HFR,Inc.
for Mobile Internet

flexAU
User Manual

http://www.hfrnet.com
Fax : +82-31-712-7948
Tel : +82-31-712-7768
5F, Hana EZ tower, 10, Seongnam-daero43beon-gil
Bundang-gu, Seongnam-si, Gyeonggi-do, 13636, Korea

Preface

Conventions in this Document

This manual describes the GUI used in the flexAU. This document is organized as follows:

1. Safety : This chapter introduces precautions when using flexAU.

2. System Introduction : This chapter introduces flexAU.

3. Troubleshooting : This chapter describes how to take action based on the cause of the flexAU failure.

Abbreviations

A

ATT : Attenuator

ANT : Antenna

AWG : American Wire Gauge

B

BER : Bit Error Rate

BiDi : Bi Directional

BTS : Base Transceiver Station

C

C-Plane : Control Plane

D

DL : Downlink

J

JIS : Japanese Industrial Standards

L

LNA : Low Noise Amplifier

M

M-Plane : Management Plane

MIMO : Multi Input Multi Output

O

O-DU : O-RAN Distributed Unit

O-RU : O-RAN Radio Unit

P

PTP : Precision Time Protocol

S

S-Plane : Synchronization Plane

SISO : Single Input Single Output

SyncE : Synchronous Ethernet

U

U-Plane : User Plane

UL : Uplink

Revision History

Version	Descriptions	Author	Date
1.0	Initial version		

Table of Contents

Figure index

Table Index

1 Safety

1.1 Overview

1.1.1 Purpose

This chapter on safety provides users of flexAU systems with the relevant information and safety guidelines to safeguard against personal injury. Furthermore, this chapter may be useful to prevent material damage to the equipment.

This chapter on safety must be read by the responsible technical personnel before carrying out relevant work on the system. The valid version of this document must always be kept close to the equipment.

1.2 General notes on safety

1.2.1 Purpose

This section provides general information on the structure of safety instructions and summarizes general safety requirements.

1.2.2 General Safety Precautions

- Read all safety information before installing, operating, and maintaining the equipment.
- To minimize risk of personal injury and equipment damage, always follow all safety precautions marked on equipment and described in manuals.
- The Note, Caution and Warning sections in the manual are only a supplement and do not represent all safety instructions.
- Use the equipment only where all design specifications are met. Otherwise, any resulting equipment failure and its negative consequences to equipment, parts, personnel, and property will not be covered by the warranty.

1.2.3 Qualified personnel definitions

- Skilled personnel:
  Possesses experience or has been trained in the technology and methodology used in the equipment. Such personnel must know about the sources and magnitude of safety risks involved.
- Trained personnel:
  Has been taught or supervised by skilled personnel and can identify the sources of safety risks involved and take precautions to avoid unintentional exposure. Such personnel should avoid risky areas under all operating conditions, be aware of operational risks, and minimize these risks.
- User or operator:

All other personnel, including those with access to the equipment or who may be in the vicinity of the equipment.

1.2.4 Basic precautions

- Trained personnel must be certified, understand all required safety regulations, and master correct operational methods before installing, operating, and maintaining the equipment.
- All work with equipment must comply with local laws and regulations. Safety information in the manual only serves as a supplement. Also, ensure that the following safety requirements are met:
  - Only skilled and trained personnel can install, operate, and maintain equipment.
  - Only skilled and trained personnel can remove safety infrastructure and maintenance equipment.
  - Operators must report faults or errors that may cause safety issues promptly.
  - All personnel working with equipment should have high-voltage operation, climbing, special equipment operation, and other operational qualifications required by the local country.
- If personal injury or equipment damage occurs during installation, stop operations immediately, report the situation to the project owner, and take effective protective measures.
- All work on outdoor equipment is strictly forbidden in lightning, rain, snow, wind, and other adverse weather conditions. Such work includes but is not limited to outdoor equipment transportation, cabinet installation, power cable installation, and outdoor cable connection.
- Do not wear watches, jewelry, or other conductive objects when working with equipment.
- Do not wear loose clothing or jewelry, such as rings, bracelets, or chains, which could become caught in the device.
- Wear safety glasses if you are working under any conditions that could be hazardous to your eyes.
- Always follow the procedures of the Product Manual while working.
- Use a voltmeter to measure the voltage at the contact point before touching any metal surface or terminal to prevent electric shocks.
- After equipment installation, conduct routine checks and maintenance. Promptly replace faulty parts as required.
- After equipment installation, clear the area of packaging materials such as the box, Styrofoam, plastic, and cable ties.
- In case of fire, evacuate from the building or equipment area and activate the fire alarm or call the fire emergency number. Do not reenter the burning building under any circumstances.

