Microstrip Patch Yagi-Uda Array for Millimeter Wave Applications

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Abstract— This paper presents a novel design of microstrip Yagi-Uda array. This proposed design has been simulated at frequency of 6.95 GHz. CST MW Studio software is used for Simulation of Yagi Uda array. Unlike conventional design of Yagi Uda array, In this design reflector, director and driven element of Yagi Uda array is designed by using microstrip patches of different dimensions with supporting dielectric FR-4 lossy at height 1.6mm and loss tangent of 0.02. It achieves very high gain and effective radiation efficiency. Moreover Return loss of antenna is very less. This Yagi-Uda antenna shows very good compatibility with microwave circuitry.

Keywords: Microstrip Yagi-Uda antenna, Dielectric constant, Return loss, Back lobe radiations.

Introduction

THE increasing growth of the wireless communications industry and sensor systems demand for low cost, compact size antennas that can be printed on a substrate. Printed antennas offers many advantages over standard antennas, such as low manufacturing costs, low profile, ease of integration with monolithic microwave integrated circuits (MMICs) and the ability to be mounted on planar, non planar and rigid exteriors.

The Yagi-Uda antenna gained its name from the research work done by two scientists Yagi and Uda. Yagi developed the proof of concept while Uda provided contribution in designing principle[1]. Right from the day of their discovery Yagi-Uda antenna have gone through tiring out investigations in the literature. The Yagi-Uda antenna is general term for Yagi-Uda array. It is a directional antenna having two kinds of elements one is driven element which is a dipole and other is parasitic elements like reflector and directors[2]. The so called reflector element has longer length approximately five percent longer than the driven dipole and directors have shorter length. Such type of designing improves antenna's directionality and gain[3]. Being highly directional with good gain these antennas are also referred as beam antennas. But this high gain of the Yagi-Uda antenna is only limited over a narrow bandwidth providing its usefulness for various communications bands inclusive of amateur radio. The Yagi-Uda antenna operates forming its basis on electromagnetic interaction between the parasitic elements and the one driven element[4][5]. Due to simplicity of its type along with its features has made it an appropriate alternative for both unprofessional and professional antenna applications[6].

Usually Yagi-Uda arrays have low input impedance and relatively narrow bandwidth. Modern well-designed Yagi achieve greater bandwidth, on the order of 5% to more than 15% [7]. This antenna has found applications from short waves to microwave frequencies for a quarter of a century. It also being widely used in radar and communication systems as it possess wide bandwidth, low cross-polarization and good isolation as compared to patch antennas. Also, Yagi-Uda antenna finds their use in industrial and medical applications.

Designing of Antenna structure

In designing of microstrip Yagi-Uda antenna, no simple formulas are employed due to the complexity in relationship between physical parameters like element length, spacing and diameter, and performance characteristics like as gain and input impedance.

Schematic diagram of proposed designed is presented in the figure1. In Proposed antenna two directors are used to increase directivity in particular direction. Each director in the proposed antenna having different dimensions also spacing between the directors are not equal. Ground plane of the proposed antenna is used as the reflector [8]. Rectangular reflector is used to designing the ground plane. By varying Height and width of the reflector we can also change the antenna gain and directivity. Feeding is provided at the patch designed in between of reflector and director. Driven element, reflector and directors are microstrip patches of certain dimensions at some distance[9]. This design of Yagi Uda is combination of patch antenna and Yagi Uda array to enhance the antenna parameters.

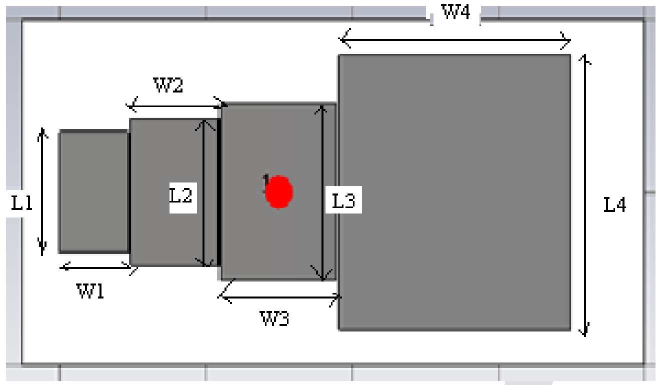

Fig.1 Front view of the antenna

Antenna Dimensions (millimeter):L=85,W=40, L_1=9.5,W_1=14,L2=12.6,W2=17,L3=15.6,W3=20.45,L4=,W4=31.8.

