Extraction of Equivalent Sources from Near-Field Scanning Data with a Restart Differential Evolution Method

W. J. Zhao
Institute of High Performance Computing, Singapore, 138632,
zhaow@ihpc.a-star.edu.sg

Complex electronic circuitry is seen in many devices, which results in a vast interference potential. To predict the electromagnetic interference, source reconstruction techniques that extract equivalent sources of current or dipole from scanned near-field (NF) data are developed. Some source reconstruction techniques need the knowledge of NF phase and they employ the least-square method to solve inverse problems (Z. Yu, et al., IEEE Trans. EMC, 1, 2013, 97-108). Due to the ill-posted nature of the problem, regularization techniques are often needed along with the least-square method to eliminate potential false solutions. However, accurate measurement of NF phase is usually difficult in practical applications, especially as the operating frequency is very high. Some other source reconstruction techniques which do not need the NF phase are also developed. They employ global optimization algorithms such as the genetic algorithm to solve inverse problems (X. Tong, et al., IEEE Trans. EMC, 2, 2010, 462-470). These techniques are generally associated with high computational complexity, and they need several hours to obtain the equivalent dipoles of a simple printed circuit board (PCB). An effective source reconstruction technique is proposed in this abstract for the prediction of radio-frequency interference (RFI). The proposed technique does not need to know the NF phase. Equivalent magnetic dipoles are used to model the radiated emission sources of devices, and they are determined by solving an inverse problem with a proposed restart differential evolution (DE) algorithm. Compared to previous methods, the present method has much lower computational complexity. It only needs around 10 minutes on normal desktop PC to extract the equivalent dipole sources of a PCB.

In the proposed method, the unknown dipole parameters $\mathbf{d}_n$ consist of the real and imaginary parts of the *x* and *y* components of a dipole moment and the *x* and *y* coordinates of the position of the dipole. Let $H_{x,m}^{mea}$ and $H_{y,m}^{mea}$ stand for the *x* and *y* components of measured magnetic near field at the m^{th} point. $H_{x,m}^{n}$ and $H_{y,m}^{n}$ represent the *x* and *y* components of magnetic fields at the m^{th} point produced by the n^{th} dipole with the parameter vector $\mathbf{d}_n$. The cost functions are given by

$$f(\mathbf{d}_n) = \frac{1}{N_m}\sum_{m=1}^{N_m}\left\{\left[\left|\sum_{n=1}^{N_d} H_{x,m}^{n}\right| - \left|H_{x,m}^{mea}\right|\right]^2 + \left[\left|\sum_{n=1}^{N_d} H_{y,m}^{n}\right| - \left|H_{y,m}^{mea}\right|\right]^2\right\}. \quad (1)$$

A restart DE algorithm is developed to find $\mathbf{d}_n$. $\mathbf{d}_1$ is first determined via the standard DE routine once the difference of the best population cost between two consecutive generations is smaller than a threshold t_1 set by program. The optimization then restarts to find $\mathbf{d}_2$. The process is repeated until a stop condition is met. The present method has been validated by some examples that will be presented at the conference.