1.3 Structure of safety statements

1.3.1 Overview

This topic describes the components of safety statements that appear in this document.

1.3.2 Example of a safety statement

Safety statements appear as follows.

1.3.3 General structure

Safety statements include the structural elements shown in Figure 1.

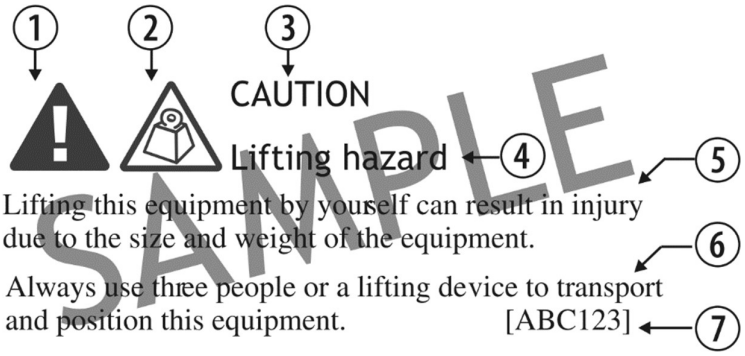

Figure 1 Structure of safety statements

Item	Structure element	Purpose
1	Safety alert symbol	Indicates the potential for personal injury (optional)
2	Safety symbol	Indicates hazard type (optional)
3	Signal word	Indicates the severity of the hazard
4	Hazard type	Describes the source of the risk of damage or injury
5	Safety message	Consequences if protective measures fail
6	Avoidance message	Protective measures to take to avoid the hazard
7	Identifier	The reference ID of the hazard statement (optional)

1.3.4 Signal words

The signal words that identify the hazard severity levels are shown in Table .

Table 1 Signal words for hazard severity

Signal word	Meaning
DANGER	Indicates an extremely hazardous situation which, if not avoided, will result in death or serious injury.
WARNING	Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
CAUTION	Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
NOTICE	Indicates a hazardous situation not related to personal injury.

1.3.5 Symbols

The signal words identify the hazard severity levels as follows:

