Radio Communication System Using Partial Leakage Coaxial Cables

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1. Introduction

With the rapid growth of wireless services the various radio waves which frequency and modulation method are different from are radiated between the several equipments. In the environment there are radio waves of the frequency such as, RFID, cellular phone, Bluetooth and wireless LAN. Whereas the communication by wireless has flexibility in the point of the establishment and the employment, the radio wave doesn't reach when there is an obstacle between the communication equipments. The weak place of the radio wave is made by interference due to the multi-path which happens by the reflection wave such as a wall in the neighborhood and so on. If a transmission distance becomes long, radio waves do not reach due to the propagation loss of the free space. On the security side, bugging, interpolation of the information, and so on cause a trouble due to the leakage of the radio wave. On the other hand the security is good in the wire communication, and the transmission distance can be extended with a few transmission losses and stable communications. However, because the equipment is connected with the wire directly, it does not have flexibility like wireless connection.

In this paper, we propose the radio communication system using partial leakage coaxial cables. This system is substituted for the existent signal transmission between the wireless systems with coaxial cables. By doing so, a transmission distance grows, and the unnecessary radio radiation can be restrained by supplying a radio wave only to the necessary place. Obtaining the good security and the high flexibility of the radio is aimed for.

2. The principle of the proposal system and experiment model

When the radio wave is radiated in the free space by a wireless system, for example wireless LAN and Bluetooth, the power radiated by the antenna falls off with r^{-2} (where r is distance from the antenna), as shown in Fig. 1. In the case of the small dipole or loop antenna like RFID, the power drops off with r^{-6}. The graph in the bottom of the Fig.1 shows the power density decayed by distance r. It can't communicate with less threshold level any more. This system transmits the radio waves received in the antenna once with the coaxial cables through the cable between the two points (b) and (d) of Fig. 1 . Then, it is radiated from the antenna of the access point (d) of Fig. 1 again. The amount of conductor loss of the coaxial cables' own, the radiations of the antenna and conversion loss are small in comparison with the diffusion loss in these losses. Then, the transmission distance can be extended from the point (c) to the point (e) of Fig. 1 by the

coaxial cable. As a result, there is also an advantage that an access point can be installed by using the coaxial cables in the area which can't communicate by the radio wave.
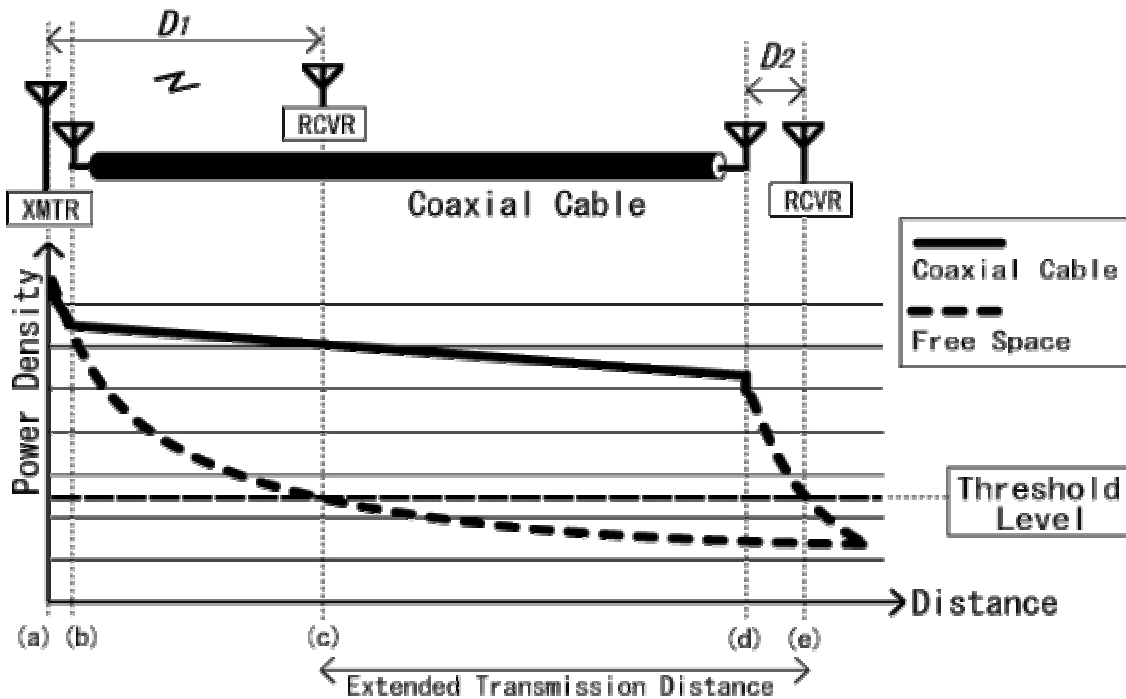
Fig.1 The principle of the proposal system and experiment model

