

Foxconn RPQN O-RU Installation and Operating Guide

≡ Property

Project name	Local 5G NR System
Version	v2.8
Date	2022/1/28

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Version History

Version	Date	Description of revision
v0.1	2020/8/19	Initial version of RPQN O-RU Installation and Operating Guide
v0.2	2020/8/20	Typo correct and append more info
v0.3	2020/8/20	Unified style and correct typos
v0.4	2020/8/21	Refine the chapter 2
v0.5	2020/8/21	Add reboot/shutdown procedure
v0.6	2020/8/26	Add reset button and LED info
v0.7	2020/11/18	Refine the information. Auto boot up. Add FAQ & Troubleshooting
v0.8	2020/11/24	Add sample app tutorial

v0.9	2020/12/03	Modify sample app tutorial about VLAN tag, VSA configuration to decode SSB, some term's definition in RU log
V1.0	2020/12/24	Power on sequence/Add normal operation and firmware image upgrade with M-plane/ V1.1.5q.432 support Multicast
V1.1	2021/01/13	Add antenna port number, correct 7901 LO, internal/external antenna
v1.3		M-plane new feature list, ptp lock example, ptp profile configuration, power cycle to recover
v1.4	2021/03/10	Modify firmware image upgrade flow
v1.5	2021/06/28	Add firmware and FlexRAN version match table
v1.6	2021/07/28	Add support bands. Add supported prach format B4. How to calculate Tx power? How to disable/enable DPD?
v.1.7	2021/10/08	Remove mounting kit section
v2.0	2021/10/20	Add C/U/S/M version
v2.1	2021/11/03	Refer to external firmware upgrade guide
v2.2	2021/11/04	Modify RU's MAC address Refer to external mounting bracket, wall-mount and ceil-mount installation guide
v2.3	2021/11/19	Add model-name Add FCC statement Add limited power source statement
v2.4	2021/11/29	Add SFP+ statement Add Class I adaptor statement
v2.5	2021/12/20	Change power supply statement
v2.6	2021/12/28	Change Figure1 of O-RU Specification
v2.7	2022/01/18	Change power supply statement
v2.8	2022/01/28	Add CE statement

Relevant documents

DOC-ID	Brief
[RP0-415]	[RP0-415] Foxconn RPQN O-RU Firmware Upgrade Guide_v1.1 Foxconn RPQN O-RU Firmware Upgrade Guide
[RP0-407]	[RP0-407] Foxconn Sample App Operation Guide_v1.2 Foxconn Sample App Operation Guide
[R00-406]	[R00-406] How to check PTP log in RPQN_v1.1 How to check PTP log in RPQN

[RP0-406]	[RP0-406] Foxconn O-RU-RPQN Mounting Bracket Installation Guide_v1.1 Foxconn O-RU-RPQN Mounting Bracket Installation Guide
[RP0-416]	Foxconn RPQN O-RU Operating instruction for V1 firmware_v1.0
[RP0-417]	[RP0-417] Foxconn RPQN O-RU Operating instruction for V2 firmware_v1.0 Foxconn RPQN O-RU Operating instruction for V2 firmware_v1.0

