopeer-cli (netopeer command prompt will open-up)

connect

<enter password>

edit-config --target running --defop replace --config= /etc/configs/uplane.xml

- After carrier has been made active user can use the following commands to start the gNB
- `export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:/home/vvvn/OAI/phy/fhi_lib/lib/build`
- `/home/vvvn/OAI/openairinterface5g/cmake_targets/ran_build/build/nr-softmodem --sa -O /home/vvvn/OAI/configs/1x1.oran.fh.band78.fr1.273PRB.conf --reorder-thread-disable --thread-pool 9,10,11,12,13,18,19,20`
- These 2 commands can be placed in a script. (run_gNb.sh)
- Packets should be received on DU as shown in below image

```
[0m[PHY] [o-du 0][rx] 0 pps 0 kbps 1524624][tx 52380 pps 39189 kbps 2022230] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Invalid_Ext1_packets 0 Total 0]
[0m[PHY] [o-du 0][pusch0 36880 prach0 3072]
[0m[NR_MAC] Frame.Slot 256.0

[0m[PHY] [o-du 0][rx] 0 pps 0 kbps 1524633][tx 104732 pps 52352 kbps 2022756] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Invalid_Ext1_packets 0 Total 0]
[0m[PHY] [o-du 0][pusch0 73744 prach0 6144]
[0m[NR_MAC] Frame.Slot 384.0

[0m[PHY] [o-du 0][rx] 0 pps 0 kbps 1524633][tx 157085 pps 52353 kbps 2022756] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Invalid_Ext1_packets 0 Total 0]
[0m[PHY] [o-du 0][pusch0 110608 prach0 9216]
[0m[NR_MAC] Frame.Slot 512.0

[0m[PHY] [o-du 0][rx] 0 pps 0 kbps 1524633][tx 209436 pps 52351 kbps 2022756] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Invalid_Ext1_packets 0 Total 0]
[0m[PHY] [o-du 0][pusch0 147472 prach0 12288]
[0m[NR_MAC] Frame.Slot 640.0

[0m[PHY] [o-du 0][rx] 0 pps 0 kbps 1524633][tx 261788 pps 52352 kbps 2022756] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Invalid_Ext1_packets 0 Total 0]
[0m[PHY] [o-du 0][pusch0 184336 prach0 15360]
[0m[NR_MAC] Frame.Slot 768.0

[0m[PHY] [o-du 0][rx] 0 pps 0 kbps 1524633][tx 314140 pps 52352 kbps 2022756] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Invalid_Ext1_packets 0 Total 0]
[0m[PHY] [o-du 0][pusch0 221200 prach0 18432]
[0m[NR_MAC] Frame.Slot 896.0

[0m[PHY] [o-du 0][rx] 0 pps 0 kbps 1524633][tx 366494 pps 52354 kbps 2022756] [on_time 0 early 0 late 0 corrupt 0 pkt_dupl 0 Invalid_Ext1_packets 0 Total 0]
[0m[PHY] [o-du 0][pusch0 258064 prach0 21504]
```

Fig 33 GNodeB Output

- After ensuring packets are received in DU and RU properly user can connect the UE.
- For Throughput testing following command is to be used:

```
docker exec -it oai-ext-dn iperf -u -t 86400 -i 1 -fk -B 192.168.70.135 -b 100M -c 12.1.1.2
```

Here 12.1.1.2 is the IP of the UE (which has to be verified before throughput testing) and -b 100M is the bandwidth pumped.

8. CLI MANAGER

```
root@vvdn_lpru:~$ telnet localhost 8888
Connected to localhost
Enter Login Credentials
Username : oranuser
Password : oranuser
CLI Manager Client Connected Successfully
```

Fig 34 cli manager log in

CLI Manager Client Connected Successfully	
Command	Description
set-Ipv4Static	- Set ipv4 interface as static
set-Ipv6Static	- Set ipv6 interface as static
set-IfaceDhcp	- Set interface as dynamic
get-IfaceStatus	- Get Management Interface is static/Dynamic
get-IfaceIpType	- Get Management Interface IP type
set-IfaceIpType	- Set IP type of Management Interface
get-SwInv	- Get Software inventory details
get-HwInv	- Get Hardware inventory details
get-SysMac	- MAC address of the box
get-SysUptime	- System Uptime Information
get-1GStatus	- Get status of 1G Mac interface
get_fh_status	- Get status of 10G Mac interface
get_counter_stats	- Gets the updated rx layer stats
get-Bandwidth	- Get Bandwidth details
set-Bandwidth	- Set Bandwidth for the RU in MHZ
set_dl_compression	- Set Downlink Compression(9/12/14/16 bit)
get_dl_compression	- Get Downlink Compression
set_du_mac_address	- Set the DU MAC Address
get_du_mac_address	- Get the DU MAC Address

