An Advanced Method of Simulation and Analysis for Electromagnetic Environment on the Mobile Receiver in a Shielded Anechoic Chamber

Jung-Hoon Kim[1] · Joong-Geun Rhee[2]

Abstract

This paper presents an advanced method of simulation for EM(electromagnetic) environment that affects on mobile receivers. A new calibration algorithm in the process of simulation is introduced. With a proposed calibration method, the time required for simulation is reduced and this makes it possible to simulate a near-real time EM environment in a shielded anechoic chamber. EM environment data acquisition and logging techniques with GPS for simulation were developed.

Key words : Advanced Bisection Method(ABM), Mobile Receiver, Electromagnetic Environment Simulation.

I. Introduction

Nowadays, electronic circuits for computation, automation and a mobile communication are commonly used. EM(Electromagnetic) environment has become more a major problem for system designers. Especially, wireless mobile receivers like cellular phones and FM Radios are very sensitive in EM environment. EM environment fluctuates time to time even in the same place and varies when the EM receivers are moving[1]. The system designer needs to make their systems operate under ideal conditions in the laboratory and also make sure that the system will work in the real world[2],[3]. Therefore, it is very difficult to evaluate objectively the receiving ability of a system in motion.

Measuring and simulation program were developed by using the calibration process with the bisection method[4], PDF(Probability Density Function)[5], NAD(Noise Amplitude Distribution), averaging method[6] and etc[7]. But the problem of these methods is that long time is required in calibration procedures which is a part of simulation. In this paper, an efficient simulation methods with an advanced bisection algorithm are presented, and the calibration time of simulation for EM environment is reduced.

II. Measurement of EM Environment

2-1 The Measurement System of EM Environment

Fig. 1 shows the measurement setup of EM environment for study. According to the ITU-R in the range of 30 to 1,000 MHz, the measuring antenna for EM environment is suggested to be 10 m above the ground to minimize the effect of the reflection wave from the ground and nearby building[8]~[11]. But in this measuring system, to get the closest result compared to the receiving environment of the vehicle, an antenna was set up on the roof of vehicle as shown in Fig. 1. The measured data include the voltage level(dBuV) of input port of a S/A(Spectrum Analyzer), video BW(Band Width), resolution BW, span, GPS information(latitude, longitude, height), operator's name, frequency range, date, time, model of vehicle and antenna, weather and etc. Usually, EM environment data are saved in V/m, A/m or dBuV/m, but power or voltage at an input stage of a receiver is more important to evaluate the receiving ability of a receiver. Therefore, the antenna factor and

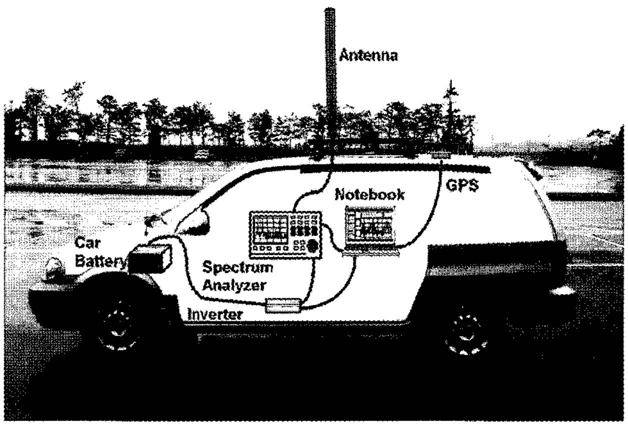

Fig. 1. The setup of an EM environment measuring system(PC controlled S/A with GPIB).

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the loss of cable are insignificant for evaluating a receiver.

2-2 The Program and Result of EM Environment Measurement

The measured data play an important role in a simulation system. As one of the results, Fig. 2 shows a view of the Hangangdaegyo(bridge) in Seoul, Korea and Fig. 3 shows the measurement result in the Hangangdaegyo (1,188 kHz). 1,188 kHz is one of AM Audio broadcasting in Seoul, Korea. The minimum voltage level is about 25 dBuV in the center place of the arch. The maximum voltage level is about 45 dBuV in the end of arch. The fluctuating voltage is caused by many posts which consist of arch of Hangangdaegyo. In this paper, these EM environments are simulated in a shielded anechoic chamber.