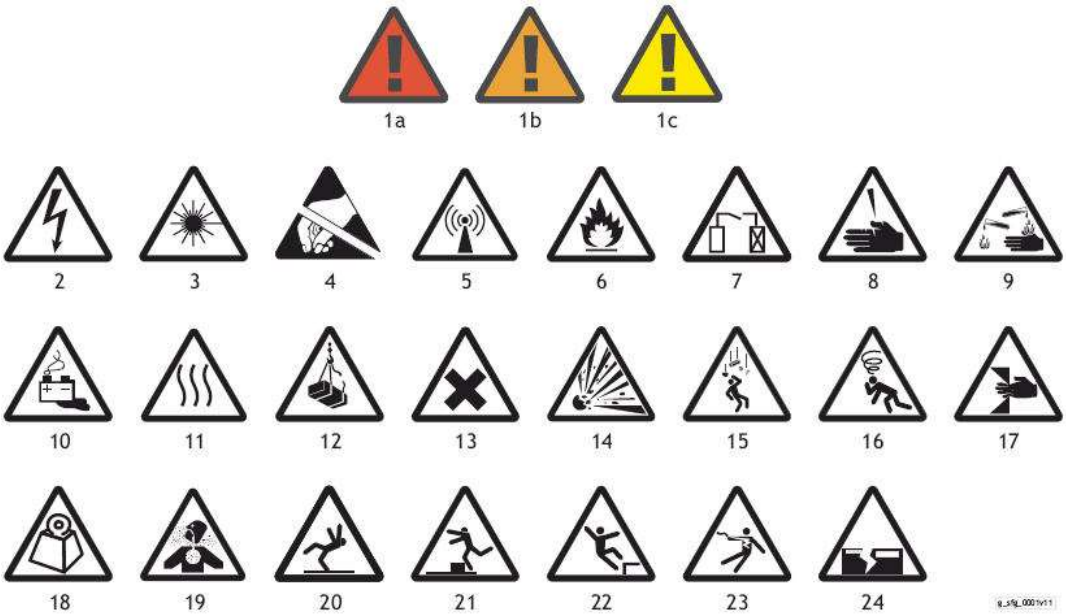

Figure 2 Symbols defined for safety instructions

Legend

1	Safety alert symbol • RED: indicates *danger* (1a) • ORANGE: indicates *warning* (1b) • YELLOW: indicates *caution* (1c)
2	Electric shock

3	Hazard of laser radiation
4	Components sensitive to electrostatic discharge (ESD)
5	Electromagnetic radiation
6	Flammable material / Risk of fire
7	Service disruption hazard
8	Laceration hazard
9	Corrosive substance
10	Hazard caused by batteries
11	Hot surface
12	Heavy overhead load
13	Noxious substance
14	Explosion hazard
15	Falling object hazard
16	Risk of suffocation
17	Pinch hazard
18	Lifting hazard, heavy object
19	Inhalation hazard
20	Slip hazard
21	Trip hazard
22	Hazard of falling
23	Arc-flash hazard
24	Equipment damage hazard

1.4 Basic Safety aspects

1.4.1 Purpose

This topic covers basic safety aspects relating to the flexAU system with which you must be familiar prior to installing or using the product.

1.4.2 General safety requirements

To reduce the risk of personal injury or damage to equipment, ensure that you read, understand, and follow the following general safety requirements prior to installing or using the flexAU system.

- Ensure that transport, storage, installation, and operation of the system are conducted only under specified permissible conditions. See the accompanying documentation and information on the system.
- Ensure that installation, configuration, and disassembly of the system are conducted only by suitably qualified personnel and with reference to the appropriate documentation. Due to the complexity of the system, it is required that personnel receive special training.
- When installing and operating, make sure to follow the standards and regulations that apply in your country.
- Identify potential hazards prior to starting the installation, so they can be avoided during the installation process.
- Ensure that the system is operated only by trained and authorized users. The user must operate the system only after having read and understood the section on safety and the parts of the documentation relevant to operation. For complex systems, additional training is recommended. Any obligatory training for operating and service personnel must be completed and documented.
- Follow all instructions marked on the product, including both general instructions and the stated methods for avoiding hazards.
- Do not operate the system unless all appropriate safety measures, precautions, and instructions have been taken or followed. Any faults and errors that might affect safety must be reported immediately by the user to appropriate personnel responsible for safety.
- Operate the system only under the environmental conditions and with the connections described in the documentation.
- Only use components that are recommended by the manufacturer and are listed in the procurement documents are used.
- Ensure that any work that has any impact on safety facilities, the clearance of faults, and the maintenance of equipment are carried out only by trained and qualified personnel and in conjunction with the appropriate documentation. Use only approved measuring and test equipment.

- Ensure that calibrations, special tests after repairs, and regular safety checks are conducted, documented, and archived.
- Use only specified chemicals or materials.

1.4.3 Summary of important safety instructions

Observe the following safety instructions, which are of particular importance for flexAU system components:

- This product should be operated only from the type of power source indicated on the marking label.
- This equipment must be provided with a readily accessible disconnect device as part of the building installation.
- This equipment is intended to be provided with an appropriate branch circuit protection on input feed as follows:

  o flexAU :

