Optimization of Yagi -Uda Antenna Gain for Wi-Fi &Wi-Max Applications

Abdulgader Elfasi *1, Marai M. Abousetta *2, Walid T. Shanab *3, Nezar G. Ayad *4
#1 Department of communication in college of Electronic Technology-Tripoli
1A.alfasi@academy.edu.ly
#2 Libyan academy of graduate studies
2M.abeusetta@academy.edu.ly
#3 Department of communication in higher institute of engineering Technology
3Walidtshanab@yahoo.com
#4 Department of communication in college of Electric and Electronic Engineering-University of Zawia
4N.ayad@zu.edu.ly

Abstract

Yagi-Uda antennas are known to be difficult to design and optimize due to their sensitivity at high gain, and the inclusion of numerous parasitic elements. There are various patch antennas used for Wi-Fi and Wi-MAX applications, but with high gain and directionality are requirement. Generally number of directors is raised to increase gain of these antennas. But, here we present modified designs of Yagi-Uda antennas, in which the directivity, gain and bandwidth can be enhanced by different techniques.

In this paper initially discuss a design of a conventional Yagi-Uda antenna with four uniform directors is undertaken and uniform spacing between them. Results show that, the proposed techniques would enhance the directivity, gain as well as bandwidth when compared with the first design of Conventional Yagi-uda antenna. Finally, it can be said that the proposed design is suitable for Wi-Fi and Wi-MAX antennas with opertating frequency range starting from 2.45 GHz.

***Keywords*—Yagi-Uda antenna, gain, Wi-Fi, WI-MAX, Bandwidth.**

I. INTRODUCTION

Antenna array design has been based on an analytic approach. This has led to many elegant to closed form solutions but it has also often led to design methods that are limited by restrictive conditions, such as the need for regularity in the array configuration (i.e. uniform element spacing and unrealizable assumptions, particularly concerning the effects of mutual coupling). For example, a Chebyshev distribution is optimum only for the idealized case of a uniformly λ/2 spaced array of isotropic elements with no coupling [1].

The antenna literature contains many useful methods for the optimum synthesis of antenna arrays. These include the use of non-uniform spacing methods to account mutual coupling, as well as numerical empirical optimization algorithm for the optimization of antenna array that account for the effects of mutual coupling and scattering between the elements of the array and the nearby environment. The method is based on measured or calculated element pattern data and proceeds in an iterative fashion to the optimum design. The algorithm can synthesize optimum element spacings and optimum element excitations; and is applicable to arrays of various element types having arbitrary configurations, including phased arrays, conformal arrays and non-uniformly spaced arrays.

This paper presents two versions of the empirical optimization algorithm. Both versions are applicable to the optimum synthesis of array element excitations. Version v2 can be used for the optimization of active element locations when inter-element spacing is > 0.5λ and coupling effects do not vary rapidly as a function of element locations. Version v2 accounts for the presence of passive elements in the near vicinity of the array, but it cannot be used to optimize their locations. This can be done with Version v2 of the algorithm.

Version v2 presents a novel method for the extraction of the admittance matrix representation of an antenna array. The admittance matrix contains the effects of electromagnetic coupling between the active and passive elements of the array. The method presented is applicable to arrays with non-uniform spacing. Other methods to account for coupling effects in arrays described in the literature normally require uniform element spacing. The admittance matrix formulation provides a means to account for coupling between the active and passive array elements as a function of their locations, and to calculate the active element scan impedances [2].

The empirical optimization method can find both the optimum set of array element locations (non-uniform spacing) as well as the optimum set of element excitations. This provides added degrees of freedom in achieving optimum array performance and in compensating for coupling effects, as compared to traditional analytical design methods. Non-uniform spacing offers special advantages in suppressing grating lobes in thinned arrays and in wide angle scan and broad frequency bandwidth array operation [3].

