Reduction of Estimation Time for Disturbance Level Using Majority Decision Considering with Current and Magnetic Current Source

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***Abstract*- The maximum value of radiated emission must be measured at a distance of 10m for the CISPR publishes. However, the test facilities are too expensive to measure at a distance of 10m. Therefore, the method has been studied to estimate radiated emissions at a distance of 10m from the measured data at a distance of 3 m. The conventional estimation method considered with three components of current vectors and this need much estimation time. In this paper, we propose the estimation method considering with current and magnetic-current sources. The equipment can be modelled by one component of the current vectors using both current and magnetic-current source, and this method can reduce the estimation time because the estimation parameters reduces from nine to five. The electric field radiated from the imitated equipment was estimated by using numerical calculation value. The results indicated that the accuracy of proposed method was almost equal to conventional method for horizontal polarization, and the estimation time decreased two thirds.**

Key words: CISPR, Far field estimation, Radiated emission, Current source, Magnetic-current source.

I. Introduction

Recent developed the electronic technology produces the electrical equipment radiating the unwanted electromagnetic waves and it may disturb the operation of the surrounding radio wave apparatus. CISPR (International Special Committee on Radio Interference) publishes the international standard to maintain EMC (Electro-Magnetic Compatibility) [1]. The CISPR publication specifies that the electric field strength should be measured at a distance of 10m. However, it is difficult to measure the electric field strength at the distance because the measurement facilities are too expensive. Therefore, the method has been studied to estimate radiated emission at a distance of 10 m from the measured data at a distance of 3m [2] - [4].

One of the methods is based on the assumption that the electric field strength decreases in proportion to the propagation distance. However, the relation does not satisfy for the measurement conditions according with the CISPR publications because of the reflection of the ground plane and the directivity of the radiated disturbances [2].

The source modeling method has been presented to improve the accuracy of the estimation [3], [4]. This method models the equipment under test (EUT) by the small current sources, and the electric field calculates by the current sources. The maximum estimation deviation is within 5 dB by employing the majority decision [4]. However, it needs a lot of computation time to estimate the electric field strength.

In this paper, we propose the estimation method using both current and magnetic-current sources to reduce the estimation time. First, we overview the source modeling and propose the new source modeling method by both current and magnetic-current sources. Next, the method applies to the estimation using the imitated equipment and the estimation accuracy is evaluated to compare with the results by the conventional method.

II. Estimation Method

A. Overview of Source Modeling Method

Figure 1 illustrates the brief overview of estimation method by the source modeling. The EUT is modeled by the small current sources to meet the calculated electric field distribution at a distance of 3 m with the measured one [3]. The electric field strength at a distance of 10m is calculated by using the current sources. Using this method, we can compensate the influence of the reflection on the ground plane and the directivity of the radiation from the EUT.

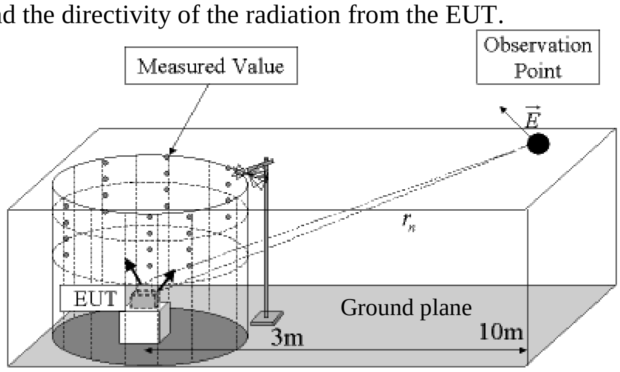


Fig. 1 Brief overview of source modeling method

B. Source Modeling by Current and Magnetic-current Sources

Generally, basic radiation sources are a small current and a magnet-current. Figure 2 shows the electric field generated by these sources whose direction is z-axis. Figure 2(a) shows the electric field by a small current source and Fig. 2(b) shows the field by a small magnetic-current source.

