Single Slot Rectangular Microstrip Antenna for Wireless Applications

P.A. Ambresh*, P. M. Hadalgi# and P.V.Hunagund$

*, #, $ Microwave Research Laboratory,
Department Of P.G. Studies & Research in Applied Electronics,
Gulbarga University, Gulbarga-585106.Karnataka. (INDIA).

Abstract:
This article presents the design of rectangular microstrip antenna. The prototype antenna is designed and fabricated on FR4 substrate of dielectric constant ϵ_r = 4.4 and thickness h = 1.66 mm. The proposed antenna is excited using co-axial probe feed. The experimental result of rectangular-shaped microstrip antenna exhibits the excellent radiation characteristic corresponding to impedance bandwidth of 320 MHz from 3.23 to 3.69 GHz, exceeding Federal Communication Commission (FCC) frequency range with a return-loss performance S_{11}= -10 dB. The experimental radiation patterns of this antenna are omni-directional. This proposed antenna can be useful for WiMax, WLAN, UK fixed satellite services, UWB system, microwave imaging and vehicular radar.

Keywords: microstrip antenna, FR4, radiation, Omni-directional, spacer.

I Introduction

Microstrip antennas are popular and are getting increased attention due to their advantages. Depending upon the application, microstrip antennas having different geometrical shapes are used [1]. Nowadays, researchers are interested in the design and development of compact microstrip radiating elements [2]-[6]. In literature, the authors have experimentally demonstrated the development of compact microstrip antenna. Many techniques have also been studied in order to overcome the narrow impedance bandwidth of microstrip patch antenna. Among the various techniques, there have been the popular ones such as use of increased substrate thickness, the use of a low dielectric constant substrate, the use of air filled dielectric medium, use of various impedance matching and feeding techniques, the use of multiple resonators, and the use of slot antenna geometry and so on [7] - [14]. In particular, the slot technique shows excellent improvement characteristics suitable for microstrip antennas with air as dielectric substrate medium. Since coaxial probe feeding technique is adopted and it introduces capacitance between the feed and the radiating patch and this capacitance cancels out the inductance due to a probe itself, this effect makes it possible to improve the impedance bandwidth of the microstrip patch antenna and the improvement in gain is also achieved. In general, this type of feed can be easily implemented by directly connecting the probe to the E-shape patch acting as a radiating element. Therefore, in this article, a new microstrip antenna structure is proposed to be suitable for easy fabrication with its good features preserved.

II Antenna Layout Configuration

The design and drafting of the proposed antenna is prepared using AutoCAD 2006 – computer application software. The rectangular patch with length L = 17.76 mm and a width W = 23.28 mm is designed and fabricated. A single slot is embedded on the patch because it is more effective in enhancing impedance bandwidth [15] of the antenna compared to the conventional antenna. A standard SMA connector with probe having 1.3 mm diameter is being soldered to the proposed patch antenna as a feeding element. For the superstrate where the patch and the slot printed on it, a FR4 dielectric material with dielectric constant ϵ_r = 4.4, thickness h = 1.66 mm is used. The slot dimensions are L_{S3} = 16.14 mm and W_{S3} = 2.68 mm with the spacing of the slots S_1 = 18.57 mm, S_2 = 1.68 mm and S_3 = 5.17 mm as shown in Figure 1. In order to support the superstrate and suspend it in air, silicon spacers are used with air filled dielectric substrate of $\epsilon_o \approx 1$ having air thickness of Δ = 8.5 mm between the patch and ground plane. Alternatively, other kind of spacers can be used to suspend the superstrate and ground plane. However, the results show no difference between two methods. The feed point location is selected on the radiating patch element on the center line of Y- axis from the edge of the patch as in Figure 1. In order to avoid drilling a hole through superstrate an inverted patch configuration is adopted, wherein a vertical probe is soldered to a horizontal slotted patch printed on the lower side of the suspended superstrate. On the other hand, the use of superstrate also provides the necessary protection for the patch from the environmental effects. These techniques offer easy patch fabrication especially for antenna array structures. The slot dimensions are taken in terms of λ_o where, λ_o is operating free space wavelength. A copper plate of dimension $L_g = W_g$ = 40 mm with thickness h_1 = 1 mm is used as a ground plane.

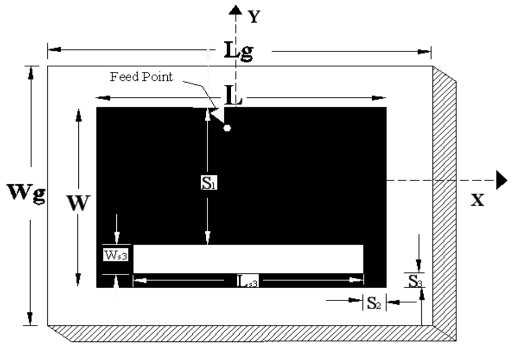


Figure1. Geometry of fabricated patch

III Results and Discussion

The designed frequency of the proposed antenna is 3.85 GHz and the antenna resonates at lower frequency of 3.55 GHz. The impedance bandwidth with return loss (RL) less than -10 dB is measured for the frequency range of 2 – 6 GHz as shown in Figure 2. The measurements are taken on Vector Network Analyzer (Rohde and Schwarz, Germany make ZVK model 1127.8651). Defining the impedance bandwidth as the frequency range where $S_{11} \leq -10$ dB, the proposed patch antenna provides 9.41 % (320 MHz) impedance bandwidth with a return loss of -19 dB with a gain of 3.47 dB at resonant frequency 3.55 GHz when compared to conventional antenna providing 1 - 2 % (45 MHz) impedance bandwidth. Since the proposed antenna resonates at a lower frequency 3.55 GHz compared to the designed frequency, a compactness of 21 % is obtained suitable for portable wireless applications.

