An Empirical 802.11b WLAN Performance Prediction Model in a noise environment by APD

Sung Jin Lim, Min Ho Hur, Se Woong Kwon, and Young Joong Yoon
Dept. of Electrical & Electronic Eng., Yonsei Univ, Seoul, KOREA
E-mail : 1imchan@yonsei.ac.kr

Abstract: This paper investigates a measurement method and an empirical model that predict a performance reduction of 802.11b WLAN service. To preserve quality of wireless digital communication service above 1 GHz in a noise environment, the prediction method is important and has many electromagnetic compatibility institutes focused in the method to determine permissible disturbance limits.

There are many methods to represent a noise signal. In CISPR committee, amplitude probability distribution(APD) method is proposed. The quality of digital communication service is usually expressed a bit error rate(BER) or throughput and it has been reported that degradation of BER or throughput can be estimated from the APD of noise amplitude. We investigate the method to measure the APD to fit 802.11b WLAN service. Therefore, we propose a simple experimental prediction method on APD to be used in permissible disturbance limits for frequency bands above 1GHz.

Key words: APD, MWO, 802.11b WLAN, time rate, permissible disturbance limits, noise

1. Introduction

Recently, there has been a dramatic increase in digital communication used at frequencies above 1 GHz. On the other hand, performance reduction problems of digital wireless communication systems in a noise environment are seriously reported. But a study on permissible disturbance limits for emission standards and measurement methods is very insufficient.

At present, the noise measurement method and permissible disturbance limits are now under discussion in International Special Committee on Radio Interference(CISPR) for frequencies above 1 GHz , and an interest of APD increases in CISPR from day to day. In recent years, it is reported that the APD of noise signal and BER or throughput are largely related and the relationships are studied.

In this paper, the experimental model is introduced to determine the peak-value and time-rate permissible limits. Also the method to measure APD characteristics of a noise signal is proposed. Consequently it shows our prediction model is profitable to determine permissible limits about the peak value and time-rate, Also APD is a useful parameter that evaluates digital wireless communication service quality.

2. Measurement Parameters

2.1 Permissible disturbance limits

International standards of permissible disturbance limits for emission and measurement methods at frequencies above 1 ~18 GHz are under discussion in two committee of CISPR H and CISPR I.

In CISPR H, permissible disturbance limits are resulted from a wanted signal by using statistic parameters, and theoretical methods which are related with statistic element, measurement receiver and bandwidth of digital wireless communication. But this approach is very difficult, because a number of statistic data must be needed. Permissible standards for emission in CISPR H are showed the table 1. In the other hand, CISPR I proposes permissible disturbance limits for emission according to permissible disturbance limits for frequencies below 1 GHz used currently. Table 2 shows them.

In the manner of deciding about permissible disturbance limits, CISPR I has more than merits, because CISPR H has difficulty in getting statistic data regardless of its exactness.

Table1. Permissible standards in CISPR H

Frequency Range	Permissible standards(3m)
1-3 GHz	45 dBμV/m
3-6 GHz	48 dBμV/m
6-18 GHz	55 dBμV/m

Table2. Permissible standards in CISPR I

Class	Frequency Range	Permissible standards(3m)	
		The average - value	The peak -value
B class	1-18 GHz	54 dBμV/m	74 dBμV/m
A class	1-18 GHz	60 dBμV/m	80 dBμV/m

* A: Industrial class, B: Home or personal class

2.2 Amplitude probability distribution

APD is very useful statistic method when emission disturbance is estimated in the digital wireless communication systems. As is shown in Fig.1, the duration of the i-th disturbance pulse Wi(k) is defined as the duration when the noise envelope is beyond the slice level E_k(k=1,2,….,m)

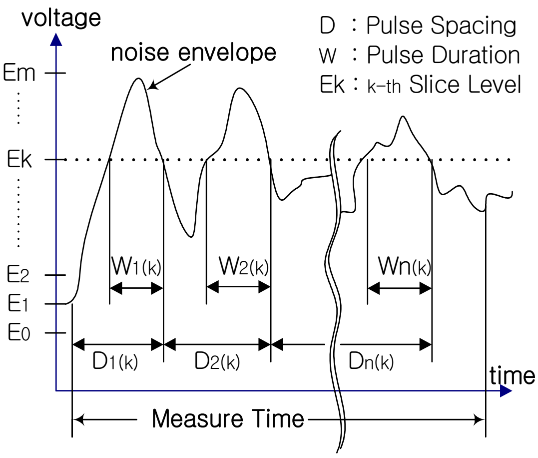

Figure 1. The change of noise signal due to time

The APD, D(Ek) is defined by

$$APD = D(Ek) = \frac{\sum_{i}^{n(Ek)} Wi(Ek)}{To} \qquad \textbf{(1)}$$

where $n(E_k)$ represents the number of pulse that exceed the level of E_k, and To means total measurement time. In other words, during some measurement time when the noise envelope is like Fig. 1, the time of noise could be represented by percentage. Also if a certain threshold is decided in time domain, APD is represented in percentage which is divided in total time, and its equation is as followed.

$$A = \frac{n(Ei > E)}{To} \times 100(\%), i = 1,2,\ldots.m \qquad \textbf{(2)}$$

3. Measurement System

In a real operation case, signals produced by 802.11b WLAN system and noise signals of an EUT are mixed and cannot measure separately. To measure quality of wireless system and noise signal separately. A wired measurement system is made to offer the environment which any other signal does not exist except the signal from an EUT. Fig.2 shows this system.

