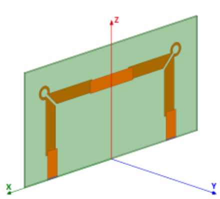
slightly larger than the 3.6 dBi predicted by circuit analysis, namely 4.1 dBi in the z direction, and it drops to 3.8 dBi in the x direction. The simulated return loss is approximately 21.6 dB at 1.2276 GHz, which is in good agreement with the value obtained by circuit theory of 20 dB at 1.2276 GHz.

The final step is to model the required reactances of the segmented antenna. The inductance corresponding to X_3 is L_3=12.03 nH. This value is realized by a small circular loop in each of the two corners of the half-loop. The trace width for this inductor was set to 1 mm. The other two lumped elements are capacitances 0.26 and 0.30 pF, which are realized by overlapping the strips located on the opposite sides of the substrate. For these three sets of printed reactive elements, the initial dimensions were determined based on static approximation. The final dimensions, i.e., the loop radius for the inductors and overlap length for the capacitors, were determined with direct optimization of these parameters in the full-wave software. This secondary optimization resulted in an omnidirectional directivity of 3.8 dBi in both x and z directions, with the input reflection coefficient magnitude of -21.6 dB at 1.2276 GHz. The dimensions for the inductive loop radius, and the overlap capacitor lengths, were 2.22 mm, 1.55 mm, and 1.95 mm, respectively. The printed circuit arrangement, and a photo of its prototype, are shown in Fig. 7. A lumped port excitation was used in the simulation model to represent the SMA end-launch connector of the fabricated prototype. The substrate used for the ground plane and feed network is a 62 mil Rogers RT/Duroid 5880. Note that the feed network is a power divider which feeds the two ports of the HLA out of phase [1].

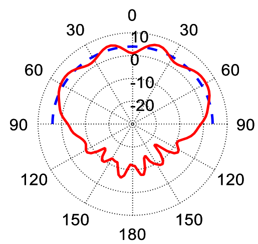


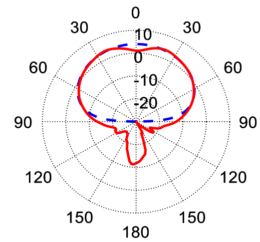
(a) (b)

Fig. 7. (a) Printed circuit version of the antenna. (b) Half-loop segmented antenna prototype.

IV. PROTOTYPE MEASUREMENTS

The radiation pattern measured with a ground plane of 1 meter diameter is compared with the simulated pattern in Fig. 8. The antenna radiation pattern and efficiency were measured using the SG64 Starlab measurement system at Kennesaw, GA. Because of the limited ground plane size, the edge diffraction effect is clearly visible. The measured value drops below the simulated value at θ = 70º. For a larger ground plane size, one would expect wider omnidirectional coverage angle. The measured radiation efficiency at the center frequency is 93%. The measured reflection coefficient magnitude is given in Fig. 9.





(a) (b)

Fig. 8. Measured (solid) and simulated (dashed) radiation patterns of the antenna at 1.2276 GHz in: (a) *xz* or φ = 0º and (b) *yz* or φ = 90º planes.

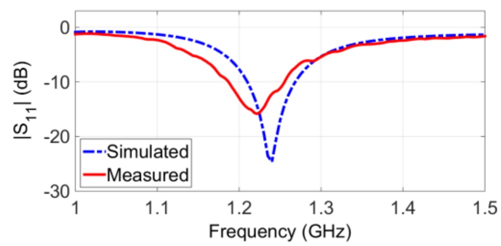


Fig. 9. Reflection coefficient magnitude of the antenna.

V. CONCLUSIONS

By allowing the individual reactances in a segmented antenna to take distinct values, it becomes possible to simultaneously optimize the radiation pattern and the input match of the antenna. A preliminary optimization is considerably speeded up by analyzing the antenna equivalent circuit. The required capacitances and inductances can be easily integrated into the printed circuit of the segmented antenna, such that no external matching circuit is necessary.

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