2. Experimental investigation

With the experiment model as shown in Fig.1, the electric field intensity in the receiving antenna was measured. The access point installed in the point where it was extended with the cable of 20m is shown in Fig. 2. For 2.45GHz of wireless LAN it is a parabolic reflector antenna, and for 315MHz of electronic weak wave it is a monopole antenna, and for 13.56MHz of RFID it is a loop antenna. Then, the behavior in the access


(a) 2.45GHz   **(b)** 315MHz   **(c)** 13.56MHz

Fig.2 The appearance of the antennas for reception and transmission in access point

point of the experiment system, which used each frequency band, was confirmed. The communication distance D_2 for two points (d) and (e) of Fig. 1 becomes short when it is compared with the distance that communication is directly possible from D_1 for two points (a) and (c). For example with measuring at 13.56MHz, D_2 is about 5cm, though D_1 is about 10cm. In other frequency band, though D_2 becomes short, the total transmission distance for two points (a) and (e) of Fig. 1 becomes long also. It confirmed that the same coaxial cable could be used with the wireless system of these different frequency bands, too.
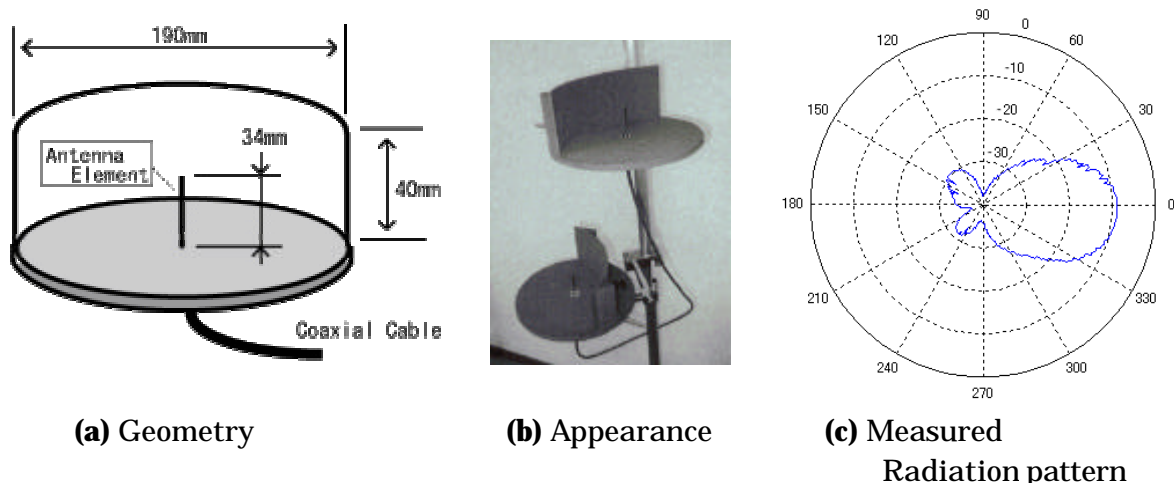
2. The application example of the system and results

An application example of the proposal system is shown in Fig.3. The system can be built by using the existing coaxial cable for the television. By using the electromagnetic coupling type antenna, the same cable is used for the communication in the different frequency bands.
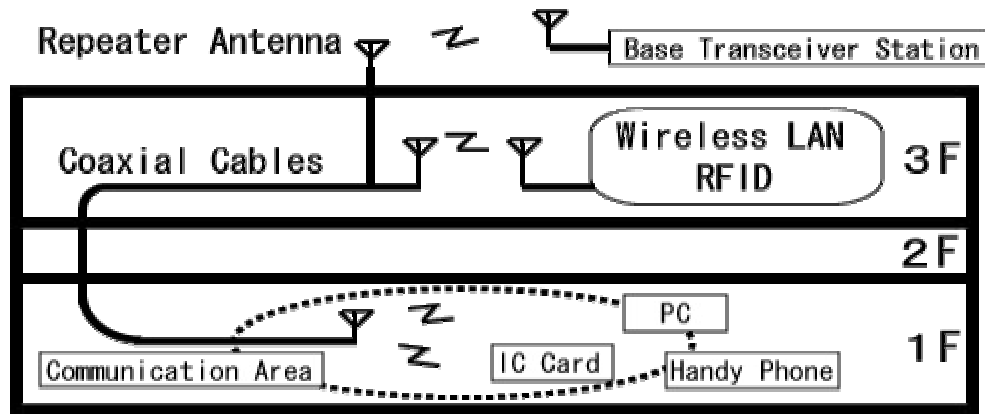
Fig.3 Radio communication system using coaxial cables.