  1 * 0.85A, –48V (–41.1 ~ -57.0V) for indoor DC unit

  The operator may use a type of SPD (surge protection device) for lightning protection based on the installation environment for outdoor equipment.
- To reduce the risk of injury, disconnect all power feeders when removing power from the system.
- Installation must include an independent frame ground drop to the building ground.
- During installation and handling (for example transport), heavy equipment like racks or preinstalled subracks must be secured to avoid tipping over.
- Install only equipment identified in the Installation and System Turn-Up Guides provided with this product. Use of other equipment may result in improper connection of circuitry leading to fire or injury to persons.
- To reduce the risk of electrical shock, do not disassemble this product. Installation and service should be performed by trained personnel only. Opening or removing covers or circuit boards may expose you to dangerous voltages or other risks. Incorrect re-assembly can cause electrical shock when the unit is subsequently used.
- Heatsink and openings in this product are provided for ventilation. To protect the product from overheating, these openings must not be blocked or covered. This product should not be placed in a built-in installation unless proper ventilation is provided.
- Never push objects of any kind into this product through slots as they may touch dangerous voltage points or short-out parts, which could result in a risk of fire or electrical shock.
- Never spill liquids of any kind on the product.
- Never install telecommunication wiring during a lightning storm.
- Never install telecommunication connections in wet locations.

1.5 Specific safety areas

1.5.1 Purpose

The aspects of "laser safety" and "handling of components sensitive to electrostatic discharge (ESD)" are of vital importance for the flexAU system. Therefore, the key safety instructions for these subjects are summarized in the following.

1.6 Electrostatic discharge

1.6.1 Introduction

Electrostatic discharge (ESD), caused by touching with the hand for example, can destroy semiconductor components. The correct operation of the complete system is then no longer assured.

Industry experience has shown that all semiconductor components can be damaged by static electricity that builds up on work surfaces and personnel. The electrostatic discharge can also affect the components indirectly via contacts or conductor tracks. The electrostatic charges are produced by various charging effects of movement and contact with other objects. Dry air allows greater static charges to accumulate. Higher potentials are measured in areas with low relative humidity, but potentials high enough to cause damage can occur anywhere.

1.10.2 The barred-hand symbol

Circuit packs containing components that are especially sensitive to electrostatic discharge are identified by warning labels bearing the barred-hand symbol.

Figure 3 Barred-hand symbol

1.6.2 ESD instructions

Figure 4 ESD NOTICE Symbol

Electrostatic discharge (ESD) can permanently destroy semiconductor components

Observe the following ESD instructions to avoid damage to electrostatic-sensitive components:

- Assume that all solid-state components and assemblies are sensitive to ESD.
- Wear working garment made of 100% cotton to avoid electrostatic charging.
- Touch the circuit packs at the edges or the insertion and removal facilities only.

- Ensure that the rack is grounded.
- Wear a properly grounded ESD wrist strap (connected to the rack ESD bonding point, example).
- Work in an ESD safe work area or workstation. An ESD safe work area should be equipped with a grounded ESD wrist strap and a grounded ESD mat or ESD dissipative work surface.
- A grounded ESD mat or work surface must have a ground cord with one end attached to the surface and the other end connected to a ground point (the rack ESD bonding point, for example). Do not work with ESD sensitive devices unless the area is properly equipped.
- Conductively connect all test equipment and trolleys to the rack ESD bonding point.
- Store and ship circuit packs and components in their shipping packaging. Circuit packs components must be packed and unpacked only at workplaces suitably protected against the build-up of charge.
- Whenever possible, maintain the relative humidity of air above 20%.
- Test and calibrate ESD safety equipment on a regular basis for a proper function.

Electric shock

Figure 5 Electric Shock Symbol

- The 4-mm banana plug at the end of the ESD wrist-strap cord is intended to be only used for connecting to the ESD jack on the rack/subrack ESD bonding point. Connecting the banana plug to AC or DC wall sockets or any type of power supply units may lead to the risk of electric shock.
- Never connect the banana plug to AC or DC wall sockets or any type of power supply units.

2 System introduction

This document provides 5G NR n79 band service and is an operation manual for O-RAN based in-building distributed small power equipment (hereinafter "flexAU") that supports up to 4x4 MIMO function.

This system is used for the purpose of providing 5G service in an Open RAN in-building environment. It provides unique capacity for each area by spatially distributing the coverage for each MIMO layer provided by the 5G base station while sharing capacity among multiple equipment.

It is implemented in a distributed structure that can expand coverage.

This system provides a service that supports 5G NR-based SA (Stand Alone) operation in the 3.55~3.7 GHz band.

