Research Paper Engineering

Complementary E-Shape Microstrip Patch Antenna for Wireless Applications

* P.A. Ambresh ** P. M. Hadalgi

*, ** Microwave research Laboratory, Department Of P.G. Studies & Research in Applied Electronics, Gulbarga University, Gulbarga

ABSTRACT

In this work, a novel microstrip patch antenna is fabricated and tested for the various antenna parameters. The slot, coaxial probe fed mechanism on a FR4 superstrate suspended through air as dielectric substrate between patch and ground plane and slits are the design constraints. An inverted microstrip antenna with coaxial feed has been fabricated for operation in the frequency range of 2 6 GHz suitable for application in European fixed satellite services, WiMax application. The proposed antenna showed an impedance bandwidth of 12.41 % (at 2.96 GHz) more than the impedance bandwidth of conventional microstrip patch antenna with return loss (RL) 18.22 dB. In the whole frequency band, an average gain of 2.47 dB with an antenna compactness of 39 % is achieved. Also the measured results show that the proposed antenna has a practically good omnidirectional radiation pattern.

Keywords : FR4 superstrate, return loss, E shape, WiMax, European fixed satellite services.

Introduction

In the past years, many techniques have 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, the use of various impedance matching and feeding techniques, the use of multiple resonators, and the use of slot antenna geometry and so on. 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 paper, a new patch antenna structure is proposed to be suitable for easy fabrication with its own good features preserved.

Antenna Layout Configuration

Figure 1 represents the simple layout of the proposed antenna. As shown in Figure 1, the rectangular patch on the lower side of a suspended superstrate with length L = 17.76 mm and a width W = 23.28 mm is fabricated. A vertical rectangular slot with length f = 16 mm and width g = 1 mm is also printed on the same radiating element. The slot is used because it is more effective in enhancing impedance bandwidth. A standard SMA connector with probe having 1.3 mm diameter being soldered to the proposed patch antenna as a feeding element. For the superstrate where the patch and the slots printed on it, a FR4 dielectric material with dielectric constant $\epsilon_r = 4.4$, thickness h = 1.66 mm is used. The various slit dimensions are, a = 7.79 mm, b = 12.81 mm, c = 7.87 mm, d = 4 mm and e = 6 mm as shown in Figure 2. In order to support this superstrate and suspend it in air, four 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 at a distance x (4.2 mm) from the edge of the patch as in Figure 1. In order to avoid the drilling a hole through superstrate an inverted patch configuration is adopted, where in 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 and slit 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 = 1mm is used as a ground plane. The design and drafting of the proposed antenna is prepared using AutoCAD 2006 computer application software.

Figure 1 : Proposed antenna layout

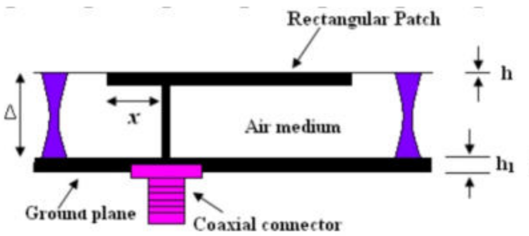
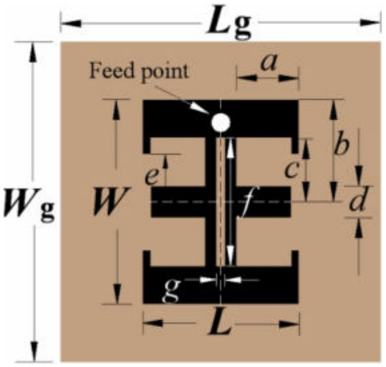


Figure 2 : Geometry of fabricated E shape patch



Test Results

The designed frequency of the proposed antenna is 3.85 GHz and the antenna resonates at lower frequency of 2.96 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 3. 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 12.41 % (430 MHz) impedance bandwidth with a return loss of -18.22 dB achieving a gain of 2.47 dB at resonant frequency 2.96 GHz when compared to conventional microstrip patch antenna providing a 1 - 2 % (45 MHz) impedance bandwidth. Since the proposed antenna resonates at lower frequency 2.96 GHz compared to the designed frequency, a compactness of 39 % is obtained suitable for portable wireless applications.

Figure 3 (a) : Return loss (RL) versus Frequency (f) of proposed antenna

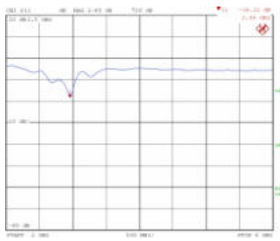


Figure 3 shows co-polarized and cross-polarized omni-directional radiation pattern measured at 2.96 GHz. Figure 4 (a) shows measured VSWR of 1.302 which is less than 1.5 at frequency 2.96 GHz signifying less reflected power and Figure 4 (b) shows the input impedance of 55.25 + j28.09 Ω on Smith chart validating better matching characteristics between input and load.

Figure 3 (b) : Radiation pattern of proposed antenna

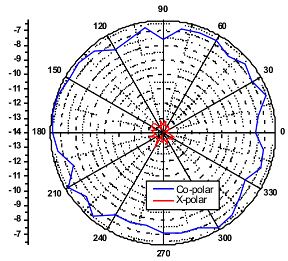
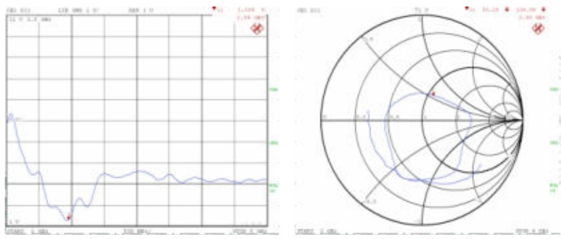


Figure 4: (a) Variation of measured VSWR with frequency (f) in Ghz, (b) Smith chart diagram



(a) (b)

Conclusion

A complementary E-shape microstrip patch antenna element has been presented. It consists of a superstrate patch with slot and slits placed above the ground plane, developed for various wireless applications. Compared with a conventional patch antenna, it has a better omnidirectional radiation pattern and provides an increase in bandwidth upto 12.41 % (430 MHz) with a compactness of 39 %. 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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