3-5 Broadcasting Systems

3-5-1 An Advanced CATV System with Wireless Distribution

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CATV(Community Antenna TV) has been started as a measure intended to improve the poor reception area since 1955 at the spa of Ikaho in Gunma prefecture. Recently CATV has come into the limelight as a multi program distributor and a new transmission media of the broadband Internet. The percentage of household CATV sets is 22% in 2000 in Japan.

The wireless distributed CATV system is able to complement the wired system. It is serviceable in where the cable cannot lay, such as the area studded with houses or isolated island.

In this paper, an advanced CATV system with wireless distribution is mentioned. The frequency band is the millimeter-wave band, because it has the characteristic of allowing broadband transmission and miniaturization of devices. The link budget of the test system using 60-GHz band is also described.

Keywords
CATV system with wireless distribution, millimeter-wave, broadband transmission, improvement of the poor reception area

1 Introduction

In Japan, CATV (Community Antenna TV) was first introduced as a measure to improve reception in poor reception areas at the Spa of Ikaho in Gunma Prefecture in 1955 (two years after TV broadcasting began). As high-rise buildings appeared in urban areas, “ghost images” became a widespread problem. Since then, CATV has been acknowledged as an effective measure against radio disturbances in these areas, serving as an method complementing terrestrial wireless transmission and enabling program reception even in areas with strong electric fields. Recently, it has entered the limelight as multi-program distributor and a new transmission medium for the broadband Internet, using coaxial cable. According to an investigation by the Ministry of Public Management, Home Affairs, Posts and Tele communications, 10.48 million households watched self-originating broadcast urban CATV by the end of fiscal year 2000, amounting to 22 percent of households in Japan (see Fig.1).

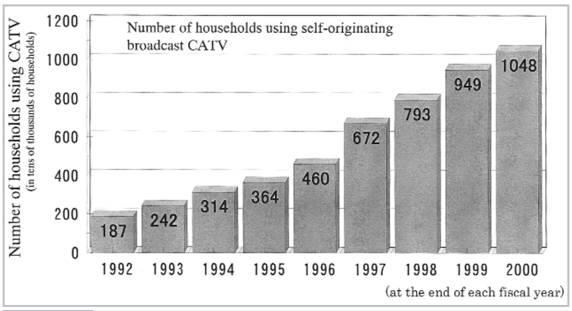

Fig.1 *Spread of CATV in Japan*

In this report, we discuss a study of the wireless distribution of CATV programs as a complement to cable transmission for the efficient operation of CATV in areas where laying of cables is difficult (such as in areas of low population density, apartment buildings, and urban areas lacking utility poles). We began studying a bidirectional radio transmission