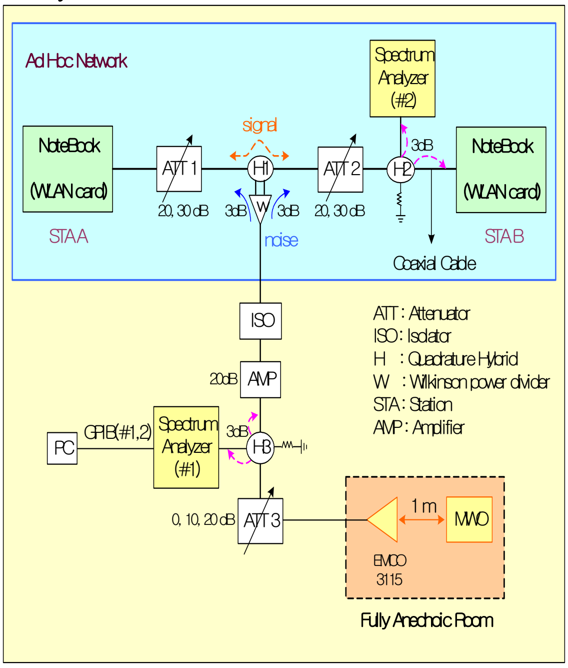

Figure 2. The measurement system

802.11b WLAN system is setted to AdHoc mode. The EUT is placed at fully anechoic room, and a noise signal of the EUT is received by wideband horn antenna. The noise signal amplitude is controlled by attenuator 1, 2, 3(ATT 1, 2, 3). A noise power of EUTs and communication distance of wireless communication service can be variously represented. Also by measuring noise and 802.11b WLAN service performance simultaneously, direct interference influence of a noise signal can be showed. So the flexible and simultaneous measurement system is constructed.

The simultaneous system is used for examining the relation between APD characteristic of EUTs of each level and quality of wireless communication service. Microwave Oven (MWO) is used for a EUT.

4. Performance Reduction Estimation by APD

4.1 Statistic Interference Characteristics of MWO

By measuring unwanted radiation from MWO in the frequency and time domain, and throughputs of the communication system, we evaluated quality reduction characteristics by the interference of a noise signal in each channel. In a radiation pattern, the maximum power is measured in front of the MWO. So the noise strength measurement is performed at the front of the MWO. The strengths from each distance is like Fig. 3. time domain radiation characteristic is shown in Fig. 4.

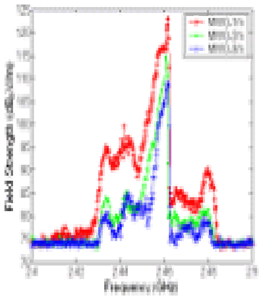

Figure 3. Characteristics of frequency

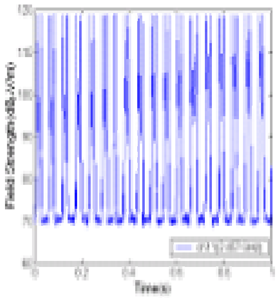

Figure 4. Characteristics of time

A sampled throughput of the non-disturbed and disturbed cases are shown in Fig. 5.

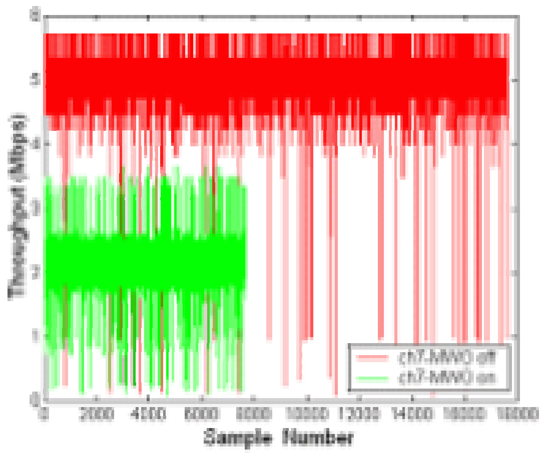

Figure 5. The throughput changed by MWO

4.2 Measurement of APD and 802.11b WLAN Performance

To estimate correlation characteristics of APD and 802.11b WLAN performance, time domain radiation of the MWO and throughput characteristics of 802.11b WLAN service are measured simultaneously. To confirm this relationship of APD and 802.11b WLAN transmission speed, this experiment is carried out various situation on the same time according to reducing amount of ATT 1,2 and ATT 3, and the data extracted for measuring 5 minutes. Also the measured frequency was set up as the center frequency of 802.11b WLAN channel. Measured time domain noise signals are transformed to APD characteristics as shown in Figure 6.

