ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 9, September 2016

A Survey on Beam Steering Techniques in Planar Antennas

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ABSTRACT: Present era of 3G and 4G wireless communication networks ,compact sized low profiled antennas with planar structure , easily integrable and low fabrication cost antennas have become highly essential. The rapid increasing demands for high-data-rate wireless communication transceivers like smartphone handsets, internet modem, and tablet devices require high signal-to-noise ratio (S/N). Therefore, their antennas need to possess enhanced gain and steerable radiation patterns. In this context, the beam-steerable antennas have become highly popular in the modern trend of antenna propagation. Reconfigurable Antennas(beam steerable antennas) allow stronger signals for both transmission and reception from and to the desired directions. Beam steering technique reduces interference, saves power, increases gain and directivity of the microstrip antenna. In this paper we discuss the beam steering principle in antenna theory, advantages of the beam steerable antennas and comparison within various beam steering techniques.

KEYWORDS: Microstrip Antennas, Beam Steerable Antennas, Electromagnetic beam theory

I.INTRODUCTION

A transducer which is designed to transmit and receive electromagnetic waves along with the conversion of electric signal to electromagnetic waves and vice-versa is termed as antenna. Antenna plays a lead role in wireless communication system. Moreover, it also has the property of reversibility which means it can work both as transmitter and receiver. In Wireless communication a small antenna provides an unidirectional radiation pattern to work for short distances. Planar antennas have immensely gained popularity due to the the increasing demand for smaller and low profiled antennas nowadays. Design procedure of steerable antenna includes the investigation of microstrip antenna, electromagnetic beam theory, and the beam steering techniques. Pattern reconfigurable antennas or (beam steerable antennas) are essential for various applications in electronic and microwave engineering such as telecommunication and radar. They mitigate interference by channelling the antennas radiation to the direction of interest. Several techniques have been used to implement beam steering over the years, most of which achieves steering at the expense of antenna performance. Beam steering technique provides the ability to differentiate between the desired signals and interference signals (jammers)and supress them.

II.ELECTROMAGNETIC BEAM THEORY

The term beam forming refers to the process of combining signals from an array of elements to form a highly directional beam of radiation. It is also used to precisely align the phases of an incoming signal from different parts of an array to form a well-defined beam in a specific direction. This is achieved by implementing a time delay on each element's signal. It originated from spatial filters that were designed to form pencil beams (i.e., highly directional radiation patterns) to receive signals from a specific location and attenuate interference from other locations It has found numerous applications in Radar, Sonar, wireless communications, acoustics, and biomedicine. Adaptive beam forming is used to detect and estimate the signal-of-interest at the output of a sensor array by means of optimal (e.g., least-squares) spatial filtering and interference rejection.

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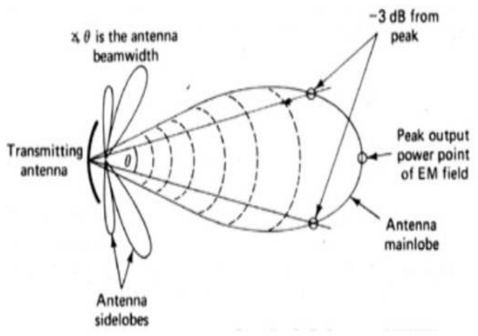

FIGURE.1 STRUCTURE OF ELECTROMAGNETIC BEAM

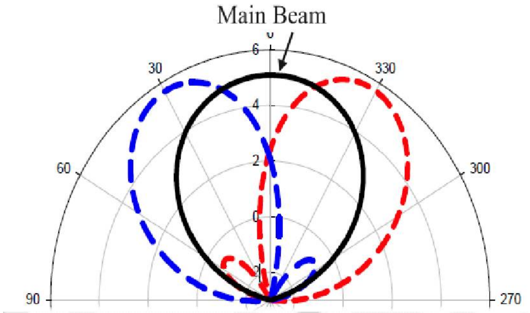

FIGURE.2 STEERED BEAM RADIATION ANTENNA PATTERN

III. LITERATURE SURVEY

The increasing requirement of smaller and low profile antenna in wireless communication has led to the popularity of microstrip patch antenna .This antenna has wide applications in military application and commercial area. Design of Geometry of Microstrip antenna can be of arbitrary nature. Beam steering technique involves the mechanism of changing the direction of main lobe of a radiation pattern of an antenna. Beam steering provides both constructive and destructive interference so as to steer the beams in desired direction. As per our investigation Beam steering antenna are used to steer It focuses the transmit power towards the desired direction.
We have investigated several methods for achieving beam steerability in a Planar antenna:

A.HIGHER REFRACTIVE SUPERSTRATES

A high Refractive superstrate is used above the radiator to patch to achieve the control on radiating wave .The directivity and gain of the MSA is manipulated by varying the superstrate parameter. Through full-wave simulations, the main beam of the antenna is shown to deflect in the plane along with the superstrate movement. When the superstrate is displaced along the E-plane, the main beam is tilted in the E-plane and no tilt in the H-plane is observed. If the superstrate is moved in both E- and H- planes, i.e., when only quarter of the antenna is covered with the superstrate, the beam is shown to deflect in both of the principle planes of the antenna. Higher angle of deflection / phase shift can be observed using high refractive index superstrate. In this study the main beam of the antenna is experimentally found to deflect at higher angles as the refractive index of the superstrate is increased. It presents a novel mechanism to control and manipulate gain and beam direction of microstrip antenna, mainly the radiated beam is deflected in E-plane and H- plane along with the position of the superstrate in $xy\ plane$.It was found that the main beam of the antenna is deflected in the direction of the part of the patch that is covered partially and also depends upon the refractive index of the superstrate is reduced to 33 degrees which indicates higher directivity.

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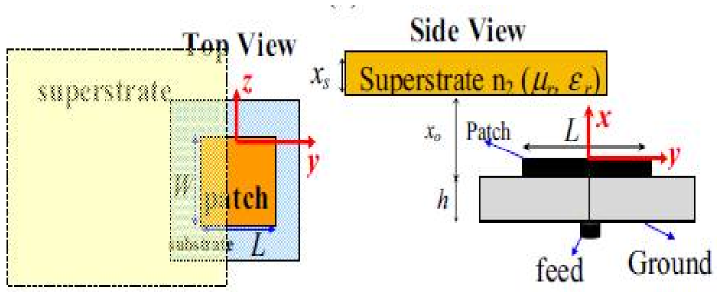
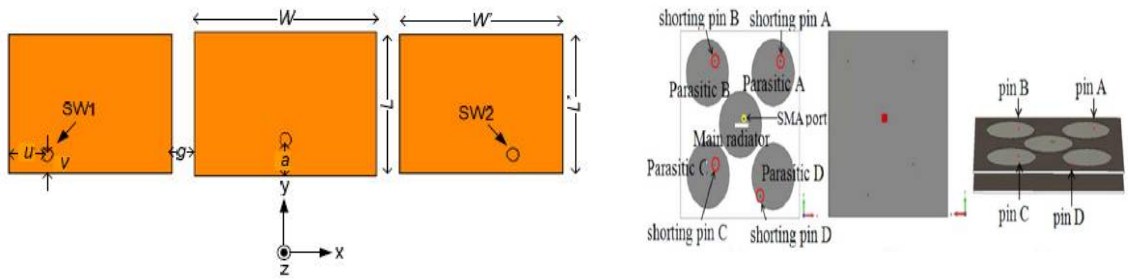


B. PARASITIC ARRAY

Beam titling is realized using parasitic element in the antenna structure that may be placed at the same layer or above to the radiator patch layer. Number of parasitic used varies from design to design, but the main thing is the parasitic elements are activated or deactivated using shorting pins referred as switch and in some design PIN diode is used as switch along with via. An antenna is capable in maintaining a minimum gain of 4 dBi from angle -53 degrees to angle +53 degrees and the parameters like the spacing between driven element and parasitic element and the length of the parasitic element influences the attainable tilt angle .