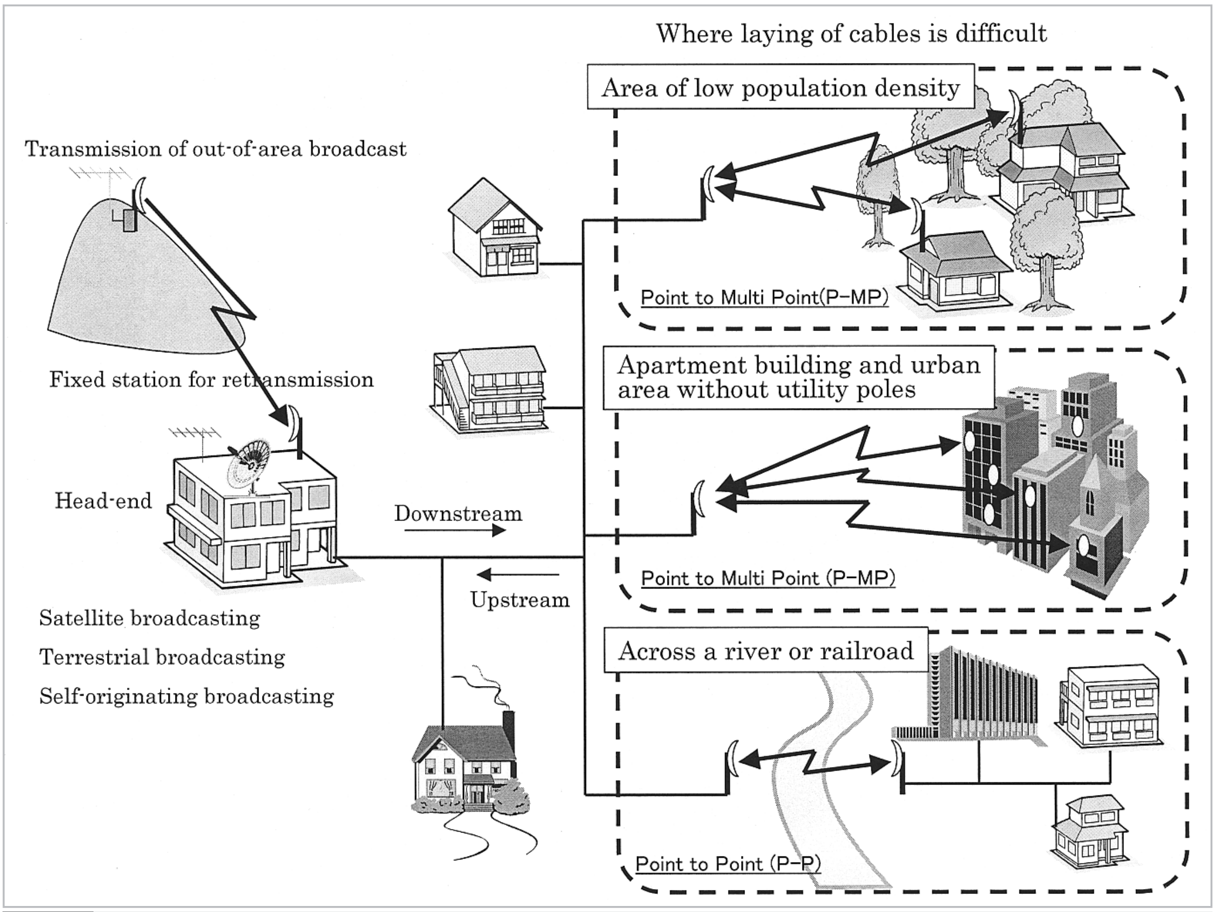

Fig.2 *Applications for wireless distribution of CATV*

system, using the 60-GHz band, anticipating growing use of various radio waves within this frequency band and the recent implementation of wireless CATV distribution, after the report entitled[1] "Technical Conditions for Radio Equipment Using Radio Waves at Frequency Band of 60 GHz" was submitted by the Telecommunications Technology Council and incorporated into legislation in 2000.

2 Need for CATV system with wireless distribution

Fig.2 shows how the wireless distribution of CATV programs works. As a complementary means to cable transmission, such a system can serve areas where laying cable is difficult. It is also useful in areas where laying cable is physically feasible but economically unfeasible due to low population density, in apartment buildings where cable installation is not physically feasible (or there is insufficient demand among residents), and in urban areas without utility poles due to the use of underground cables. These applications fall within the mode referred to as "point to multi points" (P-MP) where terminals of separate ground-based lines are linked by wireless transmission. The alternate "point to point" (P-P) mode is applied to cases when radio transmission is used to go over a river or railroad tracks. Currently, there is a radio distribution system of CATV programs in use: a fixed station for retransmission placed at a mountaintop to receive out-of-area broadcasts and relay them by radio to a head-end (or a CATV station).

3 Preliminary examination of a wireless distribution system

Bands of 23 GHz, 40 GHz, and 60 GHz are allocated to radio transmission for CATV. The 23-GHz band is already available, pur-

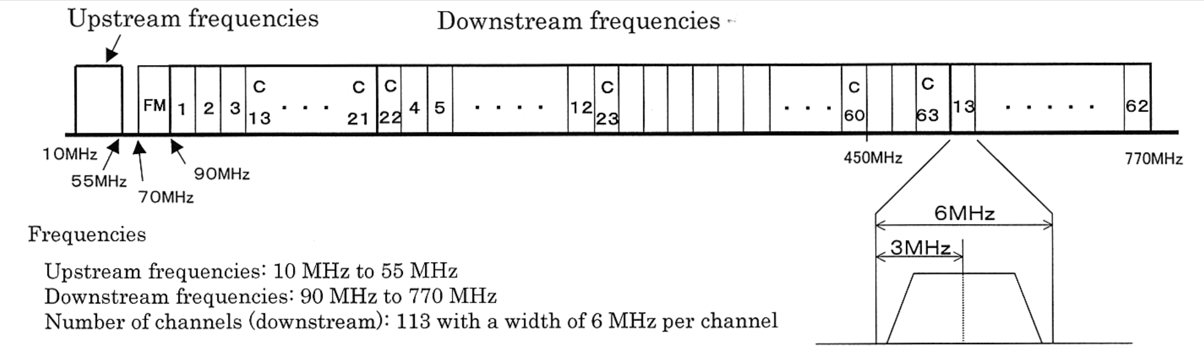

Fig.3 *Frequency allocation for CATV*

suant to legislation passed in 1998[2]. This band has a width of only 400 MHz and is not capable of transmitting the entire 770-MHz band of CATV, allowing only downlink (one-way) multiaddress transmission. The Japan Cable Television Engineering Association is currently leading a study of the 40-GHz band to establish a technical standard. Its frequency bandwidth is planned at 1 GHz. The 40-GHz band is capable of the bidirectional transmission under consideration: both 770-MHz bands, downstream and upstream, of CATV. While the 60-GHz band has a bandwidth of 7 GHz, its usable bandwidth for a specified low power radio station is scheduled to be 2.5 GHz or less. For this report, we studied a system for bidirectional transmission within a bandwidth of 1 GHz, same as the case of the 40-GHz band.

