NOKIA

Nokia RoofTop™ Wireless Routing Installation Guide

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COMPLIANCE STATEMENTS
This hardware complies with the standards listed in this section.

Emission Standards

UNINTENTIONAL EMISSIONS: FCC Part 15 CLASS B
INTENTIONAL EMISSIONS: FCC Part 15, Section 15.247

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 and correct the interference by one or more of the following measures:

—Reorient or locate 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.

Any modifications made to the unit, unless expressly approved by Nokia could void the user's authority to operate the equipment.

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CHAPTER 1

System Overview

1.1 Introduction

This chapter provides:

- A basic understanding of how a wireless router system functions
- How wireless systems self-configure

Wireless router networks bypass the wired local loop with fast “always-on” wireless Internet access.

The Nokia AIR™ Operating System (OS) provides intelligence, security and ease of use to make wireless networks practical, simple to deploy, and cost effective. Wireless Internet or intranet access across a network is completely transparent to the end user.

The Nokia RoofTop™ Wireless Routers, Models R242/242A, are both wireless Internet access devices and IP routers. The wireless router units operate in a mesh network where line of sight access is required to only one other wireless router.

1.1.1 Configuration

When the units are configured and deployed, they adapt to the network automatically to learn the network topology. The operating system then builds and maintains the network topology and routing tables, and continually updates them as the network changes.

Line of sight problems, common in point-to-multipoint networks, are eliminated by routing traffic through other units. If a node cannot connect directly to the AirHead, multihop routing protocols forward traffic through another wireless router.

Operating system protocols optimize wireless links providing hop-by-hop data integrity and efficient, intelligent multicasting. Protocols control channel scheduling, neighbor authentication, and link maintenance, as well as optimize routing in the wireless environment. By scheduling traffic streams to non-conflicting transmission times and Radio Frequency (RF) channels, quality-sensitive and/or bandwidth intensive applications co-exist with standard applications.

1.1.2 Installation Components

Each installation consists of a Nokia RoofTop™ Wireless Router, RF cabling, lightning protection, and an amplifier (optional). The antennas mount on the roof, or in a location in line of sight to other antennas in the network. RF cabling is run from the antenna to the wireless router, which is mounted indoors.

A successful installation requires:

- Site analysis and proper planning (section 2.3)
- Placement of the antenna with line of sight to at least one antenna in the network (section 2.3)
- Using appropriate antenna and cabling (Sections 2.4 and 2.5)
- Proper installation technique, including grounding and weatherproofing (Section 2.6)

- Proper placement and mounting of the wireless router (Section 3.1)
- Proper use of cabling between the wireless router and the subscribers' PC/network (Section 3.1.7)

CHAPTER 2

Antenna Installation

2.1 Introduction

Chapter topics include:

- Site Analysis
- Line of Sight Analysis
- Antenna Selection
- Cables
- Outdoor Installation Procedures
  - Safety Guidelines
  - Required Installation Components
  - Polarization
  - Test Installation
  - Grounding
  - Weatherproofing
  - Indoor Installation Procedures

2.2 Site Analysis

The goals of site analysis are:

- To determine the feasibility of RF links at each site
- To determine the antenna and cable requirements necessary to provide service

2.2.1 RF Link Feasibility

Wireless routers operate in a “mesh” network—line of sight is required to only one other radio in the network. The IP routing capability allows all units to act as repeaters for other units.

Survey all obstructions to potential sites. For most installations use an omnidirectional antenna. This assures maximum connectivity and allows the unit to forward packets for existing and future needs.

NOTE: To maintain broadband data rates, it is recommended that networks be kept within three hops.

2.2.1.1 Site Survey Steps

1. Determine if there are Line of Sight (LOS) paths for each proposed link. Line of sight exists if there are no obstructions (for example, trees, buildings, etc.) between the antennas. For best results, there should be no obstructions between the two antennas. For long distance paths there should be no obstacles close to the RF path.
2. Determine the antenna location and maximum possible antenna height. The height of the antenna is often dependent on the physical limitations of the site. For example, an antenna mast can be placed on a rooftop, an antenna can be installed on an existing structure or tower, or the mast and antenna can be installed on the ground.