When we consider the far field, the electric field radiated by the small current source is given by

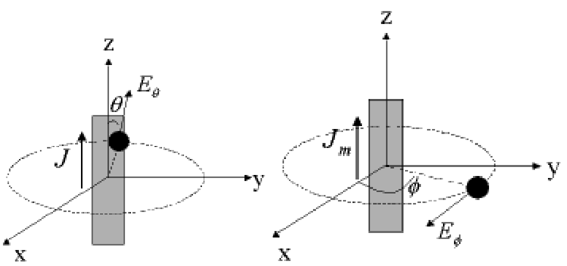
$$E_\theta = \frac{Je^{-jkr}}{j4\pi\omega\varepsilon}\left(-\frac{k^2}{r}\right)\sin\theta , \qquad (1)$$

where, J is the current source, k is the wave-number, ω is angular frequency, ε is dielectric constant, θ is angle to z-axis, and r is the distance from observation point.

The electric field radiated by the small magnetic-current source is given by

$$E_\phi = -\frac{J_m e^{-jkr}}{j4\pi\omega\varepsilon}\left(\frac{jk}{r}\right)\sin\theta , \qquad (2)$$

where, J_m is the magnetic-current source.



(a) Current source model (b) Magnetic-current source model

Fig. 2 Current and magnetic-current source model

Equation (1) and (2) present that the z direction magnetic-current only generate the ϕ direction component of the electric field, E_ϕ and z direction current source do not generate the E_ϕ. This means that the electric field of the horizontal polarization can be modeled by only magnetic-current sources, and the electric field of the vertical polarization can be modeled by only current sources.

Presented paper needs the nine parameters to present one source where, the parameters are the position of source (x_i, y_i, z_i), the x-axis components (Re{J_{ix}}, Im{J_{ix}}), the y-axis components (Re{J_{iy}}, Im{J_{iy}}), and the z-axis components (Re{J_{iz}}, Im{J_{iz}}). However, the parameters can be reduced to the five parameters, which are the position of source (x_i, y_i, z_i) and the z-axis components (Re{J_{iz}}, Im{J_{iz}}). The estimation time can also be reduced because the source modeling time depends on the number of parameters.

C. Estimation Algorithm

Figure 3 shows the algorithm of source modeling method [4].

The algorithm is categorized by six steps.

Step 1: At first, input the electric field distributions which measured electric field strength at a distance of 3m.

Step 2: Current sources for the vertical electric field or magnetic-current sources for the horizontal electric field and their locations are generated at random.

Step 3: Calculate electric field strength using the current sources or magnetic-current sources obtained in Step 2 at the same distance as the input data measurement using the Eq. (1) or Eq. (2). The new magnitude of sources and the positions are calculated to minimize the deviation between the calculated value and the measured value. The process is repeated until the deviation convergence sufficiently. The repeat number of times is called "calculation number."

Step 4: Step 1 to 3 are repeated by changing the initial value, and the parameters of the sources are determined from the minimum deviation condition. The repeat number of times is called "trial number."

Step 5: The maximum electric field strength at the distance of 10m is calculated by the current or magnetic-current sources which obtained in Step 1 to 4.

Step 6: Step 1 to 5 are also repeated by changing the initial value for several number of times. The repeat number of times is called "estimation number." The solutions, which are out of the standard deviation, are removed to exclude the local minimum solutions and the mean value of the maximum electric field strength is calculated as the estimation value.

