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DESIGN AND SIMULATION OF CYLINDRICAL AND SHEET CORNER REFLECTOR YAGI UDA ANTENNAS FOR AMATEUR RADIO APPLICATION

Akella Jharesh, K. Ch. Sri Kavya and Sarat K. Kotamraju
Department of Electronics and Communication Engineering, K L University (Koneru Lakshmaiah Education Foundation), AP, India
E-Mail: kavya@kluniversity.in

ABSTRACT

Yagi-Uda antenna is the most familiar high-gain antenna in HF, VHF and UHF bands. It is popularly used by radio amateurs due to its less manufacturing cost and simplicity in construction. In this paper, an additional corner reflector is added to the conventional structure in order to improve the gain and return loss of the antenna. Two types of corner reflectors, namely Cylindrical and Sheet reflectors are proposed and designed using HFSS software. The effects of reflector spacing and corner angle are analyzed at 1 GHz and the results are tabulated. A corner reflector and sheet reflector Yagi-Uda antennas are designed at a VHF frequency of 436MHz and results are presented. These antennas are proven to be more suitable in the environmental conditions in the southern parts of India.

Keywords: corner reflector, yagi-uda antenna.

INTRODUCTION

YAGI-UDA antennas have been widely used for VHF/UHF applications ever since they were introduced by Dr. H. Yagi and Shintaro Uda in 1926 [1]. It is one of the most used antennas by radio amateurs throughout the world. This is due to the fact that it is cheap, can be easily manufactured and exhibits a low wind loading [2].

The antenna consists of an array of parasitic elements that include a driven element, a reflector element and one or more director elements [3]. The driven element is usually a folded dipole with coaxial feed at the center [4], [5]. In order to achieve the end-fire beam, the length of reflector is generally 5% more than that of driven element. The directors are designed such that their lengths are about 5% less than the length of driven element. The directors exhibit capacitive impedance whereas the reflectors show inductive impedance [6], [7]. These parasitic elements enhance radiation in one particular direction when properly arranged on a supporting structure. The characteristics of the antenna are governed by the currents induced in the parasitic elements due to the fields produced by the driven element [8]. The gain function is known to be highly multimodal and sensitive to the choice of the physical dimensions of the antenna elements and their spacing [9].

DESIGN PROCEDURE

The basic YagiUda antenna is designed as per the design specifications mentioned in Table-1. In order to study the effects of addition of corner reflector, both the cylindrical and sheet corner reflector Yagi antennas are designed at 1GHz frequency. These antennas are simulated under various conditions such as varying the corner angle of the corner reflector, varying distance between reflector and corner reflector and by varying the sheet thickness for sheet corner reflectors. The readings of Gain Return loss, Directivity, LHCP and RHCP are tabulated.

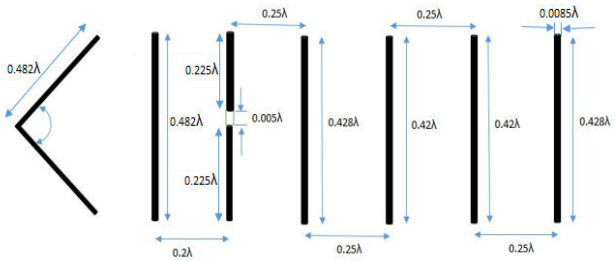


Figure-1. Corner reflector YagiUda design [10].

Table-1. Design specifications of YagiUda antenna.

Specification	Value
Length of Reflector	0.482λ
Length of Driven element	0.45λ
Width of feed element	0.005λ
Length of Director 1	0.428λ
Length of Director 2	0.42λ
Length of Director 3	0.42λ
Length of Director 4	0.428λ
Spacing b/n reflector and driven element	0.2λ
Spacing b/n driven element and director 1	0.25λ
Spacing b/n successive directors	0.25λ
Diameter of elements	0.0085λ

OBSERVATIONS

(i) Cylindrical corner reflector

Table-2. Comparison of cylindrical corner reflector Yagi Uda antenna parameters for different corner angles.

