Development of the iPASOLINK, All Outdoor Radio (AOR) Device

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Abstract

Accompanied by the recent expansion of mobile base station networks (LTE and small cell,) the trend towards larger capacities is typically affecting the backhaul network. In addition to using conventional radio transmission devices configured with IDU (indoor unit: baseband section + radio modulator/demodulator section) and ODU (outdoor unit: radio transmitter/receiver section), we have now developed an All Outdoor Radio (AOR). This device integrates the IDU/ODU functions via the utilization of a high-frequency radio bandwidth suited to larger capacities. It thereby enables the wireless backhaul construction of mobile base station networks that can be easily achieved while simultaneously increasing their capacities. This paper introduces NEC's AOR device lineup as well as the various technologies of the iPASOLINK SX (60-GHz band)/EX (70 to 80-GHz band), those use a high-frequency radio bandwidth, and also discusses our intensions regarding further developments.

Keywords

All Outdoor Radio, V-band (60 GHz), E-band (70 to 80 GHz), 256 QAM multi-level modulation, over-1-Gbps transmission, small cell backhaul

1. Introduction

Due to the increasing traffic volume that is resulting from the spread of mobile devices and smartphones, base station networks are showing a tendency to evolve from systems in which stations are accommodated in specific wide area (macro cell systems) to those for which the area is narrowed in order to increase location density (small cell). The small cell system requires an inter-base station communication device of high compactness and easy to install ability, as the transmission power of the base station is low. Moreover, there are demands from the telecom carriers to minimize the CAPEX (capital expenditure) and OPEX (operating expenditure) for provisioning of services to the many new coverage areas.

This paper discusses the iPASOLINK All Outdoor Radio (AOR) series, which is NEC's large-capacity transmission range for outdoor installations. Also discussed are: the flagship iPASOLINK iX that uses the existing licensed frequency bands (6 to 42 GHz,) the iPASOLINK SX using the 60-GHz band that is unlicensed band in many countries, and the iPASOLINK EX that uses the 70 to 80-GHz band with a large-capacity transmission capability and which features relatively reasonable license acquisition costs.

2. iPASOLINK All Outdoor Radio Lineup

The lineup of the iPASOLINK AOR and the features of each model (transmission capacity, distance, etc.) as well as application examples are shown in **Fig**.

Using the licensed frequency band of 6 to 42 GHz, the iPASOLINK iX is an ideal device for medium capacity transmissions (up to 1 Gbps) at short to long distances (up to 10 km). In contrast, the iPASOLINK SX which uses the unlicensed 60 GHz frequency, is a device that enables medium capacity transmissions (up to 320 Mbps) at short distances (under 1 km) due to the high path attenuation characteristics of the medium in this frequency band. In contrast, the iPASOLINK EX, which uses the licensed frequency band of 70 to 80 GHz is a device that enables large-capacity transmissions (up to 1.6 Gbps), albeit over short distances (of under 3 km).

The iPASOLINK EX is applicable to high density transmission line such as in pre-aggregation/aggregation areas. The iPASOLINK SX is advantageous for the last mile before the base station. The iPASOLINK iX can be applied to intermediate areas and for cases where longer hop distance is obligatory to a certain extent. Although it is not strictly wireless device, the iPASOLINK GX is included in the present iPASOLINK

NEC All Outdoor Radio lineup and applications

	iPASOLINK iX 6 to 42 GHz	iPASOLINK SX 60 GHz (V-band) 59 to 63 GHz	iPASOLINK EX 70 to 80 GHz (E-band) 71 to 76 GHz and 81 to 86 GHz
Transmission capacity/transmission distance	Up to 1 Gbps/up to 10km	Up to 320 Mbps/400 m Up to 82 Mbps/900 m	Up to 1.6 Gbps/1.6 km Up to 400 Mbps/3.3 km
- Usable radio bandwidth - License arrangement	Up to 56 MHz channels 2×5 GHz License required	Up to 4 GHz License not required in many areas	2×5 GHz Low cost, simple license format
- Device specification - Antenna size	Compact body for outdoor use Parabola, 30/60 cm	Ultra-compact body for outdoor use with an integrated Flat panel antenna, 20 cm	Outdoor compact body Parabola, 30/60 cm

The iX and EX models require sufficient line of sight when installed at the top of a building or when mounted on a mast or pole in order to achieve stable communication.

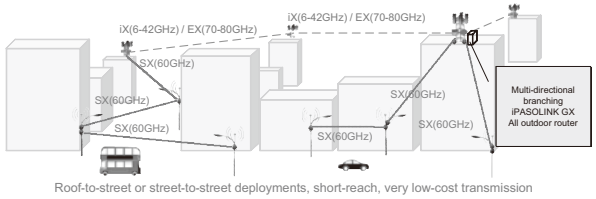

Fig. Overview of the iPASOLINK AOR series.

