Performance Comparisons of Four Different Shaped Log Periodic Microstrip Antenna Arrays

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Abstract— This paper presents performance comparisons of four different structures of log periodic structures of microstrip antenna. Bandwidth enhancement techniques for microstrip patch antenna in the application for military band short range radio communication system at frequency range of 1.49GHz to 1.95GHz. In the military aviation platform, the requirements of antenna are light weight, low volume, low profile with wide bandwidth .hence in this paper, two structures of H shaped and Bow-tie is analyzed & simulated using HFSS software tool and the performance is compared with conventional rectangular patch antenna.

Key words: Micro Strip Patch Antenna, Impedance Bandwidth, HFSS Bowtie Antenna

I. INTRODUCTION

Reconfigurable antennas [1] are becoming more widely used due to the increasing number of wireless communications and new functionalities of these systems than the passive antennas as they can provide diversity functions in operating frequency [2]-[4], polarization [5], and radiation pattern by altering the current flow on an antenna, using mechanically movable parts, phase shifters, attenuators, diodes, tunable materials, or active materials. Moreover, multiple antennas supporting different wireless bands are not a suitable solution, because of the higher demand of compact size, efficiency, low power consumption and low cost. There has been a dramatic increase in the awareness of reconfigurable antenna for applications in future wireless communications such as cognitive radio, ground pentrating radar applications and RFID applications.

Frequency reconfigurable antennas are useful to support many wireless applications, where they can reduce the size of the front end circuitry and also allow some additional receiver pre-filtering. The reconfiguration can be implemented through the PIN diode switches [6], MEMS [7] or varactor diodes. However, electronic tunability using PIN diode is more frequently used because of its efficiency and reliability especially in dynamic bandwidth allocation.

In [8], a novel both pattern and frequency reconfigurable annular slot antenna is presented. The antenna has three different frequencies by controlling the matching stubs, which are fabricated on the opposite side of the board. And it also has a reconfigurable radiation pattern, which is controlled by the dc voltage of the PIN diodes on the slot. In [9], a low-cost multiband printed-circuit board (PCB) antenna that employs Koch fractal geometry and it has tunability over the bands of several applications including 3G, Wi-Fi, Wi-MAX as well as a portion of the UWB range. In this paper, four different shaped microstrip logperiodic antennas with the feature of recon-figurability [10] were designed to meet the requirements in terms of the return loss, gain, and directivity. The proposed antennas are designed from the combination of three elements by using the logperiodic technique with the scaling factor of 1.05. As each element radiates at different frequency bands, the logperiodic antennas are easy to select required band from wideband. The commercial zealand's IE3D software is used to carry out the simulation for the reconfigurable log periodic antenna. The antenna is analyzed based on several parameters such as return loss, radiation pattern, gain, directivity and bandwidth.

II. ANTENNA DESIGN AND SIMULATED RESULTS

A. Square Shaped Logperiodic Antenna

The geometrical structures of the three element logperiodic microstrip antennas are as shown in figure 1. The concept of frequency reconfigurability is investigated based on changing the position of the switches to ON or OFF. These antennas can perform in frequency range from 2.9 GHz until 3.4GHz with two different sub bands. There are different shaped patches with inset fed lines, which are connected with a log-periodic array formation to a 50 Ω microstrip transmission line on a top layer of substrate. The antenna structures are developed on a FR-4 substrate which has relative permittivity of 4.5, with a thickness of 1.6 mm and loss tangent of 0.019. The log periodic microstrip antenna [11] is a more conventional approach for the implementation of a broadband antenna. The basis of this design is the linear array of coplanar patch antennas with the size and spacing of the patches increasing in a log periodic manner. The design principle for log-periodic wideband microstrip antenna requires scaling of dimensions from period to period so that the performance is periodic with the logarithm of frequency. The patch length(L), width(W), side length(S) and diameter(d) are related to the scaling factor (τ) by equation as shown below.

The first patch (lower frequency) is designed with resonant frequency at 3GHz and it is scaled by a factor of 1.05 to obtain the second patch dimensions. Second patch diameter is once again scaled by a factor of 1.05 to obtain the third patch dimensions. The space between each patch (Dm) is a half wavelength apart thus giving a forward fire radiation pattern and reducing mutual coupling effect. The reconfigurabilty is achieved when the RF PIN diodes are integrated with the feeding line to act as a switch and to control the ON/OFF mode. For the purpose of simulation, the switch in RF systems is represented by a open and short of the transmission line[3], [12]. Therefore, metal stripes 3mm x 1mm have been used to represent the PIN diode and located at the transmission line. The wideband operation is achieved when all switches are in ON state. By controlling the switch at the transmission line of patch, the required frequency band could be achieved. For this design, two sub-band are achieved by controlling a group of switches as in table 2. The band one operation is achieved by switching ON the first two diodes while the third is OFF state. While second band operation is attained when first pindiode is in OFF state while the remaining two PIN diodes are in ON state. In simulation process, the ohmic losses are assumed to be zero by using the ideal substrate and perfect electric conductor of patch. Hence, the ON state is representing by that metal stripe and the absence of the metal stripe is representing the OFF state.

