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Cellular / Wireless LAN Repeater System by Wireless Optical Link with Optical Power Supply

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Abstract: - Wireless market, such as cellular systems and wireless LAN, becomes huge and is still expanding. Since operational frequency and transmission bit rate are increasing, much more base stations or access points are necessary to overcome capacity and link budget problems. Most of the places suitable for the base station were already occupied by the existing systems. In the future, sometimes, new base station must be installed at the places where power supply or transmission cable is not available. The proposed repeater system is applicable for such case. The RF signals are fed to the repeater through the air by optical beams. And electrical power is fed by the optical beam, too. This paper describes the design principle and experimental results of the proposed system. For example, by using 26cm diameter optical beam for power transmission, available forward link RF power at the repeater station is 10mW in the case that the distance between the base station and the repeater station is 40 m. If a diameter of the optical beam for power transmission is 48 cm, 100 mW RF output power is available for a forward link. Since micro cell structure will become majority in the future high frequency and high bit rate cellular and wireless LAN systems, these amount of RF output power may be enough for many cases.

Key-Words: - RoF, Wireless, Optical Transmission, Optical Power Transmission, Cellular System

1 Introduction

A number of cellular base stations increases according to the increase of subscribers and transmission bit rates. It is getting difficult to build new base stations, especially in urban area. In some cases, the base station must be built on the place where neither transmission cable nor electrical power supply is available. The proposed system is applicable as a feed system in such a case.

Currently, a Radio on (over) fiber (RoF) technology is applied for the in-building cellular systems, in which repeater stations are equipped on every floor in order to provide cellular services wherever in the building. The advantage is that the size of the repeater stations equipped for ceilings are very compact because they are composed of only Electric to Optic (E/O) transducer, amplifier and antenna [1][2][3].

A power supply-less RoF technology was developed to enhance flexibility for installing repeater stations [4][5][6]. Electrical power is fed to the repeater station through the optical fiber in the form of optical energy. The optical fiber power transmission technology was already applied in the various applications, such as television broadcast repeater (gap filler) stations and remote video cameras [7]-[13]. In the former case, a receiver and a transmitter are separated by the optical cables, and the receiver power is supplied by not a wire but a fiber in order to avoid the lightning shock to the system. If a metal wire were used to connect the receiver to the transmitter, the system would easily suffer lightning. Using a high power laser of which output power is 300 mW, electrical power of around 30mW is supplied to the receiver which is 6 km apart from the transmitter. In the latter case, two graded index optical fibers are used and 400mW electrical power is supplied to the camera by two 0.8 μm lasers of which output powers are 1 W, respectively. It is said that the optical power can be fed to the fiber as much as 1 W without any damage in the fiber [14][15].

Figure 1 shows the power supply-less RoF system structure [4]. The system is composed of a base station and a repeater station. Forward link RF signal modulates optical transmit power and a photo diode recovers the RF signal at the repeater station. Optical power is generated by other high power laser. The electrical power is obtained by efficient high power photo diode at the repeater station. This electrical power is fed to other components, such as an amplifier and a laser diode.

Proposed system is based on the same principle, but the optical fiber is replaced to an optical wireless transmission.

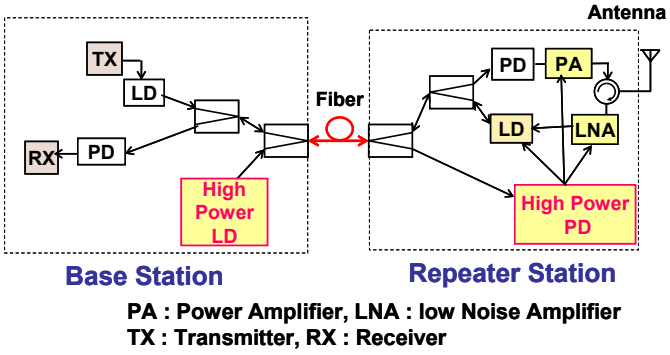

Fig.1 Power Supply-Less RoF System Structure

A fiber-space full optical connection technology is applicable for the optical signal transmission through the air, taken into account [16]. Separated two fibers are connected through the air using lenses. The system has tracking capability to over come air turbulence.