Angle	Gain (dB)	LHCP	RHCP	Return loss (-dB)	Directivity
90	11.019	8.0132	8.0045	14.3111	12.83
105	11.065	8.0582	8.0513	12.6704	13.021
112.5	11.05	8.0428	8.0366	12.4877	12.98
120	11.034	8.0219	8.0265	12.3750	12.955
127.5	11.089	8.0908	8.0673	12.1779	13.065
131.25	11.076	8.0661	8.0644	12.1406	13.074
132.187	11.064	8.0543	8.0541	12.2064	13.032
133.125	11.093	8.0893	8.0763	12.1542	13.077
135	11.046	8.0324	8.0399	12.6395	12.979
150	11.084	8.0782	8.0692	12.1333	13.091

Table-3. Comparison of cylindrical corner reflector Yagi Uda antenna parameters by varying distance from the reflector.

Distance in λ	Gain (dB)	LHCP	RHCP	Return loss (-dB)	Directivity
0.133	10.805	7.7969	7.7929	15.5375	12.227
0.166	10.971	7.9588	7.9635	13.1896	12.751
0.2	11.067	8.0595	8.0548	12.526	12.990
0.233	11.009	7.999	7.9982	12.2351	12.895
0.266	11.058	8.0478	8.0478	12.1348	13.002
0.33	11.101	8.0938	8.0883	12.1300	13.136
0.4	11.097	8.0846	8.0884	12.1495	13.131

(ii) Sheet corner reflector

Table-4. Comparison of sheet corner reflector YagiUda antenna parameters by varying distance from the reflector.

Distance in λ	Gain (dB)	LHCP	RHCP	Return loss (-dB)	Directivity
0.066	12.568	9.5585	9.5576	14.8262	18.029
0.133	12.470	9.4630	9.4554	11.0435	17.685
0.2	12.476	9.4750	9.4554	10.5803	17.729
0.266	12.59	9.5897	9.5705	10.9457	18.113
0.33	12.548	9.5380	9.5371	10.8537	18.02
0.4	12.503	9.5087	9.4767	11.2857	17.806

Table-5. Comparison of sheet corner reflector Yagi Uda antenna parameters by varying the sheet corner angle.

Angle	Gain (dB)	LHCP	RHCP	Return loss (-dB)	Directivity
90	12.491	9.4543	9.5065	11.4340	17.726
110	12.528	9.4993	9.5366	11.4180	17.91
120	12.47	9.4693	9.4498	11.4131	17.663
140	12.508	9.4971	9.4990	11.3740	17.809
150	12.485	9.4616	9.4868	11.4028	17.764
160	12.534	9.5334	9.5148	11.4162	17.935
165	12.522	9.5021	9.5216	11.3741	17.897

Table-6. Comparison of sheet corner reflector Yagi antenna parameters by varying sheet width.

Sheet width (in λ)	Gain (dB)	LHCP	RHCP	Return loss (-dB)	Directivity
0.0085	12.47	9.4614	9.4578	11.3969	17.675
0.0167	12.515	9.4947	9.5005	11.3497	17.856
0.033	12.544	9.5345	9.5332	11.3943	17.933
0.066	12.521	9.5057	9.5162	11.4081	17.863
0.133	12.478	9.4602	9.4752	11.4193	17.669
0.266	12.467	9.4598	9.4542	11.4372	17.683
0.533	12.475	9.4517	9.4782	11.4180	17.690

After analyzing the results obtained, these two types of YagiUda antennas are redesigned at a center frequency of 436 MHz. The frequency is chosen to facilitate the use of antennas in 434MHz-438MHz UHF band for amateur radio operators. [11]

RESULTS FOR CYLINDRICAL CORNER REFLECTOR YAGI ANTENNA

A Cylindrical Corner reflector Yagi Uda Antenna as shown in Figure-2, at a frequency of 436MHz is designed and simulated. Gain, LHCP and RHCP and the return loss are plotted and are shown in Figure-3, Figure-4, Figure-5 and Figure-6 respectively.