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1. List of Packages

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

1.1 Overview of RPQN O-RU

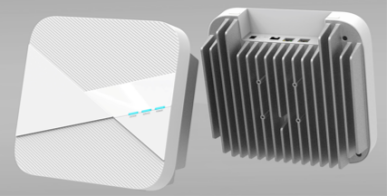
<p>ID Outlook</p>  <p>Highlight</p> <table border="1"> <tr><td>Radio</td><td>5G NR TDD</td></tr> <tr><td>MSR</td><td>Band n78/n79</td></tr> <tr><td>FPGA</td><td>Intel Arria10</td></tr> <tr><td>Throughput</td><td>up to 1.6Gbps</td></tr> <tr><td>Dimension</td><td>260mm×242mm×76.5mm (L×W×H)</td></tr> <tr><td>Weight</td><td>< 4.5Kg</td></tr> <tr><td>Power</td><td>< 60W</td></tr> </table>	Radio	5G NR TDD	MSR	Band n78/n79	FPGA	Intel Arria10	Throughput	up to 1.6Gbps	Dimension	260mm×242mm×76.5mm (L×W×H)	Weight	< 4.5Kg	Power	< 60W	<p>Technical Specification</p> <p>Hardware Configuration</p> <table border="1"> <tr><td>Fronthaul interface</td><td>O-RAN option 7.2 over 10Gbps RJ45/SFP+</td></tr> <tr><td>Internal Antenna</td><td>5G NR*4</td></tr> <tr><td>Power Supplier</td><td>12V DC/5A input and PoE++</td></tr> <tr><td>Memory</td><td>DDR4 8Gb, microSD</td></tr> <tr><td>External interface</td><td>1Gbps RJ45, microUSB, Power Jack</td></tr> </table> <p>3GPP R15</p> <table border="1"> <tr><td>Frequency</td><td>7800I (3.3-3.6GHz) 7801I (3.7-3.8GHz) 7901I (4.8-4.9GHz)</td></tr> <tr><td>chBW</td><td>100 MHz</td></tr> <tr><td>Capacity</td><td>1.6 Gbps</td></tr> <tr><td>Tx/Rx Paths</td><td>4T4R; 4 data streams</td></tr> <tr><td>Max Output Power</td><td>24dBm (per RF connector)</td></tr> <tr><td>Antenna Gain</td><td>~ 5dBi</td></tr> </table> <p>Synchronization</p> <table border="1"> <tr><td>Frequency Stability</td><td>±0.1ppm</td></tr> <tr><td>Frequency Synchronization</td><td>PTP(IEEE1588v2)</td></tr> </table> <p>Network Features</p> <table border="1"> <tr><td></td><td>SSH, IPv4</td></tr> </table> <p>Environmental</p> <table border="1"> <tr><td>Ingress protection</td><td>Class IP30</td></tr> <tr><td>Working temperature</td><td>0°C~+40°C</td></tr> <tr><td>Mounting</td><td>Wall-mount, Ceiling-mount</td></tr> </table>	Fronthaul interface	O-RAN option 7.2 over 10Gbps RJ45/SFP+	Internal Antenna	5G NR*4	Power Supplier	12V DC/5A input and PoE++	Memory	DDR4 8Gb, microSD	External interface	1Gbps RJ45, microUSB, Power Jack	Frequency	7800I (3.3-3.6GHz) 7801I (3.7-3.8GHz) 7901I (4.8-4.9GHz)	chBW	100 MHz	Capacity	1.6 Gbps	Tx/Rx Paths	4T4R; 4 data streams	Max Output Power	24dBm (per RF connector)	Antenna Gain	~ 5dBi	Frequency Stability	±0.1ppm	Frequency Synchronization	PTP(IEEE1588v2)		SSH, IPv4	Ingress protection	Class IP30	Working temperature	0°C~+40°C	Mounting	Wall-mount, Ceiling-mount
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Figure 1 RPQN O-RU Specification