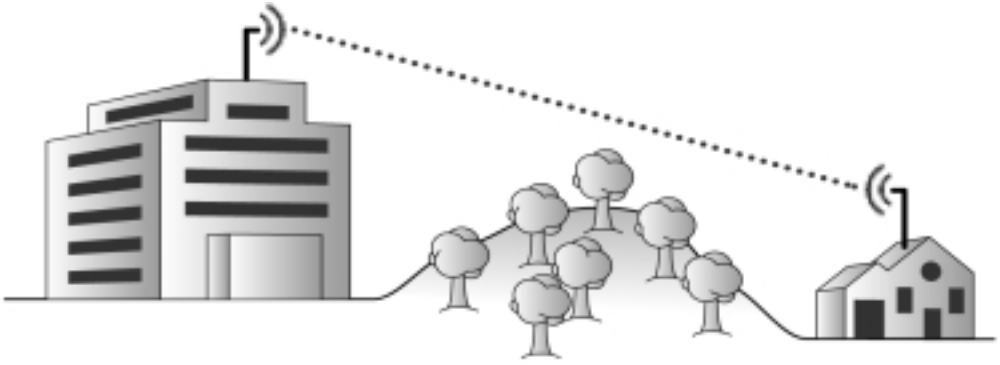
3. Determine the RF paths between the antenna at the site and the antennas at adjacent sites. For a directional link with a single antenna, there is only one RF path. For an omnidirectional antenna, determine all RF paths. The RF path can be determined by knowing the relative bearing from the current site to adjacent sites.
4. The feasibility of an RF link can be estimated based on:
   - Distances between the potential sites
   - The line of sight for the RF paths
   - Antenna RF gains
   - Cable losses
5. After one or more sites have been installed and are operational, test each new site before completing the installation.
6. After determining the feasibility of the RF link, consider the following:
   - Hardware and tools necessary to complete the installation
   - Wireless router installation location
   - The RF cable routing between the wireless router and the antenna
   - Power for the wireless router
   - Ethernet cable routing
   - Antenna grounding and lightning arrestor requirements

2.3 Line of Sight Analysis

A quality antenna installation includes:

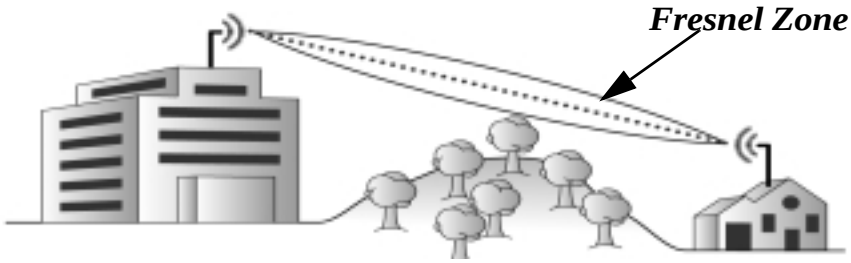
- Clear visual line of sight between antennas
- Clear radio line of sight between antennas
- Antenna and cable selection and mounting based on the site requirements and limitations

2.3.1 Visual Line of Sight



Visual line of sight exists when an imaginary straight line can be drawn between two antennas without passing through any physical obstructions. Verifying visual line of sight is the first step in planning. Observation points must be high enough to allow the viewer to see over obstructions.

2.3.2 Radio Line of Sight



Provide a clear radio path by raising the antenna as high as possible and away from objects near the radio path. A radio wave is not like a laser with a narrow, pointed beam. RF waves fan out from a single source and are diffracted or absorbed by objects that are near the visual line of sight. This area is called the Fresnel Zone. Clear radio line of sight exists when there are no physical obstructions in the Fresnel Zone.

2.3.3 Fresnel Zone

Elevate antennas as high as practical above physical obstacles to avoid obstructing the Fresnel Zone, the elliptical area adjacent to the path, that could reflect unwanted signals into the primary path and reduce signal levels. The Fresnel Zone must be considered when installing antennas.

2.3.4 Antenna Height

All antennas have a limited vertical radiation pattern. If nearby antennas are placed at different heights, verify that the vertical line of sight angle falls within the antenna specifications for a good link.

2.4 Antenna Selection

2.4.1 Omnidirectional Antennas

Omnidirectional antennas radiate spherically, providing equal coverage in all directions, and are best for multi-point links and forwarding sites. Because they receive and transmit signals in all directions, they are the best antenna for most installations.

Omnidirectional Antennas - Radiation Pattern

2.4.2 Directional Antennas

Directional antennas focus their RF beam in narrow patterns in one direction. Directional antennas provide communications over longer ranges than omnidirectional antennas, but are much more limited in the areas they cover. Directional antennas maximize link distances. They are also effective for simple, dedicated, point-to-point links.

