



WPON R1.1 solution

WPON Product Overview

3TG-00038-AAAA-TCZZA Issue: 01 August 2018

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1 Preface

This preface provides general information about the documentation for the Nokia WPON solution.

1.1 Scope

The documentation for the WPON solution provides information about safety, features and functionality, ordering, hardware installation and maintenance, and software installation procedures for the products in the current release of the WPON solution. The documentation for the WPON solution provides some information about configuring products in the WPON solution.

1.2 Audience

The documentation for the WPON solution is intended for planners, administrators, operators, and maintenance personnel involved in installing, upgrading, or maintaining the products that are part of the WPON solution.



Note — The HOU installation guide that is in the document set for the WPON solution has been prepared for use by subscribers if it is considered appropriate for them, rather than operational personnel, to install or replace an HOU. The HOU installation guide can be used by operational personnel as well.

1.3 Required knowledge

The reader must be familiar with general telecommunications principles.

1.4 Acronyms and initialisms

Expansions and optional descriptions of most acronyms and initialisms used in this document are provided in the glossary at the back of this document.

1.5 Assistance and ordering phone numbers

Nokia provides global technical support through regional call centers. Phone numbers for the regional call centers are available at the following URL:
<http://support.alcatel-lucent.com>.

For ordering information, contact your Nokia sales representative.

1.6 Nokia quality processes

Nokia's WPON quality practices are in compliance with TL 9000 requirements. These requirements are documented in the Fixed Networks Quality Manual 3FQ-30146-6000-QRZZA. The quality practices adequately ensure that technical requirements and customer end-point requirements are met. The customer or its representatives may be allowed to perform on-site quality surveillance audits, as agreed upon during contract negotiations

1.7 Safety information

For safety information, see the appropriate safety guideline chapters.

1.8 Documents

Documents are available from Nokia using ALED or OLCS.

Procedure 1 To download a ZIP file package of the customer documentation

- 1 Navigate to <http://support.alcatel-lucent.com> and enter your user name and password. If you are a new user and require access to this service, please contact your Nokia sales representative.
- 2 From the Technical Content for drop-down menu, choose the product.
- 3 Click on Downloads: Electronic Delivery.
- 4 Choose Documentation from the drop-down menu and click Next.
- 5 Select the image from the drop-down menu and click Next.
- 6 Follow the on-screen directions to download the file.

Procedure 2 To access individual documents

Individual PDFs of customer documents are also accessible through the Nokia Customer Support website.

-
- 1 Navigate to <http://support.alcatel-lucent.com> and enter your user name and password. If you are a new user and require access to this service, please contact your Nokia sales representative.
 - 2 From the Technical Content for drop-down menu, choose the product.
 - 3 Click on Manuals and Guides to display a list of customer documents by title and part number. You can filter this list using the Release drop-down menu.
 - 4 Click on the PDF to open or save the file.
-

1.9 Special information

The following are examples of how special information is presented in this document.



Danger — Danger indicates that the described activity or situation may result in serious personal injury or death; for example, high voltage or electric shock hazards.



Warning — Warning indicates that the described activity or situation may, or will, cause equipment damage or serious performance problems.



Caution — Caution indicates that the described activity or situation may, or will, cause service interruption.



Note — A note provides information that is, or may be, of special interest.

1.9.1 Steps with options or substeps

When there are options in a step, they are identified by letters. When there are required substeps in a step, they are identified by roman numerals.

Procedure 3 Example of options in a step

At step ¹, you must choose option a or b.

1 This step offers two options. You must choose one of the following:

- a** This is one option.
- b** This is another option.

2 You must perform this step.

Procedure 4 Example of required substeps in a step

At step ¹, you must perform a series of substeps within the step.

1 This step has a series of substeps that you must perform to complete the step. You must perform the following substeps: **i** This is the first substep. **ii** This is the second substep.

iii This is the third substep.

2 You must perform this step.

¹ 1.10 Multiple PDF document search

You can use Adobe Reader Release 6.0 and later to search multiple PDF files for a common term. Adobe Reader displays the results in a single display panel. The results are grouped by PDF file, and you can expand the entry for each file.



The PDF files in which you search must be in the same folder.

Procedure 5**To search multiple PDF files for a common term**

- 1

 - 2 Open Adobe Acrobat Reader.

 - 3 Choose Edit→Search from the Acrobat Reader main menu. The Search PDF panel appears.

 - 4 Enter the search criteria.

 - 5 Click on the All PDF Documents In radio button.

 - 6 Select the folder in which to search using the drop-down menu.

- Click on the Search button.
- Acrobat Reader displays the search results. You can expand the entries for each document by clicking on the + symbol.
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2 ETSI environmental and CRoHS guidelines

This chapter provides information about the ETSI environmental China Restriction of Hazardous Substances (CRoHS) regulations that govern the installation and operation of AP and HOU equipment. This chapter also includes environmental operation parameters of general interest.

2.1 Environmental labels

This section describes the environmental instructions that are provided with the customer documentation, equipment, and location where the equipment resides.

2.1.1 Overview

CRoHS is applicable to Electronic Information Products (EIP) manufactured or sold and imported in the territory of the mainland of the People's Republic of China. EIP refers to products and their accessories manufactured by using electronic information technology, including electronic communications products and such subcomponents as batteries and cables.

2.1.2 Environmental related labels

Environmental labels are located on appropriate equipment. The following are sample labels.

2.1.2.1 Products below Maximum Concentration Value (MCV) label

Figure 1 shows the label that indicates a product is below the maximum concentration value, as defined by standard SJ/T11363-2006 (Requirements for Concentration Limits for Certain Hazardous Substances in Electronic Information

Products). Products with this label are recyclable. The label may be found in this documentation or on the product.

Figure 1 **Products below MCV value label**



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2.1.2.2 Products containing hazardous substances above Maximum Concentration Value (MCV) label

Figure 2 shows the label that indicates a product is above the maximum concentration value, as defined by standard SJ/T11363-2006 (Requirements for Concentration Limits for Certain Hazardous Substances in Electronic Information Products). The number contained inside the label indicates the Environment-Friendly User Period (EFUP) value. The label may be found in this documentation or on the product.

Figure 2 **Products above MCV value label**

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Together with major international telecommunications equipment companies, Nokia has determined it is appropriate to use an EFUP of 50 years for network infrastructure equipment and an EFUP of 20 years for handsets and accessories. These values are based on manufacturers' extensive practical experience of the design, manufacturing, maintenance, usage conditions, operating environments, and physical condition of infrastructure and handsets after years of service. The values reflect minimum values and refer to products operated according to the intended use conditions. See "[Hazardous Substances Table \(HST\)](#)" for more information.

2.2 Hazardous Substances Table (HST)

This section describes the compliance of the AP and HOU equipment to the CRoHS standard when the product and subassemblies contain hazardous substances beyond the MCV value. This information is found in this user documentation where part numbers for the product and subassemblies are listed. It may be referenced in other documentation that describes the AP or HOU equipment.

In accordance with the People's Republic of China Electronic Industry Standard Marking for the Control of Pollution Caused by Electronic Information Products (SJ/T11364-2006), customers may access the Nokia Hazardous Substance Table, in Chinese, from the following location:

- <http://www.alcatel-sbell.com.cn/wwwroot/images/upload/private/1/media/ChinaRoHS.pdf>

2.3 Other environmental requirements

Observe the following environmental requirements when handling AP or HOU equipment.

2.3.1 Environmental requirements

See chapter 6 in this guide for more information about temperature ranges for the AP equipment and other AP specifications.

See chapter 7 in this guide for more information about temperature ranges for the HOU equipment and other HOU specifications.

2.3.2 Storage

According to ETS 300-019-1-1 - Class 1.1, storage of AP and HOU equipment must be in Class 1.1, weather-protected, temperature-controlled locations.

2.3.3 Transportation

According to EN 300-019-1-2 - Class 2.3, transportation of AP and HOU equipment must be in packed, public transportation with no rain on packing allowed.

2.3.4 Stationary use

According to EN 300-019-1-3 - Class 3.1/3.2/3.E, stationary use of AP and HOU equipment must be in a temperature-controlled location, with no rain allowed, and with no condensation allowed.

2.3.5 Thermal limitations

The thermal limitations for the AP and HOU equipment are:

- operating temperature (ambient): -30°C to 65°C (-22°F to 149°F)

- operating relative humidity: 5% to 85%
- short-term relative humidity: 5% to 95%, but not to exceed 0.024 kg of water/kg (0.85 oz of water/lb)

2.3.6 Material content compliance

European Union (EU) Directive 2002/95/EC, “Restriction of the use of certain Hazardous Substances” (RoHS), restricts the use of lead, mercury, cadmium, hexavalent chromium, and certain flame retardants in electrical and electronic equipment. This Directive applies to electrical and electronic products placed on the EU market after 1 July 2006, with various exemptions, including an exemption for lead solder in network infrastructure equipment. Nokia products shipped to the EU after 1 July 2006 comply with the EU RoHS Directive.

Nokia has implemented a material/substance content management process. The process is described in: Nokia process for ensuring RoHS Compliance (1AA002660031ASZZA). This ensures compliance with the European Union Directive 2011/65/EU on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS2). With the process equipment is assessed in accordance with the Harmonised Standard EN50581:2012 (CENELEC) on Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances.

2.3.7 End-of-life collection and treatment

Electronic products bearing or referencing the symbol shown in Figure 3, when put on the market within the European Union (EU), shall be collected and treated at the end of their useful life, in compliance with applicable EU and local legislation. They shall not be disposed of as part of unsorted municipal waste. Due to materials that may be contained in the product, such as heavy metals or batteries, the environment and human health may be negatively impacted as a result of inappropriate disposal.



Note — In the European Union, a solid bar under the symbol for a crossed-out wheeled bin indicates that the product was put on the market after 13 August 2005.

Figure 3 Recycling/take back/disposal of product symbol



At the end of its life, AP and HOU equipment is subject to the applicable local legislations that implement the European Directive 2012/19EU on waste electrical and electronic equipment (WEEE).

There can be different requirements for collection and treatment in different member states of the European Union.

In compliance with legal requirements and contractual agreements, where applicable, Nokia will offer to provide for the collection and treatment of Nokia products bearing the logo shown in Figure 3 at the end of their useful life, or products displaced by Nokia equipment offers. For information regarding take-back of equipment by Nokia, or for more information regarding the requirements for recycling/disposal of product, contact your Nokia account manager or Nokia take back support at sustainability.global@nokia.com.

3 ETSI safety guidelines

This chapter provides information about the mandatory regulations that govern the installation and operation of AP and HOU equipment in the ETSI market.

3.1 Safety instructions

This section describes the safety instructions that are provided in the customer documentation and on the AP and HOU equipment.

3.1.1 Safety instruction boxes

The safety instruction boxes are provided in the AP and HOU customer documentation. Observe the instructions to meet safety requirements.

The following is an example of the Danger box.



Danger — Possibility of personal injury.

The Danger box indicates that the described activity or situation may pose a threat to personal safety. It calls attention to a situation or procedure which, if not correctly performed or adhered to, may result in death or serious physical harm.

Do not proceed beyond a Danger box until the indicated conditions are fully understood and met.

The following is an example of the Warning box.



Warning 1 — Possibility of equipment damage.

Warning 2 — Possibility of data loss.

The Warning box indicates that the described activity or situation may, or will, cause equipment damage, loss of data, or serious performance problems. It identifies a possible equipment-damaging situation or provides essential information to avoid the degradation of system operations or data.

Do not proceed beyond a warning until the indicated conditions are fully understood and met.

The following is an example of the Caution box.



Caution 1 — Possibility of service interruption.

Caution 2 — Service interruption.

The Caution box indicates that the described activity or situation may, or will, cause service interruption.

Do not proceed beyond a caution until the indicated conditions are fully understood and met.

The following is an example of the Note box.



Note — Information of special interest.

The Note box provides information that assists the personnel working with AP or HOU equipment. It does not provide safety-related instructions.

3.1.2 Safety-related labels

The AP and HOU equipment is labeled with the specific safety instructions and compliance information that is related to a product, or product variant, of the equipment. Observe the instructions on the safety labels.

Table 1 provides sample safety labels on AP and HOU equipment.

Table 1 **Safety labels**

Description	Label text
ESD warning	Caution: This assembly contains an electrostatic sensitive device.

3.2 Safety standards compliance

This section describes AP and HOU equipment compliance with the European safety standards.

3.2.1 EMC compliance

The AP and HOU equipment complies with the following EMC requirements:

- Electromagnetic compatibility of multimedia equipment - Emission requirements CISPR 32, EN 55032
- Electromagnetic compatibility of multimedia equipment - Immunity requirements CISPR 35, EN55035
- Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU EN 301489-1
- Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 17: Specific conditions for Broadband Data Transmission Systems; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU EN 301489-17

3.2.2 Equipment safety standard compliance

The AP and HOU equipment complies with the requirements of the following:

- EN 60950-1, Safety of Information Technology Equipment for use in a restricted location (per R-269)
- IEC 60950-22, EN 60950-22: Information Technology Equipment- Safety - Part 22 Equipment to be installed Outdoors



Caution, hot surface



3.2.3 Environmental standard compliance

The AP and HOU equipment complies with the EN 300 019 European environmental standards.

