Estimation of Radiated Emission Sources Distribution Using CISPR Measurement System

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1. Introduction

Recently, emission radiated from an electric equipment interferes with a surrounding equipment so much, that emission levels and its measurement method are specified by CISPR (International Special Committee on Radio Interference). When the emission level from an equipment under test (EUT) exceeds CISPR limit, it must be mitigated in order to be compliant. If emission sources on the EUT can be found by using CISPR measurement system, it is very effective for mitigating the emission.

The emission sources finding technique with a near electromagnetic field probe is not based on CISPR measurement system which is referred to far-field measurement. On the other hand, some methods [1][2], which use phase data and amplitude data of far electromagnetic field, are not based on CISPR measurement system in which phase data cannot be obtained. Therefore, we have studied a new finding method through an optimization process [3], which is based on CISPR measurement system by using only amplitude data without phase data. However, the finding calculation efficiency and the estimation accuracy sometimes go down caused by the process of giving optimum initial current positions and that of determining the total current number.

In this paper, in order to solve this problem completely, we propose a new finding algorithm in which estimated current distribution is optimized. Where the total current number and the current positions are fixed from the beginning. Its validness is revealed by comparing the estimated sources with the original ones in computer simulation. Furthermore, this is experimentally verified by using two spherical dipole antennas as simulated emission sources in a semi-anechoic chamber.

2. Sources finding method

Figure 1 shows the coordinate system and current model in which a small dipole current is supposed as a radiated emission source. Ji is the current amplitude of "i (= 1 ~total current number N)" th current source, Jxi, Jyi, Jzi are its components, and Qi (xi, yi, zi) is its position. E_{mh} is the measured horizontal electric field amplitude at "m (= 1 ~M)"th measurement point, and E_{mv} is the vertical one.

As shown in Fig. 2, the basic finding algorithm starts at N = 1 with the given initial values $\alpha^{(0)}$ and $\beta^{(0)}$. Where α means xi, yi, zi, and β means Jxi, Jyi, Jzi generally. The superscript (n) means it is estimated by n times repetition. The correction values $\Delta\alpha^{(n)}$ and $\Delta\beta^{(n)}$ are led through an optimization process which minimizes *Norm* ***u***.

Norm ***u*** is the deviation between $E_{mu}^{(n+1)}$ and E_{mu}^{M} as defined in (1), E_{mu}^{M} is the measured electric field amplitude, and $E_{mu}^{(n+1)}$ is the estimated one.

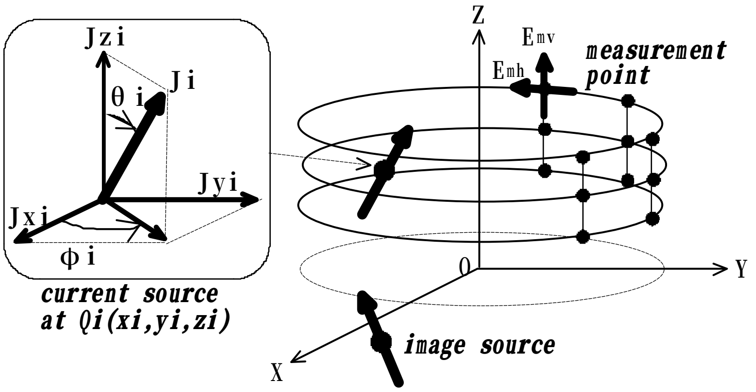


Fig. 1 Coordinate system and current model.

$$Norm_u = \frac{\sum_{m=1}^{M}\left|E_{mu}^{(n+1)} - E_{mu}^{M}\right|^2}{\sum_{m=1}^{M}\left|E_{mu}^{M}\right|^2} \quad (\mathbf{u}=\mathbf{h},\mathbf{v}) \qquad (1)$$

Where subscript **h** and **v** mean the horizontal and the vertical electric field respectively.

This n times calculation until its convergence is repeated in order to prevent the local minimum problem by giving the optimum initial positions $\alpha^{(0)}$ in which *Norm(N)* indicates its minimum value [4]. Moreover, N is determined by being added one by one in case that *Norm(N)* exceeds *Norm(N-1)*. Where *Norm(N)* means the final value of *Norm* **h** +*Norm* **v** at total current number N. However, these routines for giving $\alpha^{(0)}$ and determining N cause deterioration of the calculation efficiency and uncertainty of the estimation accuracy, particularly when sources are increased or distributed complicatedly. Hence, in order to solve this problem completely, we propose a new finding algorithm as shown in Fig. 3, in which the routines for giving $\alpha^{(0)}$ and determining N are not necessary. Where, current positions (N = Nge) are fixed equally from the beginning, thus only current amplitude β are unknown. The calculated results β are expected to be large near the true source positions.