NOTE: Directional antennas limit future growth and prevent the wireless modem from repeating signals to other units. They should be used *only* where an omnidirectional antenna will not work.

Directional Antennas - Radiation Pattern Side View

2.5 Cables

Nokia provides two types of RF cabling for wireless router installations:

1. Low Loss RF Cable - rigid low attenuation cable for long cable runs.
2. Flexible Jumper Cables - flexible cables, up to six feet long, that connect the wireless router to the low loss RF cable or connect amplifier components with the wireless router and antenna.

NOTE: Only use the RF cables provided by Nokia. Using cables or RF equipment other than that provided by Nokia may void the user's authority to operate the equipment.

2.6 Outdoor Installation Procedures

WARNING: ***Use extreme caution*** **when installing antennas in areas with overhead power lines. Outdoor antennas and their supporting masts, guy wires, and cables are electrical conductors. Contact with high-voltage electrical wires can cause serious injury or death.**

2.6.1 Safety Guidelines

- Plan the entire procedure before starting
- If necessary, obtain appropriate assistance
- Wear a hard hat and gloves
- Wear heavy toe boots to protect your feet from falling objects
- Do not install antennas on windy or rainy days
- Assemble the antenna components at or near the final site
- Ground the antenna support structure prior to erecting the antenna
- Firmly anchor the base of the support structure
- Keep the antenna at least twice the mast height from power lines
- If you start to drop an antenna, let it fall and back away from it
- Installations must be performed by a professional
- Maintain the required distance from the antenna while the wireless router is on (for more information on the MPE distance, please refer to Appendix D).
- Install antennas at least six feet (two meters) above ground

2.6.2 Required Installation Components

- RF cabling
- Lightning protector
- Antenna

- Antenna mounting hardware
- Antenna mast and hardware

2.6.3 Polarization

Polarization refers to the direction of antenna element alignment. For antennas to properly communicate with each other, all antenna must be aligned (polarized) in the same direction.

2.6.3.1 Omnidirectional Antenna

This vertically polarized antenna can only be mounted vertically.

2.6.3.2 Directional Panel Antenna

- Polarization is identified by an arrow on the rear panel
- Radiates from the front side and away from the mounting bracket
- Can be vertically or horizontally polarized; the elements can be vertical or horizontal

NOTE: If you have a combination of vertical omnidirectional antennas and directional antennas, the directional antennas must be polarized vertically.