A numerical function minimization method is used to find the set of array parameters (element excitations and/or element locations) to minimize the normed difference between the actual array pattern and some desired pattern. The use of numerical function minimization methods for optimum search removes the restrictions normally imposed by analytic methods for array geometry regularity. The use of asymmetric excitation distributions and non-uniform element spacing allows for increased degrees of freedom in design. It also allows for the optimization of arbitrary array configurations including conformal arrays. The use of embedded element pattern data means that the optimization is performed under realistic conditions that account for the effects of electromagnetic coupling between the elements of the array and the environment [4].

II. Proposed Design Method

The parameters to be used of the Yagi antenna for the proposed design method are as follows:

- wave length (λ)
- Radius of each element (a)
- Length of each element (L)
- The spacing between the elements (S)
- The number elements (N)

At first the parameters for the design need to be calculated as can be seen in figure 1 **[5].**

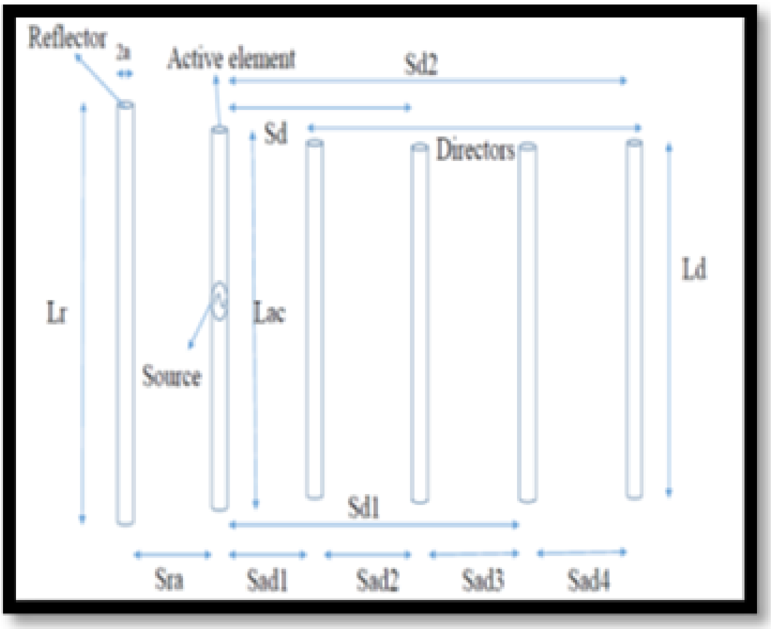

Fig. 1 Yagi antennas with parameters [5].

A. Calculation the wave length (λ):

The wave length is dependent on the frequency and the light speed in free space and can be found by the formula:

$\lambda = c / f = (3x10^8) / (2.45*10^9) = 122.448$ mm.

B. Radius of each element (a)

The Radius of each element is the same and typically it is. 0.0425λ OR (a) = 5.204 mm.

C. Length of each element (L)

The lengths of elements are not the same, the lengths are:

1) **An active element (driven)** is the one to which the source or excitation is applied. Generally, length (Lac) of this element is slightly less than λ/2 ranges from 0.45λ to 0.49λ and in this work the selected value is: (Lac) = 0.45λ = 55.1016 mm [8].

2) **Length of reflector (Lr)**

Length of reflector (Lr) is 5% greater than the length of active element. Having a length greater than the active element causes good reflections towards forward direction. Basically more than one reflector can be used, but it does not add any advantage specifically so: (Lr) = 0.5λ = 61.227 mm.

3) **Length of directors (Ld)**: In the designs of Yagi-Uda antennas, directors play a key role in achieving better gain and directivity. Usually, their length is near to 5%

smaller than the active element but in this project it will be a variable to optimize the gain of the Yagi antenna.

4) **The space between elements**: A reflector is located behind active element at a distance (Sra) of 0.25λ, and spacing between the directors and the spacing between an active element directors varies between 0.35λ to 0.4λ and the spacing will be a variable to optimize the gain of the Yagi antenna [6].

5) **The number of elements**: The number of element is a variable to optimize the gain of Yagi antenna.

