Ground de-Embedded Source Reconstruction Using a Planar Array of H-Field Probes

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***Abstract*—This paper presents an introduction to a new source reconstruction method SRM which tries to deal with a special measurement scenario involving a finite ground plane. In this particular scenario, an array of H-field probes is placed slightly on top of a finite rectangular ground plane as such the normal SRM techniques are not the best choice when it gets to source reconstruction. Our primary goal in this work is to improve the accuracy of near-field to far-field transformation via the reconstruction method. We verify our method by comparing the far-field radiation pattern calculated by this application to that of the typical plane wave spectrum method (PWS).**

Keywords——* *antenna diagnostics, inverse source, source reconstruction method, near-field to far-field, ground de-embedding

I. INTRODUCTION

Nowadays, near-filed to far-field transformation is receiving more and more attention because of the flexibility and the many applications it provides. Near-field measurements do not require far-field separation between the antenna under test and measurement probe(s). They can also be used for diagnosis purposes due to rich content of measurement data they acquire. A more recent approach [1] in near-field measurement technique is to use an array of H-field probes which enables the scanner to acquire all the field data in reasonably short time. This fast field measurement happens due to use of an array of electrically controlled probes comparing to a single mechanically sweeping one. This fast measurement process can be very useful when it comes to diagnosis purposes where a particular current distribution on the device under test cannot be held long, at least not long enough to be measured by a mechanically sweeping probe. EMScan company has introduced a scanner which uses the aforementioned technique. In the scanner, there exists a metallic plane slightly beneath the probe array to suppress the unwanted electromagnetic interference (EMI) between the probes and the RF and digital circuitry underneath. As a simple model, the plane can be assumed to be infinite which equivalently allows us to double the measured the transverse fields above it according to image theory [2]. However, this approach may not be the best one' in this work, another approach based on MOM is presented which brings into account the ground plane effects. More traditional works about near-field to far-fields fall into two categories of mode expansions [3]–[6] and MOM based reconstructions [7]–[12].

II. THRORY

As shown in Fig 1(a), the problem can be described as a radiator, radiating in front of an array of H-field probes above a ground plane. We presume that, other than position and size, any information is not given about the shape and/or the constructing materials of the DUT. Besides, the coupling between the antenna and the ground plane is not strong enough to deteriorate the antenna's reflection loss. In other words, the probes can receive enough power.

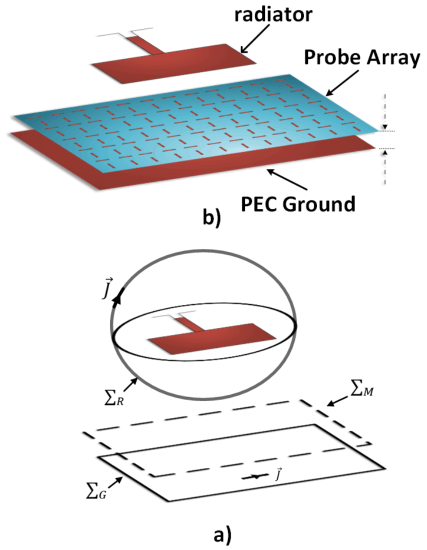

Fig 1.Measurement setup a) schematic and b) Equivalent views

As the first step, we need to model the radiator in an equivalent approach. We can reconstruct the DUT by open or close surfaces of electric and/or magnetic currents [7]–[12]. In this work, we consider the simplest version which is constructing using electric currents. Now, looking at Fig 1(b), It is realized that there are two electric current distributions (on DUT and ground plane) and two boundary conditions (on measurement plane and ground plane). Using this information, we can construct the system of integral equation (1) which is used to solve the problem.

$$\boldsymbol{n}\times\left[-\mathrm{K}\left(\boldsymbol{J_s};\boldsymbol{r}_{\Sigma M}\right)-\mathrm{K}\left(\boldsymbol{J_G};\boldsymbol{r}_{\Sigma M}\right)\right]=\boldsymbol{H_M}\left(\boldsymbol{r}_{\Sigma M}\right) \tag{1-a}$$

$$\boldsymbol{n}\times\left[-\eta_0\left(\mathrm{L}\left(\boldsymbol{J_s};\boldsymbol{r}_{\Sigma G}\right)-\eta_0\mathrm{L}\left(\boldsymbol{J_G};\boldsymbol{r}_{\Sigma G}\right)\right]=\boldsymbol{0} \tag{1-b}$$

