Single-feed dual-band square microstrip patch antenna with U-slot

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Abstract: The U-slot patch antenna has been found experimentally to provide impedance and gain bandwidths. Experiment and simulation results include impedance bandwidth, copolar and crosspolar-pattern characteristics and gain measurements. If one of the parameters such as patch width or feed position is varied, U-slot patch can also function as a dual-frequency antenna .

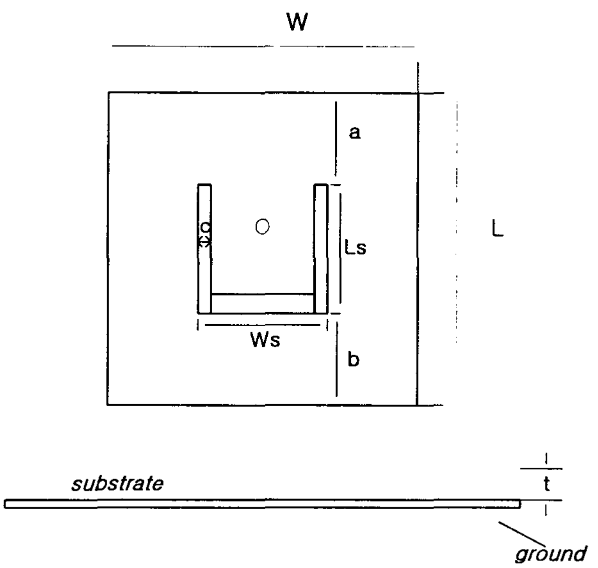
1.Introduction

Patch antennas are popular for their well-known attractive features, such as a low profile, light weight, and compatibility with monolithic microwave integrated circuits(MMICs). Their main disadvantage is an intrinsic limitation in bandwidth, which is due to the resonant nature of the patch structure. On the other hand, modern communication systems, such as the global position system (GPS), vehicular communication, as well as emerging applications, such as wireless local networks (WLAN), often require antennas with compactness and low-cost, thus rendering planar technology useful, and sometimes unavoidable. Furthermore, thanks to their lightness, patch antennas are well suitable for systems to be mounted on airborne platforms, like synthetic-aperture radar (SAR) and scatterometers. From these applications, a new motivation is given for research on innovative solutions that overcome the bandwidth limitations of patch antennas. In applications in which the increased bandwidth is needed for operating at two separate sub-bands, a valid alternative to the broadening of total bandwidth is represented by dual-frequency patch antennas. Indeed, the optimal antenna for a specific application is one that ensures the matching of the bandwidth of the transmitted and/or the received signal. Dual-frequency antennas exhibit a dual-resonant behavior in a single radiating structure. Despite the convenience that they may provide in terms of space and cost, little attention has been given to dual-frequency antennas. This is probably due to the relative complexity of the feeding network which is required, in particular for array applications. The multifrequency patch antennas found in the literature can be subdivided into two categories, namely: multiresonator antennas and reactive loading antennas. In the first kind of structure, multifrequency behaviors obtained by means of multiple radiating elements, each supporting strong currents and radiation at resonance. This category includes multilayer stacked-patch antennas fabricated by using circular, annular, rectangular [9], and triangular patches. The reactive-loading patch antenna consists of a single radiating element in which the double resonant behavior is obtained by connecting coaxial or microstrip stubs at the radiating edge of a rectangular patch. Another kind of reactive loading can be introduced by etching slots on a patch . The slot loading allows to strongly modify the resonant mode of a rectangular patch , particularly when the slots cut the current lines of the unperturbed mode.

