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A Review on Gain & Bandwidth Enhancement Techniques of Microstrip Patch Antenna

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Abstract

In the recent years the study of Microstrip patch antennas has made great progress. If we compare this antenna with conventional antennas, then it is important to note that the Microstrip patch antennas have more advantages and better prospects, Such as they are lighter in weight, low volume, low profile, smaller in dimension, ease of fabrication and conformity. Moreover, these Microstrip patch antennas can provide dual and circular polarizations, dual-frequency operation, frequency agility, broad band-width, and feed line flexibility, and beam steering & omni-directional patterning also. Because of this Microstrip patch antennas of all shapes are widely used in communication systems. However, these antennas have some limitations like low bandwidth due to surface wave losses, and low gain when used in conventional form. Hence, so this work focuses on the improvement of such parameters which are reported in literatures.

Keywords: **Microstrip antenna, Gain, Bandwidth.**

Introduction

As per the Webster's Dictionary an antenna is defined as "metallic device as a rod or as a wire which is used for transmission or reception of the radio waves through the free space". Also the *IEEE Standards define antennas* (IEEE Std 145 1983) "as a means for radiating or receiving radio waves." Initially, the Microstrip antennas are developed only for the space communication, but today due to its advantageous nature they are used in government as well as in some commercial applications [1-2].

Actually these antennas are developed by sandwiching dielectric material in between metallic patch and larger metallic sheets of ground plane. Patches are available in various configurations such as circular, square, rectangular, dipole etc. but out of all these only circular and rectangular patches are mostly preferred for the wireless applications, because which provides very low cross polarization radiation.

The Microstrip antennas are developed by using grounded substrate and metallic patch. Following Figure 1.1 shows the basic structure of Microstrip antenna.

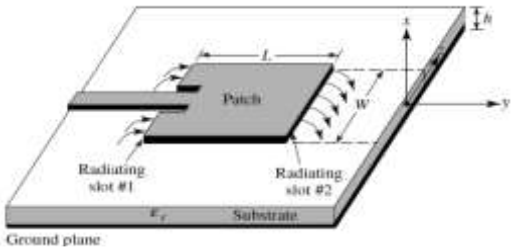

Fig 1. Basic structure of Microstrip antenna [2].

Also these antennas are very easy to integrate with microwave integrated circuits and when a particular metallic patch is selected then these are very desirable in terms of higher impedance, resonant frequency and polarization, since they are mostly preferred for wireless applications [1-3].

But along with all advantages & applications the electrical behaviour of basic Microstrip antenna is affected due to number of parameters such as very narrow bandwidth due to surface wave losses, lower gain, low cross polarization [1-2]. So the basic aim of this paper is to review different techniques which are available to enhance the bandwidth as well as gain of Microstrip antenna.

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Need of higher gain & bandwidth for microstrip antenna

Basically the analysis of antenna is taken by using two important parameters i.e. Gain & Bandwidth. The antenna efficiency & the directional capabilities are depends on the directivity of the antenna. This antenna directivity is highly correlated with the Gain of antenna & it expressed as,

$$Gain = 4\Pi \frac{\text{Radiation Intensity}}{\text{Total accepted input power}} \ldots..[2]$$

As know the Microstrip antenna has s a low profile, narrow bandwidth due to surface wave losses, lower gain, but today the development of wireless communications needs the higher bandwidth and gain. These communication systems require higher bandwidth & gain in order to operate in the broad frequency band in order to provide high speed communication.

Improvement of gain & bandwidth of microstrip antenna

The bandwidth & Gain of Microstrip antenna is improved by using various type of techniques, which are as follows,

1. By Using Modified Radiating Element

The Bandwidth of Microstrip patch antenna is closely depends on the quality factor. So, as the patch is modified then it stores very less energy & then the quality factor also degraded. Due to such degradation it generates higher radiations from the modified patch such as U-Slot, T-Slot, E-H Shaped patch. i.e. by using modified patches bandwidth of Microstrip antenna is improved more than 25.23% with the gain of more than 7 dBi [1-2].

2. Microstrip Antenna With The Multilayered & Multiresonator Structures

In multilayered structures of Microstrip antenna either aperture coupling or electromagnetic coupling is used & also the radiating patch is stacked on various layers dielectric substrate. In the aperture coupling ground plane having a slot & that slot made up on substrate with the high dielectric constant in order to reduce the radiation losses, whereas the patch is made up of the thick substrate with low dielectric constant. This structure provides the bandwidth improvement up to 70%.

In the multiresonator techniques various resonators are coupled with each other by using either gap coupling or direct coupling. Also in some of the configuration both the couplings are used simultaneously which is called as hybrid coupling technique. Multiresonator techniques are classified into two category, such as planar multiresonator configurations & Stacked multiresonator configurations.