The proposed system uses the fiber-space full optical connection technology to transmit RF signals through the air. In addition, a power supply technology by an optical wireless transmission was newly developed. This paper describes the concept, technology and experimental results of a wireless optical feed system with optical power transmission.

2 System Configuration

Figure 2 shows an image of the proposed system and Fig. 3 is a block diagram of the system. There are two stations. One is a base station and the other is a repeater station. The base station is connected to a switching station in the cellular system. The repeater station communicates with mobile terminals through the antenna. In this paper, the repeater station is supposed to be equipped on the place where both the transmission cable and the power supply do not exist.

There are three optical beams between the base station and the repeater station. Two of them carry RF signals. 1st beam is for a forward link and 2nd beam is for a reverse link. These two beams can be integrated into one beam if duplexer or half-mirror is applied. A 3rd beam transmits electrical power by optical energy. Lenses or parabolic reflectors are used so as to converge the optical beams.

As for the forward link, optical waves emitted from a LD (Laser Diode) is modulated by RF (Radio Frequency) signal which comes from TX. At the repeater station, a PD (Photo Diode) transduces optical signal to RF signal. A power amplifier is used to increase RF power to the specified output level. As for the 2nd beam, each component plays same role as that of the 1st beam, except to employ a low noise amplifier instead of the power amplifier for amplifying received signal from mobile terminals.

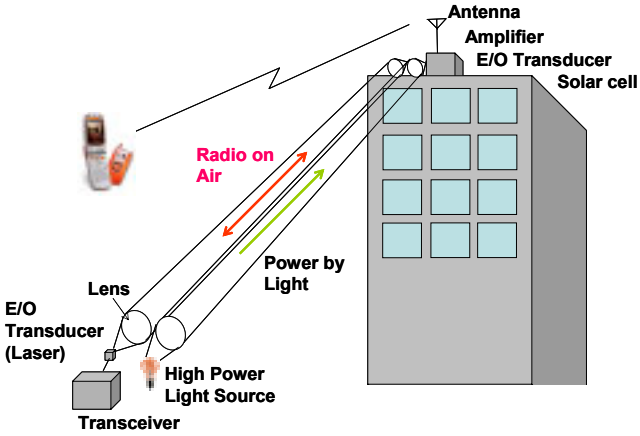

Fig.2 Proposed System Image

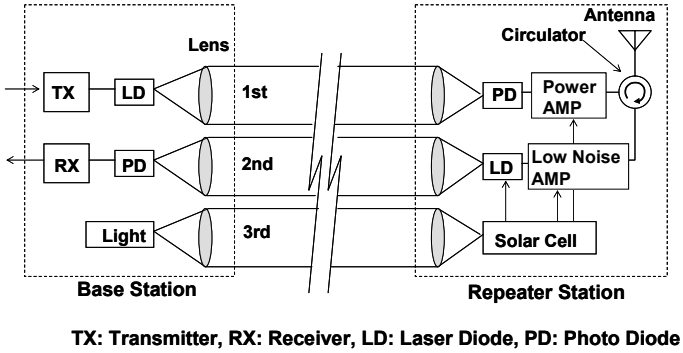

Fig.3 Proposed System Configuration

A strong light source is necessary for a 3rd beam. A high power laser is applicable, however it has a problem about eye safety. Therefore, a conventional high power light bulb is used in the proposed system. At the repeater station, received optical energy is converted to electric power by a solar cell and the obtained electric power is used to drive the LD and amplifiers.

Table 1 shows the technical requirements for the optical components used in Fig.1.

Table 1 Technical Requirements