C34240.90–D0
Nokia FlexiHopper (Plus) Product Doc, Rel. 2.7

Product Description for Nokia FlexiHopper (Plus) 2.7

Hereby, Nokia Corporation, declares that this Nokia FlexiHopper (Plus) Microwave Radio Family is in compliance with the essential requirements and other relevant provisions of Directive: 1999/5/EC.

The product is marked with the CE marking and Notified Body number according to the Directive 1999/5/EC.

Contents

1 Summary of changes to Product Description for Nokia FlexiHopper (Plus) 2.7

1.1 Changes in documentation between release 2.5 and release 2.7

- Materials usage information of Networks Electronic Information Products imported or sold in the People's Republic of China has been added to chapter *Overview of Nokia FlexiHopper (Plus)*.
- Flexbus transmission sub-module (FTFA and FIFA) information has been added to chapter *Overview of Nokia FlexiHopper (Plus)*.
- Figures 5 and 16 have been updated with FTFA/FIFA information, and in figures 17 and 18 only minor editorial changes have been done.
- A new section *Nokia FlexiHopper (Plus) as a part of Nokia Flexi WCDMA and Flexi EDGE BTSs* has been added to chapter *Applications*.
- Section *Hopper Manager* has been updated with FTFA and FIFA information.
- Nokia T4E Service Telephone information has been removed from Engineering order-wire (EOW) and section renamed as *Engineering order-wire (EOW) over IP* in chapter *Management*.
- A new section *Installing FIU 19E outdoors* has been added to chapter *Mechanical structure and interfaces*.
- A new section *Flexbus Transmission Sub-modules* has been added to chapter *Mechanical structure and interfaces*.
- Updates have been made to Tables 4, 5, 12, 17, 45, 52, 62, 76, 77, 78, 79 and 80 in chapter *Technical specifications*.

- Sections *Environment* and *FIU 19(E) power supply, dimensions and installation options* in chapter *Technical specifications* have been updated with the Outdoor case information.
- Sections *FXC transmission unit* and *IFUE interface unit* have been removed from chapter *Technical specifications*.
- Flexbus cable, connector, and connector kit information updated in section *Flexbus cable* in chapter *Technical specifications*.

2 Overview of Nokia FlexiHopper (Plus)

The *Nokia FlexiHopper (Plus) 2.7 Product Description* covers Nokia FlexiHopper Plus, Nokia FlexiHopper and Nokia FlexiHopper 4E1 products and supporting indoor units. The following rules apply:

- Nokia FlexiHopper Plus enables 2E1 to 16E1 transmission capacity and selectable modulation (4-state and 16-state).
- Nokia FlexiHopper enables 2E1 to 16E1 transmission capacity in the 4-state modulation mode.
- Nokia FlexiHopper 4E1 enables 2E1 to 4E1 transmission capacity in the 4-state modulation mode and can be upgraded to 16E1 by software licensing.
- Selectable modulation is an option for both Nokia FlexiHopper and Nokia FlexiHopper 4E1.

In this Product Description, Nokia FlexiHopper (Plus) and Nokia FlexiHopper refer to the modulation in use. Nokia FlexiHopper (Plus) refers to all Nokia FlexiHopper products.

Nokia FlexiHopper (Plus) is a reliable and flexible microwave radio, which can be used in diverse transmission networks: mobile networks, fixed networks or private networks. It provides flexible features like selectable capacity and modulation, which keeps the lifetime cost of Nokia FlexiHopper (Plus) low. Reliability is designed into Nokia FlexiHopper (Plus) by using highly integrated circuits. The high integration rate can be exemplified by indoor units which all support several outdoor units. Several indoor units have been integrated into one unit. The transmission network reliability can be greatly increased by reducing required cabling on a site. No E1-cabling at all is required on a site when Nokia base station integrated indoor units are used.

The Nokia FlexiHopper (Plus) microwave radio consists of an indoor unit (IU) and an outdoor unit (OU). The units are connected together with a single coaxial cable, Flexbus. The Flexbus cable carries power and digital baseband data.

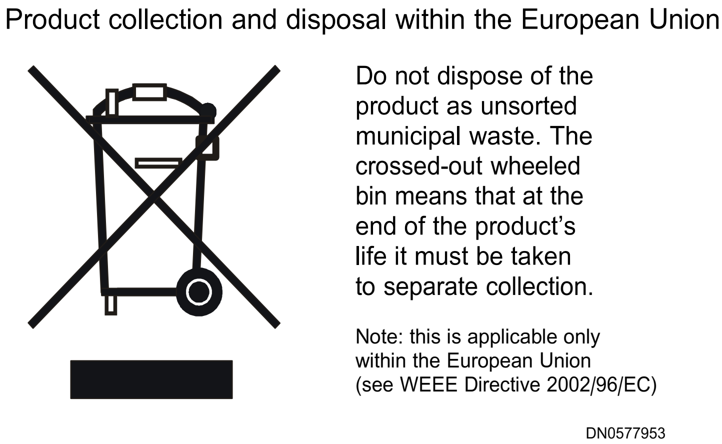
Nokia FlexiHopper (Plus) provides ultimate transmission solution as flexible transmission connectivity. Nokia FlexiHopper (Plus) is the cellular transmission solution for Nokia Base station subsystem solution and for 3G Radio Access Network. Nokia FlexiHopper (Plus) outdoor unit can be connected to several indoor units, which are integrated into Talk, UltraSite, MetroSite, and Flexi base stations. With this approach one does not need an expensive site support cabinet, which also reduces the site space and gives more flexibility on selecting a site. The Nokia FlexiHopper (Plus) indoor unit can also be integrated into Nokia AXC and MetroHub stand-alone transmission nodes. The Nokia FlexiHopper (Plus) outdoor unit can also be used as a stand-alone transmission solution with FIU 19 and FIU 19(E) for any kind of telecom or datacom transmission solutions where standard E1 or Ethernet interfaces are used.

All these cellular transmission solutions and installations above can be easily and remotely managed with the same Network Management System.

RoHS compliance

Nokia FlexiHopper (Plus) complies with the European Union RoHS Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment. The directive applies to the use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), and polybrominated diphenyl ethers (PBDE) in electrical and electronic equipment put on the market after 1 July 2006.

WEEE



Materials usage information of Networks Electronic Information Products imported or sold in the People's Republic of China

Nokia FlexiHopper (Plus) complies with the standard SJ/T 11364-2006 in the People's Republic of China on the restriction of the use of certain hazardous substances in electrical and electronic equipment. The standard applies to the use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), and polybrominated diphenyl ethers (PBDE) in electrical and electronic equipment put on the market after 1 March 2007.

One unit, all capacities – one platform, two different modulation schemes

Nokia FlexiHopper (Plus) microwave radios are available for the 7, 8, 13, 15, 18, 23, 26, 28, 32 and 38 GHz frequency bands. Nokia FlexiHopper (Plus) introduces two different modulation schemes: 4-state and 16-state modulations. To use 16-state modulation with Nokia FlexiHopper and Nokia FlexiHopper 4E1, the user must order a separate licence file from Nokia. Nokia FlexiHopper (Plus) includes selectable modulation. For more information, see *Licensing*.

The radio transmission capacities of Nokia FlexiHopper (Plus) 4-state modulation are 2x2, 4x2, 8x2, or 16x2 Mbit/s. The channel spacing is accordingly 3.5, 7, 14 or 28 MHz. For 18 GHz there are two alternative channel spacings for each capacity available. The radio transmission capacities of 16-state modulation are 8x2 or 16x2 Mbit/s and the channel spacing is accordingly 7 or 14 MHz. Operating modes can be selected using the node manager without any hardware changes on either indoor or outdoor unit. This makes upgrading a Nokia FlexiHopper (Plus) hop easy and inexpensive, as it can be done entirely remotely in some cases.

Figure 1. Nokia FlexiHopper (Plus) outdoor unit

Flexible functionality and hardware platform

The transmitter uses either 4-state modulation (π/4-DQPSK, differential quadrature phase shift keying) or optional 16-state modulation (32 TCM, Trellis coded modulation), which have the advantages of a narrow spectrum and a good output power efficiency. The optional 16-state modulation is available for 8x2 and 16x2 Mbits/s capacities. The channel bandwidth is half of the bandwidth required for the 4-state modulation.

Nokia FlexiHopper (Plus) supports ALCQ, which is an advanced method, Automatic Transmit Power Control (ATPC). This feature enables the radio transmitter to optimize the transmit power based on the receiving signal quality on the other end of a hop.

With Hopper Manager one can select the Tx frequency freely with 1 kHz frequency step inside the duplex frequency subband.

The Nokia FlexiHopper (Plus) outdoor units are small, lightweight and easy to install.

One interface in the alignment unit supports all Nokia FlexiHopper outdoor units in all frequency bands.

Cabling and grounding connections are the same for Nokia FlexiHopper 4E1 outdoor units, Nokia FlexiHopper outdoor units and Nokia FlexiHopper (Plus) outdoor units.

Antennas for Nokia FlexiHopper (Plus)

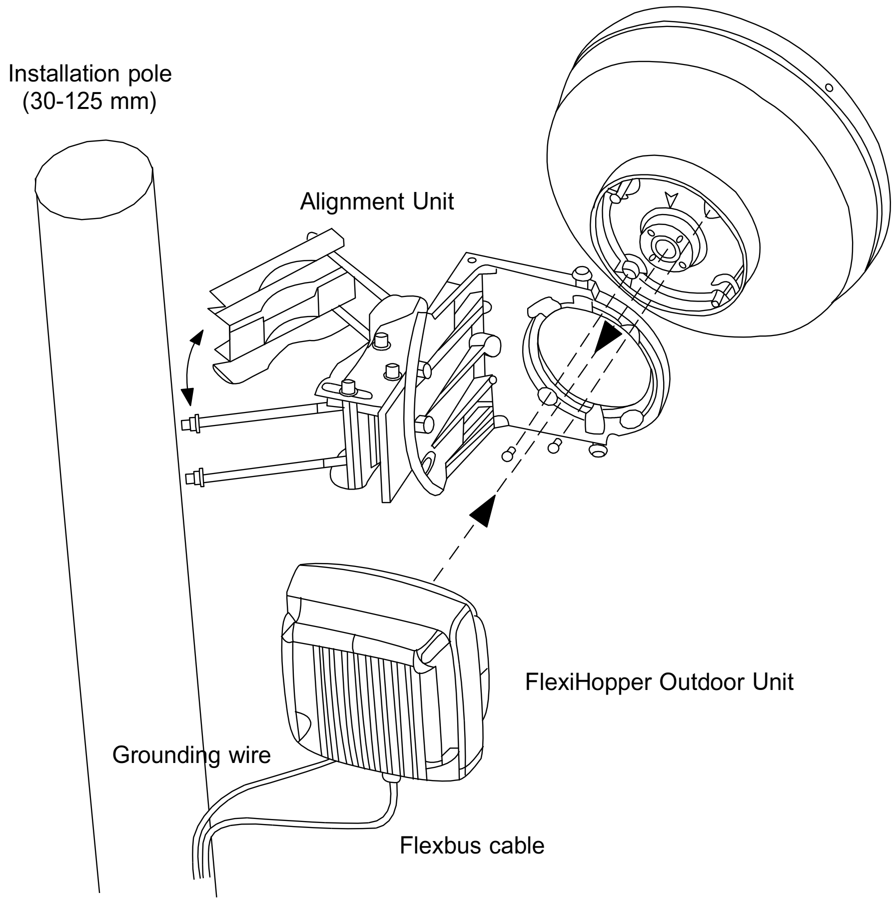


Figure 2. Nokia FlexiHopper (Plus) outdoor unit with an integrated 30 cm antenna and alignment unit

The antenna used with Nokia FlexiHopper (Plus) may be integrated or separate. Antennas are available in eight sizes: 20, 30, 60, 90, 120, and 180, 240 and 300 cm. The polarisation of the antenna can easily be changed by rotating the outdoor unit and the antenna feeder through 90°.

The Nokia FlexiHopper (Plus) radio is directly connected to a small (20, 30, or 60 cm) single antenna by using Nokia alignment unit or to a larger single antenna (90, 120, or 180 cm) by using a snap-on-adapter. No waveguides are needed. The alignment is carried out by using a ratchet or a battery-operated screwdriver.

All antennas can be used separately by using the flexible waveguide between the antenna and the radio. Large antennas (240, 300 cm) as well as all dual polarised antennas can only be used separately. 2.4m single polarised (SP) antenna is also available with a split reflector option, and the 3.0m antennas are delivered only with the split reflector option.

For more information on the antennas, see *Nokia FlexiHopper (Plus) 2.7 Antennas, Alignment Units and Electrical Specifications*.

Installation

The outdoor unit can be installed on a roof, wall, or tower. The antenna with the alignment unit can be installed on either side of a pole. Normally, no loose parts are needed in the installation of the alignment unit and the outdoor unit. The outdoor unit and the antenna are fitted with guides, which prevent installation in conflicting polarisations.

Connectors and cabling

The indoor unit and the outdoor unit are connected through a single coaxial cable (Flexbus), which also feeds DC power to the outdoor unit. The outdoor unit has one coaxial connector for the Flexbus cable and one BNC connector for measurement of the AGC (automatic gain control) voltage. AGC voltage measurement is needed when aligning the antenna.

Power supply

The power is fed to the outdoor unit from the indoor unit through the Flexbus cable. There is no need for separate power supply. The power consumption of a Nokia FlexiHopper (Plus) outdoor unit is at a maximum only 25 W, which results in high reliability and a long running time on battery backup.

One indoor unit supports several outdoor units

Nokia supplies different indoor units for Nokia FlexiHopper (Plus) to provide optimal features for different environments. All frequency bands use the same indoor units. One FIU 19(E) can support transmission in up to three directions with the maximum of four outdoor units.

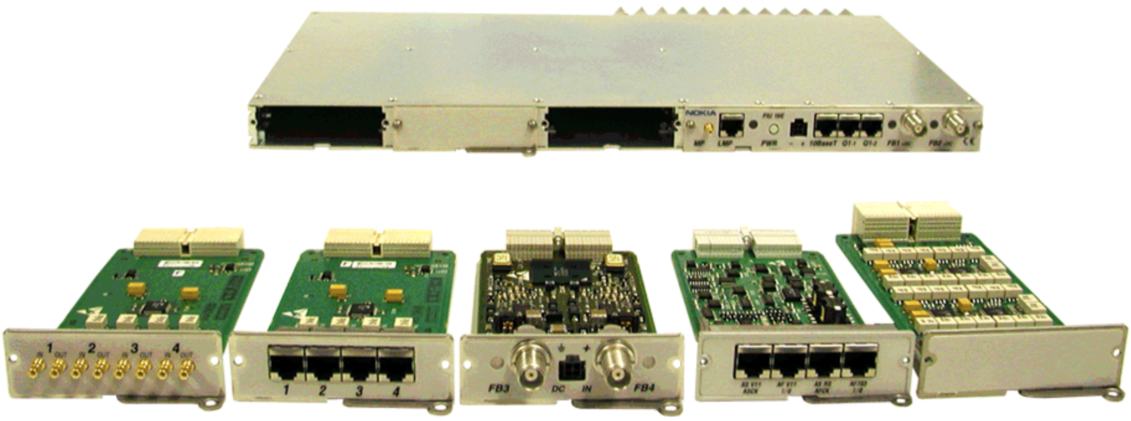


Figure 3. FIU 19(E) indoor unit

The full radio capacity from 2x2 Mbit/s up to 16x2 Mbit/s is available with all indoor unit models. The add/drop capacity varies according to the indoor unit configuration. You can use the same indoor units with the Nokia MetroHopper at fixed 4x2 Mbit/s radio capacity.

The main features of each indoor unit are described below.

FIU 19 − compact 19″ indoor unit

FIU 19 is a modular indoor unit for 19-inch applications. The main unit is only 2/3 U (29 mm) high. The interface capacity of FIU 19 can be from 4x2 up to 16x2 Mbit/s. You can easily expand it with plug-in units in 4x2 Mbit/s increments. The 16x2 Mbit/s interface capacity can be achieved by the expansion unit, which is the same size as the main unit. The 2 Mbit/s cross-connect function is integrated into the FIU 19 indoor unit. FIU 19 enables connection for up to four outdoor units and supports hot standby and diversity protection methods.

With FIU 19, Nokia FlexiHopper (Plus) can use the Q1 management channel and Nokia NetAct or NMS/10 Network Management System (NMS).

FIU 19(E)

FIU 19(E) has all the same features as FIU 19. Additionally FIU 19(E) supports the SNMP management and the Ethernet payload traffic. The FIU 19(E) indoor unit has an Ethernet interface for the IP DCN. For FIU 19 (E) there is an optional Ethernet plug-in unit, which has two Ethernet ports.

FIU 19(E) can also be installed outdoors within a special outdoor case. See *Installing FIU 19E outdoors* for more information.

FXC RRI - Nokia MetroSite BTS, Nokia MetroHub, and Nokia UltraSite BTS indoor unit

FXC RRI is an indoor unit, which can be installed in Nokia MetroSite Base Station, Nokia MetroHub Transmission Node, or Nokia UltraSite Base Station. FXC RRI enables connection to two outdoor units, supports loop protection as well as hot standby and space diversity protection methods, and also provides grooming with 8 kbit/s granularity. The add/drop capacity is 16x2 Mbit/s.

IFUE - Nokia MetroSite WCDMA and Nokia UltraSite WCDMA interface unit

IFUE is an interface unit that can be installed in Nokia MetroSite WCDMA and Nokia UltraSite WCDMA base stations. The IFUE has three Flexbus interfaces and it provides up to 16x2 Mbit/s capacity to ATM cross-connection. IFUE supports hot standby as well as diversity protection methods between Flexbus interfaces 1 and 2.

FTFA - Flexbus Transmission Sub-module for Nokia Flexi WCDMA BTS

FTFA is an interface unit that can be installed in Nokia Flexi WCDMA base stations. It has two Flexbus interfaces and it provides up to 16x2 Mbit/s transmission capacity.

FIFA - Flexbus Transmission Sub-module for Nokia Flexi EDGE BTS

FIFA Flexbus Transmission sub-module for Nokia Flexi EDGE BTS provides radio transmission interface functionality and power supply and control to Nokia microwave radios.

FIFA provides two external Flexbus interfaces and internal 2 Mbit/s interfaces (up to 16) towards Nokia Flexi EDGE System Module (ESMA).

Easy-to-use management system

Nokia FlexiHopper (Plus) can be fully controlled and managed locally by:

- Hopper Manager (with FIU 19(E))
- Nokia SiteWizard (with FXC RRI)
- Nokia AXC-FB Hopper Manager (with IFUE)
- Nokia FlexiHub Manager (with FTFA and FIFA)

or remotely with the Nokia network management system, NetAct.

The node managers feature an easy-to-use graphical user interface with Commissioning Wizard that guides the user through commissioning tasks.

Versatile maintenance and troubleshooting facilities

- The quality of the transmission can be monitored with the built-in BER (bit error ratio) measurement and with ITU-T G.826 statistics.
- Far-end and near-end loops can be used for troubleshooting.
- Software of the outdoor unit and the indoor units can be updated by using local or remote software download.
- Transmission Loader is an optional software tool, which automates the task of updating a large network.
- Alarms with troubleshooting information.

3 Features

3.1 General information

The *Nokia FlexiHopper (Plus) Product Description* covers Nokia FlexiHopper Plus and Nokia FlexiHopper products and supporting indoor units.

In this Product Description, Nokia FlexiHopper Plus and Nokia FlexiHopper refer to the modulation in use. Nokia FlexiHopper (Plus) refers to all Nokia FlexiHopper products.

3.2 Integrated radio and cross-connection

A cross-connection of 2 Mbit/s is integrated into the indoor units and can freely be programmed between different Flexbuses and 2 Mbit/s interfaces. The indoor unit has two or four (FIU 19(E)) totally independent framing/deframing sections, which can be cross-connected to external or internal Flexbus interfaces.

Flexbus − single cable interconnections

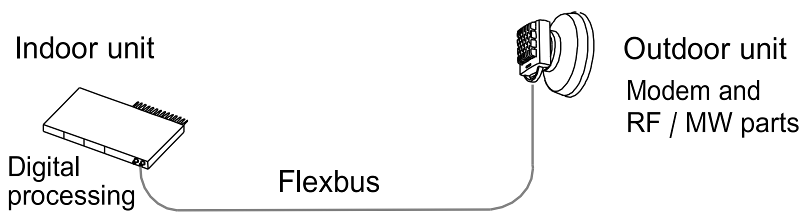


Figure 4. The basic Nokia FlexiHopper (Plus) network element configuration

The bidirectional Flexbus cable connects all system elements together. Flexbus carries digital 2 - 16 x 2 Mbit/s signals and controls data between the units of the network element, from the indoor unit to the outdoor unit, as well as from one indoor unit to another indoor unit. Flexbus also feeds DC power to the outdoor unit.

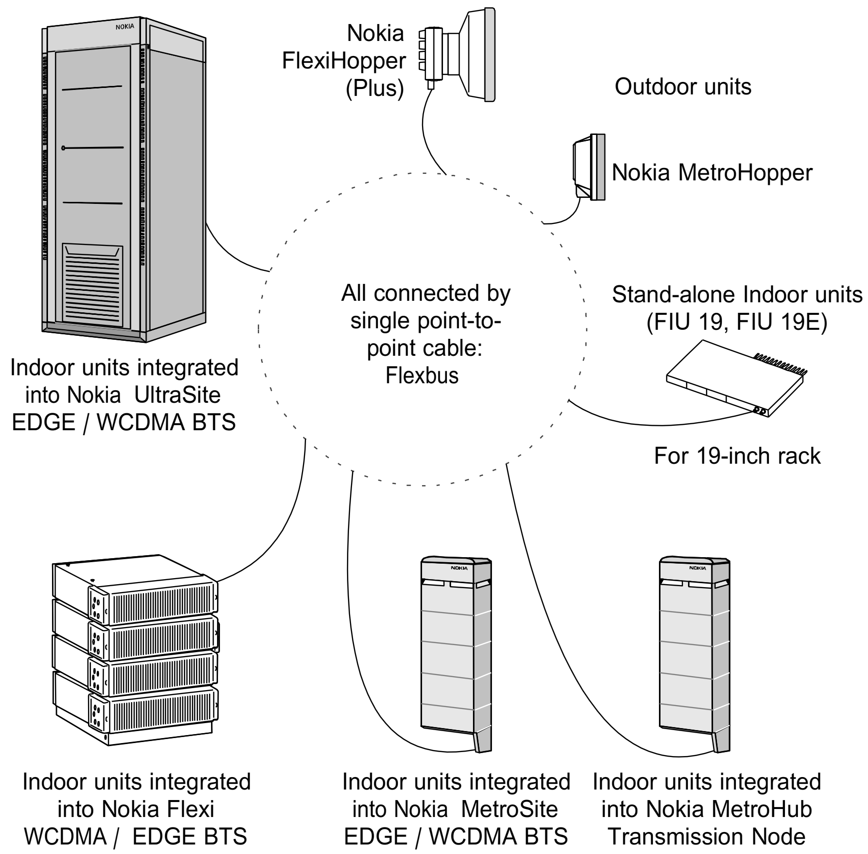


Figure 5. The Flexbus family

Flexbus gives high flexibility to PDH networks without any external multiplexers. Several different logical signals can be carried by Flexbus and all on-site cabling is made by internal electrical cross-connections. If the conventional method is needed, the separate 2M interfaces are available with the FIU 19(E) indoor unit.

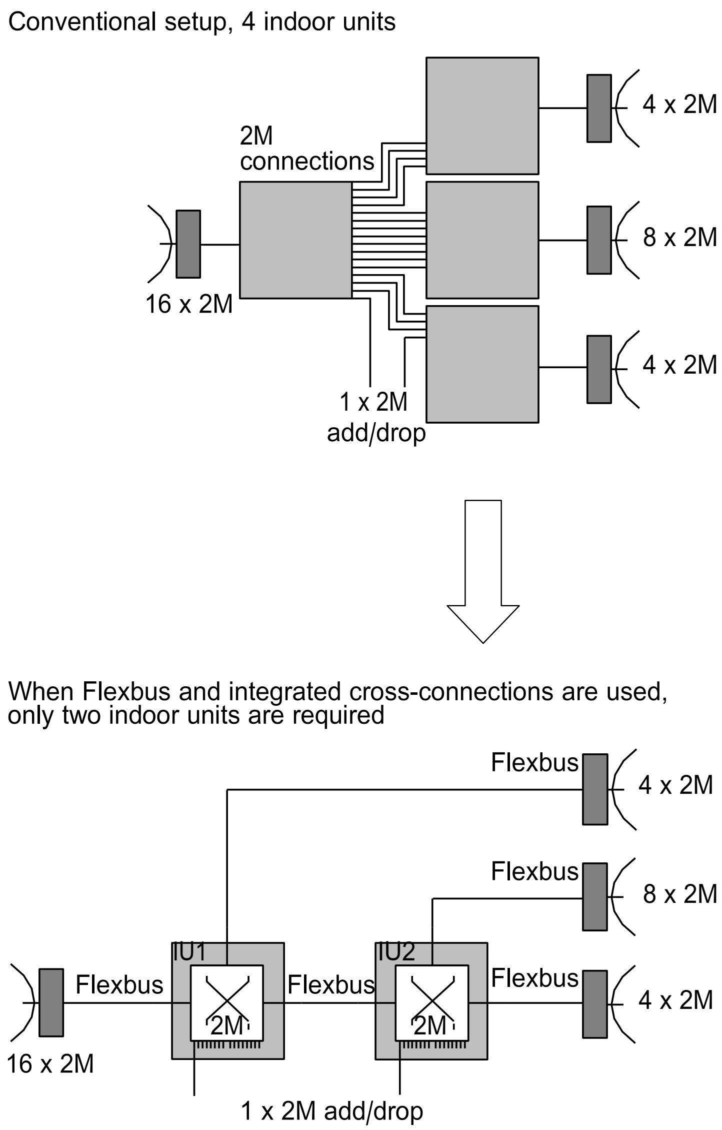


Figure 6. Removing 2M cabling from a site with FIU 19(E) and Flexbus

In a conventional setup (figure *Removing 2M cabling from a site with FIU 19(E) and Flexbus* and figure *Site cabling effect*) the system elements are connected together using several 2M cables. You can replace all these with a single Flexbus cable and figure *Site cabling effect*). Note that in this example, in a conventional 16x2 Mbit/s system, there could be up to 96 cables.

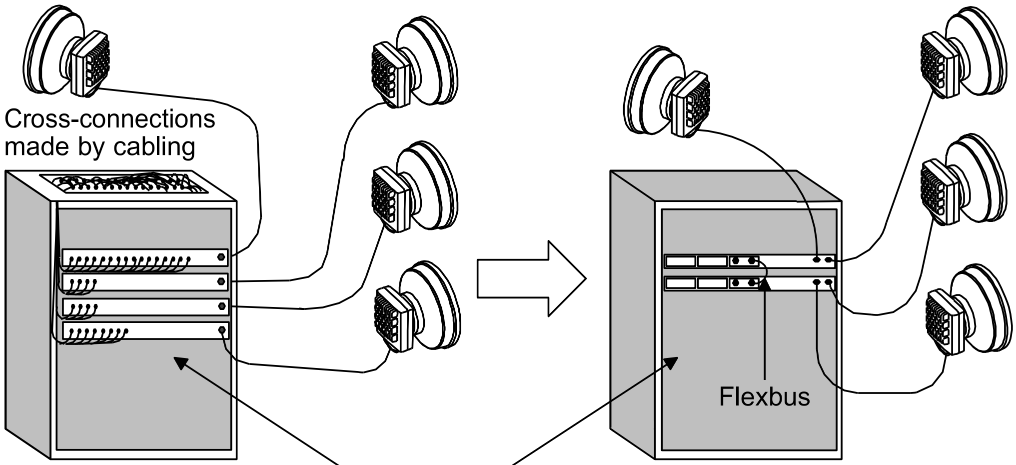


Figure 7. Site cabling effect

The cross-connections (which replace the conventional cabling) can be modified using the Hopper Manager. The cross-connections in IU2 in figure *Removing 2M cabling from a site with FIU 19(E) and Flexbus* are also pictured in figure *Cross-connections in a node manager window*.

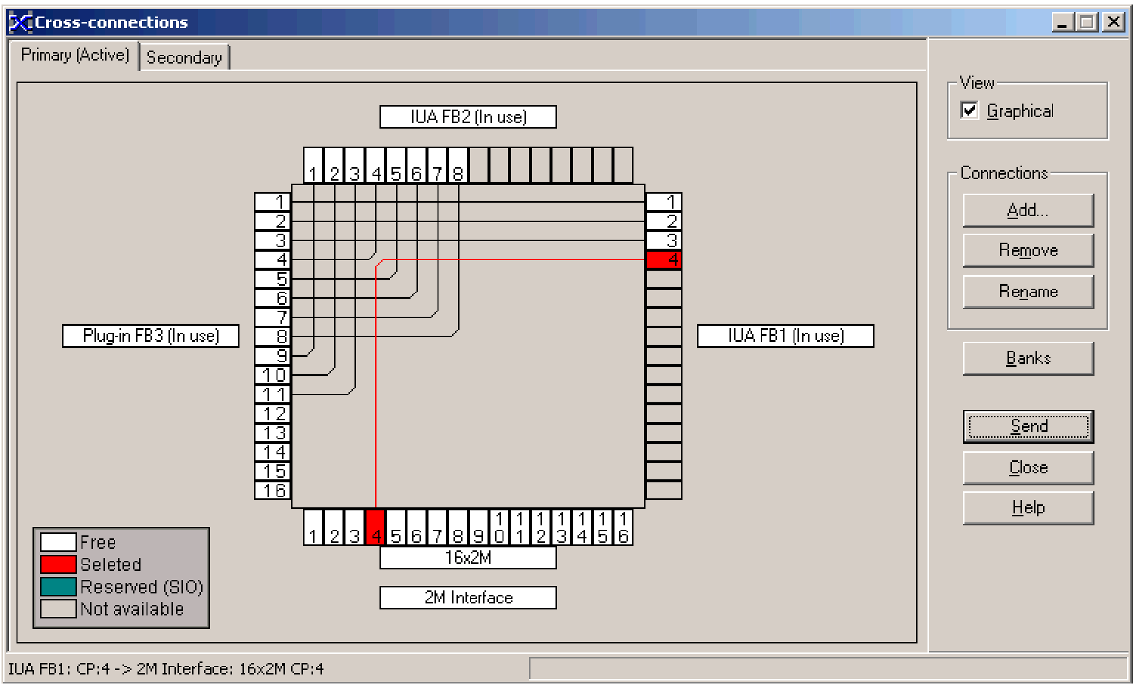


Figure 8. Cross-connections in a node manager window

3.3 Outdoor unit features

3.3.1 Overview of Nokia FlexiHopper (Plus) outdoor unit features

The figure *Block diagram of the outdoor unit* illustrates the top-level block diagram of the radio outdoor unit. The outdoor unit includes five functional units:

- a power supply unit (PSU)
- a modem board
- an intermediate frequency unit (IFU)
- a microwave unit (MWU), and
- a duplex filter.

Use a single coaxial cable when you connect the outdoor unit to the indoor unit. The cable carries the baseband data between the indoor and the outdoor unit in full duplex mode. It also carries the required DC power to the outdoor unit. The cable is connected to the unit in which the data traffic is filtered and transferred to the modem board. The needed DC voltages are generated in the PSU and delivered to other units through the modem board.