D. Optimization gain technics for Yagi antenna

Increasing the number of elements, changing in the space between elements, uniform space between directors, nonuniform space between directors and changing in the lengths of elements.

E. Uniform lengths of directors and uniform spaces between the directors

This work, focuses on the designs of conventional
Yagi-Uda antennas with 4 directors as shown in figure 2 here, 4 directors for better gain and bandwidth. Have been selected Optimized dimensions are as listed below [7].

$\lambda = c / f = (3x108) / (2.45*109) = 122.448$ mm.
(a) = 5.204 mm.
(Lac) = $0.45\lambda = 55.1016$ mm.
(Lr) = $0.5\lambda = 61.227$ mm
(Sra) of $0.25\lambda = 30.61$ mm.
(Sad1) = (Sad2) = (Sad3) = (Sad4) = $0.35\ \lambda = 42.85$ mm.
(Ld1) = (Ld2) = (Ld3) = (Ld4) = $0.4\ \lambda = 48.97$ mm.
And by (hfss) software we can see the design in figure 2.

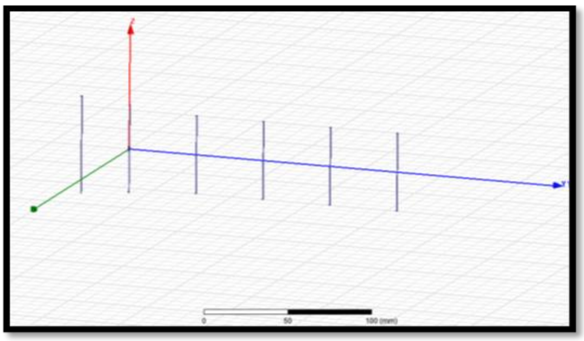

Fig. 2 Yagi antenna designed by (hfss)

F. Results of the design

Tables must be numbered using uppercase Roman numerals.

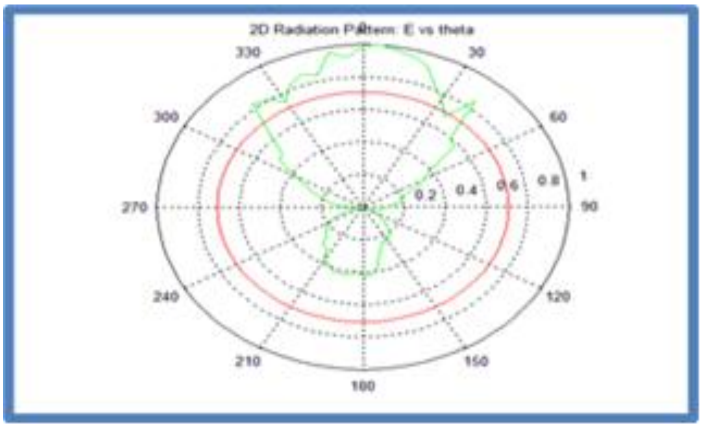

Fig. 3 Radiation pattern of Yagi antenna with 4 directors.

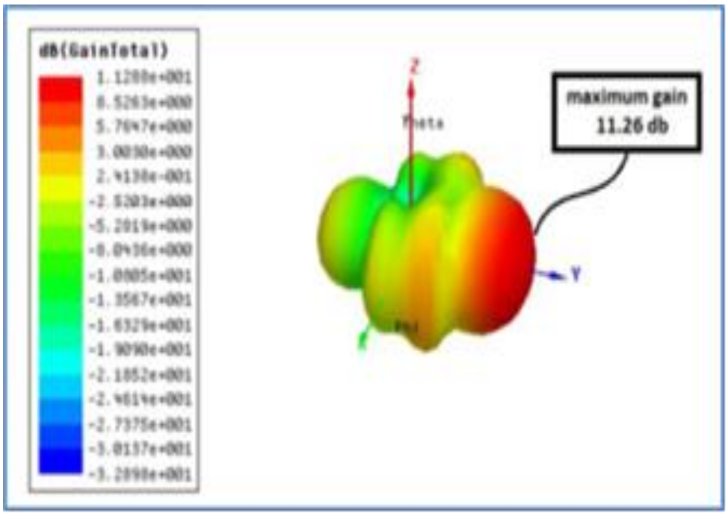

Fig. 4 polar plot of the gain with Maximum gain 11.26 Db.

