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Design of 3 Element Yagi - Uda Antenna for RFID Applications

M.M. Prasada Reddy
Professor, ECE, NCET, Hyderabad, India

***Abstract*— This paper presents the design of 3 element Yagi Uda antenna at 400MHz frequency for UHF (RFID) applications. The antenna has one active element(dipole antenna), one reflector(passive element) and 3 directors (passive elements).Adjusting the spacing between elements 50% of improvement in impedance band width,0.6 dBi improvement in gain and directivity is achieved. The antenna design is simulated in CST microwave studio.**

***Index Terms*— Yagi-Uda, Gain, Directivity, Band Width, Reflector, Dipole, Director and CST studio**

I. INTRODUCTION

Yagi - Uda antenna was invented by Shintaro Uda and Hidetsugu Yagi in 1920.It is widely used in applications where high gain and directivity is required. Usually yagi - Uda consists of an active element, reflector and directors. Reflector is placed rare side of the dipole and directors are placed in front side of the dipole .Feeding is provided at the center of the dipole , so that maximum power is transmitted from transmitter to antenna. No feeding is provided to reflector and directors. Director length is a bit shorter than the active element and the director length vary with respect to spacing between director elements. Director length and spacing between director elements has significant effect on gain and band width. The length and spacing of a reflector also affects the gain and input impedance of an antenna. A low cost Yagi - Uda antenna operating at 400 MHz is designed in this paper. Section II represents literature survey, section III describes the antenna design, section IV discusses result analysis and the paper end with a conclusion in section V.

II. LITERATURE SURVEY

In [1] the author has designed a 3 element Yagi Uda antenna at an operating frequency of 400 MHz In this the author has increased band width by 21.5 %, by increasing the reflector length and by reducing the director length. In this approach high gain (16.3 dBi) is achieved but gain is only 21.5 %.In [2] the authors have designed 6 element Yagi - Uda antenna at a frequency of 165 MHz In this approach the authors used radiation pattern optimization to achieve higher directivity. The optimized antenna has achieved a directivity of 11.5 dBi with a narrow band width. in [3] the authors have designed a 5 element Yagi Uda antenna at 160 MHz in this method a curved surface reflector is used in addition to conventional Yagi - Uda antenna. The curved surface reflector has improved gain over wired reflector from 8 dBi t0 9.67 dBi.

III. Antenna Design Parameters

The basic structure of 3 element Yagi Uda antenna is shown in the figure 1. A port is provided at the centre of the dipole and is fed by a voltage source. The proposed antenna is designed at a resonant frequency of 400 MHz the antenna design parameters at 400 MHz is given by

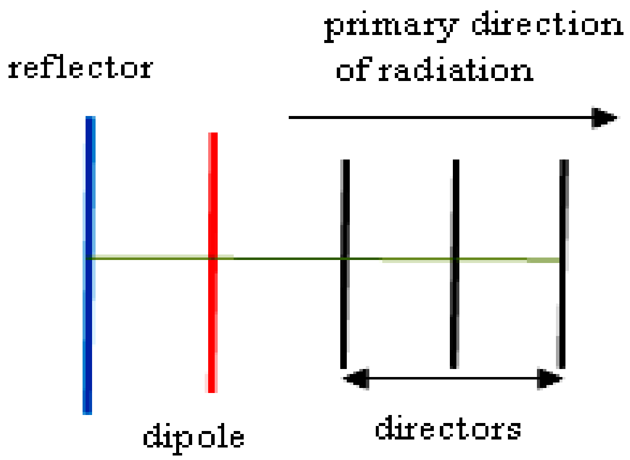

Figure 1 : basic 3 element Yagi Uda antenna

Reflector length	$L_R = 0.477\lambda$
Dipole length	$L_A = 0.451\lambda$
Director length	$L_d = 0.422\lambda$
Spacing between elements	$d = 0.25\lambda$
Radius of each element	$r = 0.00425\lambda$

Dipole length vary in between 0.45λ *to* 0.49λ, director length vary in between $0.4\,\lambda$ *to* 0.45λ, and reflector length is 5% more than dipole and spacing between elements vary in between 0.35λ *to* $0.4\,\lambda$.

