PAPER Special Issue on Recent Progress in Electromagnetic Compatibility Technology

Requirements for Controlling Coverage of 2.4-GHz-Band Wireless LANs by Using Partitions with Absorbing Board

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SUMMARY For a wireless communication system to work effectively without interference, the electromagnetic environment needs to be controlled. We experimentally and analytically investigated the requirements for controlling the electrical field strength and delay spread so as to achieve the best communication without electromagnetic interference in selected regions for a 2.4-GHz-band wireless LAN system. To control the coverage, partitions were placed around desks in a test environment and covered on the inside with electromagnetic absorbing board from the top of the desks to the top of the partitions; four indoor environments that combined one of two wall-material types and one of two partition heights were used. The transmission loss and delay spread were measured, then calculated using ray tracing to verify the effectiveness of using ray-tracing calculation. The throughput and BER characteristics were measured for the same environments to clarify the requirements for controlling the coverage. We found that covered and uncovered regions could be created by using partitions with absorbing boards and that the delay spread must be less than 15 ns and the received-signal must be stronger than −75 dBm for a region to be covered. We verified that the delay spread can be calculated to within 5 ns and the received-signal level can be calculated to within 5 dB of the measured data by using ray tracing. Therefore, ray tracing can be used to design antenna positions and indoor environments where electromagnetic environments are controlled for 2.4-GHz-band wireless LAN systems.

key words: *electromagnetic absorbing board, indoor environment, 2.4-GHz ISM-band wireless LAN, transmission loss, delay spread, throughput, BER*

1. Introduction

Wireless communication systems that use the microwave band have been installed in many offices. These systems include 2.4-GHz industrial, scientific, and medical (ISM) band wireless local area networks (LANs) [1], [2] and 1.9-GHz-band (in Japan) cordless phones. However, if the system or the indoor environment is large and complex, electromagnetic interference may occur [3]-[5]. For example, a shortage of channels may lead to channel collisions, and strongly reflected waves may lead to bit errors. Therefore, the indoor electromagnetic environment must be controlled for a wireless communication system to work effectively.

Improving the antenna systems [6] and signal-processing systems [7] are two ways to control the coverage of wireless systems. Another way is to use suitable building materials and position them appropriately [8], [9]. Because most 2.4-GHz-band wireless LANs use non-directional antennas to make it easy for users to install them, improving the antenna system is not an effective approach. Using suitable building materials and positioning them appropriately may be a better approach. For this approach, although the relationship between indoor propagation characteristics and the performance of a 2.4-GHz-band wireless LAN in a simple room has been investigated in [9], its relationship in complex office environments and a method for controlling coverage of the wireless LAN has not been investigated. Moreover, several kinds of electromagnetic absorbing boards have been tested [10] for controlling the electromagnetic environment for the 2.4-GHz band. However, the methods and requirements for using this approach have not been sufficiently clarified.

We have experimentally and analytically investigated the requirements for controlling the coverage of a 2.4-GHz-band wireless LAN that uses a direct-sequence spread spectrum (DSSS) system and monopole antennas. To control the coverage, partitions were placed around the desks used to hold the LAN equipment and covered on the inside with electromagnetic absorbing board from the top of the desks to the top of the partitions. The transmission loss and delay spread were measured for four indoor environments that combined one of two wall-material types and one of two partition heights. They were also calculated by using ray tracing to verify the effectiveness of using ray-tracing calculation in office environments. The throughput and bit error rate (BER) of a conventional wireless LAN system were also measured, and several requirements for controlling the coverage were identified. Finally, we compared the coverage estimated using ray tracing based on these requirements with the measured data.

2. Configuration of Indoor Environment

The configuration of the indoor environment is shown in Fig. 1. The room [9] was completely enclosed with electromagnetic absorbers to prevent radio waves with the same frequency bands used in our investigations from entering the room. These absorbers also prevented the escape of the radio waves used in our investigations. The room was 9.1 m long, 4.45 m wide, and 2.8 m high. The raised access floor was constructed of metallic plates (0.5 x 0.5 x 0.005 m), typical in Japanese offices. The suspended ceiling was constructed of acoustical squares (0.9 x 0.9 x 0.02 m) made of rock wool, which is also typical in Japanese offices. The walls were either 2-mm-thick metallic plates, common in Japanese offices,

Manuscript received June 28, 1999.
Manuscript revised September 30, 1999.
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