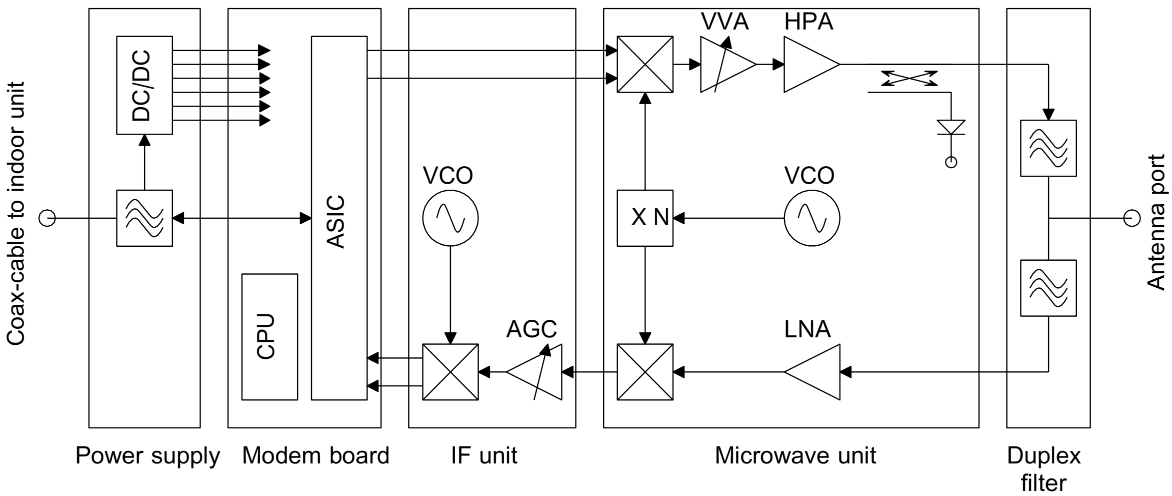


Figure 9. Block diagram of the outdoor unit

Unlike the traditional outdoor unit designs, the modem board is located in the outdoor unit, which makes it possible to use more advanced control loops between the modem board and the RF parts (IFU and MWU).

The main component of the modem board is the custom design ASIC (application-specific integrated circuit). The ASIC contains a digital modulator and demodulator with Reed-Solomon forward error correction (FEC).

The interface between the modem board and the RF part is analog I and Q signals. The modem board also includes an embedded microprocessor system, which is used to control all units inside the outdoor unit as well as to communicate with the indoor unit and the far-end unit when needed.

The RF functions are divided between two units: the IF unit and the microwave unit. The MWU includes all microwave circuits, most of which are MMICs, while the IFU includes required intermediate frequency circuits.

In the transmitter side, direct conversion architecture has been implemented to enable use of a single microwave local oscillator. Since the I/Q up-converter operates at the end frequency, a digital feedback loop is required to correct the amplitude and phase errors of the modulator.

After the up-conversion the signal is amplified enough in order to obtain the required maximum output power level. A temperature compensated power detector is used to monitor the power level after the high power amplifier (HPA), and thus, to drive the voltage variable attenuator (VVA) in order to obtain the required output power level.

In the receiver side, the single IF conversion architecture is used. After the low-noise amplifier (LNA) the received signal is down-converted to the IF. The automatic gain control (AGC) with a dynamic range of about 100 dB is used to obtain a constant rms-power level for the I/Q-demodulator.

The outdoor unit contains two separate phase-locked oscillator circuits. In the MWU, the fundamental oscillator frequency is multiplied in order to obtain the low phase noise VCO signal for the transmitter (Tx) and the receiver (Rx) up- and down-converters. Due to the common VCO frequency at Tx and Rx, the IF frequency is always equal to the duplex spacing.

The waveguide duplex filter separates the transmitter and the receiver and provides at the same time low loss connection to the antenna port.

3.3.2 Forward error correction coding, interleaving and scrambling

Nokia FlexiHopper (Plus) microwave radios use forward error correction (FEC), interleaving and scrambling to improve the transmission quality. The FEC is continuously on, the interleaving is selectable in 4-state modulation between off, 2-depth and 4-depth modes, and for the scrambling there are two optional polynomials. For 16-state modulation the interleaving is fixed to 4-depth mode.

The forward error correction uses the Reed-Solomon coding [RS(63,59)]. The code uses 4 redundancy symbols for every 59 data symbols, so the redundancy of the coding is 6.4%. Together with the interleaving also errors of burst type can be corrected. The maximum error correction effectiveness is achieved with 4-depth interleaving.

When interleaving is in use, the transmission delay increases slightly. Normally this is not a problem, but in long chains of radio links the delay accumulates, and it might be necessary to turn the interleaving off. The acceptable delay for a chain of links should be determined in the transmission planning stage and the interleaving status should be set accordingly.

For more information on FEC, interleaving and scrambling, see Technical Note 93 available in NOLS (Nokia Online Services) under Documentation → Technical Documentation → Transmission and Backbone → Microwave Radios → Maintenance Documentation.

The interleaving and scrambling polynomial settings must be the same in both ends of the hop. Otherwise, the transmitted data is not received correctly. The 4-depth interleaving setting is recommended if no special conditions are needed.

3.3.3 ALCQ - Adaptive Level Control with Quality measurement

ALCQ is a method for the Automatic Transmit Power Control (ATPC). This feature enables the radio transmitter to increase or decrease the transmit power automatically, according to the response received from the other end of the hop. This approach achieves more efficient utilization of radio frequencies than the constant power level approach. The controlled use of transmit power reduces interference between systems, which, in turn, allows tighter packing of radio links within the same geographical area or at network star points.

For more information on ALCQ, see Technical Note 79 available in NOLS (Nokia Online Services) under Documentation → Technical Documentation → Transmission and Backbone → Microwave Radios → Maintenance Documentation.

The maximum transmit power is set with the Hopper Manager. However, when the ALCQ is in use, the radio always tries to transmit at minimum power. The common idea behind ALCQ is to monitor the received signal level together with the bit error ratio (BER) of the receiver, and to adjust the far-end transmitter output power to adapt to the fading conditions.

In addition to these conventional ALCQ operation mechanisms, Nokia FlexiHopper (Plus) also applies a novel pseudo-error monitoring for controlling ALCQ. According to this Nokia invention, the bit errors detected by the forward error correction (FEC) decoder are interpreted as pseudo-errors, and further, used as an additional input for the ALCQ operation. In other words, this method can respond to degradation of signal quality before actual bit errors occur over the radio relay.

If the fading increases rapidly (multipath fading), the radio reacts immediately by increasing the power, but not higher than the set maximum value. After the fading conditions resume to normal, the power is gradually decreased. The ALCQ also reacts to slow changes in the fading conditions by gradually increasing the transmit power.

3.3.4 Fading margin measurement

During the commissioning of a microwave radio, the operator may wish to measure the fading margin of the radio hop. Traditionally this has required much work and additional hardware, such as RF (radio frequency) attenuators. In Nokia FlexiHopper (Plus), the fading margin measurement is automatic and can be started simply by using the Hopper Manager software.

For more detailed information on the fading margin measurement, see Technical Note 79 available in NOLS (Nokia Online Services) under Documentation → Technical Documentation → Transmission and Backbone → Microwave Radios → Maintenance Documentation.

3.4 Protection methods

The purpose of protection methods is to protect the transmission link against equipment failures and against disturbances in the radio path. The equipment failures mean degraded transmission quality due to transmitter or receiver defects. The disturbances in the radio path are usually caused by flat or multipath fading that degrades the signal quality in the way that there are bit errors in the received data or the receiver cannot lock to the received signal any more.

In single use, the transmission is not protected against equipment failures or propagation disturbances. If a fault occurs, the transmission remains broken until the faulty device is repaired or replaced with a functional one or the disturbance in the radio path disappears.

In general, the protection methods are divided into two categories:

1. equipment protection and
2. propagation protection.

In the Nokia FlexiHopper (Plus) microwave radios, hot standby (HSB) is used as an equipment protection method. This means that the number of outdoor units and indoor units can be doubled in order to provide protection against any equipment failure. The redundant units are switched on, but they are muted when the primary units are operating correctly.

In the Nokia FlexiHopper (Plus) microwave radios, the available modes for equipment protection are:

- hot standby with 1 indoor unit and with 2 outdoor units
- hot standby with 2 indoor units and with 2 outdoor units
- hot standby with space diversity and with 1 indoor unit and with 2 outdoor units
- hot standby with space diversity and with 2 indoor units and with 2 outdoor units.

In the hot standby configurations you can use a one-antenna configuration or a two-antenna configuration. When you use the one-antenna configuration, you need a directional coupler. In the hot standby configurations with space diversity, two antennas are needed.

The propagation protection modes supported in the Nokia FlexiHopper (Plus) microwave radios are:

- space diversity
- frequency diversity
- polarisation diversity

In each propagation protection mode, the configuration may include either one or two indoor units. Two outdoor units are needed in all protection modes.

When 2 indoor unit protection configuration is used, both E1 and Ethernet (FIU 19E C2.0 and later releases) payload can be protected.

FXC RRI is the indoor unit which can be integrated into Nokia UltraSite and MetroSite GSM/EDGE base stations, as well as the Nokia MetroHub transmission node. FXC RRI supports hot standby as well as space diversity protection using a single indoor unit (1IU + 2OU). FXC RRI also supports loop configurations, which provide both equipment protection and propagation protection. In UltraSite BTS and MetroHub, loop protection can also be implemented with two FXC RRI indoor units (2IU + 2OU).

IFUE is the indoor unit which can be integrated into Nokia UltraSite and MetroSite WCDMA base stations, as well as the stand-alone Nokia AXC transport node. IFUE supports hot standby and also space diversity protection between Flexbus interfaces 1 and 2, in addition to frequency diversity and phase diversity protection methods.

For more information on the protection methods, see Technical Note 94 available in NOLS (Nokia Online Services) under Documentation → Technical Documentation → Transmission and Backbone → Microwave Radios → Maintenance Documentation.

3.5 Dual capacity setup

In dual capacity setup for Nokia FlexiHopper (Plus), two RF bandwidths are transmitted and received in the same channel by using two orthogonal polarisations. A dual polarisation antenna can be used in order to have orthogonal separation between polarisations. Dual polarisation is available in both 4-state and 16-state modulation modes.

The frequency reuse is a technique employed to minimise frequency separation and to increase spectrum capacity without increasing spectrum occupancy. The use of two orthogonal polarisations on the same hop is a method to double the capacity without increasing RF bandwidths. The advantages of the dual capacity setup are:

1. possibility to double the capacity of the hop
2. possibility to provide less expensive equipment with only one antenna and two radios on both ends of the hop

Disadvantages of the dual capacity setup are:

1. Unavailability objectives are harder to achieve due to propagation effects.
2. Error performance targets are harder to achieve.
3. Usable maximum hop lengths are shorter due to unavailability or error performance objects.

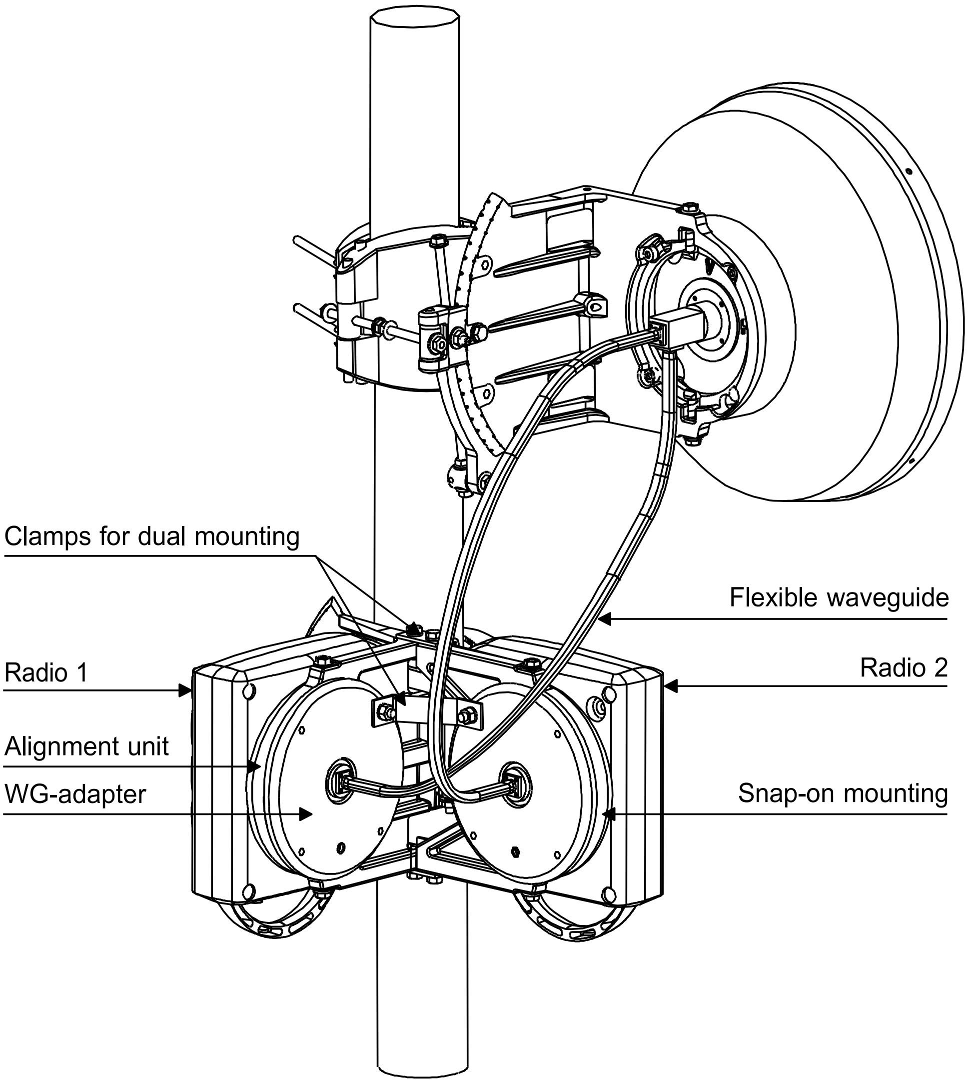


Figure 10. Dual polarisation antenna setup

For more information, see Technical Note 91 available in NOLS (Nokia Online Services) under Documentation → Technical Documentation → Transmission and Backbone → Microwave Radios → Maintenance Documentation.

3.6 FIU 19(E) with Ethernet plug-in unit

The Ethernet plug-in unit (EPIU) interface unit provides two Ethernet interfaces and makes it possible to transport Ethernet traffic over Nokia FlexiHopper (Plus) and Nokia MetroHopper radios.

The EPIU supports up to two microwave radio links with Ethernet traffic. The capacity of the radio links can be shared between Ethernet traffic and traditional E1 traffic. The Ethernet plug-in unit is available on FIU 19(E) 2.0 and later releases.

The EPIU provides two 10/100 Base-T Ethernet interfaces (IEEE 802.3, IEEE 802.3u, IEEE 802.3x) on a single plug-in unit. With the Ethernet plug-in unit you can install a 4x2Mbit/s interface unit into a FIU 19(E) indoor unit and thus share the radio capacity between TDM and Ethernet traffic. Up to 32 Mbits/s of radio path capacity can be configured for the Ethernet traffic. The capacity can be selected with 2 Mbits/s granularity. The remaining radio link capacity can be used for TDM traffic.

The EPIU can learn up to 2048 MAC addresses totally. The MAC address learning, the filtering and the ageing is done automatically at each port of the EPIU. The time for the address ageing is fixed to 5 minutes.

The EPIU can be used in any combination with 4x2M plug-in units. It can also be used with other FIU 19(E) plug-in units including the extension unit (EXU). Note, however, that the EPIU can only be used in plug-in unit slot 2 of the FIU 19(E) indoor unit.

The Ethernet plug-in unit also has LEDs for indicating the link status and the activity for each Ethernet interface.

The Hopper Manager is the primary tool for managing FIU 19(E) with EPIU. The unit also supports configuration through a custom MIB. This enables traffic data to be monitored and interfaces to be configured in a standard way using SNMP. You can also upgrade the EPIU software remotely, with Hopper Manager, in a similar way as other FIU 19(E) software modules.

The EPIU is supported for FIU 19(E) release 2.0 HW and later releases. Earlier FIU 19(E) releases cannot be upgraded to support the EPIU.

Ethernet plug-in unit operating modes

The EPIU supports three operating modes:

- channel separation
- capacity sharing
- full switch mode

The EPIU can be used in the following FIU 19(E) network configurations:

- single hop
- 2OU protected mode
- 2IU protected mode

Features supported by the EPIU

The EPIU supports the following:

- hot swap and hot plug-in
- both full and half duplex Ethernet interfaces with autonegotiation
- the use of both cross-over and straight cabling with the automatic MDI/MDIX crossover detection feature
- transparent Ethernet bridging over the radio hop
- standard Ethernet frame support, transparent bridging for VLAN tagged Ethernet frames (length max. 1522 bytes), and also extended frame sizes up to 1536 bytes are supported
- the packet buffer size is selectable towards the radio link with the following options: 32, 64 or 128 kB. In the direction of the receiver, there is a memory of 128 kB that is shared between two Ethernet ports
- Ethernet flow control by Pause frames in full duplex mode
- link loss forwarding (LLF)
- the standard MIB definitions: RMON statistics group from RFC 2819 and Interface group from RFC 2863
- selectable priority between E1 and Ethernet interfaces for 2IU changeover criteria.

Limitations and restrictions of the EPIU

- The Ethernet radio hop must be terminated at both ends of the hop with the EPIU. The EPIU is needed also in repeater/chaining station configuration.
- Network synchronization distribution is only possible if there is at least one E1 signal connected over the radio hop.
- There is no PPP support - Ethernet packet traffic is not embedded to E1 signals.
- Spanning tree protocol is not supported.
- Quality of Service (QoS) is not supported.

3.6.1 Operating modes

When FIU 19(E) is equipped with the EPIU it is possible to use either one or two radio links for the Ethernet traffic. The Ethernet traffic capacity for those radio links can be individually selected in between 0-32 Mbits/s with 2 Mbits/s granularity. The rest of the capacity of the radio links can be used for TDM traffic.

Channel separation

This operating mode provides two independent data channels for Ethernet traffic over two radio hops. Traffic from Ethernet interface 1 is passed to the first radio link (Flexbus 1 in single mode), traffic from Ethernet interface 2 is passed to the second radio link (Flexbus 2 in single mode). Both radio links and Ethernet interfaces can be configured independently from each other.

Example:

FB1 can be configured to work at 16x2M mode in which Ethernet data channels capacity can be selected in between 2-32 Mbits/s. Additionally FB2 can be configured to operate either in 2x2M, 4x2M, 8x2M or 16x2M mode in which Ethernet traffic capacity is configurable with 2 Mbits/s granularity.

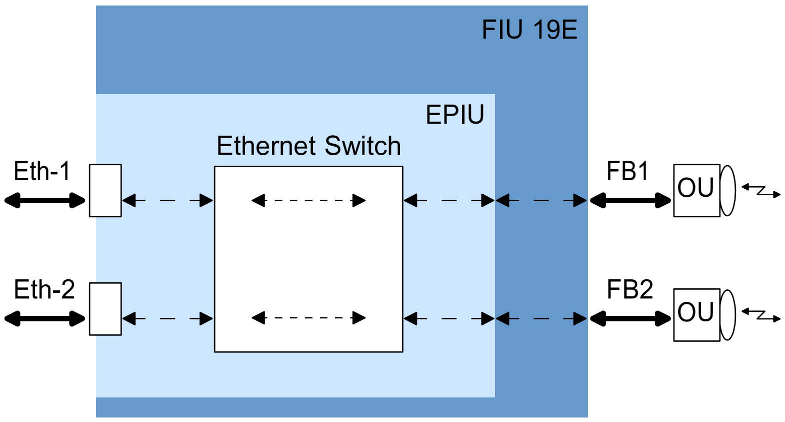


Figure 11. EPIU in channel separation mode

Capacity sharing

The capacity sharing mode allows the use of two individual Ethernet data channels through a single radio hop (FB1 or FB2 in single mode). The radio link capacity, which has been dedicated for Ethernet traffic, can be shared between those two Ethernet data channels with granularity of 1/256. The capacity sharing factor, which indicates how much of the Ethernet data capacity is used by traffic from the Eth-1 port, can be configured in range of 1/256 to 255/256. The rest of the capacity is left for traffic from the Eth-2 port.

! Caution

Ethernet traffic over the radio hop may fail if both sides of the radio hop do not use the same Flexbus interface in capacity sharing mode. Make sure both sides of the radio hop use the same Flexbus interface.

Example:

A radio that is operating in 16x2M mode is connected to FB1. All of its capacity is selected for the Ethernet traffic. In this example we use a sharing factor of 255/256. In this case a ratio of 255/256 of the link capacity is given to the Eth-1 channel and 1/256 is used by the Eth-2 channel (1/256*32.768 Mbits/s = 128 kbits/s, 255/256 =32.64 Mbits/s).

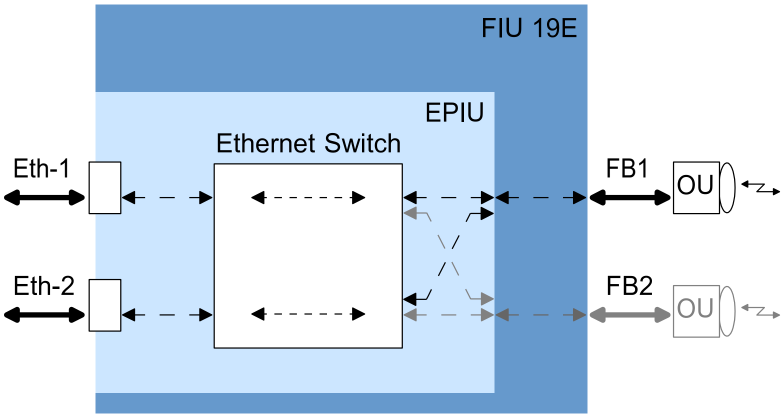


Figure 12. EPIU in capacity sharing mode

When the EPIU operates in capacity sharing mode, it is not possible to build a repeater station configuration with just one FIU 19(E). In this case two FIU 19Es, which are equipped with the EPIUs, are needed. External Ethernet cabling is needed between these EPIUs.

Full switch mode

In full switch mode, the EPIU operates as a standard Ethernet switch with four ports, two of these ports are connected towards the FB interfaces. In this operating mode it is possible to use two radio hops through single Ethernet interface or it is possible to connect two Ethernet cables to the EPIU and just use one radio link for carrying traffic from both Ethernet interfaces.

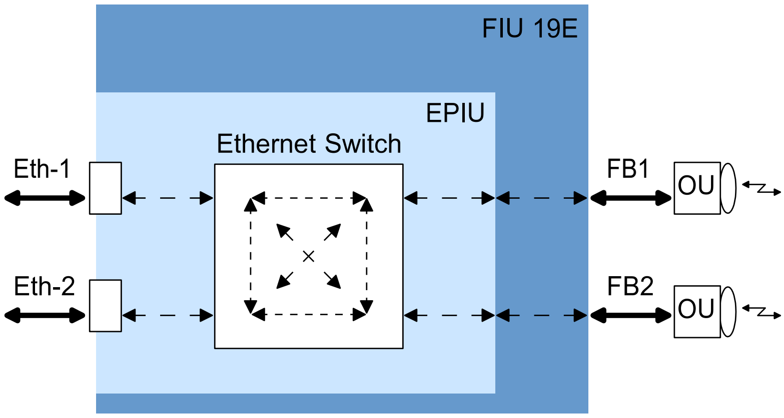


Figure 13. EPIU in full switch mode

Test loops

There are crossed and non-crossed test loops on the EPIU. All of them are implemented inside the Ethernet switch circuit. Crossed loop is a loop where traffic from one interface is connected to another interface. In non-crossed loop the packet traffic is echoed back to the same interface where it came from. Because the loops are implemented inside the Ethernet switch they can be used in all EPIU operating modes.

The crossed interface loop exists between Eth-1 and Eth-2. This loop is also implemented towards the equipment. The non-crossed loops exist for all four interfaces. All test loops for near-end devices can be set with Hopper Manager. Setting equipment loops is possible for the far-end EPIU with Hopper Manager.

For more information on loopbacks, see *Built-in test features*.

3.6.2 Packet buffering

The capacity of the radio links for Ethernet traffic cannot exceed 32 Mbits/s - that is about three times lower than the capacity of 100 Base-TX Ethernet interface. The Ethernet traffic is also bursty in nature; therefore some packet buffering is needed for adapting to it. If the packet buffers fill up, incoming packets are dropped until there is space in the packet buffer.

The EPIU has packet buffers in both transmit directions (towards the radio link, and from the radio link).The size of the packet buffer towards the radio link is configurable, you can select the size individually for each port from the following options: 32, 64 or 128 kB. If the biggest buffer size is selected, it is possible to adapt to longer packet bursts and thus it is possible to achieve better radio link utilisation. On the other hand, the longer the packet buffer is, the longer is the buffering delay before the packets are dropped. The default buffer size is 32 kB. This causes the shortest buffering delays. Note that the buffering delay grows significantly when the capacity of the radio links is decreased. The minimum and maximum latencies of a single Ethernet radio hop for different radio link capacities and buffer sizes are presented in *Propagation delays for packet traffic*.

The packet buffer towards the Ethernet interfaces (Eth-1, Eth-2) is 128 kB. This memory is shared dynamically between those two ports.

3.6.3 Naming conventions for Ethernet data channels inside Flexbus

The Ethernet packet traffic is carried over the Serial IO (SIO) data channel inside Flexbus. In unprotected radio hop configurations the data channel inside Flexbus 1 is called SIO1 and the data channel inside Flexbus 2 is called SIO2. In 2OU protected radio hop configurations SIO1 traffic is carried in FB1 (or in FB2 which is the protecting channel) and SIO2 traffic is carried inside FB3 which is an unprotected channel. In 2IU protection configurations SIO1 traffic is carried inside protected radio hop (FB1 of IUA and FB1 of IUB) and SIO2 is not used.

Port naming for EPIU statistical counters

Each EPIU port has a set of statistical counters for monitoring the Ethernet traffic statistic. Those counters can be read with Hopper Manager or through SNMP queries from the SNMP agent inside the FIU 19(E).

Altogether there are four ports whose statistics can be monitored on the EPIU. These ports are named Eth-1, Eth-2, SIO1 and SIO2. The naming is quite straightforward in full switch and channel separation modes. In capacity sharing mode both SIO ports are mapped to single Flexbus. In this case SIO1 counters count the statistics for the Ethernet packets coming from/to Eth-1 interface and SIO2 counters count the Ethernet packets coming from/to Eth-2 interface. This is independent of which Flexbus is selected for transmitting the Ethernet traffic.

Table 1. Summary of the SIO port naming for EPIU statistical counters in each EPIU operation mode

EPIU mode	SIO port name(s) inside FB1	SIO port name(s) inside FB2 (or FB3**)
Channel separation	SIO1	SIO2
Full switch	SIO1*	SIO2*
Capacity sharing of SIO1	SIO1 and SIO2	None
Capacity sharing of SIO2	None	SIO1 and SIO2

*) In full switch mode the Ethernet traffic may originate from either of the two ports Eth-1 or Eth-2.

**) The SIO2 data channel is carried inside FB3 during the 2OU-protected mode.

3.6.4 Link loss forwarding

Link loss forwarding (LLF) is supported on the EPIU in channel separation and capacity sharing modes. LLF can be enabled separately for both EPIU ports.

LLF is a method of error propagation into the Ethernet domain. The feature works by using the link state of the port to signal whether a viable connection is possible to the remote side Ethernet port. If the link is lost on the remote Ethernet port or communication across the radio channel is not possible, the link on the corresponding local Ethernet port is brought down. Whenever such fault situations cease, the Ethernet link is enabled again.

LLF enables third party equipment to detect the link loss situation faster and thus it is possible to change to the alternative route at once if it exists. This may also tie the EPIU into existing network monitoring systems, because the connected equipment detects this link loss.

Note

Link loss forwarding (LLF) is not supported in full switch mode or in 2IU protection mode.

3.6.5 Ethernet flow control

The EPIU supports Ethernet flow control on full duplex link segments. The flow control functionality is based on IEEE 802.3x where the MAC control frames are used to carry PAUSE commands. The flow control is used to prevent packet loss during link congestion.

If one of the EPIU ports gets congested, the EPIU sends a PAUSE message (with a maximum time for the pause) to the node that is causing the link congestion. When congestion disappears the EPIU sends a new PAUSE frame through the same port (with zero pause-time) to indicate that the link is ready to continue the transmission. When the EPIU receives a PAUSE frame at one of its inputs, it stops the transmission to that interface for a specified pause-time.

Note

The Ethernet flow control does not work unless both ends of a full duplex link segment support flow control based on PAUSE frames. The flow control should be disabled as default.

3.7 Built-in test features

For testing and diagnostics, there are six integrated loopbacks and an internal pseudo-random binary sequence (PRBS) generator and detector available. The table *Loopbacks* and the figure *Loopbacks with FIU 19(E)* describe the looping possibilities with the FIU 19(E) indoor unit.

The operation of the various units of the radio hop can be checked with loopbacks and with an internal or external PRBS generator and detector. PRBS is a two-level signal that has a repetitive sequence, but a random pattern within the sequence. It is used to test the radio link, since it has the basic characteristics of a noise, but in terms of parameters that are easily controlled. One generator in the indoor unit sends a PRBS signal, and the other end of the radio link detects this signal.

The **Forced Controls** window is used to switch on the PRBS generator, and to specify the used channels (the 2M channels, which are cross-connected in the ASIC to the test generator/detector) for the receiving or transmitting of test signals.

The **Internal Tests** window is used to switch on the PRBS test detector to start analysing received test patterns (see *Using internal tests (PRBS)* in *Troubleshooting Nokia FlexiHopper (Plus) 2.7*).

