

Improved Design of a Single-Layer Dual-Band and Wideband Multi-Ring Microstrip Antenna Fed by an L-probe with Outer Separated L-shaped Elements

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Abstract—This paper presents improved design of a single-layer dual-band and wideband multi-ring microstrip antenna (MR-MSA) fed by an L-probe with outer separated L-shaped elements. The proposed MSA is composed of two outer separated L-shaped patches, an inner rectangular split ring patch, and a feeding L-shaped probe (L-probe) arranged on a single-layer dielectric substrate with a relatively large thickness of approximately 0.1 wavelengths. The outer patches and the inner patch are designed for lower and higher bands around 9.5 GHz and 13 GHz, respectively. The L-probe is used to excite the both patches as well as to obtain wideband performance together with the thick substrate. In order to realize wideband characteristics for the two bands, structural parameters of the proposed MSA are tuned by using an electromagnetic simulator ANSYS HFSS. The simulated results reveal that 20.1% and 18.3% fractional bandwidths less than -10 dB reflection for the lower and higher bands are achieved by the proposed MSA, respectively. It is also confirmed by the simulation that stable unidirectional radiation pattern and good broadside gain characteristics are also obtained.

I. INTRODUCTION

Multi-band and broadband planar antennas are demanded strongly for various systems such as high-speed wireless communications, broadcasting, sensing, and radar applications. A microstrip antenna (MSA) is well known as the most typical planar antenna because of its practical advantages of small size, low profile, light weight, and low fabrication cost with PCB processes. Multi-ring microstrip antennas (MR-MSAs) fed by an L-probe have been proposed by the authors as multiband planar antennas [1], [2]. The MR-MSA consists of multiple ring patches arranged concentrically and a feeding L-shaped probe (L-probe) placed beneath the ring patches with a double-layered dielectric substrate [3]–[5]. The MR-MSAs exhibit design flexibility with respect to the number of operating frequencies and their polarizations. Another advantage of the MR-MSAs is that stable unidirectional patterns are observed at the operating frequencies. Therefore, the MR-MSAs provide excellent multiband planar antenna performance. However, when a thin dielectric substrate is used, the bandwidths of the MR-MSAs become narrow.

In order to overcome this problem, the wideband MR-MSAs fed by an L-probe for single- and dual-band operations have been presented [6]–[8]. 46.1% fractional bandwidth below -10 dB reflection is reported by the single-band ring MSA fed by an L-probe with a double-layered thick substrate with a thickness of approximately 0.15 wavelengths. 20.3% and 15.7% fractional bandwidths are obtained by the dual-band

MR-MSA with a thick triple-layered substrate. Furthermore, dual-polarized dual-band and wideband MR-MSAs fed by two L-probes arranged orthogonally have been also reported [9], [10]. In these examples, double-layered or triple-layered dielectric substrates are used. On the other hand, single-layer wideband MR-MSAs fed by an L-probe have been proposed, where one or two ring patches and an L-probe are arranged on a thick single-layer substrate [11]–[13]. In [13], a single-layer dual-band and wideband MR-MSA fed by an L-probe with outer separated L-shaped patches has been proposed. Good dual-band and wideband performance of 10.1% and 16.9% fractional bandwidths for the lower and upper bands are obtained by the electromagnetic simulation with ANSYS HFSS.

In this paper, in order to improve the two bandwidths of the single-layer dual-band and wideband MR-MSA, the geometries and the dimensions of the outer separated L-shaped patches, the inner patch, and the L-probe of the MR-MSA are modified and tuned by using ANSYS HFSS. Simulated results including two improved bandwidths of the designed single-layer dual-band and wideband MR-MSA are presented.

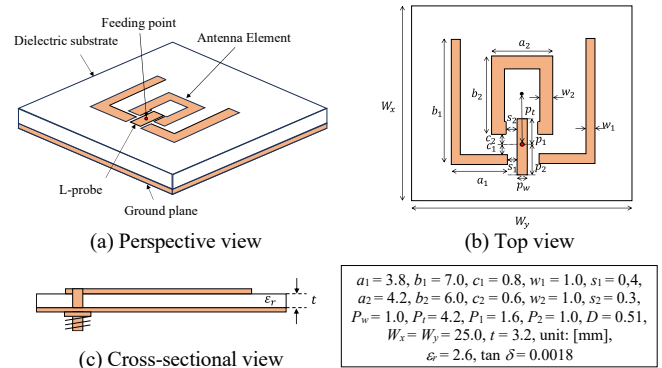


Figure 1. Structure of the proposed single-layer dual-band and wideband MR-MSA fed by an L-probe with outer separated L-shaped elements.

