A COMPACT NOVEL SLOT-LOADED DUAL-FREQUENCY H-SHAPED ANTENNA

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ABSTRACT: *A novel compact single-layer dual-frequency microstrip antenna which uses an H-shaped geometry with two U-shaped slots embedded near the radiation edges, is presented. By changing the design parameters, the lower and higher resonant frequencies can be controlled easily, and a range of frequency ratios (1.716–2.363) can be obtained in this design. For the two operating frequencies of the proposed antenna, the same polarization planes and broadside radiation patterns are achieved. Compared to the regular dual-frequency patch antenna, this antenna can realize a significant size reduction.* Microwave Opt Technol Lett 40: 248–250, 2004; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.11343

Key words: *microstrip antenna; dual-frequency; U-shaped slots; H-shaped antenna*

1. INTRODUCTION

With the development of wireless communication, dual-frequency antennas are being used in more and more fields. Microstrip antennas, which have the advantages of low profile, low cost, and ease of fabrication, are finding applications in a wide range of microwave systems. Dual-frequency (multi-frequency) microstrip antennas have received much attention in recent years. To achieve dual-frequency operation, the following methods can be used: multi-resonator, slot-loaded, or lumped-loaded (including shorting pin). (The last two methods are also called reactive loaded.) The multi-resonator method will increase the patch size or the number of patch layers, and the lumped-loaded one will require complex fabrication. Among these methods, the simplest one is the slot-

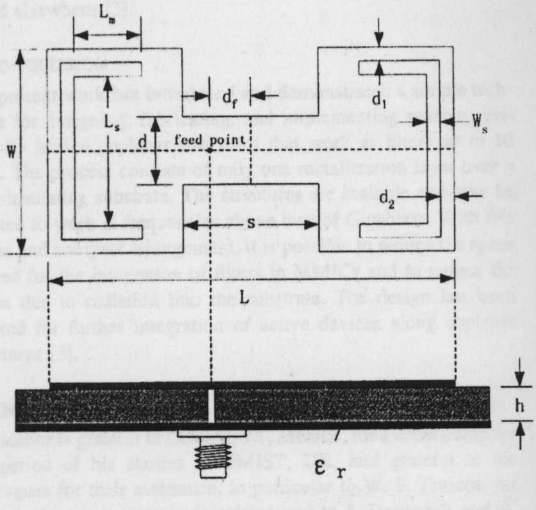

Figure 1 Geometry of the proposed dual-frequency antenna

loaded method, which can achieve dual-frequency operation with a single patch, and can be fabricated and integrated with a microwave circuit easily. The geometry of the slots can be rectangular [1], U-shaped [2], bent line [3], and so on. The H-shaped microstrip antenna was first proposed in [4]. Because the path of the surface current is lengthened, this antenna's size can be reduced for a fixed frequency by about 46%, according to [4]. By adding a shorting pin to the H-shaped antenna, dual-frequency operation can be obtained [5]. In this paper, we present a novel dual-frequency microstrip antenna by loading two U-shaped slots near the radiation edges of an H-shaped antenna (see Fig. 1). The frequency ratio can be adjusted conveniently by varying the design parameters.

2. ANTENNA DESIGN

The proposed antenna configuration is shown in Figure 1. The outline of the H-shaped microstrip antenna is $W \times L$. Two U-shaped slots are loaded near the radiation edges of the antenna. The slots have a width W_s and length $2L_m + L_s$, where L_s is the length of the section parallel to the radiation edge and L_m is the length of the arm. The dimension of the concave section is $d \times s$. The feed point is located on the axis of the antenna, and the distance from center is d_f. The dielectric constant and thickness of the substrate are ε_r and h, respectively.