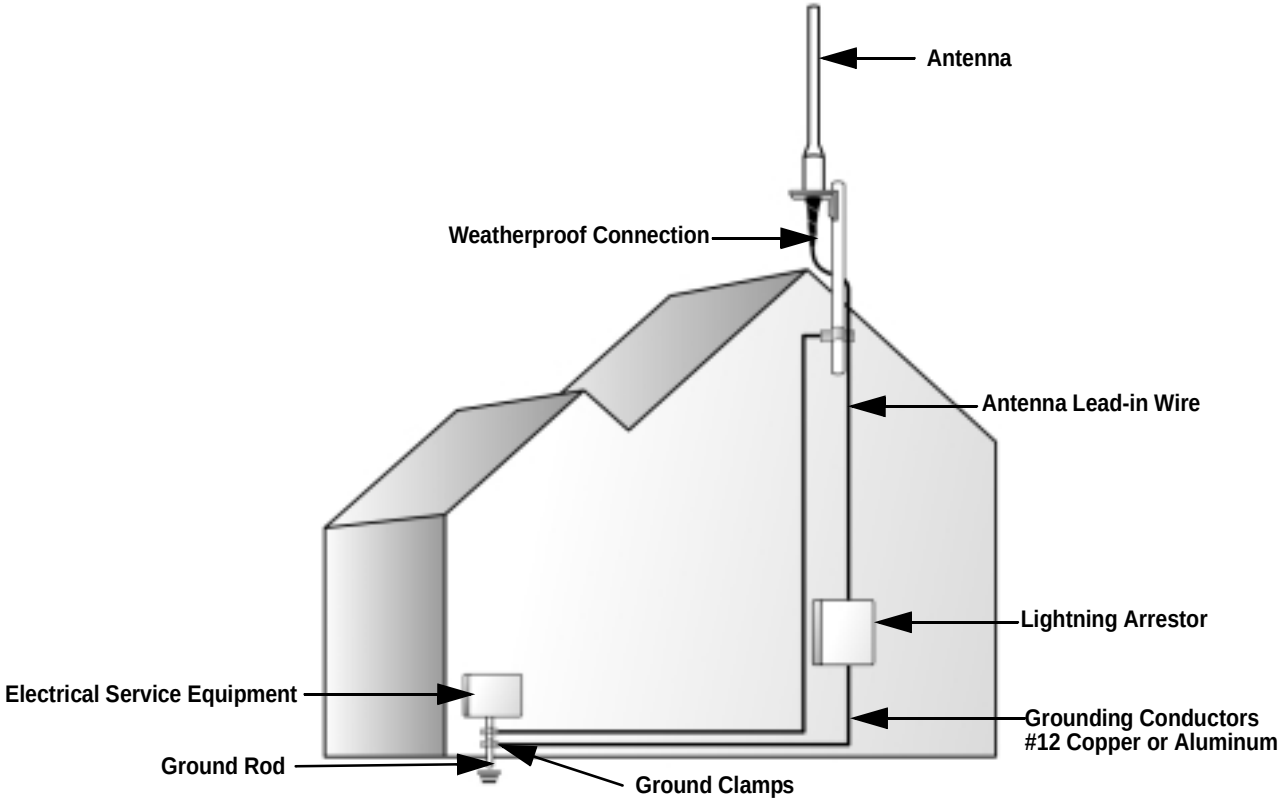
2.6.4 Test Installation

Connect and test all of the equipment prior to completing the permanent installation. After confirming operation, disassemble only as much of the equipment as is necessary to permanently reinstall it.

2.6.5 Grounding

WARNING: Because antennas are elevated metal objects with connections to ground, they attract lightning. Attach an effective ground to the antennas to provide a path for the lightning. Effective antenna grounding also minimizes electrical noise and interference, which can degrade system performance.

1. Provide a good, very low resistance wire connection from the antenna mount and wireless router to earth ground.
2. Use #12 copper or aluminum wire connected to the metal antenna support and a ground rod next to the building.



Grounding diagram

3. Mount the antenna on a mast or tower that is well grounded to earth.
4. Weatherproof all ground connectors to prevent corrosion, which interferes with the grounding connection.
5. Connect all power and antenna grounds to a common single point such as an equipment rack, cabinet enclosure chassis, or antenna tower. Connect this single-point ground to a solid ground connection to earth.
6. Install a lightning arrestor where the antenna cable enters the building or cabinet. Ground the lightning arrestor to a single point chassis ground. Follow the instructions provided by the manufacturer.

2.6.6 Weatherproofing

Good weatherproofing is the key to antennas that work well in all weather conditions. If water or moisture enters a cable or connector, it significantly reduces signal levels and often ruins the cable and/or connectors.

All connections that may be exposed to outdoor weather conditions or moisture, including condensation must be weatherproofed.

NOTE: Whenever possible, connect and weatherproof the cables, antennas, and any accessories on the ground. Minimize the amount of work performed on a roof or a ladder.

2.6.6.1 Weatherproofing Supplies

- Self-vulcanizing weatherproofing tape (available from Nokia)
- Scissors

2.6.6.2 Weatherproofing Steps

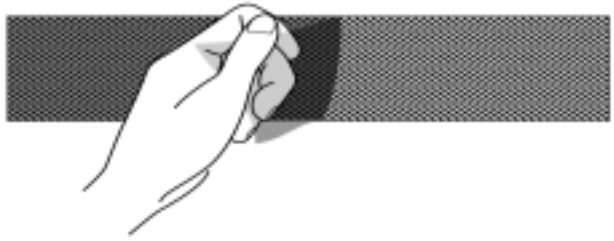
For all outdoor connections, use the following procedures to weatherproof the connections.

1. Connect the antenna and RF cable. Only connect cables at this step, attaching other mounting hardware will make applying the weatherproofing tape more difficult. See the NOTE for an exception.

NOTE: When using a flat rectangular antenna mounting bracket you must attach the antenna to the mounting bracket before weatherproofing, or you will be unable to attach the antenna to the mount, because the weatherproofing will prevent the antenna from passing through the antenna mounting hole.

Mounting Bracket

2. Cut an 8-inch section of the weatherproofing tape and remove the black plastic film from the back of the tape.



3. Stretch and apply the tape to the connection, wrapping the tape in the direction of the connector threading. Pull the tape tight while wrapping.

4. Apply the tape so that it covers the bottom of the antenna and the top of the connector without gaps. To be certain that there are no gaps apply the tape so that it overlaps half the width of the tape on each wrap. (The gaps can allow water to enter the connector and cable).

