BER Evaluation System for a Handset Antenna in a Multipath Environment Using a Spatial Fading Emulator

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1. Introduction

A number of studies of spatial fading emulators for handset antennas for land mobile communications [1]-[3] have been undertaken in order to evaluate the performance of handset antennas in a non line-of-sight (NLOS) situation. The purpose of all the spatial fading emulators developed so far is to estimate the intensity of the received power of the handset antenna in a multipath environment. Therefore, a continuous wave has been used for the transmitting signal. However, it is necessary that antenna systems such as diversity and adaptive antennas also have the capability of examining the quality of modulated signals.

This paper presents a bit error rate (BER) evaluation system for a handset antenna in a Rayleigh-fading environment by using a spatial fading emulator. The BER evaluation system comprises a spatial fading emulator [3] based on Clarke's model [4] and a transmitter and receiver set. Coherent detection of the quadrature phase shift keying (QPSK) signal with 64 kbps was used for evaluating the BER characteristics. The BER evaluation system was validated by measurements of the BER performance of the handset antenna in a multipath fading environment.

2. Experimental setup

Figure 1 shows a photograph of the setup of the BER evaluation system. Figures 1(a) and 1(b) show the spatial fading emulator, a control circuit and a computer. The fading emulator consists of 15 half-wavelength dipoles, a control circuit and a computer. The half-wavelength dipoles, which function as scattering sites, are located at even intervals on a circle of 2 m in diameter. The control circuit comprises 15 sets of phase shifters and attenuators. The attenuator can regulate the amplitudes of the signals radiated from the scattering sites to give them the same value. The computer calculates values of the phase shift of the signals in order to obtain a Rayleigh-fading channel based on Clarke's model. Figure 1(c) shows the transmitter and receiver. Coherent detection of the quadrature phase shift keying (QPSK) signal with 64 kbps was used for the transmitter and receiver. A vertically polarized wave at 2.07 GHz was radiated.

Figure 2 illustrates the configuration of the BER evaluation system. The signal modulated by the transmitter is divided into 15 parts by the power divider. To produce a Rayleigh-fading channel, the phase shifters and attenuators in the control circuit vary the phases and amplitudes of the divided signals. The BER counter is used to monitor the BER

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of the demodulated signal. In this paper, a half-wavelength dipole was used as the handset antenna. The maximum Doppler shift (fd) was set to be 20 Hz and the direction of motion of the antenna was 10 degrees from the scattering site labeled #1.

3. Performance of the fading emulator

Figure 3 shows the measured received power as a function of the product of the maximum Doppler shift and time (fd*t). The sampling frequency was 400 Hz and the number of samples was 500. In the figure, the calculated results are also plotted. As can be seen from Fig. 3, the measured data agree well with the calculated ones, demonstrating that the fading emulator was very well controlled. Figure 4 shows the cumulative distribution of the received power normalized by its medians. In Fig. 4, the theoretical curve of a Rayleigh-fading channel is also plotted. As can be seen from Fig. 4, the good agreement between the measured and theoretical data indicates that the fading emulator can produce a Rayleigh-fading environment.

4. Average BER characteristics of the handset antenna

We investigated the BER characteristics when the fading emulator was suspended at every sampling step. Figure 5 shows the cumulative distribution for the BER of a QPSK signal for an average input signal-to-noise ratio (SNR) = 25 dB. We indicate the error free rate as BER = 10^{-6}. Calculated results are also plotted in Fig. 5, which shows that the measured BER is in approximately good agreement with the calculated one. Figure 6 shows the average BER as a function of the average input SNR. The theoretical data of a half-wavelength dipole in a Rayleigh-fading environment are also plotted and is shown by the solid line in Fig. 6. From Fig. 6, the measured data are in good agreement with the calculated data and the theoretical curve. From this, it is clear that the BER performance of a handset antenna in a Multipath Environment can be determined by the BER evaluation system using a spatial fading emulator

5. Conclusion

We have presented a BER evaluation system using a spatial fading emulator for a handset antenna. The BER evaluation system comprises a spatial fading emulator based on Clarke's model and a transmitter and receiver set. We measured the BER performance of a half-wavelength dipole in a Rayleigh-fading channel using the spatial fading emulator. The measured average BER of the antenna is in good agreement with the theoretical curve. We conclude that the BER evaluation system can give a reliable estimate of the BER performance of a handset antenna in a Rayleigh-fading channel.