Fig. 6. shows APD characteristic measured after attenuators were set up to ATT3-10 dB, ATT1,2-20 dB. This attenuator level is similar to emitting strength from 3m measuring distance between MWO and receiving antenna. From the measured Results, emitting strength of MWO makes differences in each channel and the closer to the center frequency of MWO, the peak value and time rate tend to go up. it can be expected that the effect on Wireless LAN communication differs in graph shape.

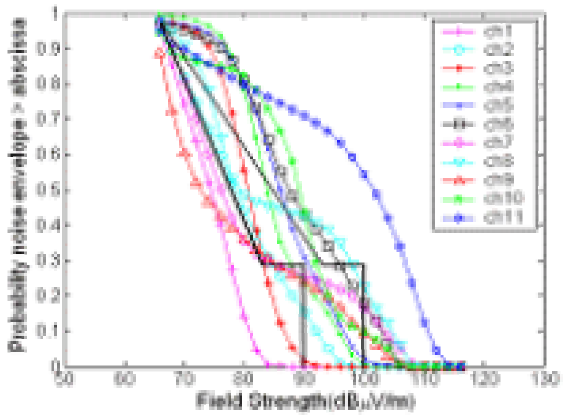

Figure 6. APD Characteristics by MWO

This is the measured result after setting up to ATT3 -10 dB and ATT1,2-20 dB, and shows that communication efficiency is severely reduced by interfering signal of MWO.

Figure 7 shows statistical analysis of performance reduction characteristics about a 802.11b WLAN transmission speed in each channel on the case of a MWO interference existence. In the transmission speed reducing characteristic, interference effect reduces when it is distant from the center frequency of MWO, and WLAN efficiency is in inverse proportion according to peak value and time rate of unwanted radiation.

From these results we propose a time-rate and peak value limit model. The limitation is shown as black solid line in figure 6. The solid line slope represents a time-rate limit and right angle solid line represents a peak-value limit. Although a noise signal has small peak value, large time late signal power (right side of the time rate solid line) reduces the performance of the wireless system.

The decision of the slope line curve is 30 % APD value. Also, although the time rate of the noise signal is small than the time-rate criteria, the large peak value is interfere to the communication performance.

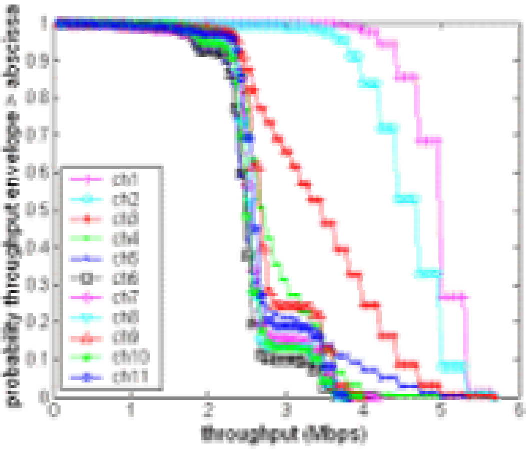

Figure 7. 802.11b WLAN Transmission speed characteristics each channel

This standard value was set up by comparing APD characteristic and the characteristic of transmission speed of each WLAN channel, and this is the created graph from attenuator level ATT3-10 dB, ATT1,2-20 dB. The peak value was fixed like Fig. 6. 90 dBμV/m 와 100 dBμV/m, and time rate was fixed 30%. from this result, the standard value for evaluation of transmission speed of each channel by APD interference is represented on Tab.3. That is, interference signal over 100 dBμV/m makes 802.11b WLAN transmission speed below 2.5Mbps and cause a severe obstacle on communication efficiency.

But, below 100 dBμV/m, WLAN transmission speed reduces the efficiency a little bit, however, it gives no influence on communication.

7. Conclusion

This paper considered the effect on wireless communication quality of the the peak value and time rate of unwanted radiation using empirical method of APD, and through the experimental approach, examined the function of statistic interference characteristic of MWO which is used in 2.4 GHz ISM bandwidth, APD characteristic and communication efficiency evaluation of 802.11b WLAN interfered by APD to represent un wanted radiation interference effect by the peak value and time rate to the numeric model. By this, APD statistic model is a suitable method of measurement to evaluate the effect on the wireless communication service of the peak value and time rate of the emission of unwanted radiation of GHz bandwidth.

Through this evaluation method, this is expected to play an important part to protect the communication quality of wireless communication service.. Moreover, in case that the additional study on the function of APD and wireless communication service based on this study, it is expected to be the leading method of evaluation on the quality progress of wireless communication.

.Table3. Permissible limits at channel

Channel	MWO (dBμV/m)	Transmission Rate (Mbps)	Permissible limits (dBμV/m)
1	84	5.2	Below 90
2	95	4.7	90 ~ 100
3	94	4	
4	102	3	Above 100
5	103	2.6	
6	106	2.4	
7	109	2.5	
8	109	2.5	
9	106	2.5	
10	107	2.5	
11	115	2.5	

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