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Table 1: Parameters of the proposed antenna

Parameter	Length in meters
L_R	0.3584
L_A	0.338
L_d	0.316
d	0.1875
r	0.00318

The length of the array (directors) is most important than number of elements present in array. The spacing between reflector and dipole, dipole and director 1, director 1 and director 2 and director 2 and director 3 determine the matching of antenna. The gain of Yagi Uda antenna depends on number of directors present in the array. The gain increases as the array increases .In this paper the length of reflector, dipole and directors is kept constant. But the spacing between elements is altered as shown in the table 2.

Table 2 : Optimized spacing between elements

	Distance between reflector and Dipole	Dipole and D1	Director -1 and Director -2	Director-2 and director-3
Initial design	0.1875	0.1875	0.1875	0.1875
Optimal design	0.1575	0.1975	0.2025	0.1975

IV. Result Analysis

The proposed Yagi Uda antenna is simulated in CST Microwave studio. The optimized antenna design parameters have achieved improved gain and directivity over initial design from 10.6 dBi to 11.2 dBi and 12 MHz improvement in bandwidth.

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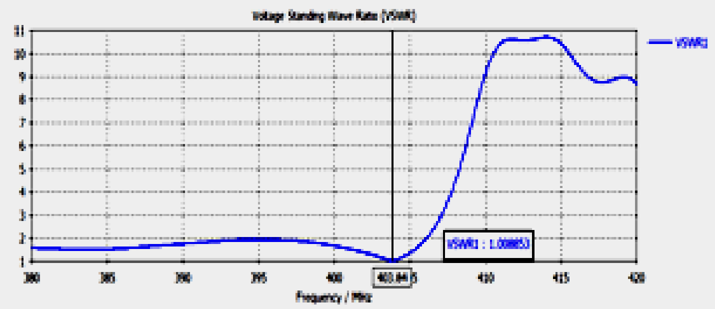

