

COMPARATIVE ANALYSES OF ENHANCING BANDWIDTH OF MICROSTRIP PATCH ANTENNAS: A SURVEY AND AN IDEA

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Abstract

Microstrip Patch Antenna (MPA) is generally used in modern communication devices, and a large part of day-to-day communication is done through it. Study of literature of past few year shows that, the leading work on MPA is focused on designing compact sized broadband microstrip antenna. But inherently MPA have narrow bandwidth so to enhance bandwidth various techniques are engaged. This review paper demonstrates some commonly engaged techniques to fabricate MPA with broader-bandwidth since last few decades.

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1. INTRODUCTION

Micro strip Patch Antenna (MPA) is commonly used because of its low profile, low cost and ease of manufacturing. A patch antenna is made by etching metal on one side of dielectric substrate where as on the opposite side there is continuous metal layer of the substrate which forms a ground plane [1]. MPAs are inherently a narrow band antennas so; various bandwidth enhancement techniques are engaged while keeping its size as compact as possible to be perfectly used as a low profile antenna.

Due to which many studies and researches are being done throughout the globe. Practically bandwidth of MPA is narrow but, today wireless communication systems require higher operating bandwidth. Such as about 7.6% for a global system for mobile communication (GSM; 890–960 MHz), 9.5% for a digital communication system (DCS; 1710–1880 MHz), 7.5% for a personal communication system (PCS; 1850–1990 MHz), and 12.2% for a universal mobile telecommunication system (UMTS; 1920–2170 MHz) [2] To achieve these required bandwidths many techniques are used and some of them are given explained further in review this paper.

2. BANDWIDTH-ENANCWMENT TECHNIQUES USED FOR MICROSTRIP PATCH ANTENNAS

The major need for today's communication devices is to operate at broader band such as to support high speed internet, multimedia communication and similarly many more broadband services, this is achieved by using microstrip patch antennas, but inherently microstrip antennas are narrow band antennas so, various techniques are used to enhance the bandwidth of microstrip antenna.

In this section bandwidth enhancement or broadband

techniques are explained Modified shape patch, Planar Multi-resonator configuration, multilayered configuration and Stacked Multi-resonator microstrip patch antenna are mainly used for broadband microstrip antenna.

2.1 Modified Shape Patch Broadband Microstrip Patch Antenna

In this technique bandwidth enhancement is done by changing/modifying the shape of radiating patch. It is found that some shapes of patches have lower Q factor as compared to other therefore having high bandwidth [5]. These patches shapes include annular ring, rectangular/square ring, shorted patch and other geometries. There are several designs of broadband microstrip patch antenna with modified patches. A design of broadband circular patch microstrip antenna with Diamond shape slot is given by Garima, et al. [6].

This antenna is applicable for C-band. Substrate used in this antenna is FR-4 and produces the bandwidth of 13.58% when compared with conventional circular patch antenna. The performance of proposed antenna is improved when compared with that of conventional circular patch antenna having identical radius. Another design for modified shape patch is T-slot Broadband Rectangular Patch Antenna [7]. A single layer single probe fed

2.2 Planar Multiresonator Configuration of Broadband Microstrip Patch Antenna

In such configuration of microstrip antenna multiple resonators are placed near to each other, only one is fed and others are parasitically coupled, it is also known as gap coupling. Another way used to feed multiresonator configuration is to directly connect the patches via microstrip

line. In some cases hybrid coupling is also used which include gap and direct coupling [10]. Design of Bandwidth Enhancement of Microstrip Antennas Using Shifted Parasitically Coupled Planar Multiresonator [11]. In this method, a wideband planar multi resonator antenna with parasitic coupling is used. Results show gradual improvement in impedance bandwidth from 65MHz to 251MHz (about four times) with very minor variation of resonance frequency from 2.989 GHz for reference patch to 3.023 GHz for anticlockwise shifted parasitically coupled elements. In multiresonator broadband microstrip patch antenna [12], gap-coupled planar T-slot broad band rectangular patch antenna is proposed. Impedance bandwidth of 25.23% with an average gain of about 7.43 dBi over the entire passband and peak gain of 9.88 dBi at -10dB return loss is achieved. Single-layer single-patch wideband microstrip antenna with U- shaped slot Embedded on the patch [8]. Enhanced bandwidth is achieved by the U-shaped slot with a thick air substrate of 12 mm and the impedance bandwidth of 500 MHz or 27.5% is achieved at the centre frequency 1815 MHz (at 10 dB return loss). One more method of achieving broadband microstrip patch antenna is Modified E-H Shaped patch antenna [9].