Results

The proposed antenna was simulated by using CST simulation software.

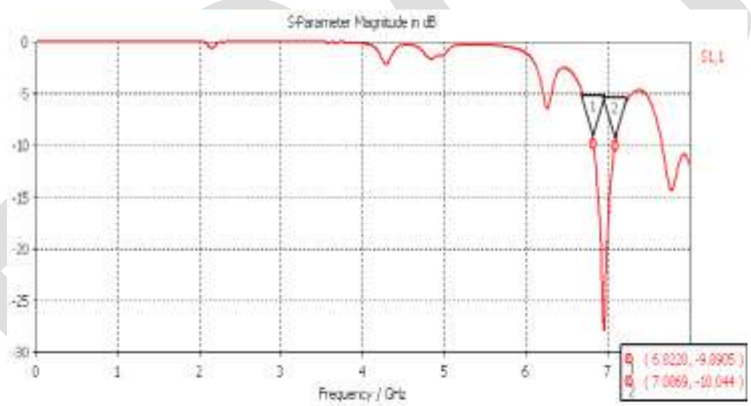

Fig.2 Return Loss of Designed Antenna

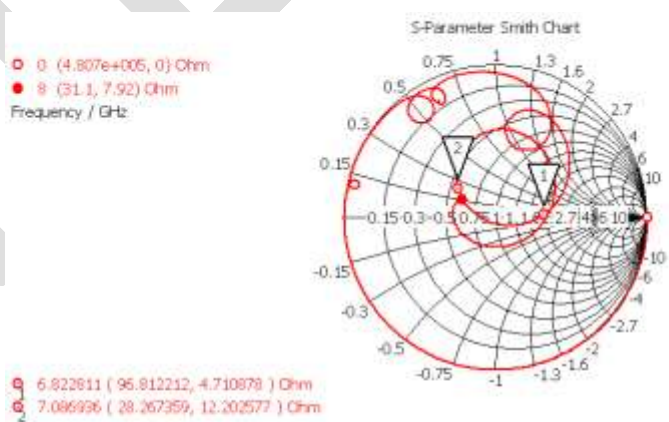

Fig.3 Smith Chart of Proposed Antenna

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Figure 2 shows the simulated return loss of proposed antenna .at resonant frequency of 6.95 GHz it achieves 29dB return loss.

Figure 3 shows the smith chart of proposed antenna at 6.95GHz frequency.

Figure 4 shows directivity of proposed antenna at resonant frequency of 6.95 GHz it achieves 7.66dBi directivity.