1.2 Outlook

1.2.1 Indoor RPQN O-RU

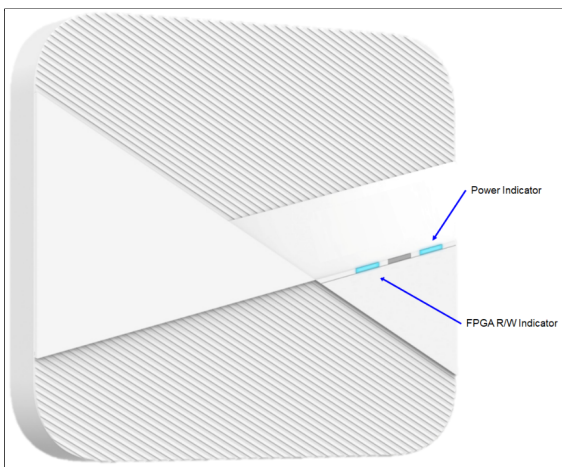


Figure 2 RPQN O-RU Interfaces

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

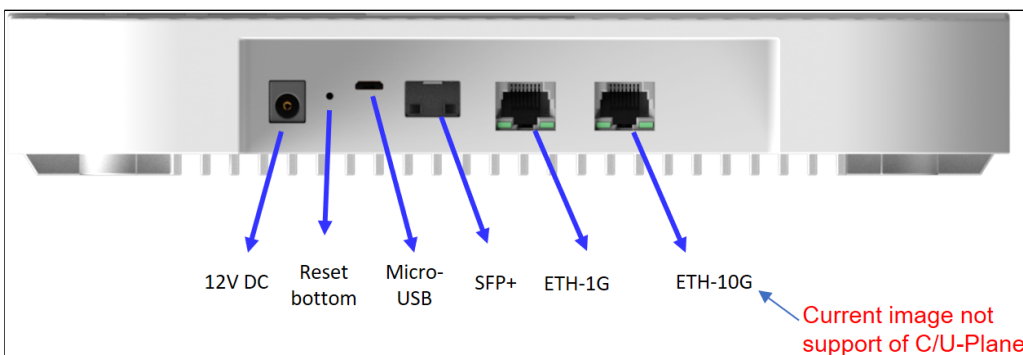


Figure 3 RPQN O-RU Interfaces

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

1.2.2 10Gb SFP+ optics (GBIC)



Figure 4 Accessories – 10Gb SFP+ optics

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

1.2.3 1Gb Active Copper SFP




Figure 5 Accessories – 1Gb Copper SFP

1.2.4 12VDC AC Adapter Power cord




Figure 6 Accessories – 12VDC AC Adapter Power cord


This product is intended to be supplied by a Listed Power Adapter or DC power source marked "L.P.S." (or "Limited Power Source"), rated 12 Vdc, 5 A minimum or 56 Vdc 1.2 A minimum (For PoE), Tma = 40 degree C minimum. If you need further assistance, please contact Foxconn for further information.

 **NOTE: If using Class I adaptor, power cord shall be connector to a socket-outlet with earthing connection**

1.2.5 Mounting Kit

Please refer to “  [\[RP0-406\] Foxconn O-RU-RPQN Mounting Bracket Installation Guide v1.0](#) ” for the mounting bracket, wall-mount and ceil-mount installation.

1.3 Software Version

To show the current software version of RPQN O-RU. Please refer to the “  [\[RP0-417\] Foxconn RPQN O-RU Operating instruction for V2 firmware v1.0](#) ” Execute command “`cat /home/root/test/version.txt`”, it may looks like below:

```
root@arria10:~/test# cat version.txt
branch: 320-modify_mechanism_of_xran_init
version: 9489b337149df1db4c52c143c1bc86546a82ebba
tag: v2.2.4q.524
```

In this example, the software version tag was **v2.2.4q.524**.

2. Regulation and Certification

2.1 Environmental and safety requirement

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

 **Warning: Electric Shock.**

Please notice that the RF ports should be connected to a 50 Ω load (for example, feeder with an antenna) before powering on the RPQN O-RU.

 **Warning: Hot parts.**

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

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

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

2.2 Federal Communication Commission Interference Statement

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

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

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

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

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



Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance 33cm between the radiator & your body.

2.3 Conformance European Interference Statement

This device complies with Directive 2014/53/EU and UK Radio Equipment Regulations 2017 SI 2017/1206. issued by the Commission of the European Community.

Declaration of Conformity

- Please add certification standards in your user manual which depended on the test standards your device performed.
 - If the DoC should be a simplified version, please take below as reference –
- Hereby, Foxconn declares that the radio equipment type 5G NR base station is in compliance with Directive 2014/53/EU and UK Radio Equipment Regulations 2017 SI 2017/1206.

The frequency and maximum transmitted power in EU are listed as follows,

- RPQN-7800E: 3450 - 3549.99MHz, 24 dBm
- RPQN-7800I: 3450 - 3549.99MHz, 24 dBm
- RPQN-7801E: 3750MHz, 24 dBm
- RPQN-7801I: 3750MHz, 24 dBm

3. Cabling and Assembly Instruction

Below the figure shows the SA L5G system.