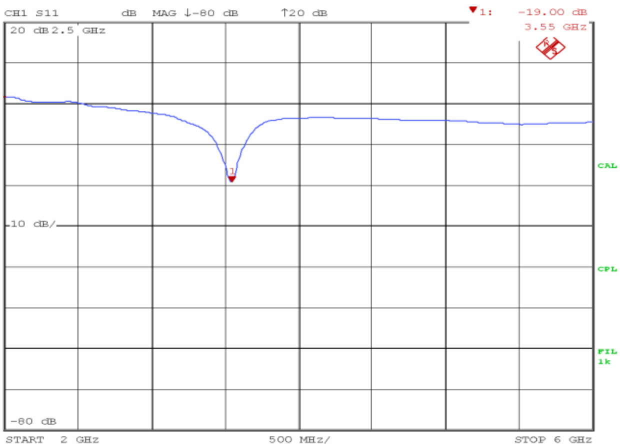


Fig. 2 Return loss (RL) versus Frequency (f) of proposed antenna

Figure 3 shows co-polar and cross-polar omni-directional radiation pattern measured at 3.55 GHz. Figure 4 (a) shows measured VSWR of 1.249 which is less than 1.5 at frequency 3.55 GHz signifying less reflected power and Figure 4 (b) shows the input impedance of 52.06 + j9.798 Ω on Smith chart validating better matching characteristics between input and load.

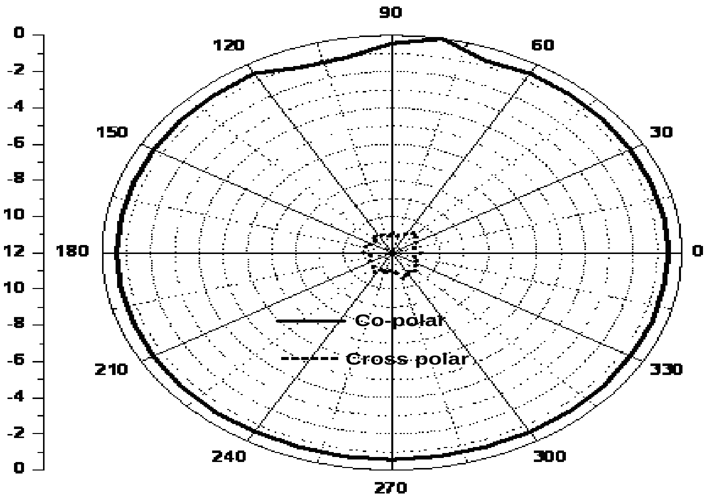
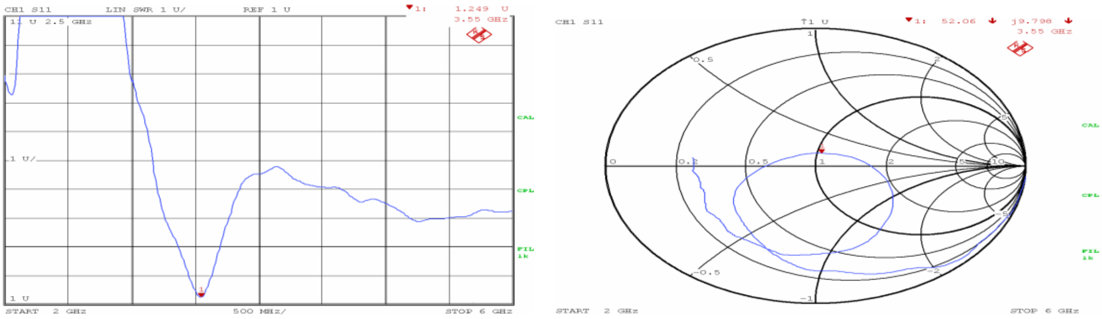


Fig. 3 Radiation pattern of the proposed antenna



(a) (b)

Fig. 4 (a) Variation of measured VSWR with frequency (f) in GHz,
(b) S mith chart diagram

IV. Conclusion

A single slot rectangular microstrip antenna element has been studied experimentally and presented. It consists of a superstrate patch with slot embedded on patch and placed above the ground plane, developed for various wireless applications. Compared with a conventional patch antenna, it has a better omni directional radiation pattern and provides an increase in bandwidth upto 9.41 % (320 MHz) with a compactness of 21 %. Hence, the proposed antenna is quite easy in design, fabrication and implementation and uses low-cost dielectric material as cost effective method. Designed antenna finds application in European fixed satellite services and in WiMax applications.

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