5. Continue applying the tape to at least 2” below the connector.
6. Squeeze the tape against the antenna and connector to remove any air gaps.
7. Attach the antenna to the mast or other mounting solution.
8. Attach the antenna to the mast or other structural support

Properly weatherproofed antenna connection. Antenna mounting brackets may vary.

NOTE: Be careful when weatherproofing RF connectors. Do not stress or bend the cable during the process.

2.6.7 Weatherproofing Flexible RF Jumper Cables

When using flexible RF jumpers in the installation, weatherproof all connectors and connections that are exposed or could potentially be exposed to outdoor conditions (including condensation). Use the same technique described for weatherproofing antenna connections. Extend the weatherproofing tape at least two inches beyond each connection on the cable.

2.6.8 Amplifier Weatherproofing

The amplifier is designed to be mounted outdoors. The connectors must be weatherproofed using the same technique described for weatherproofing antenna connections. To prevent rain or snow from falling directly on the connectors, mount the amplifier with the connectors facing down. The DC injector is designed to be mounted indoors and must be protected from moisture and excessive heat and cold.

2.7 Indoor Installation Procedures

The procedures for an indoor installation are the same as those for an outdoor installation as described in section 2.6, with the following exceptions:

2.7.1 Weatherproofing

An indoor installation does not require weatherproofing as described in section 2.6.6. All equipment must be installed away from moisture from outside doors, open windows, faucets, and so on. Do not install equipment in bathrooms.

2.7.2 Antennas

For indoor directional panel antenna installations, install the antenna at least six feet (two meters), high and six feet from human access.

2.7.3 Grounding

The antenna may be appropriately grounded in the building. It does not require a ground rod connection as described in section 2.6.5.

CHAPTER 3

Wireless Router Installation

3.1 Introduction

A wireless router system consists of two or more antennas, antenna cables, and wireless routers. One of the units is the AirHead which connects with wire to the Internet. All other units are Subscriber units that connect to remote computers or LANs. This chapter describes how to connect the system and verify the hardware installation.

3.1.1 Preinstallation Requirements

- Professional installers are responsible for moving and re-installing all equipment.
- All antenna installations on towers require licensed tower climbers.
- Use only Nokia approved accessories for all installations.
- Ground the antenna support to a ground rod or other suitable earth ground.
- Avoid placing the wireless router unit in excessively hot, cold, dusty, wet, or humid environments.

- The wireless router must be installed with its mounting bracket whether it is placed on a wall or desktop. The holder provides ventilation and helps drain spilled liquids.
- Place the wireless routers DC power unit out of the way, or tape it to the side of a vertical surface to prevent it from being stepped on or damaged.
- The wireless router can cause interference to (and interfere with) other devices operating in the 2.4 to 2.4835 GHz radio spectrum.
- Changing the Ethernet configuration from a LAN connection to a direct PC connection requires changing from a standard Ethernet cable to a crossover cable.

NOTE: The Nokia RoofTop™ Wireless Router and its associated components are Class B devices that must be installed by a professional.

3.1.2 Physical Location

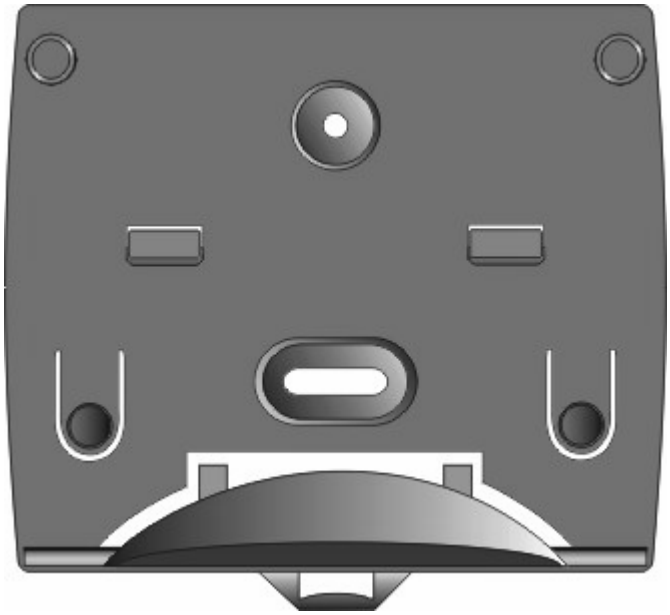
Wireless routers must be installed indoors.

Install the wireless router as close to the entry point of the RF cable into the building as is practical. Keep the cable length from the antenna to the wireless router as short as possible.

