Design &Analysis of Bandwidth of Microstrip Patch Antenna for DCS/UMTS Application

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Abstract. *This paper presents a novel approach to design a line feed microstrip antenna for wide-band operation. The proposed microstrip antenna has been presented wide bandwidth of about 59.50% covering the range 1.552 GHz-2.867 GHz which is suitable for DCS/UMTS applications. It has also been observed that for the wide-band frequency configurations studied and the proposed antenna has been designed and tested successfully. Simulated and measured results shows that the proposed antenna design meets the requirements of wide working bandwidth and provides 1.315 GHz bandwidth having very small size.*

Keywords: Wideband, Slotted patch, UMTS & Efficiency.

I. INTRODUCTION

The designing of Microstrip antenna is vital study for today's wireless communication system to achieve good radiation pattern, highly directional beam, large bandwidth and efficiency [1-4]. A microstrip patch antenna is simply a conducting patch suspended above a ground plane as seen in Fig1. The conducting patch and the ground plane are separated by a low loss dielectric material called a substrate [5].

A coaxial line can be used to carry electromagnetic energy to the patch. Regardless of which feed line is used, the energy is first carried to the region under the patch. This region acts like a resonant cavity with open circuits on all sides. At this point the energy is either reflected back along the same feed line or it leaks out and radiates into free space. The operating frequency of a microstrip antenna is determined by the dimensions of the patch, such as size and shape, as well as the thickness and dielectric constant (ε_r) of the substrate used to separate the patch and the ground plane. Generally, if the substrate is not changed, the operating frequency is lowered as the area of the patch is increased. If the dielectric constant is high, the electrical length of the antenna will be reduced but the bandwidth would be wide [6-10]

The most demanding these days are Digital communication systems (DCS: 1.71GHz-1.88GHz), Personal Communication system (PCS: 1.85GHz-1.99GHz), Universal Mobile telecommunication system (UMTS: 1.92GHz-2.17GHz), and wireless local area network (WLAN: 2.4GHz-2.484 GHz) [11-15].

The bandwidth of an antenna is defined by [5] as "the range of usable frequencies within which the performance of the antenna, with respect to some characteristic, conforms to a specified standard." The bandwidth can be the range of frequencies on either side of the center frequency where the antenna characteristics like input impedance, radiation pattern, beam width, polarization, side lobe level or gain, are close to those values which have been obtained at the center frequency. The bandwidth of a broadband antenna can be defined as the ratio of the upper to lower frequencies of acceptable operation. The bandwidth of a narrowband antenna can be defined as the percentage of the frequency difference over the center frequency [5]. According to [4] these definitions can be written in terms of equations as follows:

$$BW(\%) = \left[\frac{f_H - f_L}{f_C}\right]100$$

Where f_H = is upper frequency

f_L = lower frequency

f_C = center frequency

An antenna is said to be broadband if f_H/f_L = 2.One method of judging how efficiently an antenna is operating over the required range of frequencies is by measuring its VSWR. A VSWR ≤ 2 (RL ≥ 9.5) ensures good performance.

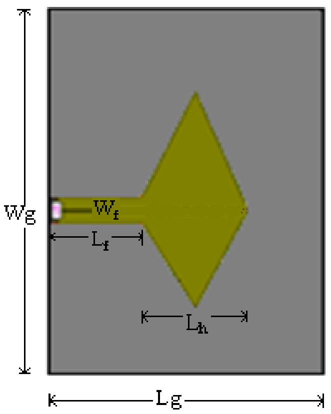

Fig. 1. Geometry of proposed antenna

II. ANTENNA DESIGN AND ANALYSIS

Fig. 1 shows the configuration of the proposed wide-slot antenna. The dimensions of the proposed antenna are as follow:

Lg = 40 mm, Wg = 60 mm, L = 23.8 mm, W = 31 mm, L_f = 10.8 mm, W_f = 4 mm, L_h = 13mm.The ground plane size is selected as 40 mm x 60 mm, and the relative dielectric constant and the thickness of the substrate are chosen as ε_r = 4.4 and h = 1.6, respectively. A substrate of low dielectric constant is selected to obtain a compact radiating structure that meets the desired bandwidth specification. The characteristic impedance of the microstrip line is 50. The characteristics of proposed design such as return loss (RL), bandwidth, and VSWR and radiation pattern have been investigated using simulation and experimentally. The calculations are based on transmission line model and the width and length of the microstrip patch have been calculated by the following equations [5].