2.1 feature

Table 2 flexAU feature

Unit	feature	Remarks
flexAU	• O-RAN Function Split Option 7-2x Category A O-RU • NR TDD configuration • N48 • 10/20/40/60/100MHz Bandwidth support • 30 kHz Sub-Carrier Spacing support • Normal CP support • 4-Layer (4T4R MIMO) support • 10 Gbps Fronthaul Ethernet link support • PRACH preamble format C2, B4 support • SyncE and IEEE 1588v2 support • VLAN tag support • Ethernet Basic frame support • C-Plane Section type 1, 3 support	

Figure 6 O-DU 와 flexAU system

flexAU performs initialization through M-Plane and synchronizes frequency, phase, and time through S-Plane.

Decompresses U-Plane transmitted by C-Plane received from O-DU, iFFT Frequency Domain Signal (I/Q) to Time Domain Signal, adds CP, converts to RF Signal, and transmits to Antenna.

In addition, after removing the CP by converting the RF signal received from the antenna into a digital signal, FFT the time domain signal to a frequency domain signal, compressing the U-Plane to be transmitted by the C-Plane received from the O-DU, and compressing the O- Send to DU.

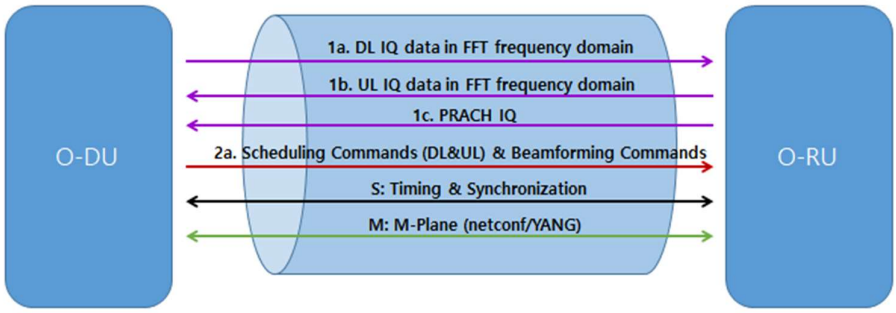

Figure 7 Lower layer fronthaul data flows

Handling and work of this equipment shall be carried out by a technical person.

Technicians and personnel being trained to handle equipment.

Each package uses components that are weak against electrical and physical shocks such as LSI and IC.

Handle it properly to avoid electrostatic breakdown or thermal breakdown, short circuit, etc.

2.2 System component

This system is integrated with an antenna.

2.3 System appearance

This chapter describes the equipment weight and external size.

2.3.1 System weight

The flexAU weight is shown in Table 3. However, the SFP+ Module is not installed.

Table 3 System weight

Unit	Max weight (kg)	Remarks

flexAU	< 2.0	Without installation Basic Bracket

2.3.2 System appearance

The size of flexAU is shown in Table 4.

Table 4 System size

Unit	height (mm)	width(mm)	depth(mm)	Remark
flexAU	225 ± 0.5	225 ± 0.5	60 ± 0.3	Without brackets and protrusions

Figure 8 shows the outline of flexAU.

