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A Review on Gain Enhancement Methods of Microstrip Patch Antenna

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ABSTRACT

The MSA is a narrowband, wide beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. MSA are low profile, lightweight and have a compatibility with integrated circuit technology. The major limitations of MSAs are their constrict impedance, axial ratio (AR), bandwidth, little gain and lower power handling capability. Here the overview of air fed high gain patch antenna is delivered. Various gain sweetening methods like microstrip antenna array, superstrate structure, change in dielectric material and partial removal of substrate will be studied and the review is delivered. Air is employed as dielectric medium between feed patch and ground plane.

KEYWORDS: Patch antenna, Bandwidth, Gain, Array, Dielectric.

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INTRODUCTION:

Microstrip antenna technology has been the most rapidly developing topic in the antenna field in the last fifteen years, meeting the originative attending of academic, industrialized, and government engineers and researchers during the world. Throughout this period there have been over 1500 published journal objects, many books and countless symposia sessions and short courses devoted to the subject of microstrip antenna and arrays. As a solution microstrip antennas have rapidly evolved from academic novelty to commercial world, with covering in a wide kind of microwave systems[1].

In recent years, microstrip ultra wideband antennas have attracted more attention owing to their advantages such as mere structure, small profile, high data rate, simple integration with monolithic microwave integrated circuits (MMICs), and ease of fabrication. When compared to traditional antenna elements such as reflectors, horns, slots, or wire antennas. Nevertheless, the electrical operation of the basic microstrip antenna or array suffers from a number of serious drawbacks; including very narrow bandwidth high feed network losses, poor cover polarization, and small power handling capacity. The aim of this paper is review various techniques for enhancing the gain of antenna[2].

Baissinot. Shortly thereafter, Lewin investigated radiation from stripline separation. Additional studies were undertaken in the late 1960's by Kaloi, who analyzed introductory rectangular and square configurations. Nevertheless, other than the pilot Deschamps study, work was not described in the literature until the too soon 1970's, when a conducting strip radiator broked from a ground plane by a dielectric substrate was depicted by Byron. This half wavelength broad and various wavelength long strip was fed by coaxial connections at periodic intervals along both radiating edges, and was applied as an array for Project Camel[3]. Afterthere, a microstrip element was patented by Munson and data on basic rectangular and circular microstrip patches were published by Howell. Weinschel built various microstrip geometries for use with cylindrical.

DEVELOPEMENT HISTORY:

The microstrip antenna concept dates back about 26 years to influence in the U.S.A. by Describe and in France by Gutton and S band arrays on rockets. Sanford described that the microstrip element could be used in conformal array designs for L band communication from KC135 aircraft to the ATS6 satellite. Extra work on basic microstrip patch elements was presented in 1975 by Garvin et al, Howell, Weinschel, Janes and Wilson. The too soon work by Munson on the growth of microstrip antennas for employ as low profile wall mounted antennas on rockets and missiles described that this was a practical conctruct for apply in many antenna system problems and thereby gave birth to the noval antenna industry[4].

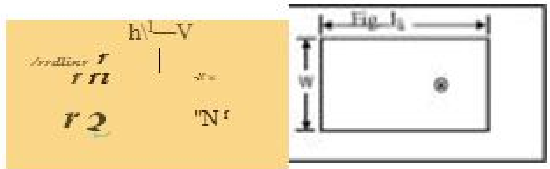

Fig-1: Basic Geometry

RECTANGULAR MICROSTRIP ANTENNA STRUCTURE:

The microstrip device in its merest form comprise of a sandwich of two parallel conducting layers different by a single dilute dielectric substrate. The let down conductor functions as a ground plane and the upper conductor may be a mere resonant rectangular patch, and the as much feed network. The feed network applied may be a microstrip transmission line and coaxial fed connector. Fig 1 depicts a microstrip line fed rectangular microstrip antenna and coaxial fed rectangular microstrip antenna severally[5].

ANTENNA GEOMETRY AND DESIGN:

A low profile microstrip patch antenna is aimed as established in Fig 1. Practical microstrip antennas have been arose for use from 400 MHz to 38 GHz, and it can be assumed that the technology will soon lead to 60 GHz and beyond.

