Development of iPASOLINK Series and Super-Multilevel Modulation Technology

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Abstract

To respond to the need to increase the capacity and efficiency of the mobile backhaul circuit of the PASOLINK series of microwave radio communications systems, NEC has developed a system applying 2048QAM super-multilevel modulation technology for the first time in the world and has released it as part of its menu of iPASOLINK series products.

This paper introduces the iPASOLINK system as well as the super-multilevel modulation and baseband technologies that make large-capacity communications possible.

Keywords

PASOLINK, microwave communications system, cellular phone base station, mobile backhaul circuit, super-multilevel modulation, header compression, RTA

1. Introduction

To deal with the changes in the environment resulting from the rapid dissemination of smartphones and tablet terminals around the world, cellular phone carriers are increasing the capacities of mobile backhauls.

Although mobile backhaul use an extensive amount of optical fibers, there are many regions of the world where optical fibers are not installed. As a result, wireless systems, for which communication lines can be built simply by installing certain equipment in the base stations, are sometimes more advantageous in terms of both economy and work period. Furthermore, microwave communications systems provide resistance against disasters and effectiveness in security, such as the terrorism countermeasures that have recently been gaining importance, and their use is expanding widely all over the world.

This paper introduces the iPASOLINK series, the latest series of PASOLINK, NEC's overseas-oriented microwave communications systems, together with the key technologies newly developed to increase the capacity of wireless transmissions.

2. iPASOLINK Series

2.1 What is PASOLINK?

NEC has shipped more than 2 million PASOLINK series products to about 150 countries around the world for use in microwave communications systems as mobile backhaul.

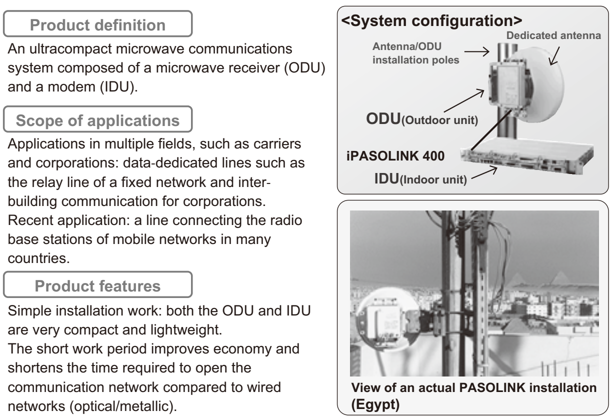

Fig. 1 Outline of PASOLINK.

PASOLINK is the generic name given for ultracompact microwave communications systems composed of a microwave transceiver installed outdoors (ODU: Outdoor Unit) and a modem installed indoors (IDU: Indoor Unit) (**Fig. 1**). The iPASOLINK products are the latest models in the PASOLINK series.

The iPASOLINK series adopts a new hybrid system compatible with both the traditional TDM transmission method and the IP transmission method as its platform, so that they can support an integrated mobile network in which 2G, 3G and LTE are mixed. The product lineup includes a wide variety of product options, such as radio branching from a single direction up to 12 directions so that an end-to-end mobile backhaul can be built by including the aggregation and metro areas in addition to the access area with which the PASOLINK series has traditionally dealt.

2.2 iPASOLINK Series Lineup

Fig. 2 shows the product lineup of the iPASOLINK series and **Table** shows their specifications.

In the series, 100E, 100 and 200 are products mainly targeted at the access area. The 100E features a downsized IDU by specializing the functionality to packet transmission, while the 400/400A are made applicable to the aggregation area by using radio branching in up to 4 directions. The 1000 supports the functions required by the metro area, such as branching in up to 12 directions, redundancy of common function blocks and CWDM, a high-speed transmission technology for optical circuits.

For the radio functions, we implemented a transmission method that uses both vertical/horizontal polarized waves and the 2048QAM modulation method with a transmission capacity of up to 1 Gbps per radio channel. The technologies for implementing large-capacity transmission include RTA (Radio Traffic Aggregation), which performs packet transfers of multiple wireless channels by handling them virtually as a single physical layer; Header Compression, which transfers packets with high efficiency; and AMR (Adaptive Modulation Radio), which secures transmission quality at a certain level regardless of weather, etc.