3.2.4 Laser product standard compliance

The AP and HOU equipment is not a laser product.

3.3 Electrical safety guidelines

This section provides the electrical safety guidelines for the AP and HOU equipment.



Note 1 — The AP and HOU equipment complies with the U.S. National Electrical Code. However, local electrical authorities have jurisdiction when there are differences between the local and U.S. standards.

Note 2 — The AP and HOU equipment complies with BS EN 61140.

3.3.1 Power supplies

The use of any non-Nokia approved power supplies or power adapters is not supported or endorsed by Nokia. Such use will void any warranty or support contract with Nokia. Such use greatly increases the danger of damage to equipment or property.

3.3.2 Cabling

The following are the guidelines regarding cables used for the AP and HOU equipment:

- All cables must be approved by the relevant national electrical code.
- Cables for connection to the AP equipment must be suitable for outdoor use.
- Cables for outdoor connection to the HOU equipment must be suitable for outdoor use.
- The HOU equipment must be used with the cabling supplied with the equipment.

3.3.3 Protective earth

Earthing and bonding of the AP and HOU equipment must comply with the requirements of local electrical codes.

3.4 ESD safety guidelines

The AP and HOU equipment is sensitive to ESD if opened. Operations personnel must observe the following ESD instructions when they handle the AP or HOU equipment.



Caution — This equipment is ESD sensitive if opened. Proper ESD protections should be used if you open the AP or HOU.

Service personnel are not required to wear wrist straps when performing normal installation or maintenance activities.

3.5 Environmental requirements

See chapter [6](#) in this guide for more information about temperature ranges for the AP equipment and other AP specifications.

See chapter [7](#) in this guide for more information about temperature ranges for the HOU equipment and other HOU specifications.

During operation in the supported temperature range, condensation inside the AP and HOU equipment caused by humidity is not an issue because the AP and HOU are sealed units.

4 ANSI safety guidelines

This chapter provides information about the mandatory regulations that govern the installation and operation of the AP and HOU equipment in the North American or ANSI market.

4.1 Safety instructions

This section describes the safety instructions that are provided in the customer documentation and on the AP and HOU equipment.

4.1.1 Safety instruction boxes in customer documentation

The safety instruction boxes are provided in the AP and HOU customer documentation. Observe the instructions to meet safety requirements.

The following is an example of the Danger box.



Danger — Possibility of personal injury.

The Danger box indicates that the described activity or situation may pose a threat to personal safety. It calls attention to a situation or procedure which, if not correctly performed or adhered to, may result in death or serious physical harm.

Do not proceed beyond a Danger box until the indicated conditions are fully understood and met.

The following is an example of the Warning box.



Warning 1 — Possibility of equipment damage.

Warning 2 — Possibility of data loss.

The Warning box indicates that the described activity or situation may, or will, cause equipment damage, loss of data, or serious performance problems. It identifies a possible equipment-damaging situation or provides essential information to avoid the degradation of system operations or data.

Do not proceed beyond a warning until the indicated conditions are fully understood and met.

The following is an example of the Caution box.



Caution 1 — Possibility of service interruption.

Caution 2 — Service interruption.

The Caution box indicates that the described activity or situation may, or will, cause service interruption.

Do not proceed beyond a caution until the indicated conditions are fully understood and met.

The following is an example of the Note box.



Note — Information of special interest.

The Note box provides information that assists the personnel working with AP or HOU equipment. It does not provide safety-related instructions.

4.1.2 Safety-related labels

The AP and HOU equipment is labeled with specific safety compliance information and instructions that are related to a product, or product variant, of the equipment. Observe the instructions on the safety labels.

Table 2 provides examples of the text in the various AP and HOU equipment safety labels.

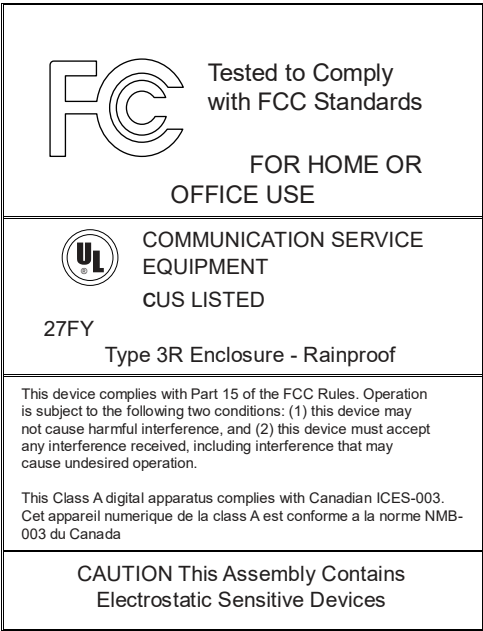
Table 2 **Safety labels**

Description	Label text
UL compliance	ETL/cETL
UL50E compliance	Type 3
ESD warning	Caution: This assembly contains electrostatic sensitive device.
FCC standards compliance	Tested to comply with FCC standards for home or office use.
Operation conditions	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.

CE marking	There are various CE symbols for CE compliance.
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Figure 4 shows a sample safety label for FCC and Figure 5 shows a sample safety label for ETL.

Figure 4 Sample safety label for FCC



18533

Figure 5 Sample safety label for ETL



27799

4.2 Safety standards compliance

This section describes the AP and HOU equipment compliance with North American safety standards.



Warning — Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

4.2.1 EMC, EMI, and ESD compliance

The AP and HOU equipment complies with the following EMC, EMI, and ESD requirements:

- Federal Communications Commission PART 15-RADIO FREQUENCY DEVICES Subpart C-INTENTIONAL RADIATORS Title 47 CFR Part 15. Part 15.247, Part 15.255

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 needed.
- Consult the dealer or an experienced radio/TV technician for help.

4.2.2 Equipment safety standard compliance

The AP and HOU equipment complies with the requirements of:

- UL62368-1, Outdoor ONTs to “Communication Service Equipment” (CSE) and Indoor ONTs to Information Technology Equipment (ITE)
- Information Technology Equipment- Safety - Part 22 Equipment to be installed Outdoors
- UL 60950-22

4.3 Electrical safety guidelines

This section provides the electrical safety guidelines for the AP and HOU equipment.



Note — The AP and HOU equipment complies with the U.S. National Electrical Code. However, local electrical authorities have jurisdiction when there are differences between the local and U.S. standards.

4.3.1 Power supplies

The use of any non-Nokia approved power supplies or power adapters is not supported or endorsed by Nokia. Such use will void any warranty or support contract with Nokia. Such use greatly increases the danger of damage to equipment or property.

4.3.2 Cabling

The following are the guidelines regarding cables used for the AP and HOU equipment:

- All cables must be approved by the relevant national electrical code.
- Cables for connection to the AP equipment must be suitable for outdoor use.
- Cables for outdoor connection to the HOU equipment must be suitable for outdoor use.
- The HOU equipment must be used with the cabling supplied with the equipment.

4.3.3 Protective earth

Earthing and bonding of the AP and HOU equipment must comply with the requirements of NEC article 250 or local electrical codes.

4.4 ESD safety guidelines

The AP and HOU equipment is sensitive to ESD if opened. Operations personnel must observe the following ESD instructions when they handle the AP or HOU equipment.



Caution — This equipment is ESD sensitive if opened. Proper ESD protections should be used if you open the AP or HOU.

Service personnel are not required to wear wrist straps when performing normal installation or maintenance activities.

4.5 Environmental requirements

See chapter [6](#) in this guide for more information about temperature ranges for the AP equipment and other AP specifications.

See chapter [7](#) in this guide for more information about temperature ranges for the HOU equipment and other HOU specifications.

During operation in the supported temperature range, condensation inside the AP and HOU equipment caused by humidity is not an issue because the AP and HOU are sealed units.

5 WPON solution overview

5.1 WPON solution

5.2 WPON topologies

5.3 WPON architecture

5.4 WPON services

5.5 WPON management

5.6 WPON planning considerations

5.7 Compatible CPE

5.1 WPON solution

The Nokia Wireless PON solution is an ideal technology for fixed operators to use as an alternative to a physical fiber drop. It provides a 60 GHz wireless drop for a PON or P2P-based optic network so that fiber optic cables are not used for connection to subscribers' homes. The WPON solution can be deployed tactically to provide ubiquitous coverage to service areas where fiber is impractical, or strategically for a whole service area as a lower-cost alternative to Gigabit fiber to the home.

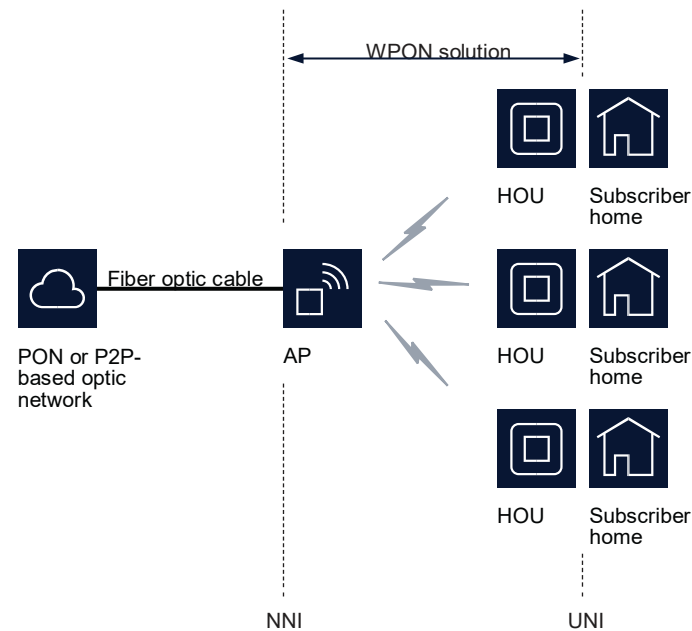
The WPON has an Access Point (AP) that physically connects to the PON or P2P-based optic network. The AP uses 1 Gbps wireless line-of-sight communication with up to eight Home Outdoor Units (HOUs) up to 100 m (328 ft) away per AP that provide Gigabit Ethernet connectivity to CPE inside the subscriber homes. Depending on certain deploy-ability conditions, the reach can be than 100 m (328 ft), but support for 1 Gbps is not guaranteed.

Connectivity from the AP to the PON, or 1 Gigabit Ethernet or 10 Gigabit Ethernet P2P-based optic network, is done through an SFP module that can be installed in the SFP cage of the AP. The SFP module can be an SFP ONT or a P2P optical Ethernet uplink SFP.

The WPON solution uses the 802.11ad standard to deliver ultra broadband access over short distances with limited interference between systems because of narrow beams and inherent propagation limitations of this standard.

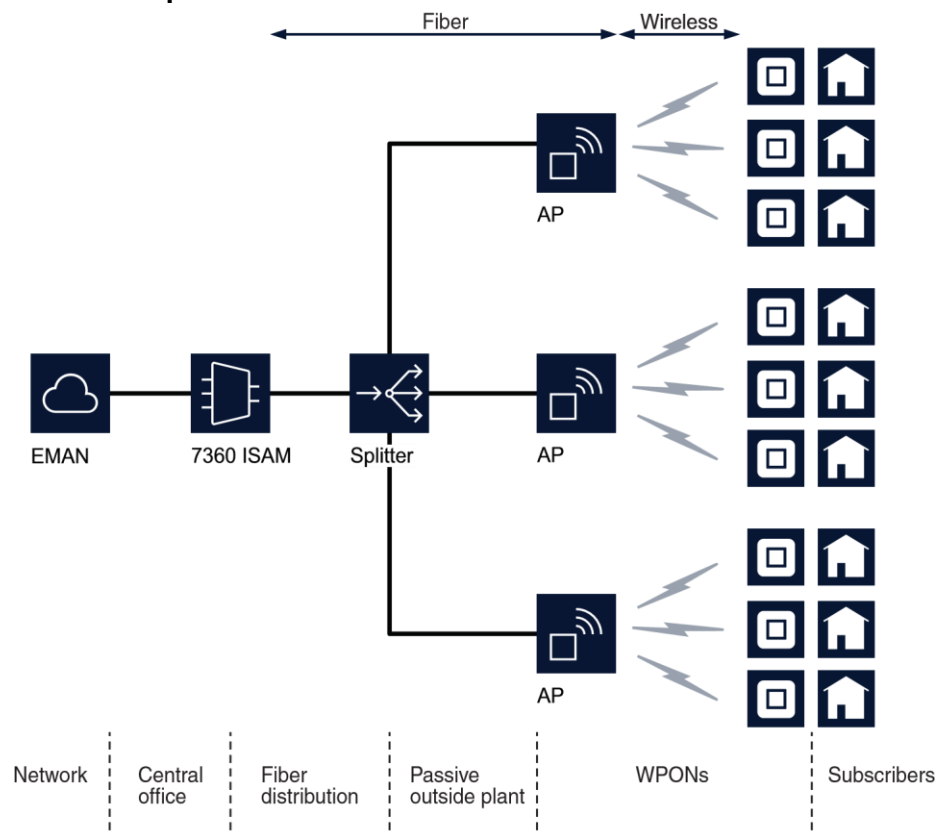
Figure 6 shows a high-level representation of the WPON solution providing a wireless drop from a PON or P2P-based optic network to three subscriber homes.

