ORIGINAL RESEARCH PAPER

Engineering

DESIGN OF BROADBAND STACKED PATCH ANTENNA FOR BLUETOOTH APPLICATION

KEY WORDS: crumb rubber, utilization, compressive strength, low cost, sustainable

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ABSTRACT

Microstrip antennas (MSA) consists of a metallic radiating patch on one side of a thin dielectric substrate backed by a ground plane. However their main disadvantage in small VSWR bandwidth typically in the range of 1-5%. Hence enhancing the BW of MSA is the major key factor towards its further design advancements. In this paper the attempt has been made to a dual-polarized stacked microstrip antenna that operates well within the ISM-band (2.0402 ~ 2.4835GHz) for Bluetooth applications is simulated using the commercial version of IE3D and experimentally verified on Agilent Vector Network Analyzer 8714ET at SAMEER. The impedance bandwidth has been obtained around 69% with an efficiency of 75% for glass epoxy and air dielectric. The driven patch is probe-fed with another two parasitic patches are stacked together to increase the operating bandwidth. The impedance and the radiation characteristic of the optimized antenna configuration are presented, having varied the sizes of the top and bottom patches and the spacing between the patches.

INTRODUCTION

In order to achieve dual-polarization capabilities a variety of aperture-coupled microstrip antennas have been reported [1-4]. With the use of aperture coupling feed, the aperture radiating both in the patch and back direction results in low gain and low front-to-back ratio. In addition the probe fed microstrip antenna can also operate with dual polarization characteristics [6]. Two most serious limitations of the microstrip antennas are its low gain and narrow bandwidth. This is because of the fact that there is a fundamental relationship between the size, bandwidth and efficiency of an antenna. As antennas are made smaller, either the operating bandwidth or the antenna efficiency must decrease. The gain is also related to the size of the antenna, that is small antennas typically provide lower gain than larger antennas.

Therefore, the size reduction, together with gain and bandwidth enhancement is becoming major design considerations for most practical applications of microstrip antennas for short length wireless communication like Bluetooth. A number of techniques have been reported by the researchers to enhance the gain and bandwidth of microstrip antennas. Some of them used to enhance the gain are, loading of high permittivity dielectric superstrate [7], and stacked configuration [8]. Use of superstrate loading technique helps in increasing the radiation efficiency. In stacked configuration two patches, driven and parasitic, are used with desired feeding technique. Thick substrate introduces surface wave excitation. Another method reported [10] for the bandwidth enhancement is by loading the suspended microstrip antenna with dielectric resonator.

Besides impedance matching, another very popular bandwidth extension technique involves the use of two or more stagger tuned resonators, implemented with stacked patches, parasitic patches, or a combination of dissimilar elements. Three dimensional patches like V-shaped patch [11], or wedge -shaped patch [12] can also be used to enhance bandwidth. The stacked patch arrangement [13] is very popular, with reported bandwidths ranging from 10% to 20%. Owing to the fact that the stacked configuration enhances both the gain and bandwidth, this particular choice is preferred in the present work. This paper discusses the gain and bandwidth enhancement technique utilizing the stacked configuration and finally applies this technique to realize a compact microstrip antenna in stacked configuration.

PARAMETRIC STUDY

In order to gain insight on how to achieve a broad well-matched impedance bandwidth, a study of the various critical parameters was carried out. Probe feeding technique is re-emerging in variety of antenna system due to its robust nature. It provides good isolation between feed network and radiating elements and due to direct contact with the radiator reduces dielectric layer misalignment difficulties. It also yields good front to back ratio which is very important where multiple arrays are located back-to-back in closed proximity. Therefore stacked configurations with probe -fed have been considered. It has been reported, that the combination of low dielectric constant and high dielectric constant can yield good impedance behavior. The broadest bandwidth can be achieved when the first-order mode on the lower patch is considerably greater in magnitude than corresponding mode on the top patch or in other words the top patch is loosely coupled. For this the substrate of lower patch should have higher dielectric constant than the upper substrate.

The thickness of each layer also plays an important role in achieving the overall bandwidth. The thicker the lower layer, the greater the bandwidth will be. The effects of varying the sizes of the top and bottom patches as well as the spacing between substrates on both bandwidth and impedance matching will be examined by means of numerical simulations. It has been suggested that the lower patch should be designed such that it is strongly capacitive over the desired range of frequency instead of designing it for the minimum return loss. But the overall impedance will become inductive when parasitic patch is placed onto the configuration, if lower layer is too thick. Hence a tradeoff must be made between the bandwidth and the impedance control. The thickness of upper substrate (h3) depends upon the thickness of lower substrate (h1). The greater h1 leaves less freedom for the h3. For lower return loss h3 must be increased. It can be observed that the matching condition is very sensitive to the spacing between the patches.

ANTENNA DESIGN

With the optimized results obtained from the simulation an antenna is designed, fabricated and tested. It must be noted that the simulation is carried out based on an infinite ground plane and dielectric substrates. The first step in the design is to select the dielectric substrate and then to fix the thickness h1 h2 and h3. Fig. 1 shows the cross-sectional view of the probe fed stacked patch antenna. The lower substrate is of FR-4 of thickness 4.77 mm whereas the middle substrate is of air with dielectric constant of 1.0 and thickness 5 mm. the upper substrate is also air.