Fig.3 shows the arrangement of frequencies in a digital CATV broadcast. The upstream frequencies lie between 10 MHz and 55 MHz, while the downstream frequencies for FM broadcasts range from 70 MHz to 90 MHz and those for TV broadcasts range from 90 MHz to 770 MHz. There are 113 channels of TV broadcasts allotted, with a width of 6 MHz per channel. In our study, the upstream frequencies between 10 MHz and 55 MHz and the downstream frequencies between 70 MHz and 770 MHz are converted into a 60-GHz band by frequency conversion.

A specified low power radio station is scheduled to have a range of usable frequencies between 59 GHz and 66 GHz. Waves near 60 GHz are significantly attenuated, due to absorption by oxygen. We also note that the specified transmission power for a radio station is as low as 10 mW. Thus, we decided to study a radio transmission system in a 1-GHz range between 64 GHz and 65 GHz, where the absorption is relatively small. Fig.4 shows observations of rain attenuation per km at 60 GHz in large cities in Japan[3]. Since attenuation varies according to the serviceability ratio, we determined rain attenuation to be about 8.5 dB at 64 GHz, which is 0.1 % of the cumulative distribution in Tokyo and considered to be average. We applied this value to estimate a relationship between the distance of transmission and the number of channels. As for the downstream CATV line, the estimation was based on the line properties given in Table 1. The frequency lies between 64 GHz and 65 GHz, the transmission power is 10 mW, the antenna gain is 33 dBi for receiving and transmitting for the P-P mode of transmission, and the beam width is about 2 degrees. In the P-MP mode, the transmission antenna gain is 15 dBi, the antenna beam angle is about 60 degrees, the receiving antenna gain is 33 dBi, the beam width is about 2 degrees, and the total feeder loss in transmitting and receiving is 1 dB. The noise figure (NF) of a receiver was assumed to be 10 dB, the atmospheric attenuation to be 6.6 dB per km, and the rain attenuation to be 8.5 dB per km. We also considered the mode of digital transmission in this study. The receive C/N was taken at 26 dB, which corresponded to the BER value of 10^{-4} without error correction for 64QAM, the CATV modulation system.