A L-probe fed microstrip patch antenna with low cross-polarization and modified E-H shaped patch design is proposed to operate at 1.79 to 2.34 GHz frequency range. The impedance bandwidth achieved is 27% (550 MHz). All these techniques provide broadband microstrip patch antennas. In such configurations broader band is achieved without increasing the surface area of patch antenna multiresonator and stacked configurations are combined to obtain wide bandwidth with higher gain with three rectangular patches stacked on a single fed patch yielded bandwidth of 830 MHz (25.7%) with more than 10 dB gain. In multiresonator broadband microstrip antenna with directly coupled and parasitic patches [13]. The impedance bandwidth of 12.7% i.e. 365 MHz at center frequency 2879 MHz is obtained with 10 dB return loss. When one patch without any coupling (i.e. direct and parasitic coupling) is analyzed, impedance bandwidth of 54 MHz (i.e.2%) is obtained at center frequency at 2710MHz's When both cases are compared (i.e. 12% Vs 2%) then the impedance bandwidth of about 6.35 times is obtained for proposed antenna.

Use of additional resonators patches either directly or gap coupled to the radiating patch will lead to a broad band configuration of microstrip antenna.

Though the size of resulting antenna is bigger but the resulting bandwidth is much more than that of a single patch microstrip antenna.

2.3 Multilayered configurations of Broadband Microstrip Patch Antenna

In multilayered configuration patches are placed over

different dielectric substrates and they are stacked on each other. Based on the coupling mechanism these configurations are of two types electromagnetically-coupled or dielectric constant. Main disadvantage of this multilayered microstrip configuration is its increased height which is not desirable in miniature devices and in aperture coupling ground plane which is having an aperture slot, and is made up of substrate with high dielectric constant to reduce radiation losses. Whereas the top patch is made up of thick substrate with lower aperture-coupled. Electromagnetic coupled microstrip antenna one or more patches are located on different dielectric layers. If two-layered configuration of broadband microstrip patch antenna is analyzed then any one of them may be fed and other is electromagnetically coupled.

Patch dimensions and dielectric constant of substrate may be different where as resonant frequency is closer to each other for obtaining broad bandwidth [14]. In aperture coupling, the field is coupled from the microstrip feed line placed on the other side of ground plane to the radiating patch through an electrically small aperture/slot in the ground plane. Two different dielectric substrates could be chosen one for the patch and other for feed line [14]. Very high bandwidth can be generated by using multilayered configurations. Near about 70% bandwidth can be generated using multilayered configuration.

Microstrip line feed electromagnetically coupled microstrip antenna [15] is a method of exciting the patch. This technique has the advantage that the dielectric constant of substrate used for microstrip feed line is high and it is thin so that radiation from feed line should be minimized, whereas the dielectric constant of substrate used for radiating patch is low and it is thick which improves the bandwidth of antenna [15]. Aperture coupled microstrip patch antenna is also an indirect technique of exciting patch. In this configuration feed line is on lower side of backward radiation is major problem [14].

2.4 Stacked Multiresonator microstrip patch antenna

In this configuration multiresonator and stacked configurations are combined to provide broadband microstrip patch antenna. A design of dual-frequency broadband stacked microstrip antenna using a reactive loading and a fractal-shaped radiating edge [16], is used to obtain dual-frequency operation antenna is loaded with stub for changing frequency and which broader bandwidth is achieved by using stacked parasitic technique.

The central frequencies of the first and second operating bands are 1.524 and 2.159 GHz, bandwidth enhancement factor achieved is 22.3 in the first band and 18.7 in the second band and bandwidth achieved is 12% and 5% respectively [16]. Another broadband design using stacked multiresonator configuration is gap-coupled planar multi-resonator and stacked configurations [12]; which is used to obtain wide

bandwidth with higher gain with three rectangular patches stacked on a single fed patch yielded bandwidth of 830 MHz (25.7%) with more than 10 dB gain. A proposed broadband design using stacked U- slot microstrip antenna incorporating

E-shape and modified half-E shape radiating patches [17] are introduced. Maximum impedance bandwidth achieved is 60.2%. It's though size of stacked multiresonator microstrip patch antenna is more but it yields high bandwidth.

