Volume 6, Issue 4, April 2016 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Design and Analysis of Monopolar Patch Antenna for Ultra Wide-band Application

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Abstract: The antenna is a device to be adaptive to behavioral as a directional device to accurate the transmitted and received energy in some particular directional. For most applications with continued research and development, monopolar patch antennas are expected to replace conventional antennas due to increase usage. Narrow bandwidth is one of the most serious disadvantages of microstrip antenna. Researches are engaged in removing this limitation and many techniques have been proposed for the design of wideband antennas for wireless communication systems. Methods for increasing the bandwidth of monopolar antenna are continuously getting upgraded. The main objective of this paper is to develop monopolar patch antenna for ultra wideband application by varying substrate thickness, varying the thickness of material according to different shape. To understand the performance parameter such as bandwidth, voltage stand wave ratio (VSWR) and reflection loss with the help of systematic manner of monopolar patch antenna.

Keywords: Monopolar Patch Antenna, VSWR, Ultra wide band.

I. INTRODUCTION

Probably the most popular and commonly used antenna type of the current decade is the microstrip patch antenna. The popularity of the microstrip patch antennas may have been fuelled by the development of the low cost manufacturing techniques of microstrip antennas. The popularity may also be attributed to the availability of the standard quality substrates for the manufacture of high frequency antennas. This may be evident from the fact that even though microstrip patch antennas were first reported in the decade of 1950 [1] it took about two decades to attract researchers to this field. Also, the development of a particular technology is basically need oriented. As it is said "necessity is the mother of invention" the need for special type of antenna for communication to be used within missile systems and in handheld communication devices have found the solution with microstrip antennas. This has resulted in tremendous research and development in the field of microstrip patch antennas in the last decade which led to the implementation of the antennas in the end-devices. Over the ages it has also been observed that one technological development is dependent on the development of the others. Here, in case of mobile communication, the practical usability of the mobile system was dependent on the size of the mobile handsets. The size of these devices was also dependent on the size of the antenna being used among other components. Previously these devices used to have large sized antenna which had to be mounted on large objects. Hence these were not truly handheld. But with the advent of monopolar Patch Antennas (MPA) among other developments, the sizes of the mobile communication devices have changed drastically.

Monopolar patch antennas are low cost, low profile, light weight, high frequency planar antenna. It is a derivative ofmicrostrip circuits. Monopolar patch antenna consists of a dielectric layer sandwiched between two very thin metal layers. One of the layer acts as the radiating layer while the other acts as the ground plane. Generally, the thickness of the dielectric layer of the MPA is very small compared to the size of the antenna. Hence it is also conformal to the surface. Since MPA are derivative of microstrip circuits, they have good compatibility. A monopolar patch antenna also finds application in many devices other than personal communication devices. It may have been used in the missile system, airborne AESA radar, body worn antenna for military personal etc. The applications are endless. These antennas may be easily fabricated using Printed Board Circuit (PCB). This makes the prototype sample easy to fabricate in a simple low cost laboratory. For large scale manufacturing, it can be manufactured with single assembly line together with the PCB circuit developing. But what makes the research in microstrip antenna design appealing is the fact that the properties of the monopolar patch antenna may be greatly varied by the shape and size of the patch. And as the combination is endless, so is the variation in properties.