The main signal control functions are equipped with protocols for dealing with the trend of IP networking and are compatible with MSTP (Multiple Spanning Tree Protocol) and ERPS (Ethernet Ring Protection Switch), which switch the path quickly in the event of a fault. Maintenance and administration functions include connection surveillance using Ethernet OAM (Operation, Administration and Maintenance) as well as loopback and various measurement functions. Furthermore, 8-class QoS (Quality of Service) control and Synchronous Ethernet functions are also supported.

For the system configuration, the main signal interfaces such as E1, STM-1, Ethernet and MODEM (radio signal modulator/demodulator) are provided as detachable modules to enable efficient traffic accommodation according to each user's network. In addition to the main signal interface modules, modules for supporting PTP (Precision Time Protocol) and PWE (Pseudo Wire Emulation) are installed to flexibly provide users with the functionality they need.

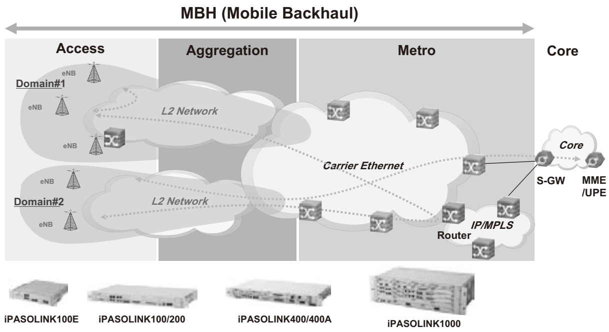

Fig. 2 iPASOLINK product lineup (IDU).

Table iPASOLINK specifications.

Item	Specifications
Radio frequency	6-52 GHz (CS: 7-56 MHz)
Duplexing method	FDD
Transmission power	+29 dBm (QPSK)
Transmission rate	600 Mbps (56 MHz, 2048QAM)
Modulation method	QPSK - 2048QAM (Hitless AMR)
Interfaces	E1, STM-1 10/100/1000BASE-T(X) 1000BASE-SX/LX
Radio configuration	1+0/1+1/N+0 (max=12)/XPIC
TDM protection	E1 SNCP/STM-1 line protection
QoS	4/8 classes queue SP/DWRR
Synchronization	Synchronous Ethernet IEEE1588v2 E1/STM-1/Radio/EXT CLK
OAM	Ethernet OAM (CC/LB/LT/LM/DM) Link OAM
Ethernet protection	RSTP/MSTP/ERPS
TDM PWE	SAToP (MEF8)

3. Super-multilevel Modulation Technology

3.1 The Need for Super-multilevel Modulation Technology

To enlarge the capacity of a wireless system, it is necessary to broaden radio channel bandwidth as well as to improve frequency utilization efficiency. However, since the frequencies and bandwidths of the radio channels permitted for use by general users are prescribed in laws, with licenses required for many frequency bands, it is not possible to expand bandwidth in the same way as through bundling optical fibers. This makes it necessary to adopt a communication method using both horizontal and vertical polarized waves and to increase the level of the modulation method.

To deal with these issues, we have developed a 2048QAM method with the highest frequency utilization efficiency in the world. This 2048QAM method improves wireless transmission efficiency by about 40% compared to the 256QAM method that has been used most frequently in traditional microwave communications systems

3.2 Implementation of 2048QAM

With the QAM modulation method, transmission capacity increases as the number of bits assigned per modulation symbol is increased. While traditional microwave communications systems generally employed modulation methods from QPSK (2 bits/symbol) to 256QAM (8 bits/symbol), we have developed other modulation methods for the iPASOLINK series such as 512QAM (9 bits/symbol), 1024QAM (10 bits/symbol) and 2048QAM (11 bits/symbol).

Fig. 3 shows the constellation of the newly developed 2048QAM. It uses very narrow signal point intervals so that the S/N ratio required to achieve a certain bit error rate becomes high (an S/N ratio 9 dB higher than with 256QAM). In addition, it is also vulnerable to the phase noise that is mainly generated in the local oscillator in the RF band analog circuitry and the nonlinear distortion that is generated in the high-power amp, and the characteristics are degraded significantly depending on the deviation of each hardware device or the quality of the received signal. We therefore advanced the digitization of the modem circuitry to improve the modem S/N ratio and eliminate the incompleteness caused by the analog circuitry. Furthermore, we also newly developed high-performance nonlinear distortion compensation technology and phase noise compensation technology and succeeded in compensating for received signal incompleteness without imposing excessive performance requirements on the RF band analog circuitry.