2.5 Tables for the Comparative Analyses of Broadband Techniques

S. No.	Broadband Techniques	Configurations	Remarks
1.	Modified Shape Patch	Diamond shape slot patch[6]	Bandwidth achieved is 13.58% when compared
		T-slot rectangular patch[7]	Impedance Bandwidth of 25.23% with average gain of 7.43 dBi is obtained.
		U-shaped slot with single-layer single- patch[8]	Air substrate of 12 mm is used to yield bandwidth of 27.5%.
		E-H shaped patch[9]	Yielded bandwidth is about 27%.
2.	Multiresonator Technique	Shifted parasitically coupled multiresonator[11]	Improves the impedance bandwidth from 65 MHz to 251 MHz (about four times) with minor variation of resonance frequency from 2.989
		Gap-coupled multiresonator and stacked configuration[12]	Yielded bandwidth of 25.7% with more than 10 dB gain.
		Directly coupled and parasitic patches[13]	Impedance bandwidth of 12.7% (365 MHz) is obtained, which is 6.35 times when compared with the simple patch i.e. 2% (54 MHz) at same center frequency of 2879 MHz
3.	Multilayered Technique	Multilayered configuration of patches[15]	Nearly 70% of bandwidth can be generated by using multilayered configuration of radiating patches.
4.	Stacked Multilayered Technique	Dual-frequency stacked patch with reactive loading[16]	Bandwidth enhancement factor is 22.3 and 18.7 for 1.524 GHz and 2.159 GHz resp. which is further 12% and 5% for their respective bands.
		Gap-coupled planar multiresonator and stacked configuration[12]	Yielded bandwidth of 25.7% with more than 10 dB gain
		Stacked U-slot microstrip antenna incorporating E-shape and modified half-E shape radiating patch	Maximum impedance bandwidth of 60.2% can be obtained.

2.6 Bandwidth Analysis by Introducing Slots in Microstrip Antenna Design Using ANN.

In this method slotted MSA is designed on a substrate of thickness 1.588mm that gives wideband characteristics using Artificial Neural Network (ANN). The patch antenna gives enhanced bandwidth as compared to antenna-without slots of the same physical dimensions. The bandwidth for the antenna is around 450 MHz The present work signifies that by introduction of two slots in the same design, the bandwidth gets enhanced about 25%-45%, i.e., from 450 to 650 MHz

2.7 Enhancing the Bandwidth of a Microstrip Patch Antenna using Slots Shaped Patch.

In this method, three different geometry shapes, the U, E and H are developed from a rectangular patch [20] shows that, bandwidth of conventional rectangular microstrip antenna can be enhanced from 4.81% (100MHz) to 28.71% (610 MHz), 28.89% (630MHz) and 9.13% (110MHz) respectively using U, E and H-patch over the substrate. The E-shaped patch antenna has the highest bandwidth followed by U-shaped patch antenna and H-shaped patch antenna.

2.8 Comparative Study of Different Feeding Techniques to Enhance Bandwidth of Microstrip Patch Antenna

This paper describes variety of feeding technique applicable to microstrip patch antenna which is one of the important aspects. A good impedance matching condition between the line and patch without any additional matching elements depends heavily on feeding techniques used. The Coaxial Probe Feed Microstrip antenna provides a bandwidth of around 20%.The bandwidth has been enhanced by using different feeding techniques are as follows.

S.no	Parameters	Coaxial probe feed	Aperture Coupled Feed	L-band Capacitive Coupled Feed
01	Frequency (GHz)	5.35	2.25	1.25
02	Gain(dB)	6.8	6	8
03	Return Loss(dB)	-14	-14	-42
04	Bandwidth (MHz)	51	5%	246

3. CONCLUSIONS

After an extensive literature survey, it has been found that the bandwidth enhancement is an important area of study and research in microwave communication. Several techniques which are reported from time to time by many researches for enhancing the bandwidth of an MPA have been revised in this paper. Principles used, advantages and disadvantages of each method have been described out of all the techniques specified in this paper, multilayered technique and stacked multilayered techniques provide maximum bandwidth. The main intension of this study is to provide a useful reference to the researchers, designers and manufacturers of MPA.

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