

Foxconn RPQN O-RU RPQN-4800 Installation and Operating Guide

≡ Property

Project name Local 5G NR System
Version v3.1.15q.551_rc10
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Version History

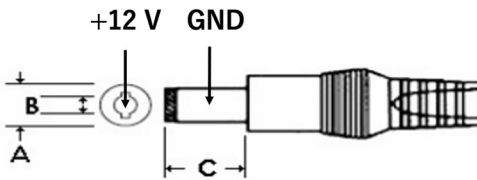
Version	Date	Description of revision
v1.0	2024/5/6	Initial version of O-RU RPQN-4800 Installation and Operating Guide

Relevant documents

DOC-ID	Brief
[RP0-415]	Foxconn RPQN O-RU Firmware Upgrade Guide
[RP0-407]	Foxconn Sample App Operation Guide
[RP0-406]	Foxconn O-RU-RPQN Mounting Bracket Installation Guide
[RP0-416]	Foxconn RPQN O-RU Operating instruction for V1 firmware
[RP0-417]	Foxconn RPQN O-RU Operating instruction for V2 firmware

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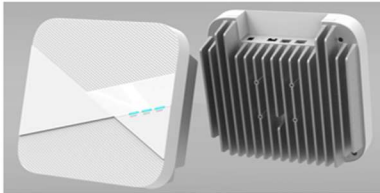
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1. List of Packages

- Indoor RPQN O-RU
- Model name:
 - RPQN-4800E, RPQN-4800I: 3550 ~ 3700 MHz
- Antenna x 4 (For external antenna type O-RU)
- Accessories: Following items are not included in the default package. Order separately.
 - 10Gb SFP+ GBIC
 - 1Gb Copper SFP
 - 12VDC power adapter and AC power cord
 - Mounting kit

1.1 Overview of RPQN O-RU

Pico Remote Radio Unit



Highlight

Radio	5G NR TDD
MSR	Band n48
FPGA	Intel Arria10
Throughput	up to 1.6Gbps
Dimension	260mm×242mm×76.5mm (L×W×H)
Weight	< 4.5Kg
Power	< 60W
Certification	FCC, CE, TELEC and NCC

Technical Specification

Hardware Configuration

Fronthaul interface	O-RAN option 7.2 over 10Gbps SFP+
Power Supplier	12V DC/5A input and PoE++
Memory	DDR4 8Gb, microSD/emmc
External interface	Power Jack, Reset Button

3GPP R15

Frequency	3.55—3.7Ghz
chBW	10, 20, 40, 100 MHz
Tx/Rx Paths	4T4R; 4 data streams
Max Output Power	24dBm (per RF connector)
Antenna Gain	~ 5dBi
Noise Figure	<5dB
RX Sensitivity	comply to 3GPP TS 138.141 spec.

Synchronization

Frequency Stability	±0.1ppm
Frequency Synchronization	PTP(IEEE1588v2)

Network Features

	SSH, IPv4
--	-----------

Environmental

Ingress protection	Class IP30
Working temperature	0°C~+40°C
Mounting	Wall-mount, Ceiling-mount