Figure 6 High-level representation of the WPON solution



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The WPON solution can be used with a fiber distribution network that includes the Nokia 7360 ISAM as shown in Figure 7; in this case, the WPON is deployed as an extension of the ISAM.

Figure 7 WPON example with a 7360 ISAM

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The WPON solution can also be used directly with a network that does not include an ISAM.

A PON or a P2P-based optic network can have multiple WPONs; for example, the EMAN that uses the 7360 ISAM shown in Figure 7 has three WPONs.

5.1.1 APs

An AP can be installed on a pole such as a utility pole or light pole, or on the outside of a building and uses 1 Gbps wireless line-of-sight communication with up to eight HOUs up to 100 m (328 ft) away; depending on certain deploy-ability conditions, the reach can be than 100 m (328 ft), but support for 1 Gbps is not guaranteed. The AP can be considered to be a directional multi-Gigabit access point. An AP contains a GPS and magnetometer, enabling it to report its location and orientation to the management system.

An AP can be a Head AP, Relay AP, or an Extension AP.

5.1.1.1 Head AP

The Head AP is an AP that is connected to a PON or P2P-based optic network; it provides the optical-to-wireless conversion for the WPON. Every WPON has a Head AP. Depending on the WPON topology, the Head AP might be the only AP in the WPON or it might have wireless connectivity to other APs in the WPON.

A pole-mounted Head AP can be connected to an Extension AP.

5.1.1.2 Relay AP

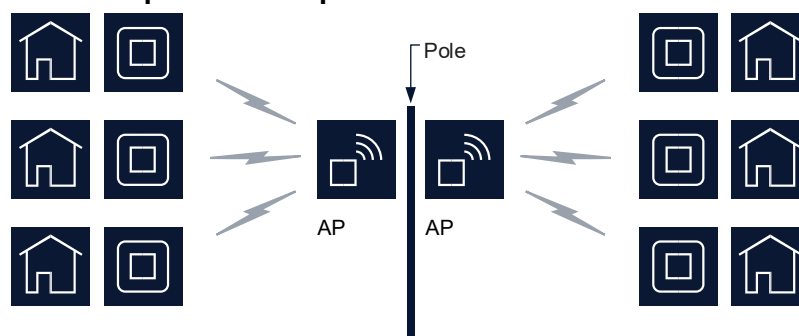
The Relay AP is an AP that has wireless connectivity to other APs in a WPON, either to the Head AP and/or to other Relay APs in the WPON. A Relay AP cannot be connected to a PON or P2P-based optic network.

A pole-mounted Relay AP can be connected to an Extension AP.

5.1.1.3 Extension AP

The Extension AP is an AP that does not have wireless connectivity to other APs in a WPON. It can be installed with a Head AP or Relay AP on a pole to provide wider wireless coverage, such as to HOU's on houses on both sides of a street. In this case the pair of APs are connected to each other through a 1 Gigabit electrical Ethernet cable that handles all the traffic between the two APs. Figure 8 shows an AP pair, with each AP of the AP pair employing wireless line-of-sight communication with three HOU's; the figure does not indicate which AP is the Head AP and which AP is the Extension AP.

Figure 8 Example of an AP pair



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An Extension AP cannot function as a Head AP or Relay AP.

5.1.2 HOUs

An HOU provides the wireless-to-Gigabit Ethernet electrical conversion for the WPON solution at the subscriber premises. An HOU can be considered to be a wireless station (STA). An HOU is installed on the outside of a subscriber's home and uses a UTP cat-5 electrical cable for physical connectivity to CPE such as a residential gateway inside the home. The same cable is used to provide power over Ethernet to the HOU, using power provided by the CPE or from a Nokia-approved PoE injector. An HOU contains a GPS and magnetometer, enabling it to report its location and orientation to the management system.

The HOU is easy to install and may be installed or replaced by subscribers if considered appropriate.

After physical installation and power up, an HOU automatically connects to the best AP available, reports its presence, gets configured, and initiates service per the customer subscribed service type.

5.1.3 APs and HOUs in WPONs

At a minimum, a WPON consists of one AP and at least one HOU.

A WPON has a single NNI point at the optical connection point of the AP with the PON or P2P-based optic network. This AP is the Head AP.

A WPON can have multiple UNI points, one at each HOU that is part of the WPON.

The number and types of APs and HOUs in a WPON depends on the topology used for the WPON. See section [5.2](#) for more information about WPON topologies.

5.2 WPON topologies

The WPON solution can be set up in the following topologies:

- basic WPON topology
- wireless daisy chain topology

5.2.1 Basic WPON topology

The basic WPON topology consists of a single AP or AP pair that connects to the PON or P2P-based optic network and provides wireless communications to HOUs through wireless line-of-sight communication. The topology shown in Figure [6](#) is an example of the basic WPON topology. The network shown in Figure [7](#) has three basic WPONs.

The basic WPON topology requires a Head AP to connect to the fiber optic network; the Head AP may also connect to an Extension AP. The basic WPON topology does not have Relay APs.

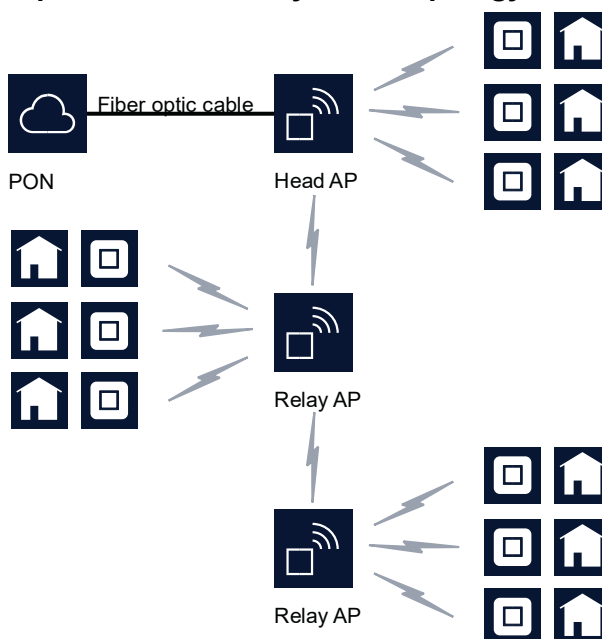
5.2.2 Wireless daisy chain topology

A WPON can be set up in a linear or a branched, non-looped, daisy chain topology so that APs can use line-of-sight wireless communication with other APs in the WPON. A Head AP is connected to the PON or P2P-based optic network; the other APs in the daisy chain are Relay APs. The fiber optical connection at the Head AP supports all the subscribers that are served by all the APs in the daisy chain. Each Relay AP in the daisy chain automatically uses self backhaul so that all upstream traffic is transmitted to the PON or P2P-based optic network through the Head AP. A total of three APs, including the Head AP, with a maximum of two hops, can be supported in a daisy chain topology. Extension APs are not included as APs and are not included in the hop count.

In a linear daisy chain topology, an AP communicates with one direct downstream AP. In a branched daisy chain topology, an AP communicates with more than one direct downstream AP.

The Head AP can use wireless line-of-sight communication with up to two downstream Relay APs and up to eight HOU. A Relay AP can use wireless line-of-sight communication with up to two APs (including one upstream AP, which could be the Head AP or another Relay AP), and up to eight HOU for a maximum of three APs in total in the daisy chain topology. The Relay AP can also function as a connection between two APs without connecting to any HOU.

Figure 9 shows a linear daisy chain that has two Relay APs. Each of the APs in the example has wireless communications with three HOU.

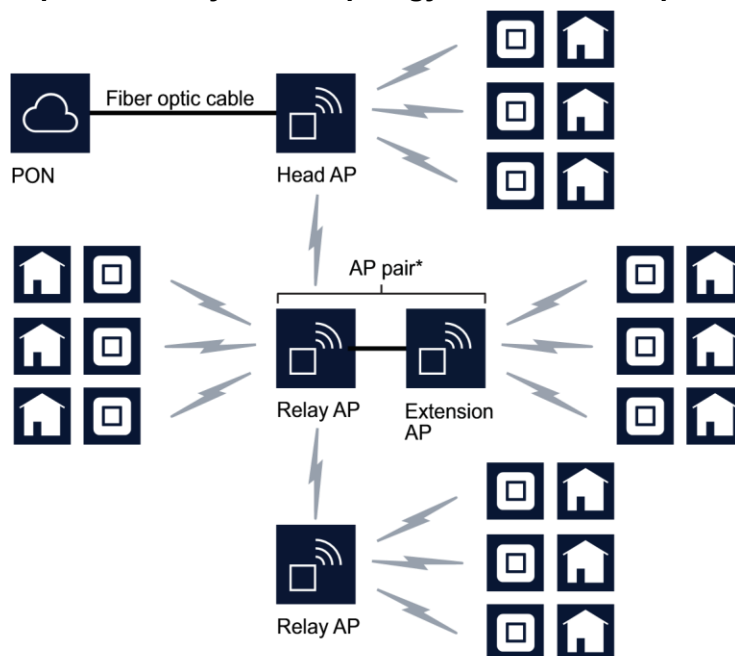
Figure 9 Example of a linear daisy chain topology

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Note — APs to be used in a daisy chain must be ordered from Nokia for use as a Head AP or as Relay APs.

If an AP pair is used in a daisy chain, the Extension AP is not part of the daisy chain. Figure 10 shows an example of a daisy chain that has a Relay AP that is part of an AP pair.

Figure 10 Example of a daisy chain topology that has an AP pair

*The Extension AP is not part of the daisy chain

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5.3 WPON architecture

A WPON is made up:

- an underlay network
- one or more overlay networks

5.3.1 Underlay network

The underlay network serves as an IP-based network that provides connectivity between all the APs and HOU's in the WPON. The underlay network uses RIP for route distribution and routing for the APs and HOU's using IP addresses that are assigned by a private DHCP server hosted in the Head AP.

The Head AP has an internal DHCP server that is private and delivers IP addresses to the HOU's. Other APs perform DHCP relay. The IGMP proxy function is in the Head AP,

A WPON has a single underlay network.

The underlay network is managed through the WPON manager. See section [5.5.1](#) for more information about the WPON manager.

5.3.2 Overlay network

The overlay network is a virtual network that provides L2 connectivity between an HOU and its associated AP through the use of a GRE tunnel. The overlay network provides logical P2P connectivity on top of the underlay network. The WPON solution behaves like a L2 network where Ethernet frames are cross connected on a tagged VLAN basis between the NNI (which is an AP) and UNI (which is an HOU).

A WPON has an overlay network for each HOU in the WPON.

If an HOU is associated with an AP that is part of a basic WPON topology, the AP (which is a Head AP) and the HOU function as a Layer 2 switch with the AP being the NNI point and a GRE tunnel endpoint and with the HOU being the UNI point and the other GRE tunnel endpoint.

The GRE tunnel is always setup between the Head AP and UNI port, regardless of the WPON topology used.

A GRE tunnel carries Ethernet frames both directions between the HOU and AP. Each HOU has a private IP address and an X.509 certificate. The Head AP has a private DHCP server to assign internal IP addresses, with each wireless segment having its own subnet. In the AP, the remote IP address is unspecified and learned dynamically, and each GRE tunnel in the WPON is assigned a unique key. The DSCP field of the IP header of the GRE tunnel packets is used to preserve QoS inside the WPON. The DSCP values match the traffic class to which the flow carried inside is mapped. On the wireless interfaces, queue selection is done based on the DSCP values.

For multicast traffic, an IGMP proxy is used in the AP to dynamically build the multicast forwarding tree so that multicast traffic is passed to the GRE tunnels for delivery to the HOUs.

In the downstream direction, the AP transmits only subscriber-specific traffic (including multicast traffic that the subscriber subscribes to) over the overlay network to the associated HOU (that is, it is the AP, not the HOU, that differentiates traffic that is not intended for the subscriber associated with each HOU, for example, traffic with an unknown destination or traffic destined for other stations associated with the AP).

APs use priority queues on a weighted fair queuing basis to ensure that each HOU gets a fair share of the bandwidth (upstream and downstream).

Overlay networks, including GRE tunnels, are created and managed through the WPON manager. See section [5.5.1](#) for more information about the WPON manager.