The stacked multiresonator configurations provides the higher bandwidth & gain as compared planar configurations due to combination of stacked configurations. Multiresonator configurations improves Bandwidth in between 12.7% to 25.7% with the Gain of more than 10 dBi [1-2].

3. By Using Feeding Techniques

The Microstrip antenna having a patch on one side of substrate, since it is required to fed the Microstrip antenna through the ground plane. There are various type of feeding configurations are available some of them are as, Microstrip line, coaxial probe, aperture coupling & proximity coupling.

Also these feeding configurations are used to improve the bandwidth of Microstrip antenna. As listed in following table Proximity coupling method provides much higher bandwidth as compared to other techniques.

Sr. No.	Feeding Configuration	Bandwidth Improvement
1	Microstrip Line.	2-5 %
2	Coaxial Probe	2-5 %
3	Aperture Coupling.	2-5 %
4	Proximity Coupling.	13%

Table 1. Bandwidth enhancement using various feeding configurations.

Comparative study

From the last two & half decades different researchers delivered the different concepts which focuses on the development of basic Microstrip antenna, but the first practical Microstrip antenna is developed by Howells & Munson [6-7] and also he proved that the Microstrip antenna is one of the solution to resolve all the antenna system related problems, and after this development wide use of Microstrip antennas comes into play.

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These Microstrip antennas are analyzed by various researchers by considering various parameters such as gain, bandwidth etc, and also they suggested some of the techniques to improve these parameters, such as by changing the shape of patch, changing the dielectric substrate or by combining different techniques [3-5].

For the enhancement of impedance bandwidth as well as axial bandwidth & gain of Microstrip antenna, Kin-Fai Tong and Ting Pong Wong effectively developed the circularly polarized Microstrip antenna with the single layer of U-Slot. For the circular polarization this antenna generates two orthogonal modes without affecting square patch, and this antenna provides impedance bandwidth of 9% and 3dB axial ratio bandwidth of 4%, with the gain of 8dBi in order to cover the satellite communication applications such as MSAT & GPS, by reducing losses in between signal and receiving antenna [5]. Pie- Yuan Qin, Andrew R. Weily, Y. Jay guo, and Chang- Hong Liang proposed the Reconfigurable U-slot patch antenna [6] to cover the wireless local area network (WLAN) applications by switching in between two circular polarization senses or in between linear and circular polarization. Also it uses dual beam PIN diode which interns allow the length of arm of U-Slot to be varied, in order to provide impedance bandwidth of 5.6 – 6.3 GHz and 5.72 – 6.02 GHz [6].

Amit A. Deshmukh & K. P. Ray proposed the broadband modified rectangular Microstrip antenna using proximity feeding technique in order to improve the bandwidth of 200 MHz (22%) with the centre frequency of 900MHz. Also he improved the bandwidth and gain by combining various multi resonator and slot configurations, which improves bandwidth more than 400 MHz with the gain of 7dBi. Since these broadband Microstrip antennas are used in GSM mobile communication applications [7].

Kin Lu Wong, Chia Luan Tang, and Jyh Ying Chiou proposed the broadband Microstrip patch antenna with a W - shaped ground plane with the flange section is developed by using probe feeding technique. This design is applicable only for patch antennas which are having planner ground plane & thin substrate of air. In this proposed design the effective thickness of substrate is increased significantly but the needed length of probe pin keeps remain same, which results in wider bandwidth and also gain is improved by properly selecting the dimensions of the W-shaped ground plane, so it provides impedance bandwidth of greater than 12% with the maximum value of gain more than 9.5 dBi [8].

All the specifications which are required to transmit any type of data i.e. voice, videos, etc through the WLAN or global positioning system (GPS) is fulfilled by using wideband or multiband patch antennas. Since to provide such a requirement Hsing Yi Chen & Yu Tao developed U-Slot patch antenna in which the frequency selective surface (FSS) is integrated in patch, also along with frequency selective surface (FSS) it uses jarusalem element to improve gain & bandwidth at the centre frequency of 2.45 GHz and 5.8 GHz [9].

To reduce the power loss it is desirable to use directional antennas instead of using omni-directional antennas. So in order to provide wideband specifications for the stationary terminals, Ahmed Khidre, Kai-Fong Lee, Atef Z, Elsherbeni, & Fan Yang developed wideband dual beam U-Slot antenna. So by operating at higher order modes TM_{02}, it improves bandwidth of 11.3% & also generates two radiating beams with the gain of 7.92 dBi for forward radiating beam & 5.94 dBi for backward radiating beam [10].

Conclusion

Various researchers were analyzed different methods to improve the gain & bandwidth of Microstrip antennas. If the gain & bandwidth of MSA is improved then it applicable to use in the frequency range of 800-1200 MHz, as well as in various wideband applications such as wireless local area network. But still there is scope for improvement of gain and bandwidth using proximity coupled feeding techniques as it improves bandwidth up to 13%.

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