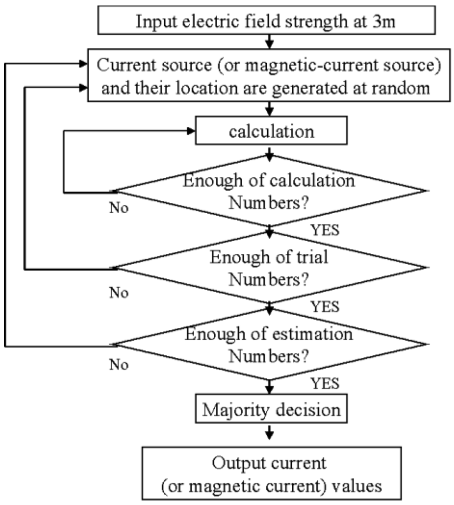


Fig. 3 Algorithm of source modeling method

III. Estimation of Disturbance Level

A. Imitated Equipment

The proposed method was evaluated by suing the imitated equipment [5]. The external view of the imitated equipment is shown in Fig. 4. The imitated equipment is composed of the shielding box whose size is 38 cm wide, 48 cm long, and 10 cm high. An O/E (optical-electro) converter operating battery places inside the box and a loop antenna places on the top of the case. The radiated electric field can be calculated with sufficient accuracy from 30 MHz to 1000 MHz because the equipment has not any metallic feeding cables [5].

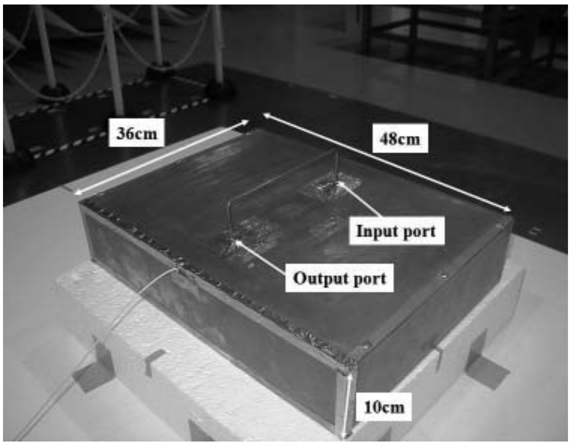


Fig .4 External view of imitated equipment

B. Calculation Model of Electric Field

Calculation value of electric field is used for the investigation because the value does not contain the influence of the measurement facilities. The calculation model is illustrated in Fig. 5 [4].

The imitated equipment was modeled by the wire grid whose segment length is 20 mm and wire diameter is 1.5mm. The voltage source with the internal resistance is places at one end of the loop antenna and the other end is terminated by the same resistance. The Bilog-antenna whose maximum element length is 1.39 m is selected as receiving antenna and modeled by the wire grids whose segment length is from 25 mm to 30 mm. The diameter of wire and the segment length were determined from the element diameter and length. The antenna output port is terminated by a resistance. The resistance of 50Ω is used in this investigation.

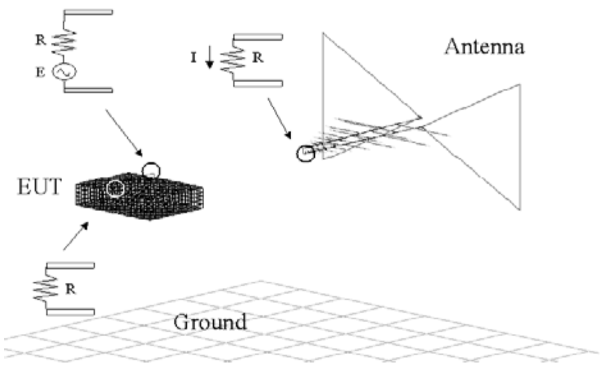


Fig .5 Calculation model of radiated field strength

The receiving antenna height was changed from 1 m to 2 m at the interval of 10 cm, and the angle toward the antenna changed from 0 degree to 345 degree at the interval of 15 degree. The electric field distribution is calculated as the output level of the antenna. The maximum electric field strength at a distance of 10 m was also calculated to evaluate the estimation accuracy. In this case, the Bilog-antenna was removed from the model. NEC2 [6] was used for the calculation.

C. Estimation Conditions

The estimation conditions are summarized in Table I. The maximum electric field strength from 1 m to 4 m was estimated. The number of frequencies is 200 points from 30 MHz to 1000 MHz.

The number of sources changes according with the frequency referred by the presented paper. The calculation number, the trial number, and the estimation number were used the same value as the conventional method [5] to compare the estimation time.

