Radiated Electromagnetic Field Immunity Test Method for Wireless LAN

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Abstract: The radiated RF (Radio Frequency) electromagnetic field immunity test to IEEE802.11g was examined by using an opened PW (Parallel Wired) cell. As a result, for IEEE802.11g using OFDM (Orthogonal Frequency Division Multiplexing), it is revealed that the immunity property for the radiated RF electromagnetic field become very wick and decrease by about 30 dB, comparing with that of IEEE802.11b using DSSS (Direct Sequence Spread Spectrum). Next, we studied on the interference test method to IEEE802.11g from IEEE802.11b as a source of the disturbance with wide-band spectrum by using the opened PW cell, and it is clear that the throughput for only 4ch, which frequency spectrum does not almost pile up with IEEE802.11b, is not almost interfered from IEEE802.11b, but the throughputs for all other channel from 5ch to 8ch are interfered and decrease below 2Mbps. In the environment existing both IEEE802.11g and IEEE802.11b, it is very important to set the channel so as to avoid the interference from IEEE802.11b.

Key words: Immunity Test, Wireless LAN, IEEE802.11g, PW Cell, Mutual Interference

1. Introduction

Wireless LAN specified by IEEE802.11 series is attractive communication system for home use as well as business use, especially IEEE802.11g realizes the maximum data rate of 54Mbps by using OFDM (Orthogonal Frequency Division Multiplexing) as a modulation form [1]. IEEE802.11g uses the ISM (Industrial, Scientific and Medical) frequency band (2.4 GHz) as well as IEEE802.11b, and the Bluetooth also uses the ISM frequency band, and then mutual interference among their system becomes very important. The mutual interference between wireless systems is verified by measuring immunity of one system to disturbance from other system. The radiated RF (Radio Frequency) electromagnetic field immunity for the wireless LAN system is usually measured in an anechoic chamber [2]. In this case, an equipment under test (EUT) applied by RF disturbance wave have to communicate a access point (AP), which is usually set out of the anechoic chamber in order to avoid the RF disturbance wave illuminated to EUT. An anechoic chamber is very expensive and has difficulty to communicate between EUT and AP. On the other hand, we proposed new radiated RF electromagnetic field immunity test method for the wireless LAN system, in which a opened parallel wired (PW) cell is used as the electromagnetic cell applying RF disturbance to EUT, and we also examined immunity measurement for a wireless LAN system IEEE802.11b that is modulated by DSSS (Direct Sequence Spread Spectrum) [3].

In this paper, we try to perform the radiated RF electromagnetic field immunity test using the opened PW cell for the wireless LAN system IEEE802.11g modulated by OFDM, in which the disturbance wave to EUT is sinusoidal wave modulated with 80 % amplitude modulation. In addition, we try to examine the mutual interference between IEEE802.11g and IEEE802.11b by using the opened PW cell.

2. Radiated RF Electromagnetic Field Immunity Test Using the Opened PW Cell

Construction of the PW cell is shown in Fig.1. The opened PW cell consists of many parallel wires, which are concentrated to a coaxial connector at input end of the cell and terminated each other by resistors at output end. Central wires as shown in Fig.1 (a) are connected to inner conductor of coaxial connector, and upper and lower wires are connected to outer conductor. If signal frequency applied to the cell exceed to several hundred MHz, resistors at output end does not work and then electromagnetic absorbers composed of a ferrite and a pyramidal absorber including carbon powder are also settled at output end. When an electric signal is applied at input coaxial connector, electric fields are created between central wires and upper or lower wires in the opened PW cell, and impressed to EUT.
Figure 2 shows the construction of the radiated RF electromagnetic field immunity test system for the wireless LAN system. A note PC within wireless LAN card is used as a EUT, which is put on the lower wires of the opened PW cell. A disturbance wave emitted from signal generator is applied on the EUT as an electric field. On the other hand, EUT also communicates radio wave with the AP of wireless LAN installed out of the cell, and sends and receives data. The throughput between the EUT and the AP is measured by sending and receiving data each other. Since the throughput measurement is often influenced by disk access, sending and receiving data are performed by using only a memory.

The disturbance wave applied to EUT is continuous wave, which is modulated with 80% AM by a signal with frequency of 1 kHz. This modulated disturbance wave is usually used to immunity test of radio receiver as well as usual electric and electronic equipments. In order to check dependence on the carrier frequency of the disturbance wave, the carrier frequencies of 2427, 2432, 2437 and 2442 MHz were selected except for the center frequency of 2447 MHz corresponding to 8ch. The spectrum of wireless LAN signal and disturbance wave is shown in Fig. 3.

