Full 3D EM modeling of Yagi Antenna for WLAN

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Abstract: The paper shows how precisely one can model Yagi antenna for WLAN with all accompanying elements (dielectric carrier, U-balun, radome), and how these elements influence the antenna characteristics. The investigation is based on simulation of a typical high gain Yagi antenna and comparison these results with measurements. It is found that dielectric carrier can be omitted from analysis, U-balun should be included for reflection coefficient results, while influence of radome is significant for both reflection coefficient and radiation pattern.

Keywords: 3D EM Modeling, Yagi Antennas, U-balun, Radome, WLAN

1. Introduction

Yagi antenna provides a simple and low cost solution for WLAN applications. Depending on construction it can easily enable gain in main direction up to 18 dB and VSWR less than 2.

Most often the Yagi is realized using half-wavelength folded dipole as driven element, little bit longer dipole behind it as reflector, and a set of little bit shorter dipoles in front of it as directors. All elements are placed on metallic or dielectric carrier. Since the antenna is usually connected to a device by coaxial line, a balun between the folded dipole and the connector is required. Finally, for outdoor applications it is necessary to protect antenna from abrasion and corrosion, e.g., by encapsulating it in a radome.

The Yagi antenna itself, without the accompanying elements (a carrier, a balun and a radome), can be easily analyzed and optimized using low cost softwares for analysis of wire structures. However, full 3D EM analysis is relatively complicated task.

The purpose of this paper is to investigate how precisely one can model Yagi antenna with all accompanying elements and how these elements influence the antenna characteristics. The investigation is based on simulation of a typical high gain Yagi antenna with dielectric carrier, U-balun, and cylindrical radome, and comparison these results with measurements.

2. Electromagnetic modeling of the antenna

Full 3D modeling of the Yagi antenna is performed using software package WIPL-D Pro [1]. The modeling is performed in 6 steps:

(1) Model of basic Yagi structure is made using wires (Fig. 1a). Wire ends are modeled as conical (almost flat) wires.

(2) Dielectric (stir foam-like) carrier is made of dielectric bilinear surfaces (Fig. 1b). However, we found that the carrier practically does not influence the antenna characteristics. Hence, we omitted the carrier in next models.

(3) Inner and outer surfaces of dielectric radome are made of bilinear surfaces, as shown in (Fig. 1c). However, we found that dielectric model of radome can be efficiently replaced by metallic model with equivalent distributed loadings, as explained in Ref. [2].

(4) Complete model of U-balun (U-shaped coaxial line) is added to model (1). We used metallic bilinear surfaces for inner and outer conductor, and dielectric bilinear surfaces for dielectric boundary surface at coaxial line openings (Fig. 1d).

(5) In similar way as in (4) we modeled coaxial line that connect U-balun with antenna connector (Fig. 1e).

(6) Metallic model of radome (with distributed loadings) is added to model (5) (Fig 1f).