$$W = \frac{c}{2f\sqrt{(\varepsilon_r + 1)/2}} \quad (1)$$

$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + 10\frac{h}{W}\right]^{-\frac{1}{2}} \quad (2)$$

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon_{eff} + 0.300)\left(\frac{W}{h} + 0.262\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.813\right)} \quad (3)$$

$$L = \frac{c}{2f\sqrt{\varepsilon_{eff}}} - 2\Delta l \quad (4)$$

Where the required frequency f0=3 GHz, c = $3X10^8$ m/s and εr = 4.2.Substituting above values, the width of the patch (W) calculated. The effective length (Leff) of the patch can be calculated with the help of equations (3) and (4).

III. RESULTS & DISCUSSION OF PROPOSED ANTENNA

As shown in the figure 3, the maximum achievable bandwidth is 59.50% which is better compare to design reported in [10]. Figure 2 shows the photograph of proposed microstrip antenna which is tested with network analyzer. Figure 3 shows simulated and measured return loss Vs frequency of the proposed antenna. The measured results have a good agreement with that of simulated results. Fig 4 shows 3D radiation pattern which is a graphical representation of the relative distribution of the radiated power in space. The numerical study has been done by using IE3D electromagnetic simulation software. Fig.5 shows the proposed microstrip antenna having good radiation efficiency of about 92%.

Fig.2. Photograph of proposed microstrip antenna

Table: 1 Parameters and obtained results

Parameters	**Values**
Band Width	59.50%
Frequency Range	1.552 - 2.867 GHz
Efficiency	92%
Applications	DCS & UMTS

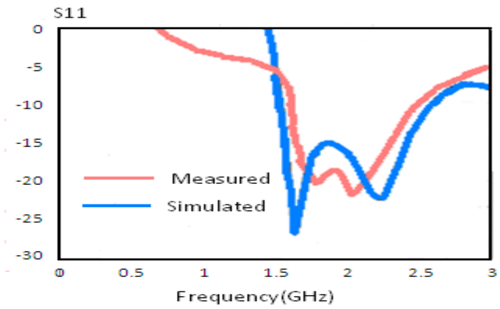

Fig.3. Measure & Simulated Return loss Vs frequency of proposed microstrip antenna

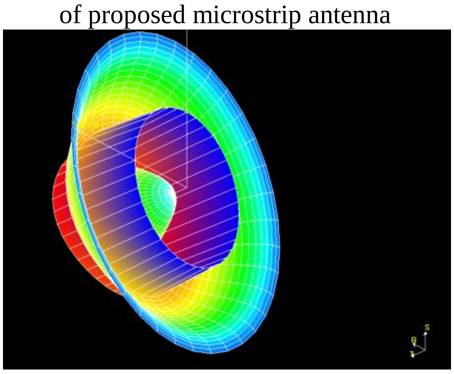

Fig.4. Radiation pattern of proposed microstrip antenna

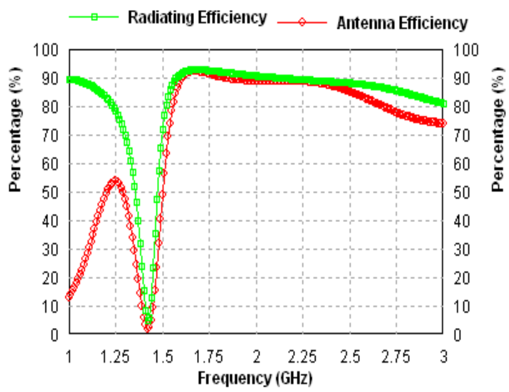

Fig.5. Efficiency Vs frequency of proposed microstrip antenna

IV. CONCLUSION

The proposed compact microstrip antenna is electrically small and suitable to digital communication system (DCS: 1.71GHz-1.88GHz) and Universal Mobile telecommunication system (UMTS: 1.92GHz-2.17GHz). The measured results are in good agreement with the simulated results. In this investigation, the B.W of 59.5% has been achieved. It is clearly observed that the impedance bandwidth, radiation efficiency improved significantly by employing proposed line feed microstrip antenna

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