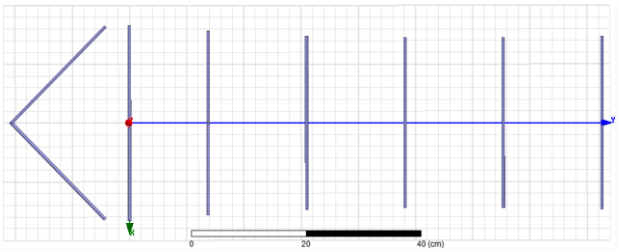


Figure-2. Cylindrical corner reflector Yagi Antenna for 436 MHz.

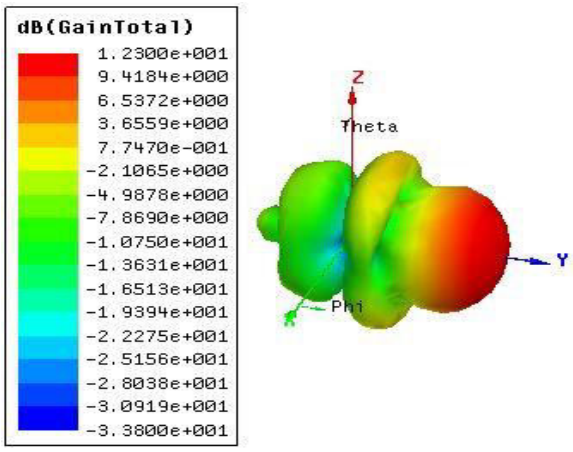


Figure-3. Gain of cylindrical corner reflector Yagi antenna for 436 MHz.

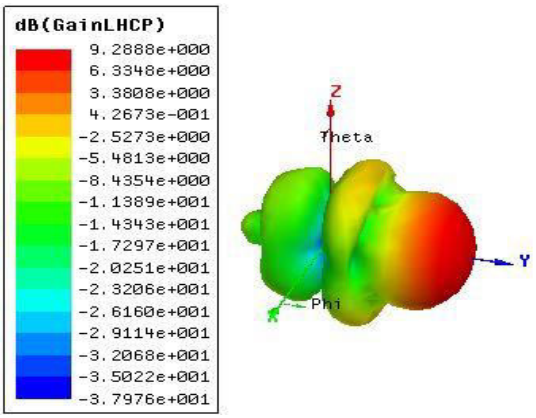


Figure-4. LHCP of cylindrical corner reflector Yagi antenna for 436 MHz.

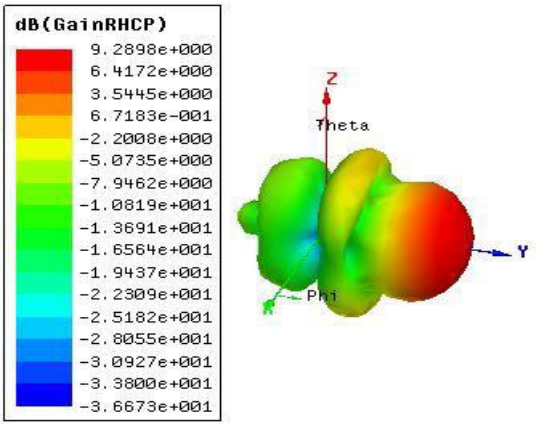


Figure-5. RHCP of cylindrical corner reflector Yagi antenna for 436 MHz.

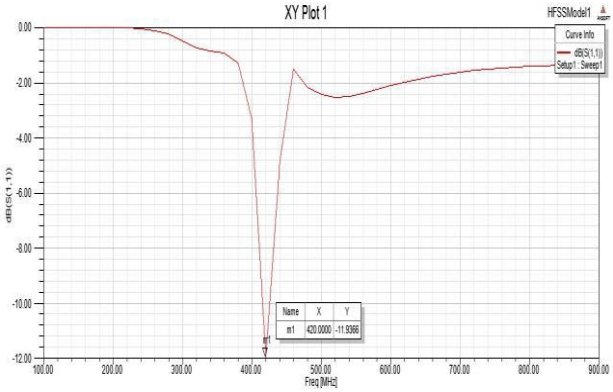


Figure-6. Return loss of cylindrical corner reflector Yagi antenna for 436 MHz.