Fig 35.a cli manager Functions

get-FpgaRegisterVersion	- Read Fpga Register details
set_pxsch_pcid	- Set PxSCH PCID L0 L1 L2 L3 (range 0 - 15)
get_pxsch_pcid	- Get PxSCH PCID
get_ru_ecpri_mac_address	- Get the RU ECPRI MAC Address
get_ru_xBAR_mac_address	- Get the RU xBAR MAC Address
get-PrachFormat	- Get PrachFormat Detail
get_DL_FPGA_DBFS_Power	- Get Downlink FPGA DBFS Power
get_UL_FPGA_DBFS_Power	- Get Uplink FPGA DBFS Power
set-CUPlaneVlan	- Set Vlan for the CU Plane in RU
get-CUPlaneVlan	- Get Vlan for the CU Plane in RU
get-dl_power_scaling	- Get dl_power scaling
set-dl_power_scaling	- Set dl_power scaling
get-ul_power_scaling	- Get ul_power scaling
set-ul_power_scaling	- Set ul_power scaling
set_ul_compression	- Set Uplink Compression(9/12/14/16 bit)
get_ul_compression	- Get Uplink Compression
get_prach_pcid	- Get the PRACH PCID
set_prach_pcid	- Set the PRACH PCID (2 2 2 2)
set-Templevels	- Set the Ambient and Fault Temperature levels
ruReset	- RU Diagnostic Triggered Restart
changePasswd	- Password change for logged in user
clear	- Clear the screen
help	- Get detailed help
exit	- Quit/Disconnect with the client

Fig 35.b cli manager Functions

CLI:/> set-Ipv4Static	
Usage: -	
Arg's: ? : show command usage	
-h : same as '?' (Applicable for all commands)	
IP : IPv4 IP Address	
MASK : Subnet mask	
BCST : Broadcast Ip Address	
<eg : set-Ipv4Static 192.168.4.10 255.255.255.0 192.168.4.1>	
CLI:/> set-Ipv4Static 192.168.4.50 255.255.255.0 192.168.4.1	

Paramaters	- Response

Status	- Configured Successfully

Fig 36 To set RU IP static

Eg:

1. set-Ipv4Static 192.168.4.20 255.255.255.0 192.168.4.1
2. set-Ipv4Static 192.168.2.20 255.255.255.0 192.168.2.1

```
CLI:/> get-IfaceStatus
```

Parameters	Response
management_interface	static

Fig 37 To get RU interface status

```
CLI:/> get-SwInv
```

Parameters	Response
slot_name	swRecoverySlot
slot_status	VALID
slot_activation	false
slot_running	false
product_code	VVDN=0-RU
vendor_code	VN
build_id	factory_img
build_name	Beta Release
build_version	3.0.6
boot_name	BOOT0003.BIN
boot_version	1.0.0
boot_integrity	OK
kernel_name	golden.ub
kernel_version	1.0.0
kernel_integrity	OK
rootFs_name	golden.ub
rootFs_version	1.0.0
rootFs_integrity	OK
md5sum	XXXX

Parameters	Response
slot_name	swSlot1
slot_status	VALID
slot_activation	false
slot_running	false
product_code	VVDN=0-RU
vendor_code	VN
build_id	factory_img
build_name	Beta Release
build_version	3.0.5
boot_name	BOOT0001.BIN
boot_version	1.0.0
boot_integrity	OK

kernel_name	- image0001.ub
kernel_version	- 1.0.0
kernel_integrity	- OK
rootFs_name	- rootfs.tar.gz
rootFs_version	- 1.0.0
rootFs_integrity	- OK
md5sum	- xxxx

Paramaters	- Response

slot_name	- swSlot2
slot_status	- VALID
slot_activation	- true
slot_running	- true
product_code	- VVDN 0-RU
vendor_code	- VN
build_id	- 90f0b6c
build_name	- Beta Release
build_version	- 3.1.6
boot_name	- BOOT0002.BIN
boot_version	- 1.0.0
boot_integrity	- OK
kernel_name	- image0002.ub
kernel_version	- 1.0.0
kernel_integrity	- OK
rootFs_name	- rootfs.tar.gz
rootFs_version	- 1.0.0
rootFs_integrity	- OK
md5sum	-

Fig 38 To get RU sw version

CLI: /> get-HwInv	8.1 How to check if RU is properly booted or not?
	For power LED should be glowed with a stable Cyan.

Paramaters	- Response

mfg-name	- VVDN-LPRU
description	- VVDN-RU
model-name	- RU_INDOOR_LPRU
serial-num	- 2404348600014
hardware-rev	- A1-20240401
software-rev	- 03-v3.1.6
uuid	- f81d4fae-7dec-11d0-a765-00a0c91e6bf6
oper-state	- enabled
usage-state	- busy
availability-state	- DEGRADED

Fig 39 To get HW info

```

CLI:/> get-SysMac

-----
Parameters                                     - Response
-----
eth0 mac_address                             - 98:ae:71:04:8c:3e
eth1 mac_address                             - 98:ae:71:04:8c:3f
-----

```

Fig 40 FH MAC address

```

CLI:/> get-SysUptime

-----
Parameters                                     - Response
-----
Days                                           - 2
Hours                                          - 19
Minutes                                       - 47
Seconds                                       - 23
-----

```

Fig 41 RU up time

```

CLI:/> get_fh_status

-----
Parameters                                     - Response
-----
10G_status                                    - up
-----