C. LEAKY WAVE ANTENNAS

A microstrip leaky-wave antenna (MLWA) is designed for fixed frequency beam steering. The main beam direction of this antenna is controlled by changing the periodic reactive loading of a microstrip line. This reactive loading is provided by a set of periodic patches closely coupled to the stubs in the microstrip line. These patches can be selectively connected to the ground using PIN diodes. Each periodic patch is connected to ground with via through a switch or PIN diode Controlling the switching states cause steering of the main beam at fixed frequency. The designed reconfigurable antenna can steer main from 40 degrees to 64 degrees at 6.2 GHz .

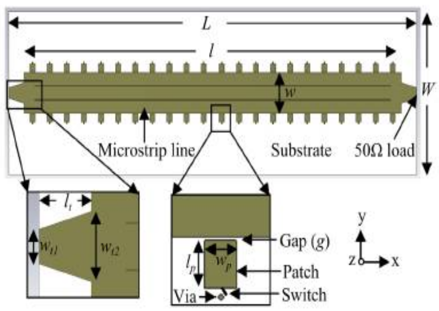


FIGURE.5 LEAKY WAVE PATCH ANTENNA STRUCTURE

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D. SWITCHING PIN DIODES

Beam steering in microstrip antenna can be realized using artificial switches in between the fed and the radiator patch. The steering angle or direction of the main is controlled by different states of the artificial switch.A single beam-steering broadband microstrip antenna. was designed, fabricated and measured. The proposed broadband antenna can perform beam steering by switching p-i-n diodes connecting stubs to a partial ground plane with operating frequency in between 2.8-4.8 GHz It is well suited for vital sign application for security and health care applications.

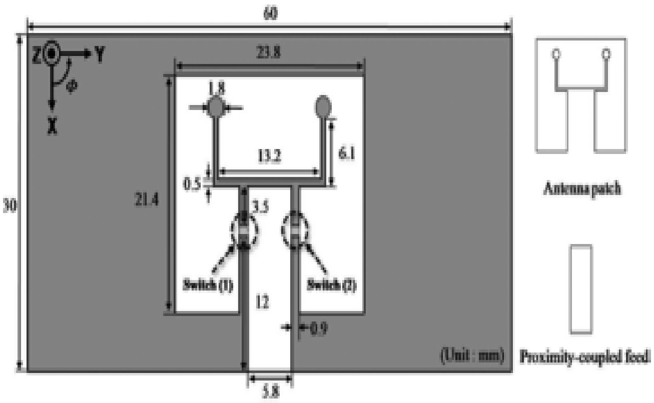

FIGURE.6 ANTENNA STRUCTURE USING SWITCHING PIN DIODES

E. PHASED ANTENNA ARRAYS

Beam steering realized using the array structure of the antenna element that may be 2×2, 4×4, 8×8 or more dimensions. The beam steering operation is performed by changing the phase of the feeding signal element used in the antenna structure. A Ka-Band slot coupled microstrip fed patch antenna and its application to 4×4 antenna array of microstrip antenna has been designed and tested This designed structure is able to give 15.6 dBi. And 23 % of impedance band width. A PET controlled Phase shifter is integrated to produce beam steering with maximum 30 degrees.

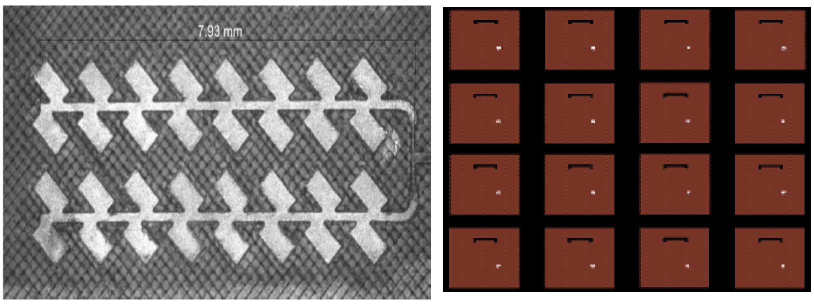

FIGURE.7 STRUCTURE OF PHASED ANTENNA ARRAY

F. PHASE SHIFTERS

Beam steering using phase shifter is another efficient technique for beam steering. The beam steering angle is depends upon the phase. delay. The phase delay is achieved using phase shifter network using switch, meanderline or any other methods. The required steering angle can be realized using switch, meanderline or any other methods The required steering angle can be realized by using specific phase delay offered by the phase shift network.