The directivity, E-Fied, H-Field and current distributions of the Cylindrical Corner reflector Yagi Uda Antenna is shown in Figure-7, Figure-8, Figure-9 and Figure-10 respectively.

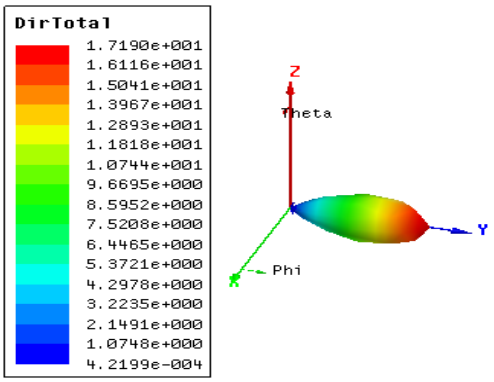


Figure-7. Directivityof cylindrical corner reflector Yagi antenna for 436 MHz.

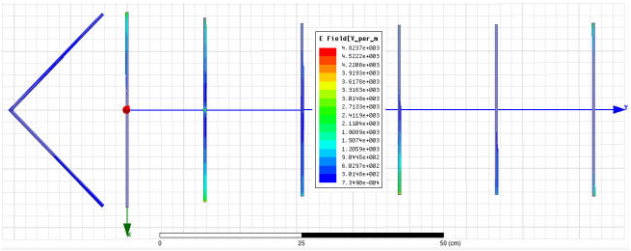


Figure-8. E-field distribution of cylindrical corner reflector Yagi antenna for 436 MHz.

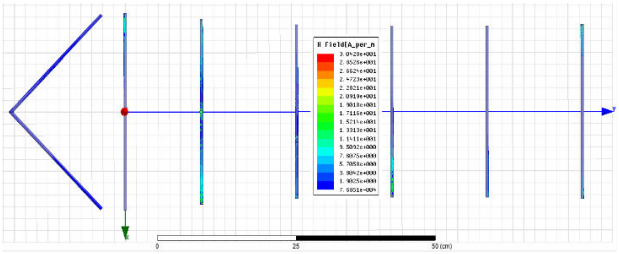


Figure-9. H-field distribution of cylindrical corner reflector Yagi antenna for 436 MHz.

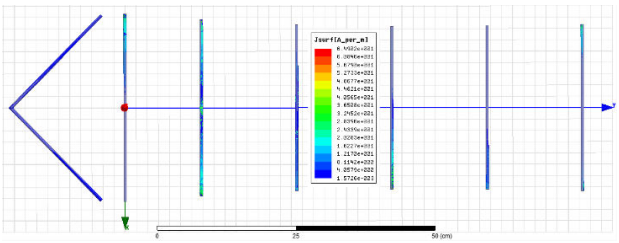


Figure-10. Current distribution of cylindrical corner reflector Yagi antenna for 436 MHz.

RESULTS FOR SHEET CORNER REFLECTOR YAGI ANTENNA

A sheet Corner reflector Yagi Uda Antenna as shown in Figure-11, at same frequency of 436MHz is designed and simulated. Gain, LHCP and RHCP and the return loss are plotted and are shown in Figure-12, Figure-13, Figure-14 and Figure-15, respectively.

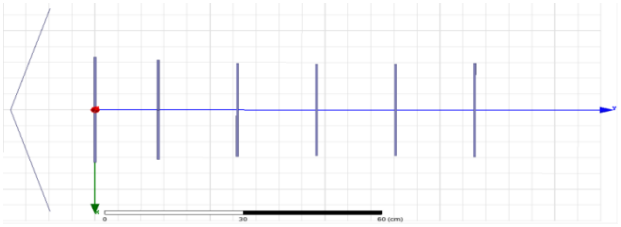


Figure-11. Design of sheet corner Reflector Yagi Antenna for 436 MHz.