MATERIAL FOR PRINTED RECTANGULAR MICROSTRIP ANTENNA:

The propagation fixed for a wave in the microstrip substrate must be accurate known in order to assumed the resonant frequency, resonant resistance, and the early antenna quantities. Antenna designers have detected that the most sensitive parameter in microstrip antenna execution idea is the dielectric constant of the substrate material, and the manufacturer's tolerance on er is sometimes inadequate. The dielectric substrate materials employed in microstrip antennas are generally classified in to relative dielectric constant range of 1 to 2 (low dielectric constant), 2 to 4 (medium level dielectric constant), and 4 to 10 (high level dielectric constant). Generally a small dielectric constant material with low loss tangent such as air, foam etc. is cost efficient[6].

There are three common types of feeding techniques in microstrip patch antenna. Microstrip line fed method, coaxial connector feed method or aperture feed. The microstrip line fed incorporates feed thick and low dielectric constant substrate substantial is involved to enhance the bandwidth of the antenna. The substrate substantial is coated with expected conducting material of antenna pattern backed by conducting ground plane. For testing purpose, commonly available FR4 substrate. (er of 4.4 and loss tangent 0.03) is generally used. This material comes in standard thickness of 1.59 to 1.6 mm and in several sheet size[7].

FEEDING METHODS:

There are generally three common types of feeding mechanisms in microstrip patch antenna. Microstrip line fed method, coaxial connector feed method or aperture feed. The microstrip line fed method incorporates feed structure on the surface of substrate itself, helping us to incorporate in microwave integrated circuits. The disadvantages of this feed are cross polar radiations and complex design of corresponding element. In coaxial feed mechanism, a coaxial connector is directly soldered to patch element and impedance matching is achieved by variable locations of feed, the retreat here is that, it is required to drill the hole in the substrate material through which the connector protrudes to the patch. In aperture feed mechanism, the patch is indirectly mad by source. The structure goes complex in this mechanism, but on the other hand it supply greater number of variable for optimizing the structure and hence better control of radiation pattern can be achieved[8,9].

THEORETICAL APPROACHES OF ANALYSIS:

The microstrip antennas (MSA) generally have a two dimensional radiating patch on a thin dielectric substrate and therefore may be categorized as a two dimensional planar component for analysis purposes. The analysis mechanism for MSAs can be broadly divided into two parts. In the first part, the methods are based on equivalent magnetic current distribution around the patch edges (similar to slot antennas). There are three popular analytical techniques:

- The transmission line model;
- The cavity model;
- The MOM.

In the second group, the methods are based on the electric current distribution on the patch conductor and the ground plane. Some of the numerical methods for analyzing MSAs are listed as follows:

- The method of moments (MoM);
- The finite element method (FEM);
- The spectral domain technique (SDT);
- The finite difference time domain (FDTD) method.

Although the transmission line model is simple to employ, all types of configurations cannot be studied using this model. Later on it does not take care of variation of field in the orthogonal direction to the direction of propagation. In the cavity model, the region between the patch and the ground plane is treated as a cavity that is surrounded by magnetic walls around the periphery and by electric walls from the top and bottom. Later on thin substrates are employed, the field inner side of the cavity is unvaring along the thickness of the substrate. The fields underside the patch for steady shapes such as rectangular, circular, triangular, and sectoral forms can be expressed as a summation of the various resonant modes of the two dimensional resonator. The fringing fields and the radiated power are not included inside the cavity but are localized at the edges of the cavity. Nevertheless, the solution for the far field, with admission walls is hard to evaluate. In multi port network model, the patch construction is divided into „n" number of ports and field configuration evaluated through each port is finally summed to get total field over the surface. The numerical methods of analysis are more accurate in calculation of dimensions of the patch, but they provide relatively less inside significance compared to analytic mechanisms[10]. On the other hand the analytic mechanisms described above are simple to understand and provides greater details inside significance.

ELEMENT LENGTH:

To choose the resonant length would also mean choosing the frequency of resonance since the resonant frequency of the patch is determined by the patch length. The length of the patch ought be somewhat less than half the dielectric wavelength since the actual patch is „longer" due to the fringing fields[11].