Figure 4 shows dependencies of a throughput on the applied level of the disturbance wave for the wireless LAN system IEEE802.11g. The applied level of the disturbance wave is very low such as -60 dBm, EUT can communicate with AP almost perfectly, and the throughput of EUT reaches about 14 Mbps. However, as the applied level of the disturbance wave increase, the throughput of EUT decreases abruptly, and fall to zero, and the link between EUT and AP is cut off. We define cut off level as the applied level, on which the link is cut off. When the frequency of the disturbance wave is near the center of bandwidth of EUT such as 2442 and 2437 MHz, the cut off level is very low and around -30dBm. However, when the frequency is just at the center of bandwidth such as 2447 MHz, the cut off level become high and reaches around 10dBm. This is considered that sub carrier wave of OFDM for IEEE802.11g does not exist on the frequency of 2447 MHz and operation of EUT is not affected.

In the radiated RF electromagnetic field immunity test as shown in Fig.4, the disturbance wave is
modulated with 80% AM by a signal with frequency of 1 kHz. In order to know dependence of the modulation, we try to do the immunity test without modulation because the peak amplitude of the disturbance wave is different between with and without the modulations. As a result, it is clear that the relation between the applied level and throughput for the immunity test without the modulation agree with that with the modulation as shown in Fig.4.

Next, we try to compare with the radiated RF electromagnetic field immunity test of IEEE802.11b as shown in Fig.5, which is modulated by DSSS (Direct Sequence Spread Spectrum) [3]. When the applied level of the disturbance wave is very low such as -60 dBm, and the throughput of EUT reaches about 5 Mpbs, but the maximum throughput of IEEE802.11b is small comparing with that of IEEE802.11g, which is about 14 Mbps. However, decreasing dependence of the throughput on the applied level of the disturbance wave for IEEE802.11b is not so steep, and the cut off level of the applied level become very high and reaches at 0 dBm, comparing with that of IEEE802.11g. IEEE802.11g using OFDM is expected as a wireless LAN with high data rate, but it is revealed that the immunity property for the radiated RF electromagnetic field become very wick and decrease by about 30 dB, comparing with that of IEEE802.11b using DSSS. However, since the cut off level on the frequency without the sub carrier wave of OFDM become high and reaches around 10 dBm as shown in 2447 MHz of Fig.4, we can avoid the problem above mentioned by prohibiting to use the frequency corresponding to the disturbance wave as the frequency of sub carrier.

3. Interference Test to wireless LAN IEEE802.11g from IEEE802.11b as a disturbance source

As for IEEE802.11g, it is found that it is interfered in the disturbance with narrow band spectrum from the measurement mentioned in section 2. We worry about interference to IEEE802.11g from the disturbance wave with wide-band spectrum, especially IEEE802.11b has the bandwidth of about 20MHz in the ISM band, which is the same frequency band as IEEE802.11g. Therefore, we try to do interference test to IEEE802.11g from IEEE802.11b as a source of the disturbance with wide-band spectrum by using the opened PW cell.

Figure 6 shows the construction of interference test system to the wireless LAN system IEEE802.11g from IEEE802.11b. The note AP attached the IEEE802.11g card is set inside the PW cell as a EUT, and EUT also communicates on radio wave with the AP installed out of the cell. A signal emitted from a wireless LAN adapter of IEEE802.11b is supplied to the input of the PW cell as a disturbance source through a variable attenuator (ATT) and RFAMP (Radio Frequency Amplifier). IEEE802.11b machine is set on the operating condition, in which it continues to transmit and receive data during the test. In consequence, the appropriate level of the disturbance signal from IEEE802.11b can be applied to EUT inside the PW cell. A throughput of IEEE802.11g is measured as the same method as shown in Fig.2.

Channel of IEEE802.11g is fixed on 8ch, and the channel of IEEE802.11b as the disturbance wave is changed such as 4, 5, 6, 7 and 8ch as shown in Fig.7. The frequency spectrum for 8ch of IEEE802.11b almost pile up that for 8ch of IEEE802.11g, but the frequency spectrum for 4ch of IEEE802.11b does not almost pile up.
so as to avoid the interference from IEEE802.11b, and it is necessary to arrange so that their spectrum might not pile up.

4. Conclusion

The radiated RF electromagnetic field immunity test to IEEE802.11g was examined by using an opened PW cell. As a result, for IEEE802.11g using OFDM, it is revealed that the immunity property for the radiated RF electromagnetic field become very wick and decrease by about 30 dB, comparing with that of IEEE802.11b using DSSS.

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References