II. LITERATURE REVIEW

The multi-resonator technique by which a microstrip patch antenna may be used for broadband operation may also be used for multi-frequency operation of microstrip patch antenna. Such design was reported by Chen and Lin [3] in the - 14 - year 2003. In the reporting Chen and Lin have mentioned two designs. One using coplanar waveguide (CPW) feed and the other with microstrip line feed. For both the designs three concentric slots are drawn on the patch in such a way that the single patch is converted into three concentric patches. Each of the two designs has been shown to resonate at three different frequencies. Using coplanar waveguide and based on monopole antenna design another multi-frequency microstrip patch antenna was reported by Song [4]. Multi-frequency microstrip patch antenna based on monopole antenna design was also reported by Rahim, Nor, Jizat, Sabran and Jamlos [5]. The patch in the design was a modified square patch. The square patch was embedded with slots which gave the antenna its unique shape. The designed antenna has the resonant frequency at 2.45 GHz and 5.8 GHz. Ray, Sevani and Kulkarni [6] presented a design which was developed after dividing the single rectangular patches to multiple rectangular patches. The multiple patches thus formed were gap coupled with the primary patch. It was also mentioned that the size of the patches decided the separation between the resonant frequencies. Another design was demonstrated by Wong, Chen, Su, S and Kuo [7] in the year 2003. The mentioned antenna design contained two planar inverted F antenna (PIFA) patches. This antenna resonates at two frequency band, 2.4 GHz band and 5.2 GHz band. Hsiao, Wu, Wang, Lu and Chang [8] in 2005 designed a microstrip antenna with microstrip feed line and a pair of rectangular strips. This designed antenna also operated in the 2.4 GHz and 5.2 GHz frequency band. A multi-frequency design based on monopole antenna design was also reported by Chang, Kim and Yoon [9]. The reported design is based on microstrip monopole antenna design and uses a dipole patch with two parasitic elements. The authors have suggested two such designs. One design for dual band operation and the other for triple band operation. The triple band antenna was found to be resonating at 1.79 GHz, 2.03 GHz and 2.41 GHz. An antenna for the use with GPS (Global Positioning System) and DMB (Digital Multimedia Broadcast) which required two different resonant frequencies was reported by Kim, Yoon and Yang [10]. It uses the air dielectric with square patch loaded with rectangular slots. Another dual band antenna based on the air dielectric substrate was reported by Yoon, Choi, Lee and Park [11]. This antenna uses an E shaped patch with a shorting pin. Sun [12] suggested a circular patch antenna for GPS system which operated in the 1.575 GHz band and the 2.4 GHz band. In the suggested design Sun used multilayer dielectric substrate. The substrate contained a layer of foam and a layer of FR4 glass epoxy. The circular patch was loaded with a cross slot and an open ring slot. Using this Sun was able to achieve good gain in the band of 1.575 GHz and 2.4 GHZ.

III. ANTENNA DESIGN

Monopolar patch antenna with dual operating frequencies is required where it has to transmit/receive the signals at two different bands of frequencies. The required band separation depends on the system where it is being used. The design and study mentioned in this chapter may be used to modify the operating frequency according to the application.