The dimensions of both the patches (driven and parasitic) are selected as optimization variable with objective to get the central frequency 2.44 GHz and to cover the whole operating range of ISM band. IE3D simulation tool is used to model the compact microstrip patch in stacked configuration. Fig 1 shows the dimension, spacing of driven and parasitic patches.

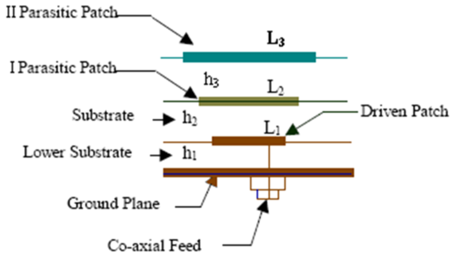

Figure 1: Cross sectional view of the probe-fed stacked patch geometry

RESULTS AND DISCUSSION

The characteristics in terms of VSWR and gain are shown in the Fig. 2 and Fig. 3. Both VSWR and gain bandwidths for the grooved patch in stacked configuration are shown to occupy a larger range than the conventional and the grooved configurations.

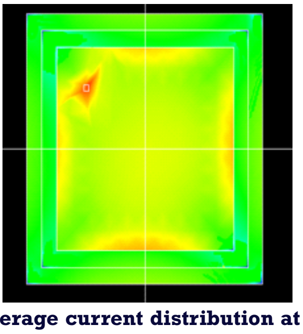

Figure 1.1: Average current distribution at Fc=2.45GHz. (Top View)

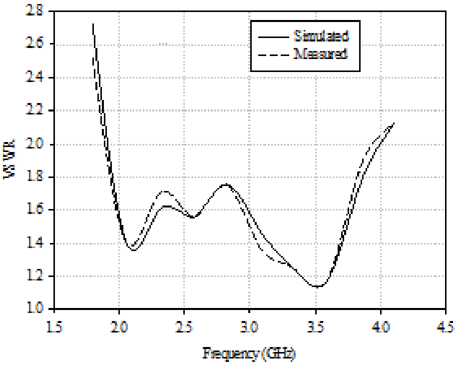

Figure 2: Measured and simulated VSWR plots

Fig. 2 Shows the measured and simulated VSWR plot of stacked patch for ISM band (2.4- 2.5GHz) Measurement results agree well with simulated results. The center frequency of the structure is 2.45GHz higher than the full structure. The span of band is from 2.4 to 2.5 GHz i. e. 100 MHz is the minimum BW requirement foe Bluetooth application. The proposed antenna gives the BW of 195 MHz at VSWR ratio of 1.5:1. The matching frequency range of stacked patch antenna is from 1.8 to 4.1 GHz. with an impedance band width of 69.79 % as shown.

Gain is seen to be almost flat over the desired range of interest. Radiation pattern is nothing but mathematical or graphical representation of the power radiated from an antenna observed at a particular distance from the location of the antenna. The main gain in both E-plane and H-plane is present. We found a maximum directivity for a 0.9 x 0.9 ground plane which is higher than previously reported in the literature. The beamwidth read on the average pattern, which should be considered as the mean bean width, is relatively large, which is an essential factor for Bluetooth application. From the radiation characteristics with stable gain, good front to back ratios and almost unchanging half power beamwidth across the well matched bandwidth. These features completely meet the demands for Bluetooth application.

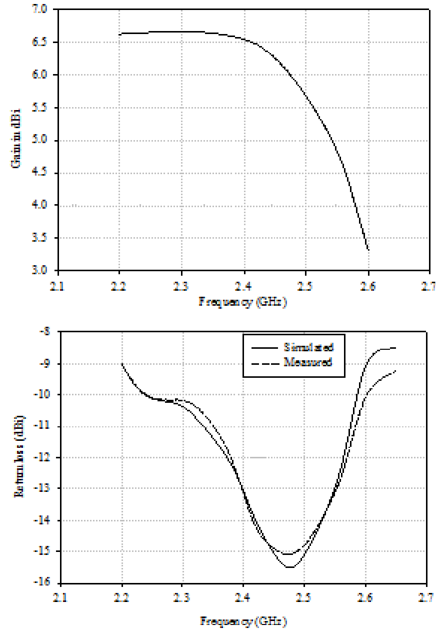

Figure 3: Simulated gain and measured return loss..

CONCLUSIONS

A probe fed stacked patch antenna has been presented. Several key geometrical parametrical of the antenna are also examined by simulation. From the optimum results obtained, an antenna was fabricated and tested experimentally. The measured results have shown that the antenna has realized a bandwidth of 69% for the VSWR 2:1 covering the 2.45GHz-ISM band well and been capable of providing a dual-polarization radiation characteristic with stable gain. Good front to back ratios and almost unchanging half-power beamwidth across the well-matched bandwidth. This feature completely meets the demands for Bluetooth application.

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