When the S/N ratio required to secure a certain transmission quality is increased through the use of super-multilevel modulation, the resistance of wireless transmission paths against drops in the receiving electric field due to rain, etc. is decreased. To deal with this, we adopted the adaptive modulation radio (AMR) method, which automatically adjusts the modulation level according to wireless circuit conditions such as bad weather or interference. The combination of ultra-multilevel modulation and AMR makes possible both large-capacity transmission based on super-multilevel modulation in normal operations and high stability and quality of communication service.

4. Baseband Technologies for Large-capacity Transmission

In addition to technologies for modulation/demodulation, technologies for signal processing in the baseband domain are also important for large-capacity transmission. This section introduces two baseband technologies: header compression and RTA (Radio Traffic Aggregation).

4.1 Header Compression

Header compression is a transmission technology for improving throughput by compressing part of the header information of a transmitted Ethernet signal and restoring the original header information before the output of the received signal. The effects of header compression are shown in **Fig. 4**. The improvement in throughput thanks to header compression is particularly high when frame length is short.

With iPASOLINK, the user can freely set whether header compression is enabled or disabled and what kind of header information is compressed.

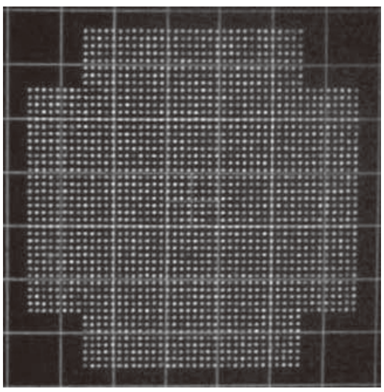

Fig. 3 2048QAM constellation.

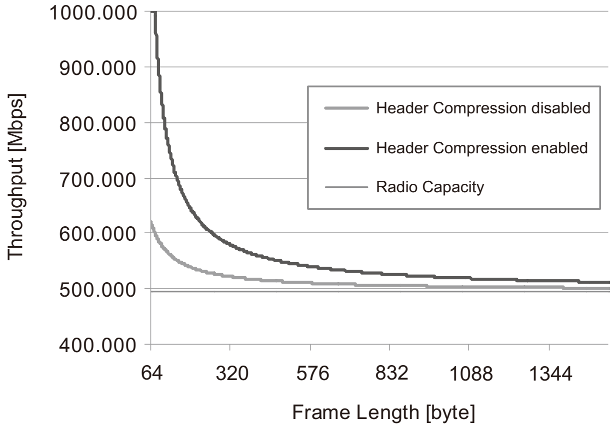

Fig. 4 Effects of header compression.

4.2 RTA (Radio Traffic Aggregation)

RTA is a technology for enabling large-capacity transmission by bundling several radio links and handling them as a single radio link. The link aggregation defined in IEEE 802.3ad is a similar technology, but we found that under certain conditions it is sometimes impossible to efficiently use the radio transmission capacity.

NEC has newly developed an RTA method that can efficiently bundle multiple radio links, independently from conditions such as packet size, by redesigning the method of distributing data to each radio link. RTA technology can also be combined with the header compression technology described above, further increasing throughput.

By using 2048QAM signals in both the horizontal and vertical polarized waves in the radio channels in the 56 MHz bandwidth and applying the baseband technologies described above, NEC eventually succeeded in implementing a wireless system capable of 1 Gbps wire rate transmission.

5. Conclusion

With the iPASOLINK series, we at NEC implemented wireless transmission with the world's highest efficiency by positively developing super-multilevel modulation and baseband technologies to increase capacity. Concurrently with this development, we also proposed the 2048 QAM method to the ETSI (European Telecommunications Standards Institute) for standardization of the new technology. While responding to the need to increase the mobile backhauls of the newly developed iPASOLINK series, we will continue our challenge to develop new technologies to further improve transmission efficiency.

* LTE is a registered trademark of European Telecommunications Standards Institute（ETSI）.
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