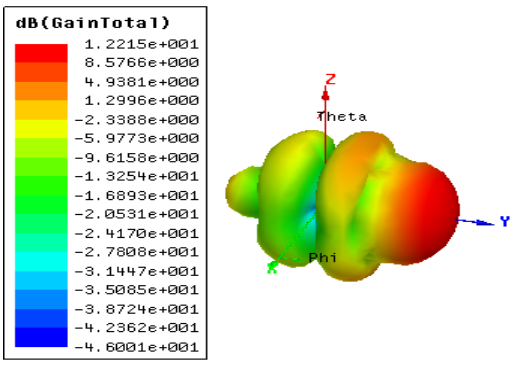


Figure-12. Gain of sheet corner reflector Yagi antenna for 436 MHz.

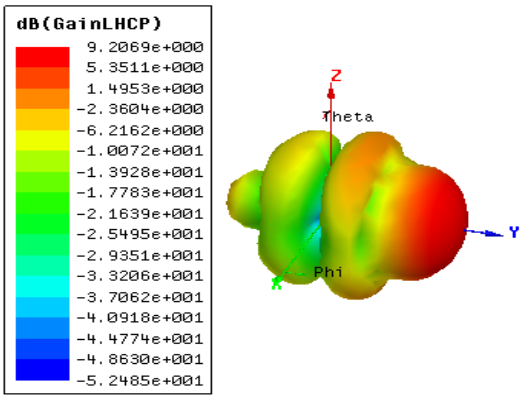


Figure-13. LHCP of sheet corner reflector Yagi antenna for 436 MHz.

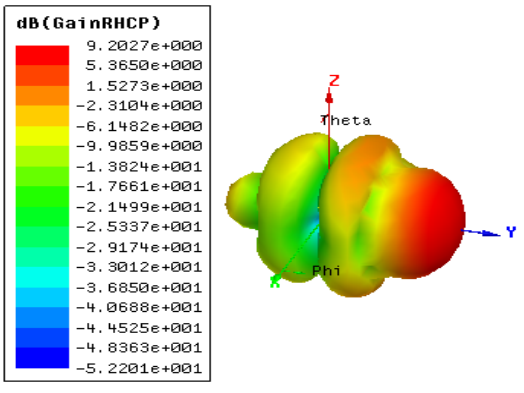


Figure-14. RHCP of Sheet corner reflector Yagi antenna for 436 MHz.

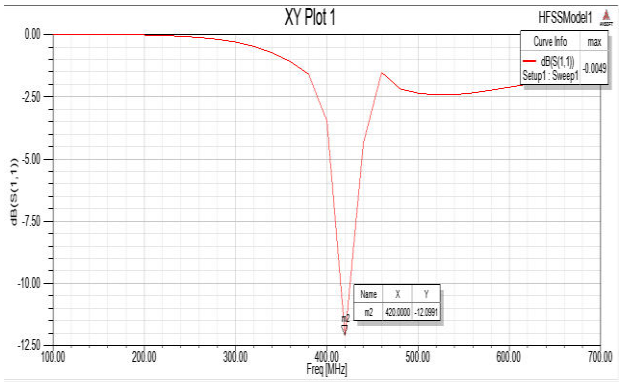
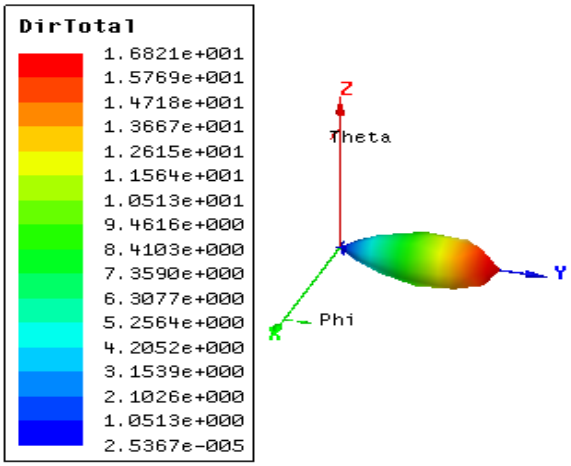


Figure-15. Return loss for sheet corner reflector Yagi antenna for 436 MHz.