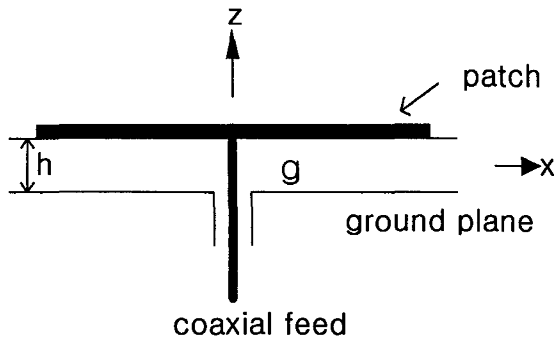
Recently, a series of investigations have been done on wideband microstip antennas, which do not rely on the use of stacked or coplanar parasitic patches. It was shown both experimentally and theoretically that a coax-fed patch antenna on a foam substrate about 0.08 wavelength thick can attain an impedance bandwidth of about 33% and an average gain of about 7dbi, if a proper U-slot is cut in the patch [1], [10]. This single-layer single-patch broadband microstrip antenna retains the thin-profile and small-size characteristics. The broadband characteristics arises because the substrate is relatively thick and the U-slot introduces a capacitance in parallel with the probe inductance. This has the effects of creating another resonance near the resonance of the patch antenna, the input impedance of which is nearly resistive across the passband. In this paper, extensive experimental and simulation results on the U-slot patch are presented. Experimental results include cross-polarization and gain measurements. Also, a U-slot patch antenna with dual-frequency behavior is presented and investigated.

2. Description of U-slot antenna

We seen that bandwidth of the basic form of coaxially fed microstrip antenna can be enhanced to 10-20% by using parasitic patches either in another layer(stacked geometry) or in the same layer(coplanar geometry). Wider bandwidth , up to about 40%,can be obtained by feeding these antennas with a microstrip line through an aperture. However, the stacked geometry has the disadvantage of increasing the thickness of the antenna while the coplanar geometry has the disadvantage of increasing the lateral size of



(a)



(b)

(a)Top view.

(b)Side view.

Fig1.Geometry of a coaxially fed square patch with a U-shaped slot.

The antenna. It would therefore be of considerable interest if a single-layer single-patch wideband microstip antenna could be developed. Such an antenna would better preserve the thin profile characteristics and would not introduce grating lobe problems when used in an array environment. Recently, Huynh and Lee [10] showed that a coaxially fed rectangular patch with a U-shaped slot can attain over 30% impedance bandwidth, with good pattern characteristics.

In this paper, we proposed U-shaped slot patch antenna for dual-band operation. It appears that, starting with a wideband, if one of the parameters such as patch width or feed position is varied, the broadband characteristic is changed into a dual-frequency characteristic. A proposed antenna is shown in table 1.

Table 1 : Dimensions of antenna A in millimeters.

[a=b, t (substrate height)=1.6mm]

	W	L	F	L_s	W_s	a	C
Antenna A	47.6	47.6	16.2	21.5	17.6	13	2

Fig.1 shows the proposed dual-band square microstrip antenna . The patch has the dimensions of L by W and is printed on a substrate of t and relative permittivity E_r. W =47.6mm, L=47.6mm, a=b=13mm c=2mm, Ws=17.6mm, Ls=21.6mm, F=L/2. The substrate was 2.2 permittivity and t=1.6mm. The center frequency, shown in Fig.2 was 6.22GHz and 6.815GHz. The VSWR/frequency curve is shown in Fig.3. The VSWR=2 Bandwidth is 160MHz and 330MHz. The maximum gain, shown in Fig.4 is 9.2dB, occurring at 6.5GHz.The upper and lower bands are mainly, but not entirely, determined by the lengths of the vertical slot and patch. Respectively. The decoupling can be increased by increasing the path length and moving the feed away from the center toward the horizontal slot.

We fabricated the u-slot patch using the teflon based on the result of simulation and measured it with HP8510c network analyzer. The experimental result is shown Fig5 and Fig. 6. The return loss is –21.6dB , –18.4dB at lower and upper band, shown in Fig.5. In our case, Resonant frequency of simulation result is equal to experimental result. And the VSWR is less than 2 in the frequency range 6.0775 to 6.2775GHz and 6.595 to 6.96GHz. In Fig.6, we see that bandwidth is 200MHz and 365MHz.

3.Conclusion

In this paper, we proposed U-slot patch antenna for dual-band operation and showed the simulation result, VSWR, gain and return loss . And we showed that experiment result was matched to simulation. So, we think that our proposed U-slot patch antenna will practically use for dual-band.

In the near future, we will study circular polarized wideband (dual-band) U-slot patch antenna design.