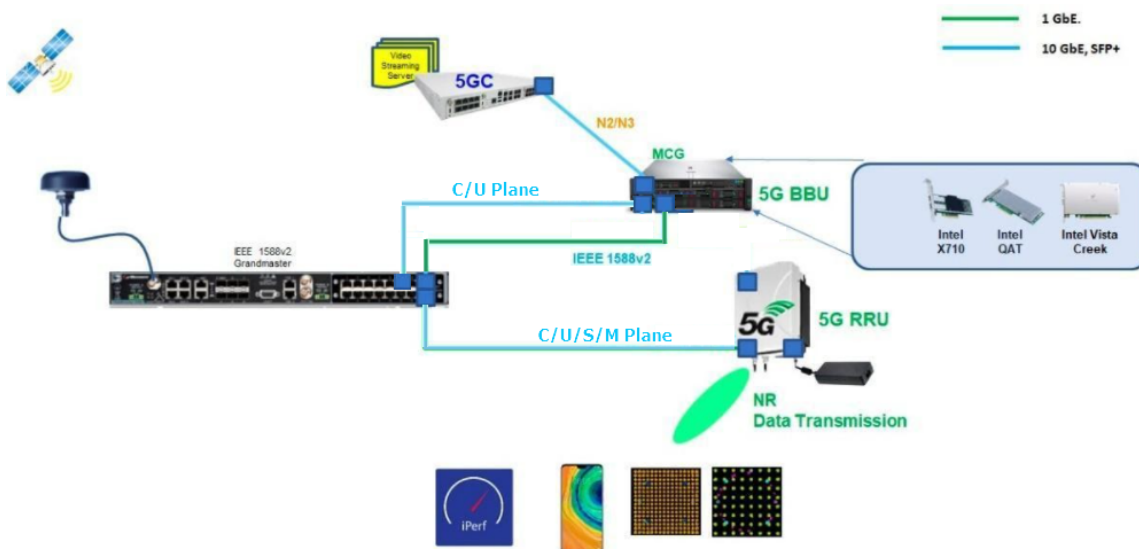


Figure 8 SA L5G System Architecture

3.1 RPQN O-RU cabling instruction

3.1.1 For O-RAN C/U/S/M-plane connection

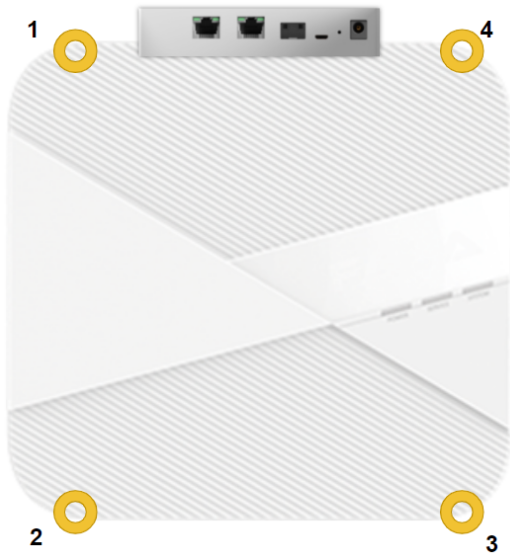
10Gb SFP+ fiber cabling

- Intel 10Gb Short Range Optics (model: E10GSFPSR, 850 nm wavelength) + multi-mode fiber

or

- Intel 10Gb Long Range Optics (model: E10GSFPLR, 1310 nm wavelength) + single-mode fiber.

3.1.2 Antenna port number



3.1.3 Power supply

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

3.1.4 Micro USB

Micro USB: for RPQN O-RU debug console.

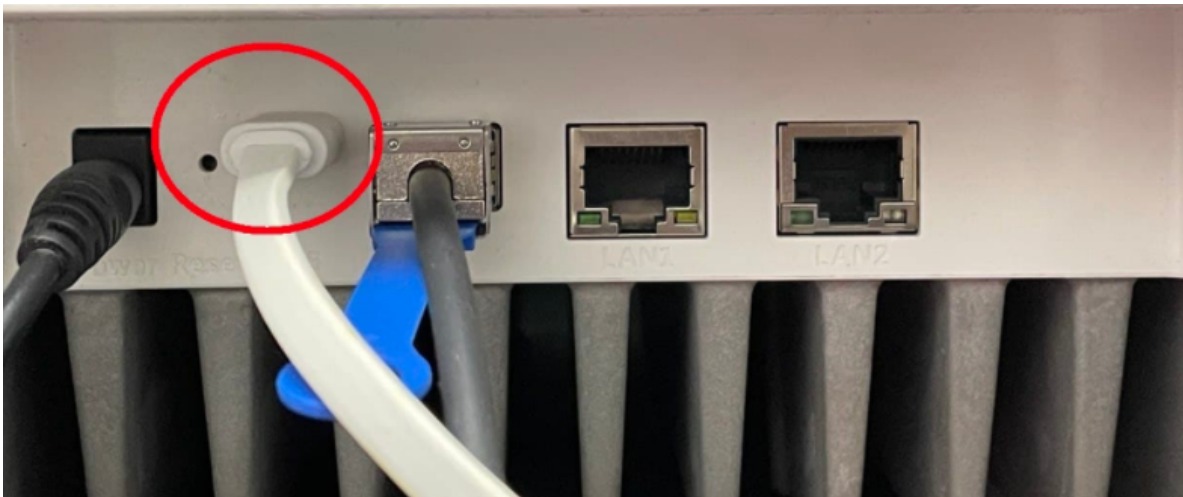




Figure 9 Example of cabling assemble

4. Operating Instruction


4.1 Operating instruction

Please refer to “  [\[RP0-417\] Foxconn RPQN O-RU Operating instruction for V2 firmware v1.0](#)” for the operating instruction.