There are two kinds of binary sequences that can be used here:

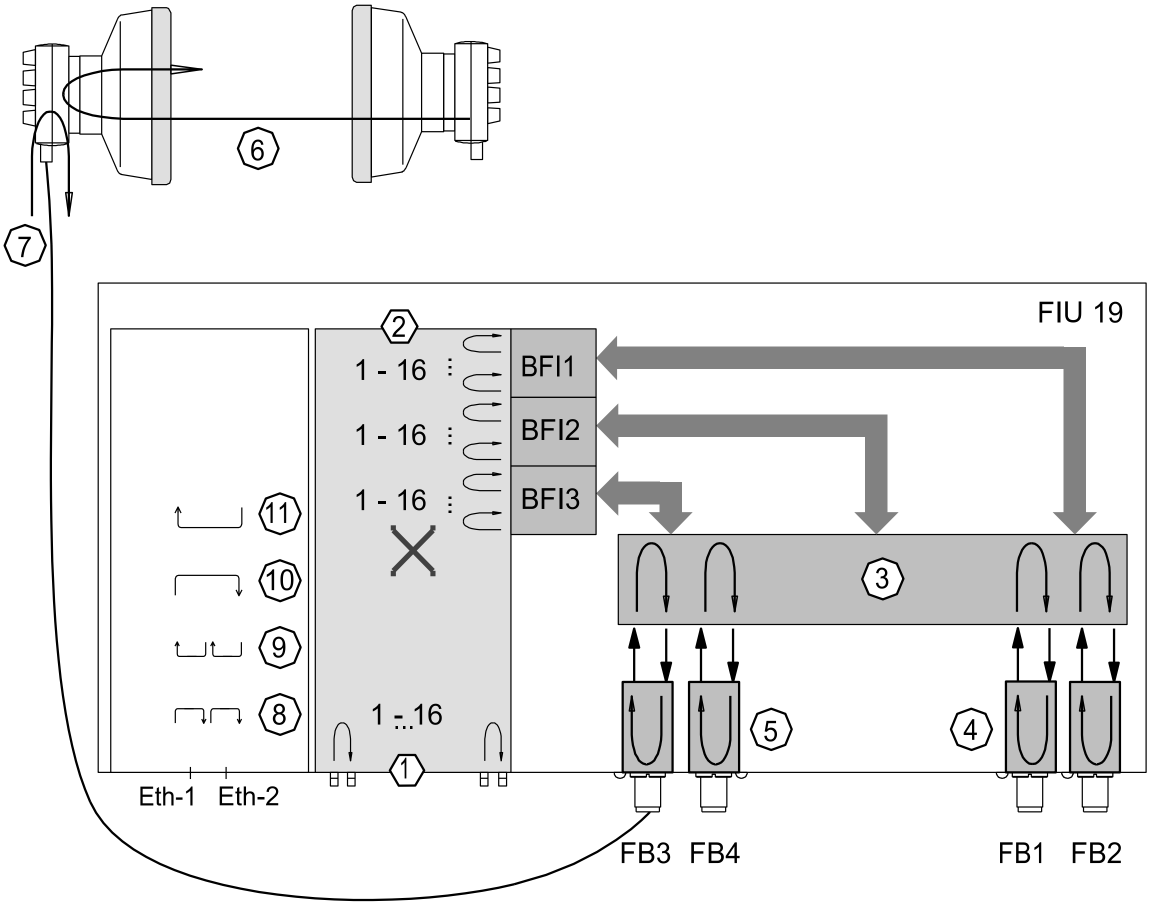
- PRBS2: pseudo-random binary sequence for 2 Mbit/s
- PRBSF: pseudo-random binary sequence for Flexbus

Table 2. Loopbacks

Loop type	Description
2M loop to interface (1)	Near-end loop Loops back the signal in the 2Mbit/s interfaces in the 2M cross-connection block.
BFI* 2M loop to interface (2)	Far-end loop Loops back the signal in 2Mbit/s interfaces in the cross-connection section. These channels are also connected to a Flexbus.
Flexbus loop to interface (3)	Far-end loop Loops back the selected Flexbus signal in Flexbus framer and cross-connection block.
Flexbus loop to equipment (FB 1-4) (4-5)	Near-end loop Loops back the selected Flexbus signal just prior to the Flexbus interface into the IU-OU cable.
Outdoor unit loop to interface (6)	Far-end loop Loops the signal back to the radio interface in the outdoor unit. It can be set for the near-end or far-end outdoor unit.
Outdoor unit loop to equipment (7)	Near-end loop Loops the signal back to the IU-OU cable in the near-end outdoor unit.
Eth-1 and Eth-2 - near-end loop (8)	Loops back the signal to the Ethernet interface.
Eth-1 and Eth-2 - far-end loop (9)	Loops the Ethernet signal back to the radio interface.
Crossed near end loop (10)	Loops the signal between Eth-1 and Eth-2.
Crossed far end loop (11)	Loops back the signal between Eth-1 and Eth-2 towards the radio interface.
*) BFI = Buffer Frame Interface in FIU 19(E)	

Note

There is no internal test generator or detector for Ethernet plug-in unit test loops. Use external equipment when testing the loops.



1) 2M interfaces: loop to interface
2) BFI 2M channels: loop to interface
3) Flexbuses: loop to interface
4) FB1 and FB2: loop to equipment
5) FB3 and FB4: loop to equipment
6) Outdoor unit: loop to interface
7) Outdoor unit: loop to equipment
8) Eth 1&2: near end loop
9) Eth 1&2: far end loop
10) Crossed near end loop
11) Crossed far end loop

Figure 14. Loopbacks with FIU 19(E)

3.8 Configuration backup

The Nokia FlexiHopper (Plus) outdoor unit and the FIU 19(E) indoor units support configuration backup. This feature makes it possible to create a backup copy of important unit configurations to other units. That information can be restored to recover from error situations or to quickly commission a unit which has been replaced.

Backups can be made automatically or manually with Hopper Manager. See *Setting the automatic backup* or *Backing up the settings manually* in *Commissioning Nokia FlexiHopper (Plus) 2.7 with FIU 19 (E)*.

The following backup cases are possible:

- Outdoor unit settings are backed up to the indoor unit.
- Indoor unit settings are backed up to all outdoor units and to the protecting indoor unit.

3.9 Licensing

Starting from releases Nokia FlexiHopper FH 6.0, Nokia FlexiHopper Plus FHP 2.2, Nokia FlexiHopper 4E1 FH 2.5, and Nokia FlexiHopper Indoor unit FIU 19E 2.0 units support software licensing.

The features under licence in the Nokia FlexiHopper family follow.

For Nokia FIU 19(E) 3.0 indoor unit

- 2nd Flexbus
- SNMP (OSPF feature is licensed also for FIU 19(E) 2.0)

For Nokia FlexiHopper 4E1 outdoor unit

- Transmission capacity upgrade licences
  - 4x2 Mbit/s → 8x2 Mbit/s
  - 8x2 Mbit/s → 16x2 Mbit/s
  - 4x2 Mbit/s → 16x2 Mbit/s
- 16-state modulation licence

  A modulation upgrade can be performed on Nokia FlexiHopper 4E1 only in 8x2 Mbit/s and 16x2 Mbit/s capacities.

For Nokia FlexiHopper outdoor unit

- 16-state modulation (32 TCM)

Nokia FlexiHopper Plus already includes all available features.

To activate these features, the user needs to order a secure licence file from Nokia and to install the licence. The file is delivered through Nokia software delivery channels and can easily be installed either locally or remotely over the Q1 management channel using Hopper Manager version HM 4.7 or newer. For transmission capacity upgrade licenses, Hopper Manager HM 4.9 is needed.

Licence is implemented using secure plain text files generated and authorised by Nokia. In case the licence file is lost or corrupted, the valid licensed user can get a replacement from Nokia without paying for the feature twice. The licence is bound to the unit's serial number and cannot be used in another unit. If radio hardware is swapped by Nokia in a hardware failure case, a new licence file is generated.

All Nokia FlexiHopper (Plus) and FIU 19(E) licences are permanent and once installed will not expire. Nokia FlexiHopper, Nokia FlexiHopper 4E1 and FIU 19(E) products include introductory time-limited trial licences for 60 days. When a licence is bought, it can be activated or deactivated as often as needed.

4 Applications

4.1 Network applications

Nokia FlexiHopper (Plus) is mainly used in macrocellular sites. It can also be used in the microcell layer when there is a need for higher capacities or longer radio hops.

After the initial roll-out phase the required capacity may increase. The capacity of Nokia FlexiHopper (Plus) can be programmed and it grows with the evolving network.

The following figure, *Example of applications with Nokia FlexiHopper (Plus) in a cellular network*, illustrates an example of transmission in a cellular network implemented using Nokia FlexiHopper (Plus).

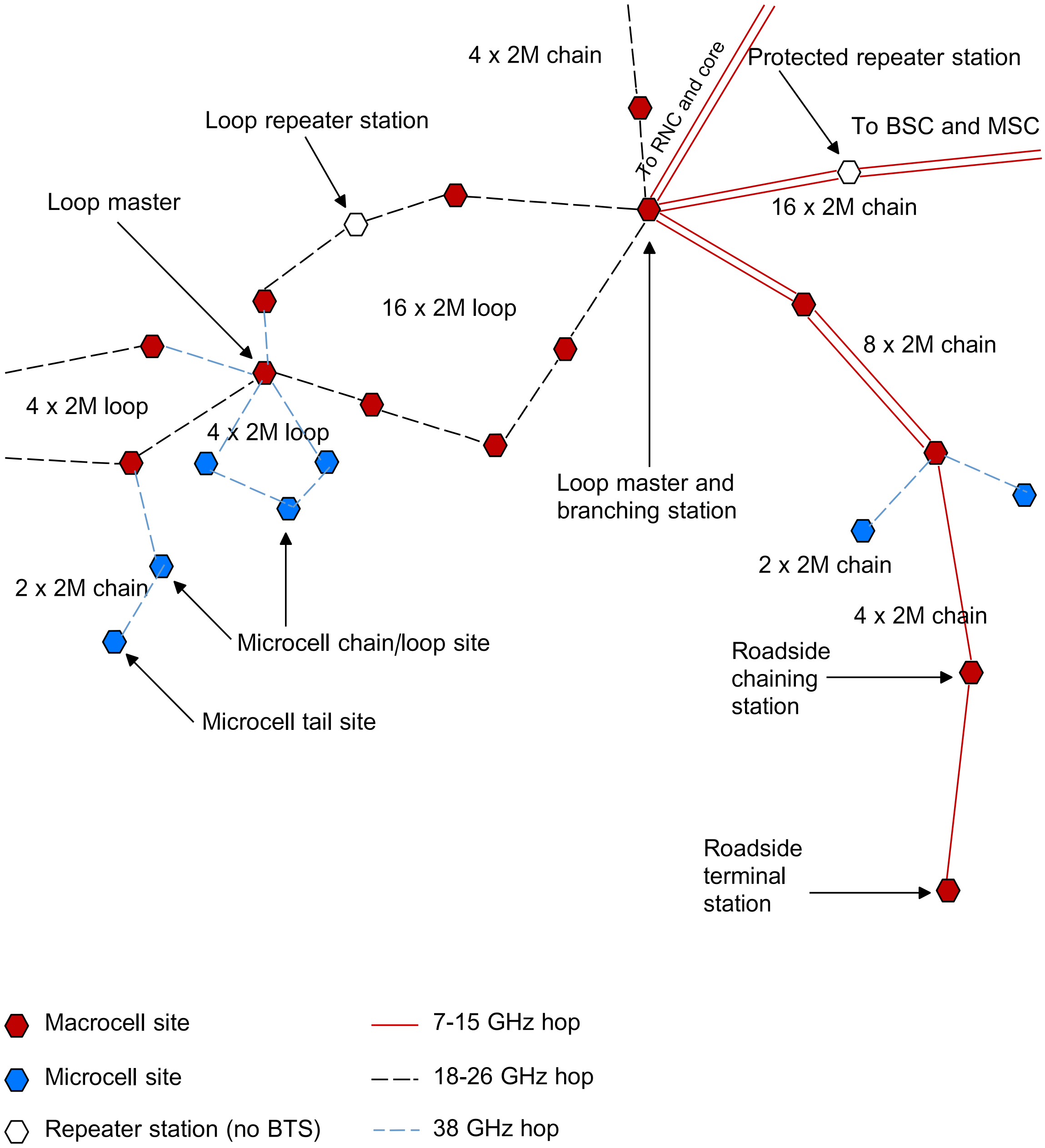


Figure 15. Example of applications with Nokia FlexiHopper (Plus) in a cellular network

4.2 Site configuration examples

In the following you can see some examples of the site configurations which can be implemented when using Nokia FlexiHopper (Plus) with various indoor units. The symbols used for the units are presented in the following figure.

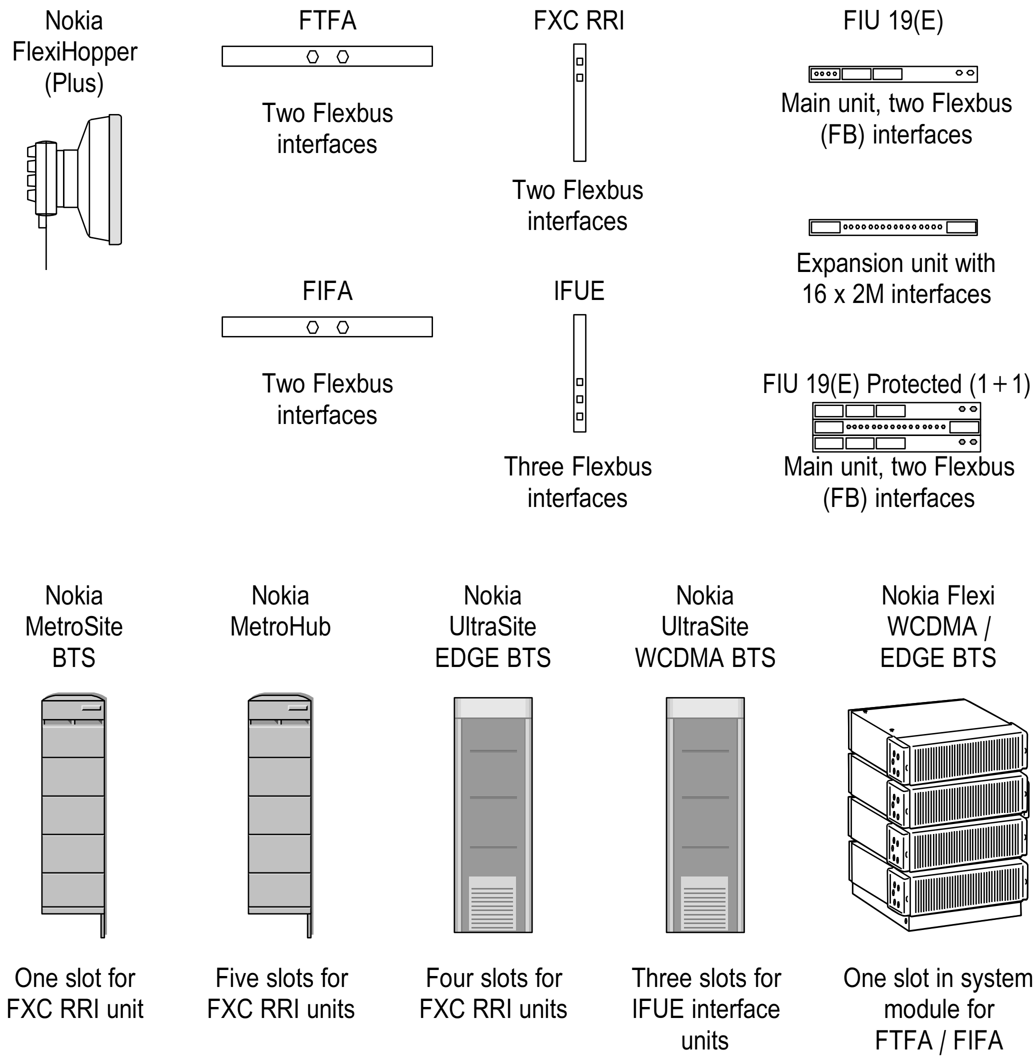


Figure 16. Key symbols

FIU 19(E) indoor unit offers many configuration possibilities. When used with a Flexbus plug-in unit, FIU 19(E) has a total of four Flexbus interfaces. Through these interfaces FIU 19(E) units can be chained without limit. When an additional power supply is connected to the plug-in unit, branching stations with one indoor unit and up to four outdoor units can be implemented. When four outdoor units are connected, one of the transmission directions must be protected.

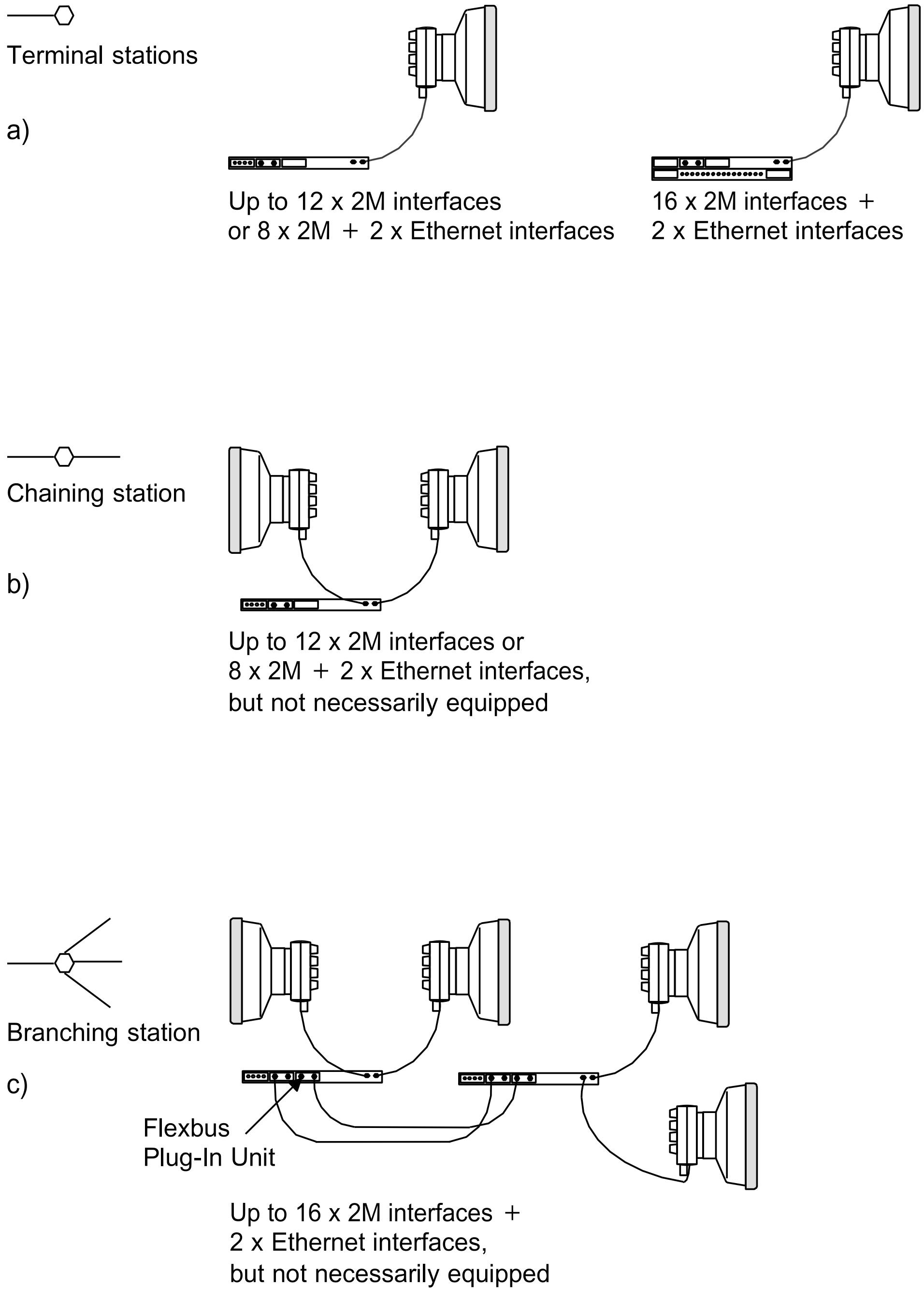


Figure 17. Unprotected stations with FIU 19(E)

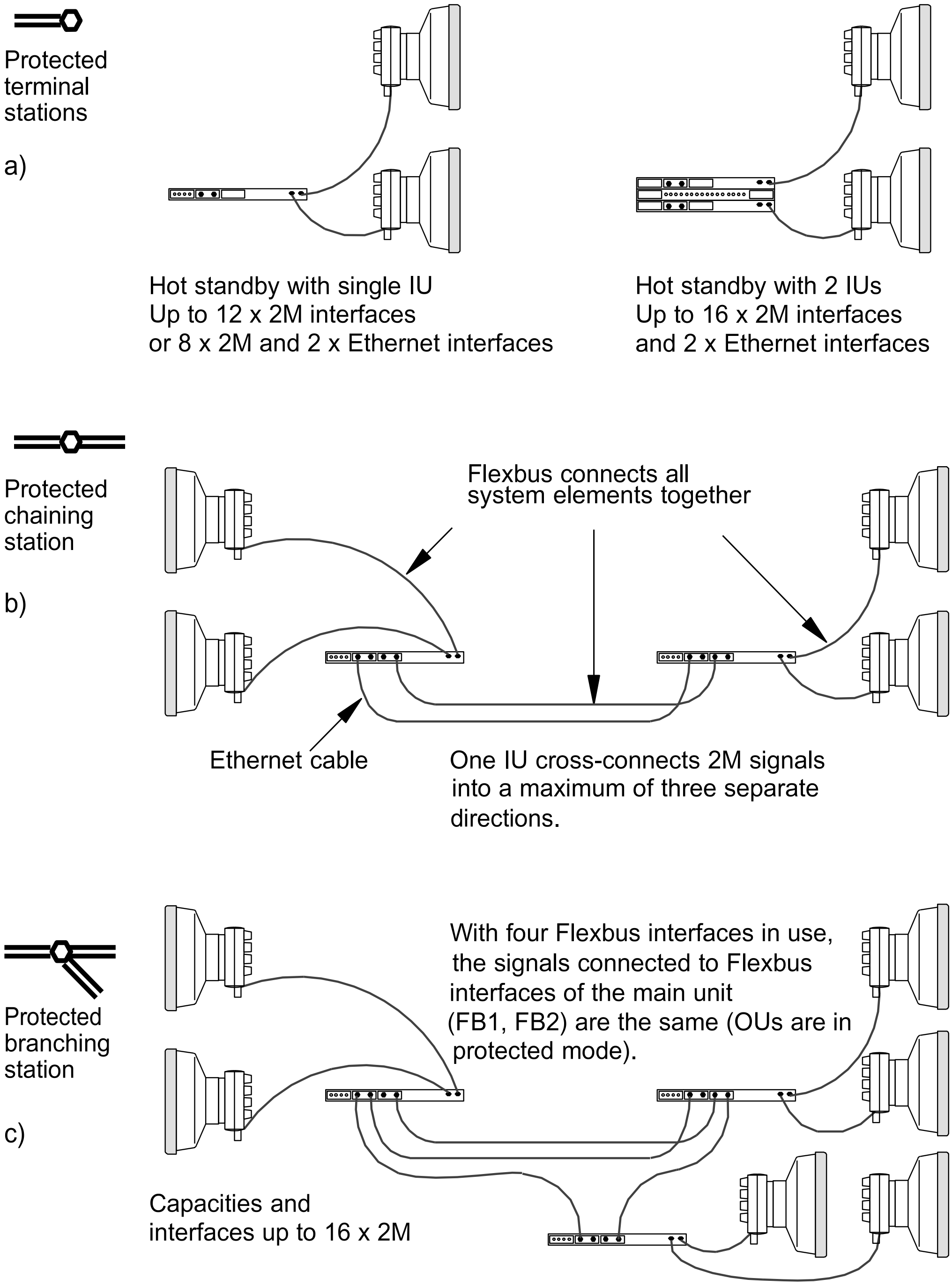
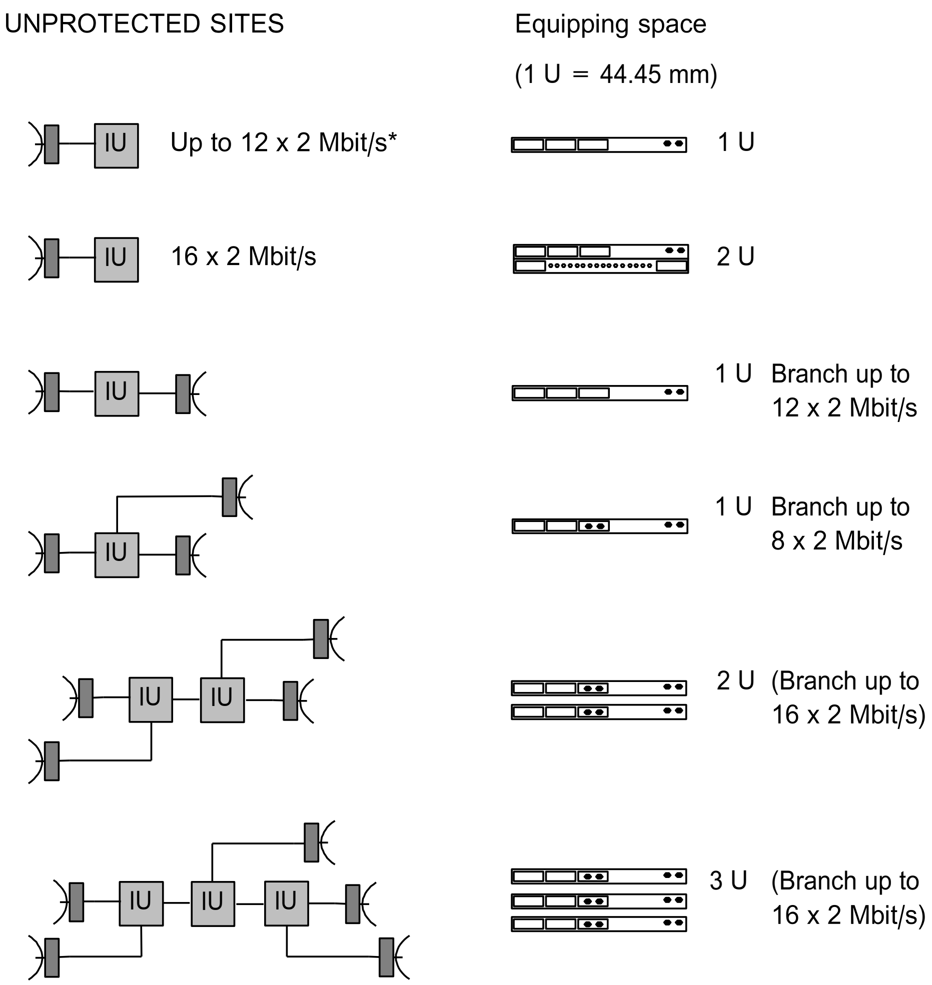


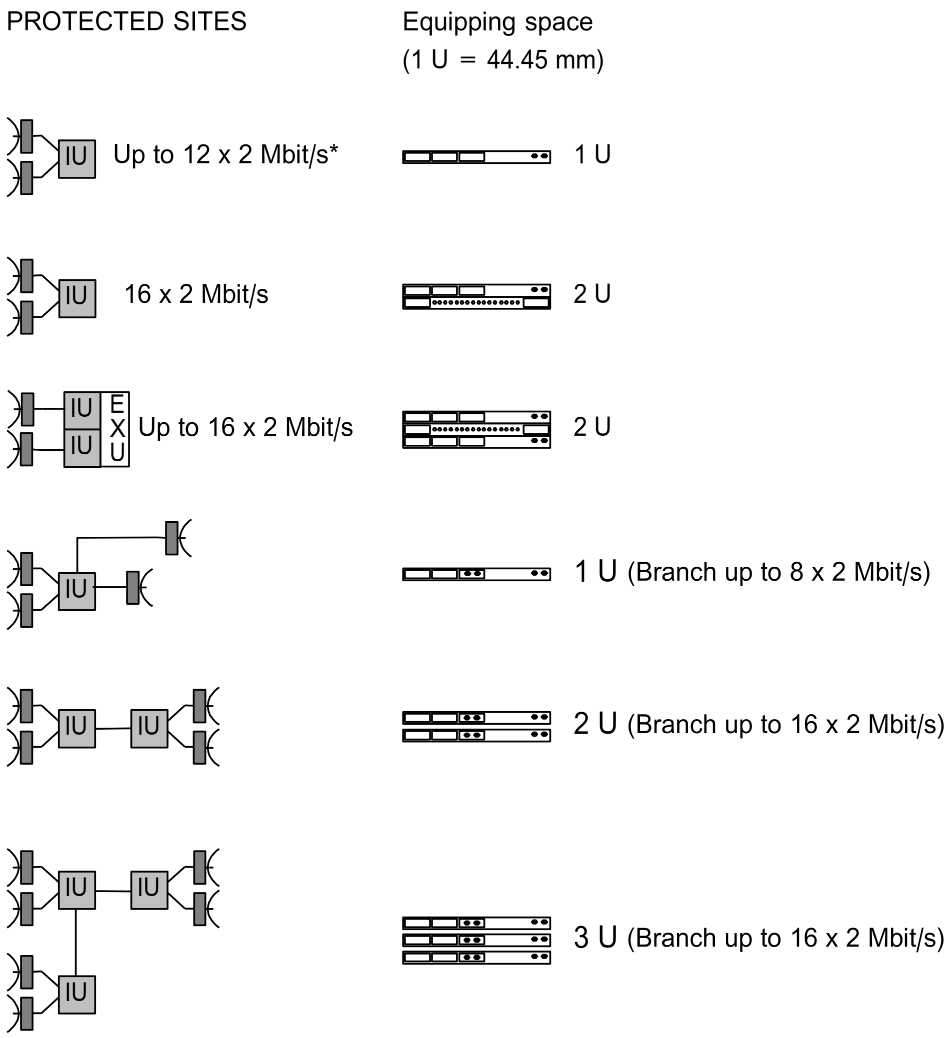
Figure 18. Protected stations with FIU 19(E)

FIU 19(E) units are only 2/3 U (29 mm) high. The actual equipping space required in a standard 19-inch rack depends on the configuration. A wide variety of site configurations can be realised with minimal use of 19-inch rack space.



*) With 12 x 2 Mbit/s payload, the outdoor unit is set to 16x 2 Mbit/s capacity.

Figure 19. FIU 19(E) site summary − unprotected sites



*) With 12 x 2 Mbit/s payload, the outdoor unit is set to 16x 2 Mbit/s capacity.

Figure 20. FIU 19(E) site summary − protected sites

4.3 Nokia FlexiHopper (Plus) as a part of the Nokia MetroSite EDGE Solution

Nokia MetroHopper is usually the radio of choice for Nokia MetroSite transmission needs, but when more transmission capacity or longer hop distances are required, Nokia FlexiHopper (Plus) can be used.

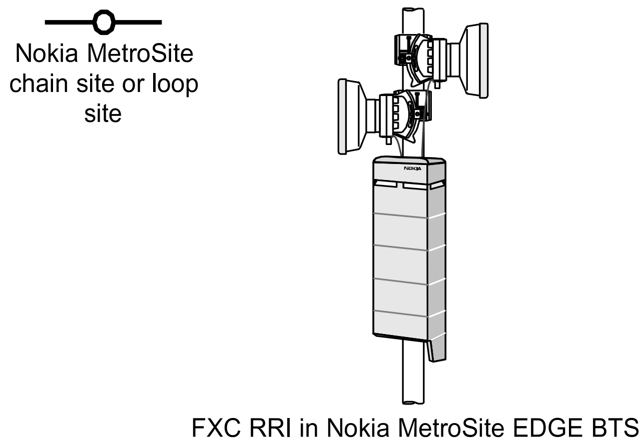


Figure 21. Nokia MetroSite EDGE BTS and Nokia FlexiHopper (Plus)

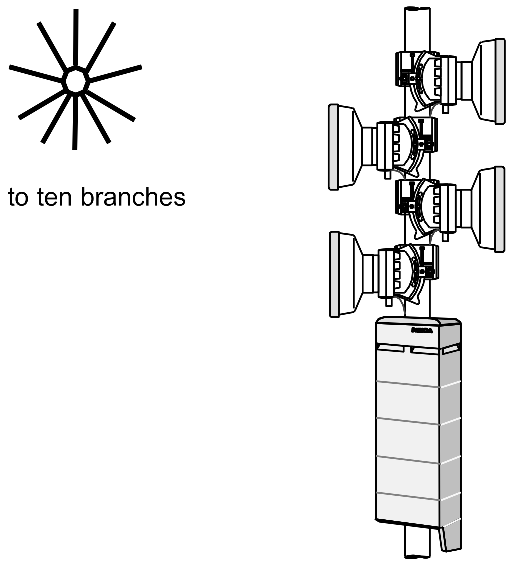


Figure 22. Nokia MetroHub and Nokia FlexiHopper (Plus)

Nokia MetroHub is a stand-alone transmission node especially applicable in outdoor installations for cross-connection. The main applications of the Nokia MetroHub are transmission concentrating with high grooming capability (down to 8 kbit/s level) and transmission protection.