II. STRUCTURE OF THE PROPOSED SINGLE-LAYER DUAL-BAND AND WIDEBAND MR-MSA FED BY AN L-PROBE WITH OUTER SEPARATED L-SHAPED ELEMENTS

Figure 1 presents the structure of the proposed single-layer dual-band and wideband MR-MSA fed by an L-probe with separated L-shaped elements. Two outer separated L-shaped patches, an inner split rectangular ring patch, and an L-probe are arranged on a thick single-layer dielectric substrate. An inner conductor of the 50Ω feeding semi-rigid coaxial cable is

connected to the L-probe from the backside of the ground plane. Two design frequency bands are around 9.5 GHz and 13 GHz. The outer L-shaped patches operate at the lower band, while the inner patch operates at the upper band. The lengths of the outer and inner patches are set to approximately a half guided wavelength at the lower band and one guided wavelength at the upper band, respectively. Furthermore, in order to obtain wideband performance at the two bands, a thick substrate with 3.2 mm thickness is used. In order to improve the two bandwidths, the geometries and the dimensions of the outer L-shaped patches, the inner patch, and the L-probe of the MR-MSA are modified and tuned from [13] by using ANSYS HFSS. A relative dielectric constant and a loss tangent of the dielectric substrate are 2.6 and 0.0018, respectively. The other dimensions of the designed MR-MSA are presented in Fig. 1.

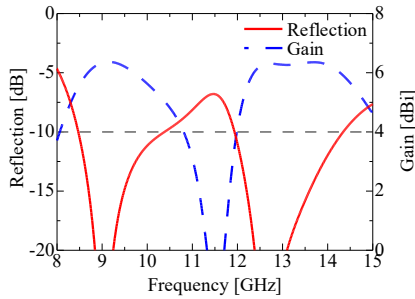


Figure 2. Simulated reflection and gain characteristics of the designed single-layer dual-band and wideband MR-MSA with outer separated L-shaped elements.

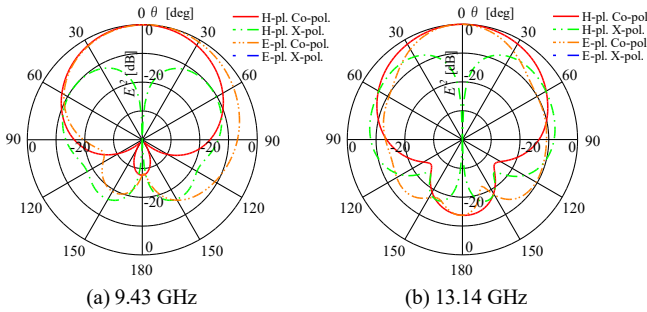


Figure 3. Simulated radiation patterns of the designed single-layer dual-band and wideband MR-MSA with outer separated L-shaped elements.

III. SIMULATED RESULTS OF THE PROPOSED MR-MSA

Figure 2 presents the simulated reflection and gain characteristics of the designed dual-band and wideband MR-MSA. The two simulated frequency bands less than -10 dB reflection are 8.48 to 10.38 GHz for the lower band and 11.94 to 14.34 GHz for the upper band. The corresponding fractional bandwidths are 20.1% and 18.3%, respectively. The central frequency ratio of the lower and upper bands is 1:1.39. The simulated gain in the above bands is 5.0 to 6.4 dBi for the lower band and 3.5 to 6.4 dBi for the upper band. Figure 3 presents the simulated radiation patterns of the designed MR-MSA at 9.43 GHz and 13.14 GHz. Stable unidirectional patterns are obtained for co-polarization in the both E- and H-planes. Relatively large cross polarization in H-plane plane

patterns is observed because of unwanted radiation from the vertical portion of the L-probe in the thick substrate.

IV. CONCLUSIONS

Improved design of the single-layer dual-band and wideband MR-MSA fed by an L-probe with outer separated L-shaped elements is presented. The proposed MR-MSA consists of the two outer separated L-shaped patches, the inner split rectangular ring patch, and the feeding L-probe arranged on the thick single-layer dielectric substrate. In order to improve the two bandwidths at around 9.5 GHz and 13 GHz, the geometries and the dimensions of the proposed MR-MSA are modified and tuned from [13] by using ANSYS HFSS. It is confirmed that by the simulation that the fractional bandwidths less than -10 dB reflection for the lower and higher bands of the designed MR-MSA are improved to 20.1% and 18.3%, respectively.

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