Robust Feed Modeling of the Asymmetric Planar Mesh Dipole-Type Antenna

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***Abstract*— This paper explores the feed method for the asymmetric planar XY-mesh dipole-type antenna and the modifications needed to prevent its exploitation by automated genetic algorithm (GA) optimization for the application of RFID tag antennas, where the antenna is optimized to the conjugate of the chip impedance. By removing certain feed parameters from the GA optimization and instead making them wavelength dependent, the goal of creating robust models which achieve accurate and matching results between various electromagnetic (EM) simulators, with a focus on the WIPL-D and Axiem EM simulators, was achieved.**

***Keywords*—antenna synthesis, antenna modeling, genetic algorithm.**

I. Introduction

In automated antenna synthesis using genetic algorithms (GA), the antenna model needs to be created such that it is robust to the multitude of various designs that can be created and not easily exploitable with unrealistic designs. The antenna feed can be a particularly sensitive component of the model. Most antennas are initially designed using an ideal feed, since this is the fastest and simplest way. These ideal feeds should not be a key component in achieving the desired antenna performance, as they are expected to be replaced with a real feed. The purpose of the ideal feed is to provide excitation of the antenna structure and the expected port impedance. In addition, since the feed methods vary with electromagnetic (EM) simulator, setting up the feed model is very important in achieving matching results between the different EM simulators. The primary focus in this paper is achieving matching results between WIPL-D and NI AWR Axiem. Both are full-wave 3D electromagnetics solvers using the Method of Moments, however WIPL-D [1] allows arbitrary 3D modeling with finite dielectric regions, whereas Axiem [2] uses stacked planar structures and vias with infinite dielectric substrate sheets. Although the feeding methods for WIPL-D and Axiem are both gap voltage sources, in WIPL-D the feed is assigned to a wire, which must be completely inside or outside of a dielectric region, whereas in Axiem the feed is assigned to the edge of a planar conductor on the surface of a dielectric substrate sheet or in air.

This paper explores the feed method for the asymmetric planar xy-mesh dipole-type antenna and modifications needed to prevent its exploitation when used for the automated design of RFID tag antennas with an atypical desired input impedance (e.g., Z_{in} = 16 + j148Ω rather than the more typical 50Ω).

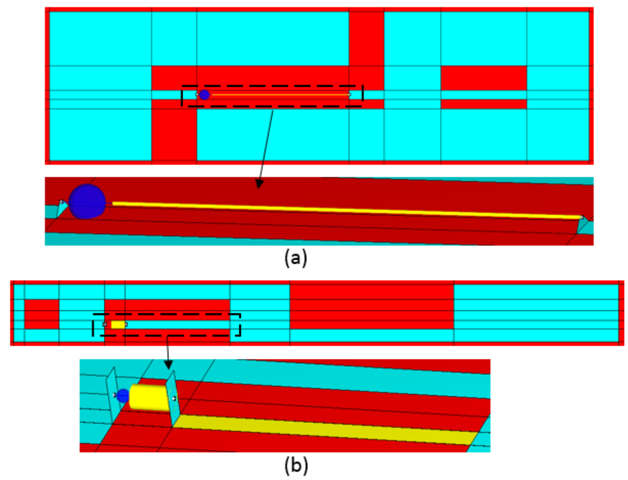

Fig. 1. Examples of WIPL-D feed models: (a) original wire and (b) final wire plus planar conducting strip.

Although the initial WIPL-D model exploited the feed wire length and diameter to meet the specifications [3], the final more robust model was also easily able to meet the specifications without needing to resort to such exploitation [4].

II. Challenges in Feed Modeling

The asymmetric planar XY-mesh dipole-type antenna in NI AWR AntSyn, a software for automated antenna synthesis, was created for use on fixed-size dielectric substrates which can simulate an environment (enviro-mesh antenna), and the capability to optimize the antenna on multiple substrates simultaneously makes it good for RFID tag applications. For RFID tag antennas, the antenna is optimized to the conjugate of the chip impedance, and a typical chip impedance value is 16 - j148Ω. This means the antenna impedance would need to have a really high inductance of j148Ω. In the initial enviro-mesh antenna WIPL-D model, the GA optimizer was easily able to exploit the feed wire to get the high inductance needed by making the feed wire really long and skinny (see Fig. 1 (a)). This did come up with a working antenna [3], however it made getting matching results in the exported Axiem model problematic, as Axiem does not use a wire feed. Fabrication would have also been more difficult. Note that other EM simulators which are able to simulate the long, skinny wire did come up with reasonably well matching results.

