Cross Polarization Reduction in Microstrip Patch Antenna: A Review

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Abstract— Generally conventional microstrip patch antennas have various drawbacks like narrow bandwidth, low polarization purity, low gain, etc. So as to reduce these researchers propose various size reduction and broadbanding techniques using shorted pins or shaped slots, post-gap, or parasitic elements cause high cross polarized radiation as a side effect. Hence reduction of cross polarization is an important aspect in antenna designing. In this paper various techniques of cross polarization have presented and a better technique of using defected ground structure to reduce cross polarization is proposed.

Key words: defected ground structure (DGS), cross polarization, microstrip antenna

I. INTRODUCTION

Antenna engineering is a vast field and has a history of over 80 years. It still remains as a vibrant field which is bursting with activity, and is likely to remain the same in the upcoming future. Now the scope of antenna design moves into new era of technology.

An antenna is the most important component in a wireless communication system. By its definition, an antenna is a device used to transform an RF signal travelling on a conductor, into an electromagnetic wave in free space. When a RF signal is fed into an antenna, the antenna will emit radiation that distributes in space in a certain way. Various parameters define the performance of an antenna such as bandwidth, radiation pattern, input impedance, return loss, directivity and gain, beam width, side lobes, polarization etc. Until now antennas have not obtained much attention among all the components in various communications systems. Yet, the way in which radio frequency energy is spread into the space and collected from space has a deep influence upon the adequate use of spectrum, the amount of establishing new communications networks and the service quality provided by those networks. The property of an antenna including physical structure varies depending upon the applications in which they are used. There are different types of antenna available now and they all have their place. Every system now a days demands for compact and efficient components to be embedded with it. Microstrip patch antenna is a perfect match component which is so popular by its compact size.

II. CO-POLARIZED AND CROSS-POLARIZED RADIATION

In the present world of advanced technology, design of novel and wide band antennas with improved polarization purity is one of the current research spotlights. In this case, microstrip antenna is probably a most appropriate microwave component to use due to its small size,simple design, ease of implementation and conformal properties. These antennas used are conformable to planar and non-planar surfaces, low profile, simple and inexpensive to manufacture using modern printed-circuit technology, compatible with MMIC designs, mechanically robust so as to mount on rigid surfaces. When the particular patch shape andparticular mode are selected, they are very versatile in terms of polarization, radiation pattern, resonant frequency, and impedance.

In spite of that, such a conventional microstrip patch antenna suffers from some serious disadvantages like narrow impedance bandwidth (3%-5%) and poor polarization purity. A microstrip antenna radiates along its broadside direction in the fundamental mode TM10. The field here is primarily linearly polarized; this is called co-polarized (CP) radiation. Nevertheless, there is some degrees of orthogonally polarized, called cross-polarized (XP) radiation take place. XP is more significant in H-plane than in E-plane. The XP radiations in H-plane are mainly due to higher-order orthogonal modes. Therefore, such a microstrip antenna suffers from the poor polarization purity (less CP-XP isolation).

This is apparently a restriction to the applications, such as RADAR and microwave communications, adaptive antenna arrays for mobile communications, where improved polarization purity is needful over wide range of frequencies. Hence, the concurrent improvement in XP radiation along with the improved bandwidth for simple microstrip antenna becomes an important issue and is of considerable interest in the scientific community also it is still an open and active field of research.

III. METHODS TO REDUCE CROSS POLARIZED RADIATION

A. *Making Patch Array*

An array of patches can be made to reduce cross polarization at some extent. Vladimir Schejbal had discussed suspended patch array method for the reduction of cross-polarized radiation. The method can be used for various antenna array systems made up of radiating elements with higher cross-polarized radiation. This solution enables numerous possibilities for selecting the position, the spacing, and the excitation coefficient of any array element. It is even possible to use two different linearly polarized arrays that use the same or different polarizations. Two examples are given: a quarter-wave microstrip antenna system operating in two frequency bands, and a suspended patch array. [3]