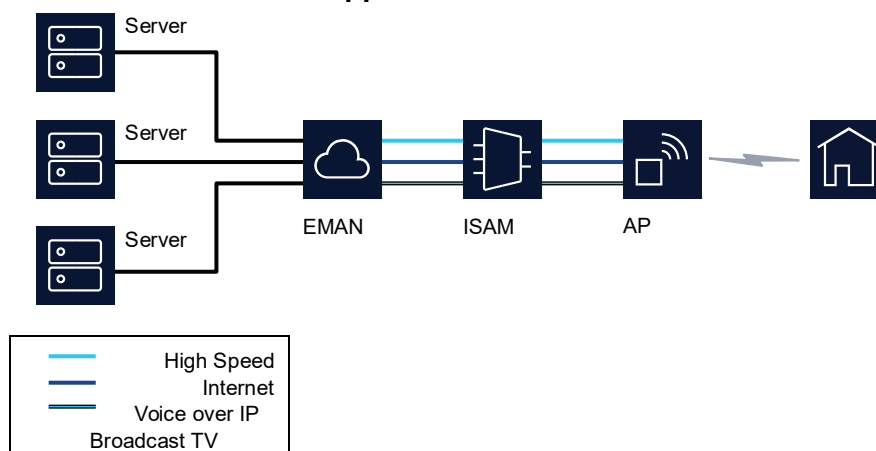
5.4 WPON services

The WPON solution supports the following services:

- high speed Internet
- voice over IP
- broadcast TV

Figure 11 shows an example of a WPON supporting all three of the above services when the WPON is deployed as an extension of an ISAM.

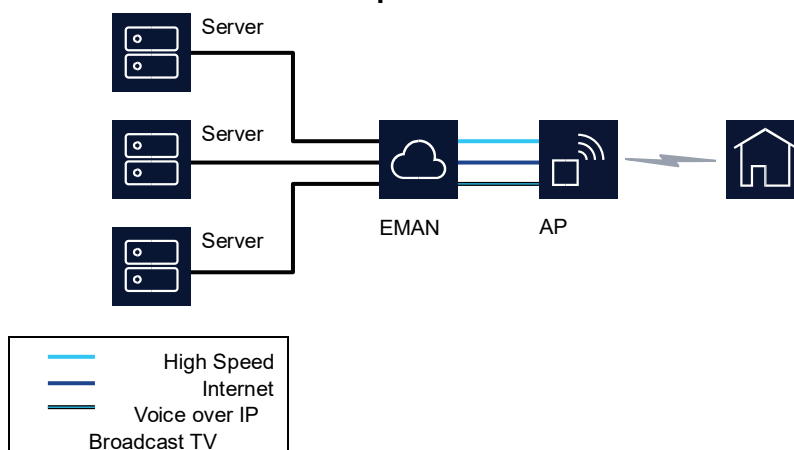
Figure 11 WPON service support with an ISAM



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Figure 12 shows an example of a WPON supporting all three of the above services when the WPON is deployed independently of an ISAM to provide layer 2 service.

Figure 12 WPON service independent an ISAM



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The WPON transports the above three services, meaning that they are transparent to the WPON. The WPON can support a voice service, but this requires an external solution.

5.5 WPON management

The following are used for management of the WPON solution:

- WPON manager (section [5.5.1](#))
- Nokia Altiplano (section [5.5.2](#))
- Bluetooth (section [5.5.3](#))

5.5.1 WPON management through the WPON manager

The WPON manager is based on the Altiplano Management System (described in section [5.5.2](#)) and it provides web server management for the WPON solution. The WPON manager serves as the element manager for the WPON and allows you to configure the following:

- equipment deployment, specifically provisioning of the basic infrastructure such as hardware components of APs and HOU in a WPON, including device management configurations, targeted software version, and the interface to the PON or P2P optical network
- the underlay network of a WPON, specifically provisioning of the wireless and/or Ethernet interfaces of APs and HOU, including IP addresses and underlying network routing aspects
- the overlay networks of a WPON, specifically provisioning of loopback interfaces, provisioning GRE tunnels by creating GRE tunnel endpoints in the WPON, and creating services

The WPON manager:

- provides abstractions for service provisioning across the various elements in a WPON
- is responsible for monitoring the health of the various elements in a WPON as well as monitoring the health of services provisioned on them
- is responsible for management of the GRE tunnels in a WPON
- is responsible for IP address assignment for the underlay network and configuration of DHCP services in the private DHCP server of the Head AP for dynamic IP assignment for all other elements in the WPON
- controls the entire QoS configuration

The WPON manager provides a GUI that provides the following:

- device list, with information such as name, type, connection status, alignment status, and health for each AP and HOU in the WPON
- topology history that shows information such as topology version, timestamp, and user name and allows you to view a graphical comparison of topology versions of the WPON
- network list that provides the AP name, interface name, interface mode, IP address, and subnet for each WPON

The WPON manager is provided as an extension or plug-in as part of the Altiplano. When you create and provision APs and HOUs and create GRE tunnels and services through the WPON manager, the information is passed to the Altiplano. See section [5.5.2](#) for more information about the Altiplano.

5.5.2 WPON management through the Nokia Altiplano

The Nokia Altiplano is a cloud-native access platform that consists of two products:

- the Nokia Altiplano Access Controller: • The Access Controller is the domain controller for unified management of both SDN and traditional access networks. It offers a wide range of APIs and tools, such as field force, service fulfillment, service assurance and task center applications that help to visualize, automate, optimize and enhance the network. It provides automation, easy integration with the OSS/BSS and flexible programming of end-to-end services in the access network.
- The Access Controller automates the network and provides software management, backup and restore, and alarm collection functions
- the Nokia Altiplano Access Virtualizer: •The Access Virtualizer is the cloud component that creates a virtualized and centralized view of the network in the cloud. It offers the logic and primitives for efficiently programming and monitoring the underlying network elements, without having to deal with challenges such as node reachability and scalability when connecting to hundreds of thousands of nodes.
- The Access Virtualizer programs nodes and provides a persistent management agent (PMA) function for the APs and HOUs in each WPON, and acts as a persistent management agent aggregator towards the WPON manager; the persistent management agent provides disaggregation of the management layer and abstraction of the WPON via standard YANG models

The Altiplano provisions APs and HOUs in response to call-home messages sent by the APs and HOUs to it after they have been created and provisioned through the WPON manager.

5.5.3 WPON management through Bluetooth

Local craft terminal access for APs and HOUs is provided through a Bluetooth interface (classical Bluetooth, reach greater than 20 m (65.6 ft)) on the AP or HOU.

The Bluetooth interface provides access to a Bluetooth server that is used for local management of the AP or HOU through an app on a Bluetooth-equipped mobile phone that can be used as a local terminal to access the AP or HOU for on-site configuration, troubleshooting, or maintenance.

The app is a Native Mobile Application, which can assist in troubleshooting the AP and HOU in case the connection towards the WPON manager is broken.

Connection between the mobile phone and the AP or HOU is established over Bluetooth with a Personal Area Network (PAN) Profile using the MAC address. The MAC address is retrieved from Quick Response (QR) code during QR scanning of the AP or HOU.

The user logs in to the app using a default password that should be changed immediately for security reasons via the Nokia Altiplano (PMA). After first login, the password is securely stored (hashed) on the mobile phone, so credentials do not need to be provided by the user in upcoming logins.

The app offers the possibility of performing different setup and troubleshooting actions, such as setup of the AP or HOU, setting the time of day, displaying some statistics, and performing resets, including to factory settings. The app can be used to display the MAC address, serial number, and product type.

The app allows you to upload Certificate Authority (CA) certificates to the AP and HOU from the mobile device. Uploading can be done by selecting the option **Upload CA certificates** from the app main screen after successful login has taken place. The app user must first manually download the certificates into the Download folder on the mobile device before they can be uploaded to the WPON devices. Only the following CA certificate names are valid for uploading to the WPON devices:

- pmaCA.pem
- radiusCA.pem
- logserverCA.pem

If the downloaded CA certificates do not adhere to these naming rules, the app user must manually rename the files prior to uploading them so that the files upload successfully.

See section [9.1.1](#) in this document for information about using the Bluetooth interface to configure an AP.

See section [9.2.1](#) in this document for information about using the Bluetooth interface to configure an HOU.

5.6 WPON planning considerations

WPON planning considerations include the following:

- planing the network:

- network topology of the APs and HOU
- address pool for the Head AP in the public DHCP server
- IP route from Head AP's address to the WPON manager needs be configured; the correct gateway address also be configured in the DHCP pool in the public DHCP server
- Public DHCP server, RADIUS server and the WPON manger need to be deployed correctly; the following are important:
 - the public DHCP server is configured for Option 125 for the WPON manager address and port and for Option 43 (vendor specific value) for all Head AP serial numbers
 - correct CA certificate is installed on RADIUS server, HTTPS file server (software image repository), and WPON manager for call home •correct software image is in the HTTPS file server
 - APs and HOU must have correct time and correct CA certificates
 - serial numbers need to be put into the WPON manager to be able to do the following:
 - preparation of configurations for AP and HOU for their serial number, setting work mode, L2/L3 configuration and WiGig configuration, update private DHCP server configuration in Head AP
 - for configuration of Option 43 in the public DHCP server for permitted access device (APs and HOU)
 - for all devices will be updated to the latest version from the WPON manager at the same time
 - for the operator to use the WPON manager to know whether the network topology is correctly deployed
 - the WPON manager needs to define the private DHCP server of the Head AP for configuration of Option 125 for the WPON manager address/port and Option 43 for all connected Relay APs, Extension APs, and HOU

5.7 Compatible CPE

The HOU supports connection of any VLAN tagging compatible residential gateway or router or similar Internet-access CPE that can connect to the HOU through the Cat5 Ethernet cable attached to the HOU.

An example of CPE that can connect to the HOU is the Nokia Beacon 1 (HA-020W-A) residential gateway.

The Cat5 Ethernet cable attached to the HOU also provides ground and PoE power to the HOU. If the CPE cannot provide PoE power to the HOU, a Nokia-approved PoE injector (PoE 802.3at/PoE+) will need to be used in conjunction with the CPE.

See chapter 7 for more information about the HOU and its physical connections.

6 AP unit data sheet

- 6.1 AP part numbers and identification
- 6.2 AP general description
- 6.3 AP software and installation feature support
- 6.4 Subscriber traffic interfaces on the AP
- 6.5 AP LED information
- 6.6 AP specifications
- 6.7 AP wireless specifications
- 6.8 Performance monitoring statistics
- 6.9 Functional blocks
- 6.10 AP standards compliance

6.1 AP part numbers and identification

Table 3 provides part numbers and descriptions for the APs.

Table 3 AP part numbers and descriptions

Part number	Description
3TG 00093 CA	This AP is designed to be used as an Extension AP in an AP pair on a pole. It has one Ethernet connection, a power connection, and one baseband unit. The baseband unit used is used for wireless connections to HOU's. This AP does not have any fiber optic connections and cannot be used as a Head AP to connect to a PON or P2P-based optic network. The Ethernet connection is used to connect to the other AP in an AP pair. It is local grid powered (48 VDC).



Note — APs to be used in a daisy chain must be ordered from Nokia for use as a Head AP or as Relay APs.

Table 4 provides a summary of the items provided in the AP kits.

Table 4 Items provided in the AP kits

Item	Kit for Head AP or Relay AP on a pole	Kit Extension AP on a pole	Kit for Head AP or Relay AP on a wall
AP	1	1	1
Ethernet cable		1	
RJ 45 connector		2	
Power adapter	1	1	1
SFP connector (only used for Head AP)	1		1
IP67 cap plug	2	1	2
Pole-mount bracket with AP mounting plate and pole adapter	1	1	
Wall-mount bracket with AP mounting plate			1
MAC label	1	1	1

Table 5 provides ordering information for AP accessories.

Table 5 Orderable AP accessories

Accessory	Orderable part number	Notes
SFP ONT	3FE 46541 AA	This is an SFP module to connect a Head AP to a PON. It is identified as G-010S-A.
P2P 1 Gigabit optical Ethernet uplink SFP	3FE 25774 AA	This is an SFP module to connect a Head AP to a P2P-based optical network with a 1 Gigabit optical Ethernet uplink.
P2P 10 Gigabit optical Ethernet uplink SFP	3FE 62600 AA	This is an SFP module to connect a Head AP to a P2P-based optical network with a 10 Gigabit optical Ethernet uplink.

6.2 AP general description

APs are designed to provide the optical-to-wireless conversion for the WPON solution by providing a fiber optic interface to the PON or P2P optical network along with providing wireless 180 degree line-of-sight communication with up to eight HOU's. Depending on the WPON topology, an AP can also provide wireless line-of-sight communication with other APs. See chapter 5 for more information about the WPON solution.

Connectivity from the AP to the PON or P2P-based optic network is done through an SFP module that can be installed in the SFP cage of the AP. The SFP module can be an SFP ONT or a P2P optical Ethernet uplink SFP.

On the wireless side, the AP uses 802.11ad supporting unlicensed 60 GHz mm Wave wireless line-of-sight communication with 1 Gbps peak speeds.

