Development Reports

Fixed Wireless Systems with Large Transmission Capacity for Entrance Circuits

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DoCoMo has developed fixed wireless systems for the purpose of constructing 155.52 Mbit/s entrance circuits at reasonable costs in order to support the rapidly increasing traffic demands owing to diffusion of FOMA.

1. Introduction

In the process of expanding the FOMA service areas, DoCoMo actively makes use of fixed wireless systems in order to construct transmission links for entrance circuits[*1] economically. At present, the number of FOMA subscribers has reached 12.88 million (as of the end of May 2005) and continues to increase rapidly, and the flat-rate charge for data communications has become widespread. Therefore the traffic demands of the transmission links are increasing exponentially. For this reason, it has been required to increase the transmission capacity of fixed wireless systems for entrance circuits drastically.

This article provides an overview of the system configurations and characteristics of the fixed wireless systems with large transmission capacity for entrance circuits (7G-150MDE[*2] and 11/15/18G-150MDE) developed against this background.

2. System Overview

7G-150MDE and 11/15/18G-150MDE achieve a transmission capacity of 155.52 Mbit/s and allow constructing transmission links with a transmission capacity that is approximately six times larger than that of existing 11/15G-26MD. Moreover, their power consumption is reduced and ease of installation is improved compared to existing systems owing to miniaturiza-

*1 Entrance circuit: The alias of transmission link between Base Transceiver Station (BTS) and Connection Node (CN).

*2 7G-150MDE: The name of one of DoCoMo's fixed wireless systems for entrance circuits. The names are constructed using the format nG-mMD (E), where n refers to the radio frequency band used (GHz) and m refers to the system transmission capacity (Mbit/s).

tion of the hardware. Furthermore, by utilizing the 7 GHz band (6.5/7.5 GHz band) for the first time for this kind of application, these systems allow long hop lengths greater than the 15 km that is the standard hop length of existing systems, which expands the applicable range of fixed wireless systems for entrance circuits.

Figure 1 shows the applicable range of these systems and **Photo 1** shows the external views of InDoor Unit (IDU)-OutDoor Unit (ODU) configuration of 11G-150MDE. Moreover, **Table 1** shows the basic specifications of the systems along with a comparison with those of existing 11/15G-26MD [1]–[3].

3. System Configuration

Figure 2 shows the system configurations. The systems modulate base band signals received from external transmission equipment via the 150M INTerface (INT) into 64 Quadrature