Figure 2:VSWR of initial design

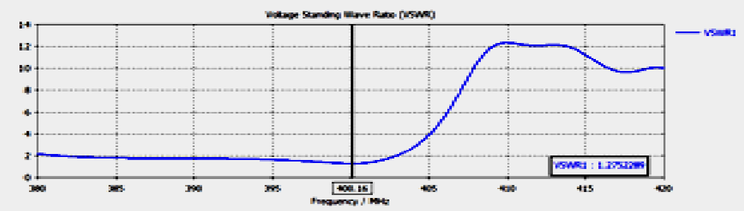

Figure -3 : VSWR of optimized design

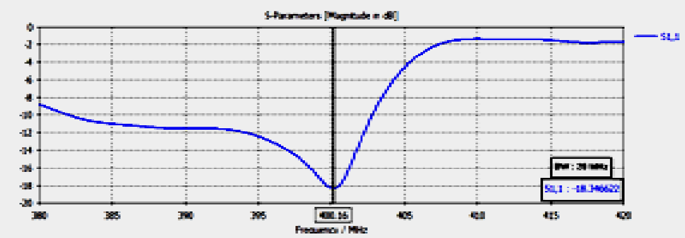

Figure-4 :Return loss of optimized design

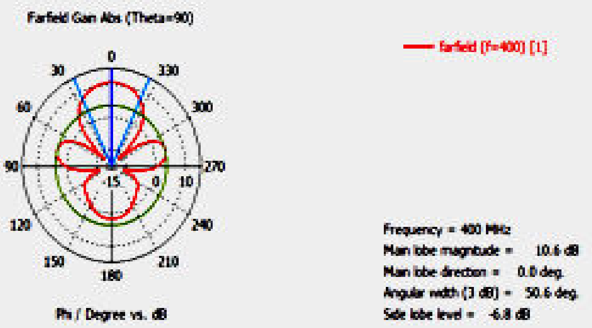

Figure 5: Far field gain of initial

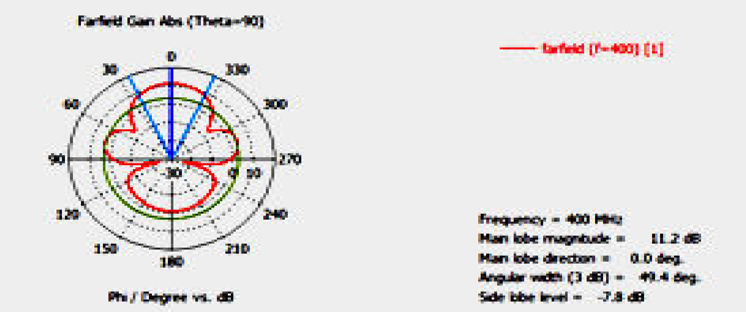

Figure 6: far field gain of optimized design

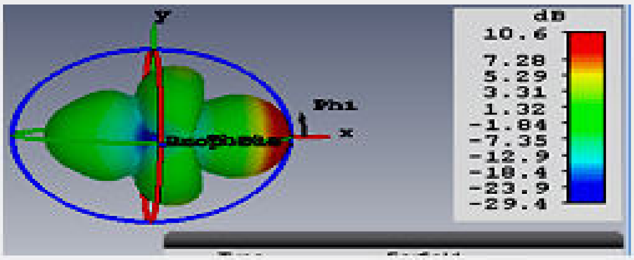

Figure 7: Gain of the initial design

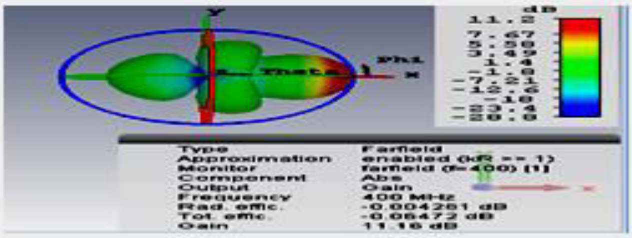

Figure 8:Gain of the optimized design

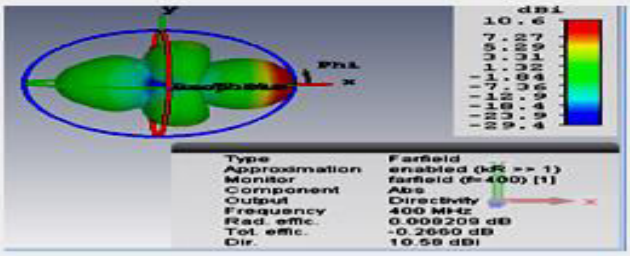

Figure 9: Directivity of initial design

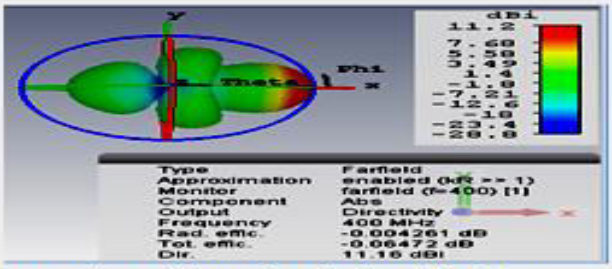

Figure 10: Directivity of optimized design

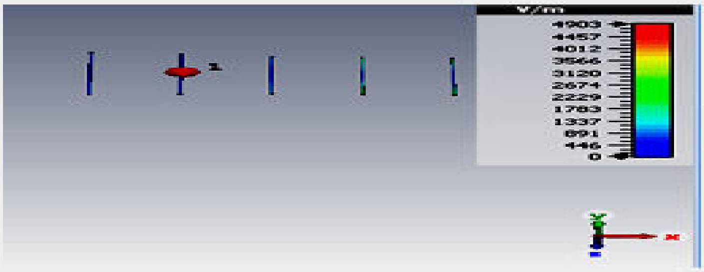

Figure 11: Electric field of initial design

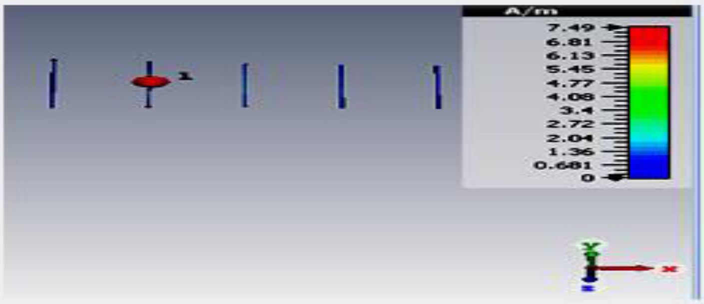

Figure 12: Magnetic field of initial design

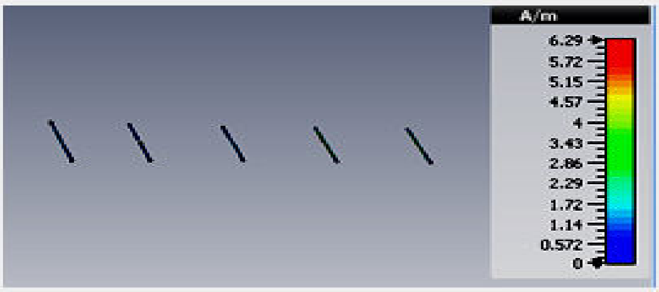

Figure 13: surface current of initial design

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Table 3: Performance comparison of initial design and optimized design