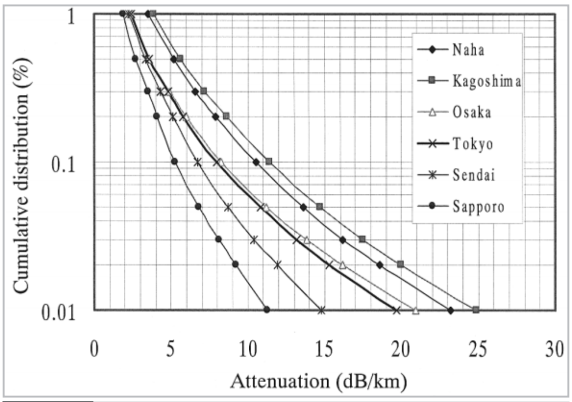

Fig.4 Rain Attenuation at 60 GHz

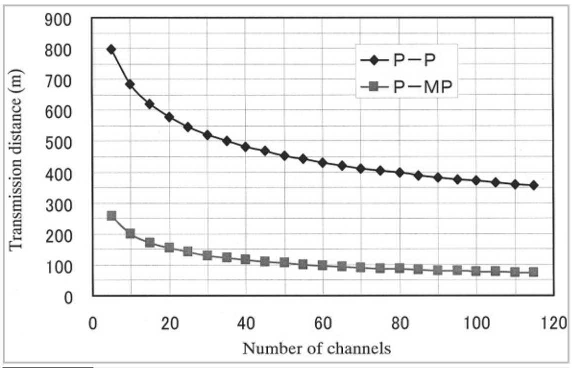

Fig.5 Relationship between the number of channels and transmission distance

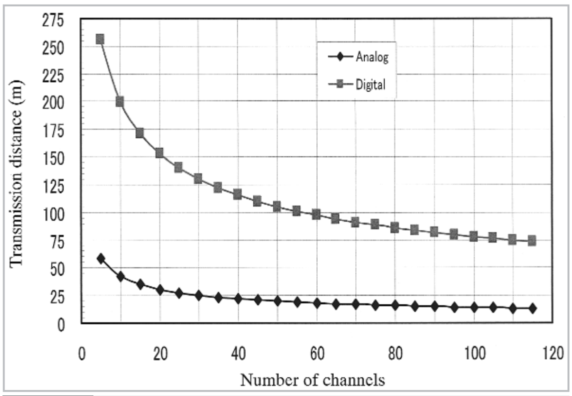

Fig.6 Transmission distance for digital transmission and analog transmission

Fig.5 shows the number of transmission channels on the horizontal axis and transmission distance on the vertical axis. This estimation indicates that as the number of channels increases, the transmission distance decreases. This is because the larger the number of channels, the less power is required per channel. For transmission of full channels, the distance is about 350 meters for the P-P mode of transmission and about 75 meters for P-MP. Fig.6 shows a similar estimate for P-MP in the analog NTSC mode of transmission and in the digital mode of transmission. This estimation was also based on the properties given in Table 1. Here, the value of C/N for NTSC, an analog TV standard, is 42 dB, equaling the desired performance (detectable limit) given in the report of Telecommunications Technology Council in 1987. For NTSC, the transmission distance is about 20 meters for 50 channels and 13 meters for full channels.

In the case of an apartment building, the multipath effect might affect radio transmission. With an antenna beam angle of 60 degrees for the key station and an antenna beam width of 2 degrees for the subscriber, this effect might appear after two reflections, depending on the shape of the building. In this study, this effect is considered to be small, as the beam width is small for the subscriber and because the radio wave attenuates through ultiple reflections.

Table 1 Line properties of the experimental apparatus

Frequency	64 to 65 GHz
Transmission power	10mW
Antenna gain and beam width P-P P-MP	 33dBi 2degrees 15dBi 60degrees (key station) 33dBi 2degrees (mobile unit)
Feeder loss	1dB
Noise figure	10dB
Atmospheric attenuation	6.6dB/km
Rain attenuation	8.5dB/km
Receive C/N	26dB (64QAM) 42dB (NTSC)

4 Outline of experimental work

After the above preliminary examination of a wireless distribution system, we are now conducting an illustrative experiment. Fig.7 shows the arrangement of units within the two systems of this experiment. Both the key station and subscriber units have the same struc-