AOR series because it is an outdoor switch/router device for configuring multi-branch networks.

3. Concept of the NEC All Outdoor Radio

The NEC iPASOLINK AOR is a compact wireless device compatible with waterproof, dustproof, and temperature-resistant outdoor environments, while retaining the predictable PASOLINK performance that has gained the trust of customers and recorded worldwide sales of more than 2 million units in total.

In developing this AOR product, we aimed at achieving an easy-to-install device that would be compatible with IP networks for which even higher speeds and multi-functionalities would be required, while at the same time minimizing the installation and operation costs. Each unit incorporates a variable modulation method and high-performance VLAN and QoS functions, thereby enabling varied and diversified IP services. In order to simplify the wiring of the device as much as possible, each device is equipped with the PoE (Power over Ethernet) power supply function, featuring operability via the simple connection of a single Ethernet cable.

4. iPASOLINK SX

The iPASOLINK SX is a compact antenna-integrated AOR device that uses a radio frequency of 60-GHz band (V-band).

4.1 Features of 60-GHz Band Radio Transmission

In general, the 60-GHz band does not require a licensing fee to use the frequency and thus has the advantage of being able to reduce the operating expenditure (Opex). The 60-GHz band also undergoes/experiences significant atmospheric attenuation during radio transmissions; for this reason, it has the characteristic of insusceptibility to interference by overreach (a phenomenon where radio waves reach too far). Furthermore, it has a large radio bandwidth (up to 4 GHz) with many available channels, enabling it to be considered as a frequency band suitable for small cell lines that require the accommodation of many stations in close proximity.

4.2 Features of the iPASOLINK SX

Developed for installation in the streets and similar locations, the iPASOLINK SX has a compact design with a built-in and newly developed flat panel antenna that meets the requirements of easy and inconspicuous installation. Furthermore, it enables FDD (Frequency Division Duplex) transmission of up to 320 Mbps, which is required for the configuration of small cell systems. The external appearance of the SX is shown in **Photo 1**, and the main specifications are displayed in **Table 1**.

Although it poses an issue regarding susceptibility to interference waves from other devices, 60 GHz band with a low modulation transmission method using a wide frequency band-

Photo 1 External appearance of the iPASOLINK SX.

Table 1 Main specifications of the iPASOLINK SX.

Item	Specifications
Radiofrequency	59-63 GHz (CS: 50 MHz)
Duplexing method	FDD
Transmission power	+3 dBm (QPSK)
Antenna gain	37 dBi
Transmission rate	320 Mbps (256QAM)
Modulation method	QPSK, 16, 32, 64, 128, 256QAM
Interfaces	2 × GbE (RJ-45 (PoE)/SFP), LCT
QoS	8 classes queue SP/DWRR
Synchronization	Synchronous Ethernet
Power consumption	25 W
Dimension/Mass	230 × 230 × 104 mm/4.6 kg

width has been popular, since this is an unlicensed band. It is also assumed that there may be effects of interference waves from other stations when many stations are established in the small cell backhaul using 60-GHz. To prevent such interference waves, the iPASOLINK SX uses a narrow bandwidth of 50 MHz. This makes it possible for the users to choose from 40 channels in the 60 GHz band and to achieve stable communications that are not susceptible to interference, even in environments with a high density of radio wave usage. The SX, moreover, is equipped with two Ethernet ports for data transmission that allows users to make use of it in various ways, such as simultaneous transmission of different data from, for example, mobile phone base stations and surveillance cameras and also constructing ring networks. As for its transmission capacity, combination with the iPASOLINK GX outdoor switch/router device makes it possible to achieve parallel power supply to four iPASOLINK SXs in order to enable users to configure wireless links of up to 1.28 Gbps.

In addition, the 60-GHz band is usable not only worldwide, but also in Japan as an unlicensed frequency band and may be used for various occasions, such as for the construction of corporate interfacility communication lines and backup lines of companies, outdoor networks in harbors, on construction sites, surveillance camera networks in public places, and for emergency lines in disaster situations.

5. iPASOLINK EX

The iPASOLINK EX is a separate antenna type AOR device that uses a radio frequency of 70 to 80-GHz band (E-band).

5.1 The Characteristics of Transmissions in the 70 to 80-GHz Band

The 70 to 80-GHz radio frequency band is an EHF bandwidth or millimeter band that can ensure a wide frequency range. Because it has a greater straight-line travelling characteristic (line-of-sight propagation) than the 60-GHz band and is hardly affected by atmospheric radio attenuation, it is suited to close-distance and large-capacity transmissions. It also has a tendency to require lower licensing fees than the 6 to 42-GHz radio frequency band, which is currently used by telecom carriers after submission of license applications. Therefore it is expected to be applied to various services in the future.