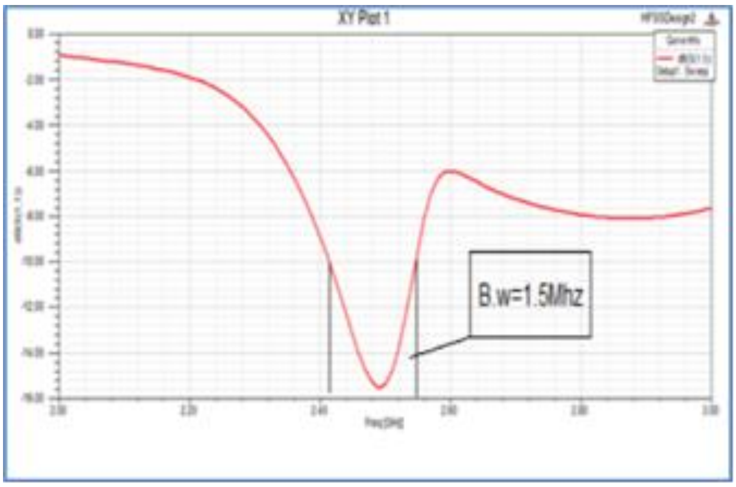

Fig. 5 Return loss of the design

G. Optimize the gain of Yogi antenna

Increasing the number of directors (uniform length – uniform space): Here we can increase the number of directors and add 6 directors with uniform lengths and the space is uniform between them as the figure 4.6 and another parameters is the same. And the number of directors in the optimized design is 10 directors:

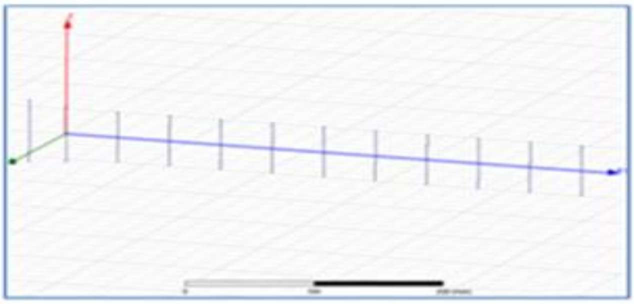

Fig. 6 Yagi antenna with 10 directors.

H. the results of the optimized Yagi antenna

In the results we can see the changing in the directivity in the figure 7 we can see that in the radiation pattern , and the gain is changing with the directivity as figure 8.

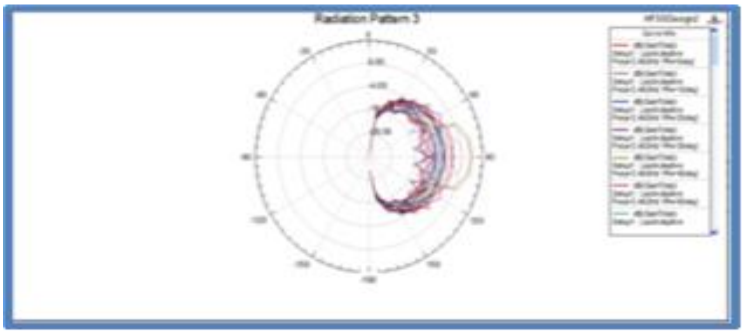

Fig. 7 Radiation pattern of optimized antenna with 10 directors.