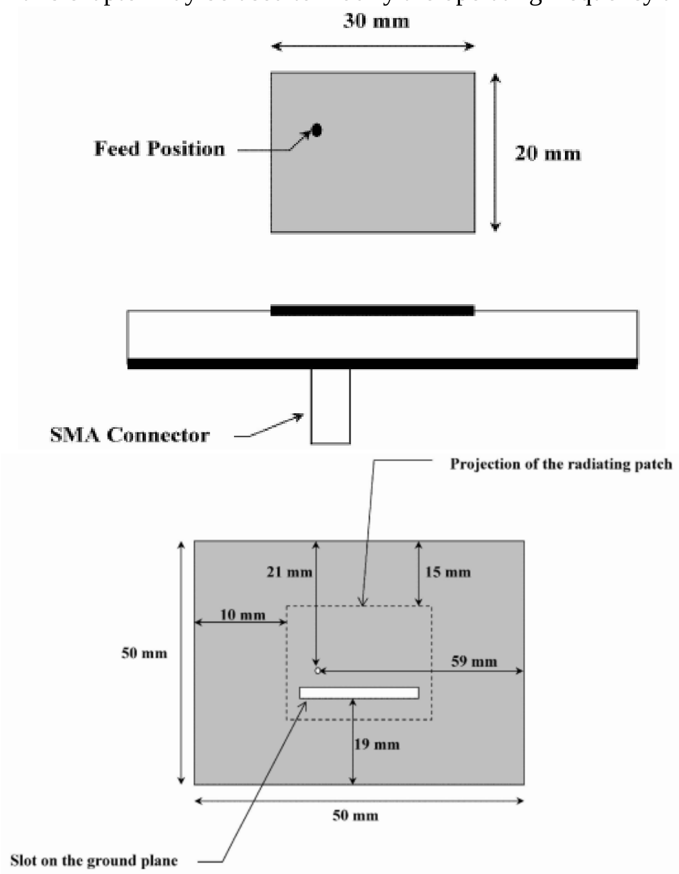

Figure 1: Layout of the antenna with single rectangular slot in the ground plane

The layout of the designed antenna is shown in figure 1. The layout has been drawn in first angle projection. As shown in the figure, the ground plane is loaded with a slot of width 1 mm and length “L” mm. The slot is positioned at equidistance from the two edges parallel to the vertical axis in the figure. The patch antenna is fed through a coaxial feed. The feeding point is so positioned to obtain better impedance matching. The radiating patch is positioned at the centre w.r.t ground plane of the antenna.

IV. RESULTS AND DISCUSSION

The mentioned antenna design, modelled with FR4 glass epoxy (εr= 4.4) as substrate and having thickness of 1.6 mm, was simulated using HFSS (based on MoM). The simulation was done for different values of "L", i.e for different lengths of the slot. The return loss plot for L=0 mm, i.e design without any slot is shown in the figure 2. In the figure 2 it may be observed that the antenna design without the slot has two resonant frequencies which are marked as F0 and F1. The simulated result of the design showing the resonant frequencies for varying slot length "L" is shown in the Table 1. Using the data in Table 1, a plot for variation in the resonant

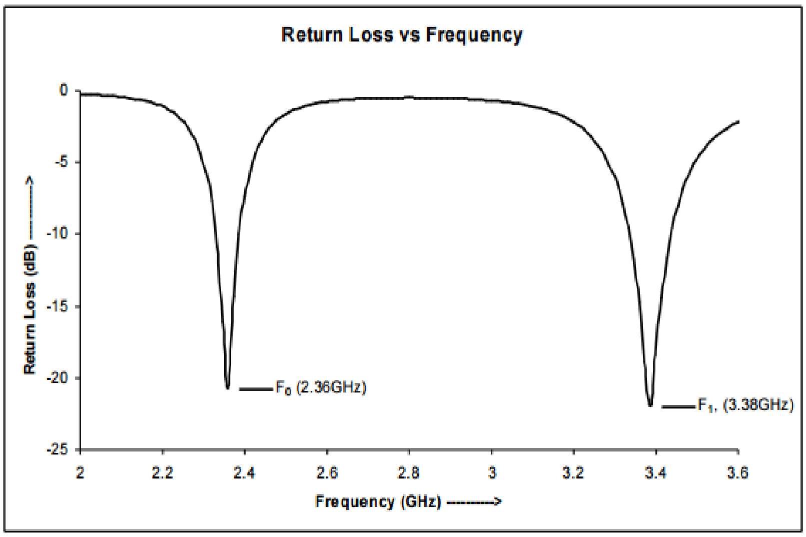

Figure 2: Simulated return loss of the antenna with slot length "L"= 0 mm

frequencies F0 and F1 w.r.t the slot length "L" has been obtained which is shown in the figure 3. This figure clearly shows that the resonant frequency F1 tends to be decreasing with the increase in the slot length "L". In other words it may be possible to place the resonant frequency F1 anywhere in the scope by modifying the parameter "L".