```

Fig 42 10G Status

```

CLI:/> get_counter_stats
-----
Parameters                                     Response
-----
RX_COUNTER_LAYER0
total_rx_packets                             - 0
rx_duplicate                                 - 0
rx_corrupt                                   - 0
rx_late                                       - 0
rx_early                                     - 0
rx_on_time                                   - 0
RX_COUNTER_LAYER1
total_rx_packets                             - 0
rx_duplicate                                 - 0
rx_corrupt                                   - 0
rx_late                                       - 0
rx_early                                     - 0
rx_on_time                                   - 0
RX_COUNTER_LAYER2
total_rx_packets                             - 0
rx_duplicate                                 - 0
rx_corrupt                                   - 0
rx_late                                       - 0
rx_early                                     - 0
rx_on_time                                   - 0
RX_COUNTER_LAYER3
total_rx_packets                             - 0
rx_duplicate                                 - 0
rx_corrupt                                   - 0
rx_late                                       - 0
rx_early                                     - 0
rx_on_time                                   - 0

```

Fig 43 RU counters

```

CLI:/> get-BandWidth
-----
Parameters                                     Response
-----
Bandwidth                                     - 100MHZ

```

Fig 44 RU Bandwidth

```

8.5 Can I add Switch between
CLI:/> set_dl_compression 9
DONE
8.6 Can I add a Switch to conn...
8.7 How to check if RU is RTP s...
CLI:/> get_dl_compression
8.8 Which packet format does R...
-----
9 FAQ
-----
9.1 How can we configure the...
Parameters
-----
DL Compression
-----
- Response
- 9 bit
8.2 How to check if RU is getting M & S plane packets properly or not?

```

Fig 45 Set and Get dl Compression

```

4 Steps to start VVDN setup
CLI:/> get_du_mac_address
-----
Fig 40 FH MAC address
-----
Parameters
-----
- Response
DU MAC Address
-----
- 00:11:22:33:44:66
9 FAQ
CLI:/> set_du_mac_address
Invalid Argument: set_du_mac_address <MAC>
8.2 How to check if RU is gettin...
CLI:/> set_du_mac_address 11:22:44:77:99:87
DONE
8.3 How to check if RU is gettin...
8.4 How to check if the SFP po...
CLI:/> get_du_mac_address
8.5 Can I add Switch between...
-----
Parameters
-----
- Response
DU MAC Address
-----
- 11:22:44:77:99:87
Fig 40 FH MAC address
CLI:/>

```

Fig 46 Set and Get DU MAC address

```

CLI:/> get_pxsch_pcid
-----
Parameters                                - Response
-----
Layer 0                                  - 0
Layer 1                                  - 2
Layer 2                                  - 3
Layer 3                                  - 4
-----

CLI:/> set_pxsch_pcid
Correct usage is: set_pxsch_pcid L0 L1 L2 L3 (range 0 - 15)

CLI:/> set_pxsch_pcid 0 1 2 3
DONE

CLI:/> get_pxsch_pcid
-----
Parameters                                - Response
-----
Layer 0                                  - 0
Layer 1                                  - 1
Layer 2                                  - 2
Layer 3                                  - 3
-----

```

Fig 47 Get and Set PXSCH PCID

```

CLI:/> get-CUPlaneVlan
-----
Parameters                                - Response
-----
CU_Plane-Vlan                            - 100
-----

CLI:/> set-CUPlaneVlan
Invalid Arguments: Correct usage is set-CUPlaneVlan vlanid[Range:1-4094]

CLI:/> set-CUPlaneVlan 89
DONE

CLI:/> get-CUPlaneVlan
-----
Parameters                                - Response
-----
CU_Plane-Vlan                            - 89
-----

```

Fig 48 Get and Set CU plane VLAN

```

CLI:/> get_ul_compression
-----
Parameters                                     - Response
-----
UL Compression                               - 16

CLI:/> set_ul_compression
Correct usage is: set_ul_compression <9/12/14/16>

CLI:/> set_ul_compression 9
DONE

CLI:/> get_ul_compression
-----
Parameters                                     - Response
-----
UL Compression                               - 9
  
```

Fig 49 Get and Set UL compression

```

CLI:/> get_prach_pcid
-----
Parameters                                     - Response
-----
LAYER 0                                     - 5
LAYER 1                                     - 6
LAYER 2                                     - 7
LAYER 3                                     - 8

CLI:/> set_prach_pcid
Argument is invalid correct usage is between 0 - 15 and enter 4 value

CLI:/> set_prach_pcid 1 5 6 7
DONE

CLI:/> get_prach_pcid
-----
Parameters                                     - Response
-----
LAYER 0                                     - 1
LAYER 1                                     - 5
LAYER 2                                     - 6
LAYER 3                                     - 7
  
```

Fig 50 Get and Set PRACH PCID

```

CLI:/> help
Usage: help { ? | -h | -d | -a }
Arg's:  ? : show command usage
        -h : same as '?' (Applicable for all commands)
        -d : list debug commands only
        -a : list all commands

CLI:/>

```

Fig 51 Help cmd

9. FAQ

9.1 How to check if RU is properly booted or not?

For power LED should be glowed with a stable Cyan.