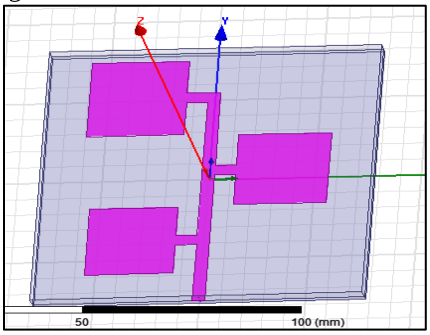

Fig. 4: Geometry of Square Shaped Log periodic antenna

Simulation results obtained by conventional Rectangular patch are given in Figure 5. It is observed that conventional rectangular patch antenna having -10dB return loss from 1.88GHz to 2.04GHz and resonant at 1.94 GHz frequency. Calculated Impedance Bandwidth is 8.23%.

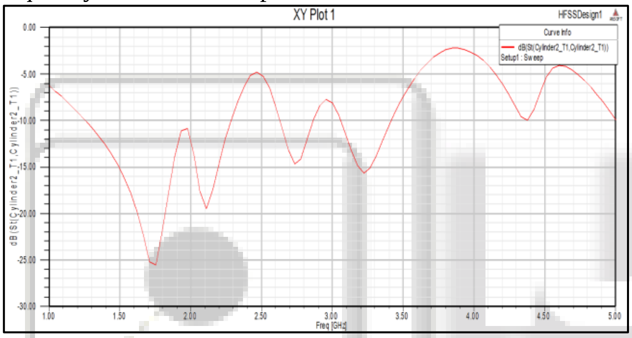

Fig. 5: Return loss versus frequency plot

Return loss is logarithmic ratio measured in dB that compares the power reflected by the antenna to power that is fed into antenna.

B. Rectangular Shaped Logperiodic Antenna

For increasing the bandwidth, two rectangular slots of 4.3 * 19.2 square mm are cut in the conventional patch. Figure 6 shows the geometry of H shaped patch antenna.

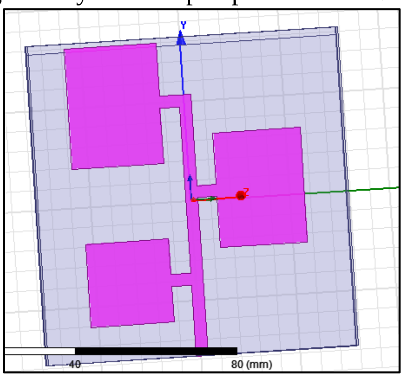

Fig. 6: Geometry of Rectangular Shaped Log periodic antenna

The simulated return loss versus frequency plot is shown in figure7. It is observed that resonant frequency is decreased and bandwidth is increased. The antenna is tuned from 1.47 to 1.88GHz having 26.13% bandwidth at 1.5688 GHz resonant frequency.

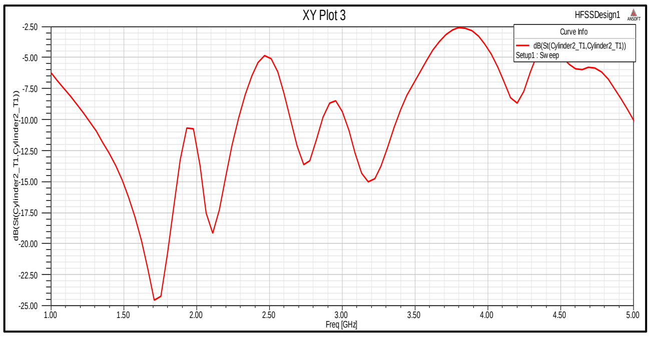

Fig. 7: Return Loss versus Frequency Plot

C. Triangular Shaped Logperiodic Antenna

For enhancing the bandwidth and reducing the size, two triangular slots are cut in the conventional patch. Figure 8 shows the geometry of Bow-tie patch antenna.

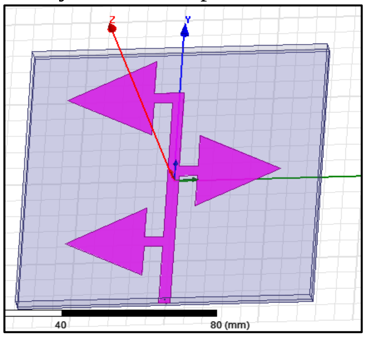

Fig. 8: Geometry of Triangular Shaped Log periodic antenna

In the return loss versus frequency plot, which is shown in figure 9, it is observed that antenna is tuned from 1.49GHz to 1.95GHz and resonated at 1.6GHz frequency. The calculated impedance bandwidth is 28.75% which is greater than conventional patch and rectangular patch.