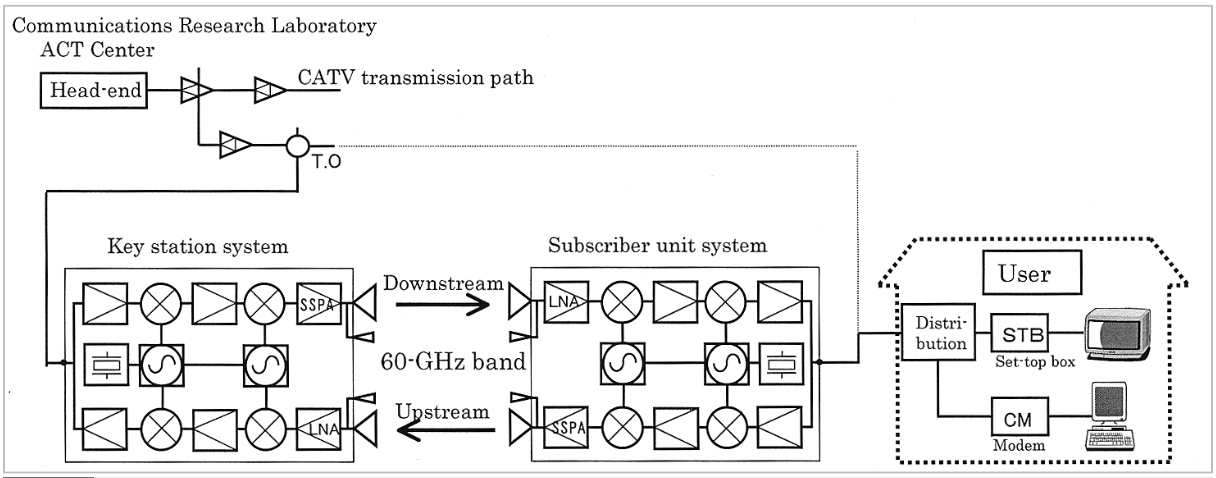

Fig.7 Arrangement of units in a CATV system with wireless distribution

ture. Table 2 describes their specifications. Downstream frequencies lie in a 700-MHz band between 64.27 GHz and 64.97 GHz, while upstream frequencies lie between 64.010 GHz and 64.055 GHz. Prior to conversion, the interval between the upstream and downstream frequencies is as small as 15 MHz, making it impossible to separate them by filters after conversion of the frequencies. Thus, in the 60-GHz band, the interval was found to be 215 MHz, as determined from the above frequency values. The antennas are separated, to prevent interference between transmission and reception and to reduce loss due to diplexers. The narrow-angle lens horn antennas (approximately 10 cm in diameter) demonstrate a gain of 35 dBi, while the large-angle sectoral horn antennas have a gain of 15 dBi. The maximum transmission power is 10 mW for both key station and subscriber units. The frequency converters are of the double-conversion type.

Table 2 Specifications of the experimental apparatus

Frequencies	
Downstream	64.27 to 64.97GHz
Upstream	64.010 to 64.055GHz
Antenna form and gain	Lens horn (10cm in diameter): 35dBi Horn (wide-angle antenna): 15dBi
Polarized electro-magnetic radiation	Linear polarization
Transmission power	10mW (maximum)

Fig.8 is a photograph showing the experimental system. The key station is on the right, while the subscriber unit is on the left. The wide-band horn antennas are attached to the lower waveguides. They can be switched to the narrow-band lens horn antennas (placed on the upper side) by turning a waveguide knob located on the side of each unit. This allows us to conduct both P-P and P-MP experiments. The central unit is used to simulate a change in transmission distance by changing the value of the attenuator in a pseudo transmission path. Currently, we are conducting a bidirectional transmission experiment using the equipment at the CATV standardization facility (known as the ACT Center) of the Communications Research Laboratory. Fig.9 shows examples of the experimental results, consisting of measured bit error rates when transmitting digital signals using the pseudo transmission path. The required C/N degradation rate was about 2 dB.

5 Concluding remarks

We outlined a CATV system with wireless distribution using the 60-GHz band under consideration. The apparatus we have developed will serve to test multi-program transmission and bidirectional in a wireless system.

CATV is a versatile tool that can be used not only for broadcasting but also for telephone and Internet. Since it can be connected to radio on fiber, a CATV system with mobile applications is currently under investigation[4]. We intend to extend the present study to combined systems of wireless and wired transmission of broadcasting and communications.

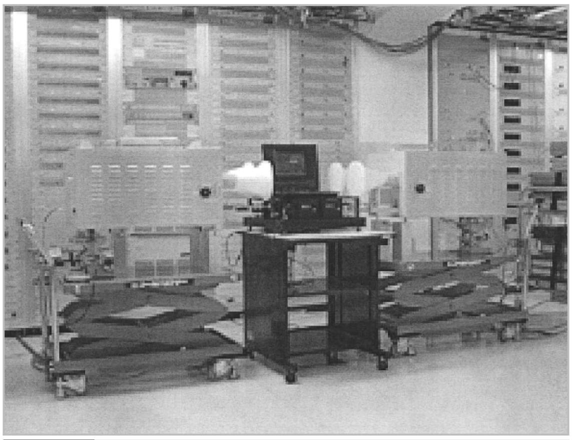

Fig.8 Experimental system appearance

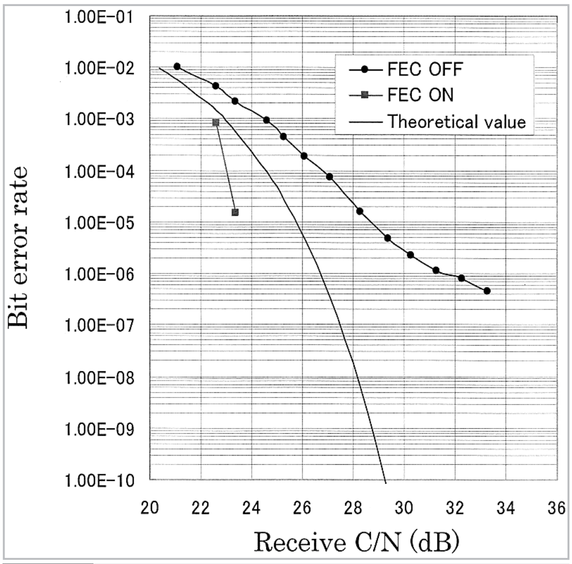

Fig.9 Relationship between the bit error rate and receive C/N of the experimental

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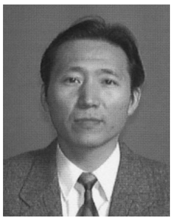

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Digital Broadcasting