III. The Algorithm for Simulation

3-1 The Test Setup for Simulation

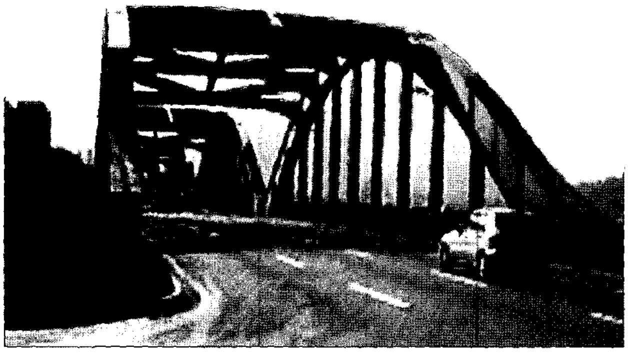

Fig. 2. A view of the Hangangdaegyo in Seoul, Korea.

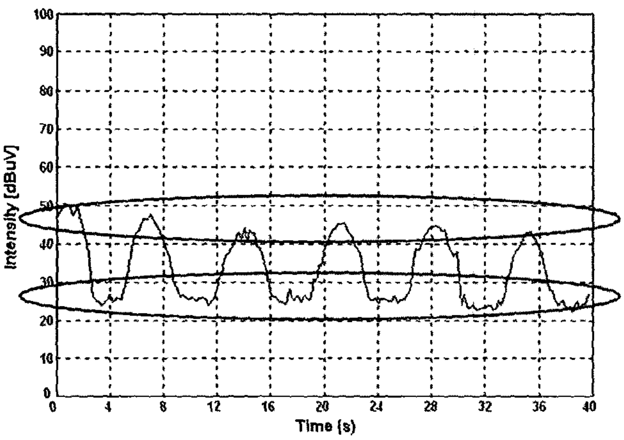

Fig. 3. The measurement result at the Hangangdaegyo (1,188 kHz).

The simulation program for EM environment can control 3 S/Gs and 1 S/A simultaneously. Modulating signals from 3 separate CD players as signal sources and modulated signals from S/Gs were transmitted by TX antenna in a shielded anechoic chamber. The transmitted signal is received by a S/A and is calibrated to the data measured in the real environment. The EM environment in a shielded anechoic chamber can be simulated by changing the number of S/Gs according to the number of interesting frequencies. Fig. 4 shows the test setup for simulation for EM environment and Table 1 shows the used equipment list for simulation.

3-2 The Calibration Algorithm for Simulation

The voltage level at the input port of a receiver is very important. In a shielded anechoic chamber, if the power level measured in a real EM environment with TX antenna is transmitted, the voltage level received at the S/A may be different from the voltage level measured in the real EM environment. Therefore, to obtain the same power level of the real environment in a shielded anechoic chamber, the calibration process must be needed. Until now, two methods for calibration were proposed. The first method named as the minimum step method in this paper is as follow. If voltage level measured in the real environment is higher than the one received at the S/A in a shielded anechoic chamber, the power of S/G is set to increase with the minimum step

Table 1. Required equipment list for simulation.

Required equipment	Model	Purpose	Quantity
Control PC	Sens640 (Samsung)	Equipment Control	1
S/A	E4402B	Power Measurement	1
Signal Generator(S/G)	VP-8133A	RF Power	3
Modulating Signal Source	-	Signal source	3
TX(Transmitting) Antennas	Biconical or LP Antenna	Transmission of Power from S/G	3
RX(Receiving) Antennas	Biconical or LP Antenna	Receive Power from S/G	1
GPIB Cable		Interface	4
GPIB Card	PCMCIA GPIB (NI)	Interface	1 1

