

Dual-Band Printed Inverted-F Antenna with a Nested Structure

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Abstract—A dual-band printed inverted-F antenna with a nested structure is proposed. In this antenna, matching can be controlled for both frequency bands by changing element lengths. The measured and calculated frequency characteristics of the antenna's reflection coefficient match very well, if the measurement cable connector is considered in the simulation. The measured -10 dB relative bandwidths of the reflection coefficient are 4.7% at 2.45 GHz (2.5 GHz to 2.62 GHz), and 9% at 5.5 GHz (5.28 GHz to 5.78 GHz). The calculated radiation efficiencies are 92% and 88%, at 2.45 GHz and 5.5 GHz, respectively, with calculated peak realized gains of 1.07 dBi and 3.36 dBi, respectively.

1. INTRODUCTION

Inverted-F antennas [1, 2] are widely used because of their compact, low profile features [3, 4]. They are also used in wireless LAN (local area network) applications, because they can be easily integrated with dielectric substrates, or printed circuit boards. There are two widely used unlicensed bands (2 GHz and 5 GHz) for wireless LANs, and there is a strong demand for compact antennas covering both these frequency bands. A dual-band printed inverted-F type antenna [5] has been proposed for this purpose. However, with the structure presented in [5], the design parameters for each one of the two bands are not explicit.

In this study, a dual-band printed inverted-F antenna with a nested structure is proposed (see Fig. 1). In this antenna, matching can be controlled for both frequency bands by changing element lengths.

2. DUAL-BAND PRINTED INVERTED-F ANTENNA

Figure 1 shows the configuration of a dual-band printed inverted-F antenna. An FR-4 (Panasonic R-1705) is used as the substrate. A $50\ \Omega$ microstrip line with a 3-milimeter-wide signal line is used for feeding the antenna. Two F-shaped patterns are nested in the upper metal layer. The longer element is used for the lower frequency band, and the shorter one for the higher band. Two via holes with a diameter of 1.27 mm connect the upper and lower metal layers. A Sub-Miniature version A (SMA) connector (shown in Fig. 2) is installed on the edge of the substrate, and used for measurement. The inner and outer conductors are connected to the upper and lower conductor layers of the FR-4 substrate, respectively. Both the SMA connector and the FR-4 substrate material properties are modeled (for simulation purposes) as in [6].

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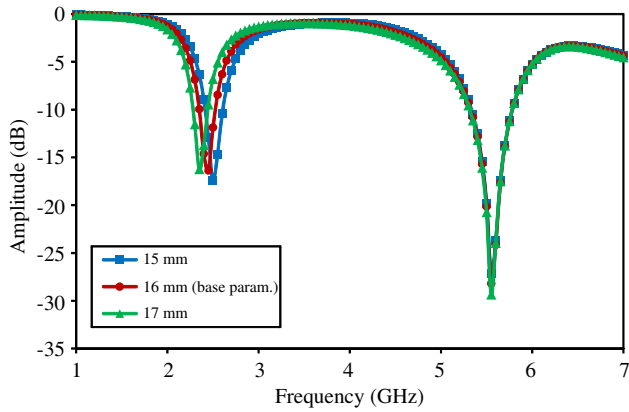


Figure 3. Frequency characteristics of the reflection coefficient for three different values of l_{1a} (calculated).

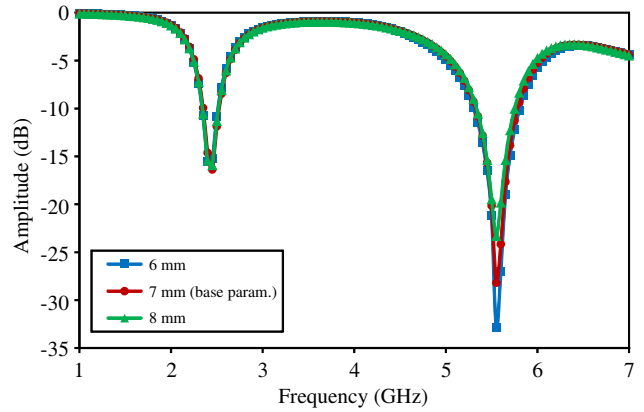


Figure 4. Frequency characteristics of the reflection coefficient for three different values of l_{1b} (calculated).