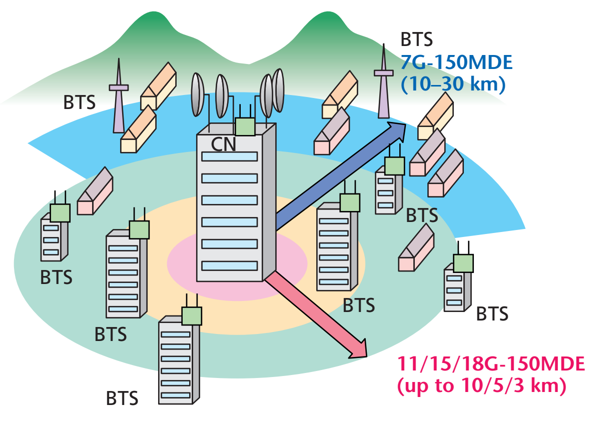


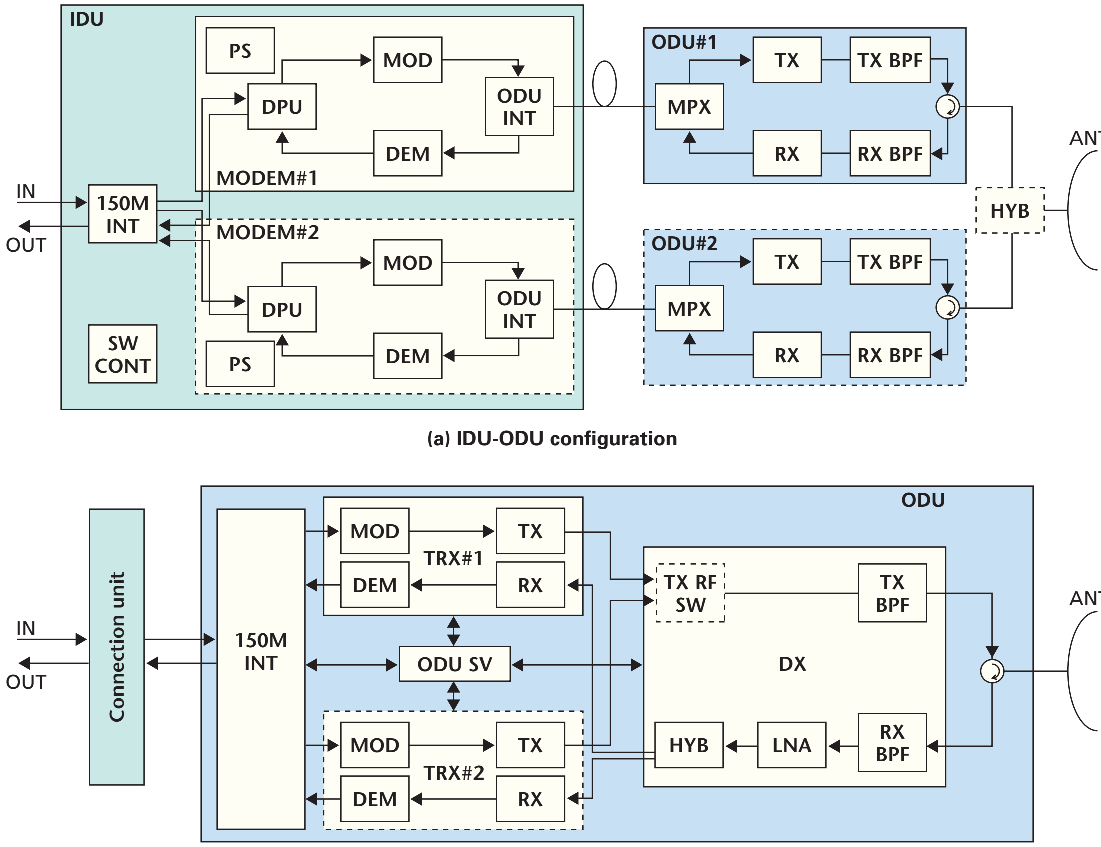
Figure 1 Applicable range of fixed wireless systems with large transmission capacity for entrance circuits (hop length)

Photo 1 External views of 11-150MDE (IDU-ODU configuration)

Table 1 Basic specifications of fixed wireless systems with large transmission capacity for entrance circuits

	7G-150MDE 11/15/18G-150MDE		Existing System (11/15G-26MD)	
Frequency band	7G-150MDE	6.57–6.87, 7.425–7.75 GHz	11G-26MD	10.7–11.7 GHz
	11G-150MDE	10.7–11.7 GHz		
	15G-150MDE	14.4–15.23 GHz	15G-26MD	14.4–15.23 GHz
	18G-150MDE	17.85–17.97, 18.6–18.72 GHz		
Frequency assignment (frequency interval between upstream and downstream)	7G-150MDE	40 MHz spacing (160 MHz)	11G-26MD	20 MHz spacing (530 MHz)
	11G-150MDE	40 MHz spacing (530 MHz)		
	15G-150MDE	40 MHz spacing (470 MHz)	15G-26MD	20 MHz spacing (470 MHz)
	18G-150MDE	40 MHz spacing (750 MHz)		
Transmission power	7G-150MDE	22/30 dBm	11G-26MD	28/31 dBm
	11G-150MDE	30 dBm		
	15G-150MDE	26 dBm	15G-26MD	24/28 dBm
	18G-150MDE	20 dBm		
Noise figure	5 dB			
Modulation scheme	64QAM		4PSK	
Occupied bandwidth	36.5 MHz or less		18.5 MHz or less	
Equalizer	DFE			
System configuration	1+1 (hot standby)/1+0 (without redundancy)		1+1 (hot standby)	
Transmission capacity	155.52 Mbit/s		25.248 Mbit/s	
Antenna diameter	7 GHz band	0.6/0.9/1.2 mφ	0.75/0.9/1.2 mφ	
	11/15 GHz band	0.75/0.9/1.2 mφ		
	18 GHz ban	0.3/0.75/1.2 mφ		

PSK: Phase Shift Keying
DFE: Decision Feedback Equalizer



(a) IDU-ODU configuration

(b) All-ODU configuration

BPF: Band Pass Filter
DEM: DEModulator
DPU: Digital Processing Unit
DX: DupleXer
HYB: HYBrid
LNA: Low Noise Amplifier
MODEM: MOdulator-DEModulator
MPX: MultiPleXer
PS: Power Supply unit
RFSW: Radio Frequency SWitch
SV: SurVeillance unit
SW CONT: SWitch CONTroller
TRX: TRansceiver unit

Figure 2 System configuration

Amplitude Modulation (QAM) signals of intermediate frequency with the MODulator (MOD), convert and amplify the signals to 64QAM signals of radio frequency with the Transmitter unit (TX) and then transmit them from the ANTenna (ANT). Conversely, when receiving 64QAM signals of radio frequency via ANT, the systems amplify and convert them into 64QAM signals of intermediate frequency with the Receiver unit (RX), demodulate them into base band signals with the DEModulator (DEM) and then output them to external transmission equipment via 150M INT.