The AP is managed through the WPON manager and the Nokia Altiplano cloud-native access platform. A local craft terminal access point is provided on the AP through a Bluetooth interface (classical Bluetooth, reach greater than 20 m (65.6 ft)) for management through an app. See section 5.5 in this document for more information about management of the WPON solution.

The AP provides the following functions and features:

- optical to wireless conversion • wireless Gigabit Ethernet channels: • In North America: an AP uses two channels: one channel is used for interfaces to other APs, the other channel is used for the drop interface to HOU
- Outside North America: an AP uses three channels: two channels are used for interfaces to other APs, one channel is used for the drop interface to HOU
- in the downstream direction, the AP filters subscriber traffic and transmits it to the respective HOU (that is, the AP discards traffic that is not intended for the subscriber associated with the HOU)
- can be installed on a pole such as a utility pole or a light pole (fits multiple pole dimensions and geometries) or on the building facade
- daisy chain with other APs using self backhaul
- up to 1 Gbps aggregate capacity per HOU, supporting 1 Gbps peak speeds to up to eight HOU up to 100 m (328) away; depending on certain deploy-ability conditions, the reach can be than 100 m (328), but support for 1 Gbps is not guaranteed
- beam-forming antennas for fast and reliable wireless connection
- built-in different antenna configurations and applications
- wide field of view for antennas: 180 degrees horizontal and 60 degrees vertical
- PON or P2P optic fiber feed (uses an SFP module)
- single mode fiber (uses SC/APC connector)
- local grid DC powered (48 VDC)
- built-in GPS and magnetometer
- IP66 protected
- compact size
- X.509 certificate-based authentication • encryption over the air:
- WPA2-Enterprise
- IEEE 802.1X/EAP-TLS for mutual authentication
- data-confidentiality protocol GCMP, added as per 802.11ad amendment

6.3 AP software and installation feature support

AP software is managed through the WPON manager and the Nokia Altiplano; see section 5.5.1 for information about the WPON manager and section 5.5.2 for information about the Nokia Altiplano.

For information about installing or replacing an AP, see chapter 8 in this guide and see the *AP Installation Guide*. See section 5.5.3 in this document for information about managing the AP through its Bluetooth interface when installing or replacing an AP.

6.4 Subscriber traffic interfaces on the AP

Table 6 describes the supported subscriber traffic interfaces for the APs.

Table 6 AP subscriber traffic interfaces

AP	Number of interfaces		
	PON/P2P optic fiber	Ethernet ⁽¹⁾	Wireless ⁽²⁾
Head AP	One	One	Two: - one for drop to the HOU's - one for daisy chaining to one downstream AP
Relay AP	-	One	Three: - one for drop to the HOU's - one for daisy chaining to the upstream AP ⁽³⁾ - one for daisy chaining to one or more downstream AP's
Extension AP used in an AP pair	-	One	One for drop to the HOU's

Notes

⁽¹⁾ The Ethernet interface is only used for connecting two APs that make up an AP pair; AP pairs are only supported for pole-mount APs.

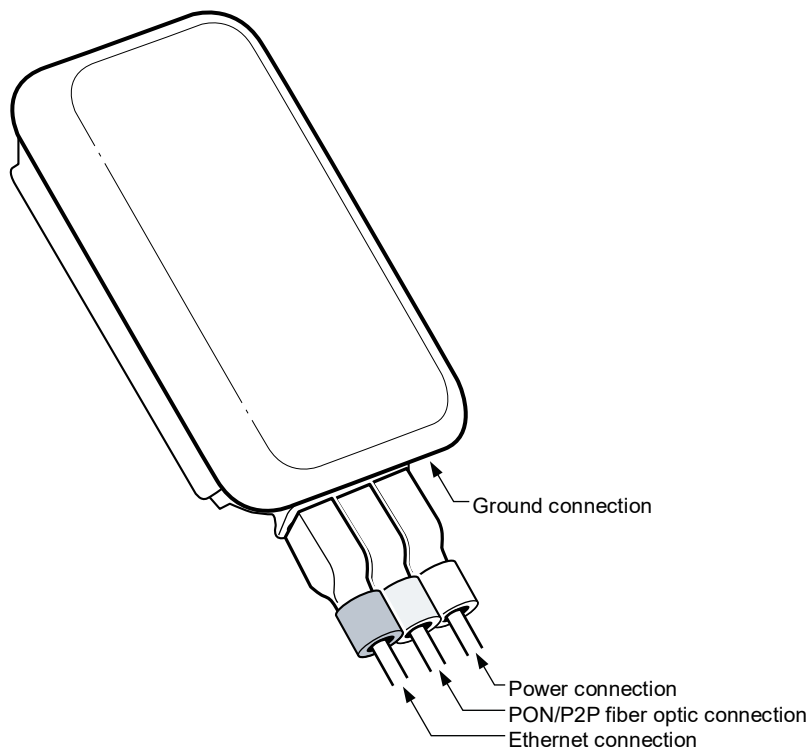
⁽²⁾ The wireless components are described in more detail in section 6.4.2.

⁽³⁾ The upstream AP can be a Rely AP or the Head AP.

6.4.1 AP physical connections and components

Figure 13 shows the AP physical connections and section 6.4.2 describes the wireless components.

Figure 13 AP physical connections



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Table 7 describes the AP physical connections and components.

Table 7 AP physical connections and components

Connection or component	Description
PON/P2P fiber optic connection	This connection is provided through single mode fiber optic cable with an SC/APC connector through an SFP ONT or a P2P optical Ethernet uplink SFP. This connection is provided on AP variants that support Head AP functionality; an IP67 cap plug is used if the connection is not supported.
Ethernet connection	This connection is provided through an RJ 45 connector. It is used for connecting two APs in an AP pair to each other through a 1 Gigabit electrical Ethernet cable. This connection is provided on AP variants that can be connected as an AP pair; an IP67 cap plug is used if the connection is not used.
Power connection	Connection to the local power grid (48 VDC) is provided through a power cable.
LED	Single multifunction LED See section 6.5 for information about the LED

(1 of 2)

Connection or component	Description
Ground connection	This connection uses an M5 screw

(2 of 2)

6.4.2 AP wireless components

Depending on the variant, the AP has wireless components that are used for the following:

- drop to HOU's:
- one baseband unit that has three single-tile 32-antenna/RF arrays that have a scan range of +/- 90° azimuth, +30°+x /-30°+x elevation, antenna tiles tilted upwards, providing total angle 180° azimuth and 60° elevation
- the 32-antenna/RF arrays use vertical polarization and are located at the center line of the AP
- daisy chaining to an upstream or downstream AP:
- two baseband units (one for upstream and the other for downstream)
- each baseband unit has a 64-antenna/RF array that is made up of two 32-antenna tiles and has a scan range of +/- 30° Azimuth, +/- 30° elevation, antenna tiles are not tilted
- the 64-antenna/RF arrays use horizontal polarization and are located towards the left and right sides of the AP
- for a wall-mounted AP, the antenna/RF arrays are angled 15° away from the wall

6.5 AP LED information

The AP has a single multi-color LED to signal alarms and states.

The LED is located at the bottom of the AP Table

8 describes the AP LED behavior.

Table 8 AP LED behavior description

LED color and behavior	LED behavior description
Red off	No alarm
Red flashing	Critical alarm
Red solid	Major alarm
Green off	OAM link is established

Green flashing slow	OAM link failure
---------------------	------------------

(1 of 2)

LED color and behavior	LED behavior description
Green flashing fast	Application startup
Green solid	Boot function

(2 of 2)

6.6 AP specifications

Table 9 lists the physical specifications for the AP.

Table 9 AP physical specifications

Dimensions	Specifications
Height	25.2 cm (9.9 in)
Width	16.6 cm (6.5 in)
Depth	8.0 cm (3.1 in)
Weight [within ± 0.23 kg (0.5 lb)]	1650 g (3.6 lb)

Table 10 lists power consumption specifications for the AP.

Table 10 AP power consumption specifications

AP	Maximum power (not to exceed)	Condition	Minimum power	Condition
Wall-mount Head or Relay	27 W	Maximum traffic load	17 W	No traffic load
Pole-mount Head or Relay	27 W	Maximum traffic load	17 W	No traffic load
Pole-mount Extension	19 W	Maximum traffic load	16 W	No traffic load

Table 11 lists the environmental requirements for the AP.

Table 11 AP environmental requirements

Mounting method	Temperature range and humidity	Altitude
Pole or on an outside wall	Operating: –30°C to 65°C (–22°F to 149°F) ambient temperature 5% to 85% relative humidity, non-condensing	Maximum operating altitude is 3048 m (10 000 ft) above mean sea level

	Storage: –40°C to 65°C (–40° to 149°F) 5% to 93% relative humidity, non-condensing	Maximum non-operating altitude is 12 192 m (40 000 ft) above mean sea level
--	--	---

6.7 AP wireless specifications

Table 12 lists the wireless specifications for the AP.

Table 12 Wireless specifications for the AP

Specification	Description
Base standard	802.11ad
Drop function	180° field of view thanks to multiple steerable beamforming high-gain patch antenna arrays
Frequency and duplexing	60GHz / TDD
Channels	1,2, 3 (center frequencies 58.32,60.48, 62.64 GHz)
Aggregate throughput	1.5 gbps (PHY rate) drop up to 100 m (328 ft)
System gain (link budget)	18 dBi
HPBW	14°

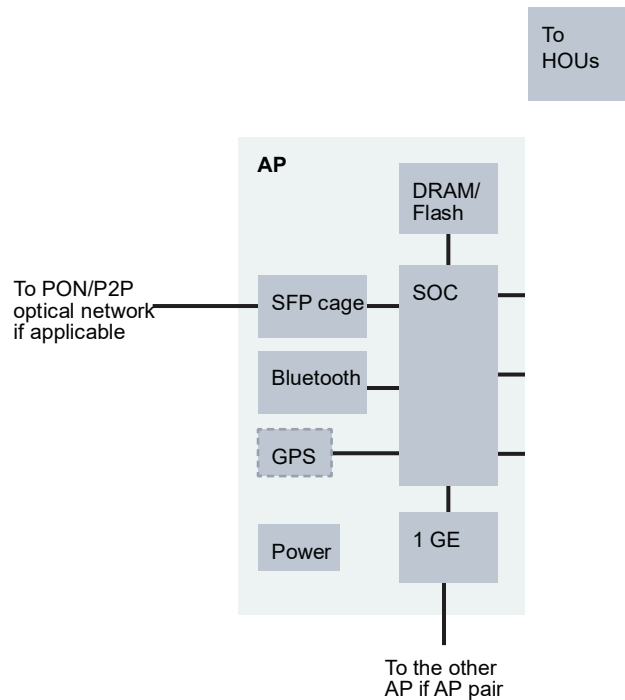
6.8 Performance monitoring statistics

WiGig statistics can be checked through the Bluetooth interface during installation of the AP.

6.9 Functional blocks

Figure 14 shows the functional blocks for an AP. Note that not all functional blocks are used in all AP variants:

- a Head AP does not use the upstream antenna/RF block • a Relay AP does not connect to a fiber optic cable
- an Expansion AP does not:
- use upstream and downstream antenna/RF blocks
- connect to a fiber optic cable
- the 1.0 G Ethernet block is only used if the AP is part of an AP pair; a UTP cat-5 cable is used for the connection between the two APs

Figure 14 Functional blocks of an AP

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6.10 AP standards compliance

The APs are compliant with the following standards:

- Environmental: IP 66, full sunload, ETSI class 4.1E, ANSI NEBS GR-487 core
- EN-300019-2-1 (Class T1.2)
- EN-300019-2-2 (Class T2.3)
- EN-300019-2-3 (Class T3.2))
- ETL
- FCC (Class B)/CAN ICES-003
- IEEE 802.11ad
- ITU-T G.984 (GPON interface framing)
- ITU-T G.984.2 (1.25 Gbps, 2.5 Gbps)
- ITU-T G.984.3 (activation with automatic discovery of a serial number and a password)

- ITU-T G.984.4 (standard and revised) (OMCI interface for management and provisioning) (done by an SFP ONT installed in the fiber optic connection point of a Head AP)
- Electromagnetic compatibility of multimedia equipment - Emission requirements CISPR 32, EN 55032
- Electromagnetic compatibility of multimedia equipment - Immunity requirements CISPR 35, EN55035
- Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU EN 301489-1
- Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 17: Specific conditions for Broadband Data Transmission Systems; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU EN 301489-17
- EN 60950-1, Safety of Information Technology Equipment for use in a restricted location (per R-269)
- IEC 60950-22, EN 60950-22: Information Technology Equipment- Safety - Part 22 Equipment to be installed Outdoors
- EN 300 019 European environmental standards
- Federal Communications Commission PART 15-RADIO FREQUENCY DEVICES
Subpart C-INTENTIONAL RADIATORS Title 47 CFR Part 15. Part 15.247, Part 15.255
- UL62368-1, Outdoor ONTs to “Communication Service Equipment” (CSE) and Indoor ONTs to Information Technology Equipment (ITE)
- Information Technology Equipment- Safety - Part 22 Equipment to be installed Outdoors
- UL 60950-22

6.10.1 Energy-related products standby and off modes compliance

Hereby, Nokia declares that the APs are in compliance with the essential requirements and other relevant provisions of Directive 2009/125/EC together with Commission Regulation (EC) No 1275/2008 and Commission Regulation (EC) No 801/2013.