Figure 1 RPQN O-RU Specifications

1.2 Overview

1.2.1 Indoor RPQN O-RU

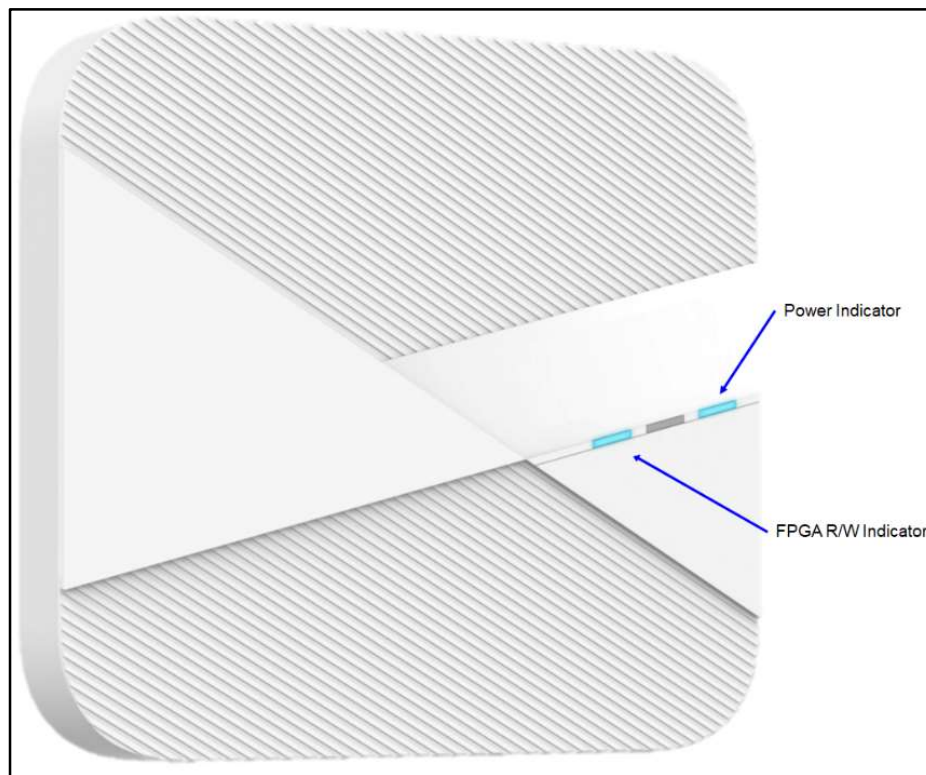
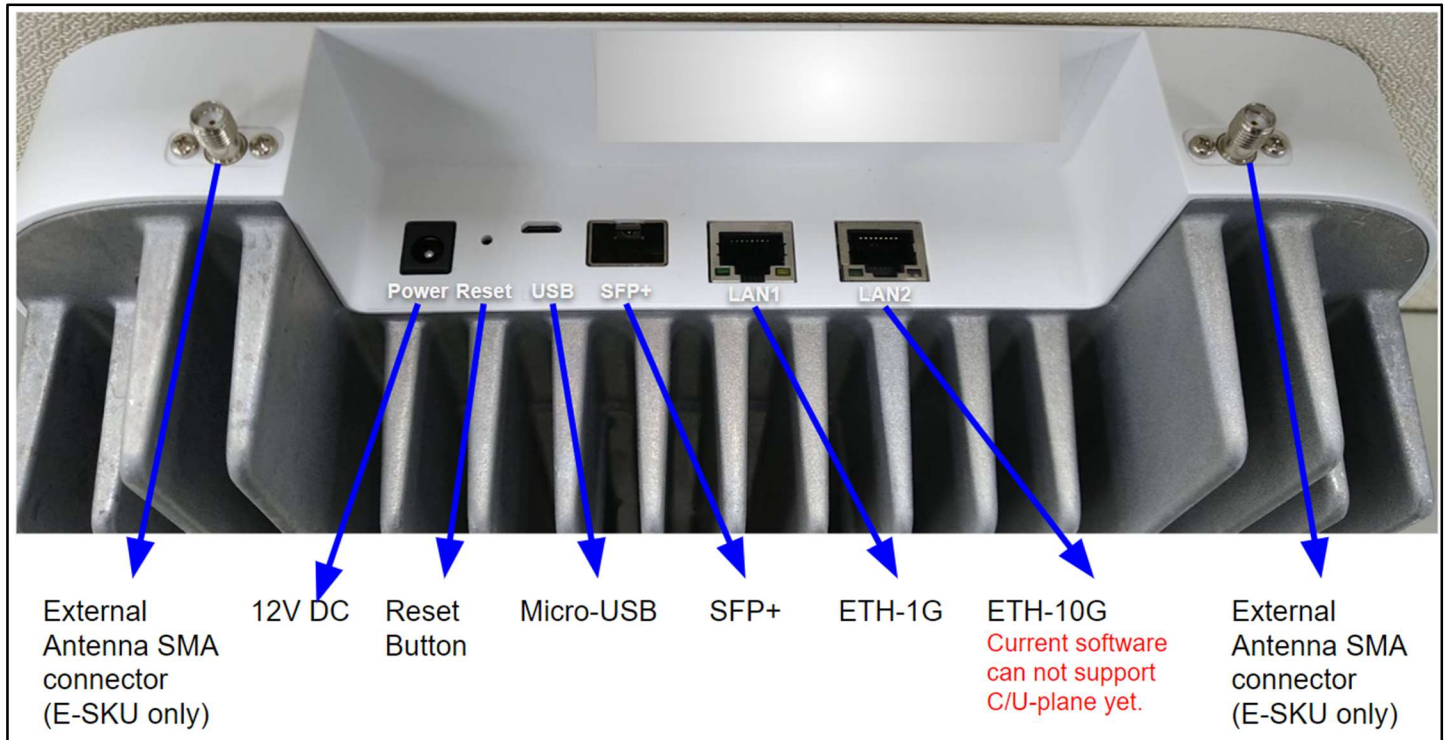


Figure 2 RPQN O-RU Interfaces

- Right (Power): Power status
 - Solid **Blue** light: normal.
 - Red light: abnormal, currently known: maybe related power adapter.
- Middle (Service): Service status
 - Solid **Green** light:
 - Operational
 - Solid **Red** light:
 - Call Home connecting
 - Fault alarms
- Left (System): System status
 - Solid **Blue** light: normal
 - Solid **Red** color: abnormal, currently known: maybe load FPGA fail、file system crash or SD card abnormal.
 - Blinking **Red** color: abnormal, currently known: maybe power on sequence is not complet

- e、power IC broken.
- Blinking Red color: normal, load FPGA during boot.