Table 1: Resonant frequencies obtained (simulated) for different values of "L"

Slot Length 'L' (mm)	F_0		F_1	
	Frequency (GHz)	Return Loss (dB)	Frequency (GHz)	Return Loss (dB)
0	2.36	-20.8	3.3867	-21.9
2	2.36	-20.1	3.3866	-21.6
4	2.36	-19.6	3.365	-22.5
6	2.36	-20.6	3.35	-23.8
8	2.36	-20.3	3.305	-25.3
10	2.36	-20.3	3.23	-27.9
12	2.36	-20.5	3.155	-35.7
14	2.36	-20.8	3.065	-31.3
16	2.36	-21.6	2.915	-25.3
18	2.355	-18.4	2.775	-23.1
20	2.37	-20.6	2.64	-20
22	2.385	-18.6	2.445	-17.1
24	2.34	-11.8	2.34	-11.8
26	2.355	-17.9	2.175	-12.8
28	2.355	-19.6	1.995	-11.7
30	2.355	-18.6	1.86	-11.8
32	2.355	-18.0	1.74	-12.7
34	2.355	-17.8	1.65	-14.4
36	2.36	-18.8	1.5	-20.2
38	2.36	-18.4	1.453	-22.0
40	2.36	-18.5	1.3866	-20.2
42	2.36	-18.3	1.3333	-27.3
44	2.36	-18.3	1.28	-20.5
46	2.36	-17.9	1.2133	-19.2
48	2.36	-17.9	1.16	-16.3

It may also be noted from the figure 3 that the resonant frequency F0 is independent to the variation in the slot length "L". If ratio of F0 to F1 is taken, the ratio may be varied from 2.03 to 0.7. It may also be reckoned here that by properly selecting the slot length "L" the resonant frequency F1 may be placed adjacent to resonant frequency F0 such that the bandwidth of the antenna is improved by staggering effect.

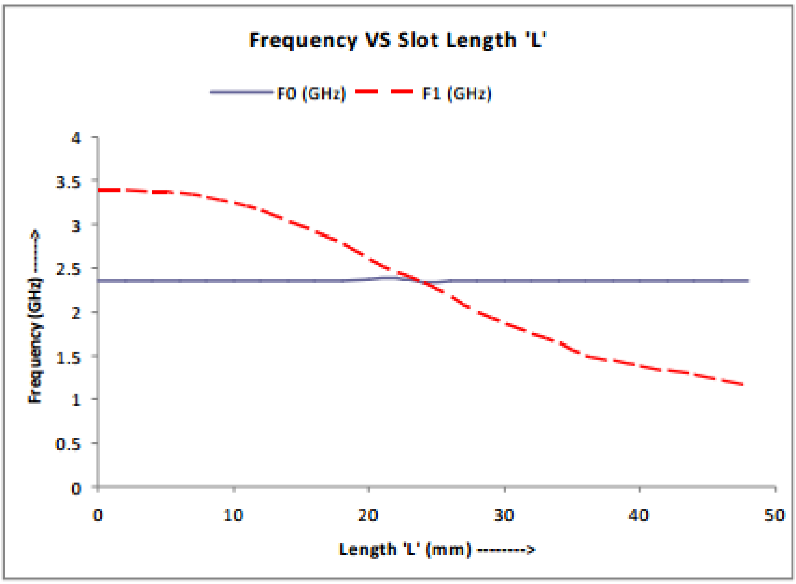

Figure 3: Variation of the two resonant frequencies with slot length "L"

V. CONCLUSION

The design was fabricated with FR4 glass epoxy substrate for physical verification of the simulated result. The fabrication was done using standard PCB fabrication technology. Agilent E5071B ENA series network analyzer was used to determine the resonant frequency of the fabricated antennas. The antennas mentioned in this paper have been studied for compactness, wideband and multi frequency operation. Different designs have been suggested for reducing the size of monopolar patch antenna. The designs for size reduction are based on the ground plane modification technique. Designs for broadband operation of monopolar antenna have also been suggested in this paper. One of the designs investigated for broadband characteristics used a modified SMA connector and slot loading in the ground plane. The other design investigated for broadband operation uses square ring patch and novel slit loading in ground plane. Two different designs have been investigated for multi frequency operation. A design was also investigated having the characteristics of compactness, wide bandwidth and multiple resonant frequencies simultaneously in a single antenna.

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