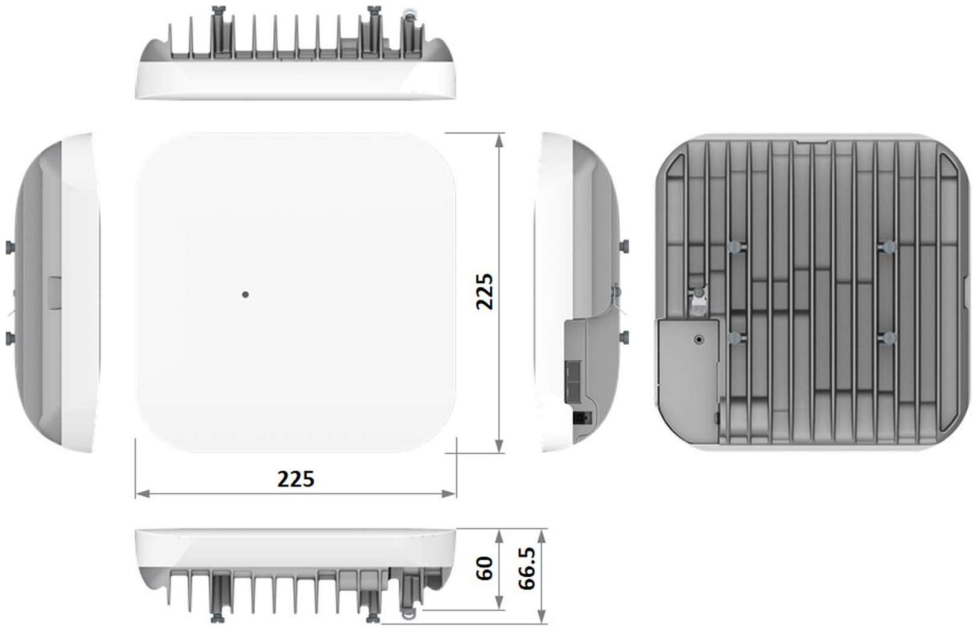

Figure 8 flexAU appearance

2.4 Basic specifications

The basic specifications of the flexAU system are as follows.

Table 5 Power specification

Item	Type	Specification	Remarks
Input power	flexAU	Voltage : DC -48 V (Range: -41.1 ~ 57 V_{DC})	
Power connector	flexAU	Part Name : 172064-0002 Mega-Fit Right-Angle Header, 2 Circuits, Gold (Au) Plating, UL 94 V-0, Glow-Wire Capable	

Power consumption	flexAU	Max. 40 W	Max output power

Table 6 Environmental conditions

Item		Specification	Remarks
operating environment	Temperature	-5 ℃ ~ +45 ℃	Room conditions with convection
	Humidity	+5 % ~ +90 %	
storage environment	Temperature	-20 ℃ ~ +50 ℃	
	Humidity	+5 % ~ +90 %	

Table 7 I/O signal interface specifications

Item		Specification	Remarks
Downlink	Output	+24 dBm / layer	flexAU ANT Port
Uplink	Input	Typ. : -40 dBm/port Max : -20 dBm/port	flexAU ANT Port

Table 8 Internal Antenna

Installation Type	Antenna Type	Remarks
Ceil	Omni type	
Wall	Patch type	

Table 9 Optical Interface (SFP/SFP+) Specifications

Item		Specification	Remarks
Optical Interface	Wavelength	TX : 1330 nm ± 10 nm	
		RX : 1270 nm ± 10 nm	
	Fiber Type	Single Mode Fiber	
	Connector Type	LC / PC (Single mode)	
	Transmission distance	Max. 30 km	O-DU – flexAU

- Optic Interface follows SFP standard.

Table 10 Monitoring Control Interface

Item	Specification	Remarks
GUI Port	Bluetooth	For device control / monitoring

2.5 RF Specification

The RF specifications of the flexAU system are as follows.

Table 11 Carrier Frequency

Carrier	Downlink (Unit : MHz)		Uplink (Unit : MHz)	
	Low	High	Low	High
Frequency	3550	3700	3550	3700

Table 12 RF Specification

Item		Specification	Remarks
MIMO (RF Path)		4T4R	TDD Duplex
DL max power		Total 24 dBm / port	100MHz
FH Delay		≤ 160 μs	
Tx port Time alignment error		≤ 65 ns	
antenna gain	Ceiling	> 3dBi	
	Wall	> 8dBi	
antenna peak gain	Ceiling	5.07dBi	
	Wall	8.87dBi	
EIRP(Max)	Ceiling	> 35.07 dBm	100MHz
	Wall	> 38.87 dBm	100MHz
DL output control range/ step		> 15 dB / 0.5 dB step	
Frequency Error		≤ ±0.05 ppm	
EVM		< 3.5 %	
ACLR		> 40 dBc @adjacent channel occupied bandwidth	
UL input level		Rated input : -40 dBm/carrier (ALC action point level) MAX input : -20 dBm/carrier	

2.6 Interface

The main interfaces of flexAU are shown in Figure 9 and Table 13.