TABLE I
ESTIMATION CONDITIONS

Terms	Parameters
Frequency range	30 MHz – 1000 MHz
Calculation points	200 points
Number of sources	2 to 11
Calculation number	150 to 250
Trial number	80 to 140
Estimation number	10

D. Investigation Result

The estimation result is shown in Figs. 6(a) and 6(b). Figure 6(a) shows the results of horizontal polarization, and the Fig. 6(b) shows the results of vertical polarization. The vertical axis of these figures presents the deviation from the calculated maximum electric field strength. The circles indicate the estimation results by the conventional method, the dotted line indicate the results by the proposed method without the majority decision, and the solid line indicate the results by the proposed method with the majority decision.

The results show that the electric field can be estimated by similar accuracy for horizontal polarization and the accuracy is improved by employing the majority decision. For the vertical polarization, the estimation accuracy deteriorates by the proposed method and the accuracy does not improve by employing the majority decision. This might be caused that the vertical component of the electric field is approximated by the E_θ. Further investigation is needed to improve the accuracy.

The comparison of estimation time is summarized in Table II. As a result, the estimation time can be reduced about two thirds comparison of conventional method.

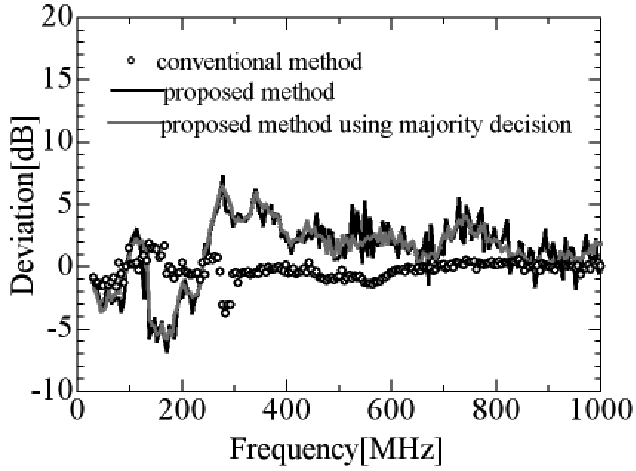


Fig. 6(a) Estimation results of horizontal polarization

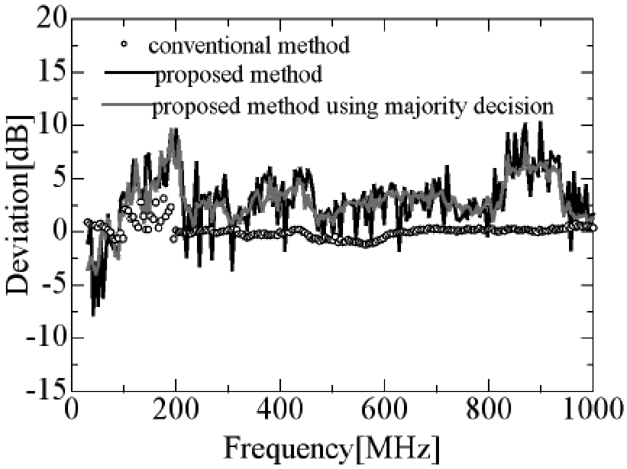


Fig. 6(b) Estimation results of vertical polarization

TABLE II
COMPARISON OF ESTIMATION TIME

	Conventional method	Proposed method
Estimation time (minutes)	12320	8800

IV. CONCLUSION

In this paper, we propose the estimation method by both current and magnetic-current sources. Using proposed method, the parameters for the estimation can be reduced from nine to five by comparison of the conventional method. As a result, the estimation time decrease compared with the conventional method.

The investigation using the calculation value of the imitated equipment presented that the similar estimation accuracy can be obtained for the horizontal polarization. However, the accuracy for the vertical polarization deteriorates by employing the proposed method. The investigation shows that the estimation time can be reduced two thirds compared with the conventional method.

Further problem improves the estimation accuracy for the vertical polarization.

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