4.2 Firmware upgrade

Please refer to “  [\[RP0-415\] Foxconn RPQN O-RU Firmware Upgrade Guide v1.3](#) ” for the firmware upgrade procedure.

4.3 How to use the sample app to verify O-RU working properly?

Please refer to “  [\[RP0-407\] Foxconn Sample App Operation Guide v1.1](#)” for using sample-app to verify the FH connection (C/U-plane), S-plane and RF TX power.

5. FAQ

5.1 How to check if the O-RU is booted up and running normally?

RU's console log shows the following.

```
Latch later 1pps time=1427f8f7 swi4010=1427f8f7 xran_sec=1427f8f4 acc_diff[1]=0
hps_sec=1602777637 cur_sec=0 PA_ON TDD
curr dBFS of ORx = 0 0 912 11910
mean dBFS of ORx = 0 0 65535 65535 count=1 1 0 0
10R: sec=1 hps=1602777638 64b=0 65to128=1 total=1 uni=0 uni>1158=0 multi=1 crc_err=0
10T: sec=1 hps=1602777638 64b=0 65to128=0 total=0 uni=0 uni>1158=0 multi=0 crc_err=0 state=1
start=0 adj=0 rstcnt=0
```

- When “Latch xxx 1pps” strings are shown, the O-RU has got synchronization with a GM/BC and finished the initialization.
- Value definition:
 - 10R...means number of packets received from BBU.
 - 10T...means number of packets transmitted to BBU.
 - 64b: number of packets with size 64 bytes.
 - 65to128: number of packets with size between 65 bytes to 128 bytes.
 - uni>1158: number of packets with size greater than 1158.
 - total: total number of packets.
 - uni: number of uni-casting packets.
 - multi: number of multi-casting packets.
 - crc_err: number of packets with CRC error.
 - state = 1 : RU is waiting for the 1st c-plane message.
 - state = 2 : RU had received the 1st c-plane and started working.

5.2 Log “xran 10GbE is not ready... d6fff000” is normal or abnormal?

No. Please check 10GbE connectivity and make sure 10GbE is linkup at DU server.

5.3 Why does RU's log seem not aligned?

Usually, it indicates PTP signal quality is not good. Please check the GM's quality with GPS satellites.

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

Yes. But, please make sure Switch supports IEEE 1588 PTPv2.

5.5 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 BBU and RU) should be in trunk mode
- Both VLAN 1 and VLAN 2 should be in those trunk ports
- Should keep VLAN tag in those ports (DO NOT set untag)
- Enable jumbo frames. Set frame size more than 9000 Bytes.

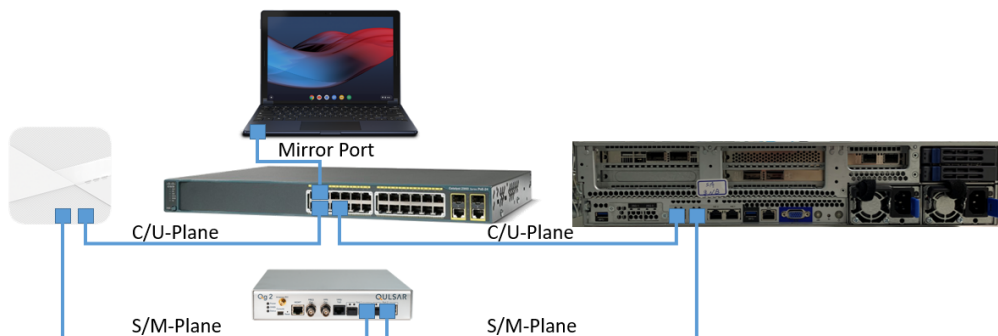


Figure 36 O-RU O-DU connectivity with Switch and GM

5.6 How to enable Auto boot up.?

If you want to make RU running when reboot without re-execute [\[RP0-417\] Foxconn RPQN O-RU Operating instruction for V2 firmware v1.0](#) setting Step.6 and Step.7, please add below lines into `/home/root/test/test.sh` to configure IP and launch CU plane:

```
if [ $(tty) = "/dev/ttyS0" ]; then
    ./set_qse.sh 100 # 100 depends on your subnet setting
    ./init_rrh_config_enable_cuplane
fi
```