9.2 How to check if RU is getting M & S plane packets properly or not?

By hitting the below-mentioned command in the RU console & check for the highlighted message

root@vvdn_lpru: bash /etc/scripts/stat_ru.sh

```

root@vvdn_lpru: /etc/scripts/
root@vvdn_lpru:/etc/scripts$ ./stat_ru.sh
*****DOWNLINK PATH*****
----- MAC COUNTERS DL -----
TOTAL_RX Packets (LSB) : 71374
TOTAL_RX Packets (MSB) : 0
-----
DL SMART INTERCONNECT COUNTERS -----
DL-PATH
Total DL Count : 0
Total Count for Same RU : 71868
Total Count for Next RU : 0
Total Drop Count : 0
C/U Packets Count : 71710
S/M/OAM DL Count : 158
C/U Good DL Count : 71710
C/U Bad/Drop DL Count : 0
S/M Good DL Count : 158
S/M Bad/Drop DL Count : 0
LBM counter : 0
LBR counter : 0
-----
eCPRI DeFramer i/p COUNTERS DL -----
Total No. of DL Pkts i/p are : 73471
-----eCPRI De-FRAMER O/P COUNTER-----
U-PLANE
AT LAYER 0 : 53624
AT LAYER 1 : 0
AT LAYER 2 : 0
AT LAYER 3 : 0
C-PLANE
AT LAYER 0 : 20342
AT LAYER 1 : 0
AT LAYER 2 : 0
AT LAYER 3 : 0

```

Fig 52 RU Counters

9.3 How to check if RU is getting CU Plane packets from DU?

By hitting the below mentioned command in the RU console & check for the highlighted messages

root@vvdn_lpru: bash /etc/scripts/stat_ru.sh

```

root@vvdn_lpru:~$ cd /etc/scripts/
root@vvdn_lpru:/etc/scripts$ ./stat_ru.sh
*****DOWNLINK PATH*****
-----
----- MAC COUNTERS DL -----
----- TOTAL_RX Packets (LSB) : 71374
----- TOTAL_RX Packets (MSB) : 0
=====
----- DL SMART INTERCONNECT COUNTERS -----
----- DL-PATH
----- Total DL Count : 0
----- Total Count for Same RU : 71868
----- Total Count for Next RU : 0
----- Total Drop Count : 0
----- C/U Packets Count : 71710
----- S/M/OAM DL Count : 158
----- C/U Good DL Count : 71710
----- C/U Bad/Drop DL Count : 0
----- S/M Good DL Count : 158
----- S/M Bad/Drop DL Count : 0
----- LBM counter : 0
----- LBR counter : 0
=====
----- eCPRI DeFramer i/p COUNTERS DL -----
----- Total No. of DL Pkts i/p are : 73471
----- eCPRI De-FRAME O/P COUNTER-----
----- U-PLANE
----- AT LAYER 0 : 53624
----- AT LAYER 1 : 0
----- AT LAYER 2 : 0
----- AT LAYER 3 : 0
----- C-PLANE
----- AT LAYER 0 : 20342
----- AT LAYER 1 : 0
----- AT LAYER 2 : 0
----- AT LAYER 3 : 0

```

Fig 53 RU CU Plane Counters

9.4 How to check if the SFP port is Link Up or not?

Hit the below mentioned command in the RU's console & check whether Link is detected or not.

root@vvdn_lpru: ethtool eth0

```

root@vvdn_lpru:~$
root@vvdn_lpru:~$ ethtool eth0
Settings for eth0:
Cannot get device settings: No such device
Link detected: yes
root@vvdn_lpru:~$
root@vvdn_lpru:~$

```

Fig 54 Link Detection

9.5 Can I add Switch between O-RU and GM?

Yes. But, please make sure Switch supports IEEE 1588 PTP.

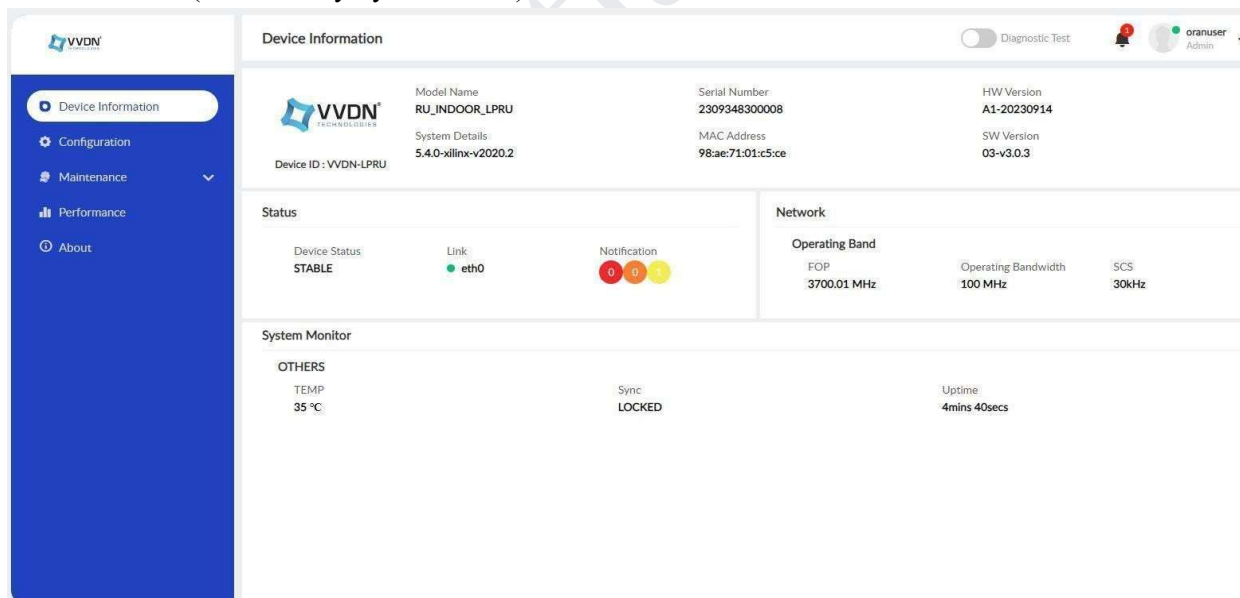
9.6 Can I add a Switch to connect O-RU and O-DU?