Nokia MetroSite EDGE Base Station has one slot for an FXC unit. Nokia MetroHub transmission node has five slots for FXC units.

For more information on site configurations with Nokia MetroHub, see the *Nokia MetroHub transmission node* documentation.

4.4 Nokia FlexiHopper (Plus) as a part of the Nokia UltraSite EDGE Solution

Nokia FlexiHopper (Plus) is connected to Nokia UltraSite EDGE BTS with the FXC RRI indoor unit.

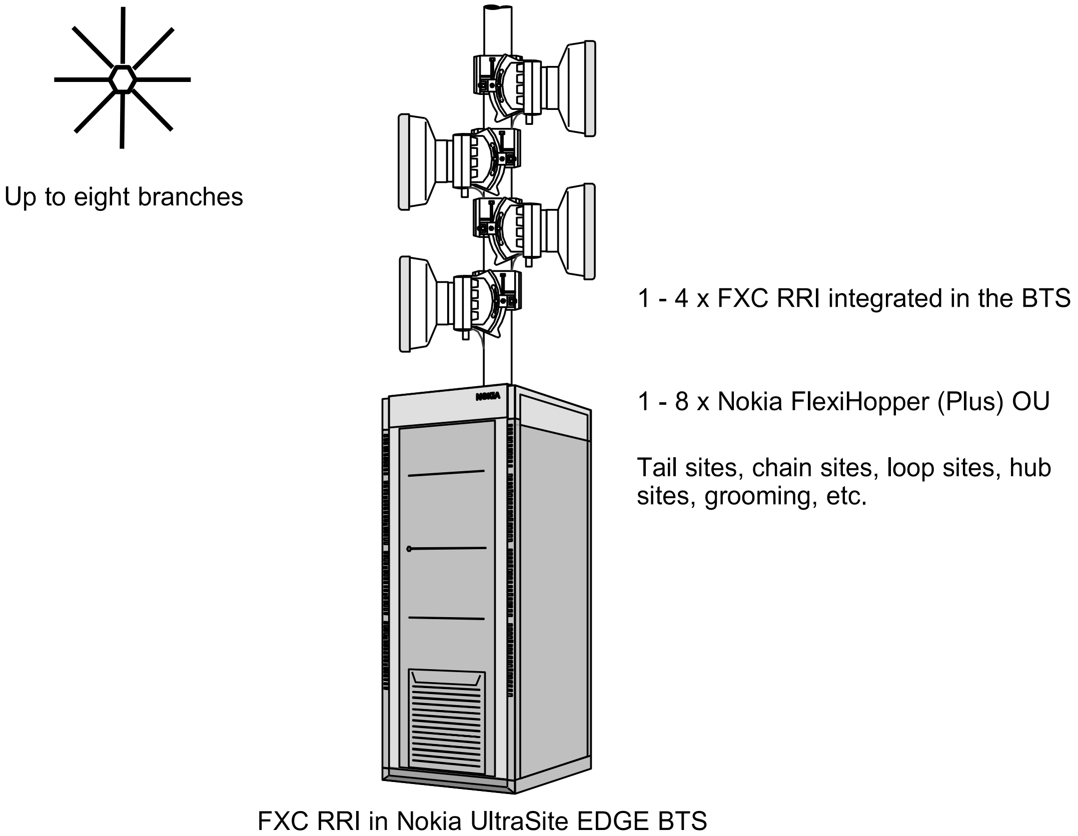


Figure 23. Nokia UltraSite EDGE BTS and Nokia FlexiHopper (Plus)

The same cross-connection and protection options concerns also the transmission part of UltraSite BTS as MetroHub. UltraSite BTS has four slots for FXC units.

For more information on site transmission configurations with Nokia UltraSite EDGE BTS, see *Nokia UltraSite Solution* documentation.

4.5 Nokia FlexiHopper (Plus) as a part of the Nokia UltraSite and MetroSite WCDMA BTSs

Nokia FlexiHopper (Plus) can be integrated into Nokia WCDMA base station solutions in 3rd generation networks. Nokia AXC is an integrated transmission node for Nokia WCDMA base stations. Nokia AXC provides different features and interfaces to transport the ATM traffic of 3rd generation mobile networks over existing transport networks. Each Nokia AXC node consists of an ATM cross-connect unit (AXU) and a number of Interface Units (IFU). IFUE unit includes three Flexbus interfaces.

For more information on the transmission configuration on Nokia WCDMA RAN, see *Nokia AXC documentation* or *Configuring Nokia FlexiHopper (Plus) and MetroHopper with IFUE.*

4.6 Nokia FlexiHopper (Plus) as a part of Nokia Flexi WCDMA and Flexi EDGE BTSs

Here are some examples of the site configurations which can be implemented when using Flexi BTS integrated indoor units (FIFA/FTFA) with various outdoor units. The following figure presents the symbols used for the units.

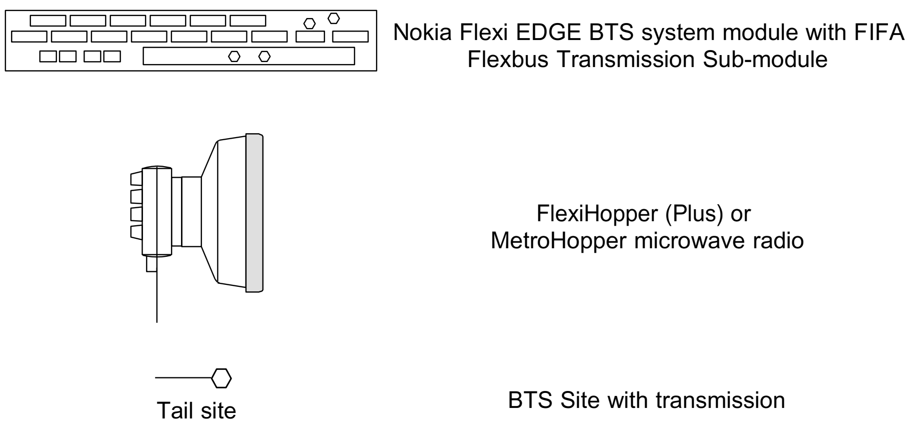


Figure 24. Key symbols

FIFA and FTFA offer different configuration possibilities. They both have a total of two Flexbus interfaces. Through these interfaces FIFA and FTFA can be chained to a practical limit, for example, up to 8 sites. When two outdoor units are connected, the transmission can be protected.

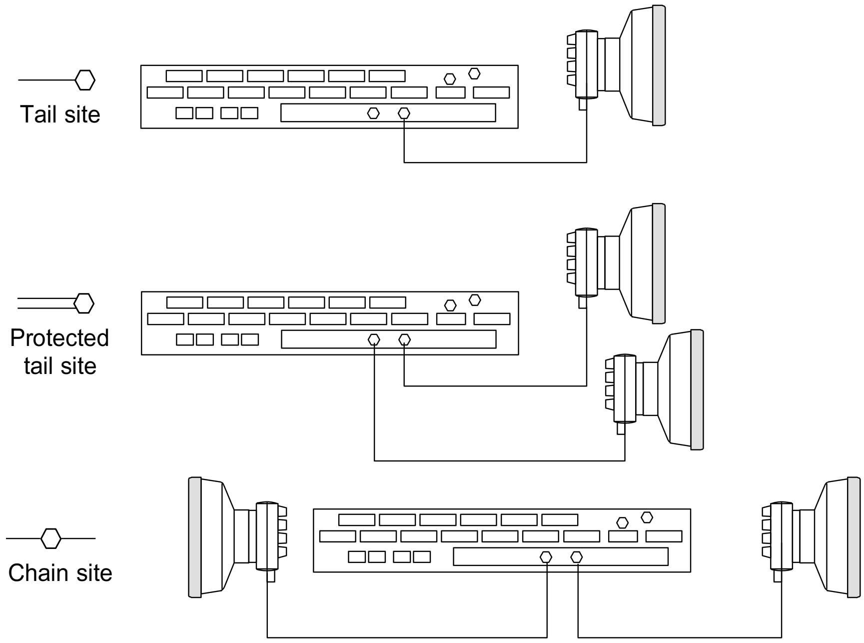


Figure 25. BTS site configurations

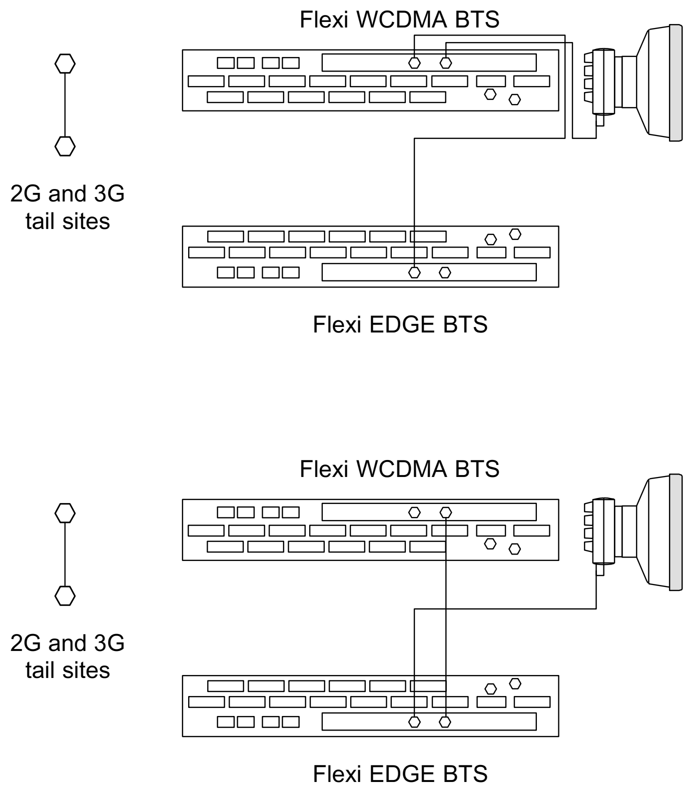


Figure 26. Co-siting with Nokia Flexi WCDMA BTS and transmission sharing

5 Management

5.1 Nokia NetAct and Nokia FlexiHopper (Plus)

Nokia NetAct (formerly known as the Nokia Network Management System (NMS)) can be used centrally to collect alarm and measurement data on Nokia FlexiHopper (Plus) radios in a network. Nokia NetAct can also be used to configure the radios. Communication between Nokia NetAct and the radios is enabled via a Nokia Q1 bus.

The Nokia NetAct provides a full range of functions including fault, performance, and configuration management and also transmission, trouble, and security management. Nokia NetAct is the recommended management system for networks consisting of more than 20 nodes.

For more information, see *Nokia NetAct* or *Nokia NMS* documentation.

5.2 Hopper Manager

Hopper Manager is a PC based software application for controlling and monitoring Nokia FlexiHopper (Plus) and Nokia MetroHopper radios with FIU 19(E) indoor units. It belongs to the Nokia product range of node managers.

Hopper Manager runs on a PC-compatible computer under Microsoft Windows 98, 2000, and XP. It has an easy to use graphical user interface with Commissioning Wizard that guides you through the commissioning tasks.

The manager is compatible with Nokia NMS/10. All NMS/10 compatible managers can be operated at the same time on a standard PC. The manager can manage one node at a time, but several instances of Hopper Manager can be run in parallel to allow management of several nodes simultaneously.

With Hopper Manager you can:

- commission a new node
- change the configuration of a new or previously configured node
- create 2 Mbit/s cross-connections (with FIU 19(E))
- troubleshoot a node
- monitor the fault status of a node
- monitor transmission quality
- download new software.

FXC RRI cross-connections and radio settings are managed with:

- MetroHub Manager, if FXC RRI is installed in Nokia MetroHub transmission node
- UltraSite BTS Hub Manager, if FXC RRI is installed in UltraSite BTS
- FXC RRI Manager, if FXC RRI is installed in MetroSite BTS.

IFUE cross-connections (2Mbit/s) and radio settings are managed with the AXC-FB Manager.

Hopper Manager can be connected to a Nokia FlexiHopper (Plus) node in three different ways:

1. directly through the local management port (LMP)
2. remotely through a Nokia Q1 connection
3. through a LAN connection (FIU 19E).

Hopper Manager can be used both online and offline. When used online, information is read directly from the node and interpreted by Hopper Manager. This information can then be easily changed and sent back to the node. When you use Hopper Manager offline, you can create settings files in the office and download to the node at a later time.

FTFA and FIFA cross-connections and radio settings are managed with Nokia FlexiHub Manager. For more information how to manage FTFA and FIFA cross-connections, see *FIFA Flexbus Transmission Sub-module for Nokia Flexi EDGE BTS Product Documentation*.

5.3 Using Nokia Q1 bus

Q1 bus is the management connection (V.11) to Nokia NetAct.

5.3.1 FIU 19(E)

The FIU 19(E) indoor unit has two Q1 ports (Q1-1 and Q1-2) on the front panel.

Inside FIU 19(E), the Q1 signal is routed through virtual branching gates. The positions of the gates are set with Hopper Manager.

The Q1 bus is transmitted on the radio path within the overhead of the radio frame. The Q1 interfaces are chained and you can connect the Q1 signal to either of them (figure *Chaining of the Q1 bus in FIU 19(E)*). In this case, a signal connected to the Q1-1 port is routed to the Flexbus interfaces (radio path), to FIU 19(E) processor, and out from the Q1-2 port. The same applies vice versa to a signal connected to the Q1-2 port.

! Caution

The equipment may short circuit if the positive voltage is earthed (grounded) on the site. Make sure the Flexbus plug-in unit supply voltage is galvanically isolated.

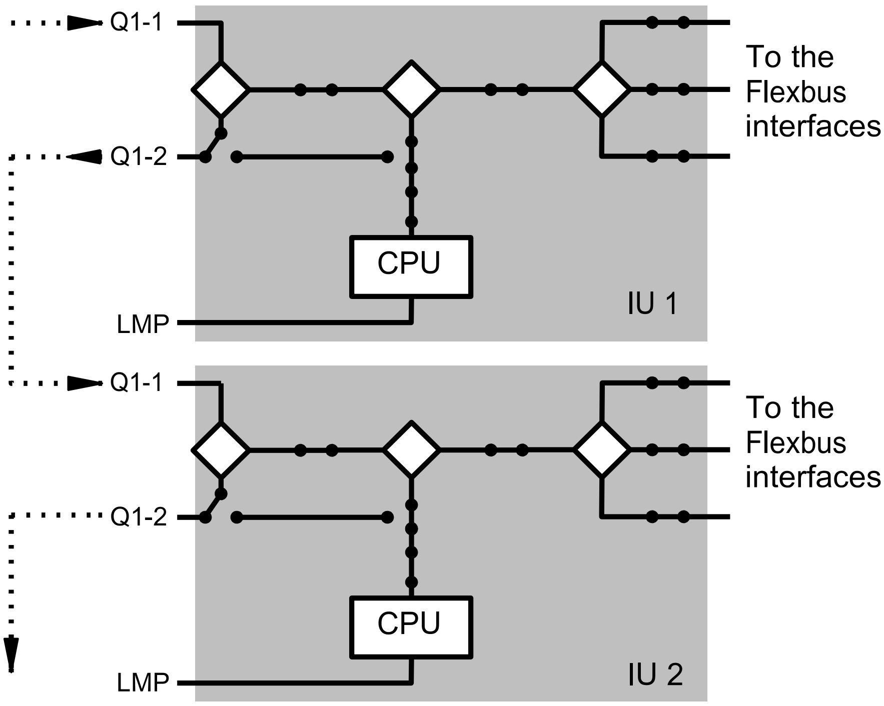


Figure 27. Chaining of the Q1 bus in FIU 19(E)

Several pieces of Q1 managed equipment can be chained at the equipment station. A cable is connected from the Q1-2 port of the first equipment to the Q1-1 port of the second equipment, another cable is connected from the Q1-2 port of the second equipment and to the Q1-1 port of the third equipment, and so on.

FIU 19(E) contains a shunt switch which ensures that when the Q1 signal is chained form Q1-1 to Q1-2, the chain does not break even if the power supply to a FIU 19(E) unit is lost or switched off.

The Q1 bus can also be carried within a 2 Mbit/s tributary. In this case, another equipment (a BTS, for example) extracts the Q1 bus and routes it further to the microwave radio. The Q1 cable from the BTS is connected to the Q1-2 port of the indoor unit and the signal from it goes straight to the processor (figure *Example of Q1 branching in FIU 19(E)*). The Q1-1 port is not used.

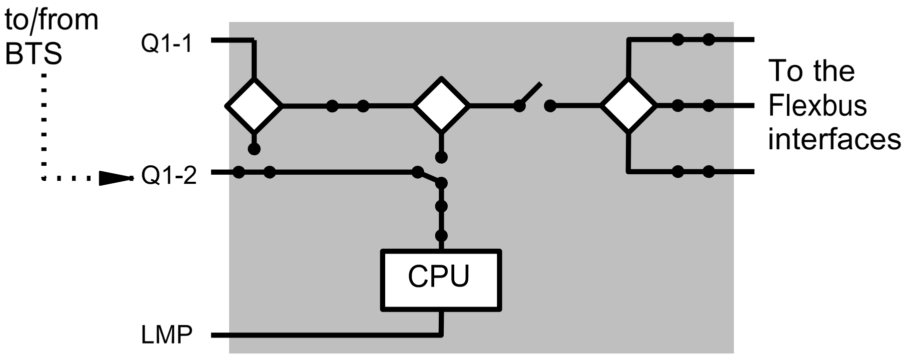


Figure 28. Example of Q1 branching in FIU 19(E)

When FIU 19(E) is used in 2IU + 2OU protected mode, the Q1 interfaces are physically connected through the backplane (figure *Q1 connection in FIU 19(E) in 2IU + 2OU protection setup*). In a chaining setup, the Q1 cabling is connected to the Q1-1 port of the indoor unit A and Q1-2 port of the indoor unit B.

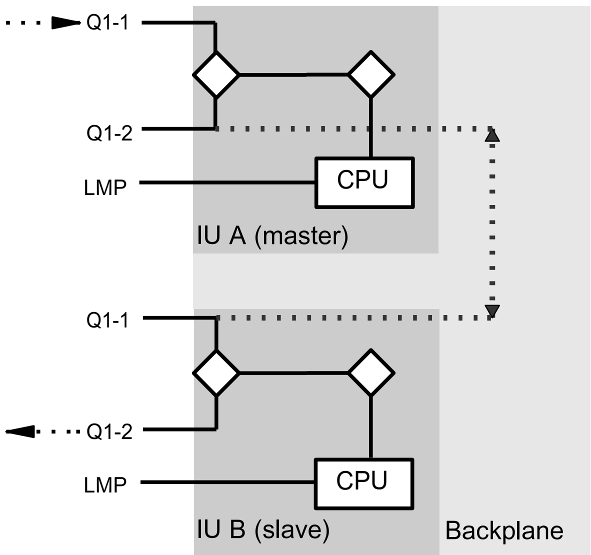


Figure 29. Q1 connection in FIU 19(E) in 2IU + 2OU protection setup

5.3.2 Q1 addresses

Each network element is given a Q1 network element address and an LMP network element address (optional). Network element addresses run from 0 to 3999. Q1 group addresses and LMP group addresses are reserved for future use.

The Q1 port address is used when managing the network element (NE) remotely. NEs within the same Q1 bus must have unique network element addresses.

The LMP address can be used when managing several network elements locally with chained LMP connection. The addressing can be the same from site to site.

All Q1 managed network elements also recognise the Q1 broadcast address 4095. When connecting to the LMP, this address is not actually broadcast. Therefore it can be used for local management.

5.4 SNMP management

As alternative to the Nokia proprietary Q1 bus the Nokia FlexiHopper (Plus), using the FIU 19(E) as indoor unit, offers the possibility to use the Internet Protocol version 4 (IPv4) for providing management connectivity. An Ethernet port is located at the front panel of the FIU 19(E) indoor unit, which can be used for connecting the FIU 19(E) to the IP data communication network (DCN). In addition it is possible to forward the IP management traffic over the radio path towards the Nokia FlexiHopper (Plus) at the other end, which avoids the need for an IP connection towards the Ethernet port of the FIU 19(E) at each site.

IP DCN on FIU 19(E)

FIU 19(E) supports routing of IP DCN traffic between its 10Base-T Ethernet interface and three point-to-point-protocol (PPP) interfaces. PPP data is carried inside radio frame overhead data channels. These channels are called HopLAN and Aux Fast. Aux Fast interface capacity is 64-512 kbits/s depending on the radio link capacity. HopLAN data channel capacity is 7-80 kbits/s depending on the radio links capacity.

HopLAN data channel capacity is shared with OU-OU communication. This is seen as lower than expected throughput (max. 15 frames/s). HopLAN is best suited for TFTP and Hopper Manager remote connections.

HopLAN is available since C1.5 HW release. Aux Fast is available since C2.0 HW release. These data channels are alternative with each other. Both ends of the radio link have to use same data channel type for ppp link to operate. Data channel type can be selected separately for each radio direction. Aux Fast channel can also be used with Flexbus connected between two indoor units.

Using Aux fast interface for DCN does not require any Aux data plug-in unit.

PPP-link MTU is 1100 bytes. If larger IP frames are sent, those will be fragmented.

The following figure shows basic IP DCN interfaces on FIU 19(E) and the cross connect functionality between PPP interfaces and Aux fast/HopLAN data channels.

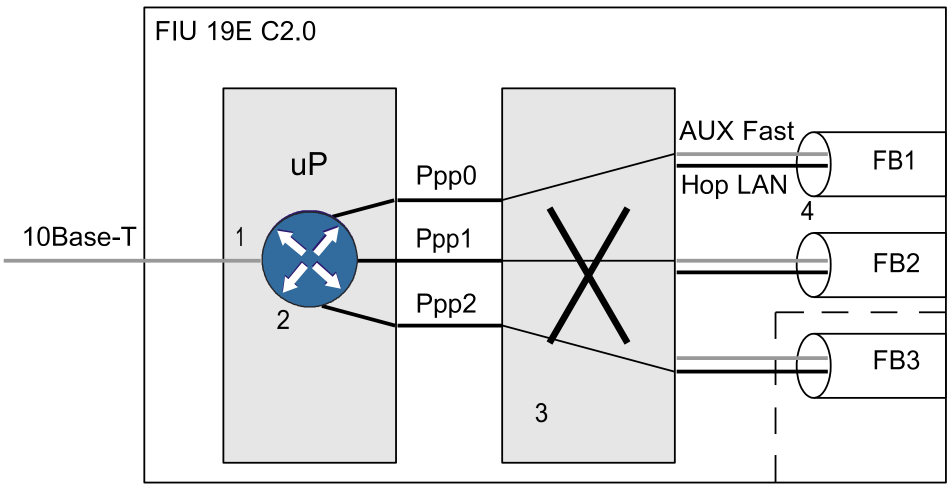


Figure 30. IP DCN interfaces on FIU 19(E)

IP DCN in 2IU protection

IP DCN can be used in 2IU-protected configuration. Both nodes share the same IP address but they have different MAC addresses. Node Ethernet interfaces should be connected together with an external hub. Only active FIU 19(E) forwards IP frames. External hub has to be bought locally for 2IU protection use. IP DCN settings are copied automatically from active unit to passive unit while configuring the active unit.

IP routing

FIU 19(E) provides IP routing functionality for network management and auxiliary IP data traffic. Static routing and dynamic routing (OSPFv2, RFC 2178) protocols are supported. Dynamic routing protocol is a licensed feature.

Static routing

Static IP routing is supported when FIU 19(E) is used as the indoor unit for Nokia FlexiHopper (Plus). It is possible to transmit IP traffic to other IP equipment located on site or to other sites connected through Nokia FlexiHopper (Plus) radio links. See figure *IP routing example* for an example.

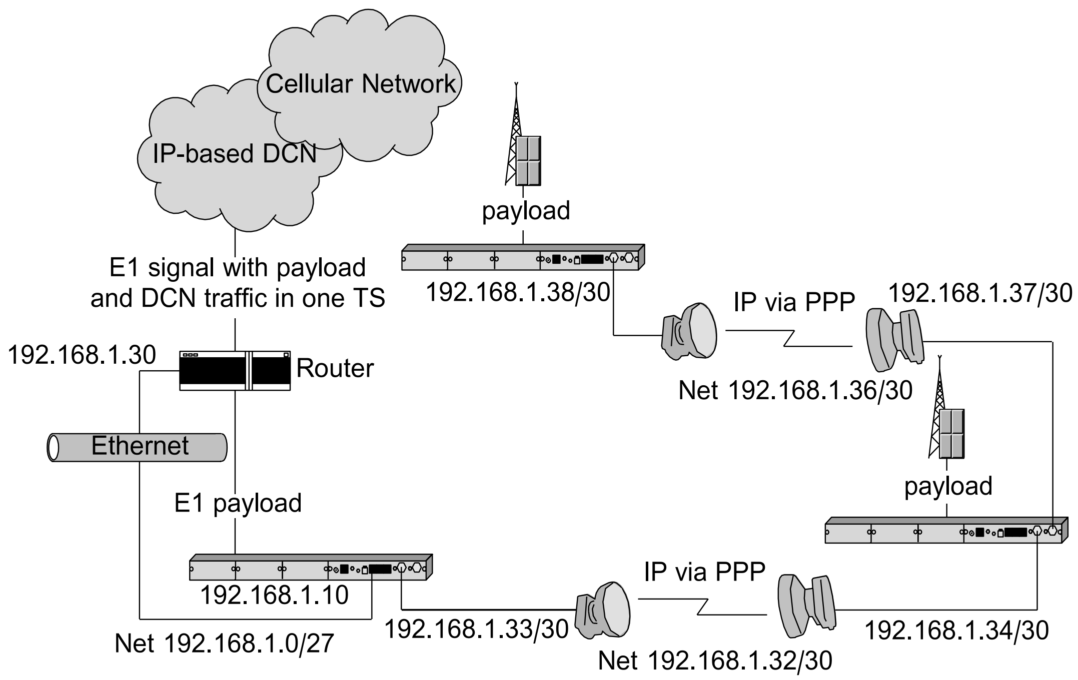


Figure 31. IP routing example

In the example the FIU 19(E), which is located at the router side, needs to have a static routing entry destination 192.168.1.36, netmask 255.255.255.252, next hop 192.168.1.34. In addition, the router located at the site has to have a static routing entry for the FIU 19(E) devices located at the other end of the Nokia FlexiHopper (Plus) radio link. One possible entry in this example would be: destination 192.168.1.32, netmask 255.255.255.248, next hop 192.168.1.10.

Dynamic routing - OSPFv2

OSPF is a dynamic routing protocol that automatically finds out IP network topology and calculates routing table for an OSPF router. This routing protocol is suitable for large and medium size IP networks. OSPF can be used together with static routing but in that case static routing has to be configured also.

FIU 19(E) can work either as an area border router or intra area router. Additionally following OSPF items are configurable for FIU 19(E): Router ID, election priority, ospf admin status for each interface, link cost for each interface, area id, area type (normal, stub, nssa), area aggregates, virtual links, OSPF interface authentication type & authentication data (none, simple password, md5). Following OSPF status information can be viewed with Hopper Manager: dynamic routing table, ospf neighbour list & link state database status.

The following router parameters are not configurable and their values are fixed: hello interval (10s), router dead interval (40s), retransmit interval (5s), inftransdelay (1s).

FIU 19(E) OSPF implementation also supports OSPF related MIB (Management Information Base) according to RFC 1850. Only mandatory groups are supported in this MIB. This makes it possible to configure and view OSPF status through SNMP.

OSPF routing protocol can be used in 2IU/2OU protected configuration. After indoor unit changeover the routing protocol restarts itself and routing table is recalculated for newly activated FIU 19(E).

It is recommended to set default gateway to 0.0.0.0 when using OSPF. This has to be done because OSPF protocol can also advertise default routes to the network. Eventually it is up to network planner how to use it. Proxy ARP should be disabled when using OSPF.

It is recommended to keep the number of routing table entries below 300 to ensure good performance of OSPF routing protocol. It is possible to minimize routing table by defining area aggregates.

Proxy ARP

At tail sites, a proxy ARP (transparent subnetting according to RFC 1027) can be used for forwarding the IP traffic towards the far-end FIU 19(E). The advantage of this configuration is that it is not necessary to have a routing entry for the far-end unit in the router responsible for forwarding IP traffic to the near-end site.

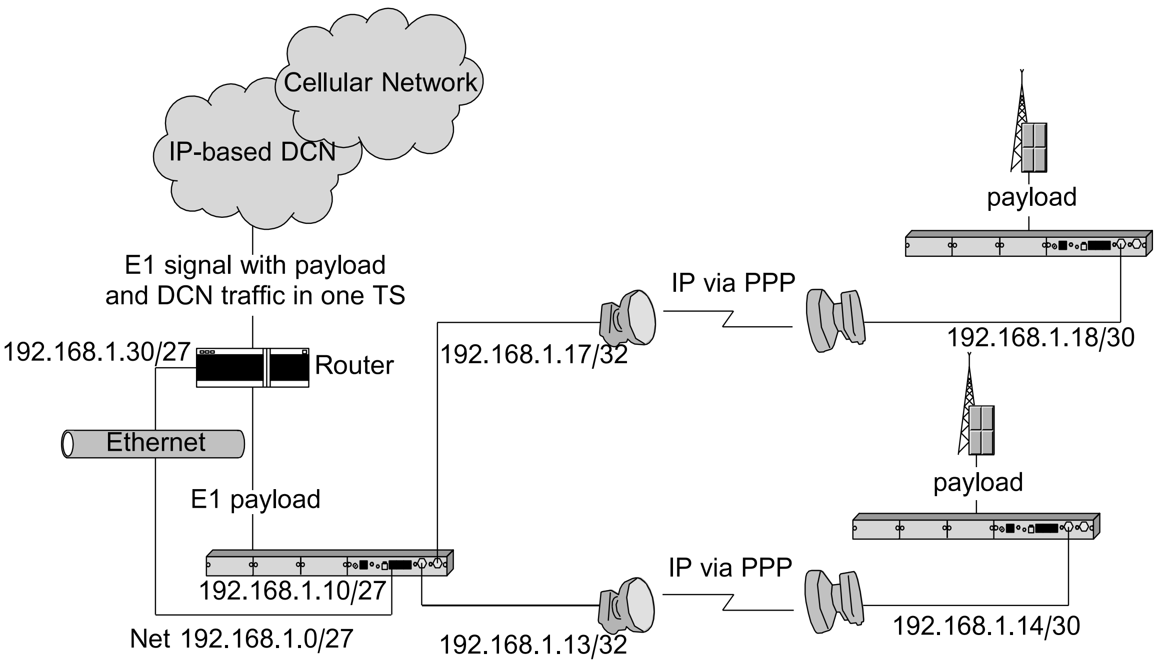


Figure 32. Nokia FlexiHopper (Plus) IP DCN example with Proxy ARP

In case of Proxy ARP, the PPP interface subnet mask at the tail site cannot be set to 255.255.255.255.

Each used port needs to be configured with one IP address. In case of point-to-point links, there is no need to establish separate subnets for the point-to-point link between two Nokia FlexiHopper (Plus), because the host route entries are automatically added to the routing table for the next hop. Therefore the IP addresses can be distributed freely to all ports.