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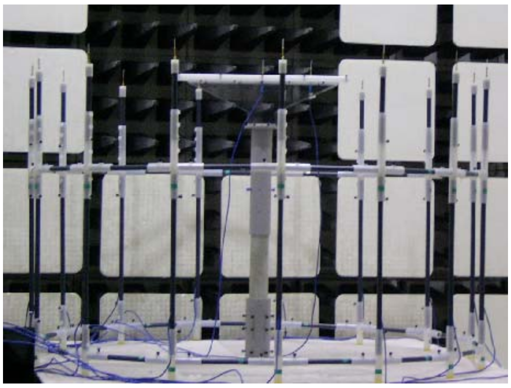
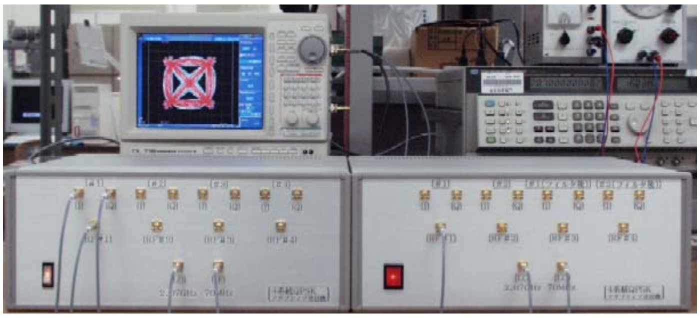


(a) Scattering sites

(b) Control circuit and computer



(c) Transmitter and receiver

Fig. 1 Photograph of the BER evaluation system.

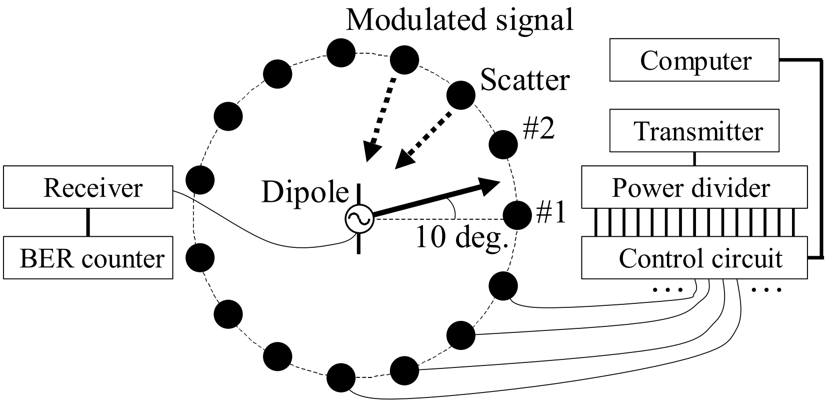


Fig. 2 Configuration of the BER evaluation system.

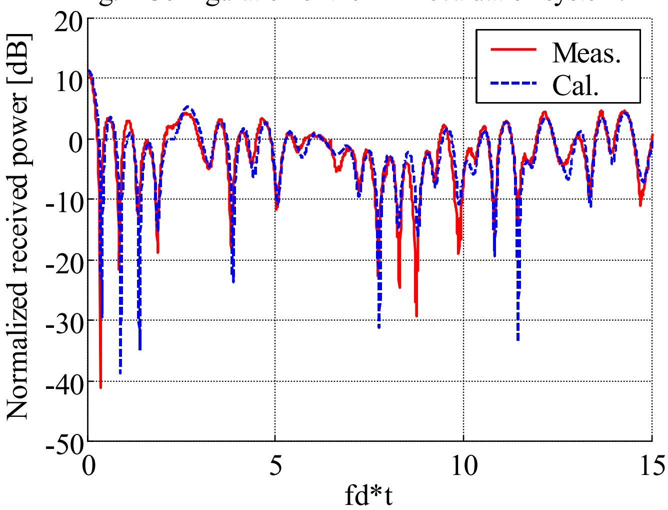


Fig. 3 Measured received power of the half-wavelength dipole.