Yes. Please make sure following items:

- The L2 switch should support VLAN with tag.
- Those ports (connected to RU & DU) should be in trunk mode and make sure both are connected to the same VLAN tag.
- Should keep VLAN tag in those ports (DO NOT set untag)
- Enable jumbo frames. Set frame size more than 9600 Bytes.

9.7 How to check if RU is PTP sync or not?

- The SYNC status can be verified from WEB GUI Dashboard System Monitor Section /CLI SYNC - Locked (Successfully Synchronised)



The screenshot displays the VVDN WEB GUI Dashboard. The left sidebar contains navigation links: Device Information, Configuration, Maintenance, Performance, and About. The main content area is divided into two primary sections: Device Information and System Monitor.

Device Information Section:

- Model Name:** RU_INDOOR_LPRU
- Serial Number:** 2309348300008
- HW Version:** A1-20230914
- System Details:** 5.4.0-xilinx-v2020.2
- MAC Address:** 98:ae:71:01:c5:ce
- SW Version:** 03-v3.0.3
- Device ID:** VVDN-LPRU

Status Section:

- Device Status:** STABLE
- Link:** eth0
- Notification:** Three colored circles (red, yellow, green) indicating status levels.

Network Section:

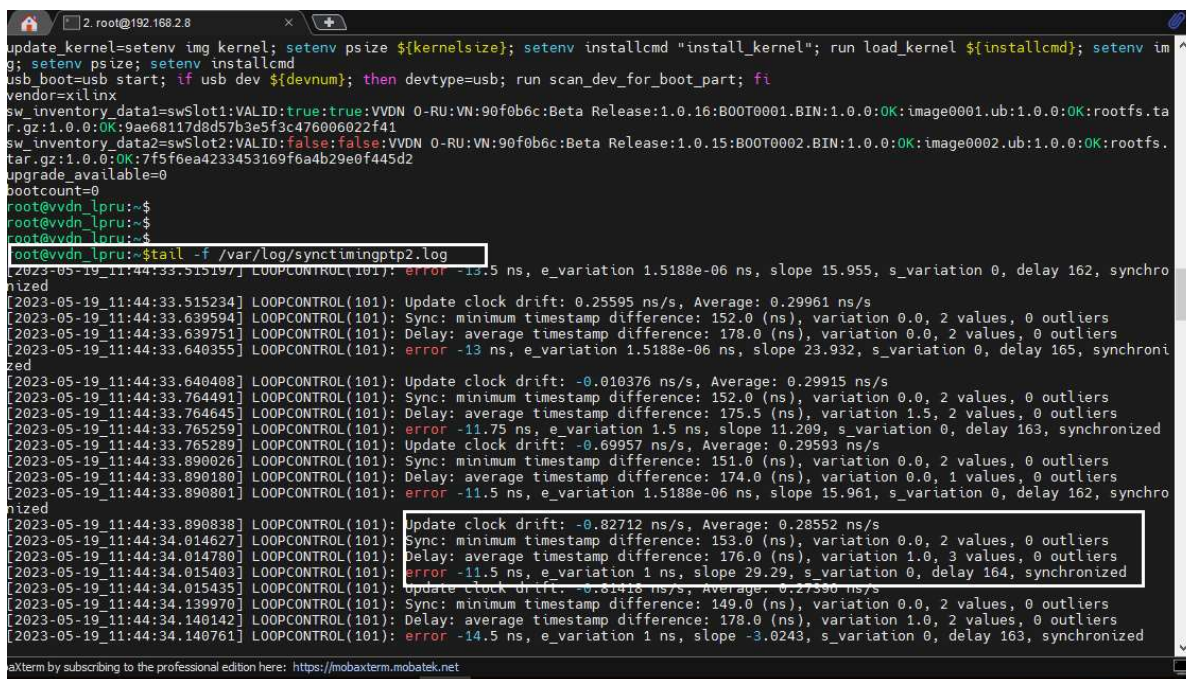
- Operating Band:** FDD 3700.01 MHz
- Operating Bandwidth:** 100 MHz
- SCS:** 30kHz

System Monitor Section:

- OTHERS:** TEMP 35 °C
- Sync:** LOCKED
- Uptime:** 4mins 40secs

Fig 55 PTP status

- By hitting the below highlighted mentioned command in the RU console.
Synchronized message denotes RU is synchronized.



```

update_kernel=setenv img kernel; setenv psize ${kernelsize}; setenv installcmd "install_kernel"; run load_kernel ${installcmd}; setenv im
g; setenv psize; setenv installcmd
usb_boot=usb start; if usb dev ${devnum}; then devtype=usb; run scan_dev_for_boot_part; fi
vendor=xilinx
sw_inventory_data1=swSlot1:VALID:true:true;VVDN 0-RU:VN:90f0b6c:Beta Release:1.0.16:BOOT0001.BIN:1.0.0:OK:image0001.ub:1.0.0:OK:rootfs.ta
r.gz:1.0.0:OK:9ae68117d8d57b3e5f3c476006022f41
sw_inventory_data2=swSlot2:VALID:false:false;VVDN 0-RU:VN:90f0b6c:Beta Release:1.0.15:BOOT0002.BIN:1.0.0:OK:image0002.ub:1.0.0:OK:rootfs.
tar.gz:1.0.0:OK:7f5f6ea4233453169f6a4b29e0f445d2
upgrade_available=0
bootcount=0
root@vvdn_lpru:~$
root@vvdn_lpru:~$
root@vvdn_lpru:~$ tail -f /var/log/syncntimngptp2.log
[2023-05-19 11:44:33.515197] LOOPCONTROL(101): error -13.5 ns, e_variation 1.5188e-06 ns, slope 15.955, s_variation 0, delay 162, synchro
nized
[2023-05-19 11:44:33.515234] LOOPCONTROL(101): Update clock drift: 0.25595 ns/s, Average: 0.29961 ns/s
[2023-05-19 11:44:33.639594] LOOPCONTROL(101): Sync: minimum timestamp difference: 152.0 (ns), variation 0.0, 2 values, 0 outliers
[2023-05-19 11:44:33.639751] LOOPCONTROL(101): Delay: average timestamp difference: 178.0 (ns), variation 0.0, 2 values, 0 outliers
[2023-05-19 11:44:33.640355] LOOPCONTROL(101): error -13 ns, e_variation 1.5188e-06 ns, slope 23.932, s_variation 0, delay 165, synchroni
zed
[2023-05-19 11:44:33.640408] LOOPCONTROL(101): Update clock drift: -0.010376 ns/s, Average: 0.29915 ns/s
[2023-05-19 11:44:33.764491] LOOPCONTROL(101): Sync: minimum timestamp difference: 152.0 (ns), variation 0.0, 2 values, 0 outliers
[2023-05-19 11:44:33.764645] LOOPCONTROL(101): Delay: average timestamp difference: 175.5 (ns), variation 1.5, 2 values, 0 outliers
[2023-05-19 11:44:33.765250] LOOPCONTROL(101): error -11.75 ns, e_variation 1.5 ns, slope 11.209, s_variation 0, delay 163, synchronized
[2023-05-19 11:44:33.765280] LOOPCONTROL(101): Update clock drift: -0.69957 ns/s, Average: 0.29593 ns/s
[2023-05-19 11:44:33.890026] LOOPCONTROL(101): Sync: minimum timestamp difference: 151.0 (ns), variation 0.0, 2 values, 0 outliers
[2023-05-19 11:44:33.890180] LOOPCONTROL(101): Delay: average timestamp difference: 174.0 (ns), variation 0.0, 1 values, 0 outliers
[2023-05-19 11:44:33.890801] LOOPCONTROL(101): error -11.5 ns, e_variation 1.5188e-06 ns, slope 15.961, s_variation 0, delay 162, synchro
nized
[2023-05-19 11:44:33.890838] LOOPCONTROL(101): Update clock drift: -0.82712 ns/s, Average: 0.28552 ns/s
[2023-05-19 11:44:34.014627] LOOPCONTROL(101): Sync: minimum timestamp difference: 153.0 (ns), variation 0.0, 2 values, 0 outliers
[2023-05-19 11:44:34.014780] LOOPCONTROL(101): Delay: average timestamp difference: 176.0 (ns), variation 1.0, 3 values, 0 outliers
[2023-05-19 11:44:34.015403] LOOPCONTROL(101): error -11.5 ns, e_variation 1 ns, slope 29.29, s_variation 0, delay 164, synchronized
[2023-05-19 11:44:34.015435] LOOPCONTROL(101): Update clock drift: -0.8448 ns/s, Average: 0.27530 ns/s
[2023-05-19 11:44:34.139070] LOOPCONTROL(101): Sync: minimum timestamp difference: 149.0 (ns), variation 0.0, 2 values, 0 outliers
[2023-05-19 11:44:34.140142] LOOPCONTROL(101): Delay: average timestamp difference: 178.0 (ns), variation 1.0, 2 values, 0 outliers
[2023-05-19 11:44:34.140761] LOOPCONTROL(101): error -14.5 ns, e_variation 1 ns, slope -3.0243, s_variation 0, delay 163, synchronized
  
```

Fig 56 RU synchronization status

- By checking the status LED of the RU.

9.8 Which prach format does RU support?

RU only supports short prach format A3,B4,C2.