Ambient temperature must be 32-104 degrees Fahrenheit. Avoid mounting the wireless router in an environment that gets extremely hot.

3.1.3 Physical Mounting

The wireless router installs in its mounting bracket. Securely attach the mounting bracket to a wall or flat surface with two screws. Typical mounting is vertical with the mounting flange and cable strain relief facing down. This forces the RF cable to bend and extend below the wireless router, creating a “drip loop”. Drip loops prevent water from running down the RF cable and into the wireless router.



Mounting Bracket

3.1.4 Connection Options

There are two ways to connect the wireless router to the subscriber's network/PC:

1. Network connection
2. Direct Personal Computer connection

3.1.4.1 Network

Use a standard Ethernet cable with an RJ45 connector at the wireless router and the appropriate connector at your LAN Ethernet connection.

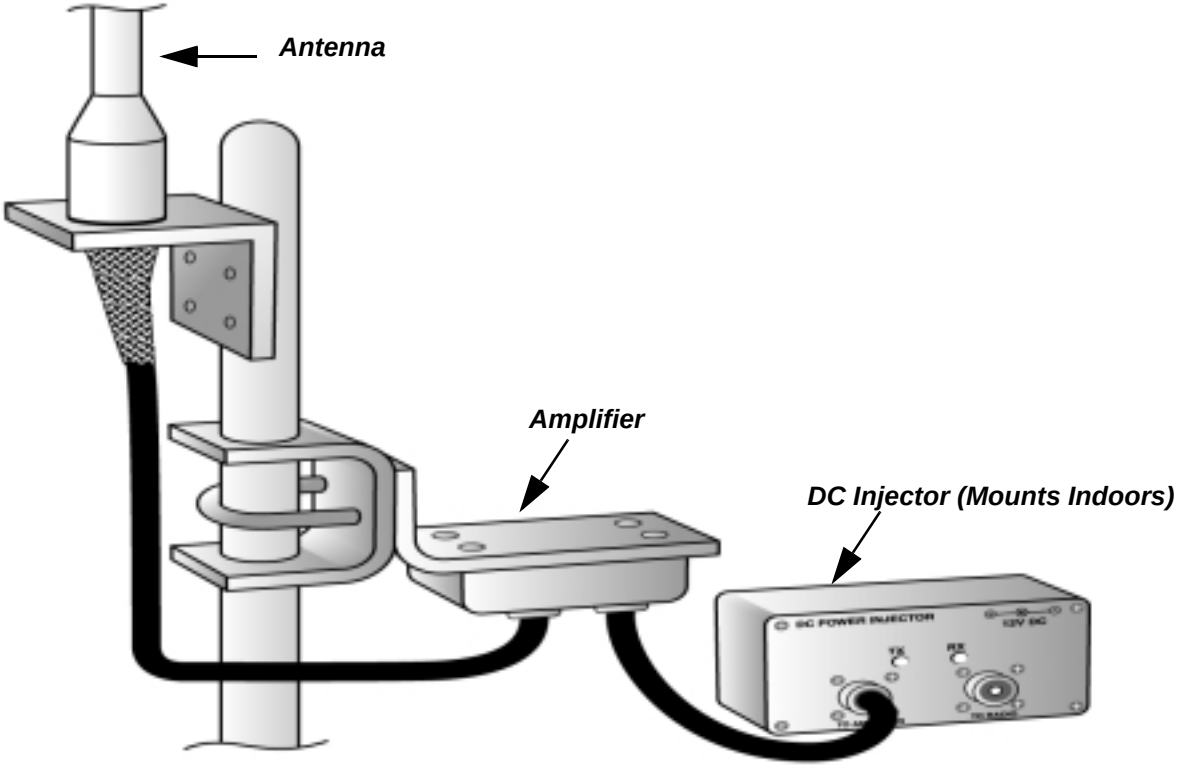
3.1.4.2 Network Connection

Connect an Ethernet crossover cable between the wireless router and the Personal Computer Ethernet connection. Use an RJ45 connector at the wireless router and the appropriate connector for your Personal Computer Ethernet connection.

3.1.5 Amplifiers

Amplifiers may be used in some installations. An Amplifier kit consists of the amplifier, which is mounted next to the antenna, and a DC injector, which requires AC power, and is mounted indoors next to the wireless router. Flexible RF jumpers connect the antenna cable to the amplifier and connect the wireless router to the DC injector. Low-loss RF cable connects the DC injector to the amplifier, usually through a small jumper cable.