I. And we can see the Return loss of the Yagi antenna and we can see that the Bandwidth of the antenna in the figure 4.9 and the bandwidth is 180 Mhz :

J. Increasing the number of directors (non uniform lengths – uniform space)

Here we increasing the number of directors to 13 directors but in the last 3 directors we decreased the lengths of them but with the same uniform space, we can see the optimized design in the figure10 the new Yagi antenna now has 13 directors; the parameters is the same but the changing is only in the number of directors and their lengths and the lengths of the directors of optimized design is:

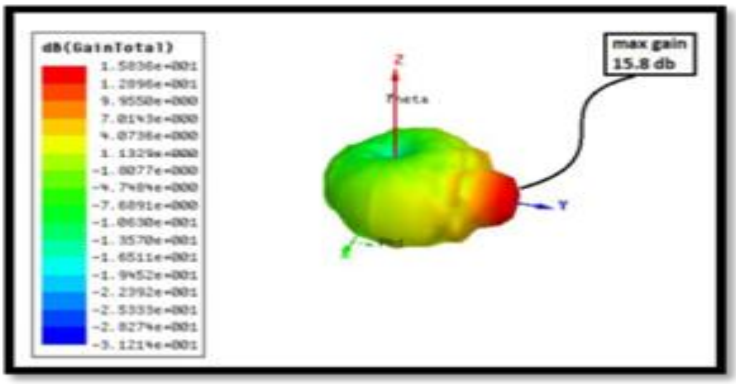

Fig. 8 polar plot of the gain with maximum gain 14.77dB

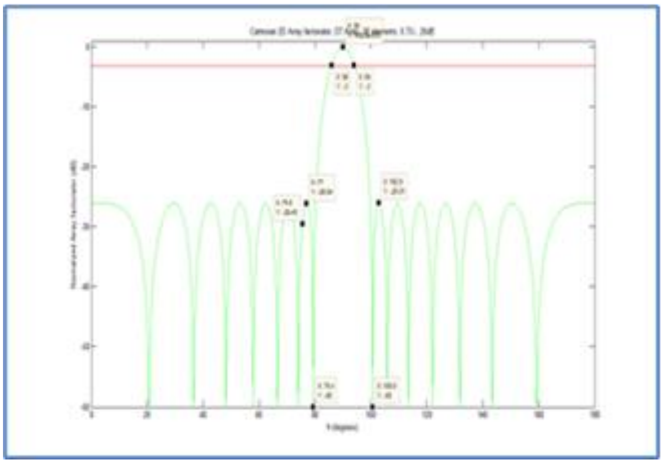

Fig. 9 Return loss of the optimized Yagi antenna with 15 directors.

(Ld1) =(Ld2) =(Ld3) =(Ld4) =(Ld5) =(Ld6) =(Ld7) =(Ld8)=(Ld9) = (Ld10)= 0.4 λ = 48.97 mm .

(Ld11) = 46.97 mm.

(Ld12) = 44.97 mm.

(Ld13) = 42.97 mm.

III. RESULTS OF THE OPTIMIZED YAGI ANTENNA

In the new design its clear the changing in the directivity in the radiation pattern we can see figure11:

And we can see the changing in the gain in the figure 12; the figure showing that the maximum gain with the red color is 15.54 dB:

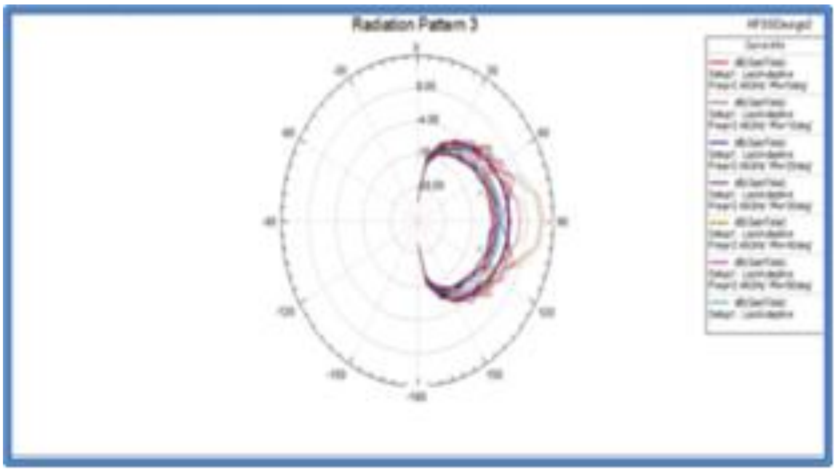

Fig. 10 Yagi antenna with 13 directors.