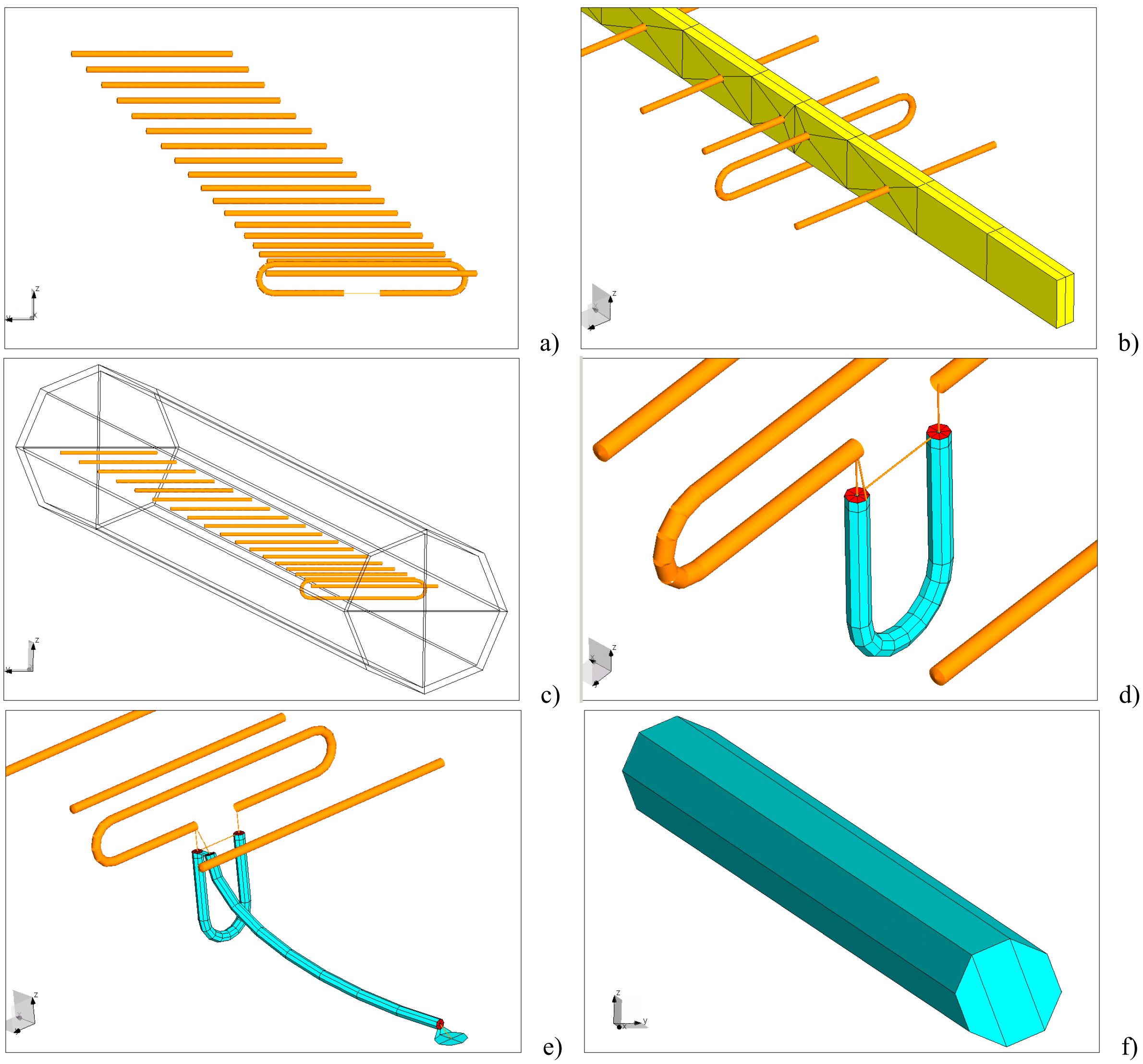


Fig. 1. Geometrical models of Yagi with/without carrier, U-balun, and radome.

3. Comparison of calculated results and measurements

Good agreement between calculated and measured results is observed.

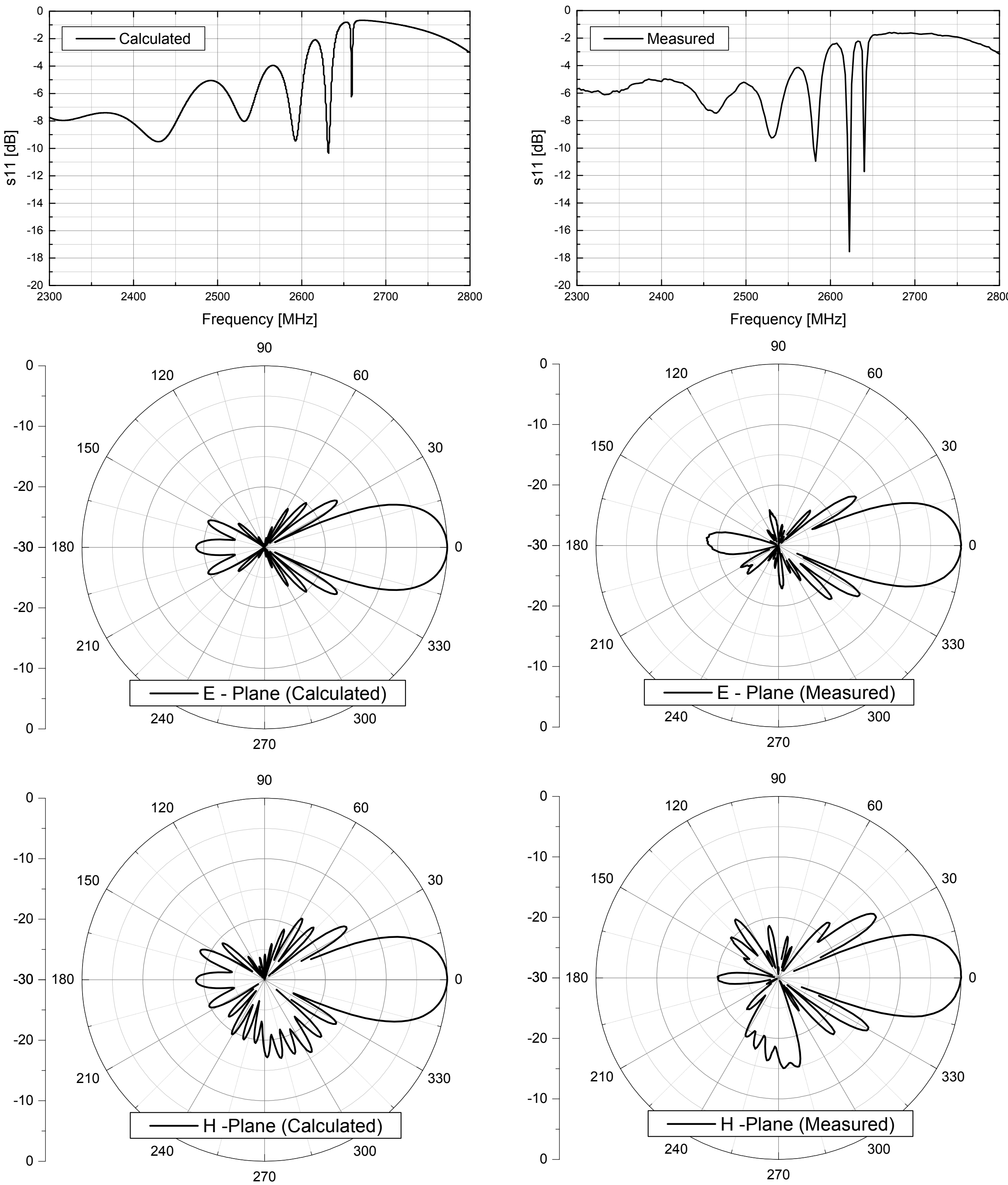
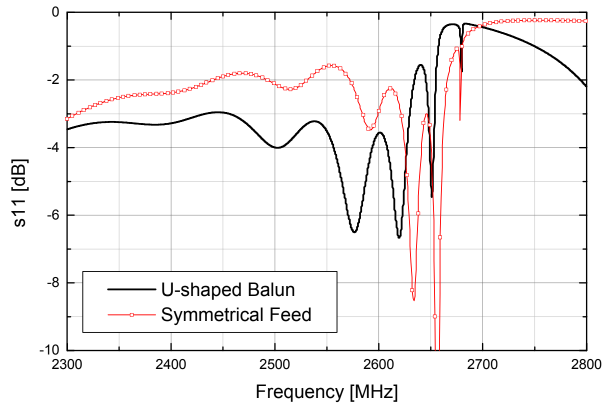
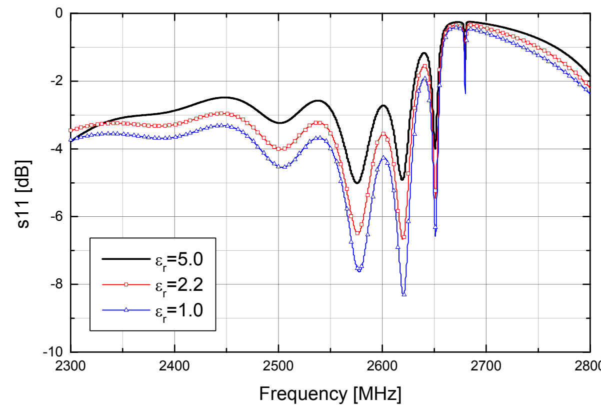