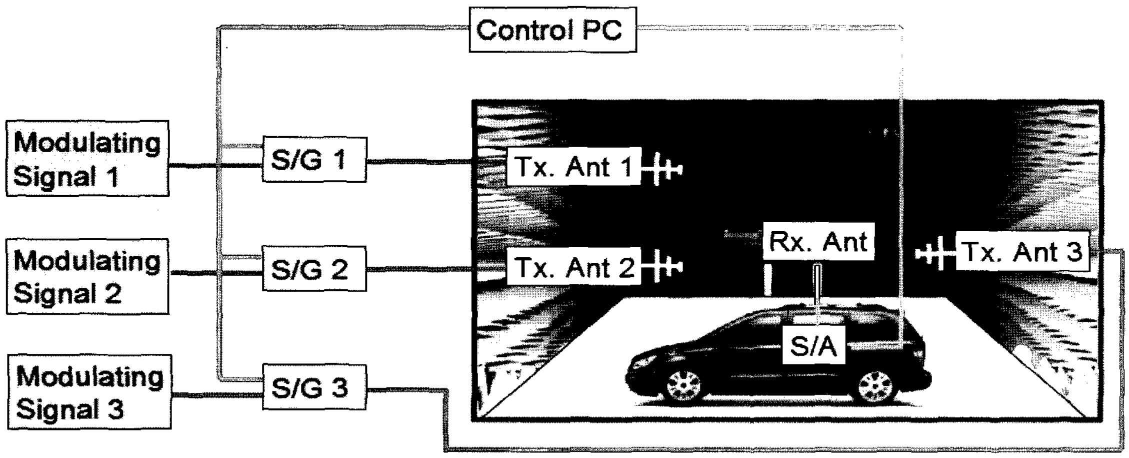

Fig. 4. The test setup for simulation of EM environment in a shielded anechoic chamber.

of S/G. On the contrary, if the measured level is low, process of reducing the power of S/G is repeated until the received signal level becomes the same with the measured signal level. The second method is the bisection method[4],[12]. It is a type of incremental search method in which the interval is always divided in half. Compared with the first method, the bisection method reduces the time required for calibration process.

3-3 The Advanced Bisection Method 1(ABM) for Simulation

Fig. 5 shows the progress stage of two methods (the minimum step method, the bisection method) for the calibration. Measured data at 89.1 MHz, 90.3 MHz and 91.9 MHz are saved in order of time. The minimum step method and the bisection method run the calibration in order of time. But calibration methods with these algorithms take long time for full calibration. In this paper, two ABMs to reduce the time required for the calibration process are proposed. Fig 6, 7 show the flowchart for the algorithm of ABM1 and the process of the ABM1 for simulation.

Using this algorithm, whole data of the first data-table are calibrated and the rest of data-tables repeat in the same way. If the calibration process of every data finish, the calibrated data is sorted in the order of time. As an antenna factor and cable loss varies with each interesting frequency, data-tables are made per each frequency and calibrated respectively. During the calibration process run by ABM1, the interval between Pmax and Pmin decreases and then the time for calibration is reduced. Compared with the bisection method, the time required for calibration in ABM1 is reduced as the number of iteration of step 4 & 5 are decreased.

Time ↓

Frequency (MHz)	Amplitude (dBm)	Calibration (dBm)
90.3	-47.3	
89.1	-15.3	
91.9	-17.3	
90.3	-54.9	
89.1	-21.9	
91.9	-11.8	
90.3	-48.2	
89.1	-24.1	
91.9	-8.82	
90.3	-16.3	
⋮		

1st Caribration ⇒

Frequency (MHz)	Amplitude (dBm)	Calibration (dBm)
90.3	-47.3	-15.3
89.1	-15.3	
91.9	-17.3	
90.3	-54.9	
89.1	-21.9	
91.9	-11.8	
90.3	-48.2	
89.1	-24.1	
91.9	-8.82	
90.3	-16.3	
⋮		

2nd Caribration ⇒

Frequency (MHz)	Amplitude (dBm)	Calibration (dBm)
90.3	-47.3	-15.3
89.1	-15.3	16.9
91.9	-17.3	
90.3	-54.9	
89.1	-21.9	
91.9	-11.8	
90.3	-48.2	
89.1	-24.1	
91.9	-8.82	
90.3	-16.3	
⋮		

3rd Calribration ⇒

Frequency (MHz)	Amplitude (dBm)	Calibration (dBm)
90.3	-47.3	-15.3
89.1	-15.3	16.9
91.9	-17.3	14.7
90.3	-54.9	
89.1	-21.9	
91.9	-11.8	
90.3	-48.2	
89.1	-24.1	
91.9	-8.82	
90.3	-16.3	
⋮		

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Fig. 5. The process of the minimum step method and the bisection method for the calibration.