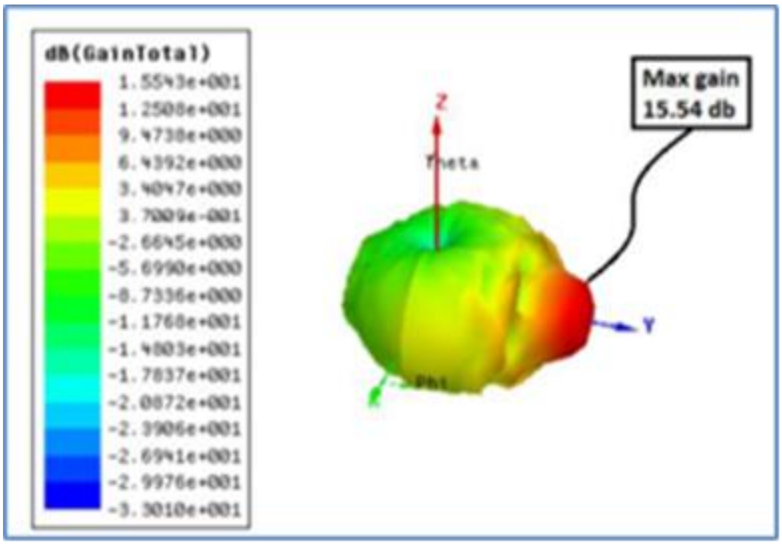

Fig. 11 Radiation pattern of optimized antenna with 13 directors.

:

- The relationship between the number of directors and the gain of Yagi antenna:

We can understand the relationship between the number of directors and gain of the Yagi antenna when we make the optimization for the gain in Yagi antenna and we can see the table 4.1 which shown the number of directors and their effective in the gain of Yagi antenna:

IV. CONCLUSION

V. IN THIS PAPER, INITIALLY WE DISCUSSED THE DESIGN OF CONVENTIONAL YAGI-UDA ANTENNA BY CONSIDERING FOUR UNIFORM DIRECTORS WITH UNIFORM SPACING

BETWEEN THEM IN WI-FI AND WI-MAX TECHNOLOGIES AND DISCUSSED THE DIRECTIVITY AND THE GAIN OF THE DESIGN , THEN WE OPTIMIZED IT BY VARIED TECHNIQUES, HERE WE OBSERVED HOW WE COULD OPTIMIZE THE GAIN AND THE DIRECTIVITY OF THE CONVENTIONAL YAGI ANTENNA SINCE WE INCREASED THE NUMBER OF DIRECTORS AND CHANGE THE SPACE BETWEEN DIRECTORS WITH VARIED LENGTHS OF DIRECTORS, THE SIMULATION RESULTS SHOWED THAT THE PROPOSED TECHNIQUES CAN ENHANCE THE DIRECTIVITY