The APs qualify as equipment with high network availability (HiNA) functionality. Since the main purpose of the APs is to provide network functionality with HiNA 7 days /24 hours, the modes Off/Standby, Power Management, and Networked Standby are inappropriate.

For information about the type and number of network ports, see [“Subscriber traffic interfaces on the AP”](#) in this chapter.

For information about power consumption, see [“AP specifications”](#) in this chapter.

7 HOU unit data sheet

- 7.1 HOU part numbers and identification
- 7.2 HOU general description
- 7.3 HOU software and installation feature support
- 7.4 Subscriber traffic interfaces on the HOU
- 7.5 HOU LED information
- 7.6 HOU specifications
- 7.7 HOU wireless specifications
- 7.8 Performance monitoring statistics
- 7.9 Functional blocks
- 7.10 HOU standards compliance

7.1 HOU part numbers and identification

Table 13 provides part numbers and descriptions for the HOU.

Table 13 HOU part numbers and descriptions

Part number	Description
3FE 47795AA	HOU with one baseband unit and one Gigabit Ethernet port. The baseband unit is used for wireless connection to an AP. The Gigabit Ethernet port is used for connection to CPE, such as a residential gateway, through a pre-attached 3 m (9.8 ft) Cat5 cable. The HOU is PoE-powered through the Cat5 cable. If required, an additional Cat5 cable can be attached to the first Cat5 cable to increase its length, to a maximum combined length of 100 m (328 ft).

7.2 HOU general description

An HOU provides the wireless-to-Gigabit Ethernet electrical conversion for the WPON solution at the subscriber premises. The HOU is installed on the facade of a subscriber's home and uses a pre-attached Cat5 cable to physically connect to the CPE, such as a residential gateway, inside the home. See chapter 5 for more information about the WPON solution.

On the wireless side, the HOU is compliant with 802.11ad DMG STA supporting unlicensed 60 GHz mm Wave wireless line-of-sight communication with 1 Gbps

peak speeds up to 100 m (328 ft). Depending on certain deploy-ability conditions, the reach can be than 100 m (328 ft), but support for 1 Gbps is not guaranteed.

The HOU is managed through the WPON manager and the Nokia Altiplano cloud-native access platform. A local craft terminal access point is provided on the HOU through a Bluetooth interface (classical Bluetooth, reach greater than 20 m (65.6 ft)) for management through an app. See section 5.5 for more management information.

The HOU provides the following functions and features:

- wireless-to-Gigabit Ethernet conversion
- automatically connects to the best AP available, reports its presence, gets configured, and initiates service per the customer subscribed service type
- beam-forming antennas for fast and reliable wireless connection
- wide field of view for antennas (180 degrees horizontal and 60 degrees vertical) means there is no need to aim the antenna • installed on the facade of a subscriber's home
- Ethernet connectivity and POE power: • provides symmetrical Ethernet connectivity at Gigabit speeds to CPE over a pre-attached Cat5 cable
- PoE-powered over the pre-attached Ethernet cable; the cable attaches to the CPE or to a Nokia-approved PoE injector (PoE 802.3at/PoE+)
- built-in GPS and magnetometer
- IP66 protected
- compact size means that it is barely noticeable on building • X.509 certificate-based authentication • encryption over the air:
- WPA2-Enterprise
- IEEE 802.1X/EAP-TLS for mutual authentication
- data-confidentiality protocol GCMP, added as per 802.11ad amendment

7.3 HOU software and installation feature support

HOU software is managed through the WPON manager based on the Nokia Altiplano Management System; see section 5.5 in this document for information about the WPON manager and Nokia Altiplano.

For information about installing or replacing an HOU, see chapter 8 in this guide and see the *HOU Installation Guide*. See section 5.5.3 in this document for information about managing the HOU through its Bluetooth interface when installing or replacing an HOU.

Note that the HOU is easy to install and may be installed or replaced by the subscriber if considered appropriate. The *HOU Installation Guide* has been prepared for use by subscribers as well as for use by operational personnel.

7.4 Subscriber traffic interfaces on the HOU

Table 14 describes the supported subscriber traffic interfaces for the HOU.

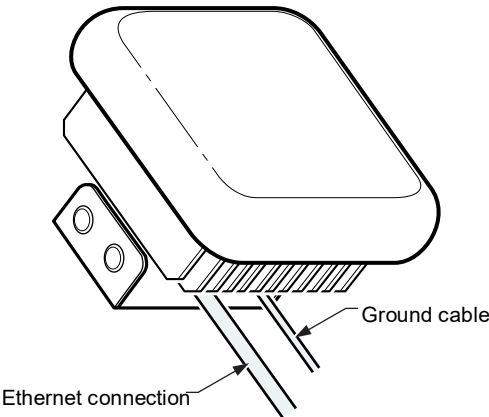
Table 14 HOU subscriber traffic interfaces

Interface	Description
Wireless	One 802.11ad wireless interface for communication with an AP
Ethernet	One Gigabit Ethernet interface for connection to CPE; the same cable is used for power over Ethernet to the HOU and provides indoor grounding

7.4.1 HOU physical connections and components

Figure 15 shows the HOU physical connections and section 7.4.2 describes the wireless components.

Figure 15 HOU physical connections



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Table 15 describes the HOU physical connections and components.

Table 15 HOU physical connections and components

Connection or component	Description
Ethernet connection	This connection is for used for CPE connection, power (PoE), and indoor grounding. The connection is provided through an RJ 45 connector at the end of a 3 m (9.8 ft) Cat5 Ethernet cable attached to the HOU. The cable is used for connecting to CPE, such as a residential gateway. The cable is a shielded RJ 45 cable that provides indoor grounding for the HOU. PoE (802.3at) power is provided through the same cable, using power supplied by the CPE, or supplied by a Nokia-approved PoE injector. If required, an additional Cat5 Ethernet cable can be attached to the Cat5 Ethernet cable to increase its length, to a maximum combined length of 100 m (328 ft).

Ground connection	An external ground point is provided on the back of the HOU in case a ground separate from the indoor ground provided by the Ethernet connection is required
LED	Single multifunction LED See section 7.5 for more information about the LED

7.4.2 HOU wireless components

The HOU has one baseband unit for wireless communication with an AP:

- the baseband unit has three single-tile 32-antenna/RF arrays that have a scan range of +/- 90° Azimuth, +30° /-30° elevation, using the supplied mounting kit the HOU can be mechanically tilted upwards or downwards.
- the 32-antenna/RF arrays use vertical polarization and are located at the center line of the HOU

7.5 HOU LED information

The HOU has a single multi-colour LED is used to signal alarms and states, as described in Table 16.

The LED is located at the bottom of the HOU.

Table 16 describes the HOU LED behavior.

Table 16 HOU LED behavior description

LED color and behavior	LED behavior description
Red off	No alarm
Red flashing	Critical alarm
Red solid	Major alarm
Green off	OAM link is established
Green flashing slow	OAM link failure
Green flashing fast	Application startup
Green solid	Boot function

7.6 HOU specifications

Table 17 lists the physical specifications for the HOU.

Table 17 HOU physical specifications

Dimensions	Specifications
Height	13 cm (5.1 in)
Width	13 cm (5.1 in)

Depth	6.5 cm (2.6 in)
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(1 of 2)

Dimensions	Specifications
Weight [within $\pm$ 0.23 kg (0.5 lb)]	800 g (28.2 oz)

(2 of 2)

Table 18 lists power consumption specifications for the HOU.

Table 18 HOU power consumption specifications

Maximum power (not to exceed)	Condition	Minimum power	Condition
16 W	Maximum traffic load	13 W	No traffic load

Table 19 lists the environmental requirements for the HOU.

Table 19 HOU environmental requirements

Mounting method	Temperature range and humidity	Altitude
On an outside wall	Operating: –30°C to 65°C (–22°F to 149°F) ambient temperature 5% to 85% relative humidity, non-condensing	Maximum operating altitude is 3048 m (10 000 ft) above mean sea level
	Storage: –40°C to 65°C (–40° to 149°F) 5% to 93% relative humidity, non-condensing	Maximum non-operating altitude is 12 192 m (40 000 ft) above mean sea level

7.7 HOU wireless specifications

Table 20 lists the wireless specifications for the HOU. **Table 20 Wireless specifications for the HOU**

Specification	Description
Base standard	802.11ad
Drop function	180° field of view thanks to multiple steerable beamforming high-gain patch antenna arrays
Frequency and duplexing	60GHz / TDD
Channels	1,2,3 (center frequencies 58.32,60.48, 62.64 GHz)

(1 of 2)

Specification	Description
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Aggregate throughput	1.5 gbps (PHY rate) drop up to 100 m (328ft)
System gain (link budget)	18 dBi
HPBW	14°

(2 of 2)

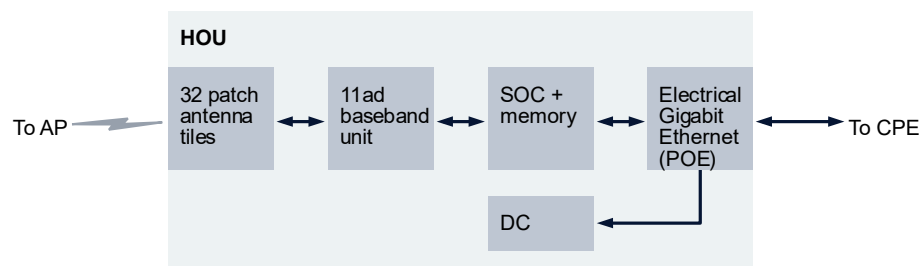
7.8 Performance monitoring statistics

WiGig statistics can be checked through the Bluetooth interface during installation of the HOU.

7.9 Functional blocks

Figure 16 shows the functional blocks for the HOU.

Figure 16 Functional blocks of an HOU



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7.10 HOU standards compliance

The HOU is compliant with the following standards:

- IEEE 802.11ad DMG STA
- Environmental: IP 66, full sunload, ETSI class 4.1E, ANSI NEBS GR-487 core
- Electromagnetic compatibility of multimedia equipment - Emission requirements CISPR 32, EN 55032
- Electromagnetic compatibility of multimedia equipment - Immunity requirements CISPR 35, EN55035

- Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU EN 301489-1
- Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 17: Specific conditions for Broadband Data Transmission Systems; Harmonized Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU EN 301489-17
- EN 60950-1, Safety of Information Technology Equipment for use in a restricted location (per R-269)
- IEC 60950-22, EN 60950-22: Information Technology Equipment- Safety - Part 22 Equipment to be installed Outdoors
- EN 300 019 European environmental standards
- Federal Communications Commission PART 15-RADIO FREQUENCY DEVICES
Subpart C-INTENTIONAL RADIATORS Title 47 CFR Part 15. Part 15.247, Part 15.255
- UL62368-1, Outdoor ONTs to “Communication Service Equipment” (CSE) and Indoor ONTs to Information Technology Equipment (ITE)
- Information Technology Equipment- Safety - Part 22 Equipment to be installed Outdoors
- UL 60950-22

7.10.1 Energy-related products standby and off modes compliance

Hereby, Nokia declares that the HOU is in compliance with the essential requirements and other relevant provisions of Directive 2009/125/EC together with Commission Regulation (EC) No 1275/2008 and Commission Regulation (EC) No 801/2013.

The HOU qualifies as equipment with high network availability (HiNA) functionality. Since the main purpose of the HOU is to provide network functionality with HiNA 7 days /24 hours, the modes Off/Standby, Power Management, and Networked Standby are inappropriate.

For information about the type and number of network ports, see [“Subscriber traffic interfaces on the HOU”](#) in this chapter.

For information about power consumption, see [“HOU specifications”](#) in this chapter.

7.10.2 HOU compliance 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.
- 2 This device must accept any interference received, including interference that may cause undesired operation.

Warning: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE: 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 needed.
- Consult the dealer or an experienced radio/TV technician for help.

8 Installing or replacing APs and HOUs

8.1 Before installing APs and HOUs

8.2 Installation scenarios for APs and HOUs

8.3 Replacement scenarios for APs and HOUs

8.4 AP installation and replacement

8.5 HOU installation and replacement

8.1 Before installing APs and HOUs

Before installing APs and HOUs, make sure that the WPON planning considerations described in section 5.6 have been addressed.