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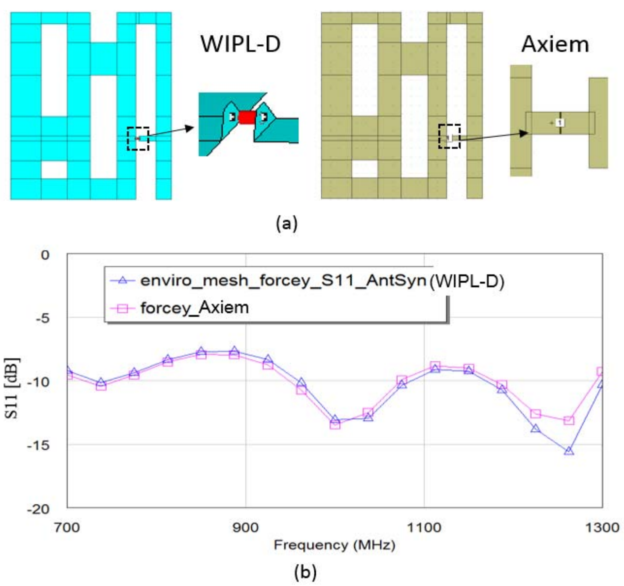

Fig. 2. Comparison of WIPL-D and Axiem for example 1 (no substrate): (a) antenna models and (b) return loss.

Several variations of feed methods in both WIPL-D and Axiem were investigated to see which would give accurate and reasonably well matching results, where an additional EM simulator was used as a tie breaker if necessary. The feed method which ended up working best utilizes a fixed, wavelength-dependent length/diameter for the feed wire in WIPL-D and an internal port with corresponding dimensions in Axiem, and the rest of the original feed was replaced by a planar conductor on the surface of the substrate, where the width is independent of the feed wire (see Fig. 1(b)). In WIPL-D, for the most accurate results with a cylindrical wire feed, the length to radius ratio should be greater than 30 [1]. Since the feed wire needs to be kept very short, this would require a much thinner wire than can be accurately represented in Axiem, as it is very hard to replicate the behavior of very thin feed wires in Axiem. The internal port in Axiem is assigned to the edge between two touching or electrically close planar conductors, and the smallest edge the mesh must represent is specified [2]. Once the internal port conductors are smaller than a certain amount, the port characteristics do not change as significantly as they would for the actual wire, and the very small edge needed to represent the very thin port conductor can significantly increase meshing time or cause errors depending on the antenna model. A tradeoff is made that achieves reasonably well matching results among the various simulators for a variety of cases. With this new WIPL-D model, the GA optimizer is not able to exploit the feed method to achieve the desired specifications but must instead work harder on the antenna design to meet tighter specifications. This new method was also able to come up with a working antenna [4].

III. Results

For comparison of the WIPL-D and Axiem results using the new feed modeling method, two enviro-mesh design examples are shown—the first without substrate and the second with various substrates. Since the purpose was to achieve matching results between the two simulators, the two antennas were not fully optimized and a 50Ω port impedance was used. Fig. 2 shows the design 1 models and return loss, whereas Fig. 3 shows the same for design 2. Both models show reasonably well matching return loss over the entire band. The design 2 results were compared on various substrate dielectrics (ε_r = 2, 4, and 8), and Fig. 3 shows the ε_r = 2 results. Reasonably well matching return loss was also achieved for the other two dielectrics with design 2. Also, the gain vs. frequency results were compared, and both design 1 and design 2 showed excellent matching between the two simulators.

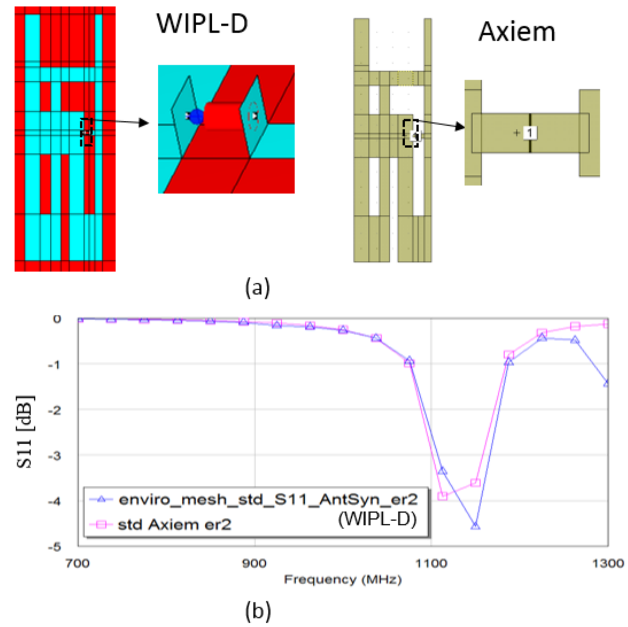

Fig. 3. Comparison of WIPL-D and Axiem for example 2 (has substrate): (a) antenna models and (b) return loss.

IV. Conclusions

The original enviro-mesh antenna model worked well and was robust for more typical 50Ω antenna impedance, however it was discovered to be easily exploitable when used with the complex impedances necessary for RFID tag antenna designs. By removing certain feed parameters from the GA optimization and instead making them wavelength dependent in addition to converting the rest of the original feed wire into a planar conducting strip, the goal of creating robust models which achieve accurate and matching results between various EM simulators, with a focus on the WIPL-D and Axiem EM simulators was achieved.

References

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