5.2 Features of the iPASOLINK EX

Targeting application in the aggregation layer that collects transmission lines in the small cell backhaul, replacement of or as complement to existing fiber optic lines, and for application in broadband backhaul, the iPASOLINK EX enables large-capacity transmissions in excess of 1 Gbps. It also employs a heat dissipation corrugated fin and features superior characteristics in both radiation capability and appearance.

The external appearance of the iPASOLINK EX is shown in **Photo 2**, and the main specifications are listed in **Table 2**.

The features of the iPASOLINK EX baseband and radio transmitter/receiver sections are discussed below.

The baseband section is compatible with carrier-class Ethernet and achieves the network surveillance and maintenance via the Ethernet OAM, as well as having a high reliability supported by its link aggregation and device protection functions. Moreover, it can further improve the quality of communications by hooking up with the iPASOLINK GX and the LTE wireless base stations (eNodeB) to perform QoS control in sync with fluctuations in the radio bandwidth.

By utilizing multilayer PCBs in the IC packages as EHF packages, the radio transmitter/receiver section adopts a structure in which a bare-chip MMIC (Monolithic Microwave Integrated Circuit) is directly mounted on the PCB. The EX model also achieves compact design, high performance, and reduced implementation cost by electromagnetically coupling the radio high-frequency circuit with the oscillator and intermediate fre-

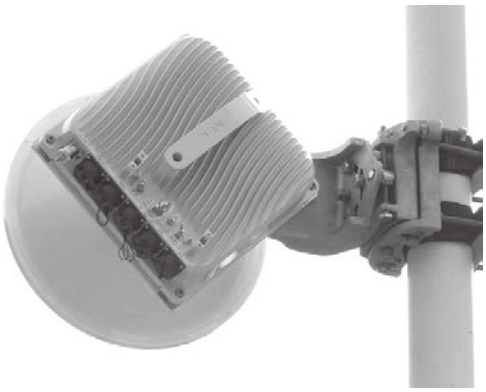

Photo 2 External appearance of the iPASOLINK EX.

Table 2 Main specifications of the iPASOLINK EX.

Item	Specifications
Radio frequency	71-76 / 81-86 GHz (CS 250 MHz)
Duplexing method	FDD
Transmission power	+18 dBm (QPSK)
Transmission rate	1.6 Gbps (256QAM)
Modulation method	QPSK, 16, 32, 64, 128, 256QAM
Interfaces	3 × GbE (RJ-45 (PoE)/SFP), DCN
QoS	8 classes queue SP/DWRR
Synchronization	Synchronous Ethernet
Ethernet OAM	IEEE802.1ag/IEEE802.3ah ITU-T Y.1731
Radio Configuration	1+0/1+1/2+0
Power consumption	55 W
Dimension/Mass	285 × 285 × 90 mm/5.5 kg

quency circuits.

While reducing power consumption to the same level as that of the conventional IDU/ODU components, the iPASOLINK EX achieves large-capacity transmissions of 1.6 Gbps in the 250-MHz broad bandwidth by being compatible with the multi-level modulation method (256 QAM). We will continue to improve functionality and capacity by adopting the 500-MHz radio transmission bandwidth as well as the cross polarization transmission system that doubles the transmission capacity by using horizontal/vertical radio polarization.

6. Conclusion

There has recently been an increasing demand for capacity to accompany the spread of LTE and the expansion of the small cell networks. Consequently, radio transmission devices are now required to have transmission capacities equivalent to those of the fiber optic lines. To meet these requirements, we will continue the development of the iPASOLINK AOR series with a view to achieving a throughput of over 10 Gbps. This will be achieved using a cross polarization transmission system and MIMO (multiple input, multiple output) functions, in addition to expanding the radio transmission bandwidth. We are committed to providing products that will contribute to the advancement of mobile networks by maximizing compactness and easy to install capabilities and by minimizing the power consumption. These will also contribute to the reduction of the installation expenses and operation costs. Moreover, our aim is to achieve harmonization with townscape perspectives in consideration of the fact that many devices will be installed on the street furnitures.

The details about this paper can be seen at the following.

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PASOLINK Series
http://www.nec.com/en/global/prod/nw/pasolink/

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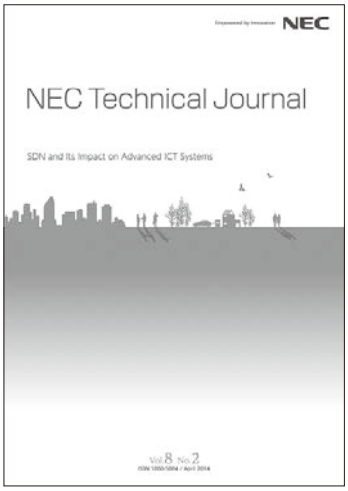

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