Be sure to consider the following for the WPON manager, RADIUS server, and public DHCP server before installing APs and HOUs:

WPON manager:

- certificate settings: • for device certificates, Nokia issues them by Nokia Factory CA, so Nokia Factory CA is put in the WPON manager Trustchain.crt
- by default, the WPON manager uses the certificate issued by Nokia Factory CA; you must install the WPON manager's private key and certificate in the WPON manager • if you want to use an operator-specific CA to issue/sign the WPON manager certificate, then besides installing WPON's private key and certificate in the WPON manager, you must also upload the CA certificate to each WPON device (that is, all APs and HOU) through the mobile app later on for authentication purposes
- the whole topology should be pre-defined in the WPON manager
- the WPON manager needs to define the private DHCP server inside the Head AP for configuration of Option 125 for the WPON manager address/port and Option 43 for all connected Relay APs, Extension APs, and HOU

RADIUS server:

- the Nokia Factory CA is automatically set as the device CA file in the RADIUS server
- if you want to use the Nokia-issued certificate for the RADIUS server, you must put the private key and the certificate provided by Nokia as the 509 certificate for wigig authentication in the RADIUS server
- if you want to use an operator-issued certificate to issue/sign the RADIUS server's certificate, then besides putting the corresponding private key and certificate in the RADIUS server for wigig authentication, you also need to upload the CA certificate to the WPON devices (that is, Relay APs, Extension APs, and HOU's) through the mobile app

Public DHCP server:

- you need to set Option 125 for the WPON manager address and port
- you need to set Option 43 (vendor specific value) for all Head AP serial numbers

For all installation scenarios, the Head AP should be configured first, then Relay APs and Extension APs, and then HOU's last of all.

If any changes are made for Option 125 or Option 43 on the public DHCP server or on the private DHCP server in the Head AP, or for CA on the RADIUS server, then all WPON devices need to be reset.

Before APs and HOU's can be brought into operation after installation, all the required back-end components have to be available:

- Altiplano
- RADIUS server
- File server with software images
- OAM network has to be provisioned and IP connectivity between Altiplano/RADIUS/file server and WPON has to be put in place. This includes configuring the public DHCP server that will be handing out IP addresses to the WPON. This DHCP server has to be configured to provide the Altiplano URL to the WPON system.

For the Head AP: configuration of the private DHCP server inside the Head AP for configuration of Option 125 and Option 43

An app on a Bluetooth-equipped mobile phone is required for installing APs and HOU's. See section [5.5.3](#) for more information.

After an AP or HOU has been installed, it can be created and provisioned in Altiplano. This can be done with or without filling in the serial number. If it is already known which serial number goes where, the serial number can be added before installation

of the AP or HOU, or if the serial number is not yet known, it can be added after the AP or HOU is installed.

8.2 Installation scenarios for APs and HOUs

A number of installation scenarios are possible for APs and HOUs, including installation of the HOU by the subscriber. Careful consideration of the installation scenarios in advance of installation can greatly speed up the installation process.

See the following sections for information about installing an AP or HOU:

- installing an AP: section [8.4](#) (operations personnel only)
- installing an HOU: section [8.5](#) (includes information for installation of the HOU by the subscriber or by operations personnel)

8.3 Replacement scenarios for APs and HOUs

The HOU is easy to replace and may be replaced by the subscriber if considered appropriate.

See the following sections for information about replacing an AP or HOU:

- replacing an AP: section [8.4](#) (operations personnel only)
- replacing an HOU: section [8.5](#) (includes information for replacement of the HOU by the subscriber or by operations personnel)

8.4 AP installation and replacement

An AP can be installed on a pole or on the outside of a building.

Refer to chapter [6](#) for detailed information about the AP before you install or replace it. See section [8.1](#) for information before installing the AP.

See the *AP Installation Guide* for instructions on how to install or replace an AP; the *AP Installation Guide* guide includes pre-installation and pre-replacement information and steps, and includes some information about using the mobile app through the bluetooth interface of the AP.

8.5 HOU installation and replacement

The HOU is designed to be installed on the outside of a subscriber's home.

The HOU is easy to install and may be installed or replaced by the subscriber if considered appropriate.



Note 1 — If the HOU is to be installed by the subscriber, it is recommended that the AP be installed before the subscriber installs the HOU as this will help to ensure that the subscriber installs the HOU in a suitable location.

Note 2 — If the HOU is to be installed by operations personnel, the AP and HOU installation sequence can be determined by the operations personnel.

Note 3 — Instructions for installing the HOU by subscribers or by operations personnel are provided in the *HOU Installation Guide*. The *HOU Installation Guide* has been prepared under the assumption that the AP to which the HOU will be connected has already been installed.

Table 21 indicates the HOU installation and replacement actions to be performed by operations personnel and subscribers.

Table 21 HOU installation and replacement actions

Action	Operations personnel	Subscriber
Refer to chapter 7 in this document for detailed information about the HOU	✓	
Perform HOU pre-installation or pre-replacement tasks: - see section 8.5.1 for HOU pre-installation tasks - see section 8.5.2 for HOU pre-replacement tasks	✓	✓ ⁽¹⁾
Install or replace an HOU according to information and steps in the <i>HOU Installation Guide</i> ⁽²⁾	✓	✓

Notes

- ⁽¹⁾ If the subscriber will be installing or replacing the HOU, some of the pre-installation or pre-replacement tasks will involve the subscriber.
- ⁽²⁾ The *HOU Installation Guide* has been prepared for use by subscribers or operations personnel.

8.5.1 HOU pre-installation tasks

The following tasks must be performed by operations personnel before an HOU can be installed by operations personnel or by a subscriber. If the subscriber will be installing the HOU; some of the pre-installation tasks will involve the subscriber.

Table 22 lists the pre-installation tasks for the HOU and indicates which tasks involve operations personnel and which tasks involve subscribers.

Table 22 Pre-installation tasks for the HOU

Task	Operations personnel	Subscriber
Create and provision the HOU in Altiplano with or without filling in the serial number. If it is already known which serial number goes where, it can be added now, or if the serial number is not yet known, it can be added after the HOU is installed. This can be done via the GUI or can be scripted. See section 8.1 for more information before installing the HOU.	✓	
Make sure that the following are available to the person doing the installation (either operations personnel or subscriber): - the HOU and any accessories that are to be supplied with the HOU - information about the mobile app to be installed on the Bluetooth-equipped mobile phone that will be used to configure or troubleshoot the HOU during installation - the <i>HOU Installation Guide</i> - additional info for the install process, such as the AP location, HOU details, and any other specific and relevant information	✓	✓
If the installation is to be done by the subscriber, make sure to provide contact information or instructions so that the subscriber can let you know when the installation is complete and you can do any other tasks that are required on the network side so that the HOU can be managed from the WPON manager and so on. Also provide contact information to the subscriber in case the HOU needs to be returned or replaced or if there are issues during the installation process.	✓	✓

Once all the tasks in Table 22 have been completed, operations personnel or the subscriber can install the HOU according to information and steps in the *HOU Installation Guide*.

8.5.2 HOU pre-replacement tasks

The following tasks must be performed by operations personnel before an HOU can be replaced by operations personnel or a subscriber. Note that if the subscriber will be replacing the HOU, some of the pre-replacement tasks in will involve the subscriber.

Table 23 lists the pre-replacement tasks for the HOU and indicates which tasks involve operations personnel and which tasks involve subscribers.

Table 23 Pre-replacement tasks for the HOU

Task	Operations personnel	Subscriber
Unprovision the existing HOU and create and provision the replacement HOU; including the following: - Option 43 set in the private DHCP server inside the Head AP associated with the serial number; this is set using the WPON manager - Any certificate authority (CA) files for update must already be manually uploaded to the RADIUS server	✓	
Make sure that the following are available to the person doing the replacement (either operations personnel or subscriber): - the replacement HOU - the <i>HOU Installation Guide</i> - information about the mobile app installed on the Bluetooth-equipped mobile phone that will be used to configure or troubleshoot the replacement HOU - additional info for the replacement process, including return or disposal information for the old HOU	✓	✓
If the replacement is to be done by the subscriber, make sure to provide contact information or instructions so that the subscriber can let you know when the replacement is complete and you can do any other tasks that are required on the network side so that the replacement HOU can be managed from the WPON manager and so on. Also provide contact information to the subscriber in case there are issues during the replacement.	✓	✓

9 Configure an AP or HOU

9.1 AP configuration

9.2 HOU configuration

9.1 AP configuration

You can configure an AP:

- remotely through the WPON manager (see section [5.5.1](#))
- remotely through the Nokia Altiplano (see section [5.5.2](#))
- locally through Bluetooth (see section [9.1.1](#))

9.1.1 Local configuration of an AP

Local craft terminal access for an AP is provided through a Bluetooth interface (classical Bluetooth, reach greater than 20 m (65.6 ft) on the AP.

The Bluetooth interface provides access to a Bluetooth server that can be used for local management of the AP through an app on a Bluetooth-equipped mobile phone.

You can perform configuration actions such as the following through the Bluetooth interface of an AP:

- perform system restart
- perform reset to factory settings and restart
- synchronize the date/time of the AP with the clock of the mobile phone
- upload certificates from the mobile device to the AP

See section [5.5.3](#) for more information about management of the AP through the Bluetooth interface; the *AP Installation Guide* has information about using the app through the Bluetooth interface when installing or replacing an AP.

9.2 HOU configuration

You can configure the HOU:

- remotely through the WPON manager (see section [5.5.1](#))
- remotely through the Nokia Altiplano (see section [5.5.2](#))

- locally through Bluetooth (see section [9.2.1](#))

Configure an AP or HOU

9.2.1 Local configuration of an HOU

Local craft terminal access for an HOU is provided through a Bluetooth interface (classical Bluetooth, reach greater than 20 m (65.6 ft)) on the HOU.

The Bluetooth interface provides access to a Bluetooth server that can be used for local management of the HOU through an app on a Bluetooth-equipped mobile phone.

You can perform configuration actions such as the following through the Bluetooth interface of an HOU:

- perform system restart
- perform reset to factory settings and restart
- synchronize the clock of the HOU with the clock of the mobile phone
- upload certificates from the mobile device to the HOU

See section [5.5.3](#) for more information about management of the HOU through the Bluetooth interface; the *HOU Installation Guide* has information about using the Bluetooth interface when installing or replacing an HOU.

10 Fiber optic maintenance

10.1 Purpose

This chapter provides the steps for proper maintenance of fiber optic devices including fiber optic receptacles and connectors.

10.2 General

Proper maintenance of fiber optic devices consists of inspection and, if necessary, cleaning of fiber optic receptacles and connectors. Recommendations for handling fiber optic devices including fiber optic jumper cables as well as the recommended acceptance criteria for fiber optic device inspections appear below.

10.2.1 Handling considerations

Consider the following when handling fiber optic devices and accessories.

- The bend radius for single-mode optical cable should not be less than 102 mm (2 in.), and the bend radius for multimode optical cable is 152 mm (6 in.).
- Handle cables with care; avoid twisting the cable while turning its connectors or routing the cable during installation.
- Connect or disconnect a connector by holding the sides of the connector and pulling gently.

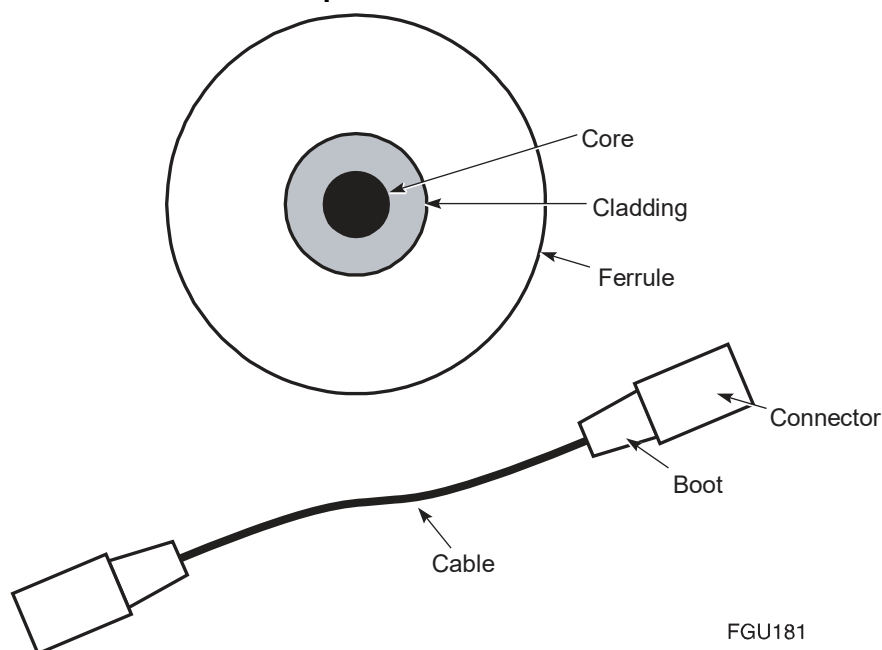


Note — Do not pull on the boot off the connector.