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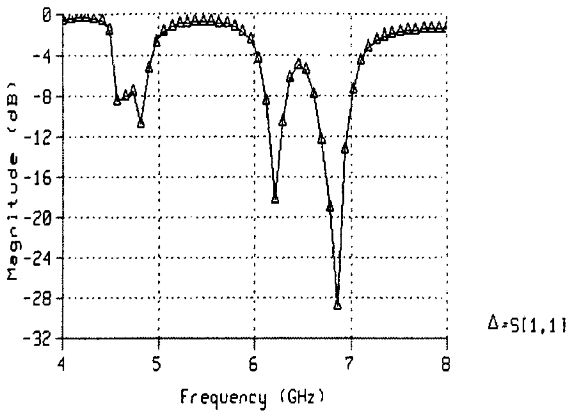

Fig.2 Simulated return loss U-slot patch antenna.

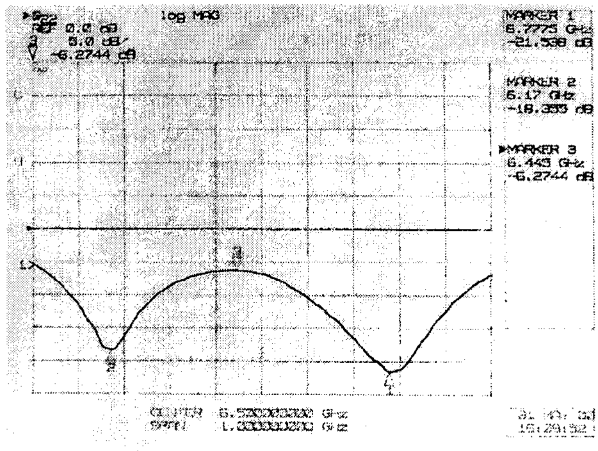

Fig.5 Measured return loss for U-slot patch antenna.

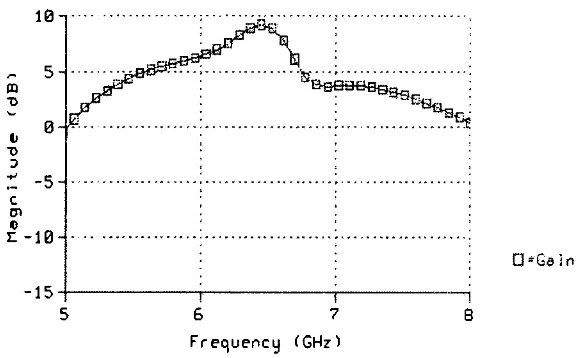

Fig.3 Simulated Gain U-slot patch atnenna.

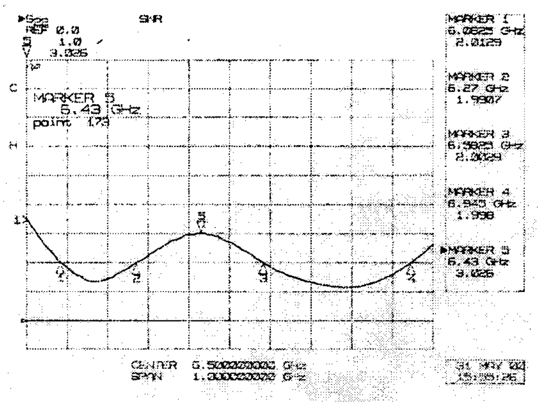

Fig.6 Measured VSWR for U-slot patch atnenna.

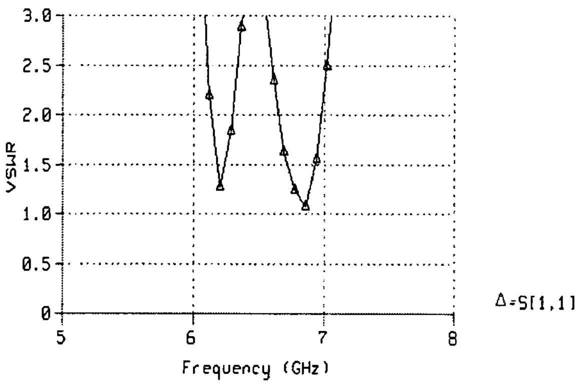

Fig.4 Simulated VSWR U-slot patch antenna