	RL	VSWR	Gain in dBi	Directivity dBi	BW MHz	E-field V/m	H-field A/m	Surface current A/m
Initial Design	-47.11	1	10.6	10.6	8.84	4903	7.49 A/m	6.29
Optimal design	-18.34	1.27	11.2	11.2	20	5493	8.53 A/m	6.88

From table 3 it is obvious that the initial design is good in terms of return loss and VSWR but poor in band width, but optimized design is still performing well, because its return loss is less than -10 and VWR is < 2.The optimized design has achieved 0.6 dBi improvement in gain and directivity, and 50 % of improvement in impedance band width. The optimized design is also showing good performance in terms of Electric field, Magnetic field and Surface current over initial design.

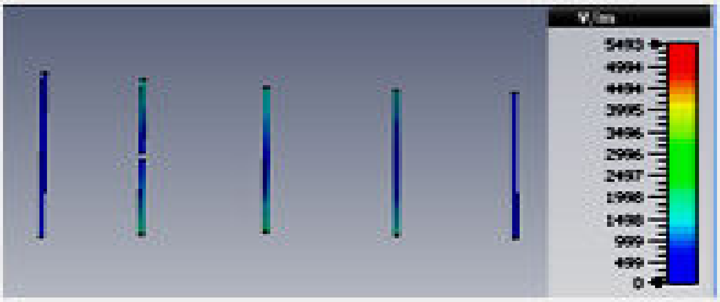

Figure 14: Electric field of optimized design

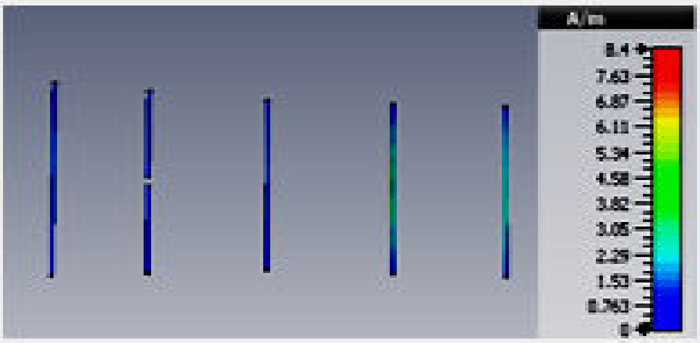

Figure 15: Magnetic field of optimized design

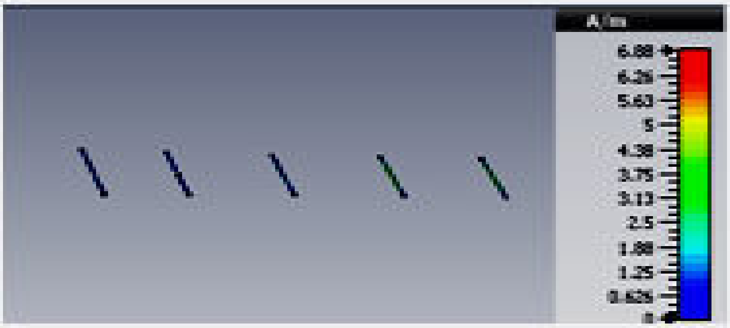

Figure 16: surface current of optimized design

V. CONCLUSION

In this paper a Yagi Uda antenna is designed and simulated using CST Microwave studio. The antenna is operated in UHF band, and band width is increased by 12 MHz by adjusting spacing between reflectors, dipole and directors .This antenna is well suited for RFID applications in UHF band. In this paper the length of reflector, dipole and directors is kept constant and spacing between elements is varied. in the future work by altering both length of the elements and spacing between elements high gain and band width can be achieved without increasing the number of directors

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AUTHOR'S BIOGRAPHY

M.M. Prasada Reddy pursuing his research on wireless communications. His research interests includes Image and signal processing, wireless communications, Microwave Engineering, VLSI and Internet of things .He has authored more than 20 research papers in reputed journals and 3 books on communication Engineering .Currently he has focused on 5G antennas and channel modeling.