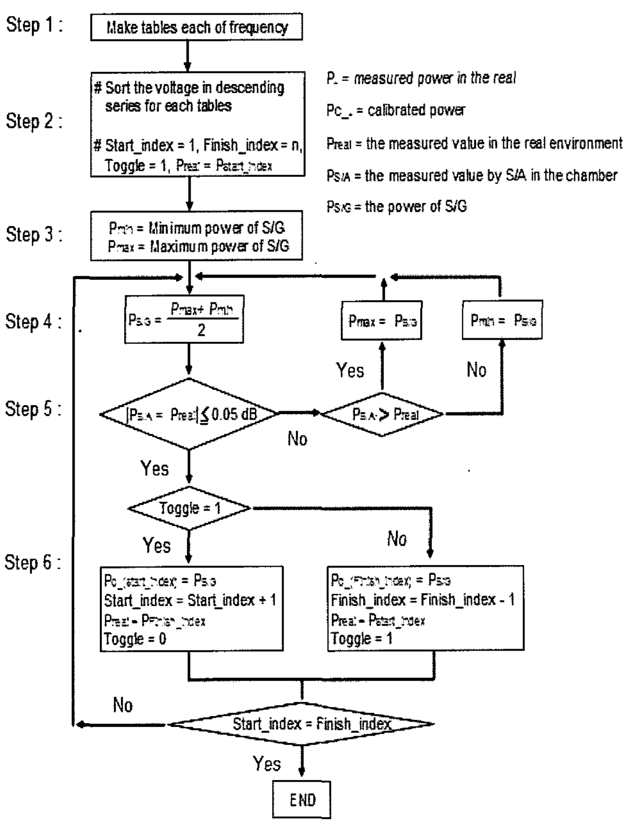

Fig. 6. The flowchart for the algorithm of ABM1.

3-4 The Advanced Bisection Method 2(ABM) for Simulation

Fig 8, 9 show the flowchart for the algorithm of ABM2.

As expected, the ABM2 also reduces the calibration time. But an adequate $P_{Interval}$ should be selected by a program operator. If a $P_{Interval}$ is selected too small value, a calibration process can not be completed. In this case, a program operator tries to select a larger $P_{Interval}$. Usually, the double value of the maximum interval value of amplitude at the step 1 of ABM2 is selected as $P_{Interval}$.

Ⅳ. Simulation Program and Result of EM Environment

A simulation program for EM environment was developed by using Visual Basic 6.0 of Microsoft Corporation. GPIB interface was used for the communication between spectrum analyzer, signal generator and a notebook PC. Developed program of measuring EM environment can be operated in all interrelated OS (Windows 95, 98, 2000). In this paper, the program was run on 128 Mbytes of RAM, 20 GB of HDD, Pentium III 650 MHz CPU. Fig. 10 shows the power spectrum