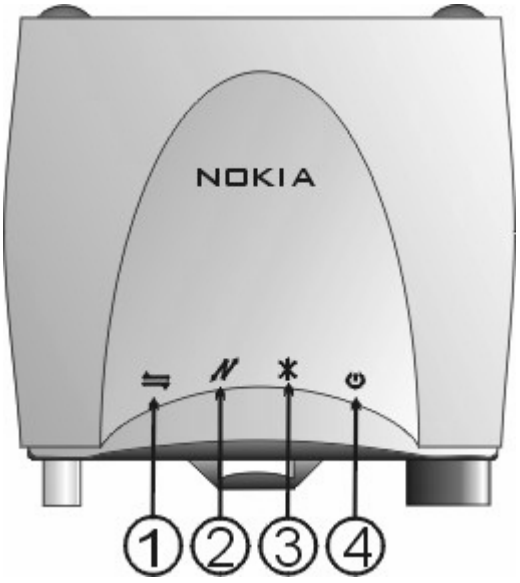
NOTE: Use only amplifiers supplied by Nokia and certified for use with the wireless router. Use of any other amplifier is a violation of FCC rules.



Amplifier Wiring

3.2 Front Panel

Wireless Router



Front Panel

3.2.1 LED Indicators

1. **LAN**: Blinking indicates packets are being transmitted between the wireless router and the LAN or PC.
2. **Radio**: Blinking indicates packet transmission and reception over the wireless interface.
3. **Anchor:** If the configured device is the AirHead, there will be no indication until another wireless router is configured. If the device is a remote, the following LED indications occur:

- **LED steady on:** The link to the next-hop (neighbor) in the path to the AirHead has a Data Rate of two Mbps and the path is <=3 hops.
- **Slow Flash** - The link to the next-hop (neighbor) in the path to the AirHead has a Data Rate of one Mbps and the path is <=3 hops.
- **Fast Flash** - Either
  - Connected to one or more neighbors but not to an AirHead, or
  - Connected to an AirHead with four or more hops in the path.
- **LED off** - The router has no neighbors.

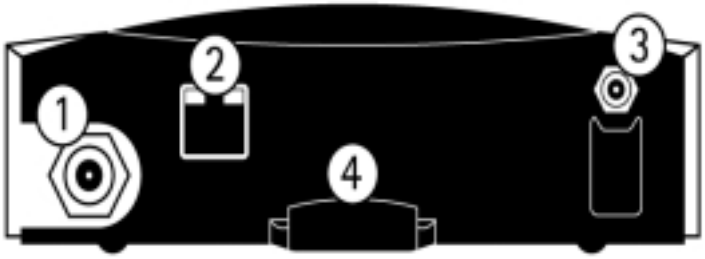
4. **Power Steady on:** the wireless router is on.

3.2.2 Configuration

Refer to the Nokia Wireless Router Manager Configuration Guide for configuration instructions.

3.3 Rear Panel

Wireless Router



Rear Panel Connections

1. **Antenna Connector:** Connect a small vertical antenna directly to the antenna jack or connect a cable to an external antenna. The connector is a reverse-polarized TNC female unit. You may need a jumper converter to attach cables to the wireless router. Most cables are supplied with reverse-polarized TNC male connectors. For systems with an amplifier, connect a small jumper cable to the DC Injector "To Radio" connector.
2. **LAN:** The LAN interface is a standard 10/100 BaseT Ethernet RJ45 jack. Connect the LAN interface on the wireless router to either:
   - The network using a standard Ethernet cable, or
   - A PC via an Ethernet **crossover** cable.

   See Appendix A for a wiring description for the Ethernet crossover cable.
3. **Power Port:** Connects the wireless router to the 12 VDC power connector.
4. **Strain Relief:** For the 12 VDC power cable.

APPENDIX A

Cables

Ethernet Crossover Cable

The wiring for an Ethernet Crossover cable for 10Base-T is as follows:

RJ45 Plug

Pin 1 (Tx+) to Pin 3 (Rx+)

Pin 2 (Tx-) to Pin 6 (Rx-)

Pin 3 (Rx+) to Pin 1 (Tx+)

Pin 6 (Rx-) to Pin 2 (Tx-)

APPENDIX B

Network Planning Guidelines

This appendix includes Network Planning Guidelines for Nokia RoofTop™ Wireless Routers.

To maintain broadband speeds in a Nokia RoofTop™ Wireless network follow these guidelines:

- Keep networks within three hops of the AirHead
- Do not connect more than 40 subscriber units to each AirHead
- Do not connect more than 6 networks to each AirHead

NOTE: Subscribers that are one hop away from the AirHead that act as a relay for customers behind them should have 2Mbps links.