SNMP

FIU 19(E) has an inbuilt SNMP agent that provides management functions for the whole radio terminal including the connected radios. Fault, performance and configuration management functions can be performed using SNMP actions. The version that is supported is the SNMP version 2c.

The SNMP interface supports only subset of the features that are implemented to Q1 interface. Commissioning, for example, is recommended to be done with Hopper Manager. Hopper Manager can be used through the Nokia Q1 Pipe Connection through the TCP/IP network. SNMP feature is under E-license.

NTP

With FIU 19(E) as the indoor unit, Nokia FlexiHopper (Plus) supports Network Time Protocol (NTP). The NTP functionality is used to update the node's real time clock by connecting to an NTP server, which must be accessible through the IP-based DCN. Up to five NTP server IP addresses can be configured and prioritized in FIU 19(E).

The NTP functionality in the indoor unit can be enabled or disabled by using Hopper Manager or through SNMP.

TFTP

The trivial file transfer protocol (TFTP) is used to transmit software binary files through IP DCN. Nokia FlexiHopper (Plus), with the FIU 19(E) as the indoor unit, utilises TFTP for remote software download. Alternatively, you can use the remove software download through the Nokia Q1 Pipe Connection and Hopper Manager.

For node security reasons the TFTP server functionality can be enabled or disabled in the indoor unit through Hopper Manager or through SNMP.

Other IP applications

Following applications can also use IP DCN network.

- FTP
- Voice over IP (VoIP, used with Aux fast only)
- Hopper Manager remote connection

5.5 Engineering order-wire (EOW) over IP

Engineering order-wire can be used for service purposes if the mobile phone coverage is not available or lost at the Nokia FlexiHopper (Plus) site.

IP DCN network (see SNMP management chapter) can be used to carry IP voice calls when Aux Fast is used as a PPP data channel. HopLAN PPP link cannot be used to carry voice calls because of its low capacity. To use IP EOW one has to acquire suitable IP phones + configure IP DCN network with FIU 19(E)'s.

Recommendations for IP phone capabilities: IP phones should support SIP v2.0 (Session Initiation Protocol), Voice codecs (G723 or G729), call dialing with recipients IP address without external SIP server.

For more information on the IP EOW, see Technical note 99 available in NOLS (Nokia Online Services) → Documentation → Product Documentation → Transmission and Backbone → Microwave Radios → Nokia FlexiHopper Indoor Units → Nokia FlexiHopper Indoor Unit FIU 19E → Maintenance Documentation.

6 Mechanical structure and interfaces

6.1 FIU 19(E) indoor unit

The FIU 19(E) indoor unit is only 2/3 U (29 mm) high. The maximum interface capacity of the indoor unit is 12x2 Mbit/s. Interface capacities over 12x2 Mbit/s are implemented by installing the 16x2 Mbit/s expansion unit underneath the indoor unit. Protected use with two indoor units is implemented using two identical FIU 19(E) indoor units and the expansion unit, so the interface capacity is always 16x2 Mbit/s. The expansion unit has the same external dimensions as the indoor unit.

When the expansion unit (EXU) is used to provide 16x2 Mbit/s interfaces, an IC (interface circuit) plug-in unit is installed to EXU plug-in unit slot A. When the expansion unit is used to provide 2IU + 2OU protection, IC plug-in units are installed to both EXU plug-in unit slots. These plug-in units connect the indoor units and the expansion unit together through a common backplane.

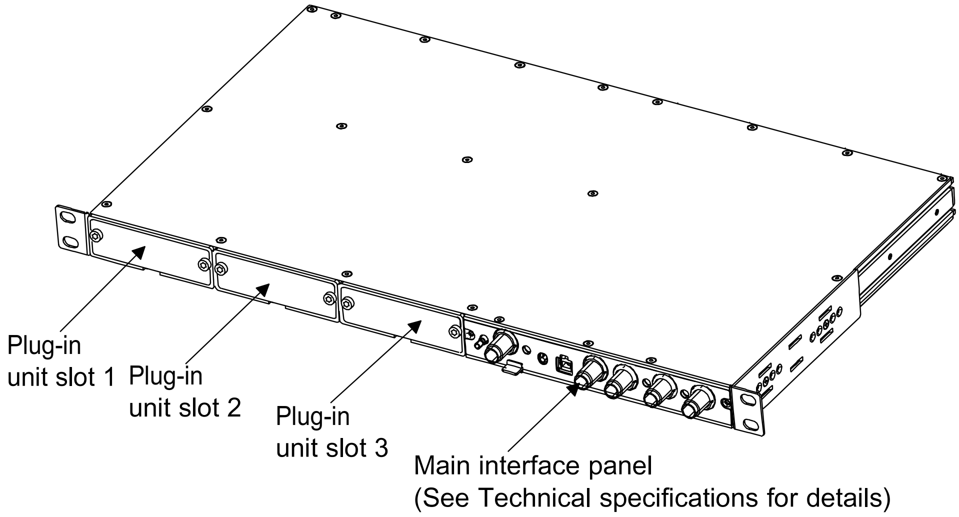


Figure 33. FIU 19 indoor unit

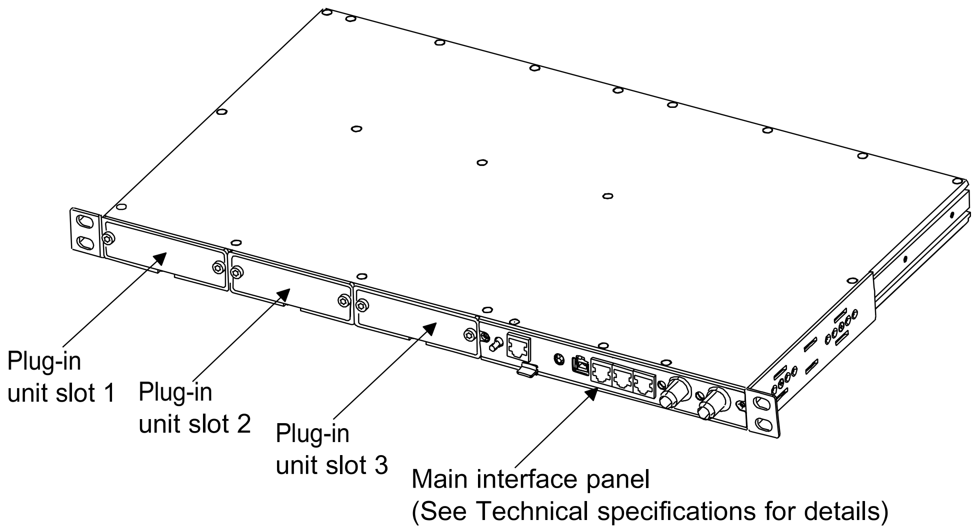


Figure 34. FIU 19(E) indoor unit

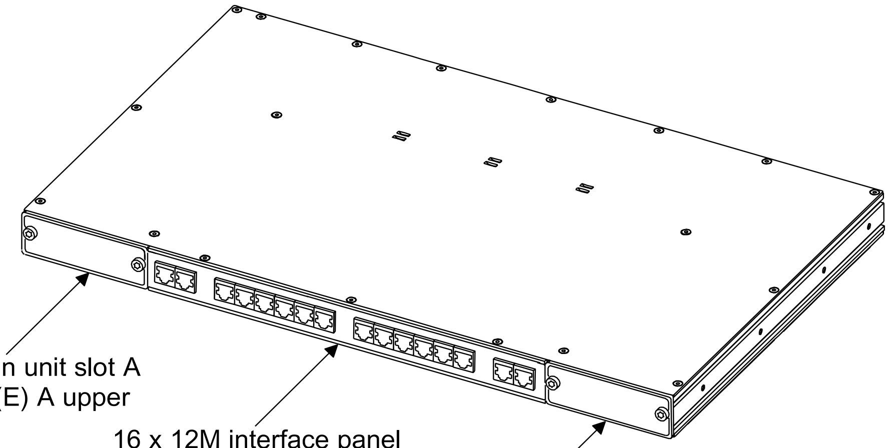


Figure 35. FIU 19(E) EXU with 120 Ω RJ-45 balanced interfaces

6.1.1 Installing FIU 19(E) indoors

The unit is installed horizontally into a 19-inch rack using special mounting brackets. As all the interfaces are located in the front panel, cabling can be performed easily. The unit can also be installed vertically depending the host equipment.

FIU 19(E) can also be installed into an ETSI 600 x 300 mm rack or a TM4 Slim rack using adapter kits. The unit can also be installed vertically depending on the host equipment.

6.1.1.1 Connectors and cabling

The FIU 19(E) indoor unit has two Flexbus interfaces (FB1, FB2: 50Ω TNC connector) on the front panel. These interfaces feed also power to the OUs connected through them. In addition the FIU 19(E) indoor unit has connectors for power supply (PWR: Molex Micro-Fit 3.0 connector) and measurement interface (MP: 75Ω SMB connector).

The FIU 19 indoor unit has also connectors for network management (Q1: TQ connector) and local management (LMP: BQ connector).

The FIU 19(E) indoor unit has management connectors for network management (Q1: RJ-45 connector), local management (LMP: RJ-45 connector) and Ethernet interface (10BaseT: RJ-45-connector).

2 Mbit/s interfaces can be added as plug-in units or as an expansion unit. The interfaces can be either balanced (120 Ω TQ, 120 Ω RJ-45) or unbalanced (75 Ω SMB).

Two Flexbus interfaces (FB3, FB4) can be added as an plug-in unit.

Auxiliary data interfaces can be added as plug-in units.

Two Ethernet payload interfaces can be added as an plug-in unit.

The cabling of the interfaces depends on the installation environment. When the units have been set up in 2IU + 2OU protection mode, the following matters have to be considered:

- a protected power supply must be connected to both indoor units
- the Q1 cabling (in a chaining setup) is connected to the Q1-1 port of the indoor unit A and Q1-2 port of the indoor unit B
- when using IP DCN, the Ethernet interface of both indoor units have to be connected with the IP DCN (only in FIU 19(E))
- auxiliary interfaces are connected together with a branching wire
- LMP cable can be connected to either unit.
- EPIU Ethernet interfaces must be connected through Ethernet hub, switch or router.

6.1.1.2 Power supply

FIU 19(E) requires a power supply input of −40.5 to −72 V_{DC}. The power consumption of a fully equipped FIU 19(E) is less than 17 W. The actual power consumption depends on the site equipment and the power losses caused by the equipment.

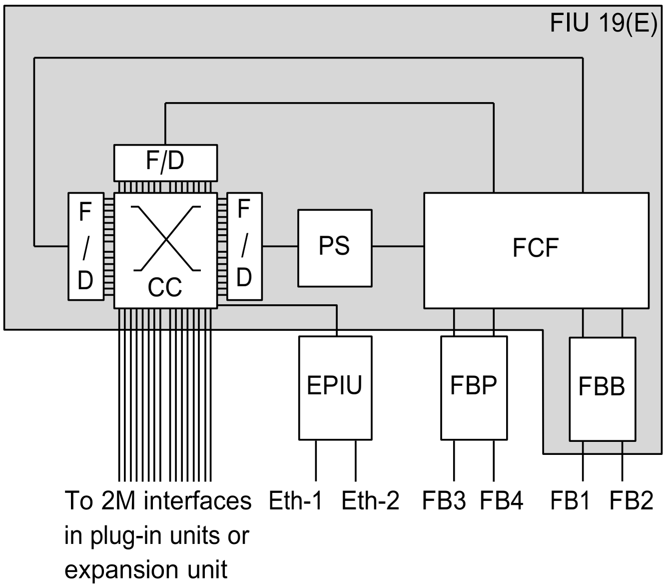
If outdoor units are connected via Flexbus to the Flexbus plug-in unit, an additional power supply input of +52 to +60 V_{DC} must be connected to the plug-in unit. If other indoor units are connected to the Flexbus plug-in unit, additional power supply is not required.

The FIU 19(E) features a slow solderable 3A fuse at the DC input, situated before the power supply unit. The Flexbus plug-in unit has 2A fuses at both of the lines of the additional power supply input.

The Flexbus connection is protected with a gas-discharge tube. The Flexbus DC input features an overvoltage protector.

Caution

Careless Q1 bus planning may cause a Q1 bus loop or more than one alarm poller for the same Q1 bus. Take care with Q1 bus planning.



CC	=	2 Mbit/s cross-connection and Ethernet connection
F/D	=	Framing/deframing section
FCF	=	Flexbus connection field
PS	=	Protection switch
FBB	=	Flexbus block
FB1, FB2	=	Flexbus interfaces in the main unit (can be used for protection)
FBP	=	Flexbus plug-in unit
FB3	=	Flexbus interfaces in the plug-in unit
FB4	=	Flexbus interfaces in the plug-in unit (only available if protection between FB1 and FB2 is in use)
EPIU	=	Ethernet plug-in unit (in FIU 19E only)
Eth-1	=	Ethernet interface 1
Eth-2	=	Ethernet interface 2

Figure 36. Routes of 2 Mbit/s and Flexbus signals in FIU 19(E)

6.1.1.3 Auxiliary interfaces

With one plug-in unit, it is possible to use one aux fast data channel and one aux slow data channel at the same time. The maximum bit rates of these channels depend on the Flexbus transmission capacity. One aux fast and one aux slow data channel can be connected to the same Flexbus direction.

One plug-in unit contains also four TTL type software controlled programmable I/O connections and/or relay control outputs. You can use input connections to trigger alarms to the network management system of external events (for example opening of the cabinet door). Relay controls can be used for example to turn on equipment rack lights.

6.1.2 Installing FIU 19E outdoors

When there is no site cabinet for indoor unit FIU 19E can be installed outdoors or indoors using FIU 19E outdoor case. FIU 19E outdoor case can be installed either vertically on a pole or wall or horizontally on the floor or on a roof.

An auxiliary data plug-in unit is required in order to monitor FIU 19E outdoor case fan alarms.

For more information, see *Installing FIU 19E indoor unit outdoors* in *Installing Hardware for Nokia FlexiHopper (Plus) 2.7*.

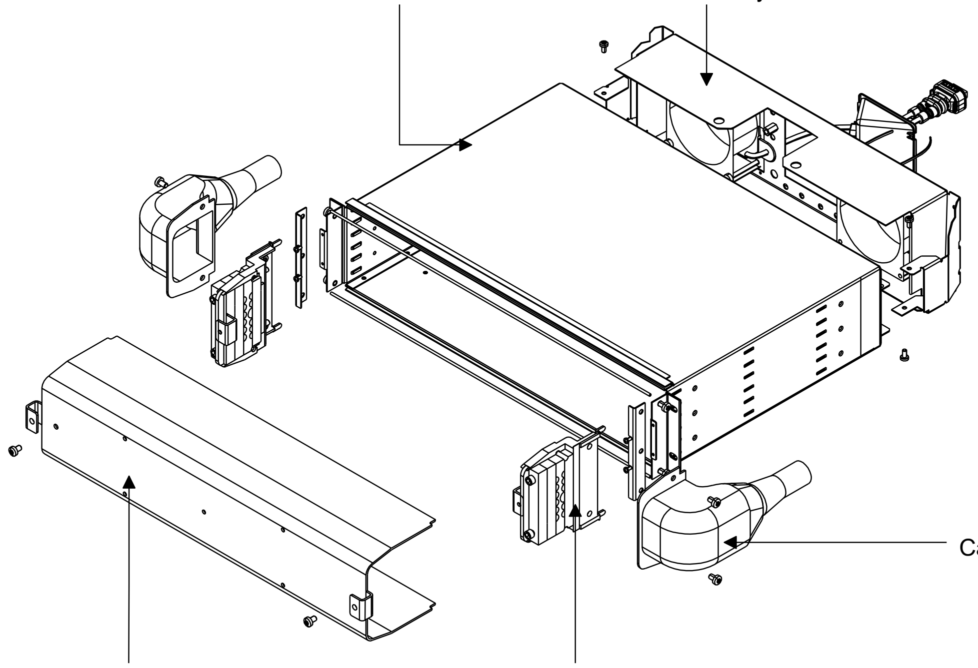


Figure 37. FIU 19E outdoor case

6.1.2.1 Connectors and cabling

The use of specific outdoor cables in outdoor installation is mandatory. Most of the cables available for FIU 19E indoor usage are also available for outdoor usage.

The use of Flexbus Jumper Cable TNC-male-TNC-female is mandatory because of the outdoor case's front cover space requirements. The outdoor cable set can also be used in indoor installation as the cables are retardant according to UL1581 VW-1.

Note that in vertical installation on a pole or a wall, the cables must be routed through lower cable entry only. For more information, see *Installing FIU 19E indoor unit outdoors* in *Installing Hardware for Nokia FlexiHopper (Plus) 2.7*.

6.1.2.2 Power supply

FIU 19E outdoor case requires a power supply input of -40.5 to -57 V_{DC}.

The maximum additional power consumption of FIU 19E outdoor case is 14 W compared to a similar indoor site configuration.

! Caution

Incorrect supply voltage may cause a breakdown of the fan units of the outdoor case. The FIU 19E outdoor case requires a power supply input of -40.5 to -57 VDC, instead of the voltage allowed for FIU 19E.

6.1.2.3 Auxiliary interfaces

Auxiliary data plug-in unit is always needed when FIU 19E is installed outdoors. The fans of the FIU 19E outdoor case are controlled with and monitored through the auxiliary data plug-in unit. For more information, see *Commissioning Aux plug-in unit with FIU 19E outdoor case* in *Commissioning Nokia FlexiHopper (Plus) 2.7 with FIU 19 (E)*.

6.2 FXC RRI transmission unit

The FXC RRI transmission unit has two Flexbus interfaces, which allow the operator to connect the unit to any radio unit with a Flexbus interface. This requires a Flexbus cable. For example, it is possible to connect FXC RRI to:

- Nokia MetroHopper radio with 4 x 2 Mbit/s capacity
- Nokia FlexiHopper (Plus) radio with 2 x 2, 4 x 2, 8 x 2 or 16 x 2 Mbit/s capacity

FXC RRI contains two Flexbus interfaces, FB1 and FB2, located on the front panel and a cross-connection bus interface on the backplane. FXC RRI does not have a separate management connector, as it is managed via the local management port (LMP) of the base station or the transmission node, or via Nokia Q1 bus.

FXC RRI has separate short circuit protection for each of the Flexbus interfaces. This ensures that a short circuit in one Flexbus interface does not affect the other in MetroHub.

If a Flexbus interface is connected to an outdoor unit, the power feed (55 V_{DC}) to the outdoor unit is done through the interface.

Currently FXC RRI supports three operating modes:

- single use
- hot standby
- hot standby + space diversity

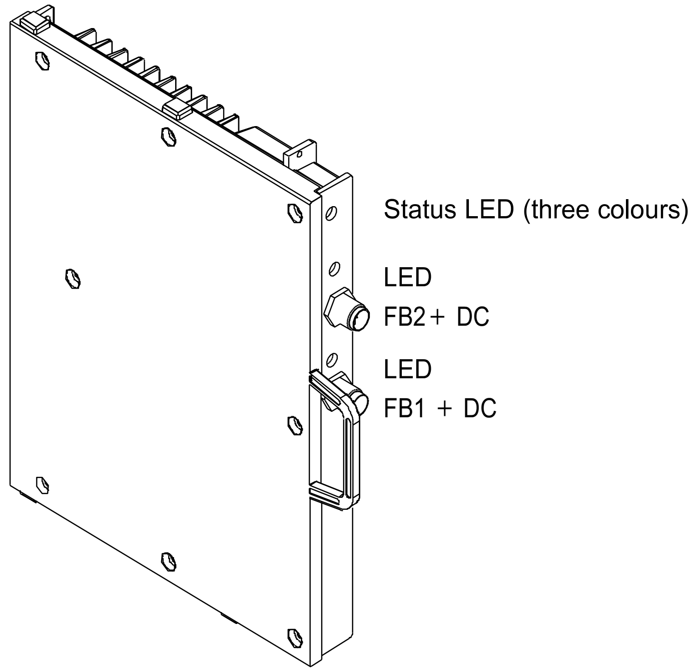


Figure 38. FXC RRI transmission unit

The FXC RRI offers a bypass cross-connection feature, which can be used to bypass traffic through the unit transparently without terminating the signal. From the performance management point of view, a link can be extended to include several nodes, while the performance data is gathered for the whole extended link. It is possible to make bypass cross-connections even if all the platform interfaces of the FXC RRI unit are in use. In other words, the bypass cross-connection does not reserve any capacity from the cross-connection bus.

The platform interfaces of each indoor unit have a maximum capacity of 16 x 2 Mbit/s. This traffic can either be dropped to the cross-connection bus or bypassed from one interface to another in the same FXC RRI in a separate 2 Mbit/s cross-connection field. If the total Flexbus interface traffic in one FXC RRI exceeds 16 x 2 Mbit/s, the surplus traffic has to be bypassed. In such a scenario, time slot 0 is not regenerated.

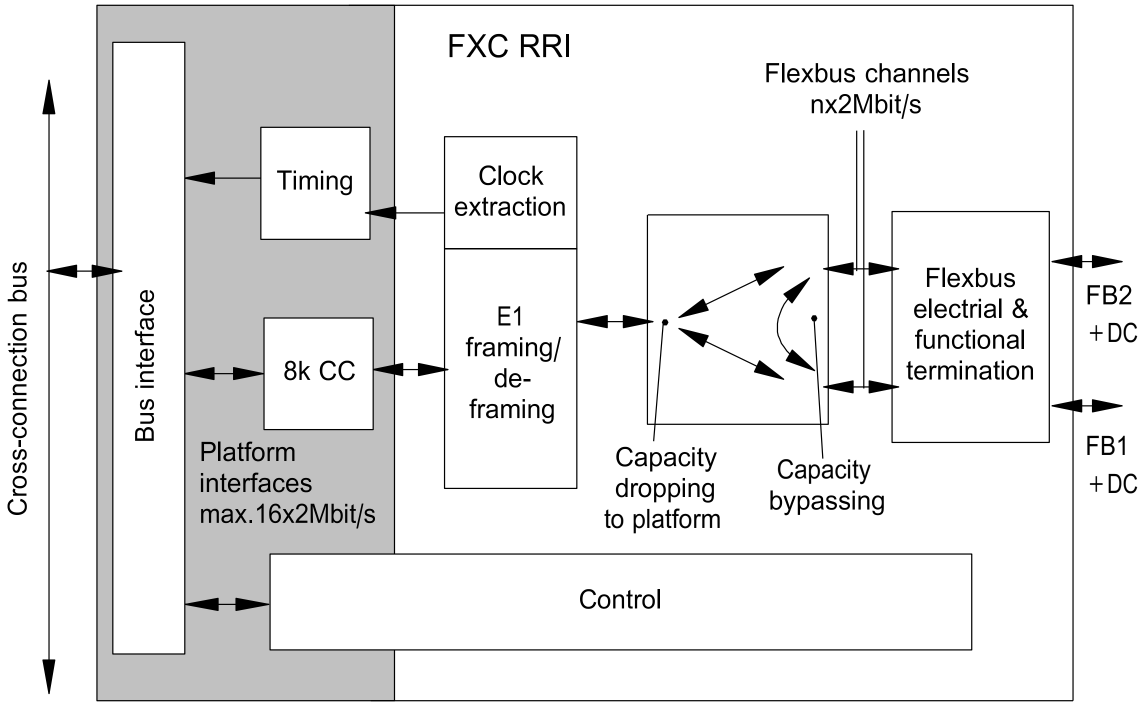


Figure 39. FXC RRI block diagram

A connection made between a Flexbus channel and a platform interface is a blocking connection. This means that the whole 2 Mbit/s frame is reserved for the connection even if only part of it, for example, one time slot, is used.

The operator defines the traffic routes in the network elements by using the cross-connection functions available in the network elements. Thus, routing traffic means managing the cross-connections in the network elements.

The cross-connection function of the FXC RRI transmission unit allows the traffic to be groomed. This ensures that the transmission paths are fully utilised, thereby reducing transmission costs.

The amount of 2M capacity add/drop towards the D-bus of a Nokia BTS is configurable, allowing you to utilise the available capacity to its maximum.

FXC RRI platform interface 15 is always connected to the D-bus, because at least 1*2M capacity is always needed for the Nokia BTS. Only FXC RRI platforms 13 and 16 are configurable.

D11, D12, and D13 are only configurable via the RRI manager in a configuration with an RRI connected to a FlexiHopper (Plus).

6.3 Interface unit IFUE

IFUE interface unit is a part of Nokia WCDMA RAN transport solution and is used in Nokia AXC and S-AXC ATM cross-connect nodes. Nokia AXC is a modular embedded transport node for Nokia WCDMA base stations and Triple-Mode Nokia UltraSite EDGE base station (with WCDMA upgrade kit). The Nokia S-AXC is a stand-alone ATM cross-connect node.

IFUE provides an interconnection to Nokia FlexiHopper (Plus) and MetroHopper radios, and to Nokia GSM/EDGE base stations. This is implemented with three Flexbus interfaces which have a maximum capacity of 16 x 2.048 Mbit/s each. They also provide power to the outdoor microwave radio units.

IFUE includes a PDH cross-connect facility between the 3 Flexbus interfaces as well as the Flexbus interfaces and the E1-ATM interworking.

IFUE supports also IMA by enabling distribution of ATM connections across up to 8 E1 channels in an IMA group. Note that due to differential delay in an IMA group, it is recommended that all E1 channels of an IMA group share the same Flexbus link.

Nokia FlexiHopper (Plus) microwave radio outdoor units connected to Flexbus interfaces 1 and 2 can be configured to protect each other (Hot Stand-by). Flexbus interface 3 is an unprotected interface that can only be operated with one single Nokia MetroHopper or Nokia FlexiHopper (Plus). Propagation protection (space diversity, frequency diversity and polarisation diversity) is also supported.

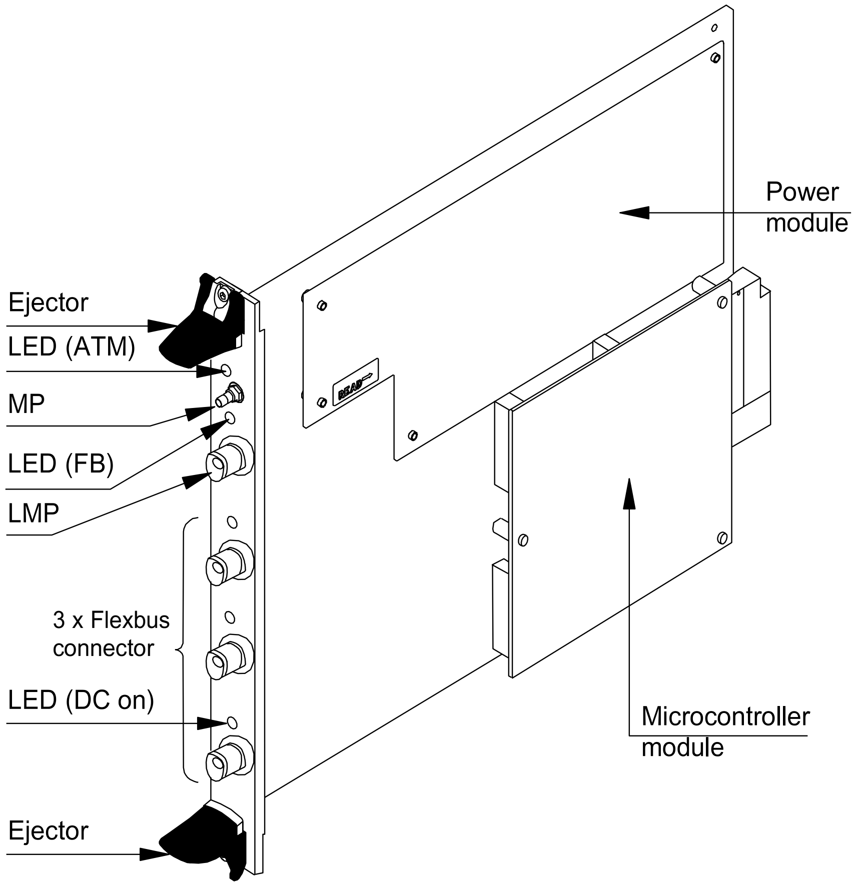


Figure 40. IFUE unit

6.4 Flexbus Transmission sub-modules

6.4.1 FTFA - Flexbus Transmission Sub-module for Nokia Flexi WCDMA BTS

FTFA is an optional interface unit that can be installed in Nokia Flexi WCDMA base stations. It has two Flexbus interfaces and it provides up to 16x2 Mbit/s transmission capacity.

FTFA provides all the functionality of an indoor unit, thus the actual radio can be directly connected to it. It is also possible to configure chain sites using 2M cross connections.

The following figure illustrates FTFA Flexbus Transmission Sub-module for Nokia Flexi WCDMA BTS.

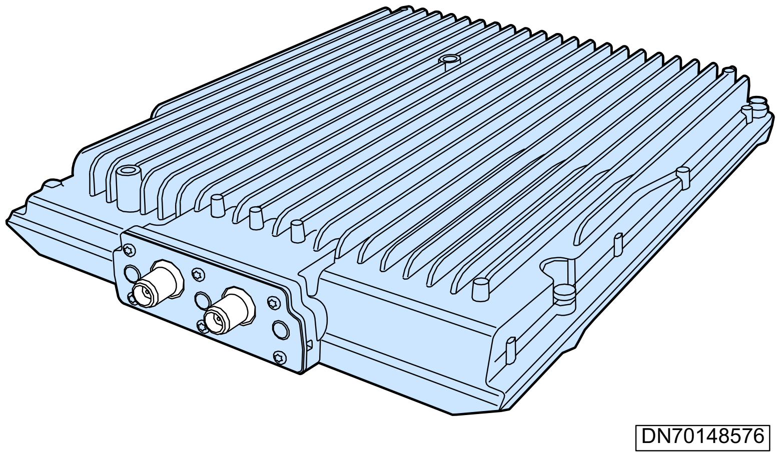


Figure 41. FTFA Flexbus Transmission Sub-module for Nokia Flexi WCDMA BTS

6.4.2 FIFA - Flexbus Transmission Sub-module for Nokia Flexi EDGE BTS

FIFA Flexbus Transmission sub-module for Nokia Flexi EDGE BTS provides radio transmission interface functionality and power supply and control to Nokia microwave radios. FIFA is an optional sub-module.

FIFA allows the operator to connect Nokia Flexi EDGE BTS to any microwave radio unit with a Flexbus interface using a single Flexbus cable. The supported microwave radios are Nokia FlexiHopper (Plus) and Nokia MetroHopper microwave radios. Nokia FlexiHopper (Plus) microwave radios support capacities of 2 x 2, 4 x 2, 8 x 2 or 16 x 2 Mbit/s whereas Nokia MetroHopper capacity is fixed to 4 x 2 Mbit/s.

FIFA can also be used to connect BTS either to a standalone indoor unit or to another BTS integrated indoor unit. The supported indoor units are FIU19, FIU 19E, FXC RRI, IFUE, and RRIC. FIFA uses 48 VDC derived from backplane and distributes the supply voltage to microwave radios through a Flexbus cable.

FIFA provides the following external and internal interfaces:

- Two external Flexbus interfaces. The use of second Flexbus interface is a licenced feature.
- Internal 2 Mbit/s interfaces (up to 16) towards Nokia Flexi EDGE System Module (ESMA).

Flexbus 1 can be used without any licence and Flexbus 2 usage requires a separate *Additional Flexbus (FB) interface* licence to be installed.

FIFA supports both single and protected operation modes. FIFA and the connected microwave radios are commissioned, monitored, and administered with Nokia FlexiHub Manager.

The following figure illustrates FIFA Flexbus Transmission Sub-module for Nokia Flexi EDGE BTS.