- How to change configuration after enabling auto boot up?
 - If you **can** remote SSH to O-RU with account/passwd : root/root
 - i. Make changes in ***RRHconfig_xran.xml***.
 - ii. Running ***/home/root/test/reboot.sh***
 - If you **can not** remote SSH to RRH, you can
 - i. Connect to O-RU via the USB Serial Port.
 - ii. Unplug Power cord and plug again.
 - iii. Once the prompt is shown, press “**Ctrl+C**” to stop the running process.
 - iv. Make changes in ***RRHconfig_xran.xml***.
 - v. Running ***/home/root/test/reboot.sh***
- How to disable auto boot up?
 - Just remove or mark the above command in ***/home/root/test/test.sh***.

5.7 What is the power-on sequence to bring up the Radio?

- Bring up from power off
 - a. stop O-DU
 - b. power on O-RU
 - c. ./init_rrh_config_enable_cuplane
 - d. wait PTP lock at O-RU
 - e. start O-DU
- restart O-RU
 - a. stop O-DU
 - b. power down O-RU
 - c. power up O-RU
 - d. ./init_rrh_config_enable_cuplane
 - e. wait PTP lock at O-RU
 - f. start O-DU

5.8 How to separate PTP log from console log?

Please refer to “ [\[R00-406\] How to check PTP log in RPQN_v1.0](#)” for the procedure to get PTP log from SSH terminal

5.9 Which FlexRAN version complies?

FlexRAN version 20.11 (the timeOffset must be changed to 484 for PRACH) and 21.03.

5.10 Which prach format does RU support?

RU only supports short prach format B4.

5.11 How to calculate Tx power?

- RRH_TX_ATTENUATION = 30.0, 30.0, 30.0, 30.0 -> output power is 0dBm per port
- RRH_TX_ATTENUATION = 20.0, 20.0, 20.0, 20.0 -> output power is 10dBm per port
- Antenna gain is 5dBi

5.12 How to disable/enable DPD?

- Disable DPD: RRH_RF_GENERAL_CTRL = 0x0, 0x0, 0x0, 0x0
- Enable DPD: RRH_RF_GENERAL_CTRL = 0x3, 0x0, 0x0, 0x0
- Note: the setting is affected for all 4 ports.

6. Troubleshooting

6.1 Why DU can not receive any data from RU?

Please check following items:

1. 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.
2. Check the 10GbE interface in the DU server is linked up.
3. Check the 10GbE interface in the DU server is running at 10Gb speed
4. Check connectivity, make sure SFP+ module is actually inserted into the cage of the connector in the DU server.
5. Check O-RU's log for xRAN packet:
 - a. If log does not contain "xRan: log.....", it means O-RU does not receive any C-Plane packet from O-DU.
 - b. Sometimes, it was caused by a PTP sync issue.

```
xRAN: log=0 toD(1) sec=656 tick=4009 smp cnt=0f115740 pkt en=0f115740 c arr=00000000 lpps=cc6e5744 f2t_en=d3c134bc jesd_en=d3c156fc
diff: sec=656 tick=4009 c_arr_vs_lpps=1000000us f2t_vs_lpps=7040004us jesd_vs_lpps=7040004us
Cmspl_p0: 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
c_kpi: total=26 early=26 on=26 late=26 dropTci=26 dropPort=26 dropSect=26
40R: idx=0 tick=4009 total=26 uni=1 64b=0 65to128=26 uni>1158=0 multi=25 fcs_err=0 cplane=00000100
```

6. Please run an Intel sample app to make sure O-RU is working properly.

6.2 Recover O-RU

When O-RU is going to a weird state like the phenomenon below, please POWER CYCLE O-RU.