NOTE: Subscribers who are two or three hops from the AirHead can have 1Mbps links without negatively affecting their performance, provided they do not act as a repeater for more than two other subscribers.

APPENDIX C

Technical Specifications

This appendix describes technical specifications for Nokia RoofTop™ Wireless Routers R242/242A.

Nokia RoofTop Wireless Router Models R242 & R242A Indoor-Mounted Unit	
Data Capacity per Cell	12 Mbps (6x2 Mbps per channel)
AirHeads per Cell Routers per Cell Routers per AirHead	Up to 6 Up to 240 Up to 40
Antenna Type (Typical	8 dBi Omnidirectional (external)
Link Range (Typical) 1 Mbps Data Rate 2 Mbps Data Rate	 0.75 Mile 0.25 Mile

Nokia RoofTop Wireless Router Models R242 & R242A Indoor-Mounted Unit (Continued)	
Radio/Modem Specifications	
Frequency Band	2.4000 - 2.4835 GHz
Radio Type	Frequency Hopping Spread Spectrum
Modulation	2 and 4-level GFSK
Transmit Power (typical)	26 dBm
Receiver Sensitivity (10^{-5} BER)	
1 Mbps Data Rate	-82 dBm (typical)
2 Mbps Data Rate	-72 dBm (typical)
Interfaces and Connectors	
Ethernet	10/100Base-TX, autosensing, RJ-45
Phoneline Networking	Not Applicable
RF	TNC-Female
Router Environment	
Operational Temperature	0^0C-45^0C (32^0 - 113^0F)
Relative Humidity	10% - 95% (non-condensing)
Router Weight	0.6 lbs.
Dimensions	
Router	5½" W x 4½" D x 1½" H
PowerSupply/Network Interface Unit	Not Applicable
Antenna (8 dBi)	20" H x 1¼" Base Diameter
Power Consumption	11 Watts @ 120/240 VAC
In-Line Lightning Arrestor	None
External Power Supply	12 VDC
Management	Nokia RoofTop Router Management System, SNMP

Nokia RoofTop Wireless Router Models R242 & R242A Indoor-Mounted Unit (Continued)	
Internet Protocols	IP, TCP, UDP, ICMP, RIPv1, RIPv2, SNMP, TFTP, IGMP, ARP, Proxy-ARP, DHCP Relay, DHCP Server, NAT
Agency Compliance	FCC Class B, FCC CFR 47 Part 15

APPENDIX D

Required Minimum Working Distances for Antennas

The installer must ensure, that the installation is such, that a minimum separation distance, as indicated in table 1, from persons is guaranteed in order to comply with exposure guidelines. When co-locating installations of dissimilar type, the installer must use the MPE distance for whichever installation has the highest MPE requirement.

Installation	Min. Feeder Cable Length (ft)	Max. EIRP at Individual Antenna (dBm)	MPE distance (cm) for number of co-located antennas					
			1	2	3	4	5	6
8 dBi omni	0	34	15	20	25	30	35	35
8 dBi panel	0							
10 dBi omni	50							
10 dBi sector	50							
12 dBi sector	50	36	20	30	35	40	40	45
8 dBi omni with amplifier	0							
15 dBi panel	0	41	30	45	55	65	75	80
17 dBi panel	0	43	35	60	70	80	90	100

Table 1. MPE safety distances

The system may also be co-located with other systems operating above 1.5 GHz which have a maximum EIRP less than 57 dBm (500 W), in which case the minimum separation distance must either be calculated as follows...

$$\text{MPE distance} = \sqrt{10^{EIRP_C/10} + 10^{EIRP_R/10}} / 3.54$$

...in which $EIRP_C$ is the sum of output power and antenna gain (in dBm) of the co-located system and $EIRP_R$ taken from Table 1. Alternatively, an MPE distance of 2 meters may be employed.

Co-location of the antenna for this device with other transmitters operating below 1.5 GHz or operating with other transmitters above 1.5 GHz with a total EIRP exceeding 500 Watts or co-location of more than 6 Wireless Routers will require an evaluation for RF exposure based on the FCC's guidelines as detailed in FCC document OET BULLETIN 65 Edition 97-01 August 1997. This might necessitate a site survey to ensure compliance with RF exposure requirements.

If more than one system is installed at a site, the installer must inform the customer of the proper MPE distance.

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