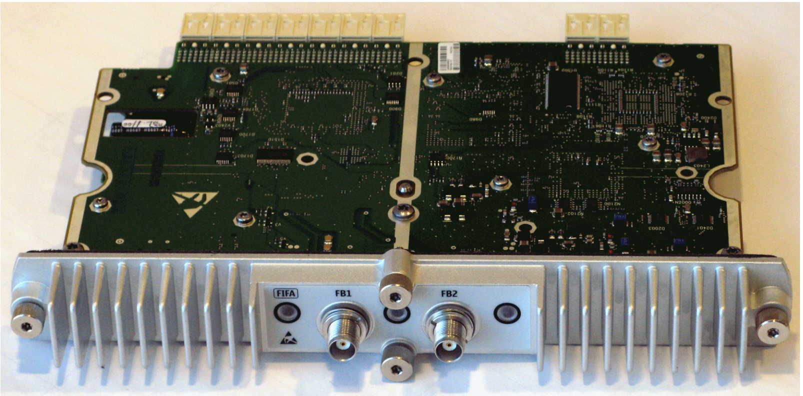


Figure 42. FIFA Flexbus Transmission Sub-module for Nokia Flexi EDGE BTS

7 Technical specifications

7.1 Technical specifications for Nokia FlexiHopper (Plus)

7.1.1 General information

Nokia FlexiHopper (Plus) 2.7 Product Description covers Nokia FlexiHopper Plus, Nokia FlexiHopper and Nokia FlexiHopper 4E1 products and supporting indoor units. The following rules apply:

- Nokia FlexiHopper Plus enables 2E1 to 16E1 transmission capacity and selectable modulation (π/4-DQPSK and 32 TCM).
- Nokia FlexiHopper enables 2E1 to 16E1 transmission capacity in the 4-state modulation mode.
- Nokia FlexiHopper 4E1 enables 2E1 to 4E1 transmission capacity in the 4-state modulation mode and can be upgraded to 16E1 by software licensing.
- Selectable modulation is an option for both Nokia FlexiHopper and Nokia FlexiHopper 4E1.

In this Product Description, Nokia FlexiHopper Plus and Nokia FlexiHopper refer to the modulation in use. Nokia FlexiHopper (Plus) refers to all Nokia FlexiHopper products.

7.1.2 Capacities

Table 3. Capacity options (programmable)

Traffic capacity (Mbit/s)	Gross bit rate (Mbit/s, ±10 ppm)

Table 3. Capacity options (programmable) (cont.)

2 x 2	4.715 127 5
4 x 2	9.430 255
8 x 2	18.860 510
16 x 2	37.721 020
Bit rate tolerances	
2 Mbit/s interface	±50 ppm

7.1.3 Operation

Table 4. Available operating modes

1 indoor unit / 1 outdoor unit (FIU 19(E), FXC RRI, AXC IFUE, FTFA, FIFA)
1 indoor unit / 2 outdoor units (FIU 19(E), FXC RRI, AXC IFUE, FTFA, FIFA)
1 indoor unit / 3 outdoor units (FIU 19(E) + additional power supply), AXC IFUE
1 indoor unit / 4 outdoor units (FIU 19(E) + additional power supply in HSB configuration)
HSB, 1 IU / 2 OU (FIU 19(E), FXC RRI, AXC IFUE, FTFA, FIFA)
HSB, 2 IU / 2 OU (FIU 19(E))
HSB + space diversity, 1 IU / 2 OU (FIU 19(E), AXC IFUE)
HSB + space diversity, 2 IU / 2 OU (FIU 19(E))
Frequency diversity 1 IU / 2 OU, (FIU 19(E), AXC IFUE)
Frequency diversity 2 IU / 2 OU (FIU 19(E))
Polarisation diversity, 1 IU / 2 OU (FIU 19(E), AXC IFUE)
Polarisation diversity, 2 IU / 2 OU (FIU 19(E))
Loop protection (FXC RRI), 1 IU / 2 OU or 2 IU / 2 OU

Table 5. Cross-connections

Indoor unit	Cross-connection level
FIU 19(E)	2 Mbit/s
FXC RRI	8 kbit/s
AXC IFUE	2 Mbit/s

Table 5. Cross-connections (cont.)

Indoor unit	Cross-connection level
FTFA	2 Mbit/s
FIFA	2 Mbit/s

Table 6. Standards followed for statistics, jitter, and AIS

Statistics	ITU-T G.826
Jitter	ITU-T G.823
AIS	ITU-T G.921, Section 1.4

Table 7. Residual bit error ratio (RBER)

RBER	$\leq 10^{-11}$

7.1.4 Interfaces

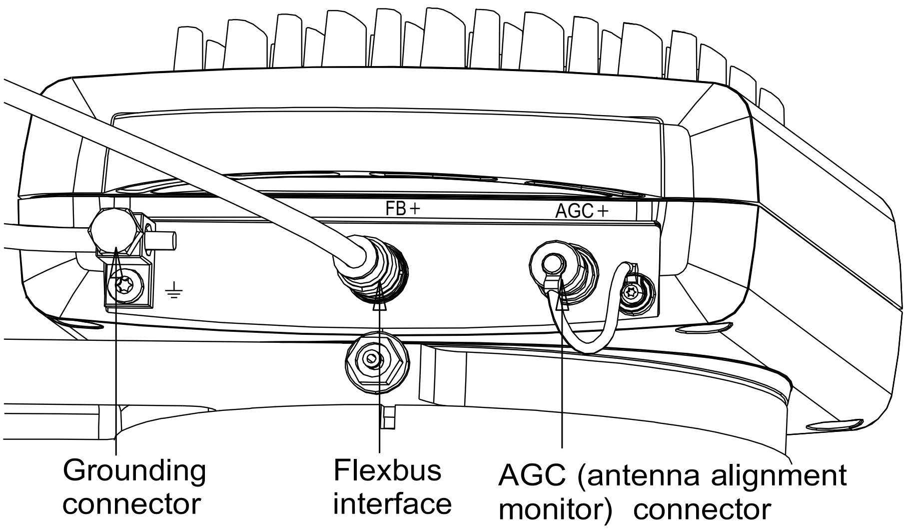


Figure 43. Nokia FlexiHopper (Plus) outdoor unit connectors

Table 8. Antenna connector

Frequency band	Waveguide flange
7, 8 GHz	UBR84
13 GHz	UBR120
15 GHz	UBR140
18, 23, 26 GHz	UBR220
28, 32, 38 GHz	UBR320

Table 9. Electrical interfaces

Flexbus interface	TNC connector (female) 50 Ω Power supply for the OU
AGC monitor interface (antenna alignment monitor)	BNC connector Voltage range: 0.5 - 4.5 V *(decreasing with increasing Rx level)* Output impedance: > 10 kΩ

Table 10. Outdoor unit dimensions without antenna and alignment units

Frequency band	Height*	Width	Depth	Weight
7, 8 GHz	230 mm	210 mm	230 mm	6.0 kg
13, 15 GHz	230 mm	210 mm	210 mm	5.5 kg
18, 23, 26, 28 GHz	230 mm	210 mm	170 mm	4.5 kg
32, 38 GHz	230 mm	210 mm	120 mm	4.0 kg

*Height with handle is 275 mm.

7.1.5 Environment

Table 11. Electromagnetic compatibility (EMC)

Emissions	
Radiated emission	EN 55022 Class B or CISPR22 30 - 230 MHz 30 dBμV/m Quasi-peak > 230 - 1000 MHz 37 dBμV/m Quasi-peak
Conducted emission	EN 55022 Class B DC port: 0.15 - 0.5 MHz: 66 - 56 dBμV Quasi-peak 56 - 46 dBμV Average > 0.5 - 5 MHz: 56 dBμV Quasi-peak 46 dBμV Average > 5 - 30 MHz: 60 dBμV Quasi-peak 50 dBμV Average Telecommunication ports: 0.15 – 0.5 MHz: 84 - 74 dBμV Quasi-peak 74 - 64 dBμV Average > 0.5 - 30 MHz: 74 dBμV Quasi-peak 64 dBμV Average
Immunities	
RF EM field	EN 61000-4-3 80 - 1000MHz, 1400 - 2000 MHz, 10 V/m: no errors
Electrostatic discharge	EN 61000-4-2 ± 8 kV air discharge: self-recovery, errors accepted ± 4 kV contact discharge: self-recovery, errors accepted

Table 11. Electromagnetic compatibility (EMC) (cont.)

Fast common mode transients	EN 61000-4-4 DC port: ±2 kV self recovery, errors accepted Signal ports: ±1 kV self recovery, errors accepted Earth port: ±1 kV self recovery, errors accepted
RF common mode	EN 61000-4-6 DC port, signal ports and earth port: 0.15 – 80 MHz, 10 V_{rms}: no errors
Surges	EN 61000-4-5 DC port: ±0.5 kV, 1.2/50µs, 2 Ω series resistance Signal ports: ±1 kV, 1.2/50µs, 2 Ω series resistance No damage, self recovery, sync loss accepted
Overvoltage tolerance of the indoor-outdoor cables and outdoor unit power input	4 kV 1.2/50 µs, 2 Ω series resistance No damage, self recovery

Table 12. Environmental standards and conditions

Nokia FlexiHopper (Plus) and FIU 19(E) indoor unit, storage	
Ambient temperature	-40 to +70°C
EN 300 019-1-1	Class 1.2
EN 300 019-2-1	Class 1.2
Nokia FlexiHopper (Plus) and FIU 19(E) indoor unit, transportation	
Ambient temperature	-40 to +70°C
EN 300 019-1-2	Class 2.3
EN 300 019-2-2	Class 2.3
Nokia FlexiHopper (Plus) outdoor unit, operation and tightness	
Operating temperature	-45°C to +55°C (operational)
Wind	< 55 m/s

Table 12. Environmental standards and conditions (cont.)

Low air pressure	70 kPa (represent a limit value for open air use, normally at about 3000 m)
IEC 60529	Class IP 55
EN 300 019-1-4	Class 4.1 E
EN 300 019-2-4	Class 4.1 E
FIU 19(E) indoor units, operation	
Ambient temperature	-10 to +55°C
EN 300 019-1-3	Class 3.2
EN 300 019-2-3	Class 3.2
FIU 19E indoor units in FIU 19E outdoor case, operation	
Ambient temperature	-35 to +55°C
EN 300 019-1-4	Class 4.1

7.1.6 Outdoor unit power supply

Table 13. Nokia FlexiHopper (Plus) outdoor unit power supply

DC supply voltage in Flexbus connector	+48 to +60 V_{DC}
Power consumption	< 25 W

7.1.7 Synchronisation, recovery, and changeover

Table 14. Synchronisation, recovery, and changeover

Transmitter turn on time (Tx off to on)	< 150 ms
Transmitter turn off time (Tx on to off)	< 50 ms
Receiver synchronisation (Rx off to on)	< 100 ms
Changeover time for E1 data, equipment protection (hot standby)	< 500 ms

7.1.8 Frequencies

Table 15. Frequency bands, duplex spacing, and sub-bands

Frequency band (GHz)*	ITU-R Rec.	Frequency band (GHz)	Duplex spacing (MHz)	Number of sub-bands		Sub band band width (MHz)	CEPT
				LO	HI		
7 (Plus)	F.385-7	7.125 - 7.435	161	4	4	56	-
		7.425 - 7.725	154	4	4	65	-
		7.415 - 7.725	161	4	4	58	-
		7.240 - 7.560	161	4	4	65	-
		7.440 - 7.740	168	3	3	65	-
		7.425 - 7.900	245	4	4	75	-
8 (Plus)	F.386-6	7.725 - 8.275	311.32	3	3	125	-
		8.280 - 8.495	119	3	3	42	-
		8.275 - 8.500	126	3	3	42	-
		7.900 - 8.400	266	3	3	90	-
13 (Plus)	F.497-6	12.75 -13.25	266	3	3	84	REC 12-02
15 (Plus)	F.636-3	14.5 - 15.35	644	1	1	203	-
		14.5 - 15.35	728	1	1	119	REC 12-07
		14.5 - 15.35	420	3	3	150	-
		14.4 - 15.35	490	3	3	170	-
18 (Plus)	F.595-8	17.7 - 19.7	1010	4	4	270	REC 12-03
		17.7 - 19.7	1008	4	4	268	-
23 (Plus)	F.637-3	21.2 - 23.6	1232	3	3	400	-
		21.2 - 23.6	1200	3	3	420	-
		22.0 - 23.6	1008	2	2	400	T/R 13-02
26 (Plus)	F.748-4	24.5 - 26.5	1008	3	3	350	T/R 13-02
28 (Plus)	F.748-4	27.5 - 29.5	1008	3	3	350	T/R 13-02
32 (Plus)	F.1520	31.8 - 33.4	812	4	4	220	REC 01-02

Table 15. Frequency bands, duplex spacing, and sub-bands (cont.)

Frequency band (GHz)*	**ITU-R Rec.**	**Frequency band (GHz)**	**Duplex spacing (MHz)**	**Number of sub-bands**		**Sub band band width (MHz)**	**CEPT**
				LO	**HI**		
38 (Plus)	F.749-2	37.0-39.5	1260	4	4	300	T/R 12-01
Administration may define frequency band and duplex-spacing.							

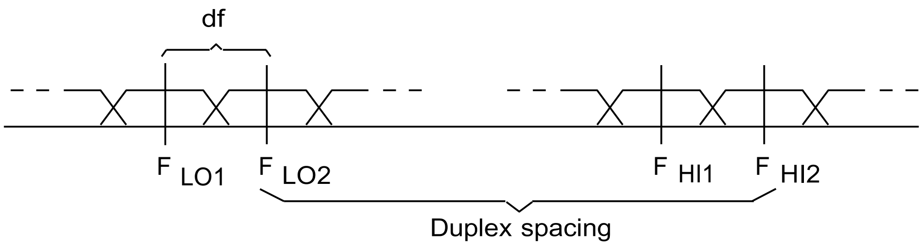


Figure 44. Channel spacing and duplex spacing

For product codes related to different sub-bands, see *Ordering Nokia FlexiHopper (Plus) and Accessories*.

The notation of the sub-bands has changed, for example: A → A LO, A' → A HI.

Table 16. Nokia FlexiHopper (Plus) 7, frequency tuning range

Sub band freq.	**3.5 MHz spacing**		**7.0 MHz spacing**		**14.0 MHz spacing**		**28.0 MHz spacing**	
	Low freq.	**High freq.**	**Low freq.**	**High freq.**	**Low freq.**	**High freq.**	**Low freq.**	**Highfreq.**
161 MHz duplex spacing, sub-bands A, B,C, D								
A LO	7125.00	7168.25	7125.00	7166.50	7125.00	7163.00	7128.00	7156.00
B LO	7150.75	7203.25	7152.50	7201.50	7156.00	7198.00	7163.00	7191.00
C LO	7185.75	7238.25	7187.50	7236.50	7191.00	7233.00	7198.00	7226.00
D LO	7220.75	7273.25	7222.50	7271.50	7226.00	7268.00	7233.00	7261.00

Table 16. Nokia FlexiHopper (Plus) 7, frequency tuning range (cont.)

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	**High freq.**	**Low freq.**	**High freq.**	**Low freq.**	**High freq.**	**Low freq.**	**Highfreq.**
A HI	7286.00	7329.25	7286.00	7327.50	7286.00	7324.00	7289.00	7317.00
B HI	7311.75	7364.25	7313.50	7362.50	7317.00	7359.00	7324.00	7352.00
C HI	7346.75	7399.25	7348.50	7397.50	7352.00	7394.00	7359.00	7387.00
D HI	7381.75	7434.25	7383.50	7432.50	7387.00	7429.00	7394.00	7422.00
154 MHz duplex spacing, sub-bands E, F, G, H								
E LO	7425.00	7477.25	7425.00	7475.50	7425.00	7472.00	7428.00	7465.00
F LO	7450.75	7512.25	7452.50	7510.50	7456.00	7507.00	7463.00	7500.00
G LO	7484.75	7546.25	7486.50	7544.50	7490.00	7541.00	7497.00	7534.00
H LO	7518.75	7571.00	7520.50	7571.00	7524.00	7571.00	7531.00	7568.00
E HI	7579.00	7631.25	7579.00	7629.50	7579.00	7626.00	7582.00	7619.00
F HI	7604.75	7666.25	7606.50	7664.50	7610.00	7661.00	7617.00	7654.00
G HI	7638.75	7700.25	7640.50	7698.50	7644.00	7695.00	7651.00	7688.00
H HI	7672.75	7725.00	7674.50	7725.00	7678.00	7725.00	7685.00	7722.00
161 MHz duplex spacing, sub-bands I, J, K, L								
I LO	7415.75	7470.25	7417.50	7468.50	7421.00	7465.00	7428.00	7458.00
J LO	7450.75	7505.25	7452.50	7503.50	7456.00	7500.00	7463.00	7493.00
K LO	7484.75	7539.25	7486.50	7537.50	7490.00	7534.00	7497.00	7527.00
L LO	7518.75	7564.00	7520.50	7564.00	7524.00	7564.00	7531.00	7561.00
I HI	7576.75	7631.25	7578.50	7629.50	7582.00	7626.00	7589.00	7619.00
J HI	7611.75	7666.25	7613.50	7664.50	7617.00	7661.00	7624.00	7654.00
K HI	7645.75	7700.25	7647.50	7698.50	7651.00	7695.00	7658.00	7688.00
L HI	7679.75	7725.00	7681.50	7725.00	7685.00	7725.00	7692.00	7722.00
161 MHz duplex spacing, sub-bands M, N, O, P								
M LO	7240.75	7302.25	7242.50	7300.50	7246.00	7297.00	7253.00	7290.00
N LO	7272.75	7334.25	7274.50	7332.50	7278.00	7329.00	7285.00	7322.00
O LO	7304.75	7366.25	7306.50	7364.50	7310.00	7361.00	7317.00	7354.00
P LO	7336.75	7398.25	7338.50	7396.50	7342.00	7393.00	7349.00	7386.00

Table 16. Nokia FlexiHopper (Plus) 7, frequency tuning range (cont.)

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.	Low freq.	Highfreq.
M HI	7401.75	7463.25	7403.50	7461.50	7407.00	7458.00	7414.00	7451.00
N HI	7433.75	7495.25	7435.50	7493.50	7439.00	7490.00	7446.00	7483.00
O HI	7465.75	7527.25	7467.50	7525.50	7471.00	7522.00	7478.00	7515.00
P HI	7497.75	7559.25	7499.50	7557.50	7503.00	7554.00	7510.00	7547.00
168 MHz duplex spacing, sub-bands Q, R, S								
Q LO	7444.75	7506.25	7446.50	7504.50	7450.00	7501.00	7457.00	7494.00
R LO	7482.25	7543.75	7484.00	7542.00	7487.50	7538.50	7494.50	7531.50
S LO	7519.75	7569.00	7521.50	7569.00	7525.00	7569.00	7532.00	7569.00
Q HI	7612.75	7674.25	7614.50	7672.50	7618.00	7669.00	7625.00	7662.00
R HI	7650.25	7711.75	7652.00	7710.00	7655.50	7706.50	7662.50	7699.50
S HI	7687.75	7737.00	7689.50	7737.00	7693.00	7737.00	7700.00	7737.00
245 MHz duplex spacing, sub-bands T, U, V, X (7.425-7.900)								
T LO	7431.50	7501.25	7431.50	7499.50	7435.00	7496.00	7442.00	7489.00
U LO	7479.75	7551.25	7481.50	7549.50	7485.00	7546.00	7492.00	7539.00
V LO	7528.75	7600.25	7530.50	7598.50	7534.00	7595.00	7541.00	7588.00
X LO	7578.75	7648.50	7580.50	7648.50	7584.00	7645.00	7591.00	7638.00
T HI	7676.50	7746.25	7676.50	7744.50	7680.00	7741.00	7687.00	7734.00
U HI	7724.75	7796.25	7726.50	7794.50	7730.00	7791.00	7737.00	7784.00
V HI	7773.75	7845.25	7775.50	7843.50	7779.00	7840.00	7786.00	7833.00
X HI	7823.75	7893.50	7825.50	7893.50	7829.00	7890.00	7836.00	7883.00

Table 17. Nokia FlexiHopper (Plus) 8, frequency tuning range

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.
311.32 MHz duplex spacing, sub-bands A, B, C								
A LO	7725.00	7840.93	7725.00	7839.18	7725.00	7835.68	7731.68	7828.68
B LO	7783.43	7904.93	7785.18	7903.18	7788.68	7899.68	7795.68	7892.68
C LO	7847.43	7963.68	7849.18	7963.68	7852.68	7963.68	7859.68	7956.68

Table 17. Nokia FlexiHopper (Plus) 8, frequency tuning range (cont.)

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.
A HI	8036.32	8152.25	8036.32	8150.50	8036.32	8147.00	8043.00	8140.00
B HI	8094.75	8216.25	8096.50	8214.50	8100.00	8211.00	8107.00	8204.00
C HI	8158.75	8275.00	8160.50	8275.00	8164.00	8275.00	8171.00	8268.00
266 MHz duplex spacing, sub-bands J, K, L								
J LO	7912.00	7994.25	7912.00	7992.50	7912.00	7989.00	7919.00	7982.00
K LO	7976.75	8064.25	7978.50	8062.50	7982.00	8059.00	7989.50	8052.00
L LO	8046.75	8129.00	8048.50	8129.00	8052.00	8129.00	8059.00	8122.00
J HI	8178.00	8260.25	8178.00	8258.50	8178.00	8255.00	8185.00	8248.00
K HI	8242.75	8330.25	8244.50	8328.50	8248.00	8325.00	8255.00	8318.00
L HI	8312.75	8395.00	8314.50	8395.00	8318.00	8395.00	8325.00	8388.00
119 MHz duplex spacing, sub-bands D, E, F								
D LO	8280.75	8319.25	8282.50	8317.50	8286.00	8314.00	8293.00	8307.00
E LO	8308.75	8347.25	8310.50	8345.50	8314.00	8342.00	8321.00	8335.00
F LO	8336.75	8375.25	8338.50	8373.50	8342.00	8370.00	8349.00	8363.00
D HI	8399.75	8438.25	8401.50	8436.50	8405.00	8433.00	8412.00	8426.00
E HI	8427.75	8466.25	8429.50	8464.50	8433.00	8461.00	8440.00	8454.00
F HI	8455.75	8494.25	8457.50	8492.50	8461.00	8489.00	8468.00	8482.00
126 MHz duplex spacing, sub-bands G, H, I								
G LO	8276.75	8315.25	8278.50	8313.50	8282.00	8310.00	8289.00	8303.00
H LO	8305.25	8343.75	8307.00	8342.00	8310.50	8338.50	8317.50	8331.50
I LO	8333.75	8372.25	8335.50	8370.50	8339.00	8367.00	8346.00	8360.00
G HI	8402.75	8441.25	8404.50	8439.50	8408.00	8436.00	8415.00	8429.00
H HI	8431.25	8469.75	8433.00	8468.00	8436.50	8464.50	8443.50	8457.50
I HI	8459.75	8498.25	8461.50	8496.50	8465.00	8493.00	8472.00	8486.00

Table 18. Nokia FlexiHopper (Plus) 13, frequency tuning range

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.
266 MHz duplex spacing, sub-bands A, B, C								

Table 18. Nokia FlexiHopper (Plus) 13, frequency tuning range (cont.)

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.
A LO	12752.75	12833.25	12754.50	12831.50	12758.00	12828.00	12765.00	12821.00
B LO	12822.75	12903.25	12824.50	12901.50	12828.00	12898.00	12835.00	12891.00
C LO	12892.75	12973.25	12894.50	12971.50	12898.00	12968.00	12905.00	12961.00
A HI	13018.75	13099.25	13020.50	13097.50	13024.00	13094.00	13031.00	13087.00
B HI	13088.75	13169.25	13090.50	13167.50	13094.00	13164.00	13101.00	13157.00
C HI	13158.75	13239.25	13160.50	13237.50	13164.00	13234.00	13171.00	13227.00

Table 19. Nokia FlexiHopper (Plus) 15, frequency tuning range

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.
420 MHz duplex spacing, sub-bands A, B, C								
A LO	14502.75	14649.25	14504.50	14647.50	14508.00	14644.00	14515.00	14637.00
B LO	14641.25	14787.75	14643.00	14786.00	14646.50	14782.50	14653.50	14775.50
C LO	14779.75	14921.00	14781.50	14921.00	14785.00	14921.00	14792.00	14914.00
A HI	14922.75	15069.25	14924.50	15067.50	14928.00	15064.00	14935.00	15057.00
B HI	15061.25	15207.75	15063.00	15206.00	15066.50	15202.50	15073.50	15195.50
C HI	15199.75	15341.00	15201.50	15341.00	15205.00	15341.00	15212.00	15334.00
490 MHz duplex spacing, sub-bands D, E, F								
D LO	14404.75	14571.25	14406.50	14569.50	14410.00	14566.00	14417.00	14559.00
E LO	14547.75	14714.25	14549.50	14712.50	14553.00	14709.00	14560.00	14702.00
F LO	14689.75	14851.00	14691.50	14851.00	14695.00	14851.00	14702.00	14844.00
D HI	14894.75	15061.25	14896.50	15059.50	14900.00	15056.00	14907.00	15049.00
E HI	15037.75	15204.25	15039.50	15202.50	15043.00	15199.00	15050.00	15192.00
F HI	15179.75	15341.00	15181.50	15341.00	15185.00	15341.00	15192.00	15334.00
644 MHz duplex spacing, sub-bands M								
M LO	14504.50	14697.00	14504.50	14697.00	14508.00	14697.00	14515.00	14690.00
M HI	15148.50	15341.00	15148.50	15341.00	15152.00	15341.00	15159.00	15334.00
728 MHz duplex spacing, sub-bands N								
N LO	14502.75	14613.00	14504.50	14613.00	14508.00	14613.00	14515.00	14606.00

Table 19. Nokia FlexiHopper (Plus) 15, frequency tuning range (cont.)

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.
N HI	15230.75	15341.00	15232.50	15341.00	15236.00	15341.00	15243.00	15334.00

Table 20. Nokia FlexiHopper (Plus) 18, frequency tuning range

Sub band freq.	3.5/5 MHz* spacing		7.0/7.5 MHz* spacing		13.75 MHz spacing		27.5 MHz spacing	
	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.
1010 MHz duplex spacing, sub-bands A, B, C, D								
A LO	17704.75	17970.75	17706.00	17969.00	17709.50	17965.50	17716.50	17958.50
B LO	17951.75	18218.25	17953.50	18216.50	17957.00	18213.00	17964.00	18206.00
C LO	18171.75	18438.25	18173.50	18436.50	18177.00	18433.00	18184.00	18426.00
D LO	18419.25	18682.50	18421.00	18682.50	18424.50	18680.50	18431.50	18673.50
A HI	18714.75	18980.75	18716.00	18979.00	18719.50	18975.50	18726.50	18968.50
B HI	18961.75	19228.25	18963.50	19226.50	18967.00	19223.00	18974.00	19216.00
C HI	19181.75	19448.25	19183.50	19446.50	19187.00	19443.00	19194.00	19436.00
D HI	19429.25	19692.50	19431.00	19692.50	19434.50	19690.50	19441.50	19683.50
1008 MHz duplex spacing, sub-bands F, G, H, J								
F LO	17722.25	17970.25	17722.25	17969.00	17722.25	17965.50	17722.25	17958.50
G LO	17953.75	18218.25	17955.50	18216.50	17959.00	18213.00	17966.00	18206.00
H LO	18173.75	18438.25	18175.50	18436.50	18179.00	18433.00	18186.00	18426.00
J LO	18421.25	18670.75	18423.00	18670.75	18426.50	18670.75	18433.50	18670.75
F HI	18730.25	18978.75	18730.25	18977.00	18730.25	18973.50	18730.25	18966.50
G HI	18961.75	19226.25	18963.50	19224.50	18967.00	19221.00	18974.00	19214.00
H HI	19181.75	19446.25	19183.50	19444.50	19187.00	19441.00	19194.00	19434.00
J HI	19429.25	19678.75	19431.00	19678.75	19434.50	19678.75	19441.50	19678.75

*Same spectrum for both channelling alternatives.

Table 21. Nokia FlexiHopper (Plus) 23, frequency tuning range

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.
1232 MHz duplex spacing, sub-bands A, B, C								
A LO	21225.75	21622.25	21227.50	21620.50	21231.00	21617.00	21238.00	21610.00
B LO	21585.75	21982.25	21587.50	21980.50	21591.00	21977.00	21598.00	21970.00
C LO	21945.75	22342.25	21947.50	22340.50	21951.00	22337.00	21958.00	22330.00
A HI	22457.75	22854.25	22459.50	22852.50	22463.00	22849.00	22470.00	22842.00
B HI	22817.75	23214.25	22819.50	23212.50	22823.00	23209.00	22830.00	23202.00
C HI	23177.75	23574.25	23179.50	23572.50	23183.00	23569.00	23190.00	23562.00
1200 MHz duplex spacing, sub-bands D, E, F								
D LO	21205.00	21618.25	21205.00	21616.50	21207.00	21613.00	21214.00	21606.00
E LO	21591.75	22008.25	21593.50	22006.50	21597.00	22003.00	21604.00	21996.00
F LO	21981.75	22398.25	21983.50	22396.50	21987.00	22393.00	21994.00	22386.00
D HI	22405.00	22818.25	22405.00	22816.50	22407.00	22813.00	22414.00	22806.00
E HI	22791.75	23208.25	22793.50	23206.50	22797.00	23203.00	22804.00	23196.00
F HI	23181.75	23598.25	23183.50	23596.50	23187.00	23593.00	23194.00	23586.00
1008 MHz duplex spacing, sub-bands M, N								
M LO	22003.75	22400.25	22005.50	22398.50	22009.00	22395.00	22016.00	22388.00
N LO	22193.75	22589.00	22195.50	22588.50	22199.00	22585.00	22206.00	22578.00
M HI	23011.75	23408.25	23013.50	23406.50	23017.00	23403.00	23024.00	23396.00
N HI	23201.75	23597.00	23203.50	23596.50	23207.00	23593.00	23214.00	23586.00

Table 22. Nokia FlexiHopper (Plus) 26, frequency tuning range

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.
1008 MHz duplex spacing, sub-bands A, B, C								
A LO	24550.75	24897.25	24552.50	24895.50	24556.00	24892.00	24563.00	24885.00
B LO	24823.75	25170.25	24825.50	25168.50	24829.00	25165.00	24836.00	25158.00
C LO	25096.75	25443.25	25098.50	25441.50	25102.00	25438.00	25109.00	25431.00
A HI	25558.75	25905.25	25560.50	25903.50	25564.00	25900.00	25571.00	25893.00
B HI	25831.75	26178.25	25833.50	26176.50	25837.00	26173.00	25844.00	26166.00
C HI	26104.75	26451.25	26106.50	26449.50	26110.00	26446.00	26117.00	26439.00

Table 23. Nokia FlexiHopper (Plus) 28, frequency tuning range

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	**High freq.**	**Low freq.**	**High freq.**	**Low freq.**	**High freq.**	**Low freq.**	**High freq.**
1008 MHz duplex spacing, sub-bands A, B, C								
A LO	27550.25	27896.75	27552.00	27895.00	27555.50	27891.50	27562.50	27884.50
B LO	27823.25	28169.75	27825.00	28168.00	27828.50	28164.50	27835.50	28157.50
C LO	28096.25	28442.75	28098.00	28441.00	28101.50	28437.50	28108.50	28430.50
A HI	28558.25	28904.75	28560.00	28903.00	28563.50	28899.50	28570.50	28892.50
B HI	28831.25	29177.75	28833.00	29176.00	28836.50	29172.50	28843.50	29165.50
C HI	29104.25	29450.75	29106.00	29449.00	29109.50	29445.50	29116.50	29438.50

Table 24. Nokia FlexiHopper (Plus) 32, frequency tuning range

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	**High freq.**	**Low freq.**	**High freq.**	**Low freq.**	**High freq.**	**Low freq.**	**High freq.**
812 MHz duplex spacing, sub-bands A, B, C, D								
A LO	31816.75	32033.25	31818.50	32031.50	31822.00	32028.00	31829.00	32021.00
B LO	31995.75	32212.25	31997.50	32210.50	32001.00	32207.00	32008.00	32200.00
C LO	32173.75	32390.25	32175.50	32388.50	32179.00	32385.00	32186.00	32378.00
D LO	32352.75	32569.25	32354.50	32567.50	32358.00	32564.00	32365.00	32557.00
A HI	32628.75	32845.25	32630.50	32843.50	32634.00	32840.00	32641.00	32833.00
B HI	32807.75	33024.25	32809.50	33022.50	32813.00	33019.00	32820.00	33012.00
C HI	32985.75	33202.25	32987.50	33200.50	32991.00	33197.00	32998.00	33190.00
D HI	33164.75	33381.25	33166.50	33379.50	33170.00	33376.00	33177.00	33369.00

Table 25. Nokia FlexiHopper (Plus) 38, frequency tuning range

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	**High freq.**	**Low freq.**	**High freq.**	**Low freq.**	**High freq.**	**Low freq.**	**High freq.**
1260 MHz duplex spacing, sub-bands A, B, C, D								

Table 25. Nokia FlexiHopper (Plus) 38, frequency tuning range (cont.)