- Power jack of 12VDC power adapter
- Reset button
- Micro USB
- 10Gbps SFP+ (support C/U/S/M-Plane)
- LAN1: 1 Gbps Ethernet RJ-45 connector (support S/M-Plane)
- LAN2: 10 Gbps Ethernet RJ-45 connector (PoE++ power supply purpose only)

1.2.2 10Gb SFP+ optics (GBIC)



Figure 4 Accessories - 10Gb SFP+ optics, multi-mode



Figure 5 Accessories - 10Gb SFP+ optics, single-mode

☐ **NOTE: Only use Laser Class 1 optical transceiver**

1.2.3 1Gb Active Copper SFP

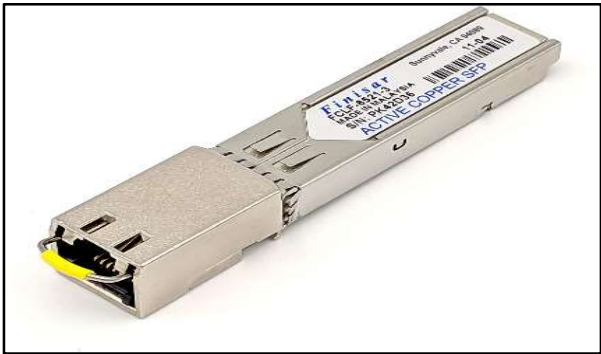


Figure 6 Accessories – 1Gb Copper SFP

1.2.4 12VDC AC Power Adapter



Figure 7 Accessories – 12VDC AC Power Adapter

This product is supplied with 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 degrees C minimum. If you need further assistance, please contact Foxconn for further information.

☐ **NOTE: If using a Class I adaptor, you must connect the power cord to a grounded-outlet.**

DC output power characteristics (CC MODE)	
1. OUTPUT VOLTAGE	+12 V
2. MAXIMUM OUTPUT CURRENT	5.5 A (full load)
3. LINE REGULATION	+/-2 %
4. LOAD REGULATION	+/-5 %

1.2.5 Mounting Kit

Please refer to:

- [\[RP0-406\] Foxconn O-RU-RPQN Mounting Bracket Installation Guide](#)

1.3 Software Version

Please refer to:

- [\[RP0-417\] Foxconn RPQN O-RU Operating instruction for V2 firmware](#)

To show the current software version of RPQN O-RU:

- Execute command “`cat /home/root/test/version.txt`” .
- The response may looks like below:

```
root@arria10:~/test# cat version.txt ↵
b_branch: (no branch)↵
b_commit: 2239975f0470be2778ce95f1e32e9df56d70c212↵
s_commit: 5adf7c5091d7b94f85cafc78da5772d7d7ef4ae3↵
tag: v3.1.10q.524↵
build_time: 202301161136↵
```

In this example, the software version tag was v3.1.10q.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-RU, 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 when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

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 35 cm between the radiator & your body.

2.3 Conformité Européenne (CE) 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

- 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 below:

- RPQN-4800E: 3550 ~ 3700 MHz, 24 dBm
- RPQN-4800I: 3550 ~ 3700 MHz, 24 dBm

3. Cabling and Assembly Instruction

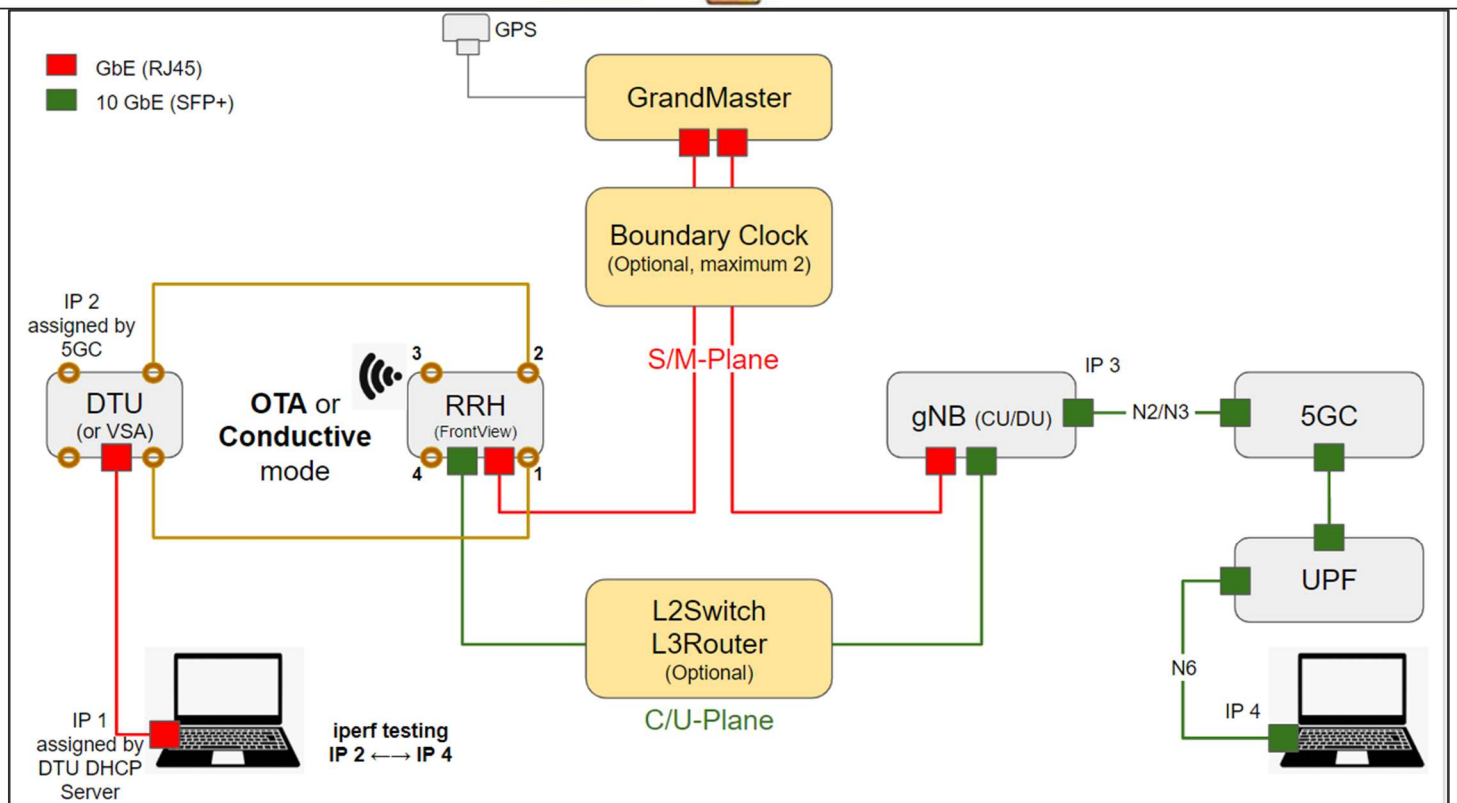
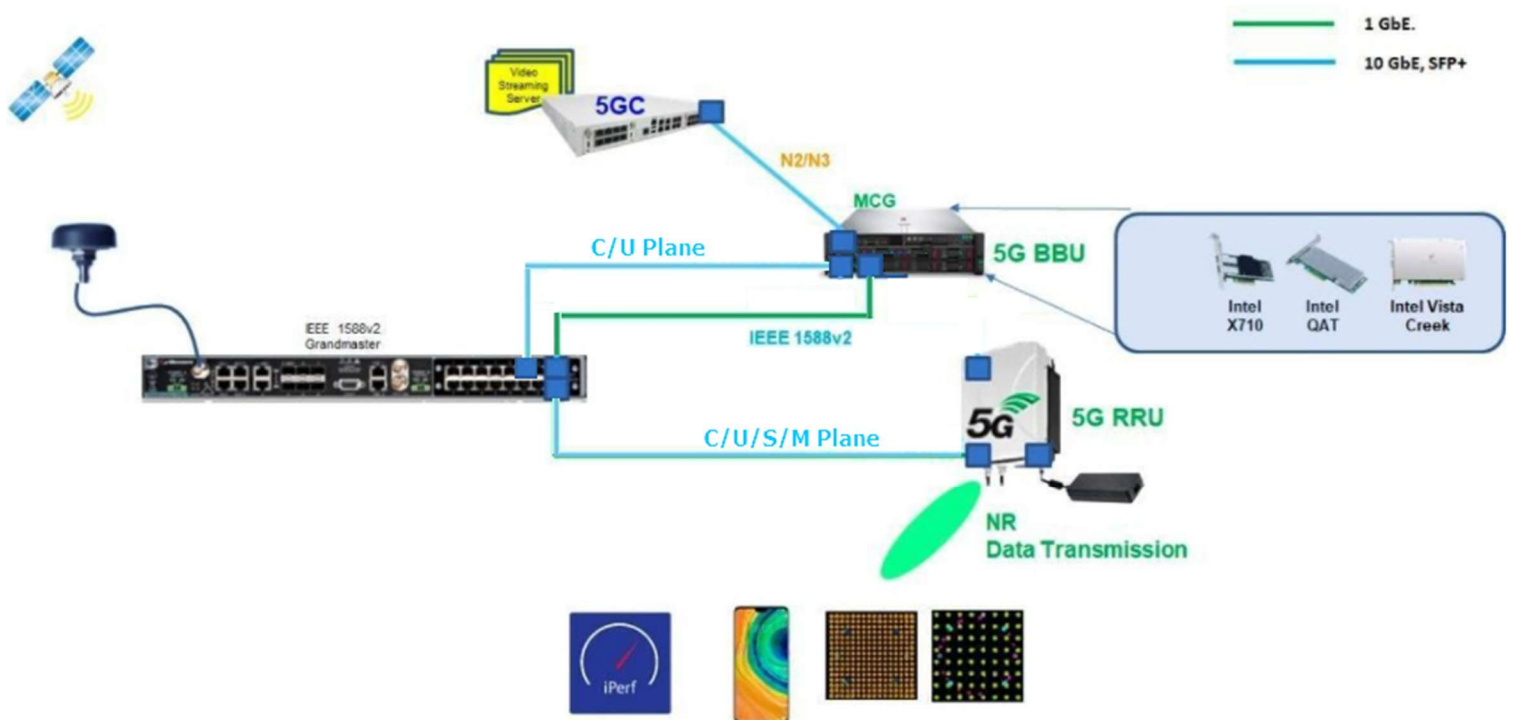