9.9 How can we configure the DU MAC address ?

[Refer section:6.11](#)

```
<processing-elements xmlns="urn:o-ran:processing-element:1.0">
  <transport-session-type>ETH-INTERFACE</transport-session-type>
  <ru-elements>
    <name>element0</name>
    <transport-flow>
      <interface-name>eth0.100</interface-name>
      <eth-flow>
        <ru-mac-address>98:ae:71:00:8a:55</ru-mac-address>
        <vlan-id>100</vlan-id>
        <o-du-mac-address>[DU_MAC_ADD]</o-du-mac-address>
      </eth-flow>
    </transport-flow>
  </ru-elements>
</processing-elements>
```

Fig 57 DU MAC address

9.10 How to add vlan ID ?

Change vlan id

```
<processing-elements xmlns="urn:o-ran:processing-element:1.0">
  <transport-session-type>ETH-INTERFACE</transport-session-type>
  <ru-elements>
    <name>element0</name>
    <transport-flow>
      <interface-name>eth0.100</interface-name>
      <eth-flow>
        <ru-mac-address>98:ae:71:00:8a:55</ru-mac-address>
        <vlan-id>100</vlan-id>
        <o-du-mac-address>[DU_MAC_ADD]</o-du-mac-address>
      </eth-flow>
    </transport-flow>
  </ru-elements>
</processing-elements>
```

Fig 58 Vlan ID

9.11 How to change PC ID ?

In U Plane jing module

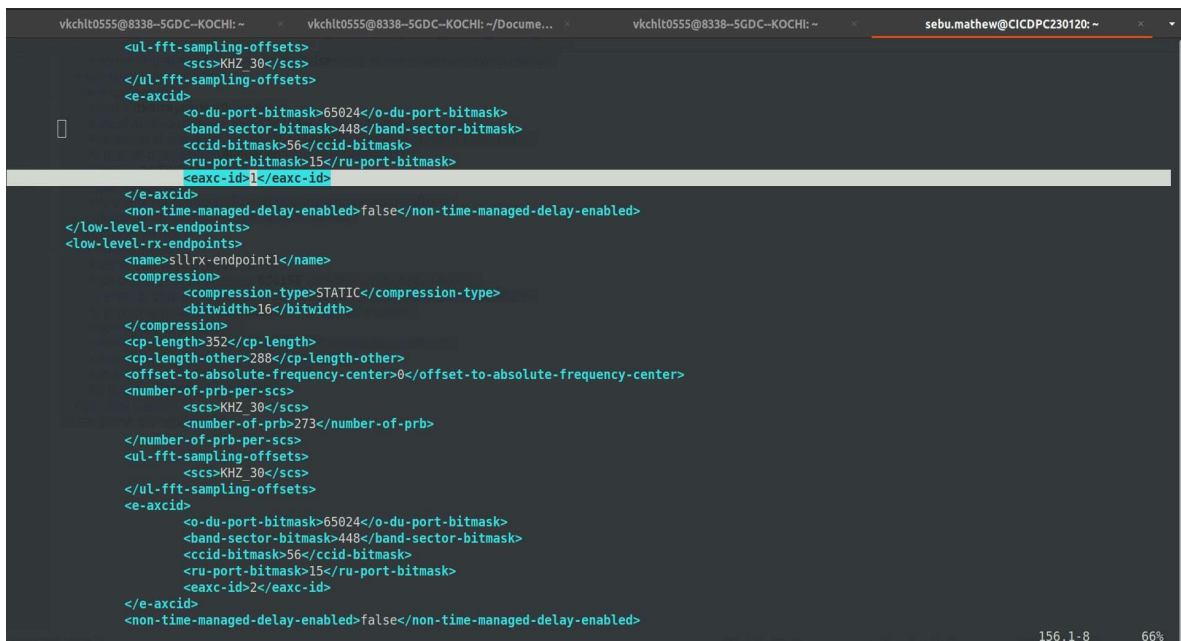


Fig 59 eAxCID or PC ID

9.12 How to Check & Select the MAC Address for fronthaul Interface ?

Chose the eth1 MAC address for fronthaul communication, go to the board console do the ifconfig to check the eth1 MAC address

9.13 If you are using INTEL E810 card, below configuration need to be installed.

The E810 NIC driver should be updated to 1.12.7 in order to create 2 VF's with same MAC address.

Link: <https://www.intel.com/content/www/us/en/download/19630/789309/intel-network-adapter-driver-for-e810-series-devices-under-linux.html>

10. Troubleshooting

Why DU can not receive any data from RU?

Please check following items:

- Check PTP is synced and GM's quality. You may need to check GM's status with satellites, O-RU's log and O-DU's log.
- Check the 10GbE interface in the DU server is linked up. Also check if DU MAC address is configured correctly in RU
- Check the 10GbE interface in the DU server is running at 10Gb speed
- Check connectivity, make sure SFP+ module is actually inserted into the cage of the connector in the DU server.