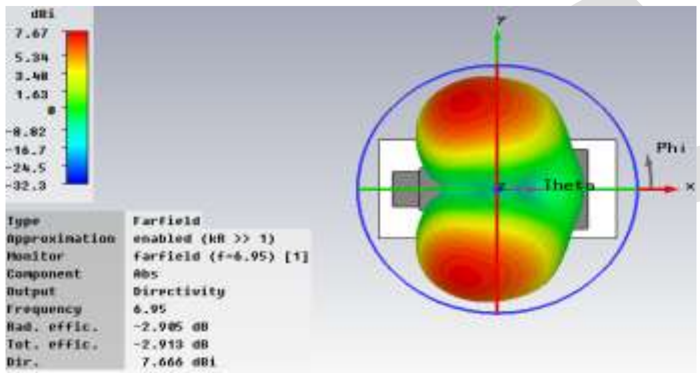

Fig.4 Directivity of Proposed Antenna

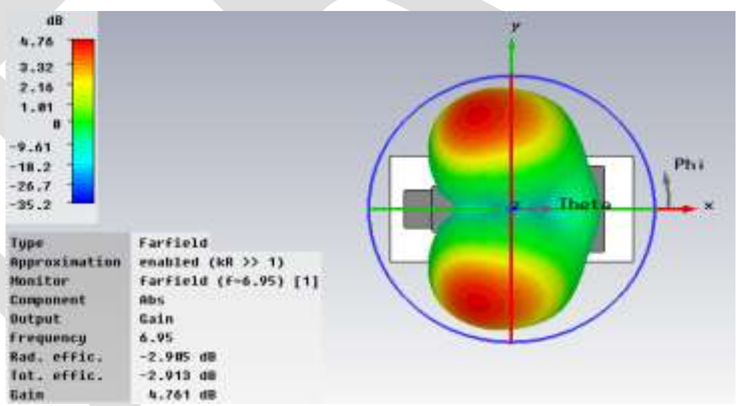

Fig.5 Gain of Proposed Antenna

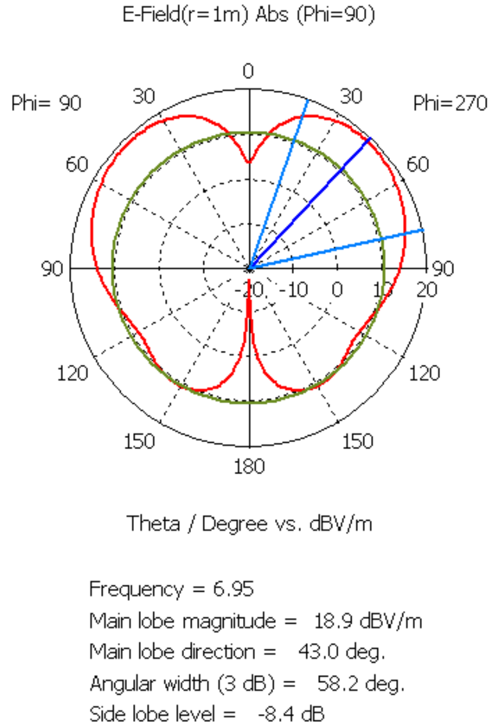

Fig.6 E-Field radiation pattern of Proposed Antenna

Figure 5 shows gain of proposed antenna at resonant frequency of 6.95 GHz it achieves 4.766dB gain.

Figure 6 shows the E-field radiation pattern of proposed antenna. It is clear that back lobe radiations are very less.

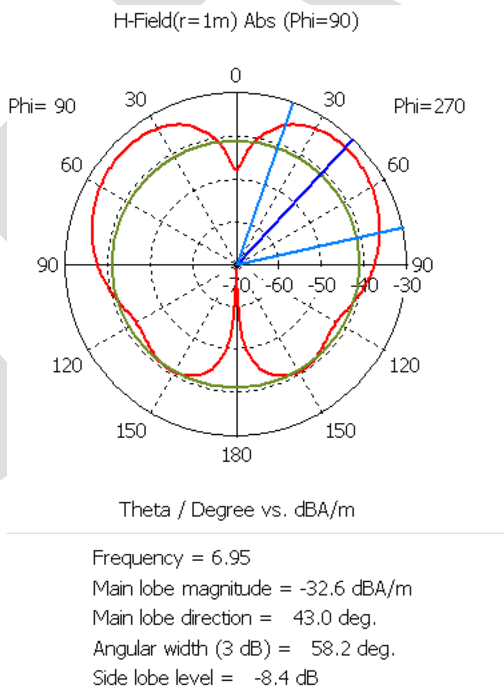

Fig.7 H-Field radiation pattern of Proposed Antenna

Figure 7 shows the H-field radiation pattern of proposed antenna which shows back lobe radiation of -8.4dB which is very less.

Table 1.1 enlists all the measuring parameters of proposed design.

Table 1.1: Analyzed Parameters

Parameters	Simulated value
Frequency (GHz)	6.95
Return loss (dBi)	29
Gain (dBi)	4.6
Directivity (dBi)	7.3
Radiation efficiency (%)	96
Bandwidth	25MHz

Conclusion

Proposed antenna achieves high gain and high directivity at resonant frequency. Radiation efficiency of this antenna is quite good. Small size and compactness of this antenna makes it very useful at particular band of frequency. These antennas are often empirical designs using an element of trial and error, often starting with an existing design modified according to one's hunch. The result can be checked by direct measurement or by computer simulation.

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