Where L and K are the famous electromagnetic operators [13] and $\boldsymbol{H_M}$ is the measured fields. As a consequence of using only electric currents, we may not have be able to increase the reconstruction accuracy, but this choice will not affect the near-field to far-field transformation significantly [12]. In the next step, we proceed with discretizing the electric current distribution by famous RWG basis functions [13][14]. Finally, after the MOM matrix is constructed, we use the T-SVD [15] method to regularize the numerical problem and find a stable solution to it.

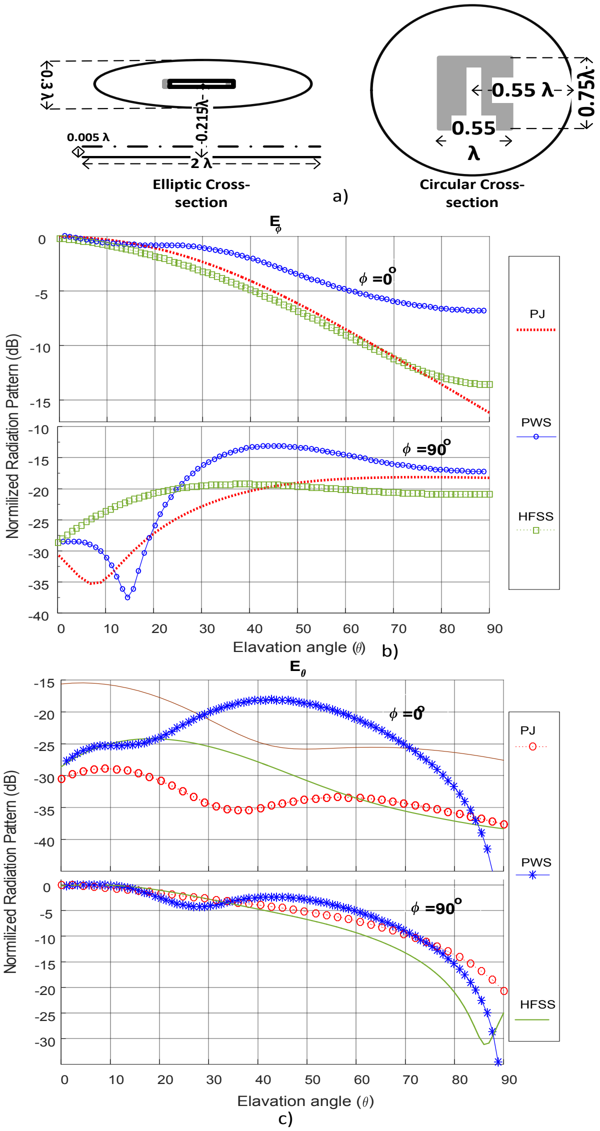

Fig 2. Slot antenna a) structure and radiation patterns b) E_ϕ c) E_θ

III. RESULTS

To verify the proposed method, the near-fields of the slot antenna (Fig 2(a)) at 2 GHz are measured using EMScan RFExpert scanner which is using an array of H-field probes in front of ground plane. Then, the accuracy of the proposed method can be assessed by comparing its angular accuracy to that of the PWS with respect to the simulated one. As explained, first, we back-project the measured field to the fictitious layer and the ground plane and calculate the far-fields of the fictitious layer only. The ellipsoid used for back-projection has 3 radiis of 11, 11, and 3 cm with meshing element length of 1.4 cm. The center of ellipsoid is 4.2 cm away from the fictitious surface, which is backed by a PEC in its 1 mm distance. As shown in Fig. 2, it can be seen that the 1dB angular accuracy has increased from 17 and 27 degrees in PWS method to 64 and 31 degrees respectively in the proposed method.

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