Analysis of Microstrip Antennas For Enhancement of Bandwidth

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Abstract - Microstrip antennas are being given focus for their versatility, low cost, compact size and high performance. In this paper we have analysed microstrip antenna at different frequencies and their parameters. And methods to enhance gain and bandwidth are discussed. Aim of this paper is to study impact of different shapes, substrate and feeding techniques on different frequencies, return loss and gain of the microstrip patch antenna.

Keywords - Microstrip patch antenna, bandwidth, patch parameters.

I. INTRODUCTION

In the coming years, there has been rapid growth in wireless communication. With the increase in number of users and limited bandwidth which is available, operators are trying hard to optimize their network for larger capacity and improved quality coverage. This need has led the field of antenna engineering to constantly evolve and accommodate the need for low cost, wideband, miniaturized and easily integrated antennas.

A widely used antenna structure which has above characteristics is microstrip patch antenna. The microstrip patch antennas have several advantages of being versatile, low profile, conformal and low cost devices. The advantages of microstrip patch antennas make them suitable for various applications like WiMax, vehicle based satellite link antennas, global positioning systems (GPS), radar for missiles and mobile handheld radios or communication devices.

But nonetheless, the microstrip patch antennas are also associated with some disadvantages such as low gain, narrow bandwidth, and the excitation of surface waves. Over the years, a lot of research has been undertaken to overcome the disadvantages associated with these antennas. Some of the popular techniques proposed by researchers to broaden the bandwidth are increasing the height of antenna substrate using aperture coupling method.

II. MICROSTRIP PATCH ANTENNA

Microstrip patch antennas consist of a patch which radiates on one side of a dielectric substrate with a ground plane on the other side The patch is normally made up of conducting material such as gold or copper and takes many possible shape. In MSA the radiating patch and the feed lines are usually photo etched on the dielectric substrate. In order to simplify performance estimation and analysis, generally rectangular, circular, triangular, square and elliptical or some other common shapes are used for designing a microstrip antenna. Microstrip patch antennas radiate due to the fringing fields between the ground plane and the patch plate. For good performance of antenna a thick dielectric substrate which has a low dielectric constant is necessary since it provides larger bandwidth, better efficiency and better radiation. Microstrip antennas have a very high antenna quality factor.[1][2] It represents the losses associated with the antenna where a large quality factor leads to low efficiency and narrow bandwidth. Quality factor can be decreased by increasing the thickness of the dielectric substrate. But along with increase in thickness an increasing fraction of the total power delivered by source goes into a surface wave. This surface wave contribution can be counted as an unwanted power loss as it is ultimately scattered at the dielectric bends and causes degradation of the antenna characteristics.

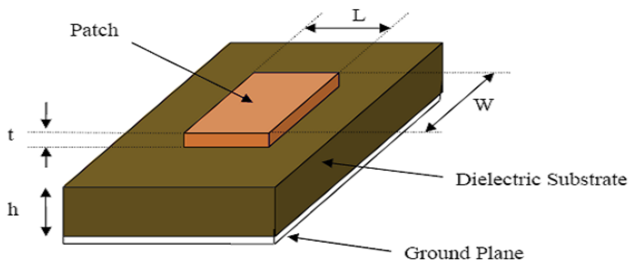

Fig (A) Microstrip patch antenna

III. METHODS TO ENHANCE

A. Gain in Microstrip Patch Antenna

Most microstrip antenna designs show decreased antenna gain resulting to the antenna size reduction. To overcome these disadvantages and obtain an enhanced antenna gain several designs for gain enhanced compact microstrip antennas with the loading of a high permittivity dielectric substrate or the inclusion of an amplifier-type active circuitry have been implemented. Use of a high-permittivity substrate loading technique gives an increase in antenna gain of about 10 dBi having smaller radiating patch. An amplifier type active microstrip antenna used as a transmitting antenna with enhanced gain and bandwidth has also been implemented

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B. Bandwidth

One of the important parameter of any antenna is the bandwidth it covers. Only impedance bandwidth is specified most of the time. Moreover it is important to realize that several definitions of bandwidth exist impedance bandwidth, polarization bandwidth, directivity bandwidth and efficiency bandwidth. Directivity and efficiency are often combined as gain bandwidth.

C. Impedance bandwidth/return loss bandwidth

It is the frequency range wherein the structure has a usable bandwidth compared to certain impedance, it is usually 50 Ω. The impedance bandwidth depends on large number of parameters related to the patch antenna element itself (e.g. quality factor ,Q) and the type of feed used. The plot given below shows the return loss of a patch antenna and indicates the return loss bandwidth at the desired S11/VSWR (S11 desired/VSWR desired). The bandwidth is typically limited to a few percent and it is the major disadvantage of basic patch antennas. The VSWR or impedance bandwidth of microstrip antenna is defined as the frequency range over which it is matched with that of the feed line within specified limits. The bandwidth of MSA is inversely proportional to its quality factor and is given by, as expressed in

$$BW = \frac{VSWR - 1}{Q\sqrt{VSWR}}$$

VSWR is defined as the input reflection coefficient (Γ) and is given by,

$$VSWR = (1 + |\Gamma|)/(1 + |\Gamma|)[2]$$

D. Directivity/gain bandwidth

It is the frequency range where the antenna meets a certain directivity/gain requirement.

E. Efficiency bandwidth

It is the frequency range wherein the antenna has reasonable radiation (application dependent) /total efficiency.

F. Polarization bandwidth

This is the frequency range where the antenna maintains its polarization.

G. Axial ratio bandwidth

The axial ratio bandwidth depends on the polarization bandwidth and the number expresses the quality of the circular polarization of an antenna.[3]

IV. SYSTEM ANALYSIS

As per the analysis done studying various papers on microstrip patch antennas it has been seen that transmission rate can be enhanced by increasing the bandwidth or transmission power.

Table 1. Analysis summary

Frequency	Shape	Substrate	Feeding technique	Return Loss	Gain	Impedance Bandwidth %
833MHz -1033 MHz	Square patch	FR4 and Foam	Coaxial	-10dB	7dBi	21
1.7Ghz-2.021Ghz	U-slot	Air (εr = 1)	Coaxial Probe feed	-35dB	5dBi	17.75
1.7GHz-2.6GHz	E-shape	Air (εr = 1)	coaxial	-28dB	7dBi	41
3.02GHz-6.38GHz	E-shape	FR4 (εr = 4.7)	coaxial	-22dB	5.57 dBi	90
3.9GHz-4.3GHz	Double crossed shaped slot	Air (εr = 1)	C axial	-48dB	8.66 dBi	15.2
4.38GHz-5.66GHz	W-slot	Air (εr = 1)	coaxial	-16 d B	6 dBi	25.78
5.1HHz	H-shape	RO303 (εr = 3)	coaxial	-24dB	5.4 dBi	45

But there is a limitation in transmission power as portable devices are battery powered. Hence large frequency bandwidth is the proper solution to achieve high data rate. The bandwidth of patch antennas can be increased using several methods like use of thick substrate, cutting a resonant slot inside the patch, the use of low dielectric substrate, use of various impedance matching and feeding techniques.

V. CONCLUSION

Bandwidth enhancement and reduction in size are becoming major design consideration for practical applications of microstrip antennas. Also position of the feeding point has a crucial effect on the performance of the antenna .It also affects the position of the resonant frequencies as well as it increases the bandwidth for the best excitation point position. Hence it is observed from the analysis done above that my making different slots in the patch, various feeding positions and different substrates are responsible for enhancement of bandwidth and other parameters.

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