Fig. 2. Comparison of calculated and measured results.

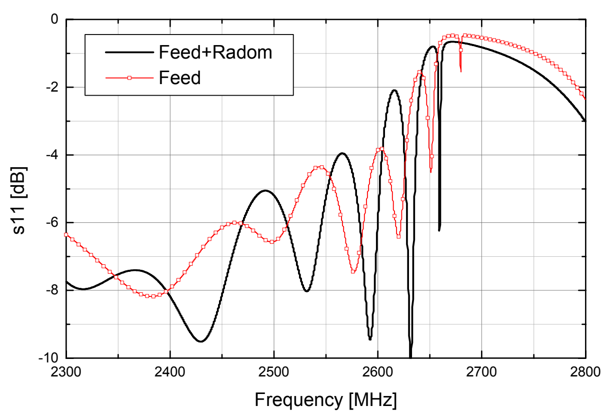
4. Influence of carrier, balun and radome on antenna characteristics



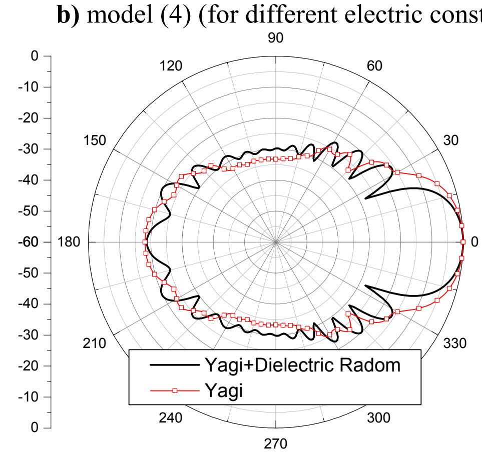
a) models (4) and (1)



b) model (4) (for different electric constants)



c) models (5) and (6)



d) models (3) and (1)

Fig. 3. Influence of carrier, balun and radome on antenna characteristics.

5. Conclusions

For precise simulation of radiation pattern the model should include dielectric radome in addition to wire model of Yagi antenna (Fig. 3d). Circuit theory can not take the U-balun (half wavelength coaxial line) precisely into account, since for various electric constants the U-balun have different physical sizes (Fig. 3b). For precise simulation of reflection coefficients radome should be taken into account, too (Fig. 3c).

References

[1] WIPL-D Pro: 3D electromagnetic solver – Professional Edition, v4.10, WIPL-D, Ltd., Belgrade: 2003.

[2] B. M. Kolundzija and A. R. Djordjevic, "Electromagnetic modeling of Composite Metallic and Dielectric structures", Artech House, Boston, 2002.