Figure 8 SA L5G System Architecture

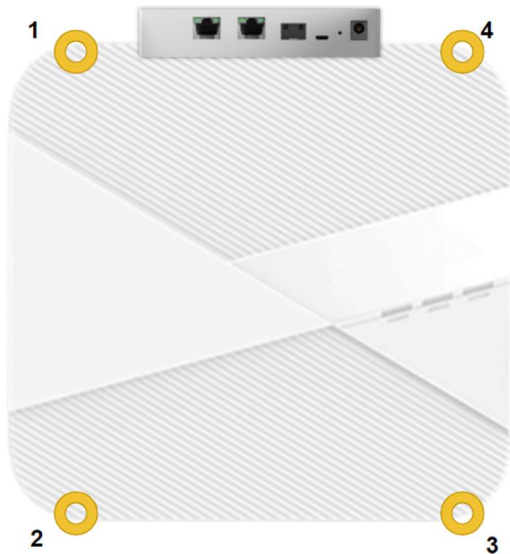
3.1 RPQN O-RU cabling instruction

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

10Gb SFP+ fiber cabling options:

- Intel 10Gb Short Range Optics (model: E10GSFPSR, 850 nm wavelength) + multi-mode fiber
- Intel 10Gb Long Range Optics (model: E10GSFPLR, 1310 nm wavelength) + single-mode fiber.

3.1.2 External Antenna port number (SMA connector)



3.1.3 RF Isolation

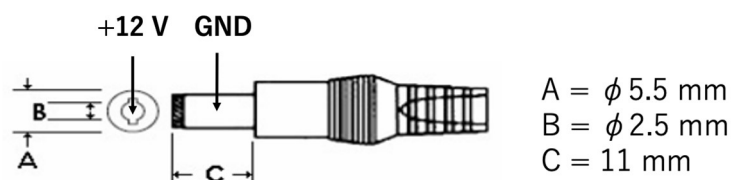
If your O-RU is an external antenna model, then suggest the following antenna direction to get better isolation. (Only old HW SKU before S4 had this issue.)



3.1.4 Power supply

There are 2 options:

- PoE++ via LAN2 (10Gb RJ-45 Ethernet port): recommend to use Cat 6A Ethernet cable.
- 12V DC INPUT:
 - Maximum rating: +12 V (+/-10 %), 5 A
 - Recommendation is to use the same spec. with optional AC Power adapter (See section [1.2.4 12 VDC AC Power adapter](#) for more information.)
 - +12 V +/-5 %, 5.5 A
 - DC INPUT jack:



3.1.4.1 Power backup system

The base station is recommended to be equipped with a backup power supply system which would include a battery system to support the system for more than four hours to avoid AC power suddenly damaging the wireless system.

Additionally, Site engineers can prepare power generators to site to keep system operation in normal. At the same time, engineers need to contact relatives to fix the AC power down problem.

3.1.5 Micro USB

Micro USB: for RPQN O-RU debug console.

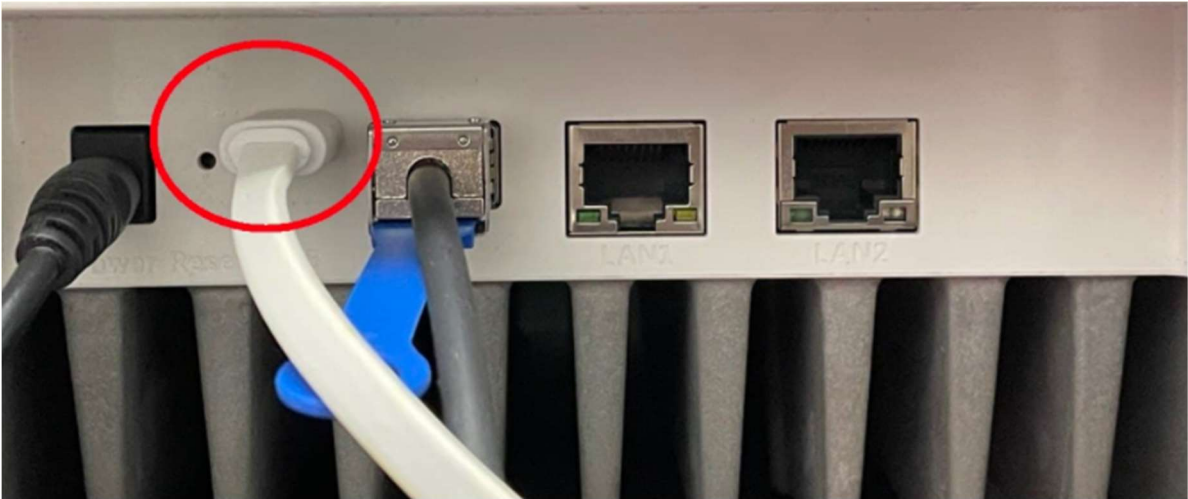


Figure 9 Example of Cable Assembly

4. Operating Instruction

4.1 Operating instruction

Please refer to:

- [\[RP0-416\] Foxconn RPQN O-RU Operating instruction for V1 firmware.pdf](#)
- [\[RP0-417\] Foxconn RPQN O-RU Operating instruction for V2 firmware.pdf](#)

4.2 Firmware upgrade

Please refer to:

- [\[RP0-415\] Foxconn RPQN O-RU Firmware Upgrade Guide.pdf](#)

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

Please refer to:

- [\[RP0-407\] Foxconn Sample App Operation Guide.pdf](#)
 - 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?

- RRH RAM logs will be saved in /var/log/rrh_log_print/rrh_log_print.log*.

This log might be useful for real-time debugging and rebooting issues troubleshooting.

tail -f /var/log/rrh_log_print/rrh_log_print.log

```
2023-07-31 11:38:51.057] ptp: state=3 sec=12 rms=5 max=9 freq=-29 delay=64
2023-07-31 11:38:51.057] proc info 0_min:2189 l_min:8198 , 0_avg:2315 l_avg:8419 , 0_max:2898 l_max:11452
2023-07-31 11:38:51.107] Latch later lpps=0x6f09bda8 swi4010=0x6f09bda8 xran_sec=0x6f09bda8 lpps_d=122880000 swi4010_lpps_d=0
2023-07-31 11:38:51.107] curr mdBFS of Rx = 56000 54500 55500 56000
2023-07-31 11:38:51.107] keep REG_AD9025_RX_BYPASS_ADDR to 0x00000f
2023-07-31 11:38:51.107] fpga REG_XRAN_SYM_DL_IO_SCALING : 0x010001
2023-07-31 11:38:52.008] 10R: sec=14 hps=14 64b=2757 65to128=3428 total=6189 uni=0 uni_gt_1158=0 multi=6189 crc_err=0
2023-07-31 11:38:52.008] 10T: sec=14 hps=14 64b=2128 65to128=11 total=2139 uni=0 uni_gt_1158=0 multi=2139 crc_err=0 state=1 st
2023-07-31 11:38:52.008] xRN: total=0 c_early=0 c_on=0 c_late=0 err_tci=0 err_ecpri=0 err_port=0 err_sct=0 err_total=0
2023-07-31 11:38:52.008] RRH_state=READY_FOR_DATA
2023-07-31 11:38:52.008] ptp: state=3 sec=14 rms=5 max=9 freq=-29 delay=64
2023-07-31 11:38:52.058] proc info 0_min:2187 l_min:8219 , 0_avg:2311 l_avg:8408 , 0_max:4863 l_max:10928
2023-07-31 11:38:52.109] Latch later lpps=0x765cbda7 swi4010=0x765cbda8 xran_sec=0x765cbda8 lpps_d=122879999 swi4010_lpps_d=1
2023-07-31 11:38:52.109] curr mdBFS of Rx = 55500 55250 55500 54500
2023-07-31 11:38:52.109] keep REG_AD9025_RX_BYPASS_ADDR to 0x00000f
2023-07-31 11:38:52.109] fpga REG_XRAN_SYM_DL_IO_SCALING : 0x010001
2023-07-31 11:38:53.010] 10R: sec=15 hps=15 64b=2774 65to128=3449 total=6227 uni=0 uni_gt_1158=0 multi=6227 crc_err=0
2023-07-31 11:38:53.010] 10T: sec=15 hps=15 64b=2141 65to128=11 total=2152 uni=0 uni_gt_1158=0 multi=2152 crc_err=0 state=1 st
2023-07-31 11:38:53.010] xRN: total=0 c_early=0 c_on=0 c_late=0 err_tci=0 err_ecpri=0 err_port=0 err_sct=0 err_total=0
2023-07-31 11:38:53.010] RRH_state=READY_FOR_DATA
2023-07-31 11:38:53.010] ptp: state=3 sec=15 rms=6 max=12 freq=-29 delay=64
2023-07-31 11:38:53.060] proc info 0_min:2191 l_min:8212 , 0_avg:2310 l_avg:8406 , 0_max:4776 l_max:10951
2023-07-31 11:38:53.110] Latch later lpps=0x7dafbda7 swi4010=0x7dafbda7 xran_sec=0x7dafbda7 lpps_d=122880000 swi4010_lpps_d=0
2023-07-31 11:38:53.110] ddpErrorCode 0x340c 0x340c 0x340c 0x340c
2023-07-31 11:38:53.110] ddpDirectEvm 0 0 0 0 m%
2023-07-31 11:38:53.110] ddpIndirectEvm 0 0 0 0 m%
2023-07-31 11:38:53.111] ddpMeanOrxPower -2147483648 -2147483648 -2147483648 -2147483648 mdBFS
2023-07-31 11:38:53.111] ddpPeakOrxPower -2147483648 -2147483648 -2147483648 -2147483648 mdBFS
2023-07-31 11:38:53.111] ddpMeanTxPower -2147483648 -2147483648 -2147483648 -2147483648 mdBFS
2023-07-31 11:38:53.111] ddpPeakTxPower -2147483648 -2147483648 -2147483648 -2147483648 mdBFS
2023-07-31 11:38:53.111] ddpMeanTxPower -2147483648 -2147483648 -2147483648 -2147483648 mdBFS
2023-07-31 11:38:53.111] ddpPeakTxPower -2147483648 -2147483648 -2147483648 -2147483648 mdBFS
```