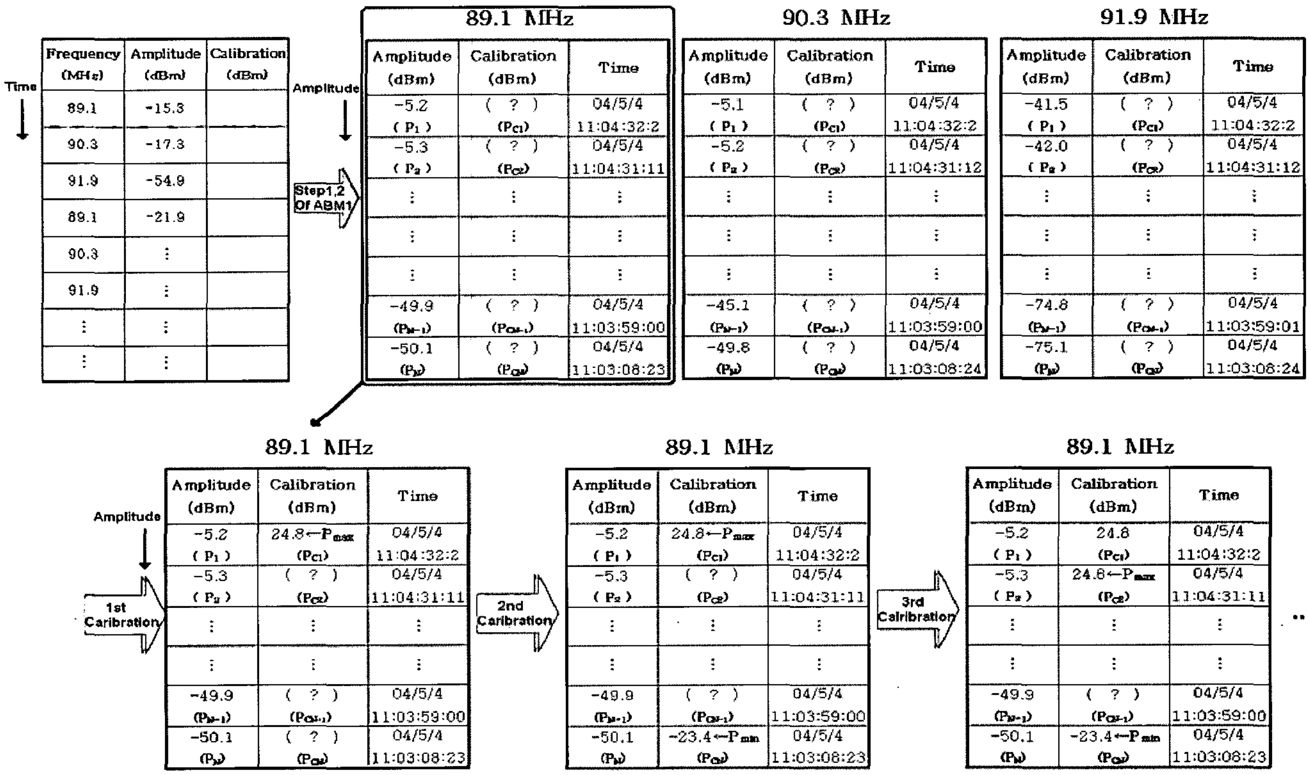

Fig. 7. The process of the ABM1 for simulation.

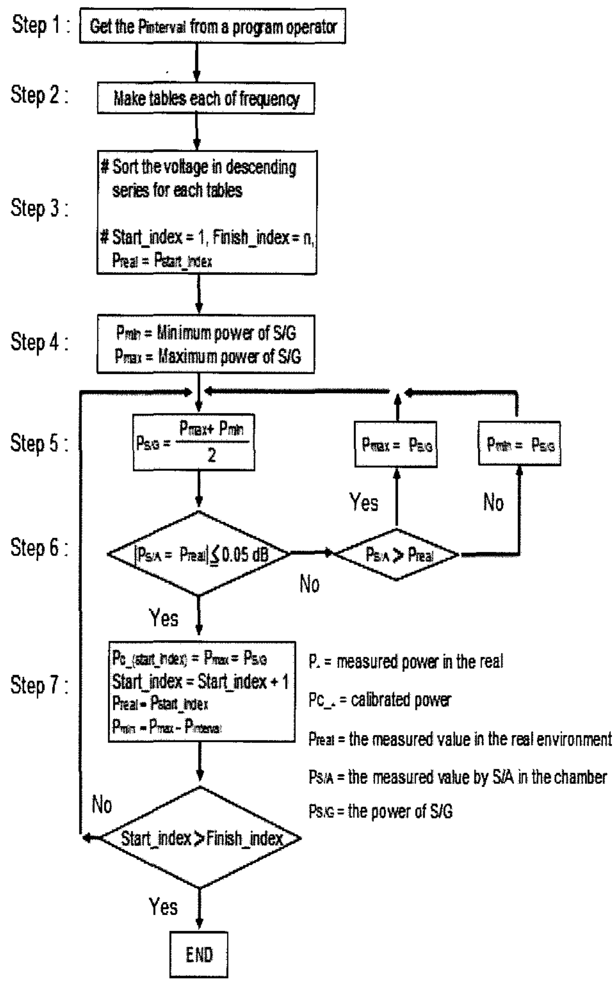

Fig. 8. The flowchart for the algorithm of ABM2.

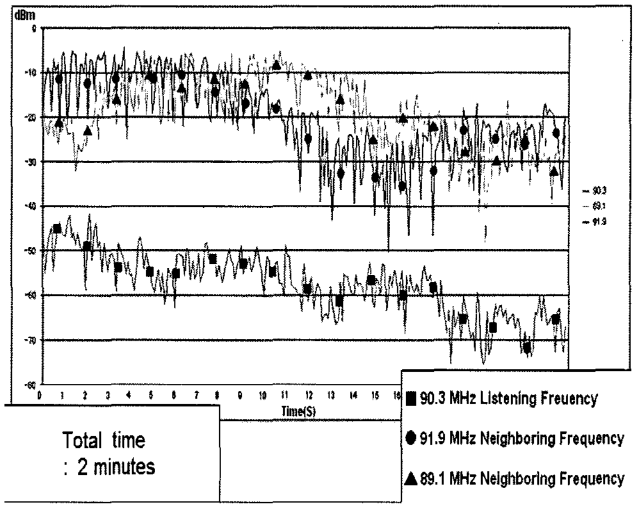

Fig. 10. The measured data of EM environment at Namsan, Korea.