Sub band freq.	3.5 MHz spacing		7.0 MHz spacing		14.0 MHz spacing		28.0 MHz spacing	
	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.	Low freq.	High freq.
A LO	37059.75	37346.25	37059.75	37344.50	37059.75	37341.00	37062.00	37334.00
B LO	37329.75	37626.25	37331.50	37624.50	37335.00	37621.00	37342.00	37614.00
C LO	37609.75	37906.25	37611.50	37904.50	37615.00	37901.00	37622.00	37894.00
D LO	37889.75	38176.25	37891.50	38176.25	37895.00	38176.25	37902.00	38174.00
A HI	38319.75	38606.25	38319.75	38604.50	38319.75	38601.00	38322.00	38594.00
B HI	38589.75	38886.25	38591.50	38884.50	38595.00	38881.00	38602.00	38874.00
C HI	38869.75	39166.25	38871.50	39164.50	38875.00	39161.00	38882.00	39154.00
D HI	39149.75	39436.25	39151.50	39436.25	39155.00	39436.25	39162.00	39434.00

Table 26. Transmitter frequency adjustment and stability

Frequency adjustment step*	0.001 MHz
Frequency stability in all conditions Ageing	< ±10 ppm < ±1 ppm / year < ±5 ppm / 15 years
*The software allows a 1 kHz step. Due to hardware limitations the actual resolution is 10 - 25 kHz.	

7.1.9 RF parameters

Table 27. Nominal transmit power with 4-state modulation (π/DQPSK) at antenna connector

Frequency band	Transmit power (dBm), nominal
7,8 GHz	23
13, 15 GHz	20
18, 23, 26 GHz	18
28, 32, 38 GHz	16

Table 28. Nominal transmit power with 16-state modulation (32 TCM) at antenna connector

Frequency band	Transmit power (dBm), nominal
7, 8 GHz	23
13 GHz	20
15, 18, 23, 26 GHz	18
28, 32, 38 GHz	16

Table 29. Transmit power stability and adjustment

Frequency band	Transmit power stability	Transmit power adjustment step
7, 8, 13, 15, 18, 23, 26, 28 GHz	< ±2 dB	1 dB
32, 38 GHz	< ±3 dB	1 dB

Table 30. Spurious outputs

Spurious emissions (Tx and Rx) at antenna connector (1 MHz reference bandwidth)	Frequency 0.03 - 21.2 GHz 21.2 - 3rd harmonic	Level < -50 dBm < -30 dBm

Table 31. Out-of-band CW interference tolerance*

Frequency of interference source	C/I (dB)	BER 10^{-6} threshold degradation
0.07 GHz to 2nd harmonic (excluding ± twice the channel bandwidth)	-35	1 dB
*Meets the standards listed in the table Radio Transmission (ETSI) in *Nokia FlexiHopper (Plus) Standards*.		

Table 32. Noise figure at antenna connector

Frequency band	**Receiver noise figure (dB), guaranteed over temperature**
7, 8 GHz	< 6
13, 15 GHz	< 6.5
18, 23 GHz	< 7
26, 28, 32 GHz	< 7.5
38 GHz	< 8

Table 33. Automatic Gain Control (AGC) tracking speed, received signal level measurement and automatic fading margin measurement

AGC tracking speed	> 100 dB/s
Received signal level measurement accuracy (from BER 10^{-3} threshold up to -30 dBm level)	< ±3 dB (typical) < ±5 dB (guaranteed)
Accuracy of fading margin measurement (measurement range 10 - 55 dB or up to -30 dBm Rx level)	±3 dB (typical)

7.1.10 4-state modulation

7.1.10.1 Transmission delay

Table 34. Transmitter - receiver transmission delay (zero length radio path, 4-depth convolutional interleaver and FEC setting RS(63,59) code)

Modulation type	**Capacity (Mbit/s)**	**Interleaver on**	**Interleaver off**
4-state modulation	2 x 2	< 480 μs	< 150 μs
	4 x 2	< 240 μs	< 65 μs
	8 x 2	< 120 μs	< 33 μs
	16 x 2	< 60 μs	< 17 μs

For calculating the transmission delay over the entire hop including indoor units and radio path, you can use the following data:

- Transmission delay caused by FIU 19(E): 30 μs
- Transmission delay caused by hop length: 3.3 μs/km

7.1.10.2 Channel spacing

Table 35. Channel spacing between adjacent channels (ITU-R)*

Frequency band	**Capacity (Mbit/s)**	**Channel spacing, df (MHz)**	
		Same polarisation	**Cross-polarisation**
4-state modulation 18 GHz	2 x 2	5.0	0
	4 x 2	7.5	0
	8 x 2	13.75	0
	16 x 2	27.5	0
All bands	2 x 2	3.5	0
	4 x 2	7.0	0
	8 x 2	14.0	0
	16 x 2	28.0	0
*Channel spacing is not limited to these values.			

7.1.10.3 Modulation and demodulation

Table 36. Modulation and demodulation

4-state modulation	Modulation method	π/4-DQPSK
	Demodulation method	Partially differential

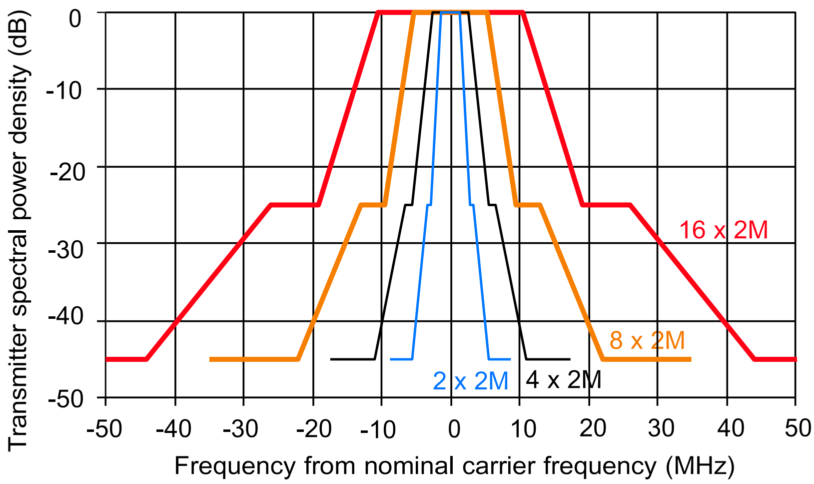


Figure 45. Spectrum mask for Nokia FlexiHopper (Plus) operating in 4-state modulation mode

Table 37. Spectrum masks for 4-state modulation; Attenuation of spectrum mask (dB) at a specific distance (MHz) from centre frequency (linear interpolation between specified points)

Frequency band	**ETSI spectral efficiency class for 4-state modulation**	**Capacity** **Channel spacing**	**Attenuation (dB)**	**Distance from centre frequency (MHz)**
All bands	Class 2	2 x 2 Mbit/s (3.5 MHz)	> 0 > 25 > 45	0 - 1.4 2.8 - 3.25 5.5 - 8.75
		4 x 2 Mbit/s (7.0 MHz)	> 0 > 25 > 45	0 - 2.7 5.6 - 6.5 11 - 17.5
		8 x 2 Mbit/s (14.0 MHz)	> 0 > 25 > 45	0 - 5.2 9.6 - 13 22 - 35
		16 x 2 Mbit/s (28.0 MHz	> 0 > 25 > 45	0 - 10.4 19.2 - 26 44 - 70

Table 37. Spectrum masks for 4-state modulation; Attenuation of spectrum mask (dB) at a specific distance (MHz) from centre frequency (linear interpolation between specified points) (cont.)

Frequency band	ETSI spectral efficiency class for 4-state modulation	Capacity Channel spacing	Attenuation (dB)	Distance from centre frequency (MHz)
Meets the standards listed in the table Radio Transmission (ETSI) in *Nokia FlexiHopper (Plus) Standards*.				

Table 38. Emission codes (ITU-R SM.1138)

Capacity	Code (4-state modulation)
2 x 2 Mbit/s	3M50G7W 5M00G7W*
4 x 2 Mbit/s	7M00G7W 7M50G7W*
8 x 2 Mbit/s	14M0G7W 13M8G7W*
16 x 2 Mbit/s	28M0G7W 27M5G7W*

*The latter emission codes only apply to 18 GHz, for which alternative channel spacing is available. As a result both presented emission codes apply to 18 GHz.

Table 39. Receiver bandwidths for 4-state modulation

Capacity (Mbit/s)	Bandwidth	Receiver -3 dB bandwidth, nominal (MHz)	Receiver noise bandwidth, nominal (MHz)
2 x 2	3.5 MHz	±0.9	1.8
4 x 2	7.0 MHz	±1.8	3.6
8 x 2	14.0 MHz	±3.6	7.2
16 x 2	28.0 MHz	±7.1	14.2

7.1.10.4 Interference sensitivity

Table 40. Co-channel interference (CCI, similar interference source)

Capacity	C/I, guaranteed (dB)			
	BER 10^{-3} threshold degradation		BER 10^{-6} threshold degradation	
	< 1 dB	< 3 dB	< 1 dB	< 3 dB
All capacities	18	15	23	19

Table 41. Adjacent channel interference (ACI, similar interference source)

Capacity	Channel spacing (MHz)	C/I, guaranteed (dB)			
		BER 10^{-3} threshold degradation		BER 10^{-6} threshold degradation	
		< 1 dB	< 3 dB	< 1 dB	< 3 dB
2 x 2 Mbit/s	3.5	-8	-11	-4	-8
	5.0	-24	-27	-19	-23
4 x 2 Mbit/s	7.0	-8	-11	-4	-8
	7.5	-9	-12	-5	-9
8 x 2 Mbit/s	14.0	-8	-11	-4	-8
	13.75	-8	-11	-4	-8
16 x 2 Mbit/s	28.0	-8	-11	-4	-8
	27.5	-8	-11	-4	-8

Table 42. Two channels away interference (similar interference source)

Capacity	C/I, guaranteed (dB)			
	BER 10^{-3} threshold degradation		BER 10^{-6} threshold degradation	
	< 1 dB	< 3 dB	< 1 dB	< 3 dB
All capacities	-24	-27	-19	-23

7.1.10.5 Power levels

Table 43. Nominal transmit power at antenna connector

Frequency band	Transmit power (dBm), nominal
7, 8 GHz	23
13, 15 GHz	20
18, 23, 26 GHz	18
28, 32, 38 GHz	16

Table 44. Minimum transmit power

Frequency band	Capacity (Mbit/s)	Minimum transmit power (dBm), nominal
7, 8 GHz	All capacities	-3
13, 15 GHz	All capacities	-6
18, 23, 26, 28, 32, 38 GHz	2 x 2	-10
	4 x 2	-7
	8 x 2	-4
	16 x 2	-1

Table 45. Receiver threshold at antenna connector

Frequency band	Capacity (Mbit/s)	BER 10^{-3} threshold (dBm)		BER 10^{-6} threshold (dBm)	
		Typical	Guarant eed	Typical	Guarant eed
7, 8 GHz	2 x 2	-94	-92	-91	-89
	4 x 2	-92	-90	-89	-87
	8 x 2	-89	-87	-86	-84
	16 x 2	-86	-84	-83	-81

Table 45. Receiver threshold at antenna connector (cont.)

Frequency band	Capacity (Mbit/s)	BER 10^{-3} threshold (dBm)		BER 10^{-6} threshold (dBm)	
		Typical	Guarant eed	Typical	Guarant eed
13, 15 GHz	2 x 2	-93	-91	-90	-88
	4 x 2	-91	-89	-88	-86
	8 x 2	-88	-86	-85	-83
	16 x 2	-86	-84	-83	-81
18 GHz	2 x 2	-93	-91	-90	-88
	4 x 2	-91	-89	-88	-86
	8 x 2	-88	-86	-85	-83
	16 x 2	-85	-83	-82	-80
23 GHz	2 x 2	-93	-91	-90	-88
	4 x 2	-91	-89	-88	-86
	8 x 2	-88	-86	-85	-83
	16 x 2	-86	-84	-83	-81
26 GHz	2 x 2	-93	-91	-90	-88
	4 x 2	-90	-88	-87	-85
	8 x 2	-87	-85	-84	-82
	16 x 2	-85	-83	-82	-80
28 GHz	2 x 2	-92	-89	-89	-86
	4 x 2	-90	-87	-87	-84
	8 x 2	-87	-84	-84	-81
	16 x 2	-85	-82	-82	-79
32 GHz	2 x 2	-91	-88	-88	-85
	4 x 2	-88	-85	-85	-82
	8 x 2	-86	-83	-83	-80
	16 x 2	-83	-80	-80	-77
38 GHz	2 x 2	-91	-89	-88	-86
	4 x 2	-90	-88	-87	-85
	8 x 2	-87	-85	-84	-82
	16 x 2	-84	-82	-81	-79

Typical values are met by about 80% of the equipment working at T=25°C at nominal power feeding.

Guaranteed values are guaranteed in full temperature range and frequency range.

Table 46. Typical receiver noise power

Frequency band	Capacity (Mbit/s)	Receiver noise power at antenna port at 25°C (dBm), typical
7, 8 GHz	2 x 2	-107
	4 x 2	-104
	8 x 2	-101
	16 x 2	-98
13, 15, 18, 23 GHz	2 x 2	-106
	4 x 2	-103
	8 x 2	-100
	16 x 2	-97
26, 28, 32, 38 GHz	2 x 2	-104
	4 x 2	-101
	8 x 2	-98
	16 x 2	-95

Table 47. Maximum receiver power level at antenna connector

Frequency band	Maximum input power at BER level		No damage
7, 8, 13, 15, 18 GHz	-20 dBm	10^{-3}	< 0 dBm
23, 26, 28, 32, 38 GHz	-20 dBm	10^{-3}	< 0 dBm
	-24 dBm	10^{-8}	< 0 dBm

7.1.10.6 System value

Table 48. System value for Nokia FlexiHopper (Plus) using 4-state modulation

Frequency band	Capacity (Mbit/s)	System value, typical (dB)	System value, guaranteed (dB)
7, 8 GHz	2 x 2	117	114
	4 x 2	115	112
	8 x 2	112	109
	16 x 2	109	106
13, 15 GHz	2 x 2	113	109
	4 x 2	111	107
	8 x 2	108	104
	16 x 2	106	102
18 GHz	2 x 2	111	107
	4 x 2	109	105
	8 x 2	106	102
	16 x 2	103	99
23 GHz	2 x 2	111	107
	4 x 2	109	105
	8 x 2	106	102
	16 x 2	104	100
26 GHz	2 x 2	111	107
	4 x 2	108	104
	8 x 2	105	101
	16 x 2	103	99
28 GHz	2 x 2	108	103
	4 x 2	106	101
	8 x 2	103	98
	16 x 2	101	96
32 GHz	2 x 2	107	101
	4 x 2	104	98
	8 x 2	102	96
	16 x 2	99	93

Table 48. System value for Nokia FlexiHopper (Plus) using 4-state modulation (cont.)

Frequency band	**Capacity (Mbit/s)**	**System value, typical (dB)**	**System value, guaranteed (dB)**
38 GHz	2 x 2	107	102
	4 x 2	106	101
	8 x 2	103	98
	16 x 2	101	96

Typical values are met by about 80 % of the equipment working at T=25 °C at nominal power feeding.

Guaranteed values are guaranteed in full temperature range and frequency range.

The system value is defined as the attenuation value between the transmitter and receiver antenna ports, which causes a BER 10^{-3}.

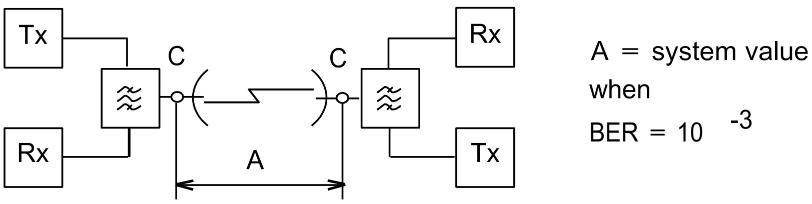


Figure 46. Defining system value

7.1.10.7 Signature

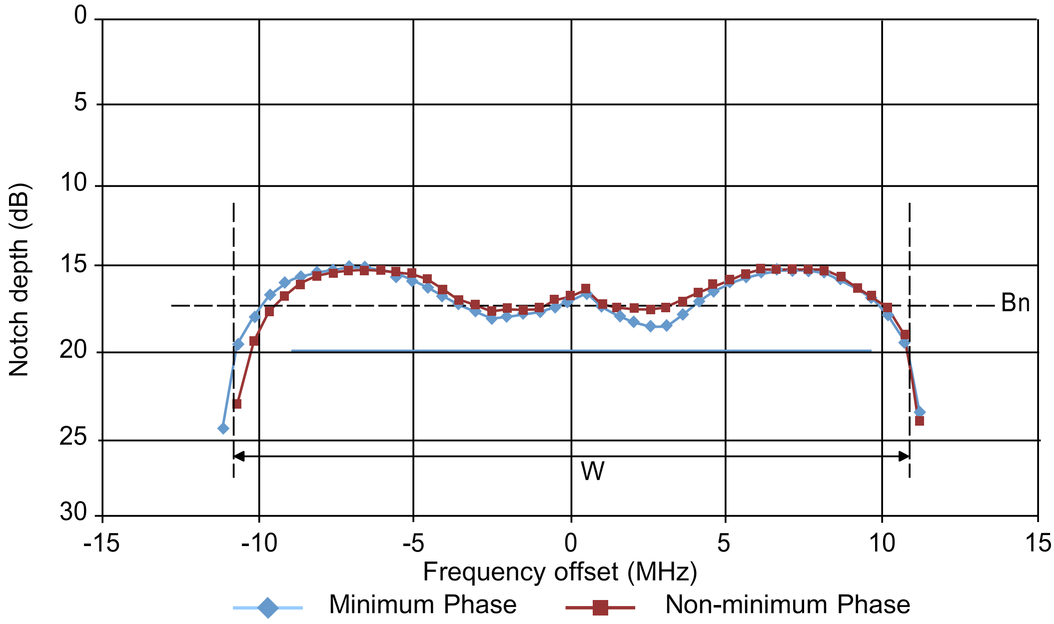


Figure 47. Typical BER 10^{-3} signature curves for Nokia FlexiHopper (Plus) with 4-state modulation and with 16 x 2M capacity

Table 49. Signature data for BER limit 10^{-3}

Minimum phase			
Capacity	**Signature width *w* (MHz)**	**Average notch depth B_n (dB)**	**Typical dispersive fading margin (dB)**
2x2	-	> 31.5	-
4x2	4.0 ± 1	27.0 ± 1	61.4
8x2	9.0 ± 1	22.0 ± 1	52.2
16x2	20.5 ± 1	17.0 ± 1	42.9

Non-minimum phase			
Capacity	**Signature width *w* (MHz)**	**Average notch depth B_n (dB)**	**Typical dispersive fading margin (dB)**
2x2	-	> 31.5	-
4x2	4.0 ± 1	26.5 ± 1	60.9
8x2	9.0 ± 1	21.5 ± 1	51.6
16x2	19.5 ± 1	16.5 ± 1	42.6

Table 50. Signature data for BER limit 10^{-6}

Minimum phase			
Capacity	**Signature width *w* (MHz)**	**Average notch depth B_n (dB)**	**Typical dispersive fading margin (dB)**
2x2	-	> 31.5	-
4x2	4.5 ± 1	25.5 ± 1	59.2
8x2	10.0 ± 1	20.5 ± 1	50.0
16x2	23.0 ± 1	15.5 ± 1	40.7

Non-minimum phase			
Capacity	**Signature width *w* (MHz)**	**Average notch depth B_n (dB)**	**Typical dispersive fading margin (dB)**
2x2	-	> 31.5	-
4x2	4.5 ± 1	25.0 ± 1	58.6
8x2	10.0 ± 1	20.0 ± 1	49.5
16x2	22.0 ± 1	15.0 ± 1	40.3

7.1.11 16-state modulation

To use 16-state modulation the user needs to order a separate licence file from Nokia. For more information, see *SW licensing*.

7.1.11.1 Transmission delay

Table 51. Transmitter - receiver transmission delay (zero length radio path, 4-depth convolutional interleaver and FEC setting RS(63,59) code)

Modulation type	Capacity (Mbit/s)	Interleaver on*
16-state modulation	8 x 2	< 765 µs
	16 x 2	< 383 µs

*For 16-state modulation the interleaver is always on.

For calculating the transmission delay over the entire hop including indoor units and radio path, you can use the following data:

- Transmission delay caused by FIU 19(E): 30 µs
- Transmission delay caused by hop length: 3.3 µs/km

7.1.11.2 Channel spacing

Table 52. Channel spacing between adjacent channels (ITU-R)*

Frequency band	Capacity (Mbit/s)	Channel spacing, df (MHz)	
		Same polarisation	Cross-polarisation
16-state modulation 7 GHz 8 GHz 13 GHz 15 GHz 18 GHz 23 GHz 26 GHz 28 GHz 32 GHz 38 GHz	8 x 2	7.0	0
	16 x 2	14.0	0
16-state modulation 18 GHz	8 x 2	7.5	0
	16 x 2	13.75	0

Table 52. Channel spacing between adjacent channels (ITU-R)* (cont.)

Frequency band	**Capacity (Mbit/s)**	**Channel spacing, df (MHz)**	
		Same polarisation	**Cross-polarisation**
*Channel spacing is not limited to these values.			

7.1.11.3 Modulation and demodulation

Table 53. Modulation and demodulation

16-state modulation	Modulation method Demodulation method	32 Trellis Coded Modulation (TCM) Viterbi detection

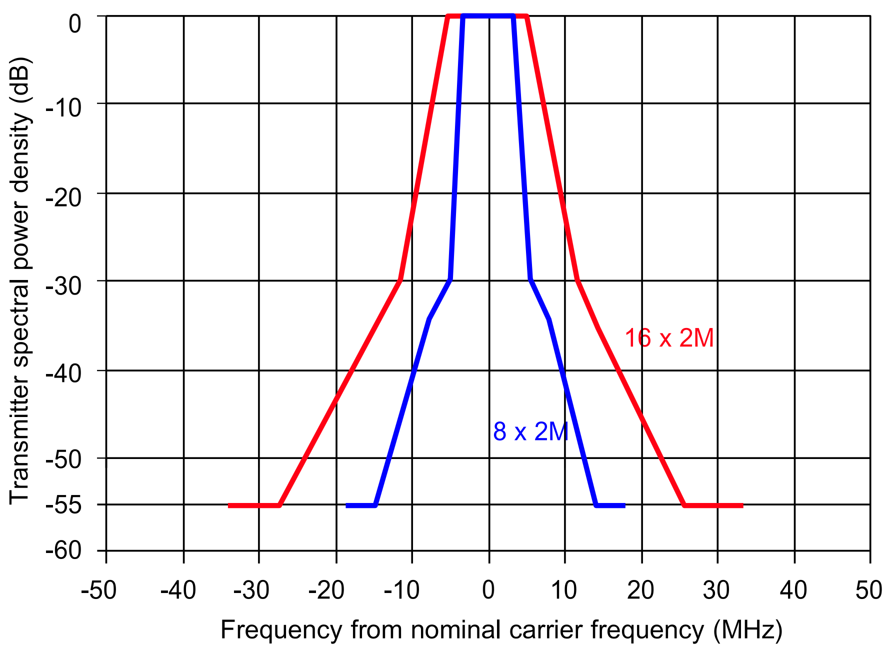


Figure 48. Spectrum masks for Nokia FlexiHopper Plus operating in 16-state modulation mode, 7 to 18 GHz

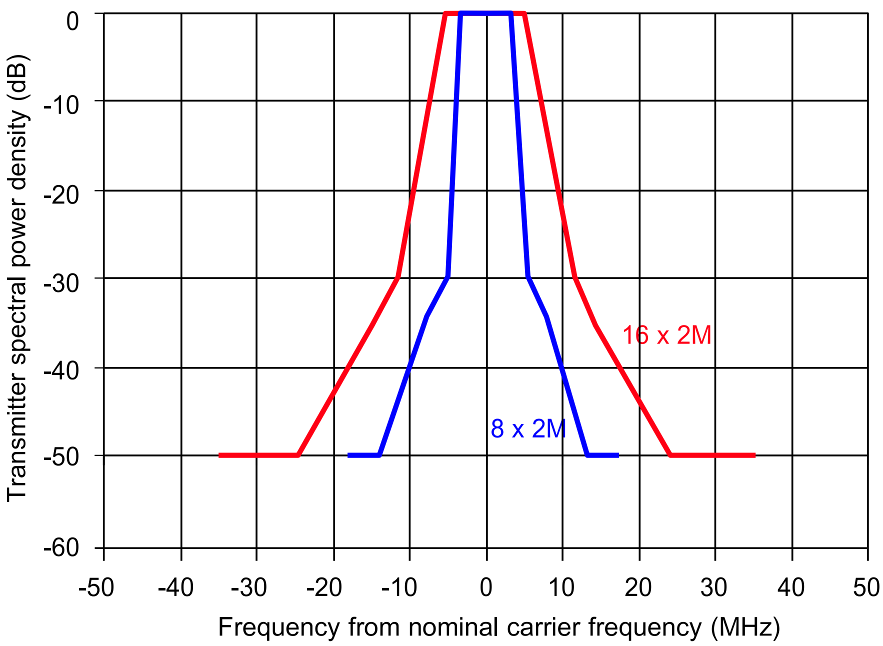


Figure 49. Spectrum masks for Nokia FlexiHopper Plus operating in 16-state modulation mode, 23 to 38 GHz

Table 54. Spectrum masks for 16-state modulation; Attenuation of spectrum mask (dB) at a specific distance (MHz) from centre frequency (linear interpolation between specified points)

Frequency band	**ETSI spectral efficiency class for 16-state modulation mode**	**Capacity** **Channel spacing**	**Attenuation (dB)**	**Distance from centre frequency (MHz)**
7 GHz 8 GHz 13 GHz 15 GHz 18 GHz	Class 4	8 x 2 Mbit/s (7 MHz)	>0 >32 >37 >55	0 - 2.8 5.6 7.0 14.0-17.5
		16 x 2 Mbit/s (14 MHz)	>0 >32 >37 >55	0 - 5.6 11.2 14.0 28.0 - 35.0

Table 54. Spectrum masks for 16-state modulation; Attenuation of spectrum mask (dB) at a specific distance (MHz) from centre frequency (linear interpolation between specified points) (cont.)

Frequency band	ETSI spectral efficiency class for 16-state modulation mode	Capacity Channel spacing	Attenuation (dB)	Distance from centre frequency (MHz)
23 GHz 26 GHz 28 GHz 32 GHz 38 GHz	Class 4	8 x 2 Mbit/s (7 MHz)	>0 >30 >35 >50	0 - 2.8 5.6 7.0 12.25 - 17.5
		16 x 2 Mbit/s (14 MHz)	>0 >30 >35 >50	0 - 5.6 11.2 14.0 24.5 - 35
Meets the standards listed in Table Radio Transmission (ETSI) in *Nokia FlexiHopper (Plus) Standards*.				

Table 55. Emission codes (ITU-R SM.1138)

Capacity	Code (16-state modulation)
8 x 2 Mbit/s	7M00D7W, 7M50D7W *)
16 x 2 Mbit/s	14M0D7W, 13M8D7W *)
*) The latter emission codes apply only to 18 GHz, for which there are two alternative channel spacing available. As a result noth presented emission codes apply to 18 GHz.	

Table 56. Receiver bandwidths for 16-state modulation

Capacity (Mbit/s)	Bandwidth	Receiver -3 dB bandwidth, nominal (MHz)	Receiver noise bandwidth, nominal (MHz)
8 x 2	7.0 MHz	±2.4	4.8
16 x 2	14.0 MHz	±4.7	9.4

7.1.11.4 Interference sensitivity

Table 57. Co-channel interference (CCI, similar interference source)

Capacity (Mbit/s)	C/I, guaranteed (dB)			
	BER 10^{-3} threshold degradation		BER 10^{-6} threshold degradation	
	< 1 dB	< 3 dB	< 1 dB	< 3 dB
8 x 2	27	23	30	26
16 x 2	27	23	30	26

Table 58. Adjacent channel interference (ACI, similar interference source)

Capacity (Mbit/s)	Channel spacing (MHz)	C/I, guaranteed (dB)			
		BER 10^{-3} threshold degradation		BER 10^{-6} threshold degradation	
		< 1 dB	< 3 dB	< 1 dB	< 3 dB
8 x 2	7.0	-9	-12	-6	-10
16 x 2	14.0	-10	-13	-7	-11

Table 59. Two channels away interference (similar interference source)

Capacity	C/I, guaranteed (dB)			
	BER 10^{-3} threshold degradation		BER 10^{-6} threshold degradation	
	< 1 dB	< 3 dB	< 1 dB	< 3 dB
All capacities	-17	-19	-16	-18

7.1.11.5 Power levels

Table 60. Nominal transmit power at antenna connector

Frequency band	Transmit power (dBm), nominal
7, 8 GHz	23
13 GHz	20
15, 18, 23, 26 GHz	18
28, 32, 38 GHz	16

Table 61. Minimum transmit power

Frequency band	Capacity (Mbit/s)	Minimum transmit power (dBm), nominal
7, 8 GHz	8 x 2	4
	16 x 2	4
13, 15 GHz	8 x 2	1
	16 x 2	1
18 GHz	8 x 2	0
	16 x 2	3
23, 26, 28, 32, 38 GHz	8 x 2	-5
	16 x 2	-2

Table 62. Receiver threshold at antenna connector

Frequency band	Capacity (Mbit/s)	BER 10^{-3} threshold (dBm)		BER 10^{-6} threshold (dBm)	
		Typical	Guaranteed	Typical	Guaranteed
7, 8 GHz	8 x 2	-85	-82	-82	-79
	16 x 2	-82	-79	-79	-76
13 GHz	8 x 2	-82	-80	-79	-77
	16 x 2	-80	-78	-77	-75

Table 62. Receiver threshold at antenna connector (cont.)