B. *Meandering Strip Feeding Structure*

Modification in feeding structure of patches can be made to reduce cross polarization. P. Lee have introduced a meandering strip feeding structure, a patch antenna for wideband and low cross-polarization operation is proposed. The investigation shows that this feeding technique is suitable for both planar and curved grounding structures, where the impedance bandwidths of 24% and 32% can be obtained, respectively. In both cases observed the cross-polarization levels are less than 20 dB in E- and H-planes across the pass band. Symmetrical and stable radiation patterns are obtained also simulation results are compared with the experiments and a good agreement is also observed. [4]

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C. Array of Split Ring Resonators

Split ring resonators can be applied to suppress the cross polarization from array of microstrip antenna to get pure axial ratio. A researcher R. Manikandan placed a pair of SRR adjacent to the patch antenna which is asymmetrical. The SRR has been optimization for size and location and examined using simulated results. The presence of SRR gives more than 28 dB cross pol isolation from its peak radiation when identical patch is compared with it, with pure axial ratio from 2.5 to 0.5. Cross pol suppression were found to be more than 10 dB over ± 15 degree at elevation angle. Measured results were well agreed with simulated results. [5]

IV. Defected Patch Structure Using Dipole Slot

Various shapes of slot structures can be made in the patch to reduce cross polarization. Abhijyoti Ghosh, L. Lolit Kumar Singh have introduced a simple and single element wide slot dipole loaded shorted rectangular microstrip antenna has been proposed and investigated experimentally for broad impedance bandwidth and improved cross polarized (XP) radiation compared to maximum co-polarized (CP) gain without changing the co-polarized (CP) radiation pattern. Around 23-35 dB isolation between CP and XP radiation along with 25% impedance bandwidth is achieved with the proposed structure. The measured gain of the antenna is around 6.2 dBi over the entire band. The present antenna is very simple and easy to manufacture. Unlike the other structures, the present one is free from back radiation in terms of XP fields. The design of the antenna structure is theoretically justified and rigorously analyzed. The present investigation provides an insightful, clear visualization-based understanding of the concurrent improvement in both the impedance bandwidth and XP performance with the present structure. [6]

V. Defected Patch Structure Using Dumbbell Shaped Slot

Various shapes of slot structures can be made in the patch to reduce cross polarization. Subhradeep Chakraborty have presented rectangular patch with dumbbell-shaped defected patch surface has been studied theoretically and experimentally to improve polarization purity over wide angular range and broad impedance bandwidth. More than 30 dB co- to cross-polarization (CP-XP) ratio over entire angular range around the broadside direction with wide impedance bandwidth is obtained. Moreover, the present structure is free from back radiation in terms of XP fields, and it can efficiently suppress the XP radiation in different diagonal planes. The present structure is very simple and easy to manufacture. The present investigation provides an insightful visualization-based understanding of concurrent improvement in impedance bandwidth and the XP radiation characteristics with the present structure. [7]

VI. Defected Ground Structure Using Dumbbell Shaped Slot

Ground plane of an antenna can be detected by different shapes of slot structures to reduce cross polarization radiation. Abhijyoti Ghosh have given simple and compact rectangular microstrip patch antenna (RMPA) with dumbbell shaped defected ground structure has been proposed and investigated experimentally for significant suppression of cross polarized (XP) radiation compared with maximum co-polarized gain without affecting the co-polarized radiation pattern. The investigation shows that the proposed antenna has an excellent co-polarized radiation to XP radiation isolation over wide elevation angle around the broadside for different aspect ratio (width to length ratio or W/L) of RMPA. The proposed idea is justified in the light of concrete theoretical analysis. [8]

VII. Defected Ground Structure Using Rectangular Slot

Ground plane of an antenna can be defected by different shapes of slot structures to reduce cross polarization radiation. Abhijyoti Ghosh have presented A simple rectangular microstrip antenna on slot-type defected ground plane is proposed for reduced cross-polarized (XP) radiation and justified theoretically. This will reduce the XP radiation field compared to a conventional microstrip antenna without affecting its co-polarized (CP) radiation characteristics.[9]