- When “Latch xxx lpps” strings appear, the O-RU is synchronized with a GM/BC and finishes the initialization.
- Execute command “/usr/utls/get/get_ru_diag.sh”, RU will automatically collect the log file “/tmp/ru_diag.tar.gz”, if RU reboot then ru_diag.zip will disappear.
- Value definition:
 - 10R...means number of packets received from BBU.
 - 10T...means number of packets transmitted to BBU.
 - 64b: number of c-plane packets with size 64 bytes.
 - 65to128: number of packets with size between 65 bytes to 128 bytes.
 - uni>1158: number of u-plane packets with size greater than 1158.
 - total: total number of packets.
 - uni: number of unicast packets.
 - multi: number of multicast packets.
 - crc_err: number of packets with CRC error.
 - state = 1 : RU is waiting for the 1st c-plane message.
 - state = 2 : RU has received the 1st c-plane and started working.
 - c_early: Number of c-plane packets arrived early.

- c_on: Number of c-plane packets arrived on time.
- c_late: Number of c-plane packets arrived late.
- err_tci: is the packet being dropped due to TCI mismatch
- err_ecpri: is the packet being dropped due to eCPRI mismatch
- err_port: is the packet being dropped due to RU_port mismatch.
- err_sct: is the packet being dropped due to section type mismatch.
- atick: keep receiving c-plane packets every second.
- iatick: how long has RU not received the c-plane packet, 0 is normal.
- ptp state: ptp state=3 is locked.

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

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

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

Yes. Please make sure the switch supports the 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.
- Keep VLAN tag in those ports (DO NOT set untag).
- Enable jumbo frames. Set frame size more than 9000 Bytes.

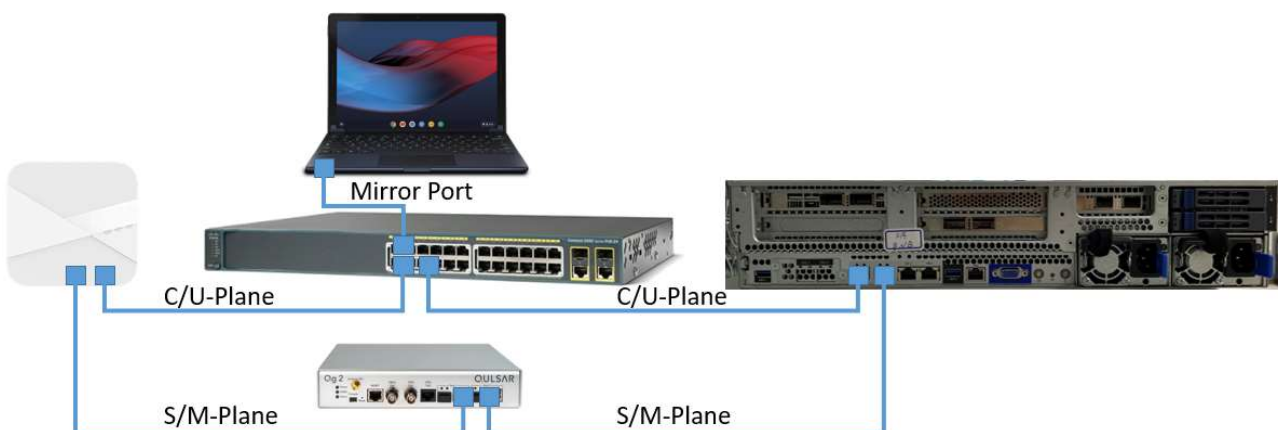


Figure 10 O-RU O-DU connectivity with Switch and GM

5.5 How to enable Auto Running?

If you want to make RU running automatically after power on, please add below lines into the bottom of file: “**/etc/profile**” : (To configure IP and launch CU plane)

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

- How to change configuration after enabling auto boot up?
 - If you **can** remote SSH to O-RU using account: root, password: e/4g;4uh/6x.6
 - i. Make changes in *RRHconfig_xran.xml*.
 - ii. Run */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 in again.
 - iii. Once the prompt appears, press “**Ctrl+C**” to stop the running process.
 - iv. Make changes in *RRHconfig_xran.xml*.
 - v. Run */home/root/test/reboot.sh*.
- How to disable auto boot up?
 - Just remove the above command in */etc/profile*.