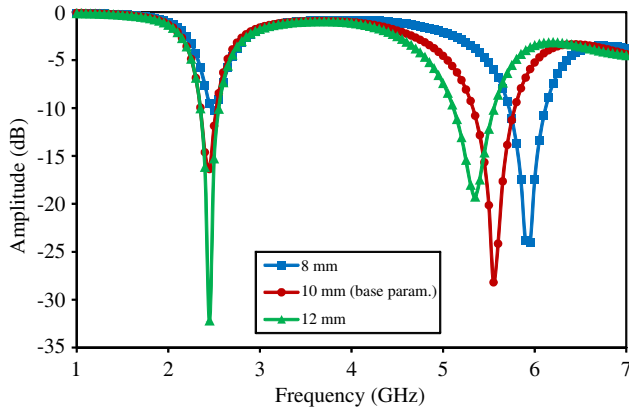


Figure 5. Frequency characteristics of the reflection coefficient for three different values of h_1 (calculated).

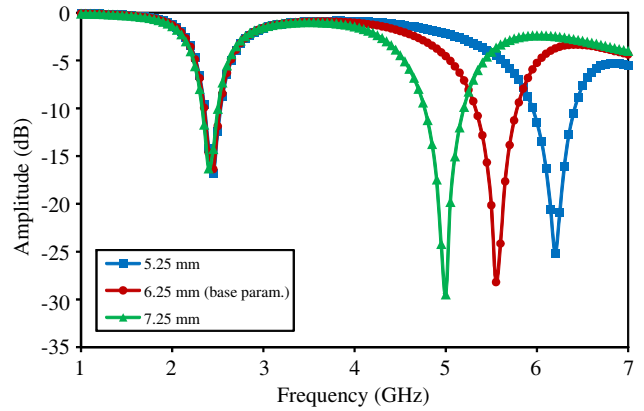


Figure 6. Frequency characteristics of the reflection coefficient for three different values of l_{2a} (calculated).

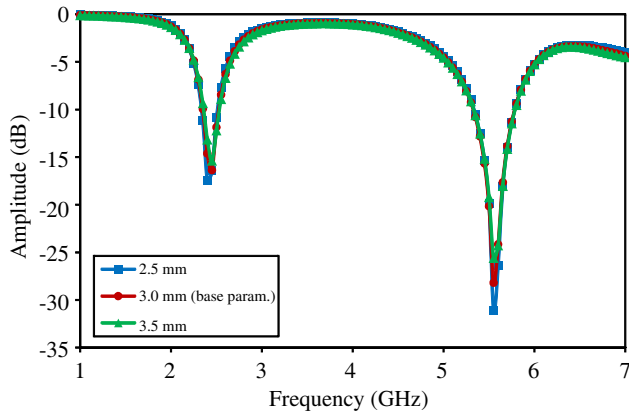


Figure 7. Frequency characteristics of the reflection coefficient for three different values of l_{2b} (calculated).

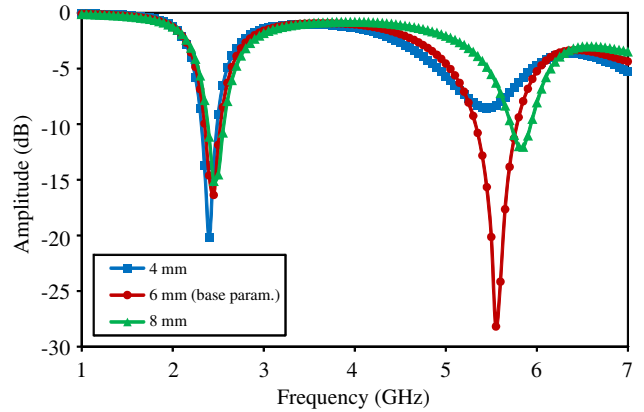


Figure 8. Frequency characteristics of the reflection coefficient for three different values of h_2 (calculated).