Frequency band	Capacity (Mbit/s)	BER 10^{-3} threshold (dBm)		BER 10^{-6} threshold (dBm)	
		Typical	Guaranteed	Typical	Guaranteed
15 GHz	8 x 2	-84	-81	-81	-78
	16 x 2	-82	-79	-79	-76
18 GHz	8 x 2	-83	-80	-80	-77
	16 x 2	-80	-77	-77	-74
23 GHz	8 x 2	-83	-81	-80	-78
	16 x 2	-80	-78	-77	-75
26 GHz	8 x 2	-81	-79	-78	-76
	16 x 2	-78	-76	-75	-73
28, 32 GHz	8 x 2	-81	-78	-78	-75
	16 x 2	-78	-75	-75	-72
38 GHz	8 x 2	-81	-78	-78	-75
	16 x 2	-79	-76	-76	-73

Typical values are met by about 80 % of the equipment working at T=25°C at nominal power feeding.

Guaranteed values are guaranteed in full temperature and frequency range.

Table 63. Typical receiver noise power

Frequency band	Capacity (Mbit/s)	Receiver noise power at antenna port at 25°C (dBm), typical
7, 8 GHz	8 x 2	-104
	16 x 2	-101
13, 15, 18, 23 GHz	8 x 2	-103
	16 x 2	-100
26, 28, 32, 38 GHz	8 x 2	-101
	16 x 2	-98

Table 64. Maximum receiver power level at antenna connector

Frequency band	Maximum input power at BER level		No damage
7,8 GHz	- 20 dBm	10^{-3}	< 0 dBm
13, 15, 18 GHz	- 20 dBm	10^{-8}	< 0 dBm
23, 26, 28, 32, 38 GHz	-20 dBm	10^{-3}	< 0 dBm
	-24 dBm	10^{-8}	< 0 dBm

7.1.11.6 System value

Table 65. System value for Nokia FlexiHopper Plus using 16-state modulation

Frequency band	Capacity (Mbit/s)	System value, typical (dB)	System value, guaranteed (dB)
7, 8 GHz	8 x 2	108	103
	16 x 2	105	100
13 GHz	8 x 2	102	97
	16 x 2	100	95
15 GHz	8 x 2	102	97
	16 x 2	100	95
18 GHz	8 x 2	100	95
	16 x 2	97	92
23 GHz	8 x 2	101	97
	16 x 2	98	94
26 GHz	8 x 2	99	95
	16 x 2	96	92
28 GHz	8 x 2	97	92
	16 x 2	94	89
32 GHz	8 x 2	97	91
	16 x 2	94	88
38 GHz	8 x 2	97	91
	16 x 2	95	89

Typical values are met by about 80 % of the equipment working at T=25°C at nominal power feeding.

Guaranteed values are guaranteed in full temperature range and frequency range.

The system value is defined as the attenuation value between the transmitter and receiver antenna ports, which causes a BER 10^{-3}.

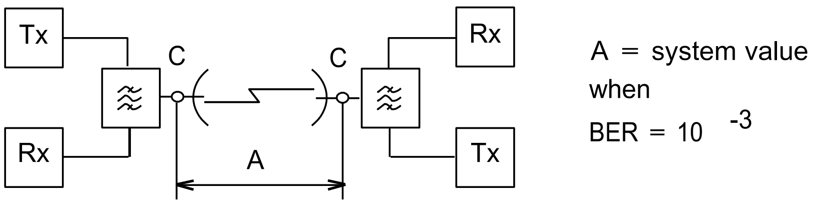


Figure 50. Defining system value

7.1.11.7 Signature

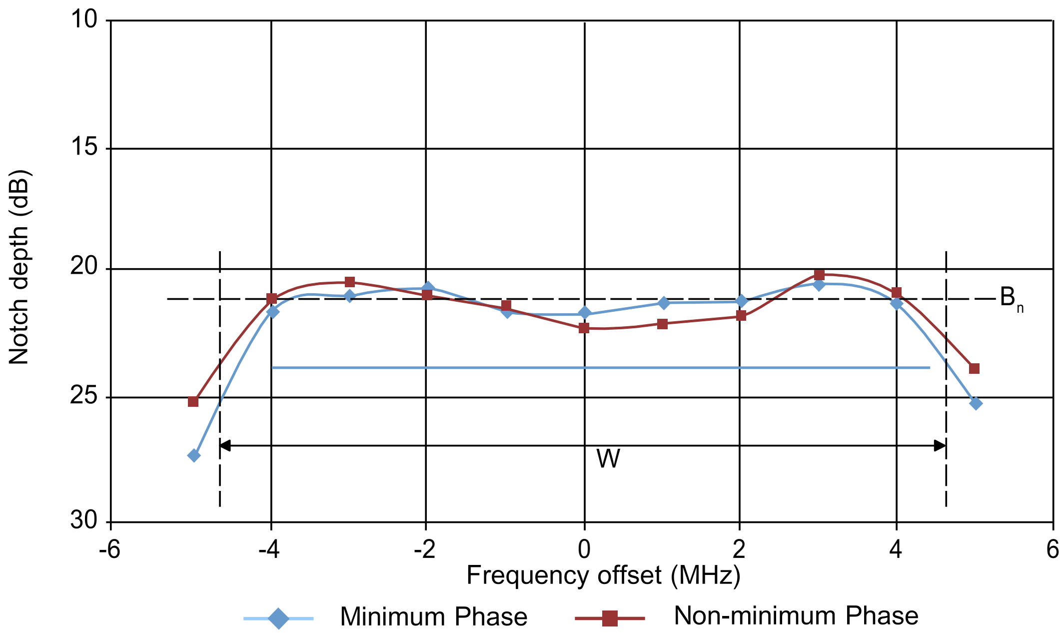


Figure 51. Typical BER 10^{-3} signature curves for Nokia FlexiHopper Plus with 16-state modulation and with 16 x 2M capacity

Table 66. Signature data for BER limits 10^{-3} and 10^{-6}

Minimum and non-minimum phase			
Capacity	**Signature width *w* (MHz)**	**Average notch depth B_n (dB)**	**Typical dispersive fading margin (dB)**
8x2	4.5 ± 1	26.5 ± 1	60.4
16x2	9.0 ± 1	20.5 ± 1	50.5

7.2 FIU 19(E) indoor unit

7.2.1 General information

The Nokia FlexiHopper (Plus) Product Description covers the technical specifications for both FIU 19 and FIU 19(E) indoor units. In this Product Description, these units are referred to as FIU 19 and FIU 19(E) according to which one of the units is in question individually. The use of FIU 19(E) refers to both of the indoor units together.

7.2.2 FIU 19(E) interfaces

Table 67. FIU 19(E) interfaces

	FIU 19	**FIU 19(E)**
Flexbus interfaces 1 and 2 (FB1, FB2)	TNC connector 50 Ω Up to 16 x 2 Mbit/s signals Embedded power supply voltage 55 V_{DC} for radio outdoor units	TNC connector 50 Ω Up to 16 x 2 Mbit/s signals Embedded power supply voltage 55 V_{DC} for radio outdoor units
Network management interfaces (Q1-1, Q1-2)	TQ connector Max. 9600 bit/s, V.11	RJ-45 connector Max. 9600 bit/s, V.11
Power supply connector (PWR)	Molex Micro-Fit 3.0	Molex Micro-Fit 3.0
Local management port (LMP)	BQ connector Max. 115 kbit/s RS-232 interface	RJ-45 connector Max. 115 kbit/s RS-232 interface

Table 67. FIU 19(E) interfaces (cont.)

	FIU 19	FIU 19(E)
Measurement point connector (MP)	SMB connector, 75 Ω Digital output for 2 Mbit/s signals and internal frequencies	SMB connector, 75 Ω Digital output for 2 Mbit/s signals and internal frequencies
Ethernet Interface 10baseT	-	RJ-45 10 Mbit/s link for management

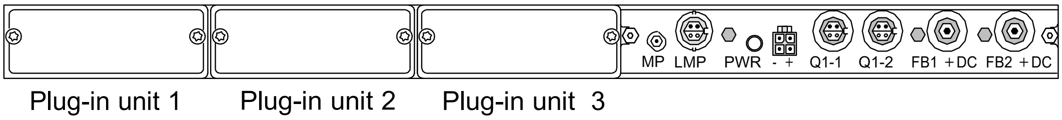


Figure 52. FIU 19 interfaces

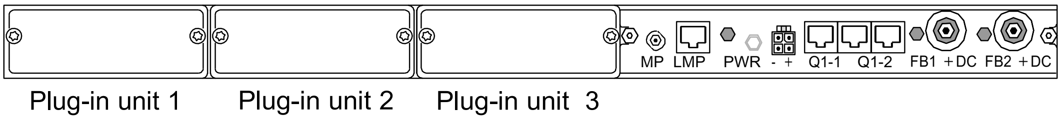


Figure 53. FIU 19E interfaces

Table 68. FIU 19(E) interfaces in the 4 x 2 M plug-in units and the 16 x 2 expansion unit

2M interfaces, n x 2 Mbit/s	SMB connector, 75 Ω *or* TQ connector, 120 Ω *or* RJ-45 connector, 120 Ω ITU-T G.703

Table 69. FIU 19(E) interfaces in the Flexbus plug-in unit

Flexbus interfaces 3 and 4 (FB3, FB4)	TNC connector 50 Ω Up to 16 x 2 Mbit/s signals, OU power supply 55 - 60 V_{DC}
OU power supply input (for third and fourth OU)	Molex Micro-Fit 3.0

Table 70. FIU 19(E) interfaces in the AUX data plug-in unit

	FIU 19	FIU 19(E)
Auxiliary interfaces (4)	Four RJ-45 modular connectors	Four RJ-45 modular connectors
	AUX slow channel	AUX slow interface: max. 4800 bit/s (at 2 x 2 Mbit/s capacity) or 9600 bit/s (at 4 x 2 Mbit/s or higher capacity), EIA-232 or ITU-T V.11
	AUX fast channel	AUX fast interface: max. 64 kbit/s, ITU-T V.11 or ITU-T G.703
	Four TTL-type programmable I/O channels	Four TTL-type programmable I/O interfaces
	Four relay controls	-

Table 71. FIU 19(E) AUX data plug-in unit, AUX slow channels

Channel type	Capacity	Max bit rate (bit/s)	Approx. sample rate (1000 /s)	Note
EIA-232	2 x 2M	4800	32	Max cable C: 2500 pF Max cable length: 25 m
	4 - 16 x 2M	9600	64	
ITU-T V.11 (RS-485)*	2 x 2M	4800	32	Max cable length: 1 km
	4 - 16 x 2M	9600	64	
* Optionally also TTL type clock outputs for synchronous data				

Only one AUX slow channel and one AUX fast channel can be simultaneously connected to a Flexbus.

Table 72. FIU 19(E) AUX data plug-in unit, AUX fast channels

Channel type	Capacity	Max bit rate (bit/s)	Approx. sample rate (1000 /s)	Note
ITU-T V.11 (RS-485)*	2 - 16 x 2M	64 000 ± 100 ppm	N/A	Co/contra-directional
ITU-T G.703 120 Ω balanced**	2 - 16 x 2M	64 000 ± 100 ppm	N/A	Co-directional
ITU-T V.11 (RS-485)***	2 x 2M	9 600	64	Sampled mode
	4 x 2M	19 200	64/128	
	8 x 2M	38 400	64/128/256	
	16 x 2M	64 000	64/128/256/512	

* Also V.11 type programmable clock channel.

** HDB3 coding used as in 2Mbit channels. Currently, no applications known to be used in.

*** Optionally also V.11 type programmable clock channel.

Table 73. FIU 19(E) AUX data plug-in unit, TTL-type I/O channels

Channel type	Input high min	Input low max	Output high min	Output low max
TTL input/output	2 V	0.8 V	3.8 V	0.45 V

Table 74. FIU 19(E) AUX data plug-in unit, relay controls

Channel type	Pos U_{in} max	Neg U_{in} max	I max	P max
Relay control	+72 V	-72 V	50 mA	300 mW

Table 75. FIU 19(E) Ethernet plug-in unit

Ethernet interfaces Eth-1 and Eth-2	RJ-45 connector 10/100 Base-T Autonegotiation support Half or full duplex Automatic MDI/MDIX detector

7.2.3 FIU 19(E) power supply, dimensions and installation options

7.2.3.1 Power supply

Table 76. FIU 19(E) power supply

	FIU 19(E)	**FIU 19E Outdoor case**
Main unit power supply	-40.5 to -60 V_{DC}	-40.5 to -57 V_{DC}
Operating range	-40.5 to -72 V_{DC}	-40.5 to -57 V_{DC}
Flexbus plug-in unit power supply	+52 to +60 V_{DC}	-52 to -57 V_{DC}
Power consumption (16 x 2M IU only)	< 15 W	< 29 W
Power consumption (16 x 2M IU + 2 OUs + maximum cable loss)	< 65 W	*
* The maximum power consumption of the heater is 100W and the maximum additional power consumption of the fan is 20W compared to a similar indoor site configuration. Fan typical operating range: on ~25°C, off ~22°C. Minimum power consumption at ~25°C (~5W). Heater typical operating range: on ~-5°C, off~+6°C. Temperature is taken from the case, not ambient.		

7.2.3.2 Dimensions

Table 77. Dimensions of the FIU 19(E) main unit and the expansion unit

Height	29 mm (2/3 U)
Width	444 mm (with 1 U brackets) 449 mm (with 1.5 U / 2 U brackets) *)
Depth	300 mm (without connectors)
Weight	2.8 kg
*) 2 U brackets only for FIU 19.	

Table 78. Dimensions of the FIU 19(E) plug-in units

Height	25 mm
Width	75 mm
Depth	160 mm
Weight	0.075 - 0.150 kg

Table 79. Dimensions of the FIU 19E Outdoor case

Height	133 mm = 3U (1 U = 44.46 mm)
Width	590 mm with outer cable entries
Depth	560 mm
Weight	12.0 kg (case without FIU 19E)
For more information about the minimum installation clearances, see *Installing FIU 19 (E) indoor unit outdoors* in *Installing Hardware for Nokia FlexiHopper (Plus) 2.7*.	

7.2.3.3 Ingress protection

Table 80. FIU 19(E) ingress protection class

Ingress protection class	IP21

Table 81. FIU 19E Outdoor case ingress protection class

Ingress protection class	IP55

7.2.3.4 Installation options

Table 82. FIU 19(E) installation options

FIU 19	FIU 19(E)	FIU 19E Outdoor case
IEC 19-inch rack	IEC 19-inch rack	Vertical pole
ETSI 600 x 300 mm rack (with adapter)	ETSI 500 mm rack (with adapter)	Vertical wall
TM4 slim rack (with adapter)	TM4 slim rack (with adapter)	Horizontal floor or roof

7.2.4 Ethernet throughput

Figure *Ethernet traffic throughput for different packet sizes as percentage of radio link capacity* shows the calculated Ethernet traffic throughput over the radio link for different packet sizes. The throughput is shown as percentage of the Ethernet capacity of the radio links. Actual bit/packet rates can be calculated from this information for different radio link capacities.

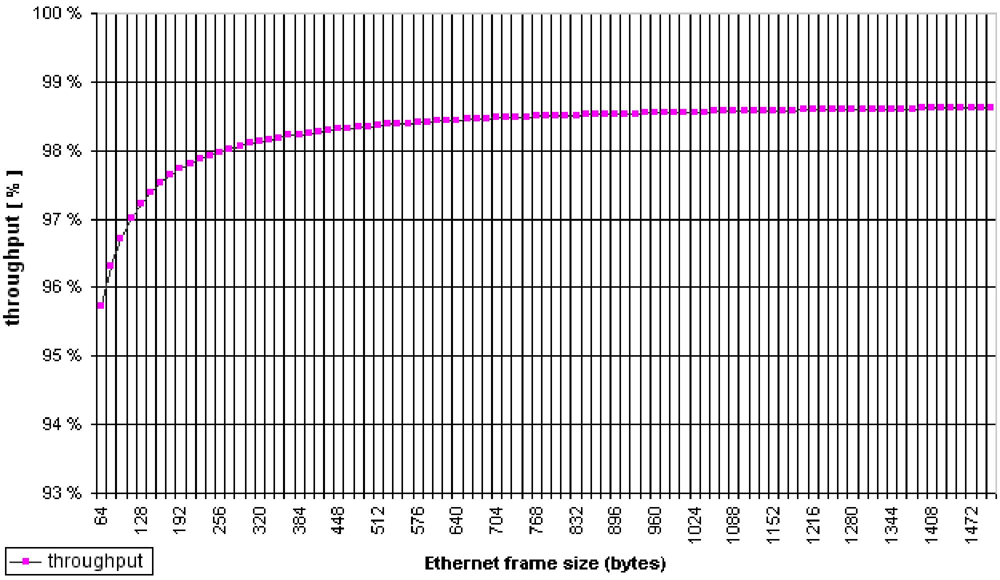


Figure 54. Ethernet traffic throughput for different packet sizes as percentage of radio link capacity

7.2.5 Propagation delays for packet traffic

The table *Packet propagation delay over single radio hop* summarizes packet propagation delays over single radio hop for different Ethernet packet sizes. Radio path propagation delay is not included in this table. Maximum propagation delay does not depend much on frame length.

Table 83. Packet propagation delay over single radio hop

	Buffer size	**Packet length**	**Propagation delay (PD) for different radio link capacities for Ethernet traffic [ms]**		
	[kB]	**[bytes]**	**2 M**	**16 M**	**32 M**
Min PD	32-128	64	0.8	0.2	0.1
	32-128	700	3.7	0.7	0.4
	32-128	1500	6.7	1.2	0.8
Max PD	32	64-1536	128	16	8.2
	64	64-1536	260	32	16
	128	64-1536	510	64	32

7.2.6 Measurement points

The indoor unit can send one of a variety of signals to its measurement point interface (MP) for analysis. The FIU 19(E) measurement point is located on the front panel.

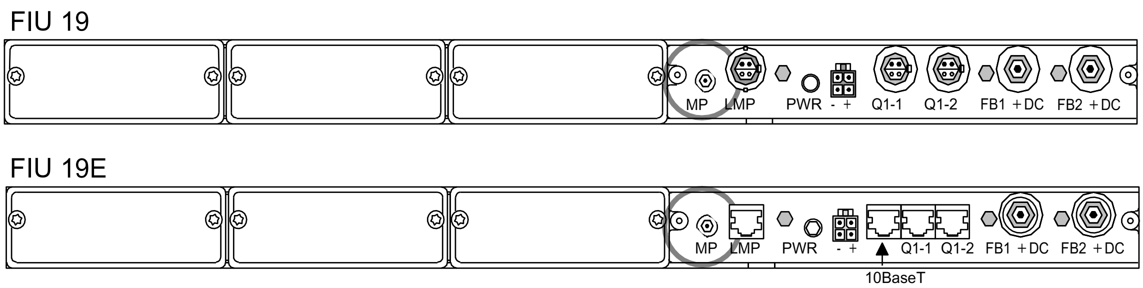


Figure 55. FIU 19 and FIU 19(E) measurement points

The available signals are:

- 2M Tx data
- BFI 2M Rx data (signals in the cross-connection section)
- 2M PRBS (pseudo-random binary sequence)
- 2M AIS (alarm indication signal)
- Flexbus Tx clock
- Flexbus 2M Rx clock
- 2M Tx clock
- BFI 2M Rx clock

In FIU 19(E), the measurement point output is 75 Ω G.703.

7.3 Flexbus cable

Table 84. Flexbus cable requirements

Cable type	Coaxial cable, double shielded or semi-rigid
Characteristic impedance	50 ± 2 Ω
DC resistance	< 4.6 Ω (sum of inner and outer conductor)
Data attenuation	2.9dB/100 m at 50 MHz
Flexbus signals	DC power supply
	Bidirectional digital data (37 Mbit/s, NRZ code, 1.4 V pulse amplitude)
Overvoltage protection and cable equaliser are integral parts of the Flexbus interface. Primary overvoltage protection is a 90 V gas-arrester.	

Table 85. Recommended cable types for Flexbus

Cables / 50 Ω	Flexbus cable
Max. length (m)	380
Character	Outdoor use, UV-stabilised, halogenfree, operational temperature range: -45 - +55 degrees Celsius.
Flame retardancy	IEC 60332-1

Table 85. Recommended cable types for Flexbus (cont.)

Cables / 50 Ω	Flexbus cable
Sales item	T55256.01
Reel length (m)	500

Nokia provides the following Flexbus connector, connector kits, and Jumper cables:

Connectors

- Flexbus TNC Connector, male (T55255.03)
- Flexbus N Connector, male (T55255.04)
- Flexbus TNC Connector, male angle (T55255.05)
- Flexbus N Connector, male angle (T55255.06)

Connector kits

The following connector kits include 3 different connectors.

- Flexbus TNC-N (RG-223) Connector Kit (T55255.13)
  - 1 TNC/90
  - 1 N/90
  - 1 N/0
- Flexbus TNC-N (RG-214) Connector Kit (T55255.14)
  - 1 TNC/90
  - 1 N/90
  - 1 N/0

Jumper cables

- Flexbus Jumper Cable TNC male-TNC female (T55257.03)

7.4 Statistics

The statistics the network element records for signal quality are kept to ITU-T recommendation G.826. The values are available as either infinite, or 15-minute and 24-hour histories (last 16 measurements).

The following statistics are recorded:

Table 86. Statistics

ID text	Unit	Description
G.826 TT	seconds	Total Time as specified in G.826
G.826 AT	seconds	Available Time as specified in G.826
G.826 ES	seconds	Errored Seconds as specified in G.826
G.826 SES	seconds	Severely Errored Seconds as specified in G.826 [1)]
G.826 BBE	counter	Background Block Errors as specified in G.826
G.826 EB	counter	Errored Blocks as specified in G.826
1) G.826 gives two definitions for SES. In Nokia Q1, the definition of SES as "≥30% errored blocks in one-second period" is adopted.		

7.5 System requirements for Hopper Manager

Hopper Manager requires the following minimum system configuration:

Table 87. System requirements

Computer	Intel Pentium -based IBM-compatible PC
Operating system	Microsoft Windows 98/2000/XP
System memory	16 MB for Windows 95 32 MB for Windows NT
Hard disk space	32 MB for the node manager software
Display	Super VGA, minimum resolution of 800 x 600
Accessories	CD-ROM drive Windows compatible mouse or pointing device Windows compatible printer (optional) LMP cable (from the PC to the node)

7.6 Nokia FlexiHopper (Plus) standards

The following tables list the standards referred to in the technical specifications.

Table 88. Signals (ITU-T)

Recommendation	Recommendation name
G.703	Physical/electrical characteristics of hierarchical digital interfaces.
G.823	The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy.
G.826	Error performance parameters and objectives for international, constant bit rate digital paths at or above primary rate.
G.921	Digital sections based on the 2048 kbit/s hierarchy.
V.11	Data communication over the telephone network; Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s.

Table 89. Frequency allocation (ITU-R)

Recommendation	Recommendation name
F.385-8 (2005)	Radio-frequency channel arrangements for radio-relay systems operating in the 7 GHz band.
F.636-3 (1994)	Radio-frequency channel arrangements for radio-relay systems operating in the 15 GHz band.
F.595-9 (2006)	Radio-frequency channel arrangements for fixed wireless systems operating in the 18 GHz frequency band.
F.637-3 (1999)	Radio-frequency channel arrangements for radio-relay systems operating in the 23 GHz band.
F.749-2 (2001)	Radio-frequency channel arrangements for radio-relay systems operating in the 38 GHz band.
SM.1138-1 (2007)	Determination of necessary bandwidths including examples for their calculation and associated examples for the designation of emissions.

Table 90. CEPT

Recommendation	Recommendation name
ECC/REC/(02)06 (2002)	Preferred channel arrangements for digital fixed service systems operating in the frequency range 7125-8500 MHz.

Table 90. CEPT (cont.)

Recommendation	Recommendation name
ERC/REC 12-07 E (1996)	Harmonised radio frequency channel arrangements for digital terrestrial fixed systems operating in the bands 14.5 -14.62 GHz paired with 15.23 - 15.35 GHz.
ERC/REC 12-3 E (1994)	Harmonised radio frequency channel arrangements for digital terrestrial fixed systems operating in the band 17.7 GHz to 19.7 GHz.
ERC/REC T/R 13-02 E (1993)	Preferred channel arrangements for fixed services in the range 22.0 - 29.5 GHz.
ERC/REC T/R 12-01 E (1991)	Harmonized radio frequency channel arrangements for analogue and digital terrestrial fixed systems operating in the band 37 GHz-39.5 GHz.
ERC/REC 74-01 E (2005)	Unwanted emissions in the spurious domain.

Table 91. Radio transmission (CENELEC)

Recommendation	Recommendation name
EN 50383 (2002)	Basic standard for the calculation and measurement of electromagnetic field strength and SAR related to human exposure from radio base stations and fixed terminal stations for wireless telecommunications system (110 MHz - 40 GHz).
EN 50384 (2002)	Product standard to demonstrate the compliance of radio base stations and fixed terminal stations for wireless telecommunication systems with the basic restrictions or the reference levels related to human exposure to radio frequency electromagnetic fields (110 MHz - 40 GHz) - Occupational.
EN 50385 (2002)	Product standard to demonstrate the compliance of radio base stations and fixed terminal stations for wireless telecommunication systems with the basic restrictions or the reference levels related to human exposure to radio frequency electromagnetic fields (110 MHz - 40 GHz) - General public.

Table 92. Radio transmission (ETSI)

Recommendation	Recommendation name
Final draft ETSI EN 302 217-1 V1.2.1 (2007)	Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 1: Overvew and system-independent common characteristics.
EN 302 217-2-1, V1.1.3 (2004)	Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2-1: System-dependent requirements for digital systems operating in frequency bands where frequency co-ordination is applied.
Final draft ETSI EN 302 217-2-1 V1.2.1 (2007)	Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2-1: System-dependent requirements for digital systems operating in frequency bands where frequency co-ordination is applied.
HEN 302 217-2-2, V1.1.3 (2004)	Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2-2 Harmonized EN covering essential requirements of Article 3.2 of R&TTE Directive for digital systems operating in frequency bands where frequency co-operation is applied.
Final draft ETSI EN 302 217-2-2, V1.2.2 (2007)	Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2-2 Harmonized EN covering essential requirements of Article 3.2 of R&TTE Directive for digital systems operating in frequency bands where frequency co-operation is applied.
EN 302 217-4-1 V1.1.3 (2004)	Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4-1: Systems-dependent requirements for antennas.
HEN 302 217-4-2 V1.2.1 (2006)	Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4-2: Harmonized EN covering essential requirements of Article 3.2 of R&TTE Directive for antennas.
EN 301 126-1, V1.1.2 (1999)	Fixed Radio Systems; Conformance testing; Part 1: Point-to-Point equipment - Definitions, general requirements and test procedures.
EN 301 126-3-1, V1.1.2 (2002)	Fixed Radio Systems; Conformance testing; Part 3-1: Point-to-Point antennas - Definitions, general requirements and tests procedures.

Table 92. Radio transmission (ETSI) (cont.)

Recommendation	Recommendation name
EN 300 166 V1.2.1 (2001)	Transmission and Multiplexing (TM); Physical and electrical characteristics of hierarchical digital interfaces for equipment using the 2048 kbit/s - based plesiochronous or synchronous digital hierarchies.

Table 93. Environment (ETSI)

Recommendation	Recommendation name
EN 300 019-1-0 V2.1.2 (2003)	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-0: Classification of environmental conditions; Introduction.
EN 300 019-1-1 V2.1.4 (2003) Class 1.2	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-1: Classification of environmental conditions; Storage.
EN 300 019-1-2 V2.1.4 (2003) Class 2.3	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-2: Classification of environmental conditions; Transportation.
EN 300 019-1-3 V2.2.2 (2004) Class 3.2	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-3: Classification of environmental conditions; Stationary use at weatherprotected locations.
EN 300 019-1-4 V2.1.2 (2003) Class 4.1	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-4: Classification of environmental conditions; Stationary use at non-weatherprotected locations.
EN 300 019-1-4 V2.1.2 (2003) Class 4.1E	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-4: Specification of environmental tests; Stationary use at non-weather protected locations.

Table 93. Environment (ETSI) (cont.)

Recommendation	Recommendation name
EN 300 019-2-0 V2.1.2 (2003)	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-0: Specification of environmental tests; Introduction.
EN 300 019-2-1 V2.1.2 (2000)	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-1: Specification for environmental testes; Storage.
EN 300 019-2-2 V2.1.2 (1999)	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-2: Specification for environmental testes; Transportation.
EN 300 019-2-3 V2.2.2 (2003)	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-3: Specification of environmental tests; Stationary use at weatherprotected locations.
EN 300 019-2-4 V2.2.2 (2003)	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-4: Specification of environmental tests; Stationary use at non-weatherprotected locations.
Final draft EN 300 132-2 V2.2.1 (2007)	Environmental Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 2: Operated by direct current (dc).
EN 301 489-1 V1.6.1 (2005)	Electromagnetic compatibility and Radio Spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements.
Final draft ETSI EN 301 489-1 V1.7.1 (2007)	Electromagnetic compatibility and Radio Spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements.
EN 301 489-4 V1.3.1 (2002)	Electromagnetic compatibility and Radio Spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 4: Specific requirements for fixed radio links and ancillary equipment and services.

Table 94. Environment (CENELEC)

Recommendation	Recommendation name
EN 55022 (2006)	Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement.
EN 61000-4-2 (1995)	Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test.
EN 61000-4-3 (2006)	Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio frequency, electromagnetic field immunity test.
EN 61000-4-4 (2004)	Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test.
EN 61000-4-5 (2006)	Electromagnetic compatibility (EMC) - Part 4-5 Testing and measurement techniques - Surge immunity test.
EN 61000-4-6 (1996)	Electromagnetic compatibility (EMC) - Part 4-6 Testing and techniques - Immunity to conducted disturbances, induced by radio frequency fields.
EN 60950-1 (2006)	Safety of information technology equipment.

Table 95. IEC

Recommendation	Recommendation name
IEC 60529 (1989)	Degrees of protection provided by enclosures (IP Code).
IEC 60950-1	Safety of information technology equipment.
CISPR 22 (2005)	Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement.

Table 96. IETF

Standard number	Standard title
RFC 768	User Datagram Protocol (UDP).
RFC 791	Internetwork Protocol (IPv4).
RFC 792	Internetwork Control Message Protocol (ICMP).

Table 96. IETF (cont.)

Standard number	Standard title
RFC 793	Transmission Control Protocol (TCP).
RFC 826	Address Resolution Protocol.
RFC 894	Standard for Transmission of IP Datagrams over Ethernet.
RFC 950	Internet Standard Subnetting Procedure.
RFC 1027	Using ARP to Implement Transparent Subnet Gateways.
RFC 1519	Classless Inter-domain Routing: An Address Assignment and Aggregation Strategy.

Table 97. IEEE standards for LMP and DCN

Standard identification	Standard title
802.3 (2005)	Part 3: Carrier Sense Multiple Access with Collision detection (CSMA/CD) access method and physical layer specifications.
802.3u (2005)	100 Base-T MAC parameters, Physical Layer, MAUs, and Repeater for 100Mb/s Operation.
802.3x (2005)	Full Duplex operation and Type 100BASE-T2.