VIII. Defected Ground Structure Using Arc Shaped Defect

Ground plane of an antenna can be defected by different shapes of slot structures to reduce cross polarization radiation. Debatosh Guha have proposed application of defected ground structure (DGS) to suppress cross-polarized (XP) radiation from a microstrip patch antenna has been reinvestigated using a new DGS geometry for much improved characteristics. Here arc-shaped defect has been used in pair which are symmetrically located under a circular patch. A number of optimization parameters have been examined using simulated results, leading to a design indicating improved XP behavior. A set of identical prototypes, with and without DGS, have been experimentally studied. The presence of the DGS shows as much as 30 dB isolation of the XP level from its peak radiation, and that compared to an identical patch without DGS indicates an enhancement by 12 dB. The relative suppression in cross pol values are found to be 7 to 12 dB over elevation around the bore sight of the patch.[10]

IX. Digitized Feed for Reflector Antennas

Carolina have expressed antenna configuration studied as part of Tandem-L project, a proposal for interferometry radar mission to monitor the Earth. It consists of a deployable reflector antenna in offset configuration having a digitized feed. High cross polar radiation level due to the reflector geometry. It must be compensated so as to fulfill the requirements of fully Polari metric applications. Synthetic Aperture (SAR) calibration methods until now are not able to reduce the cross polar component of the radiation pattern of single offset reflector antennas. So the antenna design stage itself must consist reduction of the cross polar level. It shows the characterization and combination of two different techniques to reduce the cross polar level of a large deployable single offset parabolic reflector. [11]

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X. CORNER FEED ANTENNA ARRAY

Rinkee Chopra has given design and analysis of large corner fed microstrip antenna array at C band. Two configurations of corner fed arrays are designed to analyze and compare their performance. Symmetric corner feed configuration provides reduced side lobe level and cross polarization level. A series of non-radiating edge corner fed linear array up to 31-elements are with a stable broadside beam, low cross polarization level and reduced side lobe level. Cross-polarization of lower than -35dB is achieved with beam directed at the bore sight. Planar array of 13 x 13 elements is designed using corner fed technique in E and H planes which provides moderate gain of 24dBi at C band. The side lobe level is lower than -20 and -14 dB and cross polarization of lower than -23dB in E and H plane respectively, is achieved at the bore sight for this planar array. This array can be used for long range radar and WLAN applications.[12]

XI. SPIRAL RING RESONATORS IN ARRAY

Chandan Ghosh has presented an E-shaped microstrip patch antenna array which is integrated with spiral ring resonators (SRRs) have been introduced for the reduction of cross-polar (XP) radiation. The addition of SRRs in the array structure does not affect other characteristics of the array antenna. The array is designed to function in the 5.25 GHz which corresponds to IEEE 802.11a wireless LAN application. The characteristic analysis such as bandwidth, radiation patterns and return loss of the antenna with and without SRRs has been investigated. This array offers a bandwidth of 405MHz which cover frequencies ranges from 5.175 to 5.580 GHz. Also gain of 12.60 dBi has been achieved. The array has been studied both numerically and experimentally by introducing SRRs. As they placed two sets of SSRs of similar geometry in between the patch elements of the array structure The XP radiation has been reduced by 10.5 dB. Prototype antennas are fabricated and tested with and without SRRs and a remarkable agreement is obtained between the measured and the simulated results.[13]

XII. CONCLUSION

Many researchers had gone through different techniques of size reduction and broad banding using shaped slots or shorted pins, post-gap, parasitic elements that has cause high XP as a side effect. As per above review, it seems that various researchers have given different methods for XP reduction but they carry their own drawbacks and major issues with leading to lack of performance. There must be an effective technique to reduce cross polarization. So to overcome such issues we can develop such type of system which will provide low cross polarization, and improved bandwidth. For this we can use defected ground structure based microstrip patch antenna with improved design that will provide better solution to this problem.

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