As a practical example, in particular, we investigate the radio communication system utilizing the 2GHz band, which consisted of the coaxial cables and parabolic reflector antennas. Fig.4 (a) shows the configuration of the parabolic antenna, which is designed to work in the 2GHz frequency band. This antenna is made of plastic coated with the electrically conductive paints as shown in Fig. 4 (b).

(a) Geometry   **(b)** Appearance   **(c)** Measured
                                                                   Radiation pattern

Fig.4 Parabolic reflector antenna

The design parameters of the proposed parabolic reflector antenna are set as follows; element length is 34mm; parabola width is 190mm; parabola height is 40mm; parabola focal distance is 57mm. Fig.4 (c) shows the measured radiation pattern of the parabolic antenna in the unechoic room. By the effect of the parabola, we see the sharp directivity pattern and little backward radiation.

The practical model of the system which consists of these two parabolic reflector antennas connected with the coaxial cable was built and installed in the mountain area, on the upper level of the high-rise building, and so on. Fig.5 shows the practical

propagation model. As the antenna in the base station is usually set up downward so that it can communicate suitably on the ground, the radio wave from the nearby base station becomes weak on the upper level of the high-rise building. When the base station is in the distance, a weak radio wave and a reflection wave are received. The proposed system was installed in several points where the weak radio wave comes and which interference happens in, and we examined the characteristics in the 2GHz frequency band.

Using the cellular phone and the measurement equipment, it is observed that received signal code power (RSCP) is increased with the proposed system. The strength of the radio wave improved in comparison with the one without this system as much as 5dB.
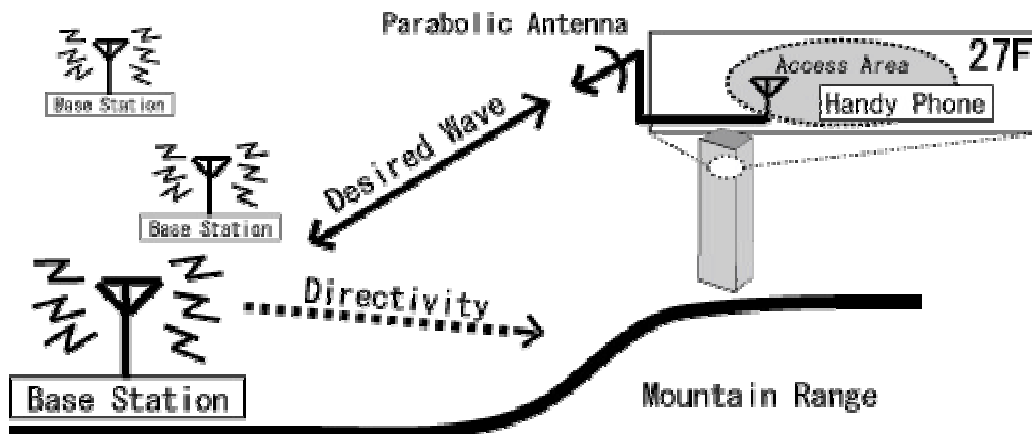
Fig.5 Practical Propagation Model

5. Conclusion

In this paper, the effect of the radio communication system using coaxial cables has been investigated. By installing a proposed system, it confirmed that the telephone call of the cellular telephone became stable even in the area which radio wave conditions were bad for. As a result of measuring the power reradiated by the antenna, the validity of the signal propagation between the wireless systems with the coaxial cables is proposed. Even the reduction unnecessary radiation is effective by utilizing the coaxial cables and limiting directivity of the parabolic reflector antenna.

As a future subject, there are the antenna design because of the profit improvement, optimization of directivity and introduction of this system in other frequency bands.

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