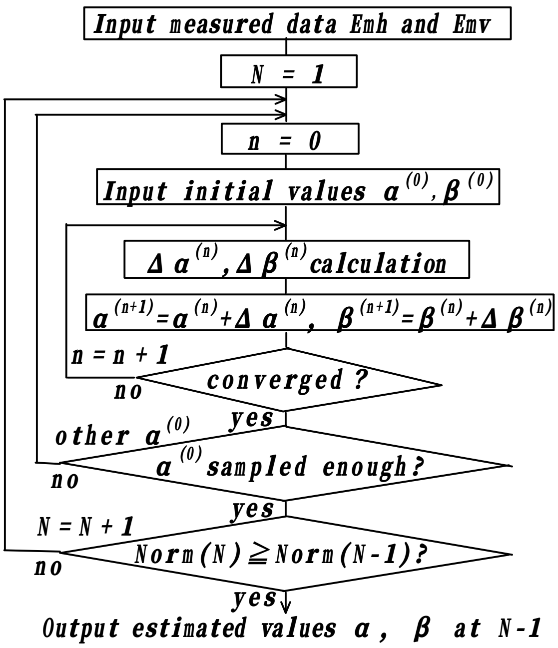


Fig. 2 Basic finding algorithm.

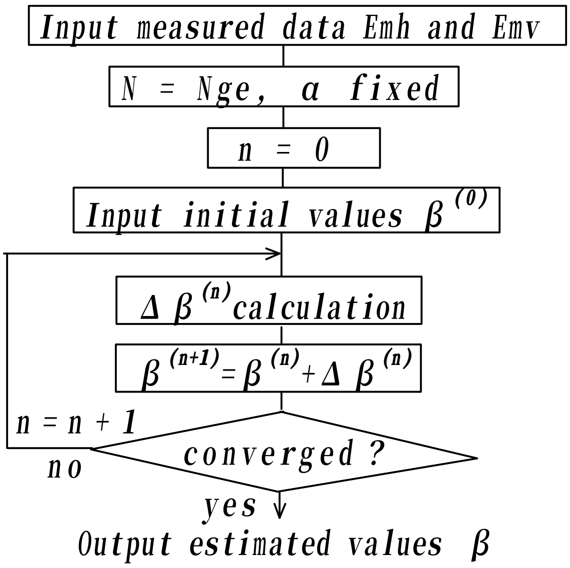
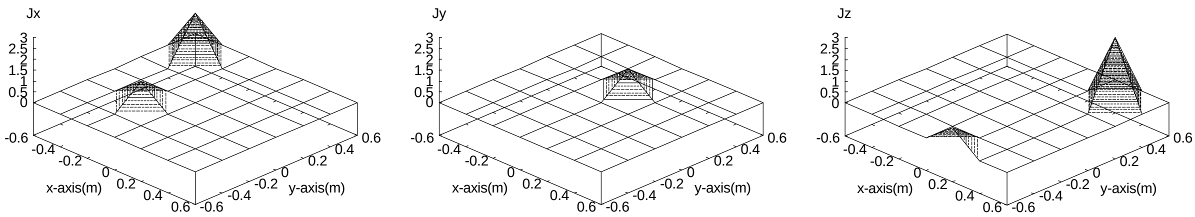


Fig. 3 Presented new finding algorithm.

3. Evaluation in computer simulation

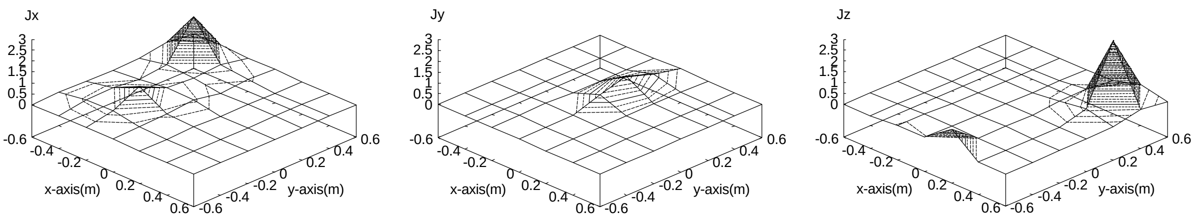
The applicability of the presented new finding algorithm is discussed by evaluating whether given unknown sources distribution can be estimated accurately in computer simulation. Figure 4 shows a given model in which five sources with arbitrary directional current components exist. The vertical axis means the value of current amplitude, where x , y and z component of the current sources are shown in (a), (b), and (c) respectively. Figure 5 shows its evaluation result. Where the estimated current positions were fixed at forty nine points (x, y = -0.6, -0.4, -0.2, 0, 0.2, 0.4, 0.6 m) on the plane of z = 1.25 m, and a contour line interval is 0.1.

As shown in Fig. 4(a) , x component of the given current sources are at the positions of (x, y)=(-0.4, 0.4)(m) and (-0.2, -0.2)(m), and it can be seen that there are peaks of the estimated ones in Fig. 5(a). Moreover, similar results were obtained for the current sources which consist of y or z component. Therefore it is clear that these estimated results accurately visualize the given sources distributions at each directional component.