- Do not touch the fiber cable end-faces.
- Do not expose the cable to excessive heat.
- Do not allow connectors to strike or drag across work surfaces, including the floor.
- Do not allow cables to support any weight.
- Do not use cable ties to secure fiber optic cables. • Do not crush or damage fibers by placing objects on top of a cable or a connector, or by rough handling while mounting other nearby devices.
- Keep dust and contaminants away from fiber optic surfaces.
- Keep dust caps on connectors and input/output plugs on receptacles until just prior to installation.
- Store unused dust caps and plugs in an anti-static, zipper-locked plastic bag for future use.
- Replace dust caps and plugs if they:
 - fall on the floor
 - are cracked or damaged in any way

- are dirty or exposed to dust in the environment

Figure 17 shows the main parts of a fiber optic cable.

Figure 17 Parts of a fiber optic cable

10.2.2 Fiber optic jumper cable care

Use the following guidelines to care for fiber optic jumper cables.

- Store all unused fiber optic jumper cables in a cabinet.
- Hang all unused fiber jumper optic cables on a cable rack, or lay them flat in a cupboard.
- Ensure there is no tension on the fiber optic cable, or any sharp bending, twisting, or kinks (micro-bends). • The radius of the bend should meet the specifications of the manufacturer, or be at least 38 mm (1.5 in.).
- When the fiber-optic jumper cable is not in use, cover the end connectors with the dust caps.

10.2.3 Acceptance criteria for fiber optic device inspections

Fiber optic connectors and receptacles must be visually inspected before every connection, including the first-time installation of components still in their original packaging. After the fiber optic devices pass inspection and the connection is made, it is not necessary to disassemble the connection for inspection.

The following guidelines apply to acceptance criteria.

- Loose contamination of any kind is not acceptable and must be cleaned from the end-face.
- For inspection purposes, pits are to be treated the same as non-removable contamination.
- When measuring oddly shaped contamination (non-round shapes), use the largest dimension.
- If contamination falls across more than one zone, use the acceptance criteria of the most stringent zone.
- For multifiber cable, each end-face must meet the inspection criteria.

10.2.4 Acceptance criteria

Acceptance criteria for single-mode end-faces are provided in Table 24. The zones referred to in Table 24 are illustrated in Figure 18.

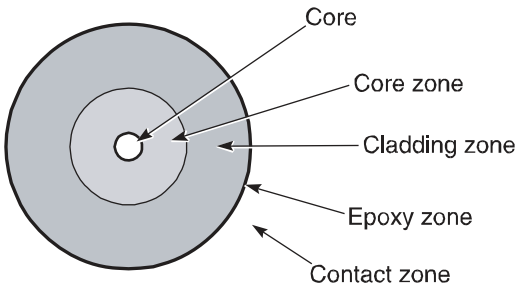
The result of an inspection can be one of three conditions:

- preferred
- acceptable
- unacceptable

Table 24 Single-mode end-face inspection acceptance criteria

Zone	Diameter	Acceptance criteria (number and size)	
		Non-removable (contamination of pits)	Scratches
Core	9 μm	None	None
Core zone	<50 μm	None	None
Cladding zone	50 to 120 μm	Quantity: 3 max. Diameter: 5 μm max.	Quantity: 2 max. Width: 2 μm max.
Epoxy zone	120 to 130 μm	Quantity: no limit Diameter: 10 μm	No limit
Contact zone	130 to 250 μm	Quantity: no limit Diameter: 10 μm	No limit

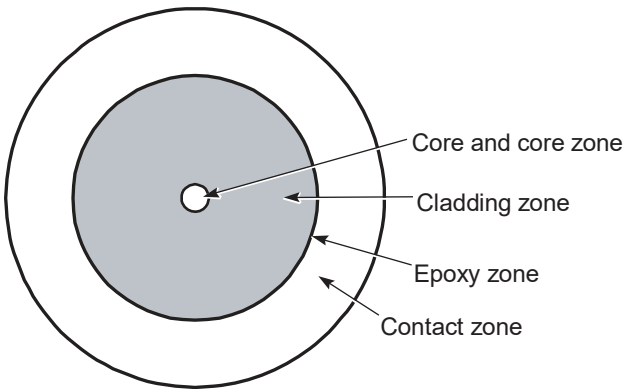
Figure 18 **Single-mode end-face zones**



FGU182a

The preferred condition of an end-face is shown in Figure 19. There should be no evidence of contamination, scratches, or any defect. Figure 19 also identifies the end-face zones shown in Figure 18. For clarity, the zones are not shown to scale, and the core and core zones are shown as one zone.

Figure 19 **Preferred condition of fiber optic end-face**

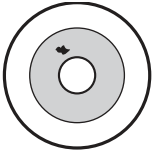
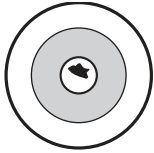
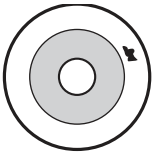
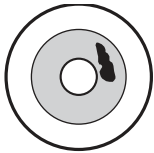
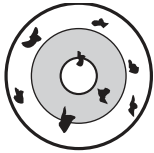
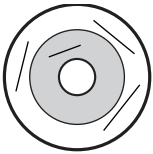
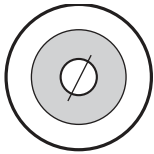
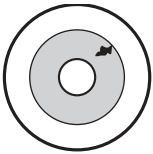
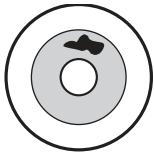


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Table 25 illustrates acceptable and unacceptable inspections.

Table 25 **Acceptable and unacceptable conditions for fiber optic end-faces**

Criteria	Acceptable	Unacceptable
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Contamination, particles, or pits in single-mode fiber	Contamination within cladding zone, but outside core zone Diameter is < 5 µm		Contamination in core zone	
	Contamination in contact zone Diameter is < 10 µm		Contamination (large particle) in cladding zone Diameter is > 10 µm	
	—	—	Removable contamination (oil)	
Scratches in single-mode fiber	One scratch in cladding zone, or multiple scratches in a contact zone		One scratch through core	
Contamination particles or pits in multi-mode fiber	Contamination in cladding or epoxy zone Diameter is < 10 µm		Contamination, large particle in cladding zone Diameter is > 10 µm	

10.3 Prerequisites

For fiber optic connection inspection, you need an inspection kit or equivalent equipment that may contain the following items:

- 200x video microscope
- video monitor
- adapters for connectors and receptacles
- instructions for the use of the kit components

The following list contains the methods used to clean a fiber optical connector. The items are listed numerically, in order of the most preferred method.

- 1 a cleaner cassette
- 2 a lint-free cloth
- 3 a stick cleaner (swab)

For fiber optic cleaning, you need the following items depending on which cleaning method you use:

- Cassette cleaner (reel type or equivalent), or lint-free, nonabrasive cloths
- Optical grade stick cleaners (swabs) that have a tightly wrapped tip (1.25 mm, 2.50 mm and 4.0 mm) (
- Pure optical-grade isopropyl alcohol for cleaning connector end-faces
- A can of contaminant-free compressed air (dry nitrogen) for removing dust from connectors (ferrule and end-face surfaces)



Note — Do not use commercially compressed air or house air.

You may also require:

- dust caps for connectors
- anti-static, zipper-locked plastic bags



Note — Do not use pink anti-static bags.

10.4 Parts list

None.

10.5 Recommended tools

None.

10.6 Procedure

Use this procedure to inspect and, if necessary, clean the fiber optic cable connectors.

-
- 1 Disconnect any power to the fiber optic device before inspection.



Danger — Never look into the end of an optical cable while optical power is being applied to the fiber. When cleaning or taking measurements, avoid eye exposure to open-ended fibers and optical connectors. The fibers and connectors may be connected to a laser transmitter. Use a microscope and video monitor when inspecting the end-face.

2 Gently disconnect the fiber optic connector from the receptacle.

3 Inspect the cable jacket for nicks, cuts, bends, kinks, or other signs of damage.



Note — Do not use the cable if there is damage.

4 Inspect the ferrule for signs of damage, for example scratches, cracks, or damaged guide holes (badly worn or out-of-round).



Note — Do not use the device if there is damage.

5 Using the inspection kit, inspect the receptacle.



Warning 1 — Clean fiber optic receptacles only when the receptacles are connected for the first time, or if there is evidence of contamination.

Warning 2 — Always use the proper cleaning materials, otherwise the fiber optic equipment may become contaminated.

Determine whether the receptacle is contaminated (does not pass acceptance criteria documented in ["Acceptance criteria"](#)).

a If yes, go to step [8](#). **b**

If no, go to step [7](#).

6 Using the inspection kit, inspect the connector.

Warning 1 — While cleaning a fiber optic connector, do not touch the surface of the connector with your fingers.

Warning 2 — Always use the proper cleaning materials, otherwise the fiber optic equipment may become contaminated.

Determine whether the connector is contaminated (does not pass acceptance criteria documented in “Acceptance criteria”). **a** If yes, go to step 8.

b If no, go to step 7.

7 Reconnect the connector and receptacle.

Warning — Be careful to maintain a bend radius of no less than 3.8 cm (1.5 in) when connecting the fiber optic cable. Too small of a bend radius in the cable can result in damage to the optic fiber.

i Check that fiber optic connection is functioning properly.



Note 1 — Do not use optical devices that do not function properly.

Note 2 — In a fiber distribution network, it is an industry best practice to use APC-based connections or spliced connections to avoid any potential network problems. Nokia recommends that the unused ports of splitters be terminated into an APC-based connector.

ii Go to step 17.

8 Clean the connector or receptacle by gently wiping the ferrule and end-face surfaces using a cleaner cassette or a dry lint-free cloth.

9 Inspect the connector or receptacle.

Determine whether the connector or receptacle is contaminated (does not pass acceptance criteria documented in “Acceptance criteria”) **a** If yes, go to step 10. **b** If no, go to step 7.

-
- 10** If the connector or receptacle fails the inspection, clean the connector or receptacle by gently wiping the ferrule and end-face surfaces using a cleaner cassette that has a drop of optical-grade isopropyl alcohol applied to it. Alternately, use a lint-free cloth that has a drop of optical-grade isopropyl alcohol applied to it.



Note — You may need to open the cleaner cassette window by hand to apply the alcohol to the cassette.

-
- 11** Remove any alcohol residue by gently wiping the ferrule and end-face surfaces with a dry section of cleaner cassette, or a lint-free cloth.

-
- 12** Inspect the connector or receptacle.

Determine whether the connector or receptacle is contaminated (does not pass acceptance criteria documented in [“Acceptance criteria”](#)) **a** If yes, go to step [13](#).

b If no, go to step [7](#).

-
- 13** If necessary, repeat step [8](#) through step [12](#) until the connector or receptacle passes the inspection.

-
- 14** If the connector or receptacle continues to fail inspection after several attempts at cleaning, use the canned, compressed air to remove any dust or debris.



Note — Do not allow the extension tube of the can to touch the fiber.

-
- 15** Inspect the connector or receptacle.

Determine whether the connector or receptacle is contaminated (does not pass acceptance criteria documented in [“Acceptance criteria”](#)) **a** If yes, go to step [16](#). **b** If no, go to step [7](#).

- 16** If the connector or receptacle fails the inspection, repeat step [14](#) through step [15](#) again until inspection is passed or fiber optic device is considered damaged and unusable.



Note — Typically you should not use a fiber optic device that does not pass inspection. However, only a live test informs you if a connector or receptacle cannot be used.

17 STOP. This procedure is complete.

11 Glossary

This glossary provides the expansions and optional descriptions of most acronyms and initialisms that appear in the WPON documentation.

ALED	Alcatel-Lucent Electronic Delivery
ANSI	American National Standards Institute
AP	Access Point
CRoHS	China Restriction of Hazardous Substances
DHCP	Dynamic Host Configuration Protocol
DSCP	Differentiated Services Code Point
EFUP	Environment-Friendly User Period
EIP	Electronic Information Products
EMAN	Ethernet Metropolitan Area Network
EMC	ElectroMagnetic Compatibility
EMI	Electromagnetic Interference
ESD	ElectroStatic Discharge
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
GEM	Generic Equipment Mode
GPS	Global Positioning System
GRE	Generic Routing Encapsulation
GUI	Graphical User Interface
HOU	Home Outdoor Unit
HST	Hazardous Substances Table
IP	Internet Protocol
L2	Layer 2
LED	Light Emitting Diode

MAC Media Access Control

MCV Maximum Concentration Value

Glossary

NNI Network Node Interface

OLCS Online Customer Support

ONT Optical Network Terminal

P2P Point to Point

PAN Personal Area Network

PDF Portable Document Format

PMA Persistent Management Agent

PoE Power over Ethernet

PON Passive Optical Network

QR Quick Response

RADIUS Remote Authentication Dial-In User Service

RIP Routing Information Protocol

SC Snap Connect

SFP Small Form-factor Pluggable

TV Television

UL Underwriters' Laboratories

UNI User Network Interface

QoS Quality of Service

VDC Volts Direct Current

VLAN Virtual Local Area Network

WPON Wireless PON

YANG Yet Another Next Generation

Glossary

FCC Statement

Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

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 Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment .This equipment should be installed and operated with minimum distance 20cm between the radiator& your body.

Note: 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.

it is not permitted to use the product on aircraft or satellites.

Customer document and product support

Customer documentation



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