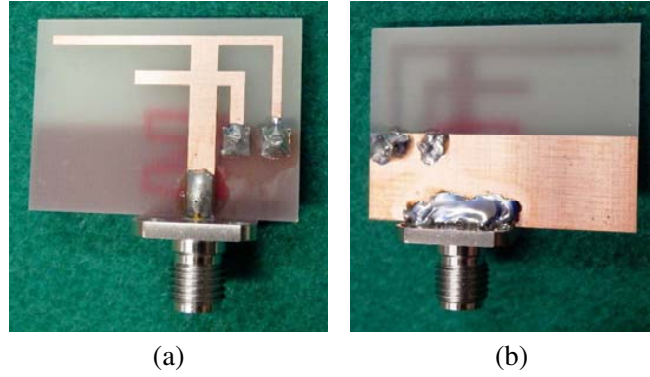


Figure 9. Photograph of the developed antenna. (a) Top view. (b) Bottom view.

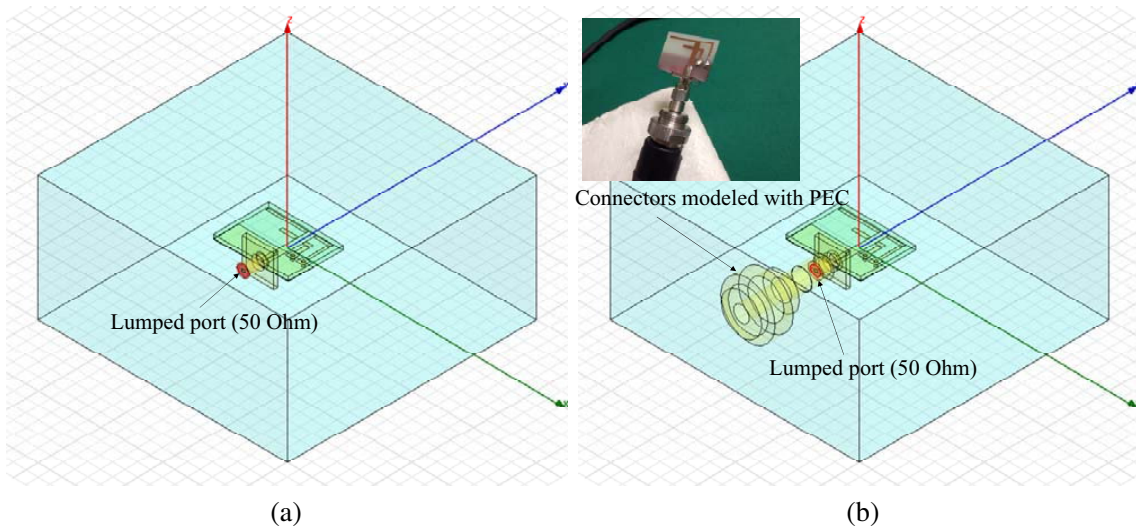


Figure 10. HFSS analysis models. Absorbing conditions are imposed at all external boundaries (radiation boundary). (a) w/o cable. (b) w/ cable.