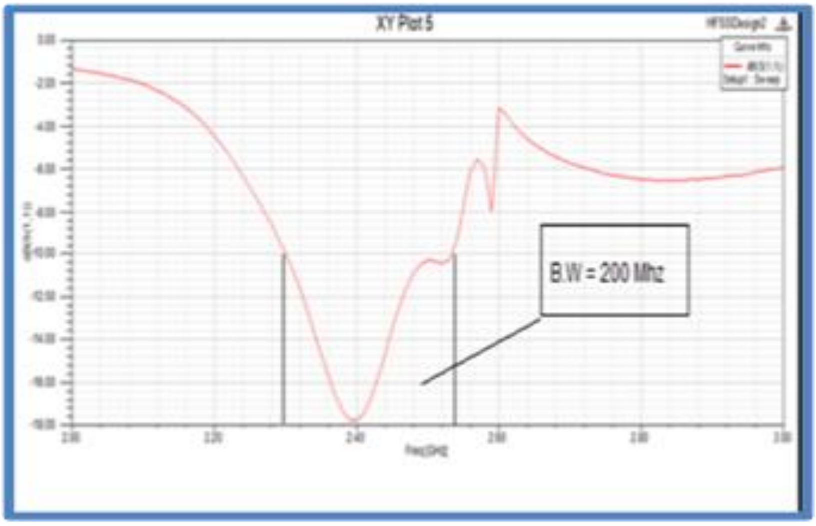

Fig. 12 polar form for the gain of optimized Yagi antenna with Maximum gain 15.54 dB:

Table 1

Number of directors	Gain dB
4	11.26
7	12.544
10	14.77
13	15.543
15	15.836

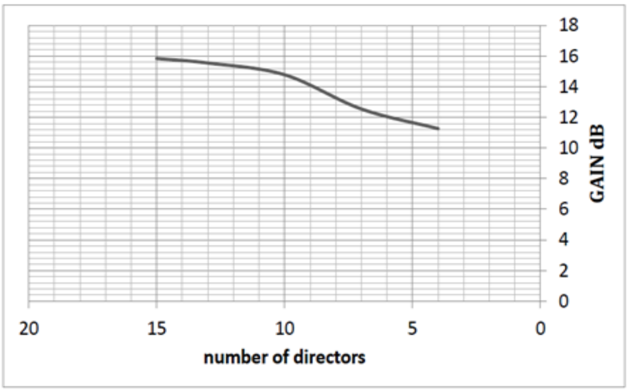

Fig.13 relationship between number of directors and the gain.

gain as well as bandwidth when compared with the initial design of the conventional Yagi antenna. Finally, we can state that, proposed designs in are most suitable antennas for Wi-Fi and Wi-MAX applications. These kinds of design are mostly useful in areas, where Wi-Fi and Wi-MAX technologies are enabled.

REFERENCES

.

[1] Payal, R. Madhusudhan Goud, Komalpreet Kaur, "Design of Yagi-Uda Antenna usingMicrostrip circuit", International Journal of Computer Applivations(0975-8887), Volume 96-No.24, June 2014.

[2] Gulshan Sharma, Vijay Sharma and P.K. Singhal, "Performance Investigation of Yagi-Uda Antenna using Different Shapes of antenna element at 2GHz", IJECCT 2013, Vol.3(2).

[3] Pristin K Mathew, "A Three element Yagi-Uda Antenna for RFID systems",© 2014 IJEDR | Volume 2, Issue 1 | ISSN: 2321-9939.

[4] Priti N. Bhagat, V.B. Baru, "Slotted Patch Antennas with EBG Structure for ISM Band", 2012 International Conference on Communication, Information & Computing Technology (ICCICT) , Oct. 19-20, Mumbai, India.

[5] Ankit Agnihotri, Akshay Prabhu, Dheerendra Mishra, "Imrovement in Radiation pattern of YagiUda antenna", Research Inventy: International Journal of Engineering and Science, Vol.2, Issue 12 (May 2013), PP 26-35, ISSN(e) :2278-4721, ISSN(p): 2319-6483.

[6] B.I.Neelgar and G.S.N. Raju, "Impedance Characteristics of Yagi-Uda Antenna", International Journal of Electronics and Communication Engineering, ISSN 0974-2166 Volume 4, Number 1(2011), pp.115-130.

[7] Gulshan Sharma , Anand N.sharma, Ashish Duvey, P.K. Singhal, "Yagi-Uda antenna for L-Band frequency Range", International Journal of Engineering and technology, 1(4) (2012) 315-320.

[8] Mirishkar Sai Ganesh, "Optimization of radiation Pattern of Yagi-Uda antenna", Edubeam Multidisciplinary-Online Research Journal Vol-Xi, Issue-1, January-2014, ISSN 2320-6314.