The directivity, E-Fied, H-Field and current distributions of the Cylindrical Corner reflector Yagi Uda Antenna is shown in Figure-16, Figure-17, Figure-18 and Figure-19, respectively.



Fgure-16. Directivity for sheet corner reflector Yagi antenna for 436 MHz.

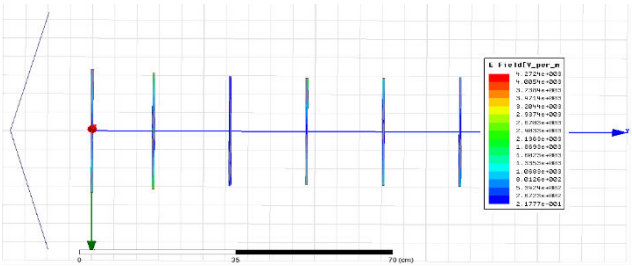


Figure-17. E-field distribution for Sheet corner reflector Yagi antenna for 436 MHz.

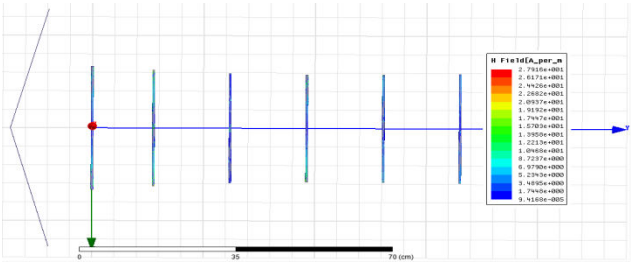


Figure-18. H-field distribution for sheet corner reflector Yagi antenna for 436 MHz.

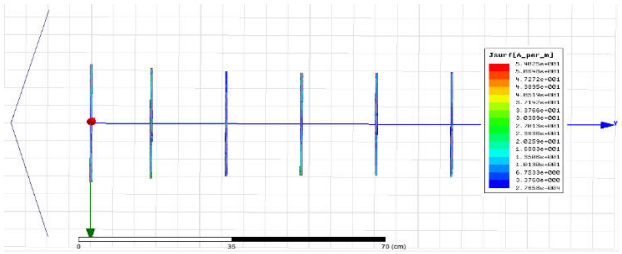


Figure-19. Current distribution for sheet corner reflector Yagi antenna for 436 MHz.

Observations

The variation of angle in a cylindrical corner reflector Yagi antenna doesn't have much effect on the antenna gain, whereas the return loss is comparatively low when the corner angle is 90^0. While varying the distance between reflector and corner reflector, the maximum gain of 11.101 dB is obtained when the reflectors are separated by a distance of 0.33λ. In case of sheet corner reflector, when the sheet reflector is placed at a distance of 0.266λ from the conventional reflector, it gives a maximum gain of 12.59 dB. Of the entire sheet corner angles simulated, the maximum Gain of 12.534 is observed at 160^0. Upon varying the Sheet width, the gain is maximum at a width of 0.033λ.

CONCLUSIONS

From the results obtained and based on the conclusions drawn, it is evident that addition of a corner reflector to the existing YagiUda antenna would lead to change in its characteristics. From Table-2 and Table-3, it can be inferred that the antenna parameters like Gain, LHCP, RHCP, and Directivity and return loss exhibit non-linear behavior when the distance between reflectors and corner angle are varied. It is also observed that there exist gain-return loss tradeoffrelation. When the gain is relatively higher, the corresponding return loss is comparatively low. In case of cylindrical corner reflector Yagi antenna, maximum gain can be obtained when the corner angle is 133.125^0 and the distance between conventional reflector and corner reflector is 0.33λ. For sheet corner reflector Yagi antenna, to obtain maximum gain, the conventional reflector and sheet corner reflector are to be separated by a distance of 0.266λ. The sheet corner angle should be 160^0. The sheet width should be 0.033λ.

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