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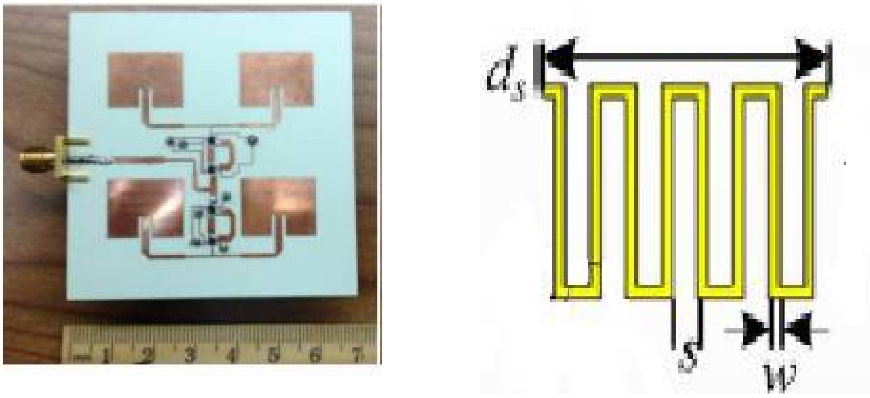
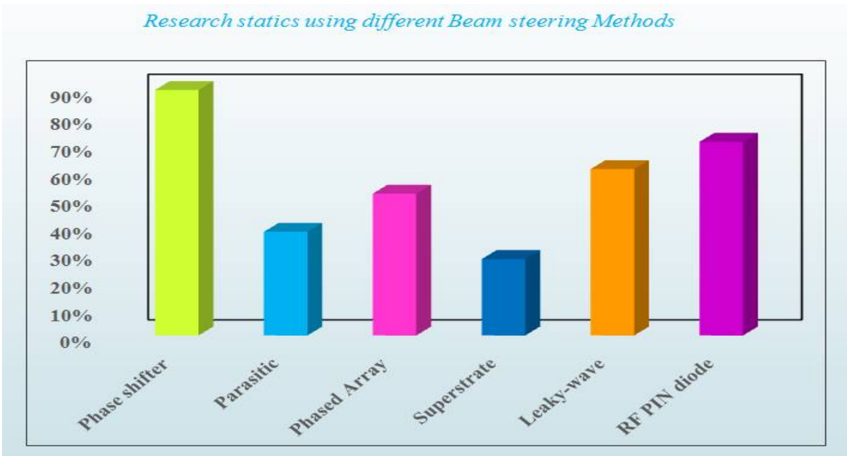


FIGURE.8 PHASED SHIFTER ANTENNA STRUCTURE

IV.SUMMARISED REPORT ON LITERATURE SURVEY



V.COMPARATIVE STUDY OF VARIOUS BEAM STEERING TECHNIQUE

Table 1. Comparison between various beam steering techniques in microstrip antenna based on the figure of merit

Sl no	Beam Steering Technique	Properties of techniques based on figure of merit
1	Higher refractive superstrate	Less complex, medium size, medium cost, high insertion loss.
2	Parasitic Array	Less complex, frequency dependent size , low cost, low insertion loss.
3	Leaky Wave Antenna	Less complex ,small size, low cost, no insertion loss.
4	Switching PIN Diodes	Medium complex, medium size, medium cost, medium insertion loss
5	Phased Antenna Array	Medium complex, medium size, medium cost, low insertion loss
6	Phase Shifters	Highly Complex ,large size, high cost, high insertion loss

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VI. CONCLUSION

This paper intends to provide a brief discussion on the numerous techniques that have been incorporated in the past, that provides a platform for attaining the principle of beam steerability in Planar antennas. It provides a clear cut idea on the variety of beam steerability phenomenon employed in microstrip antennas and are compared based on the figure of merit. Research in beam steerable antennas is generating lots of interest as efforts are being made to develop an optimum beam steering solution at millimetre wave frequency band for both point-to-point nand point-to-multipoint applications in Microwave and wireless Communication.

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