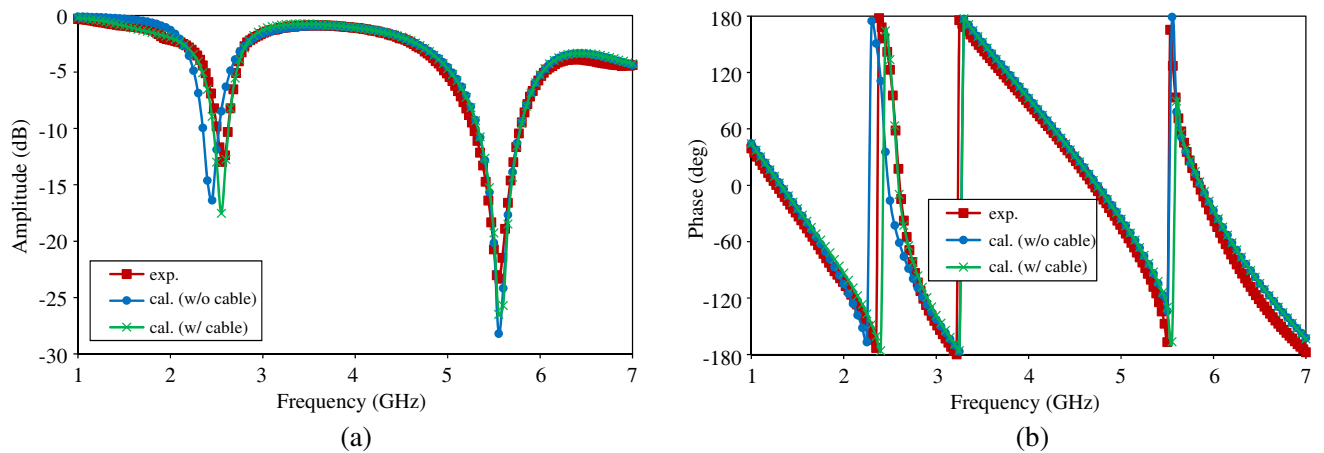


Figure 11. Calculated and obtained frequency characteristics of the reflection coefficient. (a) Amplitude. (b) Phase.

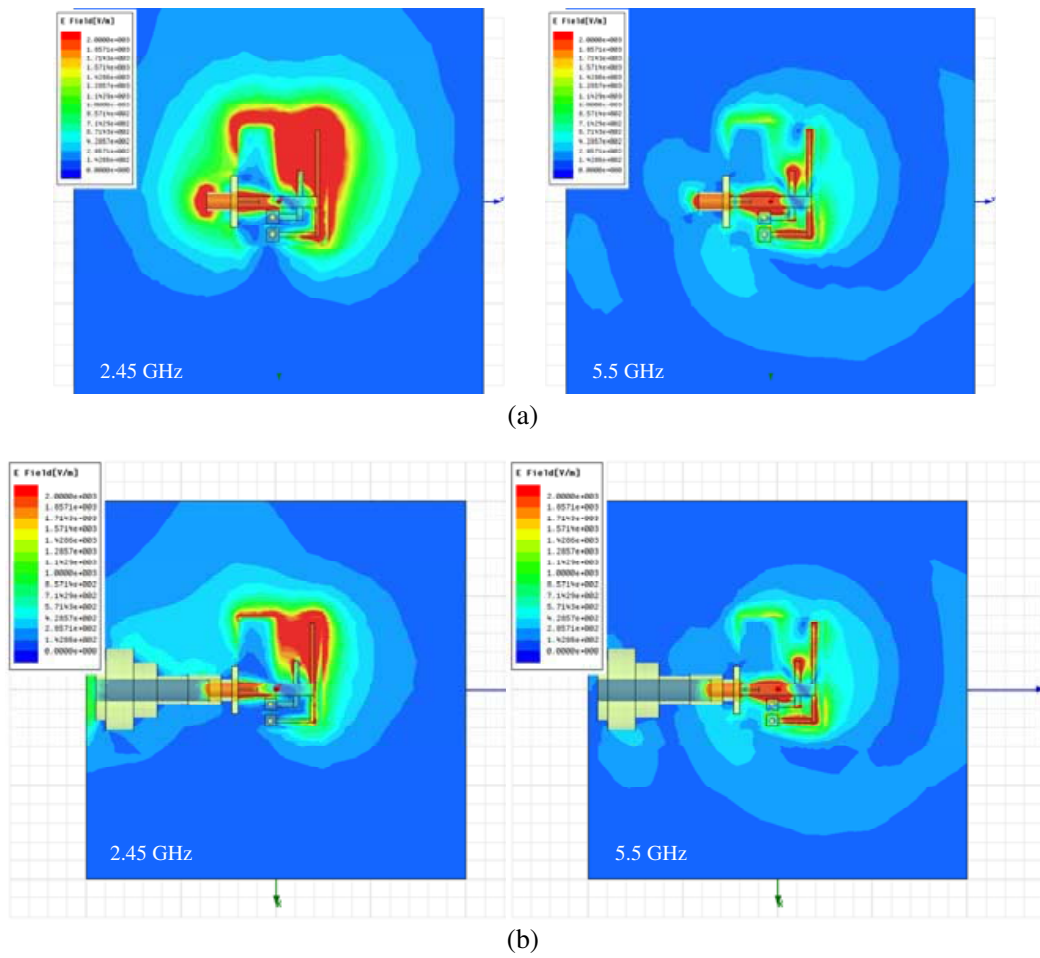


Figure 12. Calculated electric field distribution in the x - y plane (a snapshot of time). (a) w/o cable. (b) w/ cable.