5.6 How to configure IP permanently?

RPQN works as DHCP client as default at OAM image. You must prepare a DHCP server.

FW type:

- ENG FW installer file: install_**eng**_v3xxxxx.run
- OAM FW installer file: install_**oam**_v3xxxxx.run
- Enable OAM: “./set_oam_mode -e”
- Disable OAM: “./set_oam_mode -d”
- ./set_oam_mode -h for help

How to config IP:

- OAM FW and OAM is enabled:
 - 1G interface: **eth0**
 - Static IP:

```
# Append below lines into bottom but top of line “exit 0” in file
```

```
# "/etc/rc.local"  
.....  
.....  
ifconfig eth0 192.168.19.19/24 # config any IP  
exit 0
```

- 10G interface: **qse-eth**
 - Static IP: “./set_oam_mode -e {IP}”
 - DHCP: “./set_oam_mode -e”

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

- Eng FW or OAM is disabled:
 - v1.x.x FW:
 - 1G interface: **eth0**
 - Static IP:

```
# Append below lines into bottom of file "/etc/profile"
if [ $(tty) = "/dev/ttyS0" ]; then
    ifconfig eth0 192.168.19.19/24 # config any IP
fi
```

- 10G interface: Won't show up in v1.x.x FW

- v2.x.x FW or newer:
 - 1G interface: **eth0** and 10G interface: **qse-eth**
 - Static IP:
 - Before v3.1.2q.524

```
# Append below lines into bottom of file "/etc/profile"
if [ $(tty) = "/dev/ttyS0" ]; then
    ifconfig eth0 192.168.19.19/24 # config any IP
    ifconfig qse-eth 192.168.20.20/24 # config any IP
fi
```

- After v3.1.2q.524 (included)

```
# Append below lines into bottom but top of line "exit 0" in file
# "/etc/rc.local"
.....
.....

ifconfig eth0 192.168.19.19/24 # config any IP
ifconfig qse-eth 192.168.20.20/24 # config any IP
exit 0
```

5.7 How to check PTP/RRH timing log?

tail -f /var/log/rrh_timing_service.log

5.8 Which PRACH format does RU support?

RU only supports short PRACH format B4.

5.9 How to calculate Tx power?

- With HW SKU S4, which is a calibrated unit, Tx power is fixed to 24 dBm based on Max(I,Q) r.m.s 512 s ending from DU to RU.
- Peak antenna gain is 5.15 dBi (RPQN-4800E: External antenna).

5.10 How to disable/enable DPD?

- In O-RU path /home/root/test/RRHconfig_xran.xml:
 - Disable DPD: `RRH_RF_GENERAL_CTRL = 0x0, 0x0, 0x0, 0x0`
 - Enable DPD: `RRH_RF_GENERAL_CTRL = 0x3, 0x0, 0x0, 0x0`
- Note: This setting affects all 4 ports.
- CLGC (Closed Loop Gain Control), `RRH_RF_GENERAL_CTRL` 2nd word set to `0x1`
 - `RRH_RF_GENERAL_CTRL = 0x3, 0x1, 0x0, 0x0`

5.11 Is RU PTP profile compliant with ITU-T G.8273.2? (T-TSC) – please confirm?

- Yes, RU is compliant with ITU-T G.8273.2 T-TSC

5.12 What is the T-TSC clock class for RU? Is it class B or class C?

- Class B

5.13 What is the max [TE] for the RU?

- 80 ns

5.14 TX_POWER invalid value

When the O-RU goes into a weird state like the phenomenon below, Please backup the calibration table and re-inst all the software again.then the calibration mean table with multiple power points will be installed,O-RU can configure different TX power (24 to 9)

```
RRH_PTPV2_IP_MODE = IPv4
Read RRH_PTPV2_GRAND_MASTER_IP = 192.167.27.150
RRH_PTPV2_SUB_DOMAIN_NUM = 24
RRH_PTPV2_ACCEPTED_CLOCK_CLASS = 135
RRH_TRACE_PERIOD = 10
Read MAC address from /usr/src/addr.xml = 6C:AD:AD:00:06:44
Read ifconfig qse-eth = 6C:AD:AD:00:06:44
Result RRH_0RG_MAC_ADDR = 6C:AD:AD:00:06:44
Warning: invalid RRH_TX_POWER value: 20 dBm, forced to be corrected to 24 dBm
Result RRH_TX_ATTENUATION = 10.5, 11.1, 9.0, 11.5
Result RRH_RX_TOTAL_GAIN = FIXED
Result RRH_RX_ATTENUATION = 1.7, 1.7, 1.7, 1.7
Result PA Protection: Enabled
Result Thermal compensation: Disabled. Because there is no thermal compensation data
Result RRH_PTPV2_GRAND_MASTER_IP = No needed
```

1. cd /usr/src/
2. mkdir backup_cal
3. mv cal_* backup_cal/
4. cd /home/root/test/
5. ./install_eng_v3xxx.run