(a) x component of **J** (b) y component of **J** (c) z component of **J**

Fig. 4 Given model in which five sources exist at frequency 700 MHz.



(a) x component of **J** (b) y component of **J** (c) z component of **J**

Fig. 5 Estimated current sources distribution.

4. Experimental verification

This method was experimentally verified by the system as shown in Fig. 6. Two electric signals under unlocked phase are individually converted into optical signals, and they turn into the radiated electromagnetic wave by two spherical dipole antennas (SDA), where the optical signal lines hardly affect the electric field distribution. Radiation from SDAs is detected with a log-periodic antenna and a spectrum analyzer. Figure 7 shows a given model with two current sources, in which one source directs to

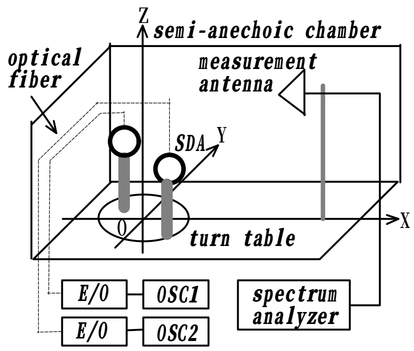
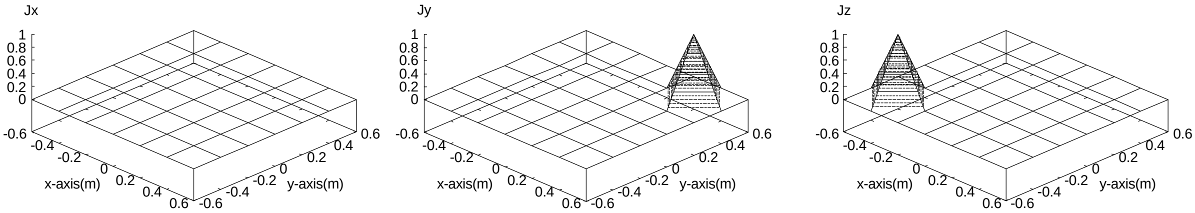


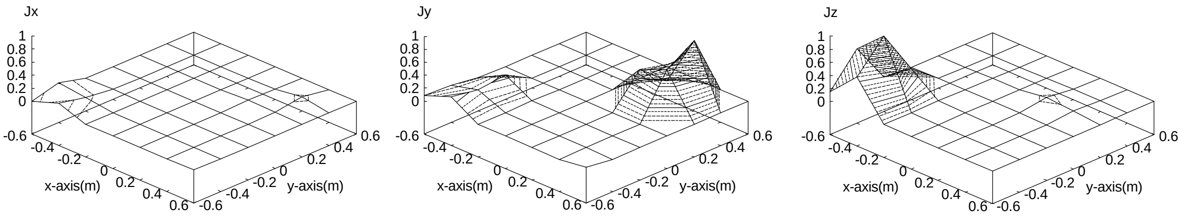
Fig. 6 Experimental system.

y axis and the other one directs to z axis, both of them do not have x component as shown in Fig. 7(a). Its estimated result is shown in Fig. 8, where a contour line interval is 0.03. It can be seen that two sources are accurately estimated.



(a) x component of **J** (b) y component of **J** (c) z component of **J**

Fig. 7 Given model in experimental verification.



(a) x component of **J** (b) y component of **J** (c) z component of **J**

Fig. 8 Estimated current sources distribution.

5. Conclusion

Relating to the radiated emission sources finding method based on CISPR measurement system, which uses only amplitude data without phase data, a new finding algorithm was proposed. It completely overcomes the problem in the optimization process of giving initial current positions and determining the total current number. This applicability was revealed by the evaluation in computer simulation and the experimental verification by using two spherical dipole antennas in a semi-anechoic chamber. As the results, the estimated values agree well with the given ones, even when the sources are increased or distributed complicatedly.

References

[1] C.Wu, K.Y.Kiu, and M.Jin., "Modeling and Correlation Algorithm for Spaceborne SAR Signals", IEEE Trans. Aerosp. and Electron. Sys., Vol. AES-18 No.5, 1982

[2] R.O.Schmidt, "Multiple Emitter Location and Signal Parameter Estimation", IEEE Trans. Antennas and Propagat., Vol. AP-34 No.3, 1986

[3] Y.Ishida, K.Murakawa, K.Yamashita, and M.Tokuda, "New Finding Method of Radiated Emission Sources Utilizing CISPR Emission Measurement System", Proc. EMC'98 ROMA, 1998

[4] Y.Ishida, K.Murakawa, K.Yamashita, and M.Tokuda, "Rasing Accuracy in Finding Method of Radiated Emission Sources Utilizing CISPR Emission Measurement System", Y.Ishida, K.Murakawa, K.Yamashita, and M.Tokuda, EMC'99 TOKYO, 1999