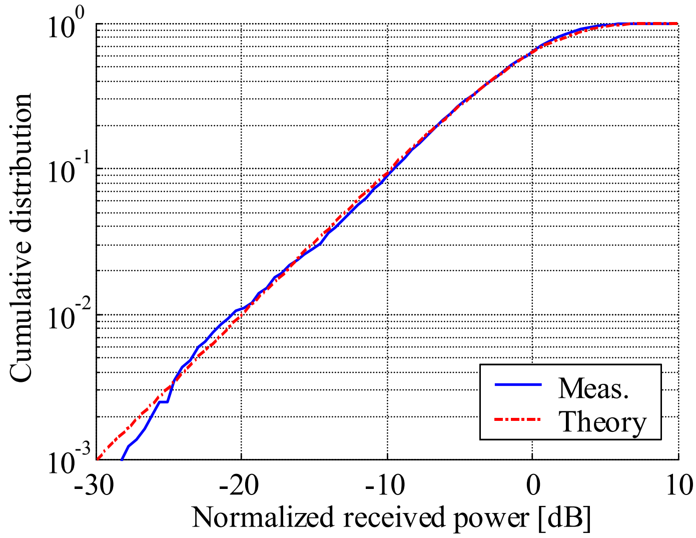


Fig. 4 Cumulative distribution of the received power of the half-wavelength dipole.

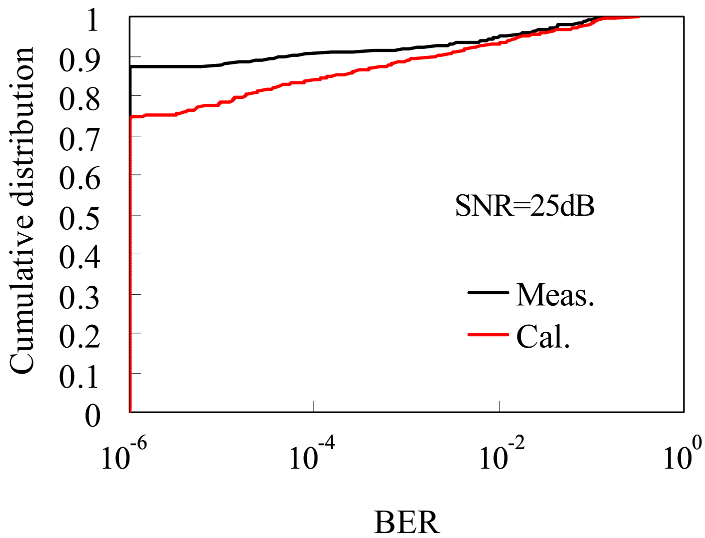


Fig. 5 Cumulative distribution for the BER of a QPSK signal for an input SNR=25 dB.

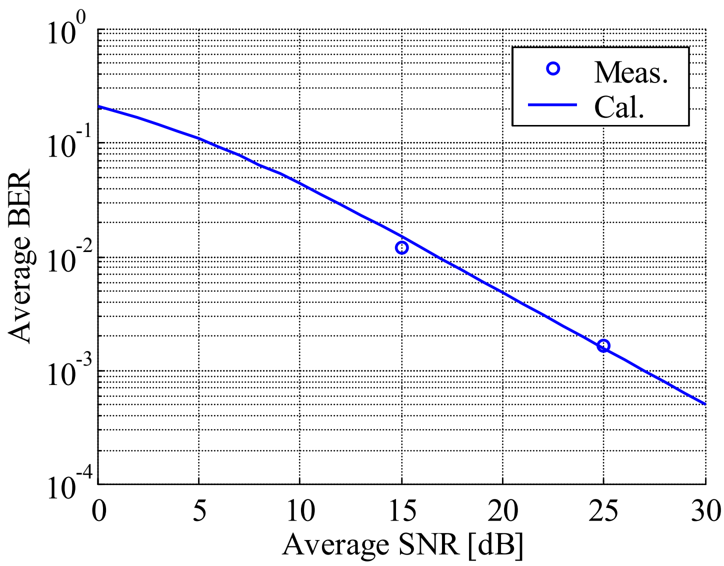


Fig. 6 Average BER as a function of average SNR.