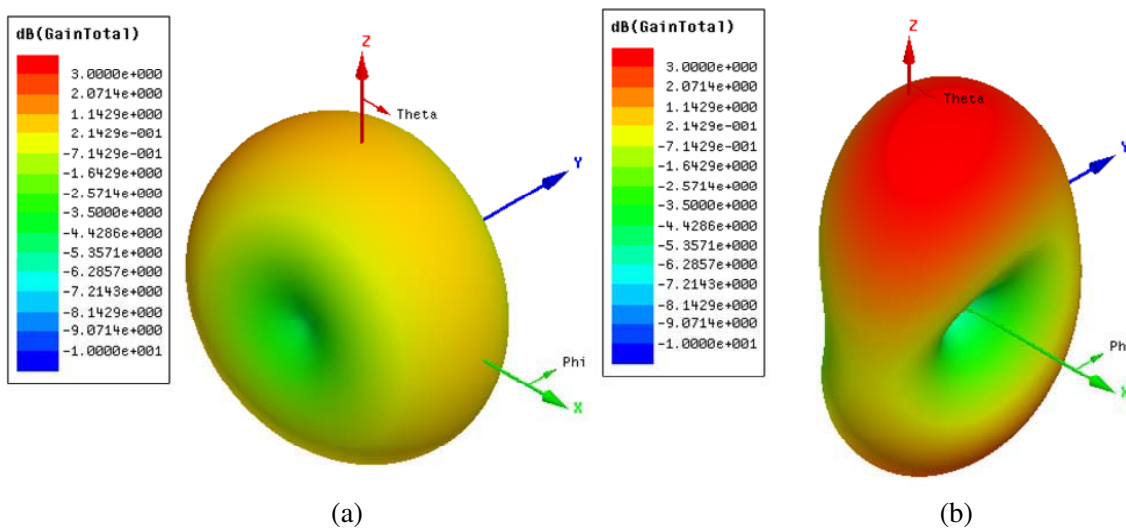


Figure 13. Calculated 3-D gain patterns. (a) 2.45 GHz. (b) 5.5 GHz.

be observed at the lower frequency band (2.45 GHz). This shift is due to the cable connectors used for measurement in the experimental setup, shown in Fig. 10(b); when the model in Fig. 10(b) was used, the calculated results (cal. (w/ cable)) matched very well with the measured values. The importance of cable connector modeling can be explained by considering electromagnetic field scattering. Fig. 12 shows calculated electric field distribution in the x - y plane. The difference of electric field distribution between two models (w/o cable and w/ cable) is significant at 2.45 GHz while it is not significant at 5.5 GHz. Therefore the modeling of the cable connector, not only the SMA connector [6], is important at 2.45 GHz due to strong perturbation of the field. The measured -10 dB relative bandwidths of the reflection coefficient were 4.7% at 2.45 GHz (2.5 GHz to 2.62 GHz), and 9% at 5.5 GHz (5.28 GHz to 5.78 GHz). Although the working band 2.5 GHz–2.62 GHz is out of IEEE 802.11b/g/n 2.4 GHz frequency band, the frequency band can be adjusted by changing l_{1a} for variety of implementations.

Figure 13 shows the calculated 3-D gain patterns for the model in Fig. 10(a). The calculated radiation efficiencies were 92% and 88%, at 2.45 GHz and 5.5 GHz, respectively, with calculated peak realized gains of 1.07 dBi and 3.36 dBi, respectively.

5. CONCLUSION

A dual-band printed inverted-F antenna with a nested structure was proposed, in which matching can be controlled for both bands by changing element lengths. The measured and calculated frequency characteristics of the reflection coefficient match very well, if the measurement cable connector is considered in the simulation. Measured relative bandwidths (at -10 dB) of 4.7% and 9% were obtained for the reflection coefficient, at 2.45 GHz and 5.5 GHz, respectively. The calculated radiation efficiencies at these frequencies were 92% and 88%, with calculated peak realized gains of 1.07 dBi and 3.36 dBi, respectively.

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