measured at Namsan, Korea. The measured data are collected at intervals of about 0.1 s. When a receiver was tuned to 90.3 MHz, strong signals of 89.1 MHz and 91.9 MHz caused an interference. By simulating a near-real world EM environment in a shielded anechoic chamber with 3 S/Gs controlled by a PC, similar interferences were observed. Table 2 shows the required time for calibration with data of Fig. 10 and represents that ABM1 and ABM2 reduce the time for calibration largely. In this example, it shows that the bisection method requires the longest time for calibration.

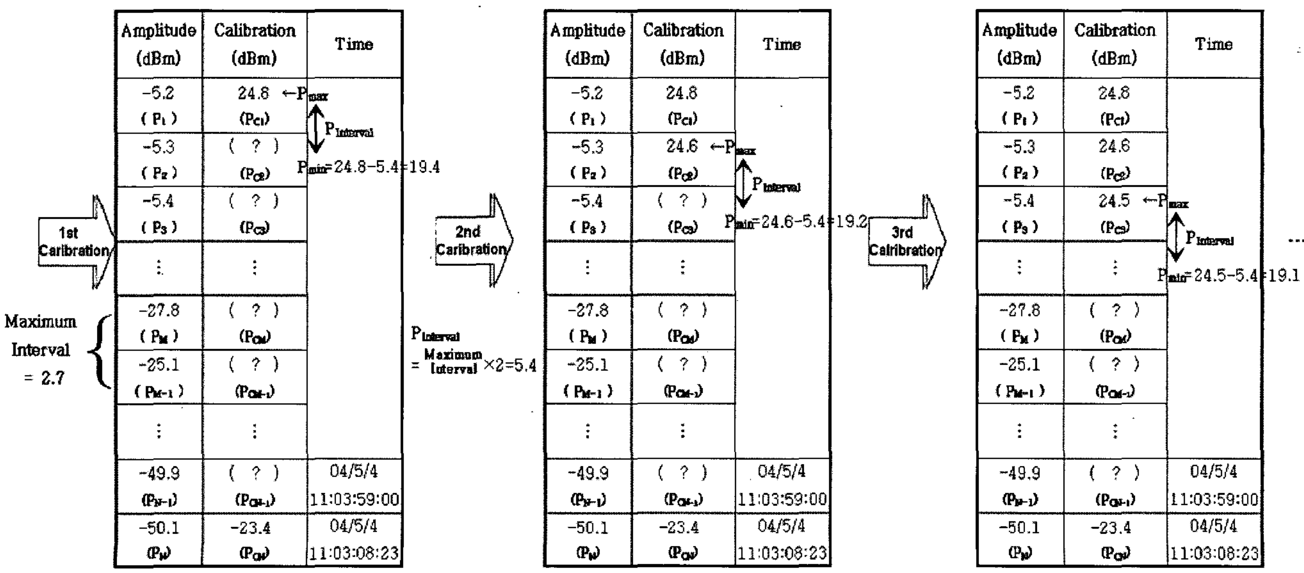

Fig. 9. The process of the ABM2 for simulation.

Table 2. Required time for calibration(with the data for Fig. 10(2 minutes)).

Bisection method	ABM1	ABM2	
		Time	Interval (dBm)
00:13:21	00:08:38	0:08:57	20
		0:08:33	15
		0:08:02	10
		0:07:55	5
		Can not be calibrated	0.1

V. Conclusion

A method of measurement and simulation for an EM environment is presented. ABM1 and ABM2 are proposed to reduce the time required for calibration which can simulate a near-real time EM environment in a shielded anechoic chamber. Up until now, in the evaluation process of mobile AV receiver systems, operator's subjective judgment has been widely accepted. However, this paper suggests simulation algorithms that can perform a near-real time EM environment in a shielded anechoic chamber with ABM1 and ABM2. The developed simulation program and algorithm will play an important role in the analysis of mobile receivers.

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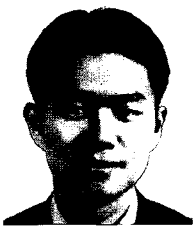

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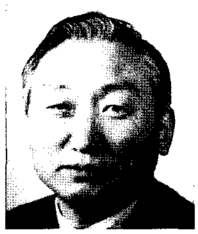

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