As the systems have "IDU-ODU" or "all-ODU" configuration, which depends on the manufacturer, the advantage of each configuration makes installation and maintenance easy. The dotted lines in Fig. 2 indicate additional components for redundancy, which can be installed when the 1+1 (hot standby) configuration is adopted.

1) IDU-ODU Configuration

In this configuration, the equipment is divided into ODU containing the TRansceiver (TRX) and IDU containing the MOdulator-DEModulator (MODEM) etc., and both units are connected with coaxial cables. 64QAM signals of intermediate frequency and surveillance and control signals between IDU and ODU are transmitted over the coaxial cables, and power is supplied to ODU over the same coaxial cables as well. As IDU can be placed indoors, this configuration has the advantage of making the maintenance of IDU easy.

2) All-ODU Configuration

As this configuration contains all the components such as TRX, MODEM and 150M INT in ODU, it requires less indoor space for installation than IDU-ODU configuration does, which makes installation in privately owned buildings easier. It also eliminates the need for coaxial cables between IDU and ODU, which means that the cable equalizer is unnecessary. Note that the external connection unit with terminals for base band signals, surveillance and control signals and power supply is used in order to make indoor connection with an operation and management system and external transmission equipment easier.

4. System Characteristics

1) Expansion of Transmission Capacity

This is the first time 64QAM modulation has been adopted for fixed wireless systems for entrance circuits in Japan, and a transmission capacity of 155.52 Mbit/s has been achieved. It greatly improves the spectrum efficiency and significantly contributes to the reduction of the transmission link cost per bit.

2) Support for New Radio Frequency Bands

In addition to the conventionally assigned radio frequency bands (11/15 GHz band), the systems make use of the 7 GHz band (6.5/7.5 GHz band) and the 18 GHz band, which were newly assigned for entrance circuits in Japan. The restrictions imposed by the Radio Law are relaxed in the 18 GHz band, which allows the use of small-diameter parabola antennae (0.3 mϕ), making the installation easier and more economical.

3) Reduction of Size and Improvement of Economy

In addition, the following points were taken into consideration for specifications, so that replacing existing systems can be conducted efficiently and at low cost.

- MODEM, 150M INT and other components that do not depend on radio frequency are shared by each system in order to reduce the equipment costs.
- Only STM-1 (155.52 Mbit/s) of Synchronous Transfer Mode (STM) is adopted for the transmission interface. The systems process STM's physical layer only, so even if the upper layers of base band signals are changed in the future, for instance due to migration from Asynchronous Transfer Mode (ATM) to Internet Protocol (IP), the systems can be used without any changes of their functions.
- General-purpose Simple Network Management Protocol (SNMP) is adopted for operation and management system interfaces in order to reduce the equipment costs.
- Considering the low use of redundant components in existing systems, standard system configuration is without redundancy, and users can add redundant components according to the desired reliability and installation costs.
- Connector shapes and metal fixtures for installation are designed such that antennae of existing 11/15G-26MD can be reused easily and economically when existing 11/15G-26MD is replaced with 11/15G-150MDE.
- Compared to existing 11/15G-26MD, a volume reduction of approximately 20% is achieved by using Large Scale Integration circuit (LSI), simplifying the transmission interfaces and various heat release methods.

5. Conclusion

This article presented an overview of the fixed wireless systems with large transmission capacity developed to support the rapid traffic increase of entrance circuits in FOMA and explained the system configurations and characteristics. The systems introduced in this article have already been put into operation and are contributing to the efficient and economical operation of DoCoMo networks. In the future, DoCoMo intends to continue examining new ways to achieve more economical and larger transmission capacity.

References

[1] T. Agari et al.: "Link Equipment Technologies," NTT DoCoMo Technical Journal, Vol. 3, No. 3, pp. 31–40, Dec. 2001.

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[3] M. Tanizawa, Y. Torai, H. Arai, A. Yamada and H. Nakamura: "11/15/18 GHz Radio Equipments for Large Capacity Links," Institute of Electronics, Information and Communication Engineers conference, 2005, B-5-247 (in Japanese).

Abbreviations

ATM: Asynchronous Transfer Mode
BTS: Base Transceiver Station
CN: Connection Node
IP: Internet Protocol
LSI: Large Scale Integration circuit
PSK: Phase Shift Keying
QAM: Quadrature Amplitude Modulation
SNMP: Simple Network Management Protocol
STM: Synchronous Transfer Mode