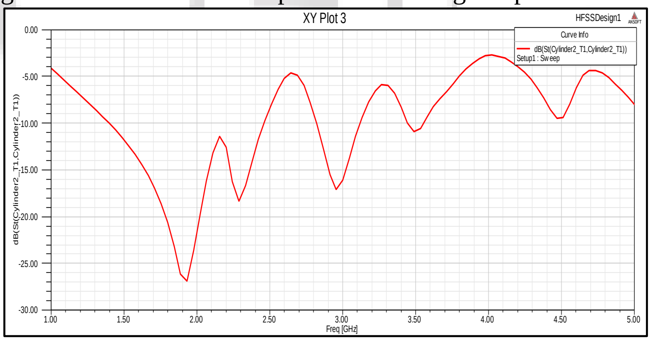

Fig. 9: Return loss versus frequency plot

D. Circular Shaped Logperiodic Antenna

For enhancing the bandwidth and reducing the size, two triangular slots are cut in the conventional patch. Figure 8 shows the geometry of Bow-tie patch antenna.

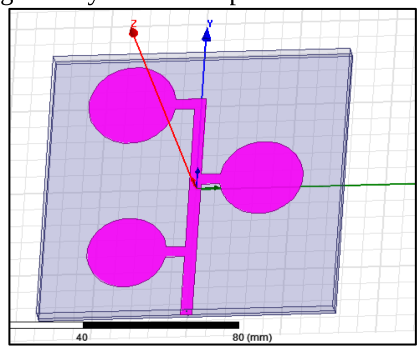

Fig. 10: Geometry of Circular Shaped Log periodic antenna

In the return loss versus frequency plot, which is shown in figure11, it is observed that antenna is tuned from 1.49 GHz to 1.95GHz and resonated at 1.6 GHz frequency. The calculated impedance bandwidth is 28.75% which is greater than conventional patch and rectangular patch.

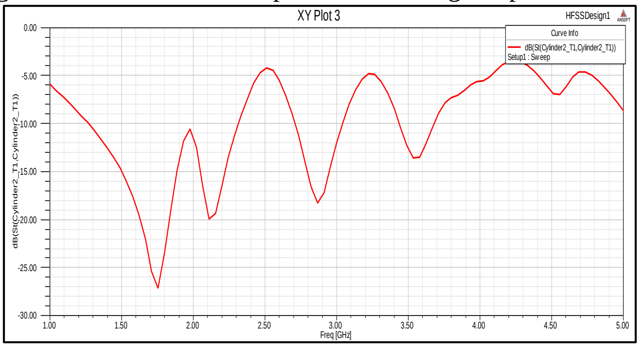

Fig. 11: Return loss versus frequency plot

E. Comparative Analysis of Bandwidth

Bandwidth is one of the important antenna performance parameter. It is observed that Bow-tie Antenna has impedance bandwidth 28.75% which is greater than other arrangements.

Comparative results are more clearly shown by table 1.

Arrangement	Bandwidth (%)	Resonant freq.(GHz)	Return loss (dB)
Square Shaped Logperiodic Antenna	60	1.75	-25.5
	10.90	2.75	-15
	10.93	3.25	-15.7
Rectangular Shaped Log periodic antenna	61.76	1.7	-24
	9.25	2.7	-13
	12.5	3.2	-15
Triangular Shaped Log periodic antenna	56.31	1.9	-27
	10.23	2.93	-17
Circular Shaped Log periodic antenna	68.57	1.75	-27
	12.22	2.85	-18
	8.4	3.55	-14

Table 1: Comparison results of return loss parameter

The Graph shown in figure 12 represents that Bow-tie Antenna having greater bandwidth and compact size than H shaped and conventional rectangular patch antenna.

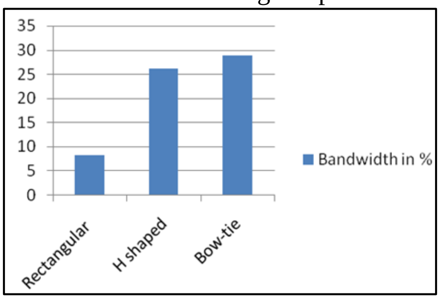

Fig. 12: Bandwidth Comparison chart

III. Conclusion

A comparative study of different shaped log-periodic microstrip antenna arrays using rectangular, square, circular and triangular electromagnetically coupled patch elements was accomplished in this paper. After the done study, was verified that the lower cut off frequency of the antenna arrays depended on the choice of the patch geometries. Thereafter, in terms of –10 dB return loss bandwidth, the circular patch presented the best performance, followed by the square, rectangle and triangle patch shapes, respectively. In terms of the gain, the rectangular patch has more gain followed by circular, square and triangle. In terms of directivity, the circular patch presents the best performance followed by square, triangle and rectangle. However, it was also verified that any of these patch geometries can be used for the design of wideband log-periodic microstrip antennas and it has been demonstrated that the required frequency band could be achieved by choosing various switching combinations.

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