- e. Check O-RU's log for CU Plane packet
 - e.1. Please ensure there should be not any C/U drop DL counts

```

root@vvdn_lpru:~$cd /etc/scripts/
root@vvdn_lpru:/etc/scripts$./stat_ru.sh
*****DOWNLINK PATH*****
-----
----- MAC COUNTERS DL -----
----- TOTAL_RX Packets (LSB) : 71374
----- TOTAL_RX Packets (MSB) : 0
=====
----- DL SMART INTERCONNECT COUNTERS -----
----- DL-PATH
----- Total DL Count : 0
----- Total Count for Same RU : 71868
----- Total Count for Next RU : 0
----- Total Drop Count : 0
----- C/U Packets Count : 71710
----- S/M/OAM DL Count : 158
----- C/U Good DL Count : 71710
----- C/U Bad/Drop DL Count : 0
----- S/M Good DL Count : 158
----- S/M Bad/Drop DL Count : 0
----- LBM counter : 0
----- LBR counter : 0
=====
----- eCPRI DeFramer i/p COUNTERS DL -----
----- Total No. of DL Pkts i/p are : 73471
-----eCPRI De-FRAMER O/P COUNTER-----
----- U-PLANE
----- AT LAYER 0 : 53624
----- AT LAYER 1 : 0
----- AT LAYER 2 : 0
----- AT LAYER 3 : 0
----- C-PLANE
----- AT LAYER 0 : 20342
----- AT LAYER 1 : 0
----- AT LAYER 2 : 0
----- AT LAYER 3 : 0

```

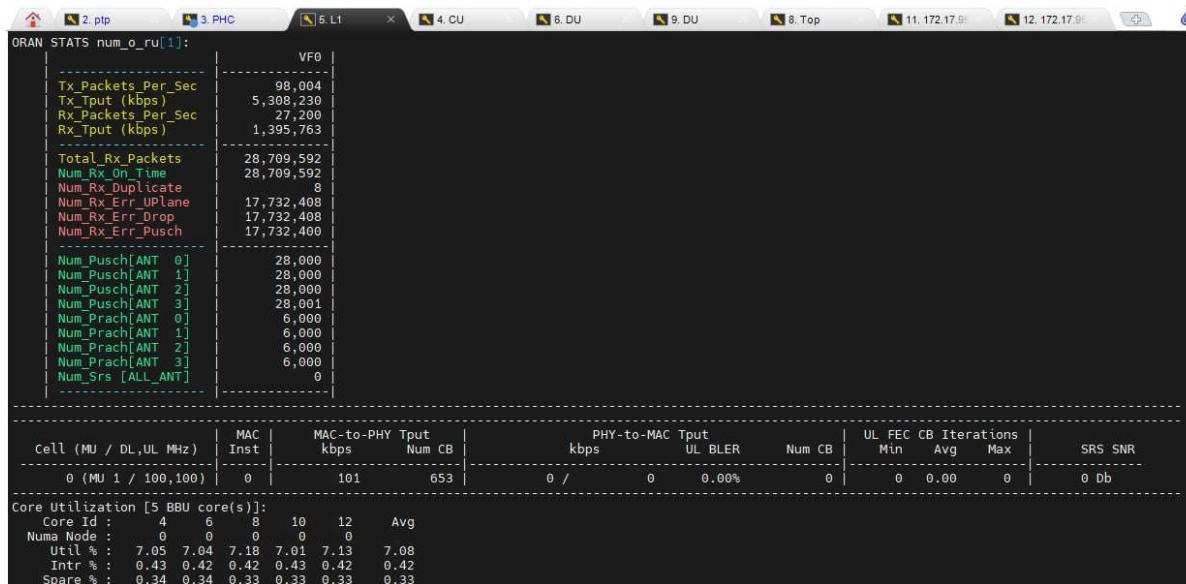
Fig 60 SMIC counters

- e.2. Make sure that there should be count for both PUSCH & PRACH on L1 side.
- f. Check if there are any late or early packets in the RU counters.

All U plane packets should be on time for the UE to connect.

If there is any late packets, check the PTP status of RU,DU and the timing and delay parameters

Count should be as shown in below image.



```

ORAN STATS num_o_ru[1]:
-----
Tx_Packets_Per_Sec      90,004
Tx_Tput (kBps)         5,309,230
Rx_Packets_Per_Sec      27,200
Rx_Tput (kBps)         1,395,763
-----
Total_Rx_Packets       28,709,592
Num_Rx_On_Time         28,709,592
Num_Rx_Duplicate         8
Num_Rx_Err_UPlane     17,732,408
Num_Rx_Err_Drop       17,732,408
Num_Rx_Err_Pusch      17,732,400
-----
Num_Pusch[ANT 0]       28,000
Num_Pusch[ANT 1]       28,000
Num_Pusch[ANT 2]       28,000
Num_Pusch[ANT 3]       28,001
Num_Prach[ANT 0]        6,000
Num_Prach[ANT 1]        6,000
Num_Prach[ANT 2]        6,000
Num_Prach[ANT 3]        6,000
Num_Srs [ALL_ANT]       0
-----

Cell (MU / DL,UL MHz)  MAC  MAC-to-PHY Tput  PHY-to-MAC Tput  UL BLER  Num CB  UL FEC CB Iterations  SRS SNR
-----
0 (MU 1 / 100,100)    0    101    653    0 / 0    0.00%    0    0 0.00 0    0 Db

Core Utilization [5 BBU core(s)]:
Core Id : 4 6 8 10 12 Avg
Numa Node : 0 0 0 0 0
Util % : 7.05 7.04 7.18 7.01 7.13 7.08
Intr % : 0.43 0.42 0.42 0.43 0.42 0.42
Spare % : 0.34 0.34 0.33 0.33 0.33 0.33

```

Fig 61 L1 counter