COMPARITIVE STUDY:

Researchers studied the MSAs considering different parameters suchlike gain, BW, radiation pattern. They also look at mechanisms to improve these parameters such as change in shape of patch antenna, vary in dielectric substrate, employing superstrate, removal of substrate, and compounding of different mechanisms. For enhancement of gain of MSAs array method is effectively used investigaters H. Wang et al planned 2 x 2 MSA line feed U-slot rectangular array these antenna gave gain of 11.5 dBi and 18% BW 1. Chao Sun, Jiu-sheng Li aimed planar microstrip antenna for WLAN application at 5GHz WLAN band without any modification as observed in 1 this structure gave gain of 19.72 dBi 2. M.T.Ali et al developed 2 x 2 MPA with air substrate at 5.8 GHz operating frequency and they found enhancement of gain up to 38.21% 3. Horng-Dean Chen, Chow-Yen-Desmond Sim, Jun-Yi Wu, and Tsung-Wen Chiu changed MSA by developing two novel array antenna i.e 3 x 2 and 3 x 3 array antennas for WiMAX application and these antenna structure gave gain of 17 dBi and blanket up to 3.3 GHz to 3.8 GHz WiMAX band running frequency 4. Tommy Reynalda et al designed 4 x 4 array antenna using dielectric constant of 2.5. This structure is inspired by 3 having difference in number of array and dielectric substrate. Afterward it compare with one patch antenna having dielectric constant of 2.5. Researcher observed that modified structure has gain 16.02 dB and 150 MHz BW, when one patch antenna has gain 6.10 dB and 50 MHz BW 5. Researchers proved that array structure enhances the gain of the MSAs. Halim Boutayeb et al proposed new design of MSA introducing cylindrical EBG structure which enhanced the gain of 2.9 dB as compare to conventional MSAs 6. Shi – Wei Qu et al in the same year designed Y shaped stub proximity coupled V-slot MPA (Microstrip Patch Antenna)and observed 21% BW enhancement and 9 dBi gain feeding technique of this antenna is different than that of researchers 7. Jung-han Kim et al used very new structure for designing MSA known as SAP i.e. Short Annular Patch structure. Researcher succeeded to improve a gain by 3.12 dBi and 300 MHz BW compare to reference simple rectangular patch antenna 8. Bahadir Yildirim et al projected antenna in which a rectangular loop shaped parasitic radiator placed at different distance away from the patch antenna at 1.6 GHz operating frequency gain increases up to 3.3 dB 9. Kaushik Mandal and Partha Prtim Sarkar designed U-shaped patch antenna with two equal arms using PTFE (poly tetra fluro ethylene) substrate. Just below the U shaped patch inserted inverted U-shaped slot on circular shaped ground plane. They achieved 4.1 dBi gain and BW enhancement of 86.76%. Structural modification in MSAs effect the gain of the MSAs these proved by the researches 10. Modifications in shape of antenna tends to increase gain of MSAs was scrutinize by these researchers.

Furthermore change in dielectric substrate also influences the gain of the MSA as researchers Sudhipta chattopadyay et al devise rectangular MPA with part of dielectric substrate as PTFE and rest is air and enhanced gain of the MSA 11. Using superstrate in MSAs also contributes in gain sweetening Avinash R. Vaidya et al deliberate the superstrate height on MSA. They found that high gain is attained by placing superstrate layer at above integral multiple of half wavelength above the ground plane 12. V. Priyashman et al analyzed the performance of elliptical shaped antenna by using superstrate with random slots at 5.8GHz frequency they also showed that gain and BW influenced by the superstrate structure 13. Researchers Dongying Li et al considered structure in which low metamaterial used as substrate at 9.45 GHz frequency range and observed 80% gain enhancement 14. Siew bee yeap and Zhi Ning Chen improved gain of MSA by partial removing the substrate and researcher observed that gain enhanced up to 2.4 dB to 2.7 dB by this method 15.

All researchers here premeditated the different methods for gain enhancement. Heading in the direction of their aim they effectively achieved the gain augmentation using the various techniques and gave new thoughts to world along with future scope for other researcher in the same field.

CONCLUSION:

Various methods were examined by the researcher for the purpose of gain enrichment such as in microstrip antenna array, superstrate structure, change of dielectric material and partial removal of substrate. All these mechanisms individually increase the gain of MSA is being proved by researches. But however there is scope for bettering gain of the antenna by hybridization techniques.

Table-1: Method comparison table

Sr. no	Method used for enhancing gain	Gain in dB
1	Array Method	17
2	Change of Dielectric	10
3	Partial Removal of Substrate	9.4
4	Change of Dielectric	10

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