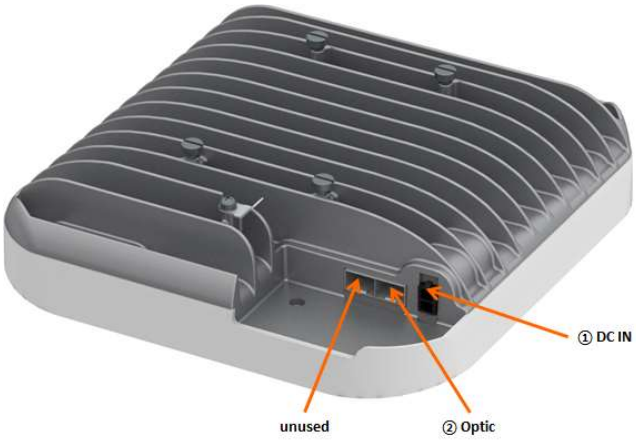

Figure 9 flexAU Interface

Table 13 flexAU Interface

Name	No	Descriptions
DC IN	①	- Port : DC -48V Input Port - Connector : 172064-0002
Optic	②	- Port : SFP/SFP+ Insert Port - Connector : SFP/SFP+ Cages

3 Troubleshooting

Table 23 Failure and inspection

Item		Cause	Action
System	Enclosure temperature upper limit alarm	Temperature rise inside the enclosure or DTU fault	Check the upper temperature limit. Check for abnormal temperature elements.
	DC alarm	PSU DC Input fault	Check the input power level
	Status monitoring connection alarm	GUI Monitoring via Bluetooth	Check the elapse of 1 minute after stopping GUI connection via Bluetooth.
DL/UL	TSSI upper limit alarm	Higher than specified input	Checking the optical cable connection. Check for eCPRI alarms. Check whether output upper limit alarm is present. Check after SFP replacement.
	TSSI lower limit alarm	Lower than specified input	Checking the optical cable connection. Check for eCPRI alarms. Check whether output lower limit alarm. Check after SFP replacement.
	DL output high limit alarm	Higher than specified output.	Check the output level value. Check the antenna cable connection.
	DL output low limit alarm	Lower than specified input	Check the output level value. Check the antenna cable connection.
	over input alarm	Abnormal operation of RF module due to excessive reverse input.	Checking and adjusting the input level.
SFP	eCPRI alarm	Occurs when eCPRI is not connected with O-DU.	Checking the optical cable connection SFP LOS, LD alarm check LD Power, PD Power check

Item		Cause	Action
			Check BIP Error count Check after SFP replacement
	LOS alarm	Bad cable or connection Excessive light loss PD device failure	Measurement with Optic Power Meter at the output end of the optical terminal box. Light wavelength check. Reunion after washing with alcohol. Replace SFP in case of defective PD. Optical adapter replacement.
	LD alarm	Bad cable or connection. LD device failure and deterioration.	Measuring Light Output Optic Power Meter. Replace SFP in case of LD failure.
	PD Pwr. upper limit alarm	Higher than specified input	Checking the optical cable connection. Check measurement with SFP input optical power Optic Power Meter.
	PD Pwr. lower limit alarm	Lower than specified input	Checking the optical cable connection. Check measurement with SFP input optical power Optic Power Meter. SFP LOS Alarm Check. If the SFP input optical power is normal, replace the SFP because the PD is defective.
ETC	DPD alarm	DPD fault	Downlink waveform check through waveform monitoring function. Confirmation of alarm reoccurrence 2 minutes after reset of occurrence path.

Item		Cause	Action
			Confirmation of alarm reoccurrence after 5 minutes of reset. Check after product replacement.

FCC Regulatory Statement

FCC Part 15.19 Statements:	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.
FCC Part 15.105 statement (Class B- For household products)	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 or more 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 Part 15.21 statement	Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.
MPE distance	The antenna(s) must be installed such that a minimum separation distance of at least **28** cm (Wall installation) or **20** cm (Ceiling installation) is maintained between the radiator (antenna) and all persons at all times.
Responsible Party information	**Supplier's Declaration of Conformity** 47 CFR § 2.1077 Compliance Information **Unique Identifier**: (e.g., Trade Name, **Model Number**): flexAU10-3.55G-4TW **Responsible Party** – U.S. Contact Information Americas Compliance Consulting, LLC dba iCertifi 1001 SW Disk Drive, Suite 250, Bend, Oregon 97702 fccagent@icertifi.com