By placing two narrow rectangular slots [1] or two U-shaped slots [2] near the radiation edges of a regular rectangular patch, dual-frequency operation (the resonant frequencies of TM_{10} and TM_{30} modes) can be achieved. In our design, two U-shaped slots are added in an H-shaped antenna, as shown in Figure 1. Similar to the antenna described in [1], the slots hardly perturb the current distribution of TM_{10} because they are located close to the current minima, and thus the first resonant frequency f_{10} is mainly determined by the primary H-shaped antenna. We can change d in order to adjust f_{10} by varying the length of surface current path when the entire size is fixed. On the other hand, the current distribution around the embedded slots is significant to TM_{30}, so that the variation of the length of L_m strongly perturbs the current distribution of TM_{30}, while the variation of d affects TM_{30} only slightly. Obviously, we can determine f_{10} and f_{30} almost independently by varying a single parameter. Compared to many others dual-frequency antenna designs, in which the variation of a single

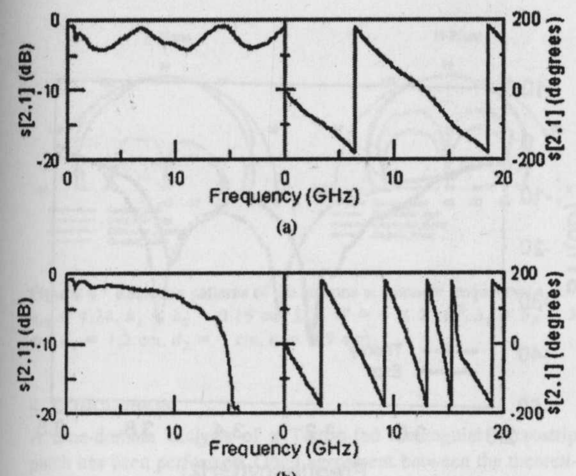

Figure 5 S_{21} VNA measurements of (a) a high-impedance coplanar strip-line and (b) a periodic structure with cutoff near 15 GHz

A mask designed with the 7.5-mm-long structure based on Figure 2 was fabricated and used for the process of filters on semi-insulating GaAs. The devices were adapted to match the 50Ω microprobes from a HP Vector Network Analyzer by extending the lines with 50Ω coplanar strip-lines. These sections were 0.75-mm long and attached to each side of the structures.

3. FABRICATION

The substrate used for the processing in this work was semi-insulating 350-μm-thick gallium arsenide. The samples were coated with photoresist, baked, and exposed to ultraviolet light from a Karl Suss mask aligner. Once exposed, the pattern was developed and then immersed into acid to achieve a 1-μm etch into the substrate. For metal deposition, the samples were placed inside a vacuum chamber with a pressure below 2×10^{-6} millibar. A 0.1-μm-thick titanium layer was deposited to improve the adherence of gold over the semi-insulating substrate. The total thickness of the gold and titanium layers was found to be 0.5 μm, as monitored by a quartz measuring system. After the metallization, the samples were removed from the vacuum chamber and soaked into acetone for a lift-off process, then cleaned with deionized water and dried.

4. MEASUREMENTS

The fabricated lines were tested from 45 MHz to 20 GHz with a HP8510B Vector Network Analyzer. In Figures 5(a) and 5(b), the S_{21} measurements of a coplanar strip-line with high impedance (120Ω) is compared with a six finger periodically loaded line with the same dimensions ($Z_0 = 55\Omega$ at 5 GHz). A calculated loss of 1 dB was expected from the resistive effects. The width of the strip-lines was 0.125 mm, the separation was 0.5 mm, the space d between capacitive loads (Fig. 4) was 0.625 mm, and the distance between fingers was 0.01 mm. The calculated velocity of propagation in the unloaded line was 110 Mm/s. This number is larger than the substrate velocity and larger than the calculated loaded line velocity of 55 Mm/s. Figures 5(a) and 5(b) show the different behavior in S_{21} magnitude and phase for both lines. The phase to frequency ratio of S_{21} indicates the reduced wave velocity in the loaded line until the cutoff is reached near 15 GHz. The design has shown to be effective for reduction of velocity and electromagnetic confinement in structures with active and capacitive loads published elsewhere [3].

5. CONCLUSION

The present work has introduced and demonstrated a simple technique for designing, fabricating, and implementing passive periodically loaded coplanar structures that work as filters up to 10 GHz. The process consists of only one metallization layer over a semi-insulating substrate. The structures are scalable and may be adapted to work at frequencies above tens of Gigahertz. With this planar and compact arrangement, it is possible to reduce the space needed for the integration of filters in MMICs and to reduce the losses due to radiation into the substrate. The design has been adapted for further integration of active devices along coplanar structures [3].

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