1. 10T state value is jumping 1&2

```
Align: 142027070 142576652 3378 17
10R: sec=2411 hps=1607671657 64b=7588 65to128=0 total=220037 uni=220038 uni>1158=212450 multi=0 crc_err=0
10T: sec=2411 hps=1607671657 64b=0 65to128=0 total=172 uni=0 uni>1158=172 multi=0 crc_err=172 state=2 start=2410 adj=0 rstcnt=0
midMax=47us @ 4010, allMax=58us @ 4010 0a7a8583 0a7a9c65 0a7a899d 0a7a8c36 0a7a9331 2
Latch later lpps time=0a7b28ec swi4010=0a7b28ec xran_sec=0a7b28e9 acc_diff[6]=-82 hps_sec=1607671657 cur_sec=2411 PA_ON TDD
Align: 142027070 142576652 3378 17
10R: sec=2412 hps=1607671658 64b=3382 65to128=0 total=98072 uni=98072 uni>1158=94690 multi=0 crc_err=0
10T: sec=2412 hps=1607671658 64b=0 65to128=0 total=0 uni=0 uni>1158=0 multi=0 crc_err=0 state=1 start=2412 adj=0 rstcnt=0
midMax=61us @ 4010, allMax=73us @ 4010 11cd855a 11cda316 11cd8977 11cd8be5 11cd9627 4
Latch later lpps time=11ce28ec swi4010=11ce28ec xran_sec=11ce28e9 acc_diff[7]=-82 hps_sec=1607671658 cur_sec=2412 PA_ON TDD
Align: 142027070 142576652 3378 17
10R: sec=2413 hps=1607671659 64b=1038 65to128=0 total=30106 uni=30108 uni>1158=29069 multi=0 crc_err=0
10T: sec=2413 hps=1607671659 64b=0 65to128=0 total=0 uni=0 uni>1158=0 multi=0 crc_err=0 state=1 start=2413 adj=0 rstcnt=0
midMax=61us @ 4010, allMax=72us @ 4010 19208556 1920a2eb 19208969 19208bdc 19209631 4
Latch later lpps time=192128ec swi4010=192128ec xran_sec=192128e9 acc_diff[8]=-82 hps_sec=1607671659 cur_sec=2413 PA_ON TDD
Temperature of RF board is 39 degree Celsius.
Align: 142027070 142576652 3378 17
10R: sec=2414 hps=1607671660 64b=5038 65to128=0 total=146087 uni=146088 uni>1158=141050 multi=0 crc_err=0
10T: sec=2414 hps=1607671660 64b=0 65to128=0 total=0 uni=0 uni>1158=0 multi=0 crc_err=0 state=2 start=2413 adj=0 rstcnt=0
midMax=47us @ 4010, allMax=59us @ 4010 20738541 20739c38 20738973 20738c0b 2073930b 2
Latch later lpps time=207428ec swi4010=207428ec xran_sec=207428e9 acc_diff[9]=-82 hps_sec=1607671660 cur_sec=2414 PA_ON TDD
Align: 142027070 142576652 3378 17
10R: sec=2415 hps=1607671661 64b=2048 65to128=0 total=59384 uni=59385 uni>1158=57337 multi=0 crc_err=0
10T: sec=2415 hps=1607671661 64b=0 65to128=0 total=0 uni=0 uni>1158=0 multi=0 crc_err=0 state=1 start=2415 adj=0 rstcnt=0
midMax=61us @ 4010, allMax=72us @ 4010 27c68558 27c6a2f0 27c68975 27c68bb9 27c69600 4
Latch later lpps time=27c728ec swi4010=27c728ec xran_sec=27c728e9 acc_diff[0]=-82 hps_sec=1607671661 cur_sec=2415 PA_ON TDD
Align: 142027070 142576652 3378 17
10R: sec=2416 hps=1607671662 64b=6048 65to128=0 total=175397 uni=175398 uni>1158=169350 multi=0 crc_err=0
10T: sec=2416 hps=1607671662 64b=0 65to128=0 total=129 uni=0 uni>1158=129 multi=0 crc_err=129 state=2 start=2415 adj=0 rstcnt=0
midMax=47us @ 4010, allMax=58us @ 4010 2f198544 2f199c12 2f198956 2f198c18 2f199315 2
Latch later lpps time=2f1a28ec swi4010=2f1a28ec xran_sec=2f1a28e9 acc_diff[1]=-82 hps_sec=1607671662 cur_sec=2416 PA_ON TDD
CTRL-A Z for help